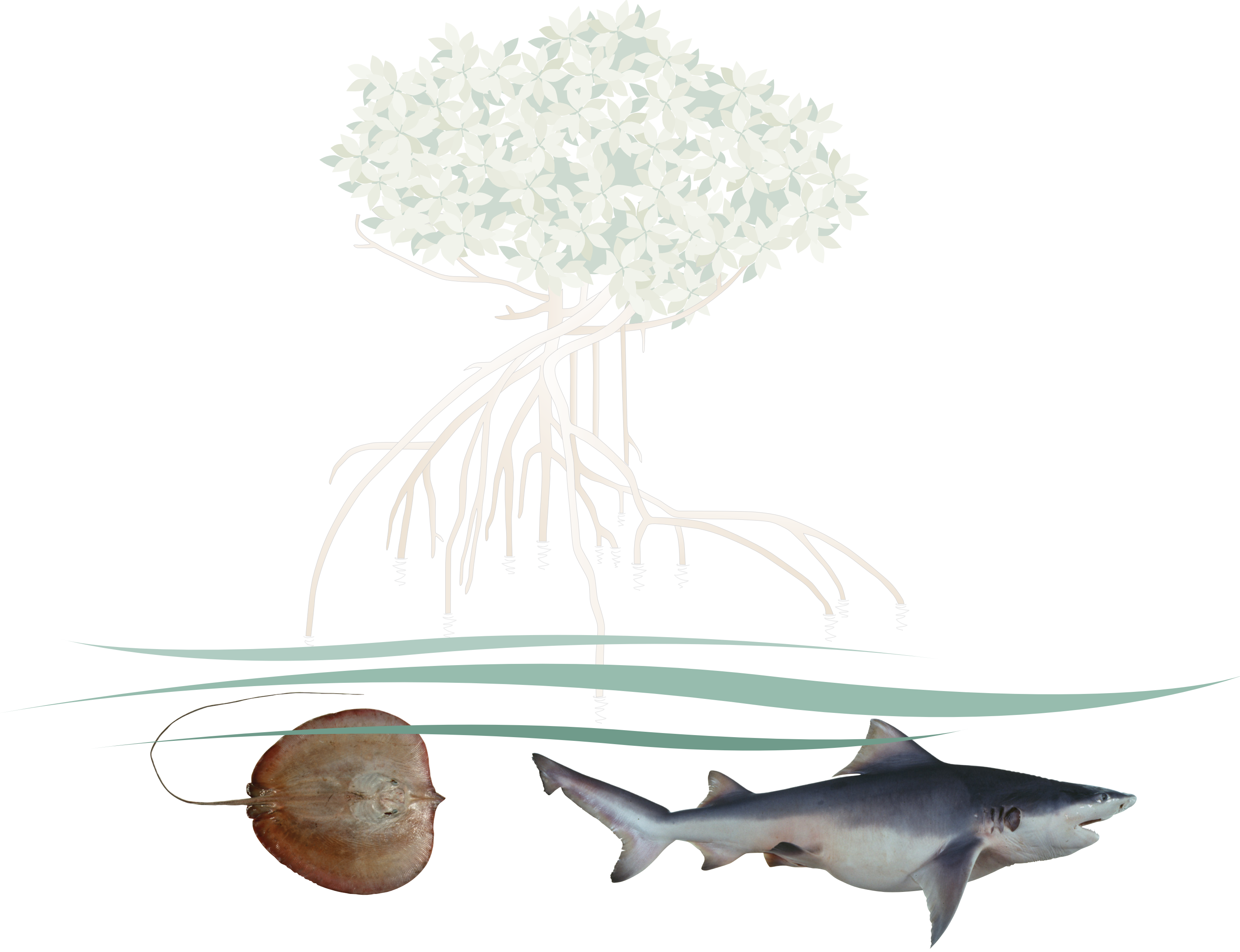

DESCRIPTIONS *of* NEW AUSTRALIAN CHONDRICHTHYANS

EDITORS:

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CSIRO MARINE AND ATMOSPHERIC RESEARCH PAPER NO. 022

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Foreword

The identification guide *Sharks and Rays of Australia* (Last & Stevens, 1994) provided the first major review of the Australian chondrichthyan fauna since 1940. The book covered 296 species of chondrichthyan fishes occurring in the seas, estuaries and freshwaters of the region. Of these, about 97 species could not be identified as known species and were thought to be unnamed. The book received positive reviews, as well as a book award (Whitley Medal), but some reviewers felt that the unnamed species needed to be described as quickly a possible to avoid creating nomenclatural problems – the unavailability of formal species names could also hinder other fields of biological science with implications for species conservation and management. In addition, several species, such as the Port Davey Skate (as *Raja* sp. L) and the Speartooth Shark (as *Glyphis* sp. A), were listed as threatened species in the *IUCN Red List of Threatened Animals* (www.iucnredlist.org) without formal epithets. By early 2006, 26 of these unnamed species had been formally described, but the bulk of them remained unnamed.

Copies of *Sharks and Rays of Australia* sold well and the book was soon out of print. Because of its high profile, CSIRO Publishing and CSIRO Marine & Atmospheric Research (through the Wealth from Oceans Flagship) provided support for a full revision to include formal species names for every taxon. Some species were described in the mainstream taxonomic literature but, to fast track the process, a trilogy of special publications in the CMAR Research Paper series was used to describe an additional 70 new species. More than 50 individual papers describe the remaining unnamed species, additional newly discovered Australian species, and four new species from adjacent bioregions. The first two publications have been published and dealt with descriptions of new species of dogfishes of the genus *Squalus* (Squalidae) and new species of skates (Rajoidei):

• Last, P.R., White, W.T. & Pogonoski, J.J. (eds) (2007) *Descriptions of New Dogfishes of the Genus* Squalus *(Squaloidea: Squalidae)*. CSIRO Marine & Atmospheric Research 014, 130 pp. [published 7 April 2007]

• Last, P.R., White, W.T., Pogonoski, J.J. & Gledhill, D.C. (eds) (2008) *Descriptions of New Australian Skates (Batoidea: Rajoidei).* CSIRO Marine & Atmospheric Research 021, 181 pp. [published 3 April 2008]

This publication is the third in the series and includes a collection 30 papers describing new sharks, rays and chimaeras of the Australasian region. A few minor errors detected in the first two publications are listed in Appendix I (at the end of this document).

A rapid taxonomic approach was used to assign formal names and provide detailed species descriptions quickly, while still retaining a high level of scientific rigour. Full revisions with skeletal treatments of species were not usually attempted or provided. Each of these special publications is available as limited, black and white hard copy, and colour PDF versions. Hard copies were deposited in several relevant Australian institutions, including the National Library of Australia, State Library of Tasmania, CSIRO Marine & Atmospheric Research Library Hobart, Museum Victoria, Western Australian Museum, Australian Museum, Queensland Museum, Museum and Art Gallery of the Northern Territory, as well as international institutions, including the Californian Academy of Sciences (USA), Muséum national d'Histoire naturelle (France), Moss Landing Marine Laboratories (USA), and Ichthyological Research Laboratory and Consultancy (Germany). Copies were also provided to all contributing chondrichthyan taxonomists. The PDF versions are available to the wider community at http://www.cmar.csiro.au/publications/cmarseries/frame.html (numbers 014 and 021) or by email request (william.white@csiro.au; john.pogonoski@csiro.au).

Many people from various institutions assisted us in this ambitious taxonomic study of Australasian chondrichthyans. Contributions include authorship, the provision of specimens and collection data, biological input, technical assistance, reviews and editorial comments on manuscripts, and expert opinion on specific groups and taxa. Individuals that provided invaluable assistance for particular treatments are acknowledged in appropriate papers within respective publications. This project was partly funded by the Wealth from Oceans (WFO) Flagship through the Sustainable Australian Fisheries and Ecosystems (SAFE) and Marine Conservation and Biodiversity Management (MCBM) themes. In particular, we thank managers Nic Bax, Campbell Davies, Dave Smith and John Gunn for their support. We thank John Manger and Briana Elwood (CSIRO Publishing) for their assistance in producing the second edition of *Sharks and Rays of Australia*. We also thank the many fishers, research scientists and research vessel crews that have helped obtain important samples from across the region. Collection staff from most Australian museums kindly made important material accessible for parts of this study, as well as specimens used as types.

The following 14 non-CSIRO ichthyologists contributed to papers included in this publication: Bernard Séret and Samuel Iglésias (Muséum national d'Histoire naturelle, France), Marcelo de Carvalho (Universidade de São Paulo, Brazil), David Ebert (Moss Landing Marine Laboratories, USA), Leonard Compagno (Iziko-South African Museum, South Africa), Kazuhiro Nakaya, Junro Kawauchi and Ryohei Sasahara (Hokkaido University,

Japan), Keiichi Sato (Okinawa Churaumi Aquarium, Japan), Michikazu Yorozu (Yokohama Hakkeijima Sea Paradise, Japan), Hiroyuki Motomura (The Kagoshima University Museum, Japan), Mabel Manjaji-Matsumoto (Universiti Malaysia, Sabah, Malaysia), Martin Gomon (Museum Victoria, Australia) and Dominique Didier (Millersville University, USA).

In addition to the editors, the following scientists provided expert reviews of one or more of the papers within this series: Bernard Séret (Muséum national d'Histoire naturelle, Paris), David Ebert (Moss Landing Marine Laboratories, USA), Brett Human (Australia), Clinton Duffy (Department of Conservation, New Zealand), Andrew Stewart (Museum of New Zealand Te Papa Tongarewa, New Zealand), Martin Gomon (Museum Victoria), Charlie Huveneers (Sydney Institute of Marine Sciences, Sydney), Ian Jacobsen (University of Queensland, Brisbane), Justin Chidlow (Department of Fisheries Western Australia, Perth), Peter Kyne (University of Queensland, Brisbane), Ross Daley and Gordon Yearsley (CSIRO, Hobart).

Finally, we thank CSIRO staff members Alastair Graham (specimen information) and Louise Conboy (imagery) for their invaluable contributions throughout this project. We especially thank Ken Graham (NSW Department of Primary Industries, Sydney) who has greatly assisted us in many aspects of our studies on Australian chondrichthyans, in particular by providing fresh chondrichthyan material and very useful and critical comments on the skate papers. We would also like to thank Louise Bell (CSIRO) for her excellent cover designs in this and the two other publications, and also for her advice on various technical aspects of the layout of these publications. Thanks to Bob Ward and Bronwyn Holmes (CSIRO) for their continuing support and technical input on the genetic barcoding of Australian chondrichthyans. We would also like to thank Janine Caira (University of Connecticut, USA), Kirsten Jensen (The University of Kansas, USA) and Gavin Naylor (Florida State University, USA) for their assistance during National Science Foundation (NSF) funded surveys of the chondrichthyan fishes of Malaysian Borneo (DEB No. 0103640). This project contributed important comparative material and images that proved invaluable throughout this project. Comparative material was also obtained from surveys of Indonesian fish markets funded by the Australian Centre for International Agricultural Research (ACIAR).

Peter Last

William White

John Stevens

Daniel Gledhill

John Pogonoski

Contents

Description of two new species of gulper sharks, genus *Centrophorus* (Chondrichthyes: Squaliformes: Centrophoridae) from Australia

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ABSTRACT.— Two new species of gulper sharks, *Centrophorus westraliensis* sp. nov. and *Centrophorus zeehaani* sp. nov., are described based on specimens from Australian waters. *Centrophorus westraliensis* was previously considered to be conspecific with *C. harrissoni* from eastern Australia, New Zealand and New Caledonia. However, recent investigations revealed that the two forms are clearly separable based on their morphology. *Centrophorus zeehaani* was previously considered to be conspecific with *Centrophorus uyato*, but the original description of the latter species clearly depicts a *Squalus* and not a *Centrophorus* species. *Centrophorus zeehaani* belongs to a subgroup of longnose *Centrophorus* species which includes *C. harrissoni*, *C. isodon*, *C. seychellorum* and *C. tessellatus*, and is clearly separable based on morphology and coloration. The two new species appear to be endemic to Australian waters and their conservation status needs to be investigated to determine if they are critically endangered as is the case with *C. harrissoni*.

Key words. *Centrophorus westraliensis* – *Centrophorus zeehaani* – *Centrophorus harrissoni* – new species – endemic – Australia

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INTRODUCTION

The Centrophoridae (Chondrichthyes: Squaliformes) comprises two genera, *Centrophorus* and *Deania*, which consist of ten and four species, respectively (Compagno *et al*., 2005). The genus *Centrophorus*, proposed by Müller & Henle, 1837, has had a very complex taxonomic history. This is due, in part, to the substantial intraspecific variation in body and fin morphology and ontogenetic changes in dermal denticle and tooth morphologies associated with growth and sexual dimorphism. Compounding the identification problem is that most species were poorly described originally and many of the characteristics used to distinguish between species were poorly defined. Furthermore, the poor representation of *Centrophorus* species in regional institutional collections, due in part to their large size and occurrence in deep benthic habitats, has also been a hindrance.

Last & Stevens (1994) provided treatments for five species of *Centrophorus* occurring in Australian waters, i.e. *Centrophorus granulosus* (Bloch & Schneider, 1801), *C. harrissoni* McCulloch, 1915, *C. moluccensis* Bleeker, 1860, *C. squamosus* (Bonnaterre, 1788) and *C. uyato* (Rafinesque, 1810). The authors noted that east and west coast populations of *C. harrissoni* required closer comparative examination. Compagno *et al.* (2005) listed the first four aforementioned species as occurring in Australian waters, plus possibly *C. atromarginatus* Garman, 1913 and *C. niaukang* Teng, 1959, but commented that *C. uyato* was not a valid taxon. Other *Centrophorus* species recognised by Compagno *et al*. (2005) which occur outside of Australia are *C. acus* Garman, 1906, *C. isodon* (Chu, Meng & Liu, 1981), *C. lusitanicus* Bocage & Capello, 1864 and *C. tessellatus* Garman, 1906. Although many authors have included Rafinesque's (1810) *Squalus uyatus* in the genus *Centrophorus* following Garman (1906), the original description and illustration (Rafinesque, 1810: 13–14, pl. 14, fig. 2) clearly depicts a *Squalus* species that is recognisable by its sharp snout, broad, slightly attenuated, narrowly rounded pectoral free rear tip, large first dorsal fin spine, second dorsal fin much lower than the first and with a deeply incised posterior margin, very large claspers with prominent spines or spurs (very small in *Centrophorus* and with relatively inconspicuous spurs), a short abdomen, an elongated precaudal tail and long caudal peduncle, a deeply notched postventral caudal margin, and no subterminal notch. However, despite the invalid species name, the Australian *Centrophorus* species treated as *C. uyato* by Last & Stevens (1994) is certainly a valid taxon. The validity of the most recent described *Centrophorus* species, *C. seychellorum* Baranes, 2003, needs to be resolved.

The critical importance of gaining a better understanding of the taxonomic status and distributions of *Centrophorus* species occurring in Australian waters is highlighted by the severe population declines reported off southeastern Australia as a result of an intensive trawl fishery. Graham *et al*. (2001) reported declines of 98.4–99.7% in the relative abundances of *C. harrissoni*, *C. moluccensis* and *C.* cf. *uyato* off the upper slope of New South Wales between 1976–77 and 1996–97. As a result of these serious declines, these three species have been listed as either endangered or critically endangered by the IUCN Red List of Threatened Animals (www.redlist.org). Therefore, given the severely threatened status of some *Centrophorus* species and populations in Australian waters it is critical that taxonomic issues for this genus are resolved so that accurate identification and proper management policies for these sharks can be implemented. Here we describe two new species of *Centrophorus*, both of which appear to be Australian endemics, redefine *Centrophorus harrissoni*, and compare these species with other closely related species of this genus. Collections of *Centrophorus* species from the Western Indian Ocean, from eastern Indonesian fish landing sites and markets, and from Taiwan and the Philippines has allowed for comparison with the new species, and other Australian representatives of this genus. The nomenclature of Australian *Centrophorus* is also discussed.

METHODS

The morphometric measurements used generally followed those detailed by Compagno (1984, 2001), but focused on direct (point-to-point) rather than horizontal measurements. Data in the literature is often unreliable for comparative purposes due to the different and unspecified methodology adopted. Measurements were taken following the methodology described by Last *et al.* (2007) for the genus *Squalus* with some additional measurements, i.e. CST — subterminal caudal-fin margin, CTL — terminal caudal-fin lobe, DPI — 1st dorsal-fin midpoint to pectoral-fin insertion, D1SL — 1st dorsal soft fin length (from perpendicular to junction of exposed spine and soft fin base to free rear tip), D2SL — 2nd dorsal soft fin length (from perpendicular to junction of exposed spine and soft fin base to free rear tip), DPO — 1st dorsal-fin midpoint to pelvic-fin origin, PDI — pelvic-fin midpoint to 1st dorsal fin insertion, and PDO — pelvic-fin midpoint to 2nd dorsal-fin origin, from Compagno (2001).

All type specimens of the two new species were measured in full and compared with 7 measured specimens of *C. harrissoni* (CSIRO CA 4103, CSIRO H 866–01, CSIRO H 866–05, CSIRO H 866–06, CSIRO H 2528–01, CSIRO T 810 and CSIRO H 6310–05) and 5 specimens of *C. isodon* (CSIRO H 5857–01, CSIRO H 5889–15, CSIRO H 5875–04, CSIRO H 6125–02, and CSIRO H 6138–01) (Tables 1–3). A subsample of measurements were also taken from the holotype of *C. tessellatus* (MCZ 1031S). Vertebral counts were obtained from radiographs of all of the type specimens of the two new species, and comparative vertebral meristics were obtained from radiographs or from dissections of fresh material of *C. harrissoni* and *C. isodon*. Counts were obtained separately for trunk (monospondylous precaudal centra), precaudal (monospondylous precaudal centra + diplospondylous precaudal centra to origin of the caudal-fin upper lobe) and diplospondylous caudal centra (centra of the caudal fin) vertebrae. Tooth row counts were taken *in situ*, by making incisions at the jaw angles to expose the teeth, or from preserved jaws. In the descriptions of the new species, morphometric and meristic values for the holotype are given first, followed in parentheses by the ranges of the paratypes.

Material examined, including type specimens of the new species, are deposited in the Australian National Fish Collection, Hobart, Australia (CSIRO), and ichthyological collections of the Australian Museum, Sydney (AMS), Museum Victoria, Melbourne (NMV), Museum of Comparative Zoology, Harvard (MCZ) and the Queensland Museum, Brisbane (QM).

Centrophorus harrissoni McCulloch, 1915

Figs 1, 2a, 3a, Table 1

Material examined. 19 whole specimens: AMS E–5570 (Holotype) eviscerated female 736 mm TL, Gabo Island, Victoria, Australia; CSIRO CA 4103, adult male 843 mm TL, north of Flinders Island, Bass Strait, 39°05′ S, 148°38′ E, 444–468 m, 06 May 1984; CSIRO H 866–01, female 420 mm TL, CSIRO H 866–05, immature male 350 mm TL, CSIRO H 866–06, immature male 417 mm TL, east of Jervis Bay, New South Wales, 34°58′ S, 151°09′ E, 490–576 m, 10 Sep 1986; CSIRO H 987–01, immature female ca. 390 mm TL, north of Flinders Island, Bass Strait, 39°02′ S, 148°37′ E, 440–448 m, 29 Nov 1984; CSIRO H 2528–01, female 1049 mm TL, east of Maria Island, Tasmania, 42°39′ S, 148°28′ E, 500 m, 15 July 1990; CSIRO H 6310–05, adult male 874 mm TL, north-east of Flinders Island, Tasmania, 39°00′ S, 148°38′ E, 500–680 m; CSIRO H 6498–03, adult male 825 mm TL, CSIRO H 6498–04, adult male 925 mm TL, southern half of Flinders Island, Tasmania, 300–500 m, 24 June 2003; CSIRO H 6500–03, adult male 910 mm TL, off Flinders Island, Tasmania, 40°15′ S, 148°45′ E, 329–512 m, 21 Aug 2003; CSIRO H 6501–01, female 1114 mm TL, CSIRO H 6501–02, adult male 882 mm TL, CSIRO H 6501–03, adult male 907 mm TL, east of Flinders Island, Tasmania, ca. 41° S, ca. 149° E, 403–439 m, 18 June 2004; CSIRO H 6502–01, adult male 890 mm TL, CSIRO H 6502–02, female 940 mm TL, south of South East Cape, Tasmania, 43°45′ S, 146°45′ E, 329–549 m, 27 Aug 2002; CSIRO T 810, female 850 mm TL, Oct 1981, off St Helens, Tasmania, 580 m; QM I 35759, immature male 387 mm TL, QM I 35770, female 600 mm TL, Fraser

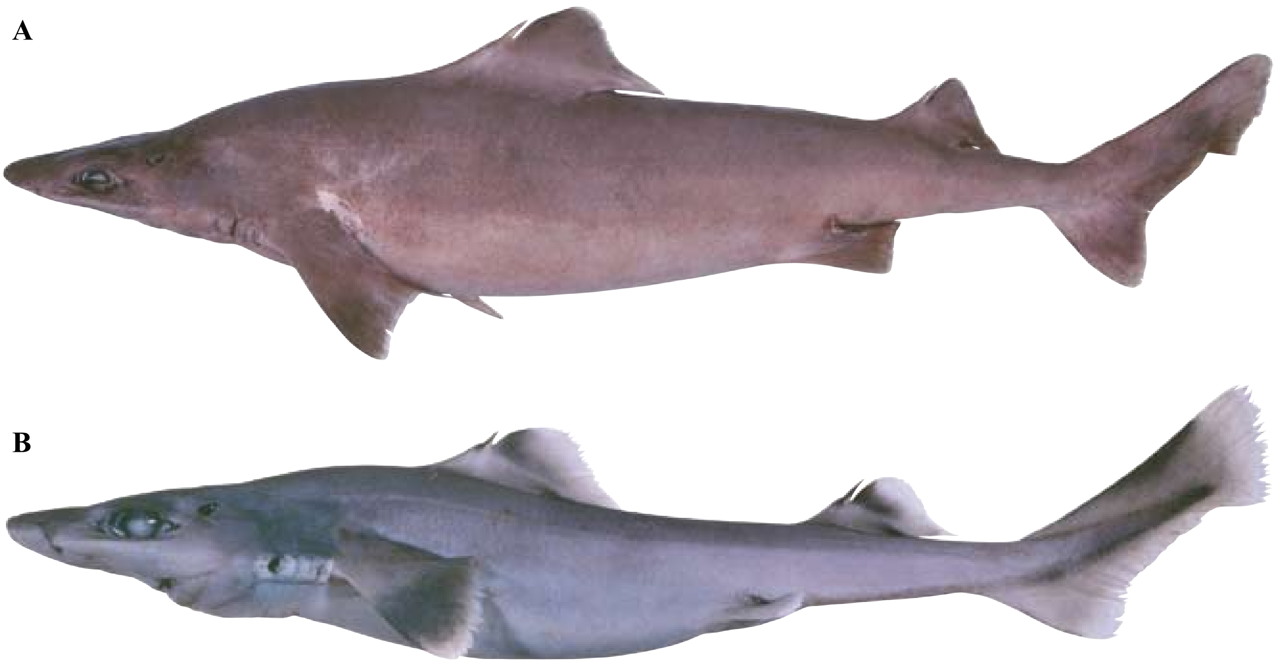

Figure 1. Lateral view of *Centrophorus harrissoni*: A. CSIRO H 2528–01 (female 1049 mm TL); B. CSIRO H 987–01 (immature female ca. 390 mm TL).

Seamount, Queensland, 24°25′ S, 155°17′ E, 670 m. 18 skeletal specimens: CSIRO H 6307–03, immature male 557 mm TL, CSIRO H 6307–04, female 1025 mm TL, CSIRO H 6307–05, immature male 565 mm TL, CSIRO H 6307–06, female 933 mm TL, CSIRO H 6307–07, adult male 891 mm TL, east of Flinders Island, Tasmania, ca. 40° S, ca. 149° E, 350–430 m, 12 July 2004; CSIRO H 6308–01, adult male 900 mm TL, CSIRO H 6308–02, female 1039 mm TL, CSIRO H 6308–03, female 716 mm TL, Banks Strait, Tasmania, ca. 40° S, ca. 148° E, 29 July 2004; CSIRO H 6309–03, adult male 902 mm TL, CSIRO H 6309–05, adult male 939 mm TL, east of Flinders Island, Tasmania, ca. 40° S, ca. 149° E, 400–450 m, 01 Aug 2004; CSIRO H 6310–01, adult male 926 mm TL, CSIRO H 6310–03, female 870 mm TL, north-east of Flinders Island, Tasmania, 39°00′ S, 148°38′ E, 500–680 m, 24 July 1986; CSIRO H 6498–03, male 825 mm TL, southern half of Flinders Island, Tasmania, 300–500 m, 24 June 2003; CSIRO H 6499–01, female 1080 mm TL, CSIRO H 6499–02, female 880 mm TL, CSIRO H 6499–03, female 1070 mm TL, CSIRO H 6499–04, female 778 mm TL, north-east coast of Tasmania, ca. 41° S, 149° E, 24 July 2003; CSIRO H 6500–01, adult male 902 mm TL, off Flinders Island, Tasmania, 40°15′ S, 148°45′ E, 329–512 m, 21 Aug 2003.

DIAGNOSIS.— A moderate-sized species of *Centrophorus* with the following combination of adult characters: pre-second dorsal length 61.9–63.2% TL, 6.6–8.4 times dorsal–caudal space; pre-first dorsal length 30.4–32.0% TL; interdorsal space 18.2–20.6% TL, 2.2–2.6 times dorsal–caudal space; dorsal–caudal space 7.5–9.4% TL, 3.2–4.0 in pectoral–pelvic space; head long and robust (length 22.4–24.6% TL, 2.7–3.0 times mouth width; width 13.2–14.0% TL, 4.5–4.8 in pre-second dorsal length; width at anterior of nostrils 7.7–7.9% TL); snout long (preoral length 11.4–12.4% TL, 2.0–2.2 times head height at anterior of mouth, 1.3–1.5 times mouth width; horizontal preorbital length 7.1–8.2% TL; horizontal prenarial length 4.4–5.4% TL); mouth large (width 7.8–8.5% TL); pectoral fin moderately large (anterior margin 11.9–12.4% TL, 2.3–2.4 times base length); caudal fin large (dorsal caudal margin 19.1–19.5% TL; 2.1–2.5 times dorsal–caudal space); first dorsal fin moderately large and tall (height 6.2–7.0% TL), spine moderately robust (base width 0.9–1.0% TL). Dorsal fins of juveniles with a distinct blackish oblique blotch anteriorly and a white blotch on the upper posterior margin; adults with a less distinct dark blotch (usually still apparent in fresh specimens) and with a white blotch restricted to a narrow white posterior margin (occasionally indistinct in largest specimens). Flank denticles of adults flat, block-like, not overlapping, crenulate. Upper teeth of females and immature males strongly oblique, similar in shape, but much smaller than, lower teeth; upper teeth of mature males erect, upright, becoming only slightly oblique laterally. Tooth row count: 37–39/30 or 31 (n=3). Total vertebral centra 117–126 (mean 121.6, n=20), monospondylous precaudal centra 53–59 (56.4, n=21), diplospondylous precaudal centra 29–37 (32.7, n=21) and precaudal centra 85–94 (89.1, n=21).

SIZE.— Specimens examined ranged from 350 to 1114 mm TL. Smallest mature male was 825 mm TL.

Table 1. Proportional dimensions as percentages of total length for the holotype (AMS E 5570; taken from Duffy, 2007), 4 adults and 3 juveniles of *Centrophorus harrissoni*, and 3 adults and 2 juveniles of *Centrophorus isodon*.

	C. harrissoni					***C. isodon***			
	Holotype	Adults		Juveniles		Adults		Juveniles	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Total length (mm)	736	843	1049	350	420	952	989	530	540
Precaudal length	78.4	80.2	80.6	76.7	77.6	81.5	82.6	78.9	79.6
Pre-second dorsal length	61.0	61.9	63.2	59.4	61.2	66.2	68.0	63.0	64.3
Pre-first dorsal length	32.3	30.4	32.0	31.8	33.0	30.8	31.9	30.2	31.8
Pre-vent length	56.2	58.4	60.1	55.4	55.6	60.1	61.1	57.0	58.9
Prepelvic length	54.6	56.2	57.4	52.6	53.8	58.3	59.7	54.9	57.4
Prepectoral length	21.7	22.0	23.8	24.6	26.0	20.9	22.8	24.1	24.2
Head length	23.5	22.4	24.6	25.5	26.2	22.0	23.3	24.2	24.8
Prebranchial length	20.2	19.7	20.5	22.3	22.6	18.3	19.8	21.1	21.3
Prespiracular length	14.5	14.1	14.9	15.9	16.2	12.3	13.2	14.4	14.6
Preorbital length	7.5	7.5	8.6	9.4	9.5	6.7	7.7	8.1	8.3
Prenarial length	4.9	4.9	5.8	5.8	6.2	4.4	4.9	4.8	5.5
Preoral length	13.2	11.4	12.4	13.0	13.5	10.1	10.8	11.0	11.9
Inner nostril–labial furrow space	7.1	6.2	6.4	7.2	7.8	5.9	6.3	6.0	6.5
Mouth width	7.3	7.8	8.5	7.9	8.3	7.4	7.9	8.1	8.5
Upper labial furrow length	2.2	2.3	2.7	2.0	2.5	1.8	2.1	1.9	2.3
Nostril width	1.9	1.7	1.9	2.0	2.3	1.6	1.9	2.0	2.0
Internarial space	4.6	3.8	4.4	4.3	4.7	3.3	3.9	3.5	4.3
Interorbital space	8.7	7.3	8.1	7.4	8.5	7.2	7.5	7.5	7.9
Eye length	5.7	5.7	6.6	6.9	7.7	5.7	5.9	5.9	6.5
Eye height	1.5	1.6	2.0	2.1	2.8	1.7	1.9	1.4	2.0
Spiracle diameter - greatest	1.5	1.3	1.7	1.4	2.1	1.7	1.9	2.0	2.1
First gill-slit height	2.4	1.6	2.5	1.9	2.4	1.7	1.9	2.1	2.1
Fifth gill-slit height	1.8	2.2	2.4	2.1	2.8	2.5	2.7	2.5	2.7
Interdorsal space	18.4	18.2	20.6	16.1	19.7	22.4	25.1	21.1	21.1
Dorsal–caudal space	8.6	7.5	9.4	8.4	8.9	5.8	6.6	6.1	7.4
Pectoral–pelvic space	26.9	29.5	31.9	25.0	26.3	32.1	33.3	29.1	29.5
Pelvic–caudal space	17.0	13.6	15.3	13.7	15.1	14.3	15.0	14.9	15.6
First dorsal length	–	18.0	19.6	16.7	18.2	18.8	19.8	18.6	19.2
First dorsal soft fin length	12.0	11.4	11.9	11.0	11.5	12.0	12.6	12.2	13.0
First dorsal anterior margin	11.1	11.5	13.5	11.5	13.4	12.2	13.5	12.6	12.6
First dorsal base length	11.0	12.7	14.1	10.6	12.7	13.8	14.3	12.3	13.2
First dorsal height	7.8	6.2	7.0	5.2	6.2	5.7	6.2	5.7	6.8
First dorsal inner margin	6.4	6.0	6.2	5.6	6.3	5.5	6.0	5.9	6.8
First dorsal posterior margin	10.4	9.2	10.9	7.8	10.4	9.1	9.8	9.4	10.3
First dorsal spine length	1.0*	2.4	2.6	1.7	1.8	1.8	2.3	2.1	2.7
First dorsal spine base width	–	0.9	1.0	0.8	0.9	0.7	0.7	0.6	0.8
Second dorsal length	–	13.7	14.7	12.7	14.1	13.4	13.9	14.2	14.3
Second dorsal soft fin length	9.5	8.3	8.8	8.1	8.7	7.8	8.6	8.7	9.0
Second dorsal anterior margin	9.1	8.5	10.0	8.6	10.1	9.1	9.6	9.5	9.8
Second dorsal base length	9.2	9.2	10.1	8.0	9.7	9.4	9.7	9.1	9.8
Second dorsal height	5.0	4.8	5.2	3.8	4.5	4.4	4.8	4.6	5.4
Second dorsal inner margin	4.9	4.1	4.7	4.7	5.3	4.1	4.4	4.3	5.3

* denotes possible damage resulting in underestimate of spine length

Table 1. cont'd.

	C. harrissoni					*C. isodon*			
	Holotype	Adults		Juveniles		Adults		Juveniles	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Second dorsal posterior margin	8.1	7.4	8.2	6.8	7.4	6.6	7.2	7.0	7.4
Second dorsal spine length	2.1	1.6	2.6	2.2	2.3	1.7	2.2	2.7	3.1
Second dorsal spine base width	–	0.7	0.8	0.6	0.9	0.6	0.7	0.8	0.8
Pectoral anterior margin	13.0	11.9	12.6	11.4	12.8	11.1	12.2	13.5	13.5
Pectoral inner margin	10.0	11.6	14.1	10.6	11.4	11.5	12.6	11.8	11.8
Pectoral base length	–	5.1	5.2	4.0	4.4	4.5	4.7	5.0	5.0
Pelvic length	10.0	9.9	11.2	9.6	10.1	7.6	10.4	9.8	10.3
Pelvic height	5.8	5.8	6.5	4.1	4.9	5.2	6.1	4.3	5.6
Pelvic inner margin	5.4	5.0	6.3	4.9	5.3	5.6	6.4	5.1	5.5
Dorsal caudal margin	21.3	19.1	19.5	21.2	23.1	16.4	18.0	20.9	21.1
Preventral caudal margin	11.7	11.6	14.1	13.2	15.4	10.8	12.3	12.8	13.1
Upper postventral caudal margin	–	6.8	7.9	8.4	9.2	7.0	8.3	6.6	7.9
Lower postventral caudal margin	–	3.1	4.7	3.3	3.6	4.0	4.9	3.1	4.0
Caudal fork width	–	6.1	7.2	6.9	7.4	6.2	7.0	6.3	6.9
Caudal fork length	–	11.3	13.0	13.2	16.0	10.4	11.7	12.8	13.3
Caudal terminal lobe	9.1	8.2	8.7	7.4	8.2	6.5	7.8	7.3	7.4
Caudal subterminal fin margin	–	2.1	2.6	2.9	3.7	1.5	2.6	3.3	3.7
Head width at anterior of nostrils	7.6	7.7	7.9	8.6	9.2	6.8	7.2	8.2	8.3
Head width at mouth	11.2	10.2	10.7	10.6	11.3	8.8	9.2	8.9	10.9
Head width	13.4	13.2	14.0	10.0	13.1	9.7	11.9	9.2	11.2
Trunk width	–	9.8	11.3	6.9	9.6	–	–	–	–
Abdomen width	–	10.5	11.7	6.1	8.1	–	–	–	–
Tail width	–	5.1	6.6	3.8	4.8	–	–	–	–
Caudal peduncle width	–	2.7	3.3	2.3	2.8	3.0	3.2	2.2	2.3
Head height at mouth	–	5.6	5.7	5.9	6.8	–	–	–	–
Head height	–	9.8	11.0	8.6	10.2	8.1	9.5	7.1	8.7
Trunk height	–	11.5	12.6	8.5	11.0	–	–	–	–
Abdomen height	–	11.8	12.5	8.1	10.9	–	–	–	–
Tail height	–	6.7	7.1	6.6	7.2	–	–	–	–
Caudal peduncle height	–	3.4	3.8	3.5	3.8	3.0	3.2	3.3	3.5
Clasper outer length	–	2.9	3.5	0.7	1.0	–	–	–	–
Clasper inner length	–	6.8	7.7	2.7	2.7	–	–	–	–
Clasper base width	–	1.0	1.0	0.6	0.7	–	–	–	–
First dorsal midpoint–pectoral insertion	–	8.4	9.7	8.9	10.4	10.0	11.0	8.3	9.5
First dorsal midpoint–pelvic origin	–	17.9	20.6	13.4	15.4	21.9	23.3	18.8	19.5
Pelvic midpoint–first dorsal insertion	–	13.8	16.5	11.0	13.3	16.0	18.6	14.6	14.8
Pelvic midpoint–second dorsal origin	–	3.6	5.2	4.7	6.1	4.9	6.2	5.3	5.6

DISTRIBUTION.— Known from the upper to mid-continental slope of eastern Australia from Clarence River (ca. 29° S) to South East Cape, Tasmania (43°45′ S), and from Fraser Seamount, Queensland (24°25′ S, 155°17′ E) in depths of 300–680 m (Fig. 11). It has also been recorded from the Kermadec Ridge (31°45′ S, 178°52′ E), Norfolk Ridge (33°07′ S, 166°52′ E) and Three Kings Ridge (31°15′ S, 172°56′ E) off New Zealand in depths of 536–710 m (Duffy, 2007) and possibly New Caledonia (Compagno *et al*., 2005; Anon., 1998). Last & Stevens (1994) recorded this species at depths of 220–790 m.

Longnose *Centrophorus* similar in general morphology and coloration to *C. harrissoni* are known from off Taiwan, the east coast of South Africa, and the Western North Atlantic but their status needs detailed investigation (Compagno *et al*., 2005).

VERNACULAR.— Harrisson's Dogfish.

REMARKS.— *Centrophorus harrissoni* is most similar in appearance to *C. isodon* (Figs 2b, 3b, 4) and *C. tessellatus*, which together form a subgroup of longnose *Centrophorus* species. Adults of *C. harrissoni* differ from those of *C. isodon* in having much closer dorsal fins (interdorsal space 18.2–20.6 vs. 22.4–25.1% TL, 2.2–2.6 vs. 3.4–4.3 times dorsal–caudal space); a longer caudal fin (precaudal length 80.2–80.6 vs. 81.5–82.6% TL, dorsal caudal margin 19.1–19.5 vs. 16.4–18.0% TL); a larger mouth (width 7.8–8.5 vs.7.4–7.9% TL); a broader head (head width 13.2–14.0 vs. 9.7–11.9% TL; 4.5–4.8 vs. 5.7–6.9 in pre-second dorsal length); the upper teeth of females far more oblique; flank denticles with low but obvious ridges (vs. no obvious ridges; Fig. 3b) and dorsal fins with a whitish posterior margin in all size classes (except some very large specimens). Juveniles of *C. harrissoni* differ from those of *C. isodon* in the following measurements and ratios: pre-second dorsal length 59.4–61.2 vs. 63.0–64.3% TL; pre-vent length 55.4–55.6 vs. 57.0–58.9% TL; dorsal–caudal space 8.4–8.9 vs. 6.1–7.4% TL; pectoral–pelvic space 25.0–26.3 vs. 29.1–29.5% TL, 2.9–3.0 vs. 3.9–4.8 times dorsal–caudal space; preoral length 13.0–13.5 vs. 11.0–11.9% TL; inner nostril to upper labial furrow 7.2–7.8 vs. 6.0–6.5% TL; first dorsal-fin soft length 11.0–11.5 vs. 12.2–13.0% TL; mid first dorsal-fin base to pelvic-fin origin space 13.4–15.4 vs. 18.8–19.5% TL.

Centrophorus harrissoni differs from *C. tessellatus* in having a longer pectoral–pelvic space (29.5–31.9 vs. 27.9% TL); shorter pelvic–caudal space (13.6–15.3 vs. 17.9% TL); a slightly larger mouth (7.8–8.5 vs. 7.4% TL); a broader head (head width 13.2–14.0 vs. 12.2% TL) and no white borders on the gill slits.

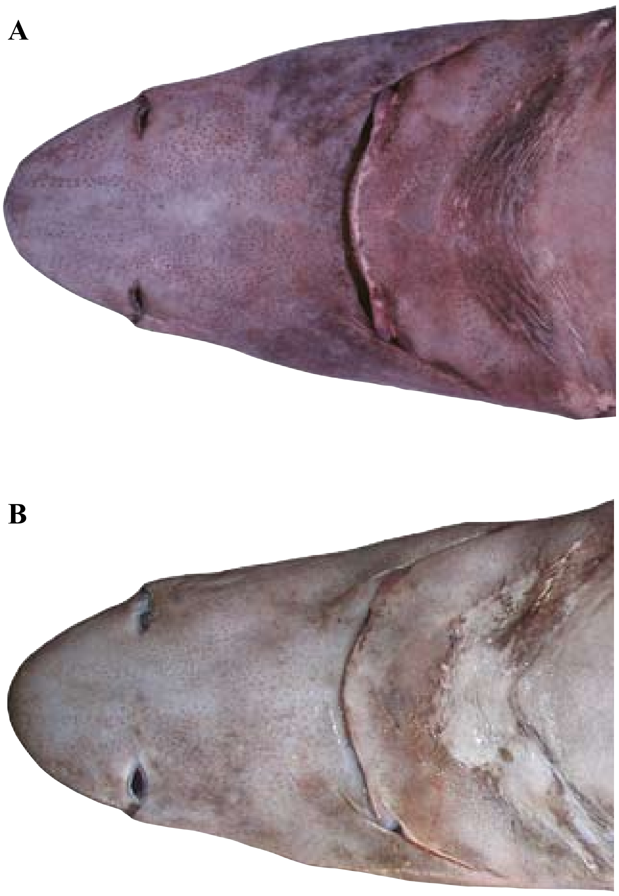

Figure 2. Ventral view of the head of: A. *Centrophorus harrissoni* (CSIRO H 2528–01, female 1049 mm TL); B. *Centrophorus isodon* (not retained, female 1010 mm TL, Kedonganan fish market, Bali, Indonesia).

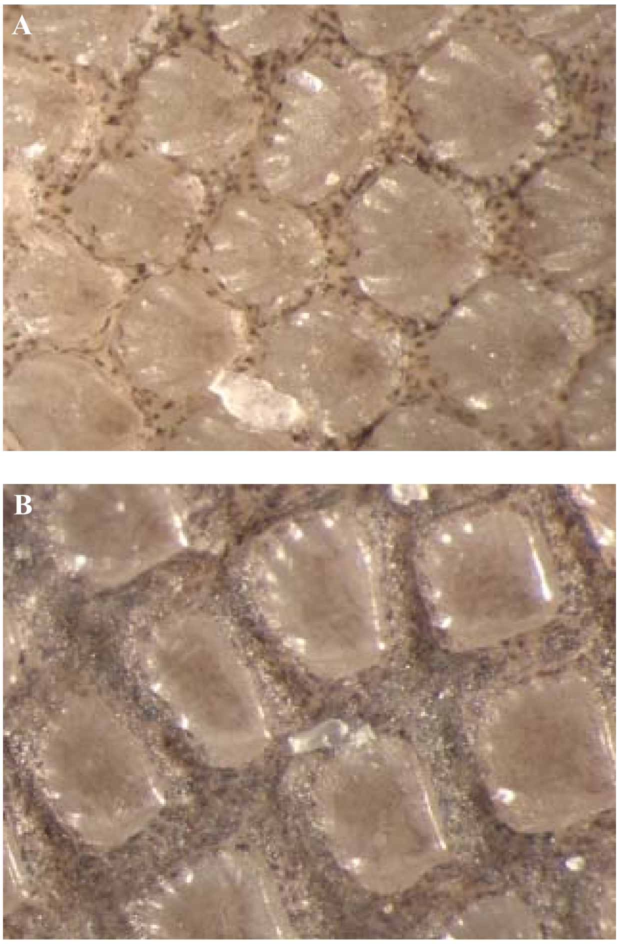

Figure 3. Cusps of the flank denticles of: A. *Centrophorus harrissoni* (CSIRO H 6309–03, adult male 980 mm TL); B. *Centrophorus isodon* (CSIRO H 6125–02, female 965 mm TL).

Figure 4. Lateral view of *Centrophorus isodon* (not retained, female 1010 mm TL, Kedonganan fish market, Bali, Indonesia).

The upper teeth of *Centrophorus harrissoni* show strong sexual dimorphism with those of females and juvenile males being strongly oblique (n=8) whilst those of mature males being erect and upright, and only slightly oblique laterally (n=5). The lower teeth of *C. harrissoni* also display sexual dimorphism, although generally not as marked as that in the upper teeth, with those of the adult males being strongly oblique and blade-like, as in females, but with the tip curved upwards. This sexual dimorphism was also recorded and illustrated for this species by Duffy (2007) in New Zealand waters. This difference in upper tooth shape was also noted by Baranes (2003) for *C. seychellorum*, with those of the female holotype possessing strongly oblique cusps and those of the adult male paratype possessing upright cusps (Fig. 22 in Baranes, 2003). The validity of this species has not yet been investigated and this issue is not helped by the fact that the holotype has a damaged caudal fin. Since all morphometric measurements are expressed as percentage of total length, they are not accurate for the holotype and thus not easily comparable to other species and so comparisons made below are based on the paratype. The preoral length of this species (10.1% TL) is smaller than in *C. harrissoni* (11.4–12.4% TL), but similar to *C. isodon* (10.1–10.8% TL) and *C. tessellatus* (10.1% TL). The upper teeth of the female holotype of *C. seychellorum* are far more oblique than in females of *C. isodon*, and these two species also differ in dorsal–caudal space (8.2 vs. 5.8–6.6% TL). *Centrophorus seychellorum* differs from *C. tessellatus* in having a shorter head (21.5 vs. 24.8% TL); larger interdorsal space (22.9 vs. 19.4% TL) and a shorter horizontal prenarial length (2.2 vs. 3.7 % TL). The flank denticles of *C. seychellorum* are also more pointed and closer together than the flatter more block-like denticles of *C. isodon*, *C. tessellatus* and *C. harrissoni* (see Figs 23 and 24 in Baranes, 2003). Thus, *C. seychellorum* is potentially a valid species belonging to the longnose subgroup, but further investigation of this species is required.

Centrophorus westraliensis sp. nov.

Figs 5–7, Table 2

Centrophorus harrissoni (in part): Last & Stevens, 1994: pp 52, 56, 57; Daley, Stevens, Last & Yearsley, 2002: pp 73.

Holotype. CSIRO H 2625–06, female 909 mm TL, west of Point D'Entrecausteaux, Western Australia, 35°00′ S, 114°42′ E, 738–750 m, 18 Feb 1991.

Paratypes. 5 whole specimens: CSIRO H 2357–03, female 789 mm TL, south of Cape Leeuwin, Western Australia, 35°02′ S, 115°02′ E, 673 m, 23 Dec 1989; CSIRO H 2358–01, immature male 371 mm TL, north-west of Geraldton, Western Australia, 28°13′ S, 113°07′ E, 616 m, 27 Dec 1989; CSIRO H 2580–01, female 414 mm TL, south-west of Shark Bay, Western Australia, 27°05′ S, 112°22′ E, 713–714 m, 31 Jan 1991; CSIRO H 2606–01, female 774 mm TL, west of Rottnest Island, Western Australia, 32°00′ S, 114°55′ E, 640–670 m, 10 Feb 1991; CSIRO H 2625–05, female 866 mm TL, collected with holotype.

DIAGNOSIS.— A moderate-sized species of *Centrophorus* with the following combination of adult characters: pre-second dorsal length 63.8–64.9% TL, 8.8–9.7 times dorsal–caudal space; pre-first dorsal length 31.3–32.7% TL; interdorsal space 20.3–21.5% TL, 2.8–3.1 times dorsal–caudal space; dorsal–caudal space 6.7–7.3% TL, 4.4–4.9 in pectoral–pelvic space; head long and moderately robust (length 23.2–24.7% TL, 3.1–3.2 times mouth width; width 11.7–12.8% TL, 5.1–5.5 in pre-second dorsal length; width at anterior of nostrils 7.1–7.6% TL); snout long (preoral length 10.9–12.4% TL, 2.0–2.2 times head height at anterior of mouth, 1.4–1.6 times mouth width; horizontal preorbital length 7.0–7.8% TL; horizontal prenarial length 4.5–4.9% TL); mouth moderately large (width 7.6–7.8% TL); pectoral fin large (anterior margin 12.9–14.2% TL, 2.6–2.8 times base length); caudal fin large (dorsal caudal margin 17.4–20.2% TL; 2.6–2.9 times dorsal–caudal space); first

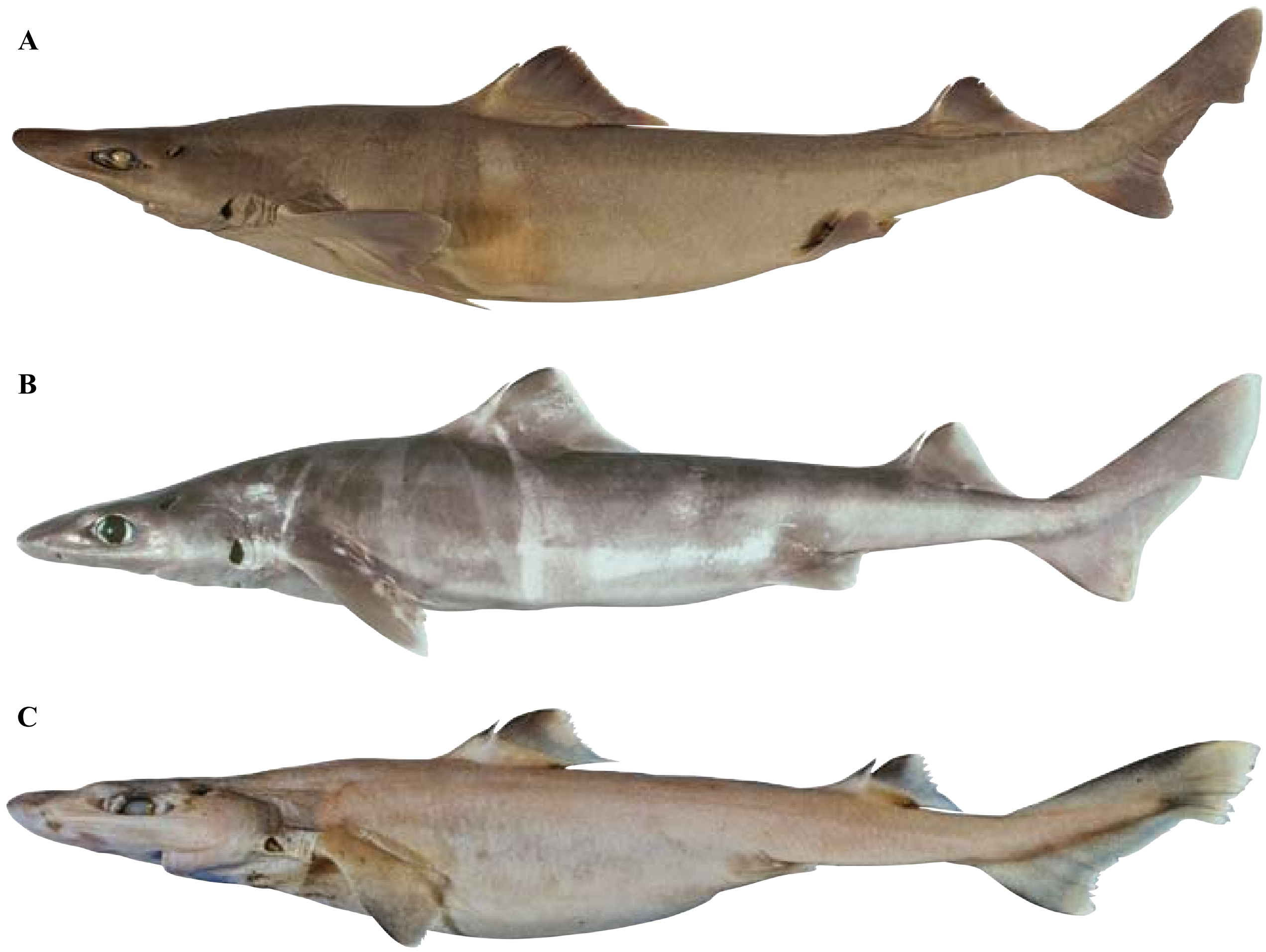

Figure 5. Lateral view of *Centrophorus westraliensis* sp. nov.: A. female holotype (CSIRO H 2625–06, 909 mm TL, preserved); B. female paratype (CSIRO H 2606–01, 774 mm TL, fresh); C. immature male paratype (CSIRO 2358–01, 371 mm TL, preserved).

dorsal fin moderately-sized (height 5.5–6.4% TL), spine relatively robust (base width 1.1–1.2% TL). Dorsal fins of juveniles with a distinct blackish oblique blotch anteriorly and a white blotch on the upper posterior margin; adults with a less distinct dark blotch (usually still apparent in fresh specimens) and with white blotch restricted to a narrow white posterior margin (can be indistinct in larger preserved specimens). Upper teeth of females and of an immature male are strongly oblique, similar in shape, but much smaller than lower teeth. Teeth count: in holotype 38/29. Flank denticles of adults flat, not overlapping, with scalloped edges. Total vertebral centra 112–117 (mean 115.3), monospondylous precaudal centra 55–57 (55.8), diplospondylous precaudal centra 29–33 (31), precaudal centra 85–88 (86.8) and diplospondylous caudal centra 27–30 (28.5).

DESCRIPTION.— Body fusiform, moderately elongate, nape moderately humped; deepest near first dorsal-fin spine, trunk height 1.42 (0.98–1.16 in 3 adult paratypes) times width, 1.02 (0.76–0.90) times abdomen height; head moderately elongate, length 23.2 (23.8–24.7)% TL; caudal peduncle moderately slender, 16.1 (13.7–14.6)% TL. Head long, moderately robust, broad, width 1.27 (1.23–1.38) times trunk width, 1.17 (1.17–1.45) times abdomen width; depressed forward of spiracles, becoming somewhat semicircular in cross-section towards pectoral-fin origin; length 2.63 (2.44–2.51) in pre-vent length; height 0.96 (0.76–0.78) times width. Snout elongate, narrowly triangular in lateral view, apex bluntly pointed; lateral prenarial margin angular; narrowly rounded in dorsal view; horizontal length 1.24 (1.04–1.23) times eye length, 0.93 (0.90–0.94) times interorbital space; horizontal prenarial length 2.50 (2.30–2.52) times in preoral length. Eye large, oval, length 4.13 (3.53–3.94) in head, 3.12 (3.10–4.48) times height; strongly notched posteriorly, notch not extending towards spiracle. Spiracle moderately-sized, somewhat triangular; no lobe-like fold on posterior margin; greatest diameter 3.30 (3.71–4.23) in eye length. Gill slits directed slightly anteroventrally from top to bottom; first four subequal in size, fifth longest, height of fifth slit 2.5 (2.8–2.9)% TL. Mouth almost transverse, upper jaw weakly concave, width 1.49 (1.43–1.63) in preoral length; upper labial

Table 2. Proportional dimensions as percentages of total length for the holotype (CSIRO H 2625–06), 3 adult paratypes and 2 juvenile paratypes of *Centrophorus westraliensis* sp. nov.

	Centrophorus westraliensis **sp. nov.**				
	Holotype	Adults		Juveniles	
		Min.	Max.	Min.	Max.
Total length (mm)	909	774	866	371	414
Precaudal length	81.8	78.8	81.1	77.9	78.3
Pre-second dorsal length	64.9	63.8	64.9	60.9	62.0
Pre-first dorsal length	32.1	31.3	32.7	32.0	33.1
Pre-vent length	61.1	58.1	61.7	56.5	58.2
Prepelvic length	58.3	56.8	60.5	54.6	56.1
Prepectoral length	22.5	22.9	23.7	25.6	26.4
Head length	23.2	23.8	24.7	25.6	26.7
Prebranchial length	19.3	20.2	21.2	22.5	22.8
Prespiracular length	13.6	14.1	14.8	16.1	16.2
Preorbital length	7.7	7.8	8.5	9.3	9.7
Prenarial length	4.9	5.0	5.5	6.0	6.4
Preoral length	11.3	10.9	12.4	13.7	14.2
Inner nostril–labial furrow space	6.3	6.4	6.8	7.6	7.7
Mouth width	7.6	7.6	7.8	7.6	10.4
Upper labial furrow length	2.1	1.9	2.2	2.4	3.3
Nostril width	1.6	1.8	1.9	2.1	2.2
Internarial space	3.9	3.8	4.6	4.4	4.7
Interorbital space	7.5	7.6	8.6	7.9	9.0
Eye length	5.6	6.3	6.7	7.3	7.9
Eye height	1.8	1.5	2.0	2.0	2.5
Spiracle diameter - greatest	1.7	1.5	1.8	2.0	2.2
First gill-slit height	2.2	1.8	1.8	2.2	2.3
Fifth gill-slit height	2.5	2.8	2.9	2.3	2.9
Interdorsal space	20.9	20.3	21.5	17.7	18.9
Dorsal–caudal space	6.7	6.9	7.3	6.2	7.8
Pectoral–pelvic space	32.7	30.9	31.8	25.4	27.8
Pelvic–caudal space	16.1	13.7	14.6	13.6	14.6
First dorsal length	18.4	17.1	18.2	16.1	18.5
First dorsal soft fin length	12.6	11.3	11.9	10.1	11.7
First dorsal anterior margin	11.2	11.4	12.3	11.5	13.2
First dorsal base length	12.2	11.4	11.9	10.8	12.6
First dorsal height	6.1	5.5	6.4	4.8	6.6
First dorsal inner margin	6.1	5.8	6.5	5.5	6.0
First dorsal posterior margin	10.2	8.8	9.7	8.1	9.8
First dorsal spine length	2.7	2.4	2.5	1.4	2.1
First dorsal spine base width	1.1	1.1	1.2	0.6	1.0
Second dorsal length	14.5	13.5	13.6	14.1	14.2
Second dorsal soft fin length	8.5	8.4	8.9	8.0	8.5
Second dorsal anterior margin	10.0	9.0	9.6	10.2	10.3
Second dorsal base length	10.4	8.7	9.5	9.5	10.2
Second dorsal height	4.6	4.6	5.0	4.5	4.6
Second dorsal inner margin	4.2	4.6	4.9	4.8	4.8

Table 2. cont'd.

	Centrophorus westraliensis sp. nov.				
	Holotype	Adults		Juveniles	
		Min.	Max.	Min.	Max.
Second dorsal posterior margin	7.4	7.1	7.6	6.3	7.6
Second dorsal spine length	2.8	1.7	2.4	1.4	2.5
Second dorsal spine base width	0.8	0.8	0.9	0.8	0.9
Pectoral anterior margin	13.1	12.9	14.2	12.1	12.2
Pectoral inner margin	13.4	12.5	14.9	11.3	11.6
Pectoral base length	5.1	4.8	5.2	4.2	4.8
Pelvic length	10.6	10.2	10.6	9.0	9.8
Pelvic height	6.2	5.6	6.6	4.7	5.4
Pelvic inner margin	5.5	5.4	6.1	4.8	5.5
Dorsal caudal margin	17.4	18.5	20.2	21.5	22.2
Preventral caudal margin	12.0	12.4	13.0	12.7	14.2
Upper postventral caudal margin	6.9	6.1	6.6	7.9	8.6
Lower postventral caudal margin	3.3	3.7	4.2	3.1	3.3
Caudal fork width	6.5	6.5	6.9	6.9	7.1
Caudal fork length	10.9	11.5	13.0	13.4	13.9
Caudal terminal lobe	7.5	8.3	8.5	7.3	8.1
Caudal subterminal fin margin	2.6	2.2	3.5	3.5	3.6
Head width at anterior of nostrils	7.1	7.3	7.6	9.0	9.1
Head width at mouth	8.7	8.9	9.7	10.7	11.3
Head width	11.7	12.3	12.8	10.7	11.6
Trunk width	9.2	8.9	10.2	7.2	8.5
Abdomen width	10.0	8.7	11.0	6.9	9.0
Tail width	5.4	5.2	5.3	4.3	4.9
Caudal peduncle width	2.9	2.6	2.9	2.5	2.5
Head height at mouth	5.6	5.5	5.9	6.0	6.3
Head height	11.3	9.5	10.0	8.8	10.1
Trunk height	13.1	9.6	11.4	9.2	11.7
Abdomen height	12.9	11.6	12.7	9.6	12.8
Tail height	7.0	6.4	6.8	6.1	7.3
Caudal peduncle height	3.3	3.3	3.7	3.5	3.8
Clasper outer length	–	–	–	0.8	0.8
Clasper inner length	–	–	–	2.8	2.8
Clasper base width	–	–	–	0.5	0.5
First dorsal midpoint–pectoral insertion	11.7	10.5	11.6	8.3	9.7
First dorsal midpoint–pelvic origin	19.6	17.5	20.7	16.2	17.4
Pelvic midpoint–first dorsal insertion	16.0	15.3	17.2	12.9	13.8
Pelvic midpoint–second dorsal origin	5.5	4.3	5.5	4.8	5.0

furrows slightly longer than lower furrows; prominent postoral groove, more than twice length of upper labial furrows, extending posterolaterally from angle of jaws. Teeth strongly differentiated in upper and lower jaws; upper teeth small, cusps slightly oblique, relatively broad and triangular, bases sometimes overlapping; lower teeth much larger, cusps very strongly oblique, blade-like, overlapping; sexual dimorphism was not established as there are no adult male specimens. Nostrils small, almost transverse; anterior nasal flap single lobed; internarial space 2.88 (2.64–3.21) in preoral length, 2.51 (1.96–2.59) times nostril length. Dermal denticles (based on paratype CSIRO H 2606–01) on flank small, flat, block-like, not overlapping; medial cusp blunt, no lateral cusps, several low blunt ridges. Denticles of juveniles (based on CSIRO H 2358–01) are smaller, more upright, with acutely pointed crowns and more obvious ridges. First dorsal fin moderately small, strongly raked, broadly rounded apically; anterior margin strongly convex; upper posterior margin straight, slanting well posteroventrally from top to bottom, moderately concave near free rear tip; free rear tip relatively thick basally, moderately long; inner margin of fin almost straight; insertion of base extremely well forward of pelvic-fin origin, just posterior to free rear tip of pectoral fin; fin-spine origin above mid pectoral-fin inner margin; spine base broad, exposed anteriorly just below junction of spine and soft portion of fin; soft portion of fin connected above mid-point of total spine length; spine rapidly tapering distally (tip often damaged), anterior margin almost straight; exposed portion of spine sloping strongly posterodorsally from base to apex, subequal in length to exposed portion of second dorsal-fin spine; pre-first dorsal-fin length 3.11 (3.06–3.19) times in TL; first dorsal-fin length 3.04 (2.83–3.11) times its height, 1.27 (1.26–1.34) times second dorsal-fin length; first dorsal-fin height 1.33 (1.20–1.30) times second dorsal-fin height; exposed first dorsal spine length 0.45 (0.39–0.45) times height of fin. Second dorsal fin of moderate size, slightly raked; anterior margin very slightly convex, apex moderately rounded; posterior margin very weakly concave, sloping strongly posteroventrally from apex; free rear tip greatly elongated, inner margin length 0.92 (0.95–1.00) times fin height; second dorsal-fin length 3.19 (2.69–2.98) times its height; spine length 0.61 (0.38–0.49) in height of fin; fin-spine origin just posterior to free rear tip of pelvic fin, exposed just below level of junction with spine and soft portion of fin; second dorsal spine moderately broad based, tapering rapidly distally, sharply pointed; interdorsal space 1.08 (1.07–1.17) in prepectoral length, 1.54 (1.50–1.60) in pre-first dorsal length; interdorsal groove weak. Pectoral fin large, anterior margin weakly convex; inner margin weakly convex anteriorly, almost straight posteriorly, length 13.4 (12.5–14.9)% TL; apex moderately rounded, lobe-like but not falcate; posterior margin almost straight from apex to free rear tip; free rear tip greatly elongated, extending to just posterior to midpoint of first dorsal-fin base; base very short, 2.58 (2.59–2.78) in anterior margin length. Pelvic fins moderately large, anterior margin almost straight, posterior margin very weakly concave, apex moderately rounded, free rear tip acute. Caudal peduncle moderately long, tapering slightly towards caudal fin; subcircular in cross-section anteriorly, becoming more compressed posteriorly; ventral groove weak (better developed in some paratypes); no lateral keels; pelvic–caudal space 2.04 (2.23–2.32) in pectoral–pelvic space, 1.40 (1.62–1.71) in prepectoral length; dorsal–caudal space 3.10 (2.83–3.04) in interdorsal length; precaudal pits absent. Caudal fin relatively long, postventral margin moderately concave, terminal lobe moderately large; apex of lower lobe moderately rounded; dorsal caudal margin 1.34 (1.18–1.34) in head length; length of lower caudal lobe 1.45 (1.44–1.56) in upper lobe length. Total vertebral centra 117 (112–117), monospondylous precaudal centra 57 (55 or 56), diplospondylous precaudal centra 30 (29–33), precaudal centra 87 (85–88) and diplospondylous caudal centra 30 (27–29). Teeth count: 38/29 (holotype).

COLOUR.— Fresh specimens: (based on paratype CSIRO H 2606–01): dorsal surfaces uniformly light greyish to brownish; ventral surfaces much paler, with ventral surface of head somewhat darker than belly area. Dorsal fins with a faint dark blotch extending from mid anterior margin to near apex to mid portion of soft fin; distinct whitish posterior margin; fin spines pale, greyish brown. Caudal fin mostly greyish, with a diffuse, narrow whitish posterior margin. In juveniles (based on CSIRO H 2358–01): similar coloration to adult, but ventral surfaces less demarcated from dorsal surfaces. Dorsal fins with very distinct, blackish oblique blotch from lower anterior margin to fin insertion; distinct white blotch on posterior

Figure 6. Ventral view of the head of *Centrophorus westraliensis* sp. nov., preserved holotype (CSIRO H 2625–06, female 909 mm TL).

Figure 7. Cusps of the flank denticles of *Centrophorus westraliensis* sp. nov. (holotype CSIRO H 2625–06, female 909 mm TL).

margin from fin apex to mid posterior margin. Pectoral fin with dark terminal blotch and a narrow, whitish posterior margin. Caudal fin with very distinctive whitish margin, quite broad on terminal lobe; distinct blackish fringe along most of dorsal caudal margin to near fin apex, becoming a blackish blotch over most of the terminal lobe; lower soft fin area mostly dark. **Preserved specimens:** (based on holotype): similar in coloration; deciduous denticles over body and head giving appearance of small white flecks (also evident in other adult type specimens). Dorsal fins mostly uniform in coloration, slightly darker near apex, white posterior margin barely evident. Caudal fin mostly uniform in coloration. Pectoral and pelvic fins with pale posterior margins.

SIZE.— Type series consists of five females between 414 and 909 mm TL and a single immature male of 371 mm TL.

DISTRIBUTION.— Type specimens collected from the mid-continental slope of Western Australia from south of Cape Leeuwin (35°02′ S) to Shark Bay (27°05′ S) in depths of 616–750 m (Fig. 11).

ETYMOLOGY.— Named in allusion to the known geographic range of this species (Western Australia).

VERNACULAR.— We propose the official English common name of “Western Gulper Shark” in allusion to its geographic distribution in Australia.

REMARKS.— *Centrophorus westraliensis* was previously considered to be conspecific with *C. harrissoni*, but Last & Stevens (1994) noted that eastern and western populations need to be critically compared. This new species is similar to other members of the longnose *Centrophorus* subgroup, in particular *C. harrissoni*. Adults of *C. westraliensis* differ from those of *C. harrissoni* in having dorsal fins slightly further apart (interdorsal space 20.3–21.5 vs. 18.2–20.6% TL, 2.8–3.1 vs. 2.2–2.6 times dorsal–caudal space); a longer pectoral anterior margin (12.9–14.2 vs. 11.9–12.6% TL); smaller first dorsal fin (base length 11.4–12.2 vs. 12.7–14.1% TL, height 5.5–6.4 vs. 6.2–7.0% TL); a smaller mouth (width 7.6–7.8 vs. 7.8–8.5% TL, 3.1–3.2 vs. 2.7–3.0 in head length); a larger mid-first dorsal base to pectoral insertion (10.5–11.7 vs. 8.4–9.7% TL) and a narrower head (head width 11.7–12.8 vs. 13.2–14.0% TL, head width at anterior of mouth 8.7–9.7 vs. 10.2–10.7% TL, 3.2–3.7 vs. 2.8–3.0 times pre-first dorsal length). Juveniles of *C. westraliensis* differ from those of *C. harrissoni* in the following measurements and ratios: pre-pelvic length 54.6–56.1 vs. 52.6–53.8% TL; pre-vent length 56.5–58.2 vs. 55.4–55.6% TL; upper labial furrow length 2.4–3.3 vs. 2.0–2.5% TL; mid first dorsal-fin base to pelvic-fin origin space 16.2–17.4 vs. 13.4–15.4% TL.

Adults of *Centrophorus westraliensis* differ from those of *C. isodon* in having a longer, slightly broader head (head length 23.2–24.7 vs. 22.0–23.3% TL; head width 11.7–12.8 vs. 9.7–11.9% TL, 5.1–5.5 vs. 5.7–6.9 in pre-second dorsal length); shorter mid dorsal-fin base to pelvic-fin origin (17.5–20.7 vs. 21.9–23.3% TL); dorsal fins closer together (interdorsal space 20.3–21.5 vs. 22.4–25.1% TL, 2.8–3.1 vs. 3.4–4.3 times dorsal–caudal space) and upper teeth with much more oblique cusps. Juveniles of *C. westraliensis* differ from those of *C. isodon* in the following measurements and ratios: pre-second dorsal length 60.9–62.0 vs. 63.0–64.3% TL; pectoral–pelvic space 25.4–27.8 vs. 29.1–29.5% TL; preoral length 13.7–14.2 vs. 11.0–11.9% TL; inner nostril to upper labial furrow 7.6–7.7 vs. 6.0–6.5% TL; head width at anterior of nostrils 9.0–9.1 vs. 8.2–8.3% TL; preorbital length 9.3–9.7 vs. 8.1–8.3% TL, 6.6–7.2 vs. 8.1–8.5 in pre-second dorsal length; first dorsal-fin soft length 10.1–11.7 vs. 12.2–13.0% TL; mid first dorsal-fin base to pelvic-fin origin space 16.2–17.4 vs. 18.8–19.5% TL.

Adults of this species differ from *C. tessellatus* in having a longer horizontal prenarial length (4.5–5.9 vs. 3.7% TL); a longer pectoral–pelvic space (30.9–32.7 vs. 27.9% TL); a shorter pelvic–caudal space (13.7–16.1 vs. 17.9% TL); a shorter first dorsal fin (length 17.1–18.4 vs. 20.1% TL) and no white borders on the gill slits.

Females of *C. westraliensis* have similar upper teeth to the holotype of *C. seychellorum*, but these two species differ in horizontal prenarial length (4.5–4.9 vs. 2.2% TL); second dorsal-fin height (4.6–5.0 vs. 3.7% TL) and pre-pectoral length (22.5–23.7 vs. 20.9% TL).

Centrophorus zeehaani sp. nov.

Figs 8–10, Table 3

Centrophorus uyato (in part): Last & Stevens, 1994: pp 52, 60, 61, key fig. 57, fig. 8.5, pl. 4; Daley *et al.*, 2002: pp 53; Gomon *et al.* 1994: pp 92, 94, figs 30, 31; Yearsley *et al.*, 2001: pp 35, 360.

Holotype. CSIRO H 6628–05, adult male 893 mm TL, south-west of Coffin Bay, South Australia, 35°14′ S, 134°29′ E, 360–600 m, 28 July 2005.
Paratypes. 8 whole specimens: AMS I 44310–001, adult male 826 mm TL, CSIRO H 6628–01, immature male 506 mm TL, CSIRO H 6628–02, immature male 645 mm TL, CSIRO H 6628–03, adult male 875 mm TL, CSIRO H 6628–04, adult male 910 mm TL, CSIRO H 6628–06, adult male 852 mm TL, CSIRO H 6628–07, adult male 906 mm TL, NMV A 29736–001, adult male 820 mm TL, collected with holotype.
Other material. 5 whole specimens: CSIRO CA 4104, adult male 843 mm TL, east of Gabo Island, Victoria, 37°40′ S, 150°15′ E, 504–508 m, 04 May 1984; CSIRO H 866–02, immature male 456 mm TL, CSIRO H 867–01, female 439 mm TL, east of Jervis Bay, New South Wales, 34°58′ S, 151°09′ E, 490–576 m, 10 Sep 1986;

CSIRO H 2268–02, adult male 800 mm TL, west of Bunbury, Western Australia, 33°03′ S, 114°25′ E, 701 m, 10 Feb 1989; CSIRO H 6504–05, adult male 861 mm TL, east of Jervis Bay, New South Wales, 35°12′ S, 150°58′ E, 320–500 m, July to Aug 2003. 8 skeletal specimens: CSIRO H 6307–01, female 1027 mm TL, east of Flinders Island, Tasmania, ca. 40° S, 149° E, 350–430 m, 12 July 2004; CSIRO H 6309–01, adult male 865 mm TL, east of Flinders Island, Tasmania, ca. 40° S, 149° E, 400–450 m, 01 Aug 2004; CSIRO H 6503–01, adult male 872 mm TL, CSIRO H 6503–02, female 991 mm TL, CSIRO H 6503–03, female 1023 mm TL, CSIRO H 6503–04, female 987 mm TL, CSIRO H 6503–05, female 957 mm TL, CSIRO H 6503–06, adult male 867 mm TL, north-east of Flinders Island, Tasmania, 39°20′ S, 148°45′ E, 370–420 m, 07 Apr 2003.

DIAGNOSIS.— A moderate-sized species of *Centrophorus* with the following combination of adult characters: pre-second dorsal length 62.8–64.8% TL, 8.3–9.8 times dorsal–caudal space; pre-first dorsal length 28.3–30.7% TL; interdorsal space 20.0–23.7% TL, 3.0–3.5 times dorsal–caudal space; dorsal–caudal space 6.4–7.9% TL, 4.2–4.7 in pectoral–pelvic space; head long and moderately robust (length 23.3–24.3% TL, 2.5–2.9 times mouth width; width 11.8–13.1% TL, 4.9–5.4 in pre-second dorsal length; width at anterior of nostrils 5.5–6.3% TL); snout moderately long (preoral length 9.4–10.1% TL, 1.6–1.9 times head height at anterior of mouth, 1.0–1.2 times mouth width; horizontal preorbital length 5.6–6.3% TL; horizontal prenarial length 3.4–4.2% TL); mouth large (width 8.3–9.6% TL); pectoral fin moderately sized (anterior margin 11.4–12.6% TL, 2.3–2.8 times base length); caudal fin large (dorsal caudal margin 17.9–20.8% TL; 2.6–2.9 times dorsal–caudal space); first dorsal fin moderately-sized (height 6.0–7.0% TL), spine relatively robust (base width 0.9–1.2% TL). Dorsal fins of juveniles with a distinct blackish margin extending from mid-anterior margin to near free rear tip; adults with a less distinct, but obvious, dark margin. Upper teeth of adults of both sexes upright, only slightly oblique laterally; different shape and much smaller than lower teeth; those of juveniles with more oblique cusps, but not strongly oblique. Tooth row count (based on non-type skeletal specimens, n=8): 37–45/30–33. Flank denticles flat, block-like, not overlapping, scalloped edges. Total vertebral centra 114–117 (mean 115.4), monospondylous precaudal centra 54–56 (55.2), diplospondylous precaudal centra 28–31 (29.4), precaudal centra 84–86 (84.7) and diplospondylous caudal centra 31 (30–32).

DESCRIPTION.— Body fusiform, moderately elongate, nape moderately humped; deepest near first dorsal-fin spine, trunk height 1.08 (0.97–1.36 in 6 adult paratypes) times width, 1.01 (0.92–0.19) times abdomen height; head moderately elongate, length 23.3 (23.3–24.3)% TL; caudal peduncle moderately slender, 13.7 (12.0–14.8)% TL. Head moderately robust, broad, width 1.10 (1.04–1.19) times trunk width, 1.07 (1.03–1.45) times abdomen width; depressed forward of spiracles, becoming somewhat semicircular in cross-section towards pectoral-fin origin; length 2.59 (2.26–2.58) in pre-vent length; height 0.88 (0.83–0.96) times width. Snout relatively short, narrowly rounded in lateral view, apex bluntly pointed; lateral prenarial margin angular; narrowly rounded in dorsal view; horizontal length 0.97 (0.88–1.12) times eye length, 0.73 (0.69–0.82) times interorbital space; horizontal prenarial length

A

B

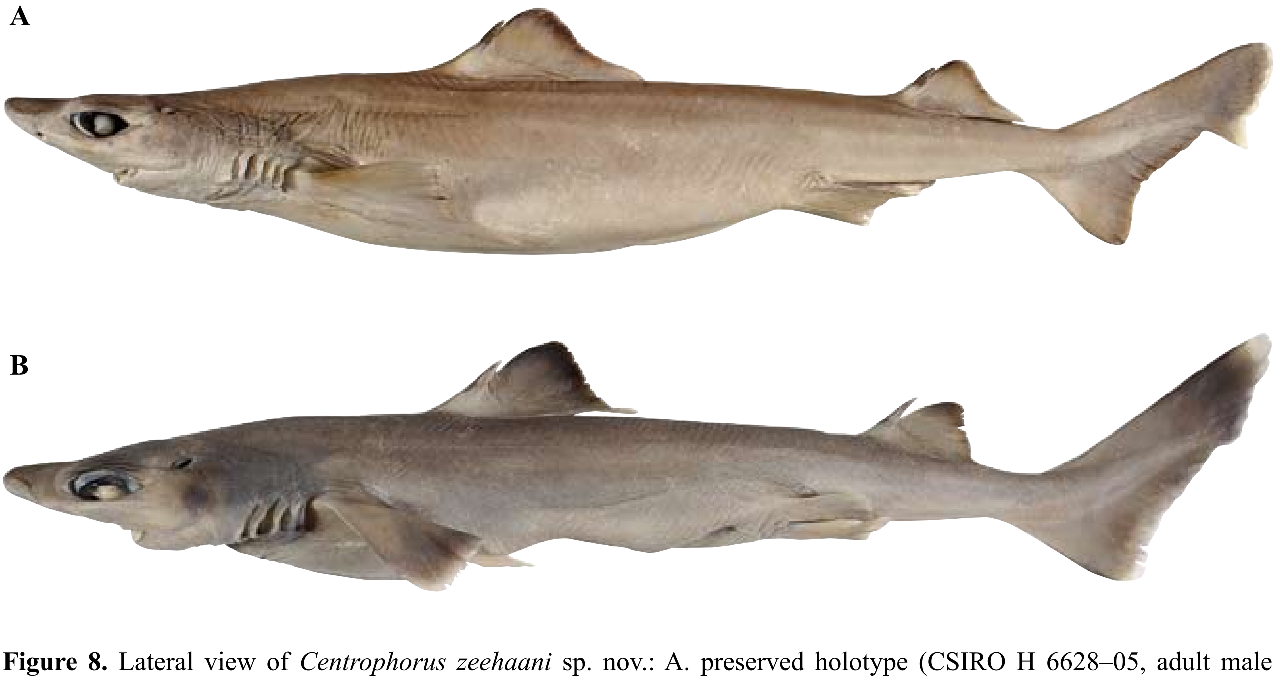

Figure 8. Lateral view of *Centrophorus zeehaani* sp. nov.: A. preserved holotype (CSIRO H 6628–05, adult male 893 mm TL); B. preserved paratype (CSIRO H 6628–01, immature male 506 mm TL).

Table 3. Proportional dimensions as percentages of total length for the holotype (CSIRO H 6628–05), 6 adult paratypes and 2 juvenile paratypes of *Centrophorus zeehaani* sp. nov.

	Centrophorus zeehaani sp. nov.				
	Holotype	Adults		Juveniles	
		Min.	Max.	Min.	Max.
Total length (mm)	893	820	910	506	645
Precaudal length	79.7	78.7	81.9	78.1	79.6
Pre-second dorsal length	63.6	62.8	64.8	62.1	63.1
Pre-first dorsal length	30.7	28.3	30.3	30.1	30.3
Pre-vent length	60.4	57.8	61.0	57.5	58.6
Prepelvic length	58.2	55.8	58.3	55.9	56.6
Prepectoral length	22.2	21.8	22.8	24.5	24.9
Head length	23.3	23.3	24.3	25.4	25.5
Prebranchial length	19.3	19.4	20.1	21.8	21.9
Prespiracular length	12.1	12.2	13.5	13.9	14.6
Preorbital length	6.1	6.3	6.8	7.2	7.4
Prenarial length	4.2	4.1	4.5	5.0	5.0
Preoral length	9.4	9.5	10.1	10.8	11.3
Inner nostril–labial furrow space	5.9	6.1	6.6	6.8	6.9
Mouth width	8.9	8.3	9.6	9.3	9.3
Upper labial furrow length	2.0	1.5	2.2	2.0	2.3
Nostril width	1.6	1.6	1.9	1.9	2.1
Internarial space	3.6	3.3	3.5	3.7	3.9
Interorbital space	7.6	7.7	8.6	7.9	8.2
Eye length	5.8	5.4	6.5	6.5	7.3
Eye height	2.2	1.7	2.2	2.1	2.4
Spiracle diameter - greatest	2.1	1.6	1.9	1.6	2.1
First gill-slit height	2.8	2.2	2.6	2.7	2.8
Fifth gill-slit height	3.6	3.0	3.8	3.5	3.6
Interdorsal space	21.9	20.0	23.7	21.5	22.4
Dorsal–caudal space	6.9	6.4	7.9	7.7	7.7
Pectoral–pelvic space	32.4	30.0	34.1	29.4	29.6
Pelvic–caudal space	13.7	12.0	14.8	12.4	14.2
First dorsal length	17.8	18.5	19.9	17.8	18.3
First dorsal soft fin length	11.8	11.1	12.7	11.5	12.0
First dorsal anterior margin	10.9	12.0	13.7	13.0	13.2
First dorsal base length	11.8	12.2	13.8	11.0	12.7
First dorsal height	6.0	6.1	7.0	6.8	7.1
First dorsal inner margin	6.2	6.2	7.0	5.8	6.7
First dorsal posterior margin	9.5	9.0	11.0	9.4	10.6
First dorsal spine length	2.6	2.1	3.1	3.0	3.2
First dorsal spine base width	0.9	0.9	1.2	1.1	1.2
Second dorsal length	14.2	12.8	14.5	13.4	13.4
Second dorsal soft fin length	8.3	7.4	8.8	8.2	8.5
Second dorsal anterior margin	9.4	9.5	10.5	10.0	10.0
Second dorsal base length	9.6	9.2	10.0	8.6	8.8
Second dorsal height	4.7	4.7	5.3	5.2	5.2
Second dorsal inner margin	4.5	3.6	4.9	4.5	5.0

Table 3. cont'd.

	Centrophorus zeehaani sp. nov.				
	Holotype	Adults		Juveniles	
		Min.	Max.	Min.	Max.
Second dorsal posterior margin	7.2	6.0	7.5	6.6	6.9
Second dorsal spine length	2.2	2.4	3.3	3.4	3.5
Second dorsal spine base width	0.9	0.7	1.0	1.0	1.0
Pectoral anterior margin	11.4	11.9	12.6	12.6	13.0
Pectoral inner margin	13.6	12.3	14.6	13.0	13.0
Pectoral base length	4.8	4.5	5.2	4.5	5.2
Pelvic length	11.2	11.1	12.2	10.7	11.0
Pelvic height	6.5	6.0	6.7	5.0	5.4
Pelvic inner margin	6.7	6.0	7.0	5.1	6.1
Dorsal caudal margin	19.6	17.9	20.8	19.8	21.7
Preventral caudal margin	12.5	12.2	13.8	13.0	14.4
Upper postventral caudal margin	7.7	7.2	8.5	8.0	8.8
Lower postventral caudal margin	4.1	4.6	5.6	4.1	4.5
Caudal fork width	7.1	7.2	7.8	7.6	7.8
Caudal fork length	11.8	11.8	12.7	11.9	14.1
Caudal terminal lobe	8.8	8.3	9.7	9.1	9.9
Caudal subterminal fin margin	3.4	2.7	3.1	1.7	1.7
Head width at anterior of nostrils	5.5	5.7	6.3	6.1	6.8
Head width at mouth	9.9	9.3	10.4	10.9	11.2
Head width	12.6	11.8	13.1	12.2	12.7
Trunk width	11.4	10.0	12.1	10.5	11.2
Abdomen width	11.7	10.4	12.7	8.4	9.3
Tail width	5.8	5.1	5.8	4.8	4.9
Caudal peduncle width	3.0	2.8	3.4	2.8	2.8
Head height at mouth	5.8	5.4	6.5	5.3	6.3
Head height	11.0	10.9	12.1	10.5	10.7
Trunk height	12.2	12.3	14.7	10.9	11.3
Abdomen height	12.1	10.8	15.2	10.3	11.0
Tail height	6.8	6.4	7.2	6.4	7.3
Caudal peduncle height	3.8	3.7	4.2	3.8	3.9
Clasper outer length	3.7	3.4	4.0	–	–
Clasper inner length	8.3	7.1	8.5	–	–
Clasper base width	1.1	1.0	1.2	–	–
First dorsal midpoint–pectoral insertion	8.2	7.4	9.6	7.1	7.5
First dorsal midpoint–pelvic origin	22.0	19.3	22.7	20.1	21.1
Pelvic midpoint–first dorsal insertion	17.9	14.5	18.7	16.7	17.5
Pelvic midpoint–second dorsal origin	3.8	3.8	5.1	4.4	4.5

2.49 (2.30–2.79) times in preoral length. Eye large, oval, length 4.05 (3.49–4.37) in head, 2.68 (2.62–3.58) times height; strongly notched posteriorly, notch not extending towards spiracle. Spiracle moderately-sized, semicircular; no lobe-like fold on posterior margin; greatest diameter 2.79 (2.99–4.49) in eye length. Gill slits directed slightly anteroventrally from top to bottom; first four subequal in size, fifth longest, height of fifth slit 3.6 (3.0–3.8)% TL. Mouth almost transverse, upper jaw slightly concave, width 1.05 (1.02–1.22) in preoral length; upper labial furrows subequal to or slightly longer than lower furrows; prominent postoral groove, more than twice length of upper labial furrows, extending posterolaterally from angle of jaws. Teeth of adult males strongly differentiated in upper and lower jaws; upper teeth small, cusps upright, narrow and triangular, bases not usually overlapping; lower teeth much larger, cusps very strongly oblique, blade-like, overlapping, apices often somewhat upright, recurved; sexual dimorphism was not established as there are no adult female type specimens. Nostrils small, almost transverse; anterior nasal flap formed as a large subtriangular lobe with a somewhat rudimentary secondary lobe mesially; internarial space 2.62 (2.77–3.10) in preoral length, 2.19 (1.74–2.21) times nostril length. Dermal denticles (based on holotype CSIRO H 6628–05) on flank small, flat, block-like, not overlapping; medial cusp blunt, no lateral cusps, ridges indistinct. Denticles of juveniles (based on CSIRO H 6628–01) smaller, more upright, with more pointed crowns and ridges more obvious. First dorsal fin moderately small, raked, broadly rounded apically (somewhat broadly angular in CSIRO H 6628–01); anterior margin moderately convex; upper posterior margin straight to slightly convex, slanting well posteroventrally from top to bottom, moderately concave near free rear tip; free rear tip relatively thick basally, moderately long; inner margin of fin almost straight (weakly concave in CSIRO H 6628–01); insertion of base extremely well forward of pelvic-fin origin, posterior to free rear tip of pectoral fin (over free rear tip in CSIRO H 6628–01, 02); fin-spine origin above mid pectoral-fin inner margin; spine base broad, exposed anteriorly just below junction of spine and soft portion of fin; soft portion of fin connected about level of two thirds of total spine length; spine rapidly tapering distally when not damaged, anterior margin almost straight to weakly convex; exposed portion of spine sloping strongly posterodorsally from base to apex, usually shorter than exposed portion of second dorsal-fin spine; pre-first dorsal-fin length 3.26 (3.30–3.54) times in TL; first dorsal-fin length 2.98 (2.58–3.14) times its height, 1.25 (1.33–1.51) times second dorsal-fin length; first dorsal-fin height 1.26 (1.19–1.39) times second dorsal-fin height; exposed first dorsal spine length 0.44 (0.31–0.47) times height of fin. Second dorsal fin moderately small, slightly raked; anterior margin slightly convex, apex moderately rounded (narrowly rounded in CSIRO H 6628–01, 02); posterior margin very weakly concave (moderately concave in CSIRO H 6628–01, 02), sloping strongly posteroventrally from apex; free rear tip greatly elongated, inner margin length 0.96 (0.73–0.96) times fin height; second dorsal-fin length 3.01 (2.56–2.89) times its height; spine length 0.47 (0.47–0.67) in height of fin; fin-spine origin anterior to free rear tip of pelvic fin, exposed just below level of junction with spine and soft portion of fin; second dorsal spine moderately broad based, tapering distally, sharply pointed when undamaged; interdorsal space 1.01 (0.94–1.14) in prepectoral length, 1.40 (1.22–1.49) in pre-first dorsal length; interdorsal groove weak. Pectoral fin moderately large, anterior margin weakly convex; inner margin weakly convex anteriorly, almost straight posteriorly, length 13.6 (12.3–14.96)% TL; apex moderately rounded to somewhat angular, lobe-like but not falcate; posterior margin almost straight from apex to free rear tip; free rear tip greatly elongated, extending to just posterior to midpoint of first dorsal-fin base (extending to first dorsal-fin insertion in CSIRO H 6628–01, 02); base very short, 2.40 (2.33–2.77) in anterior margin length. Pelvic fins moderately large, anterior margin almost straight (weakly convex in CSIRO H 6628–02), posterior margin weakly concave to nearly straight, apex moderately rounded, free rear tip acute to narrowly rounded. Caudal peduncle moderately long, compressed, tapering slightly towards caudal fin; ventral groove weak; no lateral keels; pelvic–caudal space 2.36 (2.09–2.63) in pectoral–pelvic space, 1.61 (1.50–1.98) in prepectoral length; dorsal–caudal space 3.17 (2.79–3.46) in interdorsal length; precaudal pits absent. Caudal fin relatively long, postventral margin moderately concave (nearly straight in CSIRO H 6628–01), terminal lobe moderately large, deep (relatively shallow in CSIRO H 6628–01, 02); apex of lower lobe narrowly to moderately rounded; dorsal caudal margin 1.19 (1.12–1.32) in head length; length of lower caudal lobe 1.57 (1.47–1.58) in upper lobe length. Total vertebral centra 115 (114–117), monospondylous precaudal centra 56 (54–56), diplospondylous precaudal centra 28 (28–31), precaudal centra 84 (84–86) and diplospondylous caudal centra 31 (30–32). Tooth row count (based on non-type skeletal specimens): 37–45 (mean = 40; n=8)/30–33 (mean = 31.7, n=7).

COLOUR.— Preserved specimens: (based on adult male paratypes) Upper surface of body uniformly light brownish with a distinct pale reddish tinge, becoming paler ventrally; ventral surfaces much paler; light and dark tonal areas not well demarcated on body with light and dark areas almost blending together; light and dark tonal areas well demarcated on head, extending just below lower margin of eye and just below upper margin of gill slits, pectoral-fin origin pale; eye–spiracle space with a distinct pale whitish blotch anteriorly, less distinct near spiracle (less obvious in some paratypes). Dorsal fins pale with a distinct, broad, diffuse-edged, dusky margin extending from about level of fin-spine apices to just posterior of the maximum concavity of the posterior margin; fin spines dark brownish. Pectoral and pelvic fin upper surfaces similar in colouration to dorsal surface but darker distally, with narrow whitish posterior margins. Caudal fin mostly greyish; postventral margin with a very narrow darkish postventral border (indistinct in some paratypes), a narrow whitish submarginal bar, demarcated by a broad dusky, diffuse-edged marking for its entire length; terminal lobe darker than rest of fin with a narrow whitish terminal margin. **Juveniles:** (based on CSIRO H 6628–01, 02) upper surface of body distinctly medium greyish, lacking a reddish tinge (CSIRO H 6628–02 with a number of deciduous denticles resembling small white flecks); a distinct dark greyish blotch over upper portion of gill slits, extending dorsally to level of upper margin of spiracle (less distinct in CSIRO H 6628–02). Dorsal fins much more distinct, broad, blackish margins, in same location as on adults; free rear tips whitish; fin spine bases whitish. Pectoral fin upper surface with a more distinct dark greyish distal marking and white posterior margin. Pelvic fin pale with whitish posterior margin. Caudal fin mostly similar to that of adults but with a much more distinct darker terminal lobe and apical half of preventral margin with a very narrow, blackish border.

SIZE.— Type series consists of 7 adult males between 820 and 910 mm TL and two immature males of 506 and 645 mm TL. Largest female examined was 1027 mm TL (CSIRO H 6307–01) and smallest free-swimming individual was 439 mm TL (CSIRO H 867–01).

DISTRIBUTION.— Known from the continental slope of southern Australia from off Forster in New South Wales (ca. 32° S; K. Graham, pers. comm.) to off Bunbury in Western Australia (33°03′ S; CSIRO H 2268–02), including Tasmania, in depths of 208–701 m, but usually found in depths >400 m (Fig. 11).

ETYMOLOGY.— Named after the commercial vessel *Zeehaan* from which the first specimens of this species from Tasmanian waters were collected in 1979 during the first survey to map and explore uncharted grounds (see Last & Harris, 1981).

VERNACULAR.— The official English common name of "Southern Dogfish" used by Last & Stevens (1994) for *C. uyato* in allusion to the southern Australian distribution of this species is adopted for this species.

REMARKS.— *Centrophorus zeehaani* was previously considered to be *C. uyato* (Last & Stevens, 1994; Gomon *et al*., 1994), but Garman's (1906) placement of Rafinesque's (1810: 3–14, pl. 14, fig. 2) *Squalus uyatus* into the genus *Centrophorus* was incorrect. The illustration of *S. uyatus* clearly depicts a *Squalus* species and not a *Centrophorus* species (as also highlighted by Muñoz-Chápuli & Ramos, 1989), which is particularly evident from the lack of a terminal lobe on the caudal fin typical of members of the latter genus. This new species is superficially similar to other members of the longnose *Centrophorus* subgroup, and is commonly mis-identified as *C. harrissoni* in areas where these two species co-occur. Adults of *C. zeehaani* differ from *C. tessellatus* in having a shorter horizontal head length (22.0–23.3 vs. 24.8% TL); a shallower head (10.9–12.1 vs. 9.9% TL); a narrower mouth (8.3–9.6 vs. 7.4% TL); pectoral and pelvic fins closer together (pectoral–pelvic space 30.0–34.1 vs. 27.9% TL); a shorter caudal peduncle (pelvic–caudal space 12.0–14.8 vs. 17.9% TL) and gill slits mostly pale but with no white borders vs. darker with white borders.

Adults of *C. zeehaani* differ from those of *C. isodon* in having a slightly longer, broader head (head length 23.3–24.3 vs. 22.0–23.3% TL; head width 11.8–13.1 vs. 9.7–11.9% TL, 4.9–5.4 vs. 5.7–6.9 in pre-second dorsal length); a longer pre-second dorsal length (62.8–64.8 vs. 66.2–68.0% TL); larger gill slits (first gill slit height 2.2–2.8 vs. 1.7–1.9% TL, 2.0–2.9 vs. 3.5–4.1 in head width at anterior of nostrils); more robust dorsal spines (exposed first dorsal-spine base width 0.9–1.2 vs. 0.7% TL); a longer pelvic fin (pelvic-fin length 11.1–12.2 vs. 7.6–10.4% TL); a deeper head (head height 10.9–12.1 vs. 8.1–9.5% TL); a wider mouth (mouth width 8.3–9.6 vs. 7.4–7.9% TL, 1.0–1.2 vs. 1.3–1.5 in preoral length) and dorsal fins blackish apically without a white posterior margin vs. uniformly darkish with a sometimes indistinct white posterior margin. Juveniles of *C. zeehaani* differ from those of *C. isodon* in the following measurements and ratios: a longer, broader head (head length 25.4–25.5

Figure 9. Ventral view of the head of *Centrophorus zeehaani* sp. nov. holotype (CSIRO H 6628–05, adult male 893 mm TL).

Figure 10. Cusps of the flank denticles of *Centrophorus zeehaani* sp. nov. (holotype CSIRO H 6628–05, adult male 893 mm TL).

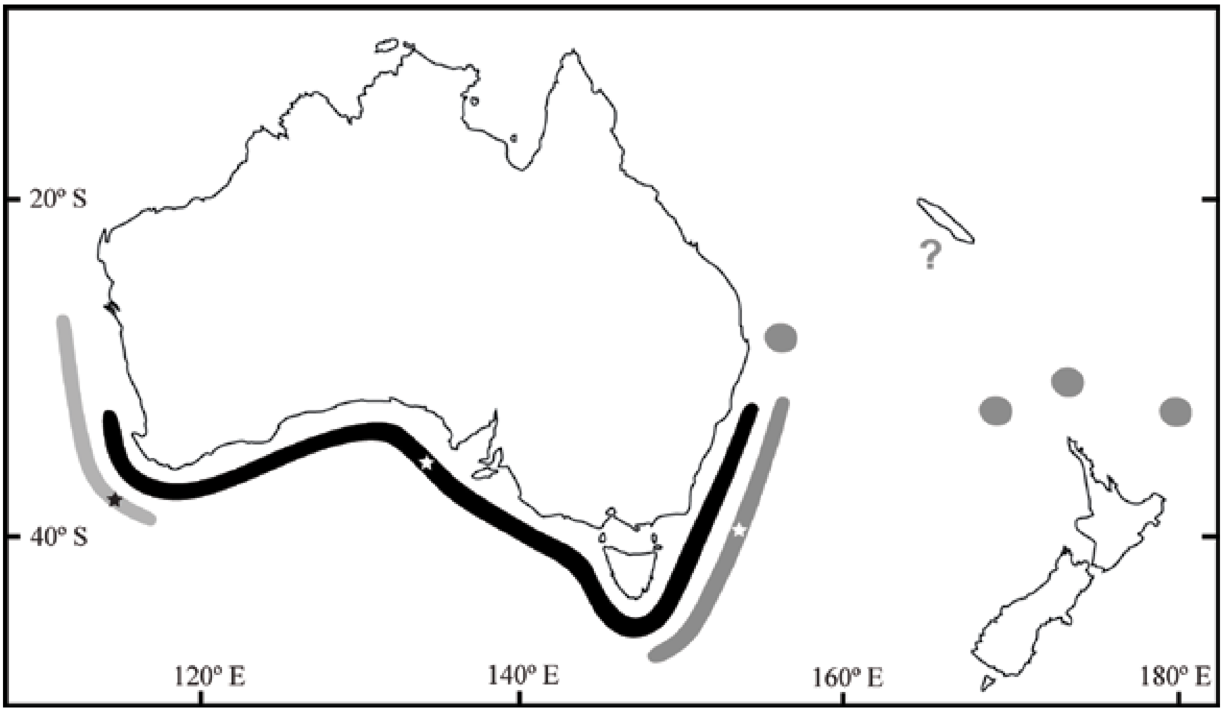

Figure 11. Map showing the geographic distribution (not indicative of depth ranges) of the three longnose *Centrophorus* species, *C. harrissoni* (dark grey), *C. westraliensis* (pale grey) and *C. zeehaani* (black), which occur in Australian waters. Collection localities of the holotype of each of the species are denoted by stars.

vs. 24.2–24.8% TL; head width 12.2–12.7 vs. 9.2–11.2% TL); a shorter, narrower snout (preorbital length 7.2–7.4 vs. 8.1–8.3% TL, width at anterior of nostrils 6.1–6.8 vs. 8.2–8.3% TL); more robust dorsal spines; larger gill slits (first gill slit height 2.7–2.8 vs. 2.1% TL); a deeper head (head height 10.5–10.7 vs. 7.1–8.7% TL); a wider mouth (mouth width 9.3 vs. 8.1–8.5% TL) and dorsal fins with distinct, broad blackish apices and posterior margins vs. dorsal fins with a blackish anterior blotch extending over apex and a white posterior blotch.

Adult males of *C. zeehaani* have similar, upright upper teeth to the adult male holotype of *C. seychellorum* (Baranes, 2003), but these two species differ in pelvic–caudal space (12.0–14.8 vs. 19.1% TL); pectoral anterior margin (11.4–12.6 vs. 13.4% TL); second dorsal-fin height (4.7–5.3 vs. 3.7% TL); mouth width (8.3–8.6 vs. 7.1% TL) and pre-pectoral length (21.8–22.8 vs. 20.9% TL).

Adults of *C. zeehaani* differ from those of *C. harrissoni* and *C. westraliensis* in having a shorter, narrower snout (preorbital length 6.1–6.8 vs. 7.5–8.6% TL, 10.0–11.6 vs. 7.7–9.3 times pre-second dorsal length, prenarial length 4.1–4.5 vs. 4.9–5.8% TL, width at anterior of nostrils 5.5–6.3 vs. 7.1–7.9% TL); a shorter preoral length (9.4–10.1 vs. 10.9–12.4% TL); a slightly longer pelvic fin (length 11.1–12.2 vs. 9.9–11.2% TL); a short internarial space (3.3–3.6 vs. 3.8–4.6% TL); height of head at anterior of mouth 1.6–1.9 vs. 2.0–2.2 in preoral length and dorsal fins with a broad, dusky to blackish apical marking (usually obvious when fresh) vs. dorsal fins with a narrow white posterior margin (sometimes indistinct in larger specimens). Juveniles of *C. zeehaani* differ from those of *C. harrissoni* and *C. westraliensis* in having dorsal fins with a distinct, broad blackish apical markings and pale free rear tips vs. a blackish anterior blotch and white posterior blotch. They also differ in the following measurements and ratios: prespiracular length 13.9–14.6 vs. 15.9–16.2% TL; preorbital length 7.2–7.4 vs. 9.3–9.7% TL; interdorsal space 21.5–22.4 vs. 16.1–19.7% TL; pectoral–pelvic space 29.4–29.6 vs. 25.0–27.8% TL; preoral length 10.8–11.3 vs. 13.0–14.2% TL; pectoral-fin inner margin length 13.0 vs. 10.6–11.6% TL; first dorsal spine-length 3.0–3.2 vs. 1.4–2.1% TL; second dorsal spine-length 3.4–3.5 vs. 1.4–2.5% TL; width at anterior of nostrils 6.1–6.8 vs. 8.6–9.2% TL; caudal-fin subterminal margin 1.7 vs. 2.9–3.7% TL; mid pelvic-fin base to first dorsal-fin insertion 16.7–17.5 vs. 11.0–13.8% TL.

The upper teeth of adults of *Centrophorus zeehaani* are not strongly sexually dimorphic (based on skeletal specimens) as they are in *C. harrissoni* and *C. seychellorum*, in which the upper teeth of females have strongly oblique cusps and those of males have upright, pointed cusps. Those of *C. isodon* also show sexual dimorphism but with the cusps of female upper teeth less strongly oblique than in the above two species. The larger female types of *C. westraliensis* have similar-shaped upper teeth to *C. isodon*, and not as strongly oblique as *C. harrissoni* or *C. seychellorum*. The upper teeth of the adult male paratypes and of female material examined (CSIRO H 6307–01, CSIRO H 6503–02, 03, 04, 05) all have upright cusps becoming only very slightly oblique laterally.

The biological data which has been collected for this species so far has revealed that females give birth to a single pup (K. Graham, NSW Department of Primary Industries and R. Daley, CSIRO Marine & Atmospheric Research, unpubl. data). In contrast, all pregnant females of *C. isodon* examined in Indonesia contained 2 embryos (unpubl. data) and most pregnant females of *C. harrissoni* examined from southeastern Australia contained two pups (K. Graham and R. Daley, unpubl. data). This particularly low fecundity highlights the vulnerability of members of this genus to fishing pressure.

Comparative material.
Centrophorus isodon: CSIRO H 5857–01, immature male 540 mm TL, Kedonganan fish market, Bali, Indonesia, 9 Apr 2001; CSIRO H 5889–15, female 530 mm TL, Kedonganan fish market, Bali, Indonesia, July 2002; CSIRO H 5875–04, female 989 mm TL, Tanjung Luar fish landing site, Lombok, Indonesia, 26 Mar 2002; CSIRO H 6125–02, female 965 mm TL, Kedonganan fish market, Bali, Indonesia, 27 Aug 2002; CSIRO H 6138–01, female 952 mm TL, Tanjung Luar fish landing site, Lombok, Indonesia, 25 Mar 2002; CSIRO H 6233–02, immature male 306 mm TL, CSIRO H 6233–03, immature male 304 mm TL, CSIRO H 6233–04, immature male 305 mm TL, CSIRO H 6233–05, female 241 mm TL, CSIRO H 6233–06, immature male 256 mm TL, Kedonganan fish market, Bali, Indonesia, 16 Mar 2005; SAM unregistered, Taiwan Fisheries Research Institute Fishery Researcher 1 sta. FR1–PHI–14–95, 950927, 435–451 m, 14°41–42′ N, 123°24–21′ E, adult male 905 mm TL, northern Luzon, Philippines.
Centrophorus tessellatus: MCZ 1031S (holotype), adult male 875 mm TL, Sagami Bay, Japan, 35°08′ N, 139°31′ E, ca. 730 m, 09 Aug 1903.

Key to the Australian species of *Centrophorus*

1 Lateral trunk denticles with leaf-like flattened crowns on elevated narrow to broad pedicels extending above their bases; denticle crowns with strong medial and lateral cusps on their posterior ends 2

Lateral trunk denticles with flat, sessile crowns on their bases, without separate pedicels; denticle crowns sometimes with a posterior medial cusp but no lateral cusps.. 3

2 Free rear tips of pectoral fins broadly angular without an expanded lobe; lateral trunk denticles of adults leaf-like and on narrow pedicels .... *C. squamosus* (Indo–West Pacific, Eastern Atlantic)

Free rear tips of pectoral fins expanded into a short lobe; lateral trunk denticles of adults with a prominent angular cusp on a short, broad pedicel .. .. *C. acus* (scattered Indo–West Pacific)

3 Second dorsal fin relatively small, about half height of first dorsal fin; dorsal fins relatively well spaced (interdorsal space >24% TL), second dorsal-spine origin behind pelvic-fin free rear tip .... *C. moluccensis* (Indo–West Pacific)

Second dorsal fin relatively large, about three quarters height of first dorsal fin; dorsal fins relatively close together (interdorsal space <23% TL), second dorsal-spine origin usually above pelvic-fin inner margin.. 4

4 Free rear tips of pectoral fins moderately elongate, usually not extending past first dorsal spine; lateral trunk denticles with somewhat elongated crowns and a prominent angular cusp in adults; large species, attaining >150 cm TL…..

.... *C. niaukang* (= *C. granulosus sensu* Last & Stevens, 1994; Indo–West Pacific)

Free rear tips of pectoral fins greatly elongated, extending past first dorsal spine; lateral trunk denticles with rounded or oval crowns and a low obtusely angular cusp; medium sized species, attaining ca. 110 cm TL....................................... 5

5 Dorsal fins with broad, dark greyish to blackish margins (less distinct in adults but still obvious when fresh), without distinctive whitish markings; snout moderately long (depth at front of mouth less than 1.9 times preoral length; mouth width less than 1.2 in preoral length).. .... *C. zeehaani* sp. nov. (southern Australia)

Dorsal fins with dark anterior blotch (less obvious in adults) and broad white posterior margin (much narrower in adults but still obvious when fresh); snout long (depth at front of mouth more than 2.0 times preoral length; mouth width more than 1.3 in preoral length)... 6

6 Dorsal fins widely spaced (interdorsal space more than 2.8 times dorsal–caudal space); relatively narrow head (width at front of mouth less than 10% of total length); mouth width more than 3.1 in head length .... *C. westraliensis* sp. nov. (Western Australia)

Dorsal fins close together (interdorsal space less than 2.6 times dorsal–caudal space); relatively broad head (width at front of mouth more than 10% of total length); mouth width less than 3.0 in head length .... *C. harrissoni* (Australia, New Zealand, New Caledonia)

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A new species of sawshark, *Pristiophorus delicatus* sp. nov. (Pristiophoriformes: Pristiophoridae), from northeastern Australia

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ABSTRACT.— A new species of sawshark, *Pristiophorus delicatus* sp. nov., is described based on material from the upper continental slope of northeastern Australia. *Pristiophorus delicatus* is relatively small compared with other Australian *Pristiophorus*, and is clearly separable from all known congeners by a combination of morphometric characters, meristics, size and colour. Specimens of another eastern Australian sawshark, identified as *Pristiophorus* sp. A, conform well to those of *P. cirratus* and differ only in coloration. Thus, *P*. sp. A is tentatively considered a synonym of *P. cirratus*, with detailed examination of specimens from the eastern and western populations required in the future.

Key words. Pristiophoridae – *Pristiophorus delicatus* – *Pristiophorus cirratus* – sawshark – new species – Australia

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INTRODUCTION

The family Pristiophoridae (sawsharks) is comprised of 9 currently recognised species that are unique amongst sharks in possessing a long, flat, saw-like snout with a pair of ventral barbels situated anterior to the nostrils. Pristiophorids are an ancient group of sharks with a fossil record dating back to the Upper Jurassic that show a parallel evolution with the sawfishes (Pristidae) by the possession of an elongate, saw-like rostrum (Keyes, 1982). All species occur in the Indo–West Pacific, with the exception of *Pristiophorus schroederi* Springer & Bullis, 1960 from the western North Atlantic, and have narrow distributional ranges (Compagno *et al.*, 2005). The genus *Pristiophorus* currently comprises 4 nominal and 4 undescribed species: *P. cirratus* (Latham, 1794), *P. japonicus* Günther, 1870, *P. nudipinnis* Günther, 1870, *P. schroederi* and *P*. spp A–D (Compagno *et al*., 2005). Last & Stevens (1994) identified 4 species of sawsharks from Australian waters, all of which appear to be endemic: *P. cirratus* from across southern Australia, *P. nudipinnis* from southeastern Australia and the Great Australian Bight, *P*. sp. A from southeastern Australia, and *P*. sp. B from northeastern Australia.

This paper provides a formal description of *Pristiophorus* sp. B (*sensu* Last & Stevens, 1994) and discusses the validity of *P*. sp. A (*sensu* Last & Stevens, 1994).

METHODS

Morphometric characters were selected to facilitate comparisons of the new *Pristiophorus* species (previously identified as *P*. sp. B [*sensu* Last & Stevens, 1994]) with nominal *Pristiophorus* species. Measurements generally followed a widely adopted scheme for elasmobranchs (Compagno, 1984, 2001), but focused on direct rather than horizontal measurements and included explanations of how measurements were taken based on sawsharks' atypical body shape (see Table 1). Dorsal and caudal-fin origins were identified by feeling for the anteriormost point of the embedded fin, and then marked by inserting a pin. Distances to the nostril (e.g. nostril to barbel origin and mouth to nostril) were calculated to the anterior margin of the nostril. The holotype (CSIRO H 931–01) and 9 paratypes (CSIRO H 601–11, CSIRO H 601–12, CSIRO H 617–01, CSIRO H 617–02, CSIRO H 630–14, CSIRO H 630–15, CSIRO H 954–01, CSIRO H 1113–07 and CSIRO H 1113–08) of the new species were measured in full (Table 2), and comparative measurements were obtained from 6 specimens of *Pristiophorus cirratus* from southeastern Australia (CSIRO H 3426–01, CSIRO H 3579–04, CSIRO H 3582–04, CSIRO H 3784–01, CSIRO H 4257–01 and CSIRO H 4441–01), 6 specimens of *P. nudipinnis* (CSIRO CA 3356, CSIRO H 2726–01, CSIRO H 2727–01, CSIRO H 3401–01, CSIRO H 3777–01 and CSIRO H 4252–02), and one specimen

Table 1. Definition of the main morphometric characters taken for *Pristiophorus*.

Morphometric character	Methodology
Total length	Direct distance from snout tip to posterior tip of caudal-fin
Precaudal length	Direct distance from snout tip to the origin of the upper caudal lobe
Pre-second dorsal length	Direct distance from snout tip to the second dorsal-fin origin
Pre-first dorsal length	Direct distance from snout tip to the first dorsal-fin origin
Snout–vent length	Direct distance from snout tip to anterior of vent
Prepelvic length	Direct distance from snout tip to anterior of fin cartilage
Prepectoral length	Direct distance from snout tip to anterior of fin cartilage with fin at 45° to body axis
Interdorsal space	Distance between first dorsal-fin insertion and second dorsal-fin origin
Dorsal–caudal space	Distance between second dorsal-fin insertion and upper caudal-fin origin
Pectoral–pelvic space	Direct distance from ventral insertion of pectoral fin to pelvic-fin origin
Pelvic–caudal space	Direct distance from ventral insertion of pelvic fin to lower caudal-fin origin
Head length	Direct distance from snout tip to dorsal origin of fifth gill slit
Prebranchial length	Direct distance from snout tip to anteriormost point of first gill slit
Prespiracular length	Direct distance from snout tip to anterior of aperture
Pre-eye length	Direct distance from snout tip to anterior of exposed eye
Preoral length	Direct distance from snout tip to central posterior margin of upper-jaw tooth band
Prenarial length	Shortest horizontal distance from snout tip to anterior of nostrils
Prebarbel length	Shortest horizontal distance from snout tip to origin of barbels
Eye length	Length of exposed eye
Interorbital space	Minimum cranial cartilage width across interorbit (not to 'eye-lids')
Inter-eye space	Measured to extremity of dorsal 'eye-lid'
Spiracle length	Longitudinal measurement of aperture
Eye–spiracle space	Minimum direct distance between eye and spiracle
First gill slit height	Maximum interior height
Fifth gill slit height	Maximum interior height
Nostril width	Greatest longitudinal (diagonal) measurement
Anterior nasal flap length	Distance from anteriormost point of base to tip of flap
Internarial space	Shortest distance between nasal apertures
Barbel length	Direct distance from anterior origin to tip
Rostral tooth length (anterior of nostrils)	Length of longest tooth immediately anterior to barbel; taken from notch anterior to tooth extremity
Rostral tooth width (anterior of nostrils)	Width of exposed base of above tooth
1° rostral tooth interspace	First complete interspace anterior to barbels
2° rostral tooth length	Longest complete tooth within above primary interspace
Rostral width (at nostrils)	Width at anterior of nostrils
Rostral width (at anterior of barbels)	Width at anterior of barbels; taken on ventral surface
Rostral tooth length (posterior of nostrils)	Longest rostral tooth in this region
Mouth width	Taken from fleshy corners of mouth, not including total jaw
Head width	Taken at anterior of mouth
Trunk width	Taken at pectoral-fin insertions
Tail width	Taken at pelvic-fin insertions
Head height	Taken at anterior of mouth
Trunk height	Taken at pectoral-fin insertions
Tail height	Taken at pelvic-fin insertions
Caudal peduncle height	Taken at upper caudal-fin origin

Table 1. cont'd.

Morphometric character	Methodology
First dorsal fin - length	Distance from origin (marked with a pin) to free rear tip
First dorsal fin - base	Distance from origin to insertion
First dorsal fin - height	Vertical distance from an imaginary line between origin and insertion to apex
First dorsal fin - inner margin	Distance from insertion to free rear tip
Second dorsal fin - length	Distance from origin (marked with a pin) to free rear tip
Second dorsal fin - base	Distance from origin to insertion
Second dorsal fin - height	Vertical distance from an imaginary line between origin and insertion to apex
Second dorsal fin - inner margin	Distance from insertion to free rear tip
Pectoral fin - anterior margin	Distance from anterior of fin cartilage to midpoint of apex
Pectoral fin - base	Distance from anterior of fin cartilage to ventral insertion
Pectoral fin - posterior margin	Distance of margin between curve apices
Pectoral fin - inner margin	Distance from ventral insertion to midpoint of apex of free rear tip
Pelvic fin - length	Distance from anterior of fin cartilage to free rear tip
Pelvic fin - anterior margin	Distance from anterior of fin cartilage to midpoint of apex
Dorsal caudal margin	Distance from upper caudal origin to midpoint of apex of dorsal caudal lobe
Ventral caudal margin	Distance from insertion to subterminal notch
Subterminal caudal margin	Distance between curve midpoints
Terminal caudal margin	Distance between apices of margin
Caudal fin height	Maximum vertical distance across caudal fin

of *P. japonicus* (BMNH 1936.7.25.11). In addition, full morphometrics were also obtained from 6 specimens of *Pristiophorus cirratus* from Western Australia (CSIRO H 2267–01, CSIRO H 2267–02, CSIRO H 2361–01, CSIRO H 2620–04, CSIRO H 2620–05 and CSIRO H 2612–04) and 6 specimens of non-spotted *P. cirratus* (CSIRO CA 3204, CSIRO H 904–04, CSIRO H 904–05, CSIRO H 3582–03, CSIRO H 3683–02 and CSIRO H 3706–02), previously identified as *P*. sp. A [*sensu* Last & Stevens, 1994]. Meristics were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and caudal (centra of the caudal fin) vertebrae. All types of the new species were radiographed. In the description of the new species, morphometric and meristic values for the holotype are followed in parentheses by the ranges of the paratypes. Rostral tooth counts were taken *in situ* from the most intact paratype (CSIRO H 954–01) and for the holotype. Tooth row counts were taken *in situ* from one paratype (CSIRO H 617–01) by cutting the corners of the mouth to facilitate accurate counts. Specimens, including types, are referred to by the following prefixes for their registration numbers: Australian National Fish Collection, Hobart, Australia (CSIRO); British Museum of Natural History, London (BMNH).

Pristiophorus delicatus sp. nov.

Figs 1, 2; Table 2

Pristiophorus sp. B: Last & Stevens, 1994: pp 107–109, key fig. 8, fig. 10.2, pl. 44; Compagno, 1998: p 1234, fig.; Compagno *et al*., 2005: pp 134, 135, pl. 16.

Holotype. CSIRO H 931–01, female 698 mm TL, south of Saumarez Reef, Queensland, 22°59′ S, 152°59′ E, 343–350 m, 18 Nov 1985.

Paratypes. 11 specimens: CSIRO H 601–11, juvenile male 438 mm TL, CSIRO H 601–12, female 448 mm TL, south of Saumarez Reef, Queensland, 22°35′ S, 153°40′ E, 314–319 m, 16 Nov 1985; CSIRO H 617–01, female 585 mm TL, CSIRO H 617–02, female 577 mm TL, south of Saumarez Reef, Queensland, 22°10′ S, 153°29′ E, 303–333 m, 19 Nov 1985; CSIRO H 630–14, juvenile male 506 mm TL, CSIRO H 630–15, juvenile male 509 mm TL, south of Saumarez Reef, Queensland, 22°36′ S, 153°50′ E, 345–350 m, 17 Nov 1985; CSIRO H 931–02, female 845 mm TL, CSIRO H 931–03, female 780 mm TL, collected with holotype; CSIRO H 954–01, female 809 mm TL, south of Saumarez Reef, Queensland, 23°12′ S, 153°33′ E, 399–405 m, 18 Nov 1985; CSIRO H 1113–07, female 438 mm TL, CSIRO H 1113–08,

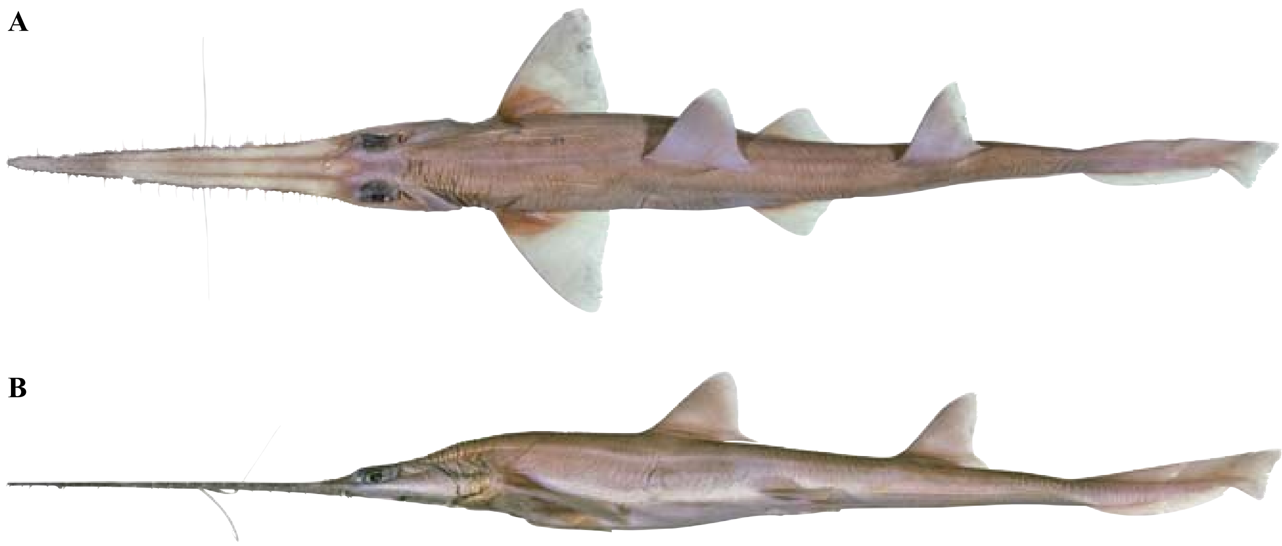

Figure 1. *Pristiophorus delicatus* sp. nov., female holotype (CSIRO H 931–01, 698 mm TL, fresh): A. dorsal view; B. lateral view.

adolescent male 625 mm TL, south of Saumarez Reef, Queensland, 22°06′ S, 153°18′ E, 246–254 m, 19 Nov 1985.

DIAGNOSIS.— A small species of *Pristiophorus* with the following characters: nostril to barbel origin 3.2–3.7 times mouth to nostril; prenasal length 1.7–1.8 times prebarbel length; preoral length 2.1–2.4 times interdorsal space; pectoral anterior margin 1.2–1.5 times dorsal–caudal space; dorsal caudal margin 4.4–5.0 times caudal-fin depth; mouth width 2.7–3.7 times spiracle length; colour pale to medium yellowish brown dorsally, pale whitish to yellowish ventrally; monospondylous centra 49–55; precaudal diplospondylous centra 50–54; total vertebral centra 149–156.

DESCRIPTION.— Body slender, firm, depressed forward of gills, abdomen subcircular in cross-section, tail subtriangular in cross-section, deepest at abdomen; not tapering gradually and evenly beyond pectoral fins; snout flattened, greatly extended, saw-like; abdomen elongate, pectoral–pelvic space 17.1 (15.1–17.0)% TL; pelvic–caudal space 2.26 (1.74–2.33) times pelvic-fin length; tail flattened ventrally, elongate, snout–vent length 1.48 (1.30–1.39) times post-cloacal tail length; caudal peduncle short, dorsal–caudal space 7.8 (7.7–8.4)% TL; lateral keels absent; ventral keels well developed, extending from about level of free rear tip of pelvic fins to beyond origin of ventral lobe of caudal fin, converging strongly near their posterior extremity; no precaudal pits; weak median predorsal, postdorsal and preventral caudal grooves (most paratypes with weak interdorsal groove).

Head narrow, subtriangular and deepest at fifth gill slit, strongly depressed above eyes, head width 6.7 (6.6–7.3)% TL, 2.23 (2.09–2.33) times head height. Snout forming a very elongate, blade-like rostrum; triangular in dorsal view; a slender, filamentous, dorsoventrally flattened barbel originating on the ventrolateral margin near its midlength on each side, barbel length 1.66 (1.26–1.65) in prebarbel length, 1.72 (1.26–1.80) in length from barbel to mouth; pre-eye length 6.23 (5.53–6.28) times mouth width, 17.7 (15.8–22.4) times spiracle length, 2.68 (2.68–3.04) times first dorsal-fin length; extremely narrow in lateral view; preoral length 4.61 (4.11–4.59) times head width, 5.69 (5.02–5.56) times width at nostrils, 9.03 (8.21–9.10) times width at barbels, 2.04 (1.97–2.09) times prebarbel length, 1.16 (1.17–1.19) times prenarial length, 2.39 (2.13–2.43) times interdorsal space. Rostrum constricted slightly just forward of eyes (constriction barely evident in some paratypes), tapering evenly to its tip; tip very narrowly rounded; extending laterally below eyes as a well-defined suborbital ridge, terminating behind posterior edge of spiracle (at level of posterior edge of spiracle in some paratypes); suborbital ridge near ventral surface of head. Rostral teeth of prenarial portion of blade variable in length, lateral, distally recurved, closely spaced, with both primary and interstitial teeth; primary teeth very slender, longest slightly shorter than spiracle length (about half spiracle length in smallest paratypes), almost symmetrically placed; interspaces between them variable, usually slightly longer than adjacent teeth, with 2–3 smaller, variable interstitial teeth; holotype and largest paratypes with intermediate sized interstitial tooth midway between some primary teeth (not as obvious in smaller paratypes); primary teeth longest near middle of rostrum, distinctly shorter near apex of rostrum and before nostrils (sometimes absent); primary teeth absent from posterior edge of suborbital ridge, interstitial-like teeth present, short, closer together than main rostral teeth,

Table 2. Morphometrics for the holotype (CSIRO H 931–01) of *Pristiophorus delicatus* sp. nov., and ranges for measured paratypes (n=9) and means for all measured types. Values are expressed as percentages of total length.

	Holotype	Paratypes		Mean
		Min.	Max.	
Total length	698	438	809	
Precaudal length	82.1	80.2	82.2	81.1
Pre-second dorsal length	68.8	66.3	68.7	67.4
Pre-first dorsal length	47.7	46.9	48.5	47.6
Snout-vent length	59.6	56.5	58.1	57.7
Prepelvic length	57.9	54.4	56.8	55.6
Prepectoral length	39.3	36.9	39.1	37.9
Interdorsal space	12.9	12.5	14.1	13.2
Dorsal–caudal space	7.8	7.7	8.4	8.1
Pectoral–pelvic space	17.1	15.1	17.0	16.2
Pelvic–caudal space	20.5	21.9	24.0	22.5
Head length	39.1	37.2	39.4	38.0
Prebranchial length	36.0	34.2	35.9	35.0
Prespiracular length	31.8	29.6	31.0	30.5
Pre-eye length	28.5	26.4	27.6	27.2
Preoral length	30.9	29.1	30.4	30.0
Prenarial length	26.6	24.7	25.9	25.5
Prebarbel length	15.2	13.9	15.4	14.8
Eye length	2.9	2.7	3.2	2.9
Interorbital space	2.6	2.5	2.9	2.7
Inter-eye space	4.3	4.3	4.7	4.4
Spiracle length	1.6	1.2	1.7	1.5
Eye–spiracle space	0.9	0.5	0.9	0.7
First gill slit height	1.1	1.1	1.7	1.4
Fifth gill slit height	1.2	1.3	1.9	1.5
Nostril width	0.8	0.7	1.2	0.8
Anterior nasal flap length	0.8	0.7	0.9	0.8
Internarial space	2.9	2.7	3.2	2.9
Barbel length	9.2	8.4	11.8	10.5
Rostral tooth length (anterior of nostrils)	1.2	0.7	1.4	1.0
Rostral tooth width (anterior of nostrils)	0.2	0.1	0.3	0.2
1° rostral tooth interspace	1.1	0.5	1.1	1.0
2° rostral tooth length	0.6	0.3	0.6	0.4
Rostral width (at nostrils)	5.4	5.2	6.0	5.6
Rostral width (at anterior of barbels)	3.4	3.3	3.7	3.5
Rostral tooth length (posterior of nostrils)	0.4	0.3	0.6	0.4
Mouth width	4.6	4.4	4.9	4.6
Head width	6.7	6.6	7.3	6.9
Trunk width	6.3	6.1	7.1	6.5
Tail width	4.5	4.2	5.2	4.6
Head height	3.0	2.9	3.5	3.1
Trunk height	5.9	5.3	6.2	5.7
Tail height	3.9	3.4	4.3	4.0
Caudal peduncle height	2.1	1.8	2.4	2.1

Table 2. cont'd.

	Holotype	Paratypes Min.	Paratypes Max.	Mean
First dorsal fin - length	10.6	8.9	9.9	9.6
First dorsal fin - base	7.7	6.2	7.0	6.7
First dorsal fin - height	6.5	6.3	7.1	6.7
First dorsal fin - inner margin	3.0	2.8	3.2	3.0
Second dorsal fin - length	8.4	8.7	9.3	8.8
Second dorsal fin - base	6.1	5.9	6.7	6.2
Second dorsal fin - height	6.4	6.0	6.6	6.3
Second dorsal fin - inner margin	2.5	2.5	2.9	2.7
Pectoral fin - anterior margin	11.7	10.1	11.5	10.7
Pectoral fin - base	3.1	2.8	3.4	3.0
Pectoral fin - posterior margin	9.1	7.1	9.3	8.4
Pectoral fin - inner margin	6.1	6.4	7.3	6.7
Pelvic fin - length	7.6	7.2	8.7	7.6
Pelvic fin - anterior margin	5.1	4.6	5.4	5.0
Dorsal caudal margin	18.1	18.4	19.2	18.7
Ventral caudal margin	11.0	12.0	14.4	12.9
Subterminal caudal margin	3.1	2.6	3.4	3.0
Terminal caudal margin	4.3	3.1	4.1	3.6
Caudal fin height	3.9	3.8	4.4	4.1

directed almost ventrally; longest rostral tooth anterior to barbels 1.2 (0.7–1.4)% TL, 1.07 (0.80–1.54) times interspace between 1st primary teeth anterior of barbels. Rostral teeth of female paratype CSIRO H 954–01 (the most intact specimen) mostly symmetrical between left and right hand sides; left side with 21 primary teeth, right side with 20; usually three interstitial teeth between each pair of primaries; anteriormost primary tooth about one quarter of a spiracle length from snout tip, with one medium-sized tooth (intermediate in size between primary and interstitial teeth) anterior to the anteriormost primary, located very close to snout tip; about 25 small teeth on left side posterior to posteriormost primary tooth. Rostral teeth of holotype damaged but similar to those described above for paratype CSIRO H 954–01, probably 20 primary teeth on left side; rostral tip with 2 small- to medium-sized teeth, anteriormost pair longest.

Eye lateral on head (slightly dorsolateral in some paratypes), large, oval, length 2.9 (2.7–3.2)% TL; interorbit weakly concave (flat in some paratypes); widely separated, inter-eye space 1.47 (1.45–1.62) times eye length, 6.64 (5.78–6.48) in pre-eye length; weak subocular groove present. Spiracle large, weakly crescentic, oblique, directed posteroventrally from top to bottom, close to eye, separated by a deep vertical groove, shorter than eye; anterior margin flap-like, weakly concave; posterior margin firm, almost flat; upper edge at a similar level to top of eye; greatest diameter 1.6 (1.2–1.7)% TL. Gill slits small, upright, weakly pleated, lateral on head, close to ventral surface (extending slightly onto ventral surface in some paratypes), subequal in length, fifth slit located at origin of pectoral fin.

Mouth large, strongly inferior, broadly arched, originating behind level of mid-eye, width 4.6 (4.4–4.9)% TL, 1.47 (1.43–1.61) in head width; upper labial furrows absent, lower furrows short; corner of mouth partly concealed by lateral muscles of jaw. Teeth of female holotype unicuspid, in well defined rows, bases oval and flattened with pronounced, narrow, pointed cusps near middle of jaw, width of teeth exceeding length, largest near symphysis of lower jaw; cusps diminishing greatly in length towards angle of jaw, absent or indistinct near jaw corner; about 3 series of functional teeth; teeth of adolescent male (CSIRO H 1113–08) similar to female; tooth rows, in CSIRO H 617–01, 42 in upper jaw, 37 in lower jaw.

Nostrils small, widely separated, subcircular, nostril width 0.8 (0.7–1.2)% TL, 6.03 (3.94–6.84) in mouth width, 7.16 (4.78–8.34) in width of rostrum at nostrils; located slightly forward of level of anterior margin of eye. Anterior nasal flap well-developed, lobe-like,

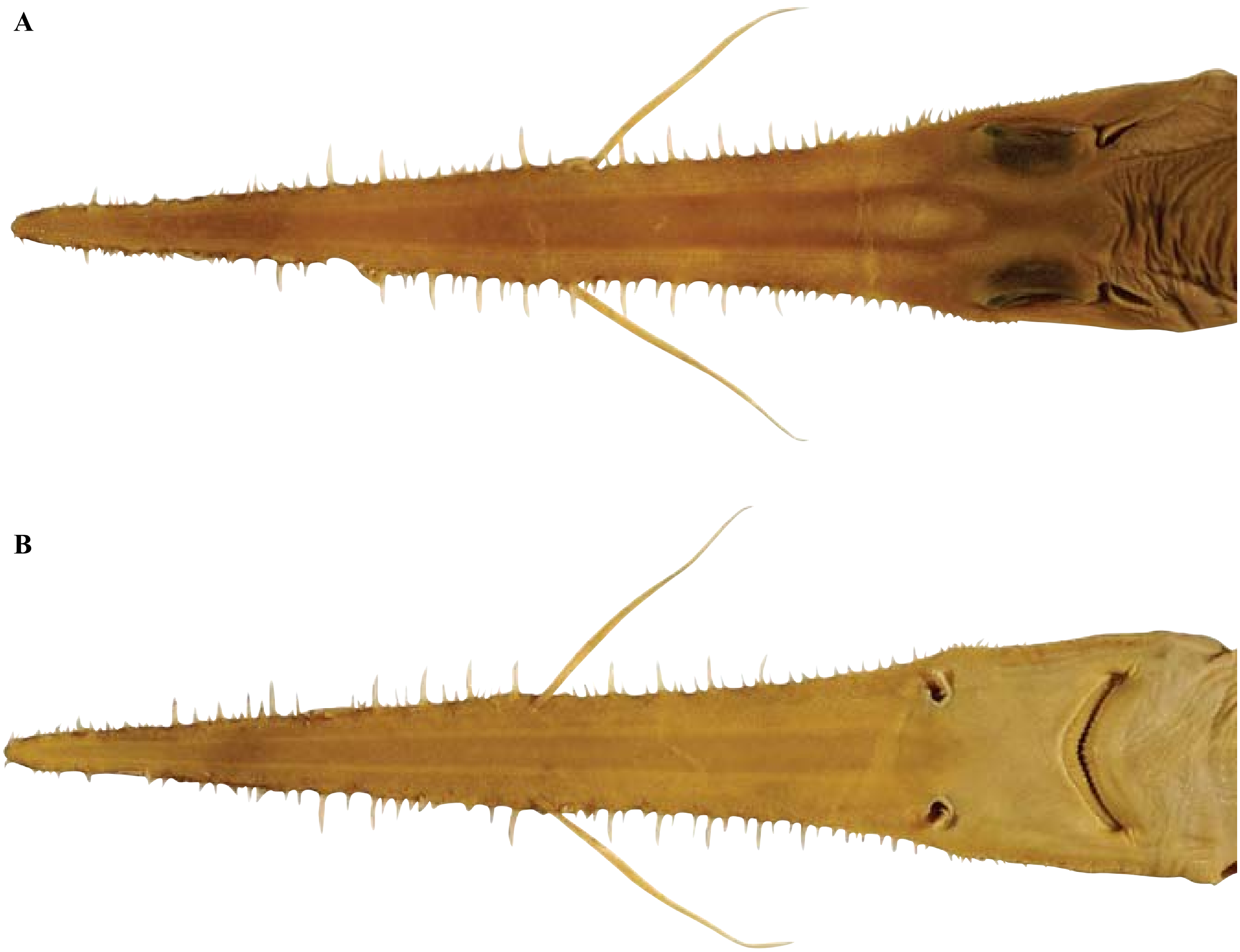

Figure 2. Prebranchial head of *Pristiophorus delicatus* sp. nov., holotype (CSIRO H 931–01, female 698 mm TL): A. dorsal view, B. ventral view.

extended ventrally beyond nostrils; excurrent aperture with a narrow posterior marginal lobe; no nasoral or circumnarial grooves; no dermal lobes.

Dermal trunk denticles minute, very strongly imbricate, similar-sized, with long pedicels; crowns broad, leaf-shaped to subovate, with short, bluntly pointed apices and a pronounced median ridge.

Pectoral fins large, anterior margin 11.7 (10.1–11.5)% TL, 1.91 (1.39–1.81) times inner margin; anterior margin weakly convex; apex narrowly rounded; posterior margin weakly concave (nearly straight in some paratypes), directed across horizontal axis at about origin of first dorsal fin; inner margin almost straight (slightly convex in some paratypes), strongly notched basally; free rear tip broadly rounded. Pelvic fins small, anterior margin 5.1 (4.6–5.4)% TL, length shorter than dorsal fins; anterior margin almost straight (weakly convex in some paratypes); apex somewhat angular; posterior margin almost straight (weakly convex in most paratypes); inner margin almost straight (weakly convex in adolescent male CSIRO H 1113–08; weakly concave in some other paratypes), weakly notched basally; free rear tip narrowly acute; origin below free tip of first dorsal fin (slightly anterior in most paratypes); free rear tip well forward of second dorsal fin. Claspers of adult male unknown. First dorsal fin longer and broader than second, well separated, height of first 1.00 (1.00–1.10) times height of second, length of first 1.26 (0.99–1.13) times length of second. First dorsal-fin anterior margin weakly convex (almost straight in some paratypes); apex narrowly rounded; posterior margin weakly convex distally, strongly concave near basal three quarters; inner margin straight, free rear tip narrowly pointed. Second dorsal-fin anterior margin weakly convex, apex very narrowly rounded; posterior margin weakly convex distally, strongly concave near basal three quarters; inner margin straight, free rear tip narrowly pointed; interdorsal space 1.22 (1.29–1.46) times first dorsal-fin length, 1.65 (1.59–1.75) times dorsal–caudal space; second dorsal-fin inner margin 0.79 (0.81–1.12) times subterminal caudal-fin margin. Caudal fin short, ventral lobe absent, merged with postventral margin, terminal lobe well developed, apices angular; dorsal caudal margin weakly convex, 18.1 (18.4–19.2)% TL, 1.14 (1.17–1.28) in pelvic–caudal space, 4.19 (4.56–6.11) times terminal caudal margin; ventral margin weakly convex, caudal-fin height 3.9 (3.8–4.4)% TL, 3.90 (3.36–3.91) in prebarbel length.

Vertebral counts: monospondylous centra 52 (49–55); precaudal diplospondylous centra 50 (50–54); caudal centra 48 (46–52); total centra 150 (149–156).

COLOUR.— Preserved specimens: Medium yellowish brown dorsally becoming paler yellowish brown laterally; pale yellowish ventrally, strongly demarcated from dorsal coloration; two dark brown medial stripes extending from near rostral tip to level of anterior of eye, converging strongly to become a single broad marking between eyes; rostral teeth not dark-edged (primary rostral teeth of CSIRO H 954–01 with dark edges, most common and prominent on anterior edge of tooth); fins pale to medium yellowish brown, without dark markings, posterior margins distinctly paler; dorsal fins usually slightly darker than dorsal body coloration; eye membrane semi-translucent; claspers of adolescent male pale yellow; barbels pale. **When fresh:** Based on photograph of holotype: Dorsal coloration medium brown, white ventrally; white posterior margins of dorsal and caudal fins more pronounced than in preserved specimens; pectoral and pelvic fins mostly pale with only basal portion brownish and strongly demarcated from rest of fins.

SIZE.— Type specimens range from 438–845 mm TL for females and 438–625 mm TL for males. No adult males examined; one adolescent male at 625 mm TL.

DISTRIBUTION.— Known from the upper continental slope off Queensland from south of the Samaurez Reef (22°06′ S, 153°18′ E to 23°12′ S, 153°33′ E), at depths of 246–405 m. Last & Stevens (1994) reported this species occurring northwards to off Cairns.

ETYMOLOGY.— Derived from the Latin *delicatus* (dainty, delicate) in allusion to the fine, delicate rostral teeth on the elongated rostrum of this small species of sawshark. Vernacular: Tropical Sawshark.

REMARKS.— *Pristiophorus delicatus* is clearly separable from other known species of *Pristiophorus* by a combination of morphometric characters, coloration and size. It differs significantly from *P. schroederi* in possessing unicuspidate (vs. largely tricuspidate) lateral denticles and a slightly longer rostrum (pre-eye length 26.4–28.5 (mean 27.2) vs. 28.6–28.7% TL; prenarial length 24.7–26.6 vs. 26.9–27.7% TL based on Springer & Bullis, 1960). *Pristiophorus delicatus* has a shorter pre-first dorsal length (46.9–48.5 vs. 49.6–49.8% TL based on Springer & Bullis, 1960), and the nostril to mouth distance is 1.4–1.8 (vs. about 1.2) times the internarial space (Compagno 1984).

Pristiophorus delicatus differs from *P*. sp. C [*sensu* Compagno *et al*., 2005] from the Philippines in having smaller spiracles (spiracle length 0.43–0.59 vs. 0.75 times eye diameter), a higher nostril to mouth distance times internarial space ratio (1.4–1.8 vs. 1.1–1.2), and a pale to medium yellowish brown dorsal coloration vs. uniform dark brown in *P*. sp. C (Compagno, 1998; Compagno *et al*., 2005).

Pristiophorus delicatus differs from *P*. sp. D [*sensu* Compagno *et al*., 2005] from the western Indian Ocean in having a large first dorsal fin with the posterior margin almost perpendicular to the horizontal axis of the body and the free rear tip not extending far behind the pelvic-fin origins vs. a very large first dorsal fin with posterior margin slanting strongly posteroventrally from top to bottom and a free rear tip extending beyond the pelvic-fin bases (Compagno *et al*., 2005). The new species also differs from *P*. sp. D in having a much paler dorsal coloration, more anteriorly located barbels (only slightly closer to mouth than rostral tip vs. much closer to mouth than rostral tip), and is larger in size (one male adolescent at 625 mm TL vs. males mature at 450–500 mm TL).

Pristiophorus delicatus differs from *P. japonicus* in having the first dorsal-fin rear tip about level with the pelvic-fin origins (vs. level with pelvic-fin mid-base), shorter barbels (barbel length 1.3–1.7 vs. 2.4 in prebarbel length, 1.3–1.8 vs. 2.3 in barbel to mouth distance), less robust head (head height 2.9–3.5 vs. 5.2% TL, 2.1–2.3 vs. 1.2 in head width), larger eyes (eye length 2.7–3.2 vs. 2.2% TL), larger nostrils (nostril width 0.7–1.2 vs. 0.6% TL, 3.9–6.8 vs. 7.9 times mouth width), fewer teeth in the upper jaw (42 vs. 46–56), and attains a much smaller size (largest specimen 845 mm TL vs. up to 1500 mm TL).

Pristiophorus delicatus differs from *P. nudipinnis* from southeastern Australia in having more anteriorly positioned barbels (barbel to mouth distance 14.8–15.7 vs. 9.5–11.2% TL, barbel to nostril distance 10.1–11.5 vs. 5.9–6.9% TL), a much longer head (head length 37–39 vs. 32–34 % TL; prebranchial length 34–36 vs. 28–30% TL; prespiracular length 30–32 vs. 23–25% TL; pre-eye length 26–28 vs. 20–22% TL; preoral length 29–31 vs. 22–25% TL), a narrower rostrum (preoral length 5.0–5.7 vs. 3.5–4.2 times width at nostrils, 8.2–9.1 vs. 5.0–6.3 times width at barbels), and smaller pelvic fins (pelvic anterior margin 4.6–5.4 vs. 6.0–6.7% TL).

Pristiophorus delicatus differs from *P. cirratus* (spotted southeastern Australian specimens) in having a slightly longer snout (prespiracular length 29.6–31.8 (mean 30.5) vs. 26.1–29.7 (mean 28.2)% TL, pre-eye length 26.4–28.5 vs. 23.0–26.2% TL, prebarbel length 13.9–15.4

Table 3. Ranges and means of morphometrics for the spotted (eastern and western Australia) and non-spotted forms of *Pristiophorus cirratus*. Values are expressed as percentages of total length.

	spotted form - eastern n=6			spotted form - western n=6			non-spotted form n=6		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Total length	443	970		423	973		440	1066	
Precaudal length	79.3	82.1	80.7	81.3	81.9	81.6	80.0	83.0	81.5
Pre-second dorsal length	66.0	67.8	66.9	67.3	68.3	67.6	66.5	69.2	67.8
Pre-first dorsal length	46.1	47.9	46.9	47.3	48.7	48.1	46.6	48.8	47.4
Snout-vent length	55.8	59.4	58.1	57.4	59.4	58.6	57.5	58.9	58.3
Prepelvic length	54.1	57.6	55.9	55.4	57.2	56.3	55.4	58.3	56.5
Prepectoral length	34.0	37.6	36.2	36.6	39.4	37.7	34.2	37.4	36.5
Interdorsal space	12.0	13.5	13.1	11.9	14.0	12.9	11.6	15.6	13.5
Dorsal–caudal space	6.4	8.0	7.3	7.1	7.9	7.4	6.6	7.8	7.3
Pectoral–pelvic space	16.4	19.6	17.7	14.6	17.5	16.4	15.9	20.8	17.7
Pelvic–caudal space	21.1	22.6	21.9	21.2	24.2	22.8	19.5	23.8	21.7
Head length	34.5	38.0	36.4	36.9	39.9	38.0	34.5	37.7	36.9
Prebranchial length	31.0	34.9	33.4	33.1	36.7	34.7	31.4	34.7	33.8
Prespiracular length	26.1	29.7	28.2	28.0	32.1	30.0	25.8	30.7	28.8
Pre-eye length	23.0	26.2	25.0	24.8	28.1	26.7	22.6	26.9	25.5
Preoral length	26.1	29.7	27.9	27.9	31.2	29.7	25.6	30.1	28.5
Prenarial length	22.3	24.8	23.6	23.6	26.5	25.3	21.3	25.3	24.0
Prebarbel length	11.1	13.0	12.1	11.2	13.1	12.4	11.0	14.6	13.0
Eye length	2.2	3.2	2.6	2.6	3.4	2.9	2.3	3.0	2.7
Interorbital space	2.7	2.8	2.8	2.6	3.0	2.8	2.6	3.2	2.9
Inter-eye space	4.2	4.7	4.4	4.0	4.9	4.4	4.3	5.0	4.6
Spiracle length	1.4	1.8	1.6	1.7	1.8	1.7	1.7	2.0	1.8
Eye–spiracle space	0.5	0.9	0.8	0.6	0.8	0.7	0.6	1.0	0.8
First gill slit height	1.5	2.2	1.7	1.5	1.9	1.7	1.5	2.0	1.7
Fifth gill slit height	1.8	2.2	2.0	1.7	1.9	1.8	1.6	2.0	1.8
Nostril width	0.7	1.1	0.8	0.8	1.0	0.9	0.6	0.9	0.8
Anterior nasal flap length	0.6	1.0	0.7	0.8	1.0	0.9	0.6	1.1	0.9
Internarial space	2.7	3.0	2.8	2.7	3.4	2.9	2.9	3.2	3.0
Barbel length	8.9	13.8	10.8	10.0	14.8	11.8	8.4	12.8	10.7
Rostral tooth length (anterior of nostrils)	0.8	1.5	1.1	0.8	1.7	1.1	0.9	1.5	1.2
Rostral tooth width (anterior of nostrils)	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.2
1° rostral tooth interspace	0.9	1.2	1.0	0.4	1.1	0.9	0.8	1.2	1.0
2° rostral tooth length	0.3	0.7	0.5	0.2	0.6	0.4	0.3	0.7	0.5
Rostral width (at nostrils)	5.0	5.8	5.3	5.2	6.2	5.5	5.0	6.3	5.7
Rostral width (at anterior of barbels)	2.9	3.4	3.1	3.1	3.8	3.3	3.1	3.9	3.5
Rostral tooth length (posterior of nostrils)	0.4	0.6	0.5	0.4	0.9	0.5	0.3	0.7	0.5
Mouth width	5.1	5.6	5.3	5.0	5.4	5.2	4.9	5.5	5.2
Head width	7.3	7.7	7.5	6.6	7.9	7.2	7.2	7.9	7.5
Trunk width	7.4	8.9	8.0	6.4	9.2	7.2	6.4	8.8	7.5
Tail width	4.3	5.4	4.9	4.0	4.9	4.4	4.2	5.5	4.8
Head height	2.9	3.3	3.2	2.9	3.4	3.1	3.0	3.6	3.3
Trunk height	5.5	6.7	6.0	5.3	6.9	6.2	5.6	6.8	6.1
Tail height	3.9	4.9	4.4	3.5	4.3	3.9	4.1	4.6	4.3
Caudal peduncle height	2.1	2.5	2.3	2.0	2.3	2.2	1.9	2.4	2.2

Table 3. cont'd.

	spotted form - eastern			spotted form - western			non-spotted form		
	n=6			n=6			n=6		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
First dorsal fin - length	10.5	11.7	10.9	10.0	11.6	10.6	10.1	11.4	10.9
First dorsal fin - base	6.8	8.4	7.5	6.7	8.4	7.3	6.8	8.1	7.5
First dorsal fin - height	5.9	7.2	6.9	6.5	7.9	7.1	6.5	8.0	7.2
First dorsal fin - inner margin	3.2	3.9	3.5	3.0	3.7	3.3	3.0	4.1	3.5
Second dorsal fin - length	9.6	10.3	9.9	8.9	9.9	9.5	9.1	10.5	9.7
Second dorsal fin - base	6.5	7.2	6.8	6.5	7.1	6.8	6.2	6.9	6.6
Second dorsal fin - height	5.7	6.8	6.5	6.3	6.8	6.6	6.1	7.4	6.7
Second dorsal fin - inner margin	2.8	3.6	3.1	2.4	3.0	2.8	2.8	3.8	3.2
Pectoral fin - anterior margin	11.4	12.4	11.8	11.9	13.7	12.5	11.3	13.3	12.0
Pectoral fin - base	3.3	3.6	3.4	2.9	3.6	3.2	2.8	3.6	3.2
Pectoral fin - posterior margin	10.0	12.1	10.7	9.4	11.6	10.5	9.3	10.9	9.9
Pectoral fin - inner margin	7.0	7.7	7.3	6.8	7.7	7.3	6.9	8.2	7.5
Pelvic fin - length	7.9	8.5	8.3	8.2	9.2	8.6	7.5	9.7	8.3
Pelvic fin - anterior margin	5.2	6.1	5.7	5.8	6.4	6.1	4.9	5.8	5.5
Dorsal caudal margin	17.8	19.4	18.7	17.8	18.7	18.2	16.8	19.5	18.3
Ventral caudal margin	12.4	14.3	13.4	11.4	13.0	12.3	12.2	14.4	13.1
Subterminal caudal margin	2.5	2.9	2.7	2.7	3.7	3.0	2.2	3.0	2.6
Terminal caudal margin	4.8	5.1	4.9	4.1	5.0	4.5	4.3	4.9	4.6
Caudal fin height	4.6	5.1	4.8	4.4	4.9	4.7	4.4	5.2	4.8

vs. 11.1–13.0% TL), a narrower mouth (mouth width 4.4–4.9 vs. 5.1–5.6% TL, 5.5–6.3 vs. 3.6–4.1 in pre-eye length), slightly more slender body (trunk width 6.1–7.1 vs. 7.4–8.9% TL), smaller pectoral fin (anterior margin 10.1–11.7 vs. 11.4–12.4% TL, posterior margin 7.1–9.3 vs. 10.0–12.1% TL), first dorsal-fin free rear tip at level of pelvic-fin origins (vs. over pelvic-fin mid-base), and being smaller in size (<850 vs. up to 1340 mm TL).

Smaller specimens of *P. delicatus* have a relatively longer barbel than larger specimens, i.e. barbel length 0.9–1.0 times nostril to barbel distance in specimens <590 mm TL vs. 1.1–1.3 in specimens >620 mm TL. This ontogenetic change in relative barbel length was also evident in *P. cirratus* and *P. nudipinnis*.

Comparisons of *Pristiophorus cirratus* specimens from southeastern and southwestern Australia with those identified as *P.* sp. A from southeastern Australia failed to identify any morphometric (Table 3) or vertebral count differences. *P. cirratus* was thought to possess a pattern of brownish spots and blotches on a sandy-coloured background (e.g. Last *et al*., 1983). While specimens with such coloration have been commonly encountered across southern Australia, plain greyish-brown specimens from southeastern Australia were considered to represent a separate species, *P.* sp. A (Last & Stevens, 1994). Furthermore, the description of *P. cirratus* (type locality, Port Jackson, NSW) by Latham (1794) documented and illustrated a plain-coloured fish. A concurrent study that aims to genetically barcode Australia's fish species found no differences between cytochrome oxidase subunit 1 (CO1) sequences from eastern (n=5) and western (n=3) specimens of *P. cirratus* (Ward *et al*., 2005, 2008). Specimens of *P.* sp. A were unavailable for CO1 comparison. We provisionally consider *P.* sp. A to be a synonym of *P. cirratus* but additional work is required to resolve the nomenclature and determine its validity.

Comparative material.
Pristiophorus cirratus. 22 specimens: CSIRO CA 3204, female 583 mm TL; CSIRO H 904–04, female 1066 mm TL; CSIRO H 904–05, female 705 mm TL; CSIRO H 2267–01, female 973 mm TL; CSIRO H 2361–01, juvenile male 568 mm TL; CSIRO H 2612–04, juvenile male 423 mm TL; CSIRO H 2620–04, juvenile male 603 mm TL; CSIRO H 2620–05, juvenile male 666 mm TL; CSIRO H 3426–01, female 705 mm TL; CSIRO H 3579–04, juvenile male 588 mm TL; CSIRO H 3582–01, female 705 mm TL; CSIRO H 3582–02, female 730 mm TL; CSIRO H 3582–03, juvenile male 608 mm TL; CSIRO H 3582–04, female 622 mm TL; CSIRO H 3683–02, adult male 842 mm TL; CSIRO H 3706–02, female 440 mm TL; CSIRO H 3707–01, female 450 mm TL; CSIRO H 3784–01, female 894 mm TL; CSIRO H 3789–01, female 1000 mm TL; CSIRO H 4257–01, female 970 mm TL;

CSIRO H 4441–01, juvenile male 443 mm TL; CSIRO H 6632–01, female 1168 mm TL.
Pristiophorus japonicus. Japan: BMNH 1936.7.25.11, female 1132 mm TL.
Pristiophorus nudipinnis Southern Australia (6 specimens): CSIRO CA 3356, juvenile male 621 mm TL; CSIRO H 2726–01, female 398 mm TL; CSIRO H 2727–01, juvenile male 636 mm TL; CSIRO H 3401–01, juvenile male 378 mm TL; CSIRO H 3777–01, adult male 937 mm TL; CSIRO H 4252–02, female 992 mm TL.

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Parascyllium elongatum sp. nov., a new collared carpetshark (Orectolobiformes: Parascylliidae) from southwestern Australia

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ABSTRACT.— *Parascyllium elongatum* sp. nov., which is based on the holotype taken from the stomach of a School Shark (*Galeorhinus galeus*) caught on the continental shelf near Perth, Western Australia, is described using external morphology. It can be readily distinguished from all other members of the genus by its unusually long and slender body, small head lacking a collar-like marking, and the presence of vertical rows of white spots on the flanks.

Key words: Parascylliidae – *Parascyllium elongatum* – carpet shark – new species – Australia

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INTRODUCTION

Members of the genus *Parascyllium* Gill, 1862, are endemic to the temperate southern seas of Australia (Last & Stevens, 1994; Compagno, 2001; Compagno *et al*., 2005). The group is comprised of four valid nominal species: *P. collare* Ramsay & Ogilby, 1888; *P. ferrugineum* McCulloch, 1911; *P. sparsimaculatum* Goto & Last, 2002; and *P. variolatum* (Duméril, 1853). All of these species, except the eastern Australian *P. collare*, are thought to occur off Western Australia. In 1990, during the preparation of a guide to Australian sharks and rays, a fifth and also undescribed species of the genus was collected by one of us (JS) during a field trip to the same region. The 421 mm TL female (CSIRO H 2508–01) was removed in good condition from the stomach of a School Shark (*Galeorhinus galeus*) caught on the inner continental shelf south of Augusta, southern Western Australia. However, despite requests to recreational and commercial fishermen, and local scientists, no other material has surfaced. This undescribed species, which differs from other members of the genus in coloration and morphology, is described below.

METHODS

Morphometric characters were selected to facilitate comparisons with other species of the genus *Parascyllium*. Our methods generally followed a widely adopted scheme for elasmobranchs (Compagno, 1984, 2001), but focused on direct rather than horizontal measurements. Morphometric and meristic values were obtained for the holotype. Meristics were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and total vertebral centra. The unique type specimen is deposited in the Australian National Fish Collection, Hobart (CSIRO).

Parascyllium elongatum sp. nov.

Figs 1, 2; Table 1

Holotype. CSIRO H 2508–01, female 421 mm TL, near Chatham Island, Western Australia, 35°02′ S, 116°28′ E, 50 m, 24 Oct 1990.

DIAGNOSIS.— A species of *Parascyllium* with the following combination of characters: a very long, slender body (depth 18.5 in length) and a very small head (length less than 13% TL); a small eye (eye length less than 8% of head length); small pectoral fins (anterior margin ca. 8% TL); small, low dorsal fins with narrowly rounded apices; a greyish body with darker bands separated by slightly diagonal, vertical rows of white spots; and no dark collar-like marking over gill region.

DESCRIPTION.— Body very slender, maximum depth 5.4% TL; trunk suboval, tail moderately compressed. Head very short, subcylindrical behind eye, length 12.7% TL. Snout very short, slightly depressed dorsally, suboval in cross section, direct length 3.7% (horizontal length 2.9%) TL; its tip broadly rounded, blunt; deep medial groove extending from posterior eye to above mouth;

Figure 1. *Parascyllium elongatum* sp. nov., female holotype (CSIRO H 2508–01, 421 mm TL): A. lateral view (fresh, right side of specimen); B. dorsal view (preserved).

preoral length 6.6 in head length. Nostrils small, located immediately in front of mouth angles; well separated, internarial space 1.2 times preoral snout; oronasal grooves deep, covered with anterior nasal flap mesially; nasal barbels very short, broad distally, not extending beyond mouth; circumnarial fold well developed, with weak fringe on posterolateral corner. Mouth weakly arched, well forward of eye, width 5.6 in head length. Upper labial furrows very short, transverse, length 4.2 in eye length, 0.8 in lower labial furrows. Eyes small, spindle-shaped, length 7.1 in head length; lateral on head and close to dorsal surface. Spiracles absent. Gill slits upright; anterior four slits very small, well separated, subequal in size, height of first slit 3.6 in eye length; fifth slit relatively closer to fourth, greatly enlarged, height 3.3 times that of first slit.

Pectoral fin moderately large, lobate (left fin damaged); anterior margin weakly concave to almost straight; posterior margin nearly straight; free rear tip very broad; base length 4.6 in head length, 2.9 in anterior margin length, anterior margin 1.6 times in head length. Pelvic fin small (right fin very damaged, apical damage to left fin); apex possibly rounded; free rear tip narrowly rounded; pectoral–pelvic space 1.3 times distance from pelvic-fin origin to first dorsal-fin origin. First dorsal fin small (posterior margin damaged), low, strongly raked; anterior margin elongate; apex narrowly rounded; inner margin long, almost straight; base length 2.0 in head length, fin height 1.5 times base length. Second dorsal fin possibly slightly larger than first, similar in shape; anterior margin elongate; apex narrowly rounded; posterior margin slightly oblique (directed posterodorsally from base to apex); inner margin long, weakly convex; origin just behind midpoint of anal-fin base; interdorsal space subequal to head length, 3.5 in pre-first dorsal length. Anal fin low, smaller and shorter than dorsal fins; anterior margin concave; apex broadly rounded; posterior margin nearly straight; free rear tip subangular, inner margin straight; origin below about posterior third of interdorsal space; base length 1.5 in head length, height 3.4 times base length. Caudal fin very elongate (origin indistinct), barely elevated above body axis; dorsal caudal margin slightly convex, 1.5 times head length; lower lobe not prominent, margin broadly convex near origin, straight posteriorly; subterminal notch distinct; terminal lobe subrectangular, posterior margin convex, height 3.7 in head length. Dorsal–caudal space 1.2 in head length; anal–caudal space subequal to head length.

Symphysial teeth of lower jaw small, weakly tricuspidate; with long caniniform medial cusp and short blunt lateral cusps; medial cusp pungent, recurved labially (tooth counts not taken because jaw delicate and would be damaged). Dermal denticles on body small, leaf-like with acute apices; strongly imbricate with long pedicels;

Figure 2. Ventral view of head of *Parascyllium elongatum* sp. nov., female holotype (CSIRO H 2508–01, 421 mm TL, preserved).

Table 1. Morphometric data for the holotype of *Parascyllium elongatum* sp. nov. (CSIRO H 2508–01). Measurements expressed as a percentage of total length.

Total length (mm)	421	Eye length	1.8
Precaudal length (upper)	82.7	Internarial space	2.4
Precaudal length (lower)	81.7	Mouth width	2.3
Pre-first dorsal length	47.2	Upper labial furrow length	0.4
Pre-second dorsal length	66.3	Lower labial furrow length	0.3
Prepectoral length	12.3	First gill-slit height	0.5
Prepelvic length	34.3	Fifth gill-slit height	1.6
Snout-vent length	34.2	First dorsal-fin base	5.1
Preanal length	62.3	First dorsal-fin height	3.4
Interdorsal space	13.4	Second dorsal-fin base	6.2
Dorsal–caudal space	10.3	Second dorsal-fin height	3.7
Pectoral–pelvic space	16.8	Anal-fin base	8.3
Pelvic–anal space	26.6	Anal-fin height	2.4
Anal–caudal space	12.4	Pectoral-fin anterior margin	8.1
Head length	12.7	Pectoral-fin base	2.8
Prebranchial length	9.0	Pelvic-fin length	7.7
Preorbital length	3.7	Pelvic-fin base length	3.2
Preoral length	1.9	Dorsal caudal margin	19.3

crowns almost smooth, usually without ridges (sometimes with 1–3 low, indistinct median ridges).

Monospondylous centra 42; precaudal centra 140; total centra 188.

COLOUR.— Preserved specimen: Body pale brown with darker brown bands separated by diagonal vertical rows of white spots. Head without collar-like saddle over gill region, but with an indistinct brownish saddle; similar faint saddle on snout; interorbit slightly paler yellowish brown; no white spots on head but pale areas where denticle patches have been removed. Trunk with two broad dark brown bands; first band originating just behind pectoral fins, its thickness slightly shorter than pectoral-fin anterior margin; separated from larger second band by narrow pale band; pale band with about 3 slightly oblique, vertical rows of small white spots (each about half to third of eye diameter); second band broad, thickness about equal to head length, with 2 oblique, vertical rows of small white spots preceding pelvic fins; eight additional, oblique vertical rows of white spots extending from pelvic fins to second dorsal fin, these almost equally spaced and separated by brownish saddles (most pronounced dorsally); post-dorsal tail with scattered white spots. Ventral surface mostly whitish. Pectoral and pelvic fins dark brownish dorsally, paler ventrally; dorsal fins pale brown, edges of inner margins dark brown; anal fin uniformly pale brown; caudal fin pale brown with scattered small white spots. **When fresh:** Mostly dark greyish, strongly contrasted with white spots on sides; dark saddles on head not conspicuously darker than those of trunk (no collar-like marking).

SIZE.— Based on the female holotype, 421 mm TL.

DISTRIBUTION.— Known only from near Chatham Island, Western Australia (35°02′ S, 116°28′ E) from the stomach of a school shark collected in 50 m depth.

ETYMOLOGY.— Derived from the Latin *elongatus* (prolonged) in allusion to its distinctive, elongate body shape. Vernacular: Elongate Carpet Shark.

REMARKS.— This eel-like shark is much more elongate than all other species of *Parascyllium*, and differs from these species in having a much smaller head (head length 12.7% vs. 13.8–18.0% TL, n=6), smaller eye (eye length 7.1 vs. 9.5–15.3% of head length), and a lower first dorsal fin (height 3.4 vs. 4.9–6.4% TL). Like its sympatric relative *P. variolatum*, it is partly covered in white spots, but lacks a distinctive 'collar-like' marking on the head and large blackish spots on the fins. It also may have a relatively narrower mouth (width 2.3% vs. 2.9-3.5% TL) and smaller dorsal fins (height of first 3.4% vs. 4.2–5.7% TL; height of second 3.7% vs. 3.9–5.3% TL). More specimens are required.

Comparative material.
Parascyllium collare: 7 specimens. CSIRO CA 3314, female 336 mm TL; CSIRO H 2692–11, female 452 mm TL; CSIRO H 2692–12, female 540 mm TL; CSIRO

H 2692–13, female 581 mm TL; CSIRO H 2692–14, female 545 mm TL; CSIRO H 2692–15, adolescent male 475 mm TL; CSIRO H 2692–16, female 472 mm TL.
Parascyllium ferrugineum: 2 specimens. CSIRO CA 3309, adult male 727 mm TL; CSIRO T 279, adult male 652 mm TL.
Parascyllium sparsimaculatum: 3 specimens. CSIRO H 2269–02 (holotype), female 781 mm TL; CSIRO H 2360–01 (paratype), female 555 mm TL; CSIRO H 2360–02 (paratype), female 684 mm TL.
Parascyllium variolatum: 8 specimens. CSIRO CA 3311, adult male 627 mm TL; CSIRO CA 3312, female 605 mm TL; SAMA F 3563 462 mm TL; SAMA F 3783 378 mm TL; SAMA F 4388 280 mm TL; SAMA F 167 437 mm TL; SAMA F 2876 660 mm TL; SAMA F 2953 437 mm TL.

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Orectolobus reticulatus sp. nov., a new wobbegong shark (Orectolobiformes: Orectolobidae) from the continental shelf of northwestern Australia

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ABSTRACT.— Western Australia has an unusually diverse wobbegong shark fauna with 8 nominal species in three genera. A new species, *Orectolobus reticulatus* sp. nov., collected from the inner continental shelf off northwestern Australia, is herein described and figured based on three specimens collected in shallow waters off the Kimberley coastline (Western Australia) and off Darwin (Northern Territory). *Orectolobus reticulatus*, which belongs to a subgroup of small wobbegongs with very simple dermal lobes, has a distinctive colour pattern of dark spots, saddles, and fine reticulations. It has been misidentified as *Orectolobus wardi* Whitley, another small, tropical wobbegong shark, with simple dermal lobes and a similar colour pattern. The new species differs from *Orectolobus wardi* primarily by its colour pattern, but also in external morphology. A possible third species in the 'wardi complex' exists off central Western Australia, but more material is required to elucidate its distributional range and taxonomic status. More detailed taxonomic and genetic studies of the colour forms in the wardi complex are warranted to determine the conservation status of these species.

Key words: Orectolobiformes – Orectolobidae – *Orectolobus reticulatus* – *Orectolobus wardi* – wobbegongs – new species – Australia

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INTRODUCTION

Three genera and 10 valid nominal species of wobbegong sharks (F. Orectolobidae) are known to occur in the Indo–Pacific (Last *et al*., 2006; Huveneers, 2006; Last & Chidlow, 2008) with only one species not recorded from Australia, i.e. *O. japonicus* Regan, 1906. Of these, 8 species *Eucrossorhinus dasypogon* (Bleeker, 1867), *Orectolobus floridus* Last & Chidlow, 2008, *O. halei* Whitley, 1940, *O. hutchinsi* Last, Chidlow & Compagno, 2006, *O. maculatus* (Bonnaterre, 1788), *O. parvimaculatus* Last & Chidlow, 2008, *O. wardi* Whitley, 1939, and *Sutorectus tentaculatus* (Peters, 1864), occur off Western Australia. However, the importance of the continental shelf off Western Australia as a centre of endemicity for wobbegongs has been strengthened recently by the discovery off northwestern Australia of an additional, narrow-ranging species belonging to the genus *Orectolobus*. The new wobbegong is formally described below and compared to other nominal members of the genus.

Orectolobus wardi was described by Whitley (1939) from a specimen collected by Mel Ward at Cape Keith on Melville Island in the Northern Territory. Whitley's description was brief and lacked a figure, but the immature female holotype was deposited in the Australian Museum, Sydney (AMS IA 7784). Compagno (1984) provided a brief diagnosis and illustrated the species, reporting its size to at least 45 cm TL and its distribution as being from Queensland to Western Australia. Last & Stevens (1994) figured the species, provided a description and specified its distribution as Onslow (Western Australia) to Fraser Island (Queensland). However, the latter record cannot be validated based on material and there are no confirmed Queensland records south of the Torres Strait (Jeff Johnson, Queensland Museum, pers. comm. 2007). No known synonyms of *Orectolobus wardi* are in existence (Compagno, 2001; Hoese *et al*. 2006). *Orectolobus wardi* belongs to a subgroup of small wobbegongs ('wardi complex') attaining less than 1m in length and possessing simple dermal lobes, of which *Orectolobus floridus* and *Sutorectus tentaculatus* may also be members. Closer investigation of *Orectolobus wardi* specimens from Australian fish collections has revealed a complex of at least three colour forms; one described by Whitley and two (or more) potentially undescribed species. These colour forms were initially thought to be intraspecific variants, but we now have multiple specimens exhibiting consistent differences in colour pattern as well as some morphological differences. The 'wardi complex' requires further taxonomic and genetic research to elucidate the true number of species, their distributions and conservation status.

Specimens of the new species treated below have been collected by hook and line or rotenone in shallow waters (none trawled), suggesting that the critical habitat may be caves and ledges on rocky or coral reefs. Observations from divers in central and northern Western Australia have confirmed that such habitats are occupied by members of the *Orectolobus wardi* complex. However, these habitats have not been well sampled in northern Australia and more specimens are required. The new species described in this paper is probably another Australian endemic and highlights the strong diversity and speciation of wobbegongs in the eastern Indian Ocean.

METHODS

Terminology for external structures and abbreviations, and methodology for measurements, follows the widely used scheme proposed by Compagno (1984) with some modifications initiated by Last *et al*. (2006). Measurements were direct (taken from point to point) unless otherwise specified: prenarial length (PRN) was taken almost transversely from the middle of the snout tip to the junction of the nostril and nasal barbel; intereye (INE) taken rather than interorbital distance (INO); mouth width (MOW) taken as the width across the jaws to their outer lateral angles; ventral caudal margin was not subdivided into highly subjective measurements of the preventral caudal (CPV) and lower postventral (CPL) margins.

Measurements and counts were made for the dermal lobe configurations consisting of two groups of preorbital lobes and two groups of postspiracular lobes (Last *et al*., 2006). The first preorbital group (PO1) extends from near the posterolateral margin of the nostril to the end of the first distinct grouping on the snout above the upper jaw; second preorbital group (PO2) extends from just forward of the eye (or near the jaw angle) to below the eye (difficult to determine the junction between these groups in some species); first postspiracular group (PS1) consists of 1–2 small lobes below the hind margin of the spiracle; second postspiracular group (PS2) is closer to the gill slits than the spiracle, and is often rudimentary or simple and sometimes absent. The distance across these groups and their interspaces proved useful in diagnosing species. Measurements were taken sequentially between points A–F (see Fig. 1 in Last *et al*., 2006) where A is the origin of the nasal barbel; B the insertion of PO2; C, D the respective origin and insertion of PS1; and D, E the respective origin and insertion of PS2.

A comprehensive series of measurements were taken for the holotypes and paratypes of the new species and converted to percentages of total length (Table 1). Morphometric data for paratypes are given in parentheses after the holotypes in the species descriptions. Additional ratios of selected measurements are included in the species descriptions. Counts of monospondylous, diplospondylous, and total centra were obtained for types from radiographs (NTM S 13251–001, WAM P 30307-027 & CSIRO CA 4079). Tooth row counts were taken from a single paratype (CSIRO CA 4079) by dissection and may be subject to minor error; teeth near the jaw angle are small, often acuspid (sometimes damaged), and are often difficult to count. Dentition terminology is based on Compagno (1970, 1979). Vertebral count terminology follows Compagno (1979, 1988). Specimens, including types, are referred to by the following prefixes for their registration numbers: CSIRO – Australian National Fish Collection, Hobart; NTM – Northern Territory Museum & Art Gallery, Darwin; and WAM – Western Australian Museum, Perth.

Orectolobus reticulatus sp. nov.

Figs 1–3; Table 1

Holotype. NTM S 13251–001, adolescent male 503 mm TL, East Arm, Darwin Harbour, Northern Territory, 12°29′ S, 130°54′ E, <18 m, 16 Jun 1991.
Paratypes. 2 specimens. WAM P 30307–027, female 301 mm TL, Long Reef, Kimberley region, Western Australia, 13°48′ S, 125°47′ E, <1 m, 17 Aug 1991; CSIRO CA 4079, female 523 mm TL, no other data.
Other material. WAM P 31088–001, sex and size not recorded, visual record from Louis Island, Napier Broome Bay, Western Australia, 14°01′ S, 126°32′ E, <1 m, 21 Nov 1995, specimen released.

DIAGNOSIS.— A small *Orectolobus* (to at least 523 mm TL) with the following combination of characters: a strong colour pattern of dark saddles, spots and fine reticulations; nasal barbel simple, thallate, without other lobes; postspiracular lobes poorly developed, posterior postspiracular lobe (PS2) simple, narrow or weakly thallate, smaller than anterior postspiracular lobe (PS1); distance across preorbital group 1.3–1.6 times interspace between preorbital group and anterior postspiracular lobe (PO/PO–PS1), 4.2–5.4 times base length of anterior postspiracular lobe (PO/PS1); base of anterior postspiracular lobe 3.3–3.9 in its distance from postorbital group (PO–PS1/PS1), 1.5–2.1 in its distance from posterior postspiracular lobe (PS1–PS2/PS1); prominent tubercle above eye; no wart-like tubercles on back; interorbital denticles widely spaced, anterior margins strongly crenulate; dorsal fins tall, upright; first dorsal-fin origin over mid pelvic-fin base; interdorsal

Figure 1. *Orectolobus reticulatus* sp. nov., adolescent male holotype (NTM S 13251–001, 503 mm TL, preserved): A. lateral view; B. dorsal view; C. ventral head and pectoral fins.

space 0.3–0.5 times anal-fin base length; anal-fin inner margin 0.4–0.6 times anal-fin posterior margin; tooth rows in upper jaw about 21, medial row at symphysis of upper jaw absent; monospondylous centra 46–49; total vertebral centra 141–147.

DESCRIPTION.— Body moderately elongate, strongly depressed anteriorly and relatively firm-bodied; trunk depressed, depth relatively uniform, constricted at pelvic-fin insertion; tail subcircular in cross-section, becoming more compressed posteriorly; abdomen relatively elongate, laterally distended, pectoral–pelvic space 19.6 (18.9–19.1)% TL, 0.81 (0.76–0.82) of head length; pelvic–anal space 1.62 (1.93–2.23) times anal-fin base; caudal peduncle absent, anal and caudal fins connected ventrally at their bases; tail depth 1.41 (1.18–1.46) times width at second dorsal-fin insertion, 1.86 (1.54–1.56) times width at anal-fin insertion.

Head broad, strongly depressed, parabolic in dorsoventral view, narrowly rounded in lateral view, height at eye 6.8 (6.1–6.8)% TL. Snout short, subtruncate to broadly rounded in dorsoventral view, apex not indented (slightly indented in smallest paratype WAM P 30307-027); preoral length 2.5 (2.1–2.5)% TL, 4.45 (4.54–4.66) in mouth width; prenarial snout 1.59 (1.57–2.11) times eye length. Eyes very small, slit-like, dorsolateral on head, length 12.9 (14.0–18.9) in head length; low supraorbital ridge present; prominent denticulate tubercle below supraorbital ridge above hind margin of eye; deep supraocular pocket separating ridges over posterior half of eye; ridges and associated pockets slightly more pronounced posteriorly; subocular pockets relatively weak, arched ventrally, length subequal to eye length; interorbit weakly concave, intereye distance 3.66 (3.92–5.11) times eye length, 1.16 (0.98–1.01) times direct preorbital length, 0.70 (0.76–0.69) times direct prespiracular length, 2.22 (2.10–2.32) times spiracle length; moderate pit on mid-snout, extending forward to tip of snout as a shallow groove (better defined on paratypes). Spiracles slit-like, dorsolateral, oblique to longitudinal axis, much longer than eye, length 1.65 (1.69–2.43) times eye length, origin below hind margin of eye (more anterior in smallest paratype); anterior margin thickened, weakly concave, forming a marginal ridge flanked internally by a deep medial depression; posterior margin poorly defined, almost flat, shelving into spiracular cavity. Gill slits large, dorsolateral, upper edge becoming progressively more elevated posteriorly; 2nd slit above pectoral-fin origin; 5th slit longest, 1.19 (1.02–1.24) times 4th, located well forward of mid-base of pectoral fin; last two slits very close together, distance between 4th and 5th slits more than 2.5 times distance between 1st and 2nd slits. Mouth of moderate size, subterminal, horizontally expanded, well arched, width 11.0 (9.6–11.4)% TL, 1.37 (1.37–1.50) in head width at eye; upper labial furrows originating below nostrils; lower labial furrows longer, almost connected at symphysis of lower jaw, length 0.49 (0.47–0.49) of mouth width; symphysial groove deep, well developed, length subequal to distance between lower labial furrows. Teeth in larger paratype (CSIRO CA 4079) in about 21 rows in upper jaw (damaged laterally), 17 in lower jaw; caniniform at symphysis of both jaws, unicuspid; upper teeth not exposed when mouth closed; two symphysial canines in upper jaw, more than twice length of those adjacent, small median series absent; three symphysial canines in lower jaw, of similar size to each other and those in upper jaw; teeth gradually decreasing in size laterally from those adjacent symphysial canines; small, partly embedded and acuspid near angle of jaw. Nostrils small, well separated, internarial space 4.8 (4.5–5.0)% TL; adjacent upper lip of mouth; circumnarial folds well developed, projecting anterolaterally. Nasal barbel simple, thallate, large, subequal in length to upper labial furrow, 3.7 (3.5–3.5)% TL; subterminal on head (further forward in larger paratype), strongly depressed, weakly tapering, proboscis-like distally. Dermal lobes poorly developed; PO1 simple, thallate, larger than circumnarial folds; PO2 with one broad lobe, thallate, weakly bilobate, insertion below anterior margin of eye (slightly further forward in larger paratype); PS1 with one large, broad, flattened lobe (relatively smaller in smallest paratype), with an entire outer margin but not expanded distally, origin below hind margin of spiracle (slightly further forward in larger paratype); PS2 smaller than PS1, simple, narrow or weakly thallate, rounded distally; PO distance 1.28 (1.26–1.58) times PO–PS1 interspace; PO distance 5.02 (4.17–5.38) times PS1 base length; PO–PS1 interspace 3.92 (3.32–3.41) times PS1 base length; PS1–PS2 interspace 1.94 (1.48–2.08) times PS1 base length.

Dermal denticles on side small, weakly imbricate (less so on sides of abdomen); crowns rhomboidal, thick, apices broadly pointed; anterior extremity of crown crenulate, with up to 5 very short, parallel longitudinal ridges (confined to anterior part of crown above the pedicel); larger female paratype with similar denticles, longitudinal ridges sometimes extending across entire anterior margin of crown; posterior portion of crown broadly arrow shaped, margins entire, surface smooth; interorbital denticles broadly rhomboidal or irregular, widely spaced, anterior margins strongly crenulate; denticles on lower surface of spiracle slender, elongate, lanceolate, several times larger than those adjacent, in 1-3 (mainly 1 medially) rows.

Dorsal fins subtriangular, tall, upright, height of first 1.1 (1.01–1.18) times height of second; first slightly larger than second, similar in shape. First dorsal fin anterior margin weakly convex, apex narrowly rounded, posterior margin weakly convex and almost upright, free rear tip broadly angular, inner margin almost straight; origin over midpoint of pelvic-fin base, insertion over posterior of pelvic-fin free rear tips; first dorsal-fin inner margin 0.79 (0.88–1.05) times spiracle length. Second dorsal fin anterior margin weakly convex, apex narrowly rounded, posterior margin weakly convex and almost straight, free rear tip broadly angular, inner margin almost straight;

Table 1. Morphometric data for the holotype of *Orectolobus reticulatus* sp. nov. (NTM S 13251–001), with ranges provided for the measured paratypes, and for the holotype of *O. wardi* (AMS IA 7784). Measurements expressed as a percentage of total length.

	O. reticulatus **sp. nov.**			***O. wardi***
	Holotype	Paratypes		Holotype
		Min.	Max.	
TL–Total length (mm)	503	301	523	365
PRC–Precaudal length	78.1	77.4	79.0	–
PD1–Pre-first dorsal length	52.3	50.6	53.4	51.2
PD2–Pre-second dorsal length	64.6	63.8	64.4	63.6
PP1–Prepectoral length	21.9	21.1	22.8	–
PP2–Prepelvic length	47.4	46.3	47.9	–
SVL–Snout-vent length	51.9	50.5	52.4	47.3
PAL–Preanal length	71.2	70.0	72.7	–
IDS–Interdorsal space	3.4	3.9	4.9	4.5
DCS–Dorsal–caudal space	5.5	6.5	6.9	7.0
HDL–Head length	24.1	23.3	24.8	25.7
PG1–Prebranchial length	19.6	18.7	19.2	20.2
PSPd–Prespiracular length	9.8	8.3	10.0	9.8
POBd–Preorbital length	5.9	6.2	7.1	7.0
PRN–Prenarial length	3.0	2.6	2.8	2.6
POR–Preoral length	2.5	2.1	2.5	1.9
EYL–Eye length	1.9	1.2	1.8	1.8
EYH–Eye height	0.5	0.3	0.4	0.6
INO–Interorbital space	6.8	6.3	6.9	7.6
SOD–Subocular pocket length	2.4	2.0	2.3	2.1
SPL–Spiracle length	3.1	3.0	3.0	3.2
ESL–Eye–spiracle space	1.8	1.6	1.8	2.0
NOW–Nostril width	1.1	0.8	1.1	0.8
INW–Internarial space	4.8	4.5	5.0	5.0
ANF–Anterior nasal flap length	3.7	3.5	3.5	3.4
MOL–Mouth length	6.2	5.3	6.4	2.6
MOW–Mouth width (across jaws)	11.0	9.6	11.4	10.0
ULA–Upper labial furrow length	4.2	3.8	4.6	3.2
LLA–Lower labial furrow length	5.4	4.5	5.6	5.7
GS1–First gill-slit height	2.0	2.0	2.3	2.2
GS2–Second gill-slit height	2.1	2.3	2.4	2.1
GS3–Third gill-slit height	2.0	2.3	2.3	2.2
GS4–Fourth gill-slit height	2.1	2.2	2.2	2.3
GS5–Fifth gill-slit height	2.6	2.2	2.7	2.8
D1L–First dorsal-fin length	11.4	11.3	12.0	11.4
D1A–First dorsal-fin anterior margin	11.8	10.7	11.9	11.8
D1B–First dorsal-fin base	8.4	7.6	9.2	8.5
D1H–First dorsal-fin height	7.6	7.1	7.4	8.0
D1I–First dorsal-fin inner margin	2.4	2.6	3.1	3.4
D1P–First dorsal-fin posterior margin	7.9	7.0	7.7	7.8
D2L–Second dorsal-fin length	10.8	10.2	10.8	11.6
D2A–Second dorsal-fin anterior margin	10.2	10.2	10.5	11.3
D2B–Second dorsal-fin base	7.8	7.8	8.5	7.9

Table 1. cont'd.

	O. reticulatus **sp. nov.**			***O. wardi***
	Holotype	Paratypes		Holotype
		Min.	Max.	
D2H–Second dorsal-fin height	6.9	6.3	7.1	7.5
D2I–Second dorsal-fin inner margin	2.5	2.5	2.5	2.9
D2P–Second dorsal-fin posterior margin	7.2	6.6	7.2	7.7
ANL–Anal-fin length	12.3	9.9	10.8	10.1
ANA–Anal-fin anterior margin	10.7	9.3	10.4	10.0
ANB–Anal-fin base	9.9	8.5	9.6	9.4
ANH–Anal-fin height	4.1	3.5	3.6	3.5
ANI–Anal-fin inner margin	1.5	1.7	2.2	1.8
ANP–Anal-fin posterior margin	3.6	3.3	3.5	2.6
CDM–Dorsal caudal margin	20.9	22.0	24.3	21.7
CPV–Preventral caudal margin	16.3	20.5	20.7	16.7
CST–Subterminal caudal margin	2.2	2.4	2.8	2.7
CTR–Terminal caudal margin	3.8	4.0	4.9	4.2
CTL–Terminal caudal lobe	3.8	3.2	5.1	3.4
P1L–Pectoral-fin length	13.7	12.7	13.7	14.2
P1A–Pectoral-fin anterior margin	14.7	11.9	15.1	15.1
P1B–Pectoral-fin base	8.8	7.9	8.2	7.5
P1H–Pectoral-fin height	11.6	10.0	12.9	10.8
P1I–Pectoral-fin inner margin	3.9	4.0	4.6	5.7
P1P–Pectoral-fin posterior margin	11.0	9.0	11.2	10.9
P2L–Pelvic-fin length	13.7	11.4	12.4	12.9
P2A–Pelvic-fin anterior margin	9.4	8.0	9.3	9.5
P2B–Pelvic-fin base	8.9	7.4	8.2	9.8
P2H–Pelvic-fin height	7.7	7.2	7.7	7.1
P2I–Pelvic-fin inner margin	4.2	4.0	4.5	4.5
P2P–Pelvic-fin posterior margin	8.6	7.6	8.5	7.0
HDH–Head height (at eye)	6.8	6.1	6.8	7.6
HDW–Head width (at eye)	15.0	14.4	15.7	15.0
TRH–Trunk height	10.8	9.9	10.0	–
TRW–Trunk width	19.1	16.8	19.7	–
CPHd–Caudal peduncle height (D2 insert)	3.9	3.7	4.8	4.1
CPHc–Caudal peduncle height (caudal origin)	3.6	3.5	3.9	3.5
CPWd–Caudal peduncle width (D2 insert)	2.8	3.1	3.3	3.2
CPWc–Caudal peduncle width (caudal origin)	1.9	2.1	2.6	2.0
DPI–First dorsal midpoint–pectoral insertion	32.1	30.4	31.3	–
DPO–First dorsal midpoint–pelvic origin	13.9	11.1	12.8	12.1
DAO–Second dorsal origin–anal origin	8.2	6.7	9.4	6.1
DAI–Second dorsal insert.–anal insert.	7.8	7.0	7.7	7.9
PPS–Pectoral–pelvic space	19.6	18.9	19.1	15.6
PAS–Pelvic–anal space	16.1	18.5	18.8	18.8
PCA–Pelvic–caudal space	26.0	25.4	26.3	28.7

Figure 2. Dorsal view of *Orectolobus reticulatus* sp. nov., female paratype (WAM P 30307–027, 301 mm TL).

insertion just posterior to anal-fin origin (anterior to in larger paratype). Anal fin well developed, elongate with short posterior margin, directed posteroventrally, lobe-like; anterior margin almost straight, apex broadly rounded, posterior margin strongly convex, free rear tip broadly angular (broadly rounded in smallest paratype), inner margin very short; origin obscure; base 9.9 (8.5–9.6)% TL, 0.34 (0.46–0.51) in interdorsal space; anal-fin height 2.43 (2.39–2.66) in base length; anal-fin length 3.4 (2.98–3.1) times posterior margin length; inner margin length 0.41 (0.5–0.63) times posterior margin length. Pectoral fin small, lobate, length 13.7 (12.7–13.7)% TL; base fleshy; anterior margin strongly convex, apex broadly rounded, posterior margin weakly convex, free rear tip broadly rounded, inner margin weakly convex; anterior margin 3.81 (2.95–3.31) times inner margin. Pelvic fins small, length 13.7 (11.4–12.4)% TL, anterior margin weakly convex to straight, apex broadly rounded, posterior margin strongly convex, free rear tip broadly rounded, inner margin concave; origin well forward of dorsal fins, origin to midpoint of first dorsal fin 13.9 (11.1–12.8)% TL. Clasper of adult male unknown. Caudal fin relatively short, dorsal caudal margin length 20.9 (22.0–24.3)% TL; origin of upper lobe indistinct, but usually evident as a low ridge; lower lobe weakly developed, outer margin strongly convex, united at its origin to insertion of anal fin, strongly notched at junction of terminal lobe; terminal lobe moderately deep, length 1.25 (1.08–1.70) times spiracle length, posterior margin incised (not incised and strongly convex in both paratypes), rounded to angular ventrally, bluntly angular to broadly rounded dorsally.

Spiral valve count not taken. Vertebral counts: monospondylous centra 49 (46–48, n=2); precaudal centra 93 (96–98); caudal centra 51 (45–49); total centra 144 (141–147).

COLOUR.— Preserved specimens: Body medium greyish brown with a series of darker brownish saddles (more distinct in juvenile), between fine light and dark reticulations; some dark spots on and around saddles, fins and on head. Head on dorsal surface blotched with fine reticulations, indistinct bands across interorbit and through first gill slits (smaller paratype with more pronounced bands, obvious V-shaped transverse stripe extending across interorbit and onto snout); sides of head similar, mainly with fine white spots and dark reticulations; posterior band on head of largest types with dark, diffuse-edged, brownish black spots (largest slightly smaller than eye); diffuse-edged white postspiracular spots present, less distinct in smallest specimen; dermal lobes mostly greyish, slightly paler ventrally. Trunk with four prominent, dark, transverse markings; two dark brown saddles above abdomen, extending just onto ventral surface, bordered weakly by brownish black spots; first saddle centred over pectoral-fin insertion; second saddle more distinct, slightly forward of pelvic-fin origin; second saddle slightly broader than first, maximum width subequal to interorbital space, about its width forward of first dorsal-fin origin; smaller paratype with two prominent ocellate saddles, first suboval with a vague whitish margin, second subcircular with a whitish margin, dark spots around perimeter of saddle and more centrally; strong subdorsal bands (broadest below first dorsal fin and broadest dorsally), connected beneath inner margin of fins (more pronounced ventrally in juvenile paratype). Dorsal fins similar to body, finely reticulate with some diffuse darker spots, prominent dark blotch at their origins; anal and caudal fins similar to body, reticulations less pronounced, 4 small blotches along dorsal caudal margin, first extending ventrally and present on anal fin as a vertical marking; paired fins reticulated dorsally, similar to abdomen between saddles, with some irregular darker spots, posterior margins slightly more uniformly dark yellowish brown. Ventral surface of head and abdomen largely pale yellowish, anterior head and lateral margins somewhat darker, not strongly

Figure 3. Lateral view of tail of *Orectolobus reticulatus* sp. nov., female paratype (WAM P 30307–027, 285 mm TL).

differentiated; tail darker, similar to lateral surface; paired fins almost uniformly greyish brown (sometimes weakly reticulated), paler near base; claspers uniformly greyish brown. **Fresh specimen:** WAM P 31088–011 with similar colour and pattern to types (reticulations more strongly contrasted), paired fins slightly more yellowish, dermal flaps distinctly yellowish to white.

SIZE.— No adult males are known. Male adolescent at 503 mm TL. Largest female specimen 523 mm TL.

DISTRIBUTION.— A micro-endemic Australian shark; known from four individuals (one released), collected from very shallow water in the Kimberley region of northern Western Australia between Louis Island (Napier Broome Bay, 14°01′S, 126°32′E) and Long Reef (13°48′ S, 125°47′ E) and one specimen (holotype) from Darwin Harbour (12°29′S, 130°54′E) in the Northern Territory. Inner continental shelf in depths less than 20 m.

ETYMOLOGY.— Derived from the Latin *reticulatus* (net-like or netted) with reference to the characteristic network pattern on its dorsal surface. Vernacular: Network Wobbegong.

REMARKS.— *Orectolobus reticulatus* is a small, distinctive wobbegong with a reticulated colour pattern unlike any other nominal species of the family. It also differs from other wobbegongs in colour and dermal lobe configuration. It has been misidentified as *O. wardi* but has a more elaborate colour pattern (i.e. with network of fine reticulations located between main saddles vs. plain or weakly blotched; and dark spots located around weak saddles vs. spots absent and saddles usually strongly demarcated; saddles longitudinally constricted and extending further ventrally vs. saddles almost oval to subcircular), a more anteriorly positioned anterior postspiracular dermal flap, with interorbital denticles more widely spaced and with more deeply scalloped anterior margins. Also, while the numbers of specimens available for morphometric comparison are low there appear to be some differences in morphology between the species. *Orectolobus reticulatus* (based on all three types, 301-523 mm TL) appears to have smaller dorsal fins (height of first dorsal 7.1–7.6% vs. 8.0% TL in the holotype of *O. wardi*, 365 mm TL; height of second dorsal 6.3–7.1% vs. 7.5% TL; first dorsal inner margin length 2.4–3.1% vs. 3.4% TL; second dorsal inner margin length 2.5% vs. 2.9% TL), a shorter head (23.3–24.8% vs. 25.7% TL), wider interorbital space (6.3–6.9% vs. 7.6% TL), and a longer snout-vent length (50.5–52.4% vs. 47.3% TL).

Orectolobus reticulatus shares a simple arrangement of dermal lobes with *O. floridus* and *O. wardi* (mainly 2 simple or weakly lobate lobes vs. 3–6 complex lobes in each of the preorbital groups in *O. halei*, *O. ornatus*, *O. maculatus* and *O. parvimaculatus*). Unlike *O. maculatus*, it lacks a dorsal colour pattern dominated by pale ocelli but its pattern is marginally more complex than in *O. hutchinsi*. *Eucrossorhinus dasypogon* has a much broader head with a much more complex arrangement of dermal lobes, and *Sutorectus tentaculatus* has a row of warty tubercles extending along the middle of the head and back (absent in *O. floridus*). Its base coloration differs from *O. floridus* in being greyish brown (rather than yellowish brown) with less well-defined cross-markings, its dermal flaps are broader, and its dorsal fins more upright.

Little is known of the biology of *O. reticulatus* but, as all known specimens were taken by hook and line or rotenone in shallow waters (no known material has been presented from trawls), it is likely to live mainly on reefy bottoms. Its dentition, which is similar to *O. wardi*, suggests a diet predominantly of small fishes.

Comparative material.
Orectolobus wardi: AMS IA 7784 (holotype), female 365 mm TL.

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Methodology for the taxonomic description of members of the genus *Apristurus* (Chondrichthyes: Carcharhiniformes: Scyliorhinidae)

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ABSTRACT.— The genus *Apristurus* presently comprises 32 valid species, but the taxonomy of this genus of deepwater catsharks is very complicated and confusing. The genus contains a number of species which are known only from the type specimens, synonymous species and many poorly known species. In addition, many undescribed species still remain to be discovered and to be formally named. Morphometrics are one of the most important taxonomic characteristics used for discriminating shark taxa, but the soft and easily deformed body and fins of *Apristurus* species often results in inaccurate measurements. The methodology of the morphometrics taken for this genus is also poorly-defined. To obtain objective and comparable taxonomic data, we have provided a detailed explanation and illustrations of the measurements and meristic counts taken and techniques used for describing members of the genus *Apristurus*. Importance of variations in the morphometrics and counts is discussed.

Key words. sharks – Scyliorhinidae – *Apristurus* – morphometrics – meristics – technical terms – variation – taxonomy

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INTRODUCTION

The genus *Apristurus* Garman, 1913 is a group of deepwater catsharks, which inhabit continental slopes and submarine elevations at depths of 400–2000 m in all marine waters, except for the polar regions. A total of 41 nominal species have been described, of which 32 are currently recognised as being valid species. However, some species are poorly known only from the type specimens and, for many species, their intraspecific variations (e.g. individual, ontogenetic, sexual and geographical) are poorly understood due to the lack of many specimens. Additionally, the presence of many undescribed or unidentifiable species has been suggested (Paulin *et al*., 1989; Last & Stevens, 1994). Thus, as a result of the high number of species and many poorly known species, the genus *Apristurus* is considered one of the most diverse and taxonomically confusing genera among living sharks.

Taxonomic revisions of the genus *Apristurus* have been made by Springer (1966, 1979), Nakaya (1975, 1991), Cadenat & Blache (1981), Compagno (1984, 1988), Nakaya & Sato (1998, 1999, 2000) and Iglésias & Nakaya (2004). In order to gain a better understanding of the taxonomy of this genus, Nakaya & Sato (1999) separated the known species into three groups, i.e. the 'longicephalus group', the 'spongiceps group' and the 'brunneus group', based on several phenetic characteristics. These groupings were further supported by morphological systematics (Sato, 2000) and molecular systematics (Iglésias *et al*., 2005). However, taxonomic problems still exist for members of this genus due mainly to the difficulty in taking accurate measurements. This, in turn, is caused largely by the soft body characteristic of this group which is easily deformed during investigation and often becomes shrivelled in preservative.

Since there are only a small number of meristic characteristics useful in the taxonomy of sharks, the morphometric characteristics become increasingly important in the taxonomic investigations. However, the methods of taking the measurements have not usually been described well in the literature. Springer (1966) followed Garrick & Schultz (1963), but later in his revision of the Scyliorhinidae (Springer, 1979), he only briefly mentioned the morphometric methodology used. Nakaya (1975) followed the methods of Bigelow & Schroeder (1948), but again the methodology used was not fully described. Later, Compagno (1984) defined the terminology of the measurements used for sharks in general and provided a general, broad description of the methods. Since the revision of the Atlantic catsharks by Springer (1966), taxonomic treatments for members of the genus *Apristurus*, such as the new species descriptions, redescriptions of poorly known taxa, synonymisation, and description of intraspecific variation, have been partially completed (Taylor, 1972; Nakaya, 1975, 1988a, 1988b, 1989, 1991; Springer, 1979; Chu *et al*., 1981, 1986; Deng *et al*., 1983, 1985, 1988; Meng *et al*., 1985; Dolganov, 1985; Nakaya & Séret, 1989, 1992, 1999; Nakaya & Sato, 1998, 1999, 2000; Nakaya & Stehmann, 1998; Sato *et al.*, 1999; Iglésias & Nakaya, 2004; Iglésias *et al*., 2004). However, the taxonomy of the genus *Apristurus* still requires further detailed revision to resolve the many problems still present.

For future revision of the genus *Apristurus*, it is necessary to have a standard methodology for the measurements and counts to be taken from individuals, thus allowing objective comparisons with data available for other nominal species collected by different authors. The main aims of this paper are to define the morphometric and meristic methodology used to discriminate the species of *Apristurus* and to provide detailed definitions and illustrations of the measurements and counts used to assist in this process. The variation of morphometric and meristic characters was further referred to for the definition and identification of the species.

METHODOLOGY

Type specimens and comparative materials examined for the purpose of taxonomy are deposited and numbered in ichthyological collections around the world. Acronyms for such repositories are given in Leviton *et al*. (1985) and/or Eschmeyer (1998).

Morphometric characters

Morphometric characters were selected to discriminate between taxa and enable comparisons to be made with published information on nominal *Apristurus* species. The measurements used are explained in Table 1 and are illustrated in Figs 1–3. The longer measurements, such as the total length and the lengths from the snout tip to the pectoral, pelvic, dorsal, anal and caudal fins, are typically taken using a measuring board, thus these measurements are taken horizontal to the body axis (Fig. 1). Total length is taken from the snout tip to the posterior end of the slightly raised (ca. 15°) caudal fin, along the body axis.

The shorter measurements are generally taken point-to-point using calipers (Figs 2 and 3). However, the measurements from the snout tip to the paired structures, e.g. nostrils and orbits, are taken from the snout tip to a line connecting anterior ends of the paired structures (see Figs 1, 2A). The measurements between paired structures, such as the distance between the pectoral-fin origin and pelvic-fin origin, are also taken between two lines connecting the paired structures (see Fig. 2A). The reason for adopting such methods is that the point-to-point measurements are often inaccurate in such cases that the body or body parts are twisted, bent, or deformed, which is often the case in the specimens of the genus *Apristurus*.

In addition to the body measurements listed in Table 1, the width of dermal denticles is sometimes taken for closer taxonomic analyses. For such purposes, the denticles from upper lateral side of the trunk before first dorsal fin and above pelvic fin are selected and measured. Widths of 15 typical dermal denticles in good shape are measured under the microscope and are averaged. This mean width is regarded as a dermal denticle width for that specimen.

The following is an additional explanation of some measurements:

Characters 9, 41 and 42: The measurement terminates at the origin of the anal fin formed by the ceratotrichia, not the muscle (Figs 1, 2B).

Characters 10, 68 and 70: Since the origin of the dorsal caudal-fin is impossible to determine due to the absence of elevation or any discriminating marks, the origin of the caudal fin is designated as the origin of the ventral caudal fin (Figs 1, 2B). Since the anal and ventral caudal fins practically meet each other and are separated only by a notch, the measurements from or to the ventral caudal-fin origin are taken to or from the notch between the anal and caudal fins.

Character 15: The pre-inner nostril length is the distance from the snout tip to a line connecting the innermost ends of the right and left inner nostrils and not to the posterior margin of the nostrils (Fig. 2A).

Characters 37, 38, 39 and 40 (Fig. 2A): These measurements should be carefully taken, as the abdominal regions shrink easily in preservatives, especially alcohol. If specimens appear to have shrunk in this region, they should be restored to as close to the original natural state as possible when taking these measurements. If this is not possible for a certain specimen, these measurements should not be taken and this should be noted.

Character 61: The anal base length (ceratotrichia) is the distance from the origin of the anal fin formed by the fin's ceratotrichia, which lies on ventral side of the anal fin muscle, to the insertion of the fin (Fig. 3E).

Character 62: The anal base length (muscle) is the distance from the origin of anal fin muscle to the insertion (Fig. 3E). This origin is often unclear and difficult to determine.

Character 65: The anal fin height (muscle) is the perpendicular distance from the line between the fin muscle and the body muscle to the apex of the anal fin (Fig. 3E). This line between the fin muscle and body muscle is more clearly distinguishable than that between the fin muscle and ceratotrichia, thus is considered a more accurate measurement.

Table 1. Terms and definitions of the morphometric characters taken for *Apristurus*.

#	Term	Definition
1	Total length (TL)	Distance from snout tip to caudal-fin tip (parallel to body axis)
2	PreD2-insertion length	Distance from snout tip to second dorsal-fin insertion (parallel to body axis)
3	PreD2-origin length	Distance from snout tip to second dorsal-fin origin (parallel to body axis)
4	PreD1-insertion length	Distance from snout tip to first dorsal-fin insertion (parallel to body axis)
5	PreD1-origin length	Distance from snout tip to first dorsal-fin origin (parallel to body axis)
6	PreP1 length	Distance from snout tip to a line connecting origins of right and left pectoral fins (parallel to body axis)
7	PreP2 length	Distance from snout tip to a line connecting origins of right and left pelvic fins (parallel to body axis)
8	Pre-vent length	Distance from snout tip to anterior end of cloaca (parallel to body axis)
9	Preanal length	Distance from snout tip to anal-fin origin (parallel to body axis)
10	Precaudal length	Distance from snout tip to ventral origin of caudal fin (parallel to body axis)
11	Pre-branchial length	Distance from snout tip to a line connecting right and left 1st gill slits (parallel to body axis)
12	Pre-spiracular length	Distance from snout tip to a line connecting right and left spiracles (parallel to body axis)
13	Pre-orbital length	Distance from snout tip to a line connecting right and left orbits (parallel to body axis)
14	Pre-outer nostril length	Distance from snout tip to a line connecting anterior ends of right and left outer nostrils
15	Pre-inner nostril length	Distance from snout tip to a line connecting inner ends of right and left inner nostrils
16	Pre-oral length	Direct distance from snout tip to mouth without teeth (lip)
17	Head length	Distance from snout tip to a line connecting right and left 5th gill slits (parallel to body axis)
18	Head height	Head height at 5th gill slit
19	Head width (mouth corners)	Head width at mouth corners
20	Head width (max)	Greatest width of head
21	Mouth width	Width of mouth cleft between mouth corners
22	Mouth length	Length of mouth from a line connecting mouth corners to centre of upper lip
23	Internarial width	Shortest distance between inner nostrils
24	Upper labial furrow length	Length of furrow along upper jaw
25	Lower labial furrow length	Length of furrow along lower jaw
26	Orbit length	Length of orbit
27	Orbit height	Height of orbit
28	Nostril length	Oblique length of outer+inner nostrils
29	Nostril-mouth space	Shortest distance between inner nostril and mouth (upper lip)
30	Interorbital width	Distance between anterior ends of orbits
31	1st gill height	Vertical height of first gill slit
32	3rd gill height	Vertical height of third gill slit
33	5th gill height	Vertical height of fifth gill slit
34	D1-D2 space	Direct distance from first dorsal-fin insertion to second dorsal-fin origin
35	D1-D2 origins	Direct distance from first dorsal-fin origin to second dorsal-fin origin
36	D1-D2 insertions	Direct distance from first dorsal-fin insertion to second dorsal-fin insertion
37	P1-P2 space	Distance between two lines connecting right and left insertions of pectoral fin and pelvic-fin origins
38	P1 tip to P2 origin	Distance between two lines connecting right and left pectoral-fin tips and pelvic-fin origins
39	P1-P2 origins	Distance between two lines connecting right and left origins of pectoral and pelvic fins
40	P1-P2 insertions	Distance between two lines connecting right and left insertions of pectoral and pelvic fins

Table 1. cont'd.

#	Term	Definition
41	P2-anal space	Direct distance from pelvic-fin insertion to anal-fin origin (ceratotrichia)
42	P2-anal origins	Direct distance from pelvic-fin origin to anal-fin origin (ceratotrichia)
43	D1 length	Distance from first dorsal-fin origin to posterior end of the free lobe
44	D1 base length	Distance from first dorsal-fin origin to the insertion
45	D1 height	Greatest height of first dorsal-fin free lobe
46	D1 free lobe length	Distance from first dorsal fin insertion to posterior end of the free lobe
47	D2 length	Distance from second dorsal-fin origin to posterior end of the free lobe
48	D2 base length	Distance from second dorsal-fin origin to the insertion
49	D2 height	Greatest height of second dorsal-fin free lobe
50	D2 free lobe length	Distance from second dorsal fin insertion to tip of the free lobe
51	P1 base length	Distance from pectoral-fin origin to the insertion
52	P1 anterior margin	Distance from pectoral-fin origin to the outer corner
53	P1 posterior margin	Distance between pectoral-fin outer and inner corners
54	P1 inner margin	Distance from pectoral-fin insertion to the inner corner
55	P1 width	Greatest width of pectoral fin
56	P2 anterior margin	Distance from pelvic-fin origin to the outer corner
57	P2 length	Distance from pelvic-fin origin to posterior end of free lobe
58	P2 base length	Distance from pelvic-fin origin to the insertion
59	P2 posterior margin	Distance between pelvic-fin outer and inner corners
60	P2 inner margin	Distance from pelvic-fin insertion to the inner corner
61	Anal base length (ceratotrichia)	Distance from anal-fin ceratotrichia origin to the insertion
62	Anal base length (muscle)	Distance from origin of anal-fin muscle to the insertion
63	Anal anterior margin	Distance from origin of anal-fin ceratotrichia to the outer corner
64	Anal posterior margin	Distance from anal-fin outer corner to the inner corner
65	Anal height (muscle)	Greatest height from a line separating fin muscle and body muscle to the outer corner
66	Anal inner margin	Distance from anal-fin insertion to the inner corner
67	Caudal peduncle height	Height at ventral caudal-fin origin
68	Caudal length	Distance from ventral caudal-fin origin to the tip
69	Caudal height	Greatest height from caudal-fin dorsal margin perpendicularly to apex of the ventral lobe
70	Caudal preventral margin	Distance from ventral caudal-fin origin to apex of the ventral lobe
71	Caudal postventral margin	Distance from apex of caudal-fin ventral lobe to subterminal notch
72	Caudal terminal lobe height	Height at subterminal notch
73	Caudal terminal lobe length	Distance from subterminal notch to the tip
74	Clasper outer length	Length of outer margin of clasper from junction of pelvic-fin to the tip
75	Clasper inner length	Length of inner margin of clasper from anterior end of cloaca to the tip

Meristic characters

Meristic characters are obtained separately for vertebrae, spiral valves, teeth and dermal denticles.

Vertebral count — The trunk vertebrae (monospondylous vertebrae), precaudal vertebrae (monospondylous + diplospondylous vertebrae to ventral caudal-fin origin) and caudal vertebrae (diplospondylous vertebrae of the caudal fin from ventral caudal-fin origin to the tail tip) are counted. It should be noted that the posterior-most caudal fin vertebrae are often difficult to count accurately, thus caudal counts are not as reliable as precaudal counts.

Tooth count — Total tooth row counts are taken directly from specimens from both the left and right side of the upper and lower jaws as they are very difficult to obtain from radiographs. The counts are taken for the tooth rows that make lines perpendicular to the jaw, never those of the oblique rows.

Dermal denticle count — This count is sometimes taken for detailed taxonomic examination. The denticles from upper lateral side of the trunk before first dorsal fin and above pelvic fin are counted. All the denticles in a 2.0

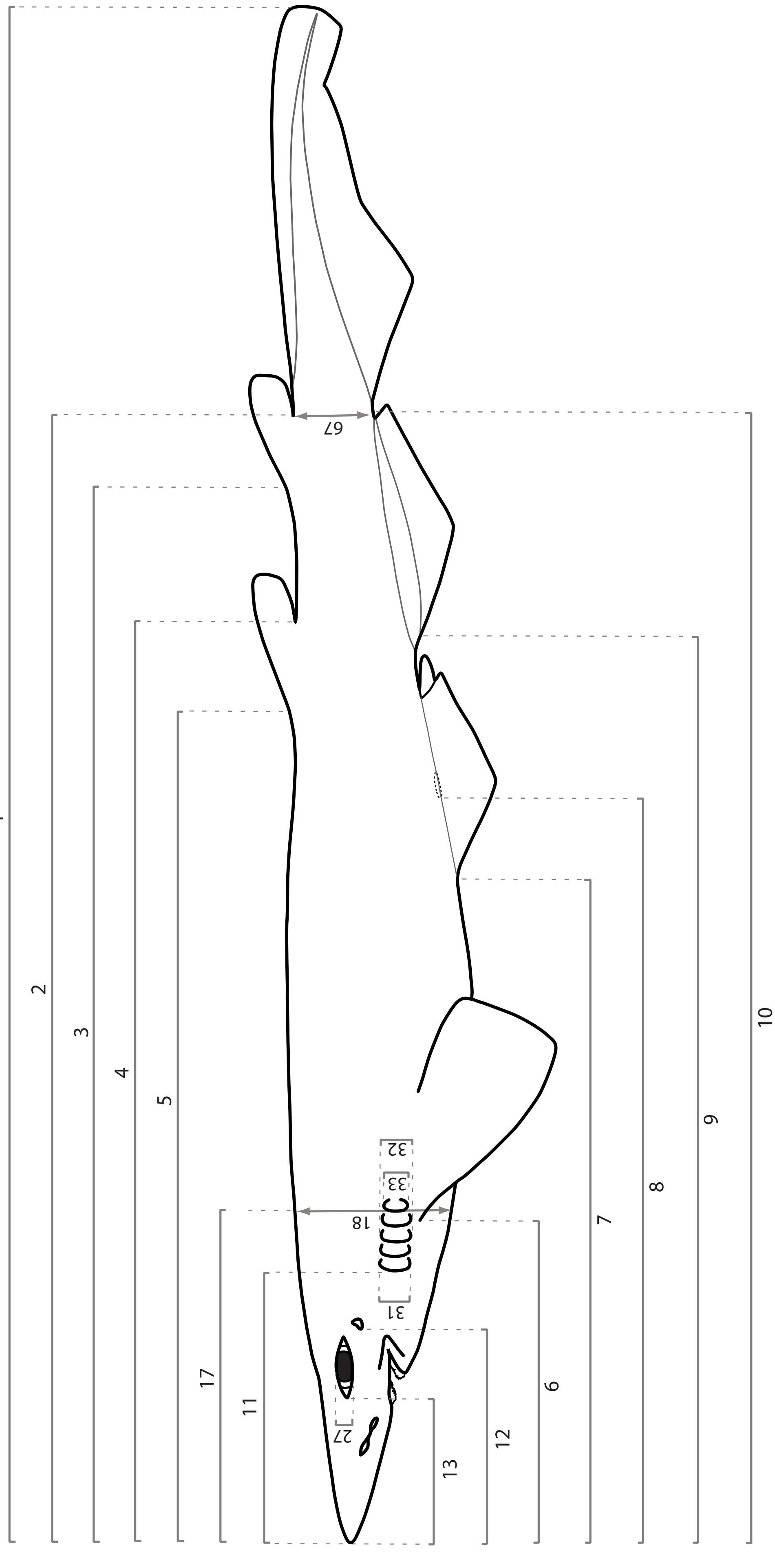

Figure 1. Lateral aspect of *Apristurus*, showing diagrammatic representation of the morphometric characters. Refer to Table 1 and text for definitions and explanation of measurements.

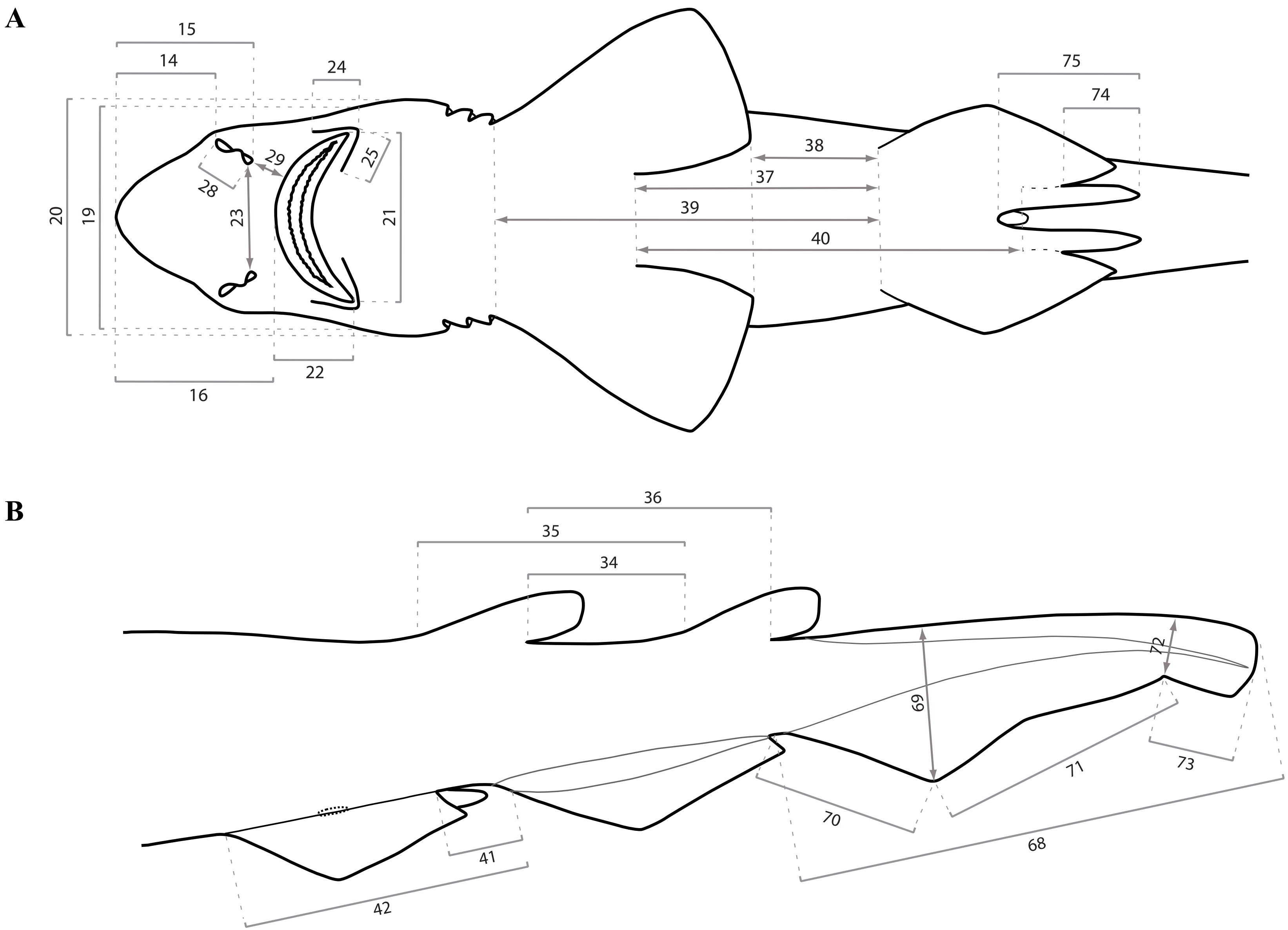

Figure 2. Ventral (A) and lateral caudal (B) aspects of *Apristurus*, showing diagrammatic representation of the morphometric characters. Refer to Table 1 and text for definitions and explanation of measurements.

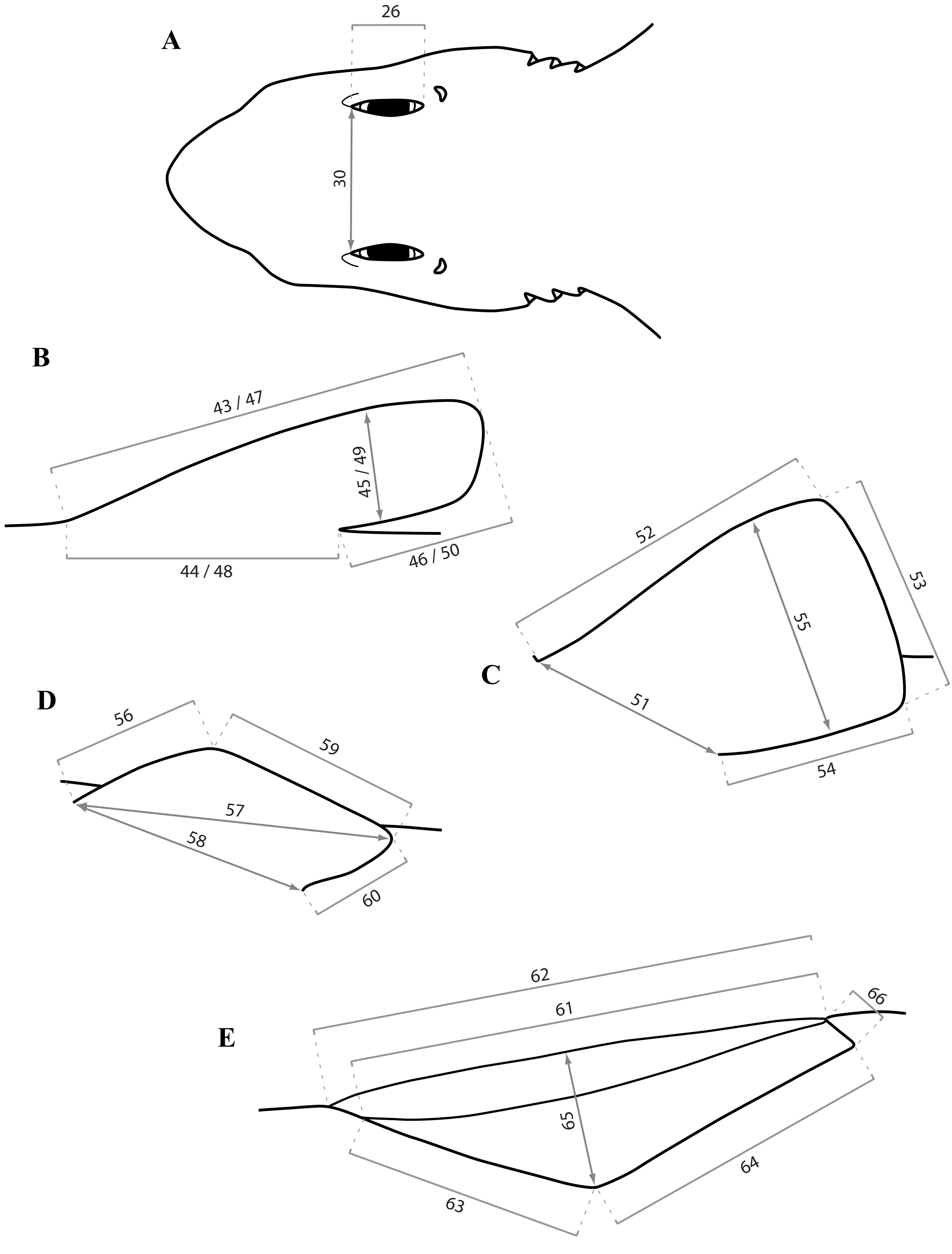

Figure 3. Dorsal view of head (A) and dorsal (B), pectoral (C), pelvic (D) and anal (E) fins of *Apristurus*, showing diagrammatic representation of the morphometric characters. Refer to Table 1 and text for definitions and explanation of measurements.

x 2.0 mm square are counted, including those on the marginal lines. This count is repeated three times on different areas and these three values are averaged to represent the dermal denticle count for that particular specimen. Special care should be taken to count the denticles on naturally stretched skins, not on dried and/or shrunken skins.

Spiral valve count — Numbers of all the turns are counted after performing a shallow cut along the intestine.

Maturity stages

Maturity stages are defined as follows, mainly based on Nakaya & Stehmann (1998).

Maturity stage 1 (immature) — claspers short and completely undeveloped, not reaching inner tips of pelvic fin; gonads small and completely undeveloped; ovarian eggs very small without any developing eggs; shell gland undeveloped and almost indistinguishable from oviduct; reproductive tracts thin.

Maturity stage 2 (adolescent) — An intermediate stage not included in the maturity stage 1 (immature) and maturity stage 3 (adult); claspers developing, but soft and bendable; gonads and reproductive tracts developing.

Maturity stage 3 (adult) — claspers long, stiff and not easily bendable, extending far beyond inner tips of pelvic fin in most cases; gonads and reproductive tracts developed, with some very large eggs among smaller eggs in the ovary; egg capsules sometimes present in oviducts.

REMARKS

A new species is described, based usually on the holotype and paratype(s), according to the provisions of the International Code of Zoological Nomenclature (International Commission on Zoological Nomenclature, 1999). After the original description of a new species, the holotype represents the species, as a name-bearing type, and the paratypes supplement the holotype.

Figure 4 is a scatter diagram of the proportional dimensions of caudal fin length in the type specimens of two *Apristurus* species, *A. kampae* Taylor, 1972 and *A. manis* (Springer, 1979). *Apristurus kampae* was described based on two immature specimens collected from the eastern North Pacific Ocean, and the two black symbols in the figure denote the holotype (circle) and one paratype (triangle). *Apristurus manis* is based on five immature specimens (holotype and four paratypes) from the western North Atlantic Ocean. However, it is difficult to distinguish whether they are different species or conspecific, because the dimensions of these type specimens are so close each other, or greatly overlapping (31.6–34.9 % TL vs. 33.9–38.3 % TL in *A. kampae* and *A. manis*, respectively). Figure 5 is the same diagram, with additional dimensions taken from the non-type specimens of the two species. Then, this clearly shows that the proportional dimensions of caudal fin shorten with growth in both species, and that *A. kampae* and *A. manis* follow different modes of reduction, completely separate from each other. Thus, the two species are distinguished as different and valid species. These facts also demonstrate that the original dimensions provided by the type specimens represent only a fraction of the total variation, and the accurate definition and discrimination of a species can be done, only when these additional dimensions are effectively combined to cover the variation.

Proportional dimensions, which are one of the important taxonomic characters in sharks, rays and chimaeras, involve numerous variations, such as individual, ontogenetic, sexual and geographical variations. Bass (1973) discussed ontogenetic variation of proportional dimensions in scyliorhinid, carcharhinid and sphyrnid sharks, and emphasised the importance of the variation in the identification and definition of shark species.

Figure 6 is a schematic diagram showing ontogenetic variation of a character K, with length of the specimen on x-axis and proportional dimension of character K on y-axis. Suppose that species A is known by a limited number of smaller individuals (spread of character K is encircled), and three other individuals (S1, S2 and S3) are dotted on the graph. If character K shows a wide variation, S1, S2 and S3 may be identified as species A. If character K shows a narrow range of variation and remains proportionally constant with growth (C in Bass, 1973), S3 may be identified as species A, but both S1 and S2 may belong to a different species. If character K

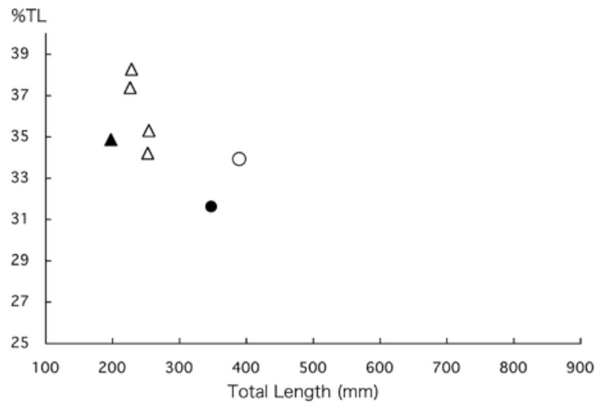

Figure 4. Scatter diagram of proportional dimensions of caudal length in the type specimens of *Apristurus kampae* and *A. manis*. Closed symbols, *A. kampae*; open symbols, *A. manis*; circles, holotypes; triangles, paratypes.

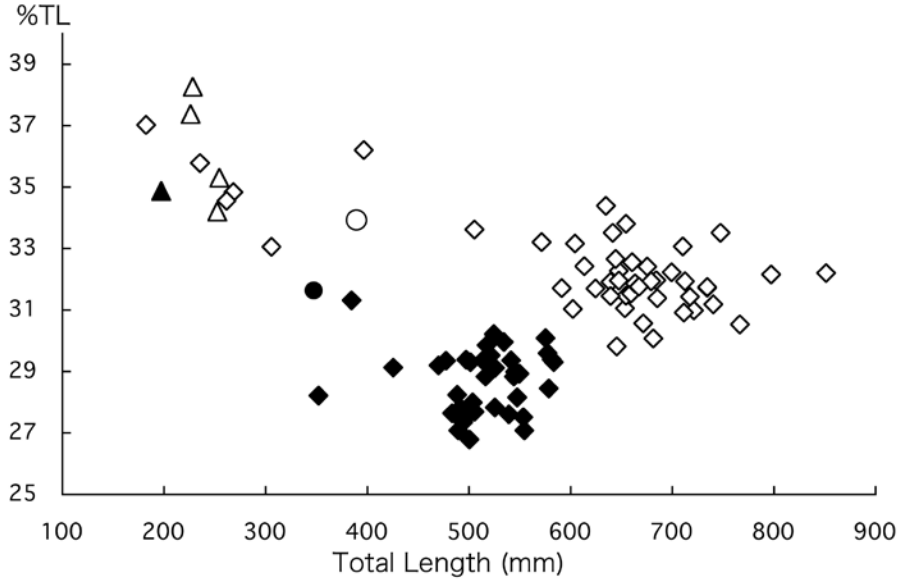

Figure 5. Scatter diagram of proportional dimensions of caudal length in *Apristurus kampae* and *A. manis*. Closed symbols, *A. kampae*; open symbols, *A. manis*; circles, holotypes; triangles, paratypes; diamonds, non-types.

shows a narrow range of variation and linearly increases with growth (SU in Bass, 1973), S2 may be identified as species A, but S1 and S3 each may be identified as different species. If character K shows a narrow range of variation and linearly decreases with growth (SD in Bass, 1973), S1 and S3 may be conspecific, but S2 may belong to the other species, both different from species A.

Bass (1973) recognised 9 types of variation in proportional dimensions, and the relationship of species A and 3 individuals in Figure 6 could be variously understood depending on the type of variation that the character involves. Ignorance of the variation may result in incorrect taxonomic treatments, such as misidentification and ill-definition of the species.

The size of dermal denticles is sometimes useful in identification of the species. Species with rough skin tend to have larger dermal denticles, but it is difficult to take accurate measurements of denticle lengths, because the denticles are not always parallel to the epidermis but stand at various angles. However, the width of denticle can be correctly taken, even if the denticle is oblique. The widths of dermal denticles are effectively used for discrimination of the species in Iglésias *et al.* (2004, Fig. 13), Nakaya *et al*. (2008, Fig. 10) and Sasahara *et al.* (2008, Fig. 11).

The number of dermal denticles is also available in discrimination of the species. Dermal denticles are closely packed in some species but sparsely distributed in other species. However, as the density of dermal denticles may be changeable by condition of the specimens or skin samples, i.e. stretched, shrunken, or dried, special care should be taken to use specimens or samples in counting. The number of dermal denticles taken according to the method mentioned above was quite effective in separation of the species, as shown in Sasahara *et al*. (2008, Fig. 9).

Some species of *Apristurus* are large in size, growing up to 900 mm TL (908 mm TL in *A. exsanguis*; Sato *et al*., 1999), and some species are smaller than 500 mm TL maximum size (407 mm TL in *A. riveri*; original data). Therefore, the maturing sizes are considerably different by species, and the maturity stages can be used for

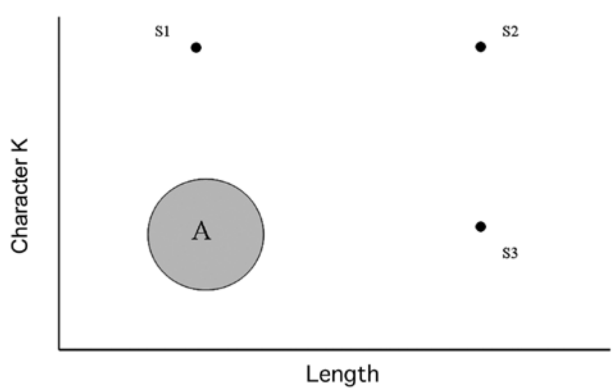

Figure 6. Schematic diagram showing variation and species identification. X-axis, length of the specimen; Y-axis, proportional dimension of character K. Refer to the text for details.

taxonomic purposes. The maturity stages defined here consist of only three stages, but the definition of present maturity stages is effectively used in Iglésias *et al*. (2004, Fig. 8), Kawauchi *et al*. (2008, Fig. 18) and Sasahara *et al*. (2008, Fig. 10).

This paper treated taxonomic issues and problems in the genus *Apristurus*, and finally we refer to the present status and problems of the type specimens. Some holotypes are very poor in condition, i.e. damaged [e.g. *A. herklotsi* (Fowler, 1934) and *A. verweyi* (Fowler, 1934)], strongly shrunken [e.g. *A. investigatoris* (Misra, 1962)], shrunken and broken [e.g. *A. sibogae* (Weber, 1913)], and shrunken and broken into small pieces [e.g. *A. profundorum* (Goode & Bean, 1896)]. It is very difficult to obtain new and accurate taxonomic information from these holotypes. The holotypes of *A. platyrhynchus* (Tanaka, 1909), *A. microps* (Gilchrist, 1922), *A. saldanha* (Barnard, 1925) and *A. nasutus* de Buen, 1959 are lost or missing, which makes the resolution of the taxonomic problems of the species and its related species quite difficult, and the designation of a neotype is strongly suggested for such species.

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Occurrence of *Apristurus melanoasper* from the South Pacific, Indian and South Atlantic Oceans (Carcharhiniformes: Scyliorhinidae)

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ABSTRACT.— North Atlantic species *Apristurus melanoasper* Iglésias, Nakaya & Stehmann, 2004 is confirmed to occur in the waters of Australia, New Zealand, New Caledonia, Indian Ocean and eastern South Atlantic Ocean. This is the largest range extension for a species of the genus *Apristurus*.

Key words. Scyliorhinidae – *Apristurus melanoasper* – new record – range extension – distribution – North and South Atlantic Ocean – South Pacific Ocean – Indian Ocean

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INTRODUCTION

The genus *Apristurus* Garman, 1913 comprises a group of deep-water catsharks, inhabiting continental slopes and submarine elevations to depths of 400–2000 m except in polar waters. Forty-one nominal species have been described, and 32 of them are currently recognised as valid. However, with so many species, this is one of the most diverse and taxonomically confusing genera among living sharks. No *Apristurus* species had been reported from the waters around Australia, New Zealand and New Caledonia before Paulin *et al*. (1989) noted 5 unnamed species in an identification guide to the fishes of New Zealand. Last & Stevens (1994) reported 8 species of *Apristurus* from Australia, but only identified one as a nominal species *A. longicephalus* Nakaya, 1975 and treated the other 7 species as unidentified (*Apristurus* sp. A–G). Later, Sato *et al*. (1999) described *Apristurus exsanguis* from New Zealand, and Nakaya & Séret (1999) described *A. albisoma* from New Caledonia. Present authors KS and KN have confirmed presence of several unknown *Apristurus* species in the waters of Australia and New Zealand, after visiting the ichthyological collections of AMS, ANFC (CSIRO) and NMNZ. SI and KN have also undertaken preliminary investigations of the sharks around New Caledonia, and recognised several unnamed species of *Apristurus* in those waters. Most of the species of the genus *Apristurus* have been reported from the Northern Hemisphere, and only several species are reported from the Southern Hemisphere, including *A. microps* (Gilchrist, 1922) and *A. saldanha* (Barnard, 1925) from South Africa, and *A. nasutus* de Buen, 1959 from Chile, in addition to the above mentioned species.

We made extensive survey of the specimens of the genus *Apristurus* from the Southern Hemisphere (Australia, New Zealand, New Caledonia, Indian Ocean and eastern South Atlantic Ocean), and here we report the occurrence of North Atlantic species *Apristurus melanoasper* Iglésias, Nakaya & Stehmann, 2004 from the western South Pacific, Indian, and eastern South Atlantic Oceans.

METHODS

Morphometrics and meristics were taken according to Nakaya *et al*. (2008). Vertebral counts were determined from radiographs. Egg capsule terminology follows Cox (1963) and Gomes & Carvalho (1995). Clasper terminology follows Compagno (1988). Dermal denticles were taken from the dorsolateral side of the body below the first dorsal fin. Anterior teeth in 5–8th rows and lateral teeth in 15–18th rows from the symphysis of both jaws were used for description. Sexual maturity stages follow Nakaya *et al*. (2008). Institutional acronyms follow Leviton *et al*. (1985) and Eschmeyer (1998).

SYSTEMATICS

Apristurus melanoasper Iglésias, Nakaya & Stehmann, 2004

Figs 1–10; Tables 1–5

Apristurus melanoasper Iglésias, Nakaya & Stehmann, 2004: pp 346.

Apristurus sp. C: Paulin *et al*., 1989: 22 (key); Last & Stevens, 1994: pp 169, 175, key fig. 26, fig. 26.3, pl. 20.

Apristurus sp.: Quéro *et al*., 2003: pp 25, photo, pl. 2.

Apristurus sp. 6: Iglésias, Lecointre & Sellos, 2005, Tab. 1, fig. 2.

MATERIALS.— Australia (15 specimens): CSIRO H 1190–04, male 701 mm TL, east of Sydney, New South Wales, 33°44′ S, 152°01′ E, 990–1005 m, 18 Feb 1988; CSIRO H 1282–03, male 577 mm TL, east of Broken Bay, New South Wales, 33°44′ S, 152°08′ E, 972–1000 m, 02 May 1984; CSIRO H 1284–03, female 571 mm TL, east of Broken Bay, New South Wales, 33°28′ S, 152°13′ E, 1026–1089 m, 02 May 1984; CSIRO H 1546–02, male 615 mm TL, south-east of Cape Everard, Victoria, 38°20′ S, 149°40′ E, 1020–1030 m, 14 May 1992; CSIRO H 2811–03, male 391 mm TL, South Tasman Rise, 47°12′ S, 148°49′ E, 1115–1120 m, 31 Jan 1992; AMS I 24058–006, female 596 mm TL, off Kiama, New South Wales, 896–932 m; AMS I 24356–008, female 633 mm TL, off Shoalhaven Bight, New South Wales, 1069–1124 m; AMS I 24978–003, male 260 mm TL, south-east of Broken Bay, New South Wales, 1043–1061 m; AMS I 27192–001, male 569 mm TL, off Sydney, New South Wales, 1053–1066 m; HUMZ 139935, female 599.5 mm TL, east-northeast of Jervis Bay, New South Wales, 34°53′ S, 151°14′ E, 1060–1105 m; HUMZ 139936, male 695.3 mm TL, west of Trial Harbour, Tasmania, 41°57′ S, 144°31′ E, 990–1025 m; HUMZ 139937, male 688 mm TL, south-west of Port Davey, Tasmania, 43°32′ S, 145°39′ E, 940–945 m; HUMZ 189942, male 684.5 mm TL, west of Sandy Cape, Tasmania, 41°27′ S, 144°27′ E; HUMZ 189943, female 678.2 mm TL, west-southwest of Cape Grim, Tasmania, 40°56′ S, 143°41′ E, 1105–1100 m; HUMZ 189944, male 667.5 mm TL, west of Trial Harbour, Tasmania, 41°58′ S, 144°30′ E, 1215–1275 m. New Zealand (14 specimens): HUMZ 135341, male 702.2 mm TL, Southern Canterbury Bight, 44°01′ S, 173°39′ E, 888–891 m; HUMZ 135342, male 729.5 mm TL, off Banks Peninsula, 44°35′ S, 174°06′ E, 880–900 m; HUMZ 135343, female 676.2 mm TL, east of Urry Bank, 44°44′ S, 175°41′ E, 906–930 m; NMNZ P 16021, female 704 mm TL, Chatham Rise, 42°47′ S, 175°46′ E, 1174–1180 m; NMNZ P 11812, female 423 mm TL, north-west of Urry Bank, 44°47′ S, 173°35′ E, 961–1015 m; NMNZ P 11847, male 576 mm TL, north-west of Urry Bank, 44°50′ S, 173°54′ E, 938–970 m; NMNZ P 12878, female 456 mm TL, Northern Chatham Rise, 42°47′ S, 177°14′ E, 1015–1040 m; NMNZ P 12909, male 394 mm TL, Northern Chatham Rise, 42°47′ S, 179°26′ E, 1040–1045 m; NMNZ P 13149, female 696 mm TL, Northern Chatham Rise, 44°42′ S, 173°05′ E, 841–852 m; NMNZ P 13166, female 692 mm TL, north-west of Urry Bank, 44°42′ S, 173°39′ E, 870–986 m; NMNZ P 15066, male 462 mm TL, Southern Canterbury, 44°46′ S, 173°38′ E, 1043–1103 m; NMNZ P 19682, male 670 mm TL, off Doubtless Bay, 34°33′ S, 174°02′ E, 1030–1041 m; NMNZ P 20382, male 739 mm TL, north of Urry Bank, 44°41′ S, 173°44′ E, 888–928 m; NMNZ P 23289, female 473 mm TL, north-east of Chatham Rise, 42°48′ S, 175°49′ E, 1153–1154 m. New Caledonia (4 specimens): MNHN 2003–1979, male 287 mm TL, Lord Howe Seamounts, 24°01′ S, 162°05′ E, 1142–1151 m; MNHN 2003–1980, male 373 mm TL, Coriolis Bank, 21°08′ S, 157°40′ E, 1014–1198 m; MNHN 2003–1981, male 641 mm TL, MNHN 2003–1982, male 548 mm TL, Coriolis Bank 21°25′ S, 157°51′ E, 953–1022 m. Indian Ocean (7 specimens): PPSIO-Nakaya No. 327, male 674 mm TL, Eastern Indian Ocean, 32°00′ S, 95°41′ E; PPSIO-Nakaya No. 328, female 685 mm TL, Western Indian Ocean, 32°25′ S, 43°44′ E; PPSIO-Nakaya No. 338, female 614 mm TL, Eastern Indian Ocean, 30°55′ S, 93°27′ E; PPSIO-Nakaya No. 339, male 751 mm TL, Eastern Indian Ocean, 31°40′ S, 95°37′ E; PPSIO-Nakaya No. 340, male 677 mm TL, Eastern Indian Ocean, 30°55′ S, 93°27′ E; PPSIO-Nakaya No. 352, female 606 mm TL, Eastern Indian Ocean, 30°55′ S, 93°27′ E; PPSIO-Nakaya No. 365, female 637 mm TL, Western Indian Ocean, 33°07′ S, 44°37′ E. South Atlantic Ocean (1 specimen): HUMZ 146747, male 617 mm TL, off Namibia, 25°30′ S, 13°22′ E, 1007–1008 m.

DIAGNOSIS.— A large species of *Apristurus* maturing at about 550 mm TL and attaining at least 760 mm TL, with the following characters: upper labial furrow much longer than lower; first dorsal fin slightly smaller than second dorsal fin, originating above posterior half of the pelvic-fin base; second dorsal-fin insertion about opposite anal-fin insertion; abdomen long, P1–P2 space longer than anal-fin base length (ceratotrichia); pectoral fin small and slender with angular corners and free tip not reaching to 1/3 of P1–P2 space; anal fin rather short and triangular; 19–23 spiral valves; 36–42 monospondylous and 26–33 precaudal diplospondylous vertebrae; large dermal denticles (0.4–0.6 mm in width) giving a rough texture to body surface; body and fins uniformly blackish brown.

DESCRIPTION.— The specimens from the western South Pacific, Indian, and eastern South Atlantic oceans are described below. Proportional measurements and meristic counts are given in Tables 1 and 2.

Body cylindrical, slender and elongate (Fig. 1); abdomen long, P1–P2 space longer than anal base length and equal to D1–D2 insertions; caudal peduncle high, height about half of D1–D2 space. Head dorso-ventrally flattened, posterior part of body compressed laterally. Snout rather long and slender; tip relatively narrowly rounded (Fig. 2A–C). Pre-outer nostril longer than internarial width. Pre-oral length slightly less than pre-orbital length, about 2.2–2.8 times internarial width, slightly greater than mouth width and greater than interorbital width. Pre-orbital length about 1.3–1.8 times interorbital width, about 2.9–3.7 times orbit length. Internarial width subequal to orbit length and nostril length. Nostril large and oblique; nostril length about half of pre-inner nostril length, about equal to internarial width and orbit length. Nostril-mouth distance about half of internarial width. Mouth deeply

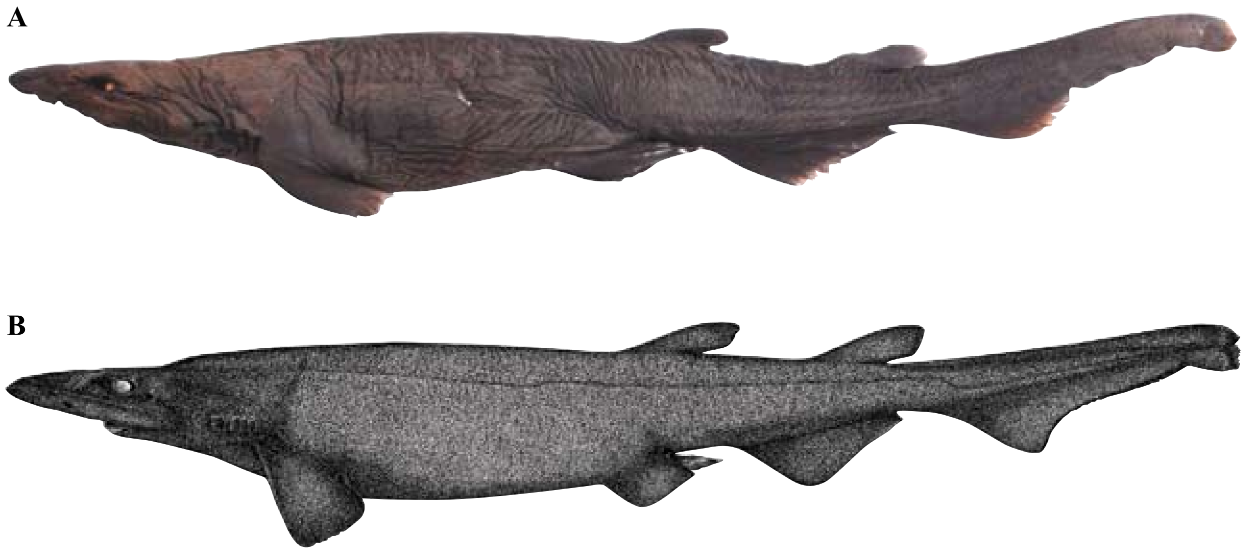

Figure 1. *Apristurus melanoasper* Iglésias, Nakaya & Stehmann, 2004 from Australia (A) and the North Atlantic (B). A. HUMZ 139936, male 695.3 mm TL; B. MNHN 2000-1757 (holotype), male 718 mm TL (from Iglésias *et al*., 2004).

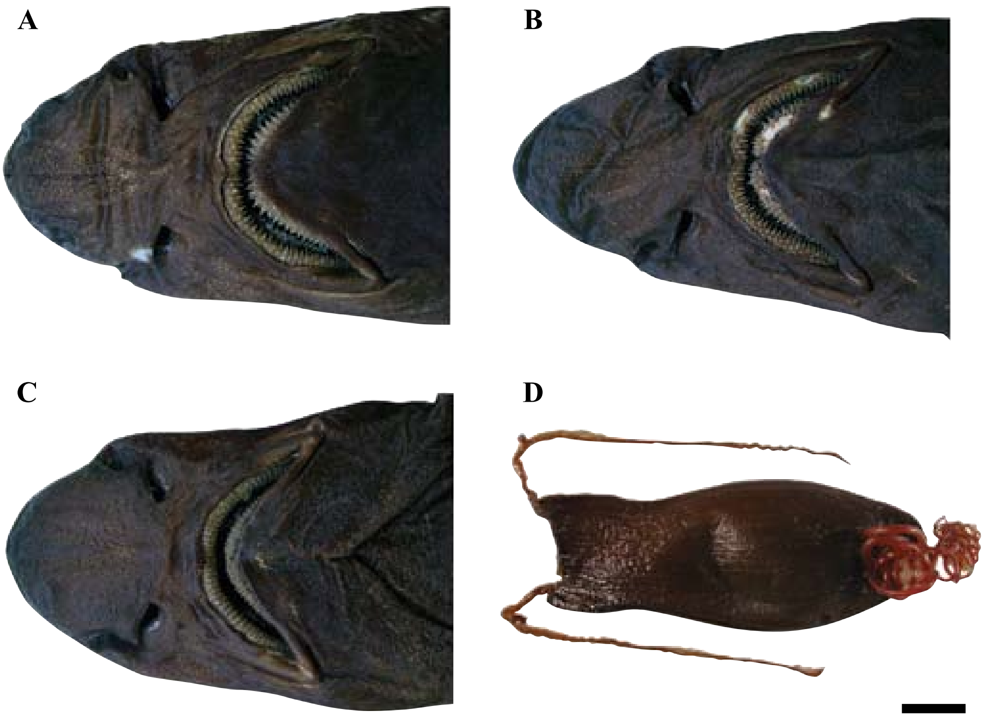

Figure 2. Ventral views of head (A–C) showing variation of snout shape and an egg capsule (D) of *Apristurus melanoasper*. A. Australian specimen, HUMZ 189942, male 684.5 mm TL; B. Australian specimen, HUMZ 139936, male 695.3 mm TL; C. North Atlantic specimen, MCZ 125408, paratype, male 692 mm TL; D. egg capsule from a New Zealand specimen, NMNZ P 16021, female 704 mm TL. Scale bar = 1 cm.

Table 1. Proportional measurements (%TL) and meristics in present specimens and *Apristurus melanoasper*. Locations: New Caledonia (NC), Australia (Aust), New Zealand (NZ), Indian Ocean (IO), Namibia (Nam).

		Present specimens examined						*A. melanoasper*
	Locality	NC	Aust	NZ	IO	Nam	**Total**	North Atlantic
	n (male, female)	4 (4, 0)	15 (10, 5)	14 (7, 7)	7 (3, 4)	1 (1, 0)	41 (25, 16)	53 (36, 17)
1	Total length (mm)	287–641	260–701	394–739	606–751	617	260–751	243–761
3	PreD2-origin length	62.6–65.3	59.6–67.3	62.7–66.4	64.6–67.0	64.5	59.6–67.3	57.3–68.3
5	PreD1-origin length	47.0–50.2	47.3–51.3	47.5–51.3	49.0–52.0	47.8	47.0–52.0	43.7–52.1
6	PreP1 length	19.7–23.1	18.8–23.7	20.0–23.6	19.4–23.3	21.4	18.8–23.7	18.6–23.8
7	PreP2 length	45.1–46.9	42.9–47.3	42.8–46.6	43.4–46.6	44.8	42.8–47.3	41.8–48.8
9	Preanal length	57.5–59.7	53.1–60.2	54.6–59.5	55.4–59.4	57.9	53.1–60.2	51.4–60.2
10	Precaudal length	69.6–70.2	65.4–72.9	68.8–73.1	70.0–72.1	71.2	65.4–73.1	67.8–73.7
11	Pre-branchial length	16.4–19.3	17.7–20.6	18.4–20.3	15.7–20.3	18.9	15.7–20.6	14.9–22.2
13	Pre-orbital length	8.3–11.2	8.5–10.3	9.0–9.6	8.2–10.8	9.2	8.2–11.2	7.8–12.9
14	Pre-outer nostril length	3.9–5.3	3.7–4.9	3.9–4.3	3.8–5.5	3.7	3.7–5.5	3.4–5.4
15	Pre-inner nostril length	5.6–7.3	6.3–7.8	6.1–7.0	6.0–7.6	6.1	5.6–7.8	5.3–9.3
16	Pre-oral length	7.2–9.4	7.5–9.9	7.7–9.0	7.6–9.9	7.8	7.2–9.9	7.0–11.0
17	Head length	20.0–24.1	21.5–23.4	21.0–23.8	20.0–23.2	21.7	20.0–24.1	18.8–26.0
21	Mouth width	8.0–10.2	6.4–9.2	7.3–8.9	7.1–8.8	7.7	6.4–10.2	6.6–9.7
23	Internarial width	3.4–4.3	3.0–3.7	3.0–3.5	3.1–4.1	3.3	3.0–4.3	2.9–4.8
24	Upper labial furrow length	3.1–3.5	3.3–4.1	3.3–4.3	3.5–4.1	3.6	3.1–4.3	2.8–4.2
25	Lower labial furrow length	2.0–2.7	1.7–3.0	2.0–2.1	1.8–2.7	2.6	1.7–3.0	1.6–2.8
26	Orbit length	2.7–3.2	2.8–3.5	2.5–3.6	2.6–3.3	3.1	2.5–3.6	2.5–3.7
28	Nostril length	3.0–4.4	2.7–4.3	2.9–4.2	2.7–3.6	3.0	2.7–4.4	2.7–4.9
30	Interorbital width	6.1–8.0	6.2–7.7	6.2–6.5	5.9–7.2	6.2	5.9–8.0	5.4–8.8
31	1st gill height	1.4–1.6	1.0–1.8	1.2–1.8	1.3–2.4	2.3	1.0–2.4	0.9–2.0
32	3rd gill height	1.6–2.0	1.2–2.5	1.3–1.9	1.7–2.3	3.0	1.2–2.5	1.0–2.3
33	5th gill height	1.1–1.6	1.3–2.0	1.3–1.7	1.1–1.9	2.0	1.1–2.0	0.8–1.8
34	D1-D2 space	8.3–10.0	6.7–9.3	6.7–9.1	7.8–9.3	8.2	6.7–10.0	5.8–10.7
35	D1-D2 origins	15.0–15.6	13.0–15.7	14.1–17.5	13.4–15.8	17.1	13.0–17.5	12.8–16.4
36	D1-D2 insertions	13.9–16.4	13.2–16.0	13.6–15.8	13.5–16.2	15.8	13.2–16.4	12.8–16.0
37	P1-P2 space	16.7–18.3	11.6–17.0	13.4–18.4	15.0–17.8	17.0	11.6–18.4	13.0–21.2
39	P1-P2 origins	23.2–25.3	19.0–24.7	21.1–24.9	21.4–24.6	25.2	19.0–25.3	20.1–27.9
44	D1 base length	5.9–6.6	4.7–6.8	5.2–7.2	5.6–7.0	8.7	4.7–7.2	5.4–8.0
45	D1 height	2.0–2.3	1.7–2.5	2.2–2.5	1.6–2.3	2.5	1.6–2.5	1.7–3.0
48	D2 base length	6.2–7.2	5.3–7.3	6.9–7.3	5.3–7.2	8.5	5.3–8.5	5.3–7.8
49	D2 height	2.4–2.8	2.2–2.9	2.5–3.1	2.2–2.6	2.8	2.2–3.1	2.3–3.5
52	P1 anterior margin	7.3–11.4	10.7–12.4	10.2–12.0	10.4–11.7	–	7.3–12.4	8.6–13.3
57	P2 length	7.7–9.8	9.0–11.9	10.4–12.4	8.9–11.8	11.4	7.7–12.4	7.9–11.7
61	Anal base length (ceratotrichia)	11.4–14.7	11.9–14.4	12.1–14.7	12.5–15.3	13.0	11.4–15.3	12.6–16.4
65	Anal height (muscle)	3.4–5.5	3.9–5.6	3.7–5.5	4.1–5.7	5.7	3.4–5.7	3.8–7.9
68	Caudal length	26.5–30.0	27.5–33.1	26.8–28.6	27.8–29.8	28.9	26.5–33.1	24.3–32.7
74	Clasper outer length	0.8–3.7	1.2–5.4	1.5–5.2	4.1–4.3	4.6	0.8–5.4	0.8–5.2
	Tooth rows:							
	upper	68–86	63–78	63–78	64–73	76	63–86	59–93
	lower	63–88	57–68	57–74	64–70	74	57–88	58–97
	Vertebrae:							
	monospondylous	36–38	39–42	39–41	38–41	39	36–42	36–43
	precaudal diplospondylous	26–27	27–33	27–33	26–31	30	26–33	26–32
	Spiral valves	20–23	19–22	19–22	20–23	22	19–23	19–23

arched, with well developed labial furrows; upper labial furrow much longer than the lower one. Upper labial furrow reaching beyond midpoint between mouth corner and posterior margin of nostril. Orbit relatively large, with an indistinct subocular fold; orbit length about equal to internarial width, a little less than half of interorbital width. Spiracle small placed slightly below level of horizontal axis of orbit. Five small gill slits present; 4th gill slit above pectoral fin origin; 5th gill slit smallest above pectoral-fin base. Gill septa lacking projections, covered closely with dermal denticles.

Pectoral fin small, slender and sub-quadrangular; outer margin almost parallel to inner margin; pectoral-fin rear tip not reaching anterior 1/3 of P1–P2 space; right and left fins separated by a space of 2/3 of mouth width. Pelvic fin moderate in size. Dorsal fins similar in shape. First dorsal fin slightly smaller than second dorsal fin; origin over posterior two thirds of pelvic-fin base; insertion slightly before anal-fin origin (ceratotrichia). Second dorsal-fin origin above middle of anal-fin base; insertion slightly before, above or slightly behind anal-fin insertion. Anal fin high, triangular, with a base shorter than P1–P2 space, but longer than P1 tip to P2 origin space; posterior margin almost straight; anal and caudal fins separated only by a notch. Caudal fin slender; ventral lobe relatively high; apex of ventral lobe rather rounded; subterminal notch distinct; terminal lobe long, more than twice caudal terminal lobe height.

Intestinal spiral valves 19–23. Monospondylous vertebrae 36–42, precaudal diplospondylous vertebrae 26–33.

Teeth (Fig. 3) numerous and small, 63–86 rows in total on upper jaw and 57–88 rows on lower jaw; anterior and lateral teeth on both jaws with a long robust central cusp and one or two short lateral cusps on both sides of the central cusp in female; upper teeth in male with a long

Figure 3. Upper (left) and lower (right) teeth of Australian *Apristurus melanoasper*, HUMZ 139936, male 695.3 mm TL. Scale bar = 0.5 mm.

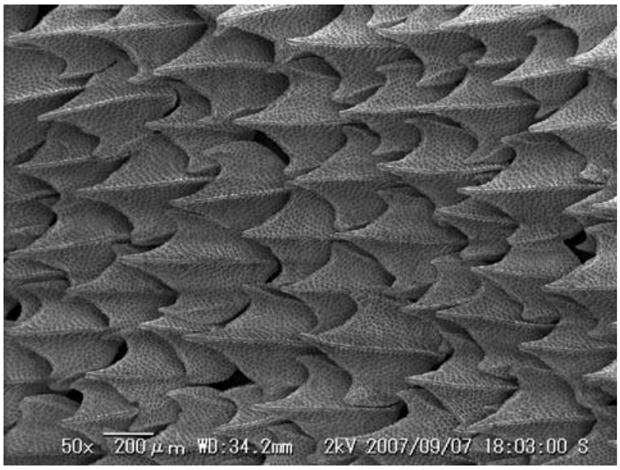

Figure 4. Dermal denticles of Australian *Apristurus melanoasper*, CSIRO H 1190–04, male 701 mm TL. Scale bar = 0.2 mm.

robust central cusp and one short lateral cusp on both sides; lower teeth in male with one or two lateral cusps.

Dermal denticles (Fig. 4) from dorso-lateral side of body large with widths of 0.4–0.5 mm, overlapping each other, tricuspid in shape with a long ridged central cusp and a shorter lateral cusp on both sides; outer surface of denticles completely structured by reticulations. No modified dermal denticles on the dorsal margin of the caudal fin. Dermal denticles densely present around the gill slits and on gill septa, but absent from palate and tongue.

Clasper short and robust, tapering toward the tip; ventral and outer lateral sides densely covered by dermal denticles; dorsal side of clasper naked except for outer posterior half of exorhipidion; inner margin of exorhipidion lined with a few rows of slightly enlarged tricuspid dermal denticles; clasper groove covered by rhipidions except for posterior one third; pseudosiphon distinct as a narrow deep groove at postero-inner side of cover rhipidion.

Egg capsule from a female of 704 mm TL (Fig. 2D) is characterised by the following features: length 58.8 mm, width 22.3 mm; posterior end tapering, with two very long and tightly coiled tendrils set closely together at base; anterior margin of the capsule concave, with a short blunt horn of about 2 mm length at each corner; a neckline constriction at about one third of the length from anterior end; surface of the capsule entirely covered by very fine fibres, forming fine longitudinal striations on surface of egg capsule; lateral edge rounded; two respiratory fissures present as plugged grooves on anterior-left side and posterior-left side of the capsule; capsule dark greenish brown in alcohol; colour of the tendrils brownish.

COLOUR.— Preserved specimens: Upper and lower surfaces of body and fins uniformly blackish brown. Tongue and palate dark, peritoneum pale to dark grey.

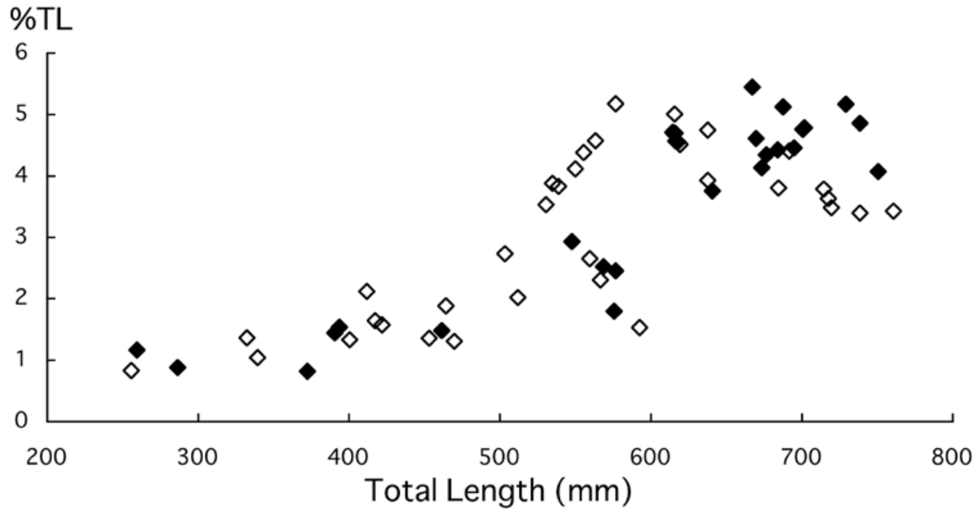

Figure 5. Clasper development in *Apristurus melanoasper*. ♦, present specimens; ◊, North Atlantic specimens.

Table 2. Frequency distribution of meristic counts by locality in present specimens of *A. melanoasper*.

Monospondylous vertebrae

number	36	37	38	39	40	41	42
Australia			2	4	4	4	1
New Zealand				4	7	3	
New Caledonia	2	1	1				
Indian			2	4		1	
Namibia				1			
(Total)	**2**	**1**	**5**	**13**	**11**	**8**	**1**

Precaudal diplospondylous vertebrae

number	26	27	28	29	30	31	32	33
Australia		3		8	2	1		1
New Zealand		1	1	5	4		2	1
New Caledonia	1	3						
Indian	1	1	1	1	1	2		
Namibia					1			
(Total)	**2**	**8**	**2**	**14**	**8**	**3**	**2**	**2**

Spiral valves

number	19	20	21	22	23
Australia	2	4	2	1	1
New Zealand	3	3	1	7	
New Caledonia		1		1	2
Indian		1	2		2
Namibia				1	
(Total)	**5**	**9**	**5**	**10**	**5**

SIZE.— Maximum sizes of males and females examined in this study were 751 and 704 mm TL, respectively, maximum sizes attained for this species are 761 and 732 mm TL, respectively (Iglésias *et al*., 2004). Males <472 mm TL possess short claspers, <1.5 % TL, which is ranked as maturity stage 1 (immature: Nakaya *et al*., 2008). Males of 569–577 mm TL possess small but developing claspers (1.8–2.9% TL, maturity stage 2) and those >615 mm TL have long developed claspers (3.7–5.4% TL, maturity stage 3) (Fig. 5). Maturity in both sexes (Fig. 6) indicates that males and females <473 mm TL are immature (maturity stage 1), 548 mm TL (male) and 576–599 mm TL (female) are adolescent (maturity stage 2), and males >615 mm TL and females >596 mm TL are adult (maturity stage 3). One female (NMNZ P 16921, 704 mm TL) contained an egg case in utero.

DISTRIBUTION.— Mid continental slope and seamounts of Australia (from New South Wales to Tasmania), New Zealand, Lord Howe Seamounts and Coriolis Bank (between Australia and New Caledonia), Indian Ocean (east and west), and Namibia in the eastern South Atlantic for present specimens. Also known from the North Atlantic Ocean (east and west). Collected in depths of 880–1275 m for present specimens, and 512–1520 m for the species (Iglésias *et al*., 2004) (Fig. 7).

REMARKS.— We examined specimens from the waters of Australia and New Zealand, Indian Ocean and eastern South Atlantic Ocean, and no specific differences were recognised in their morphometrics (Table 1) and meristic characters (Table 2). These specimens are also characterised by the following features: first dorsal fin which is slightly smaller than second dorsal fin, originating above posterior half of the pelvic-fin base; slender snout with tip rather narrowly rounded; upper labial furrows

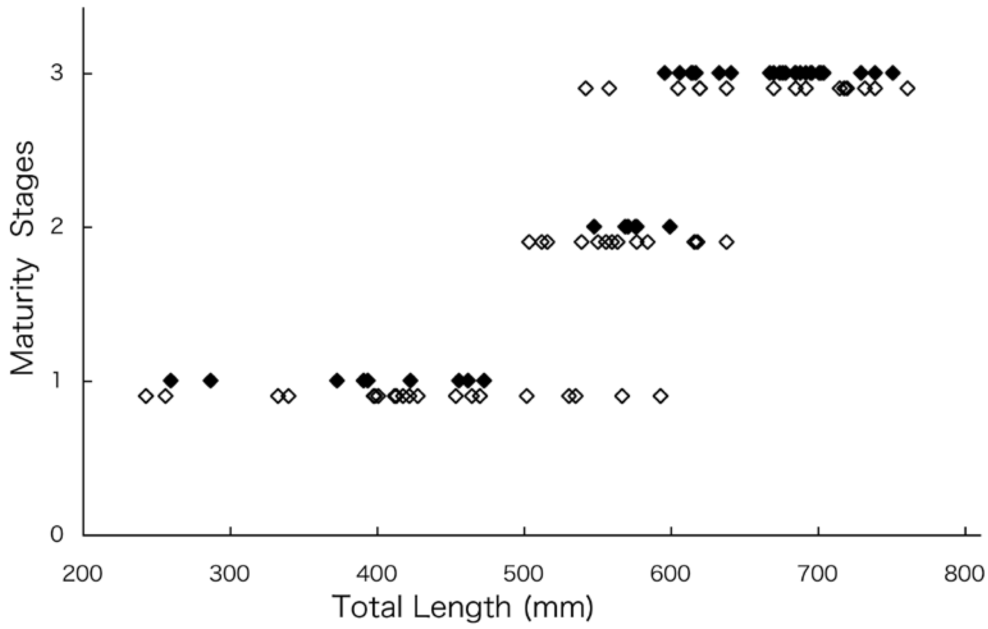

Figure 6. Maturity stages in *Apristurus melanoasper*. ♦, present specimens; ◊, North Atlantic specimens. 1, immature; 2, adolescent; 3, adult.

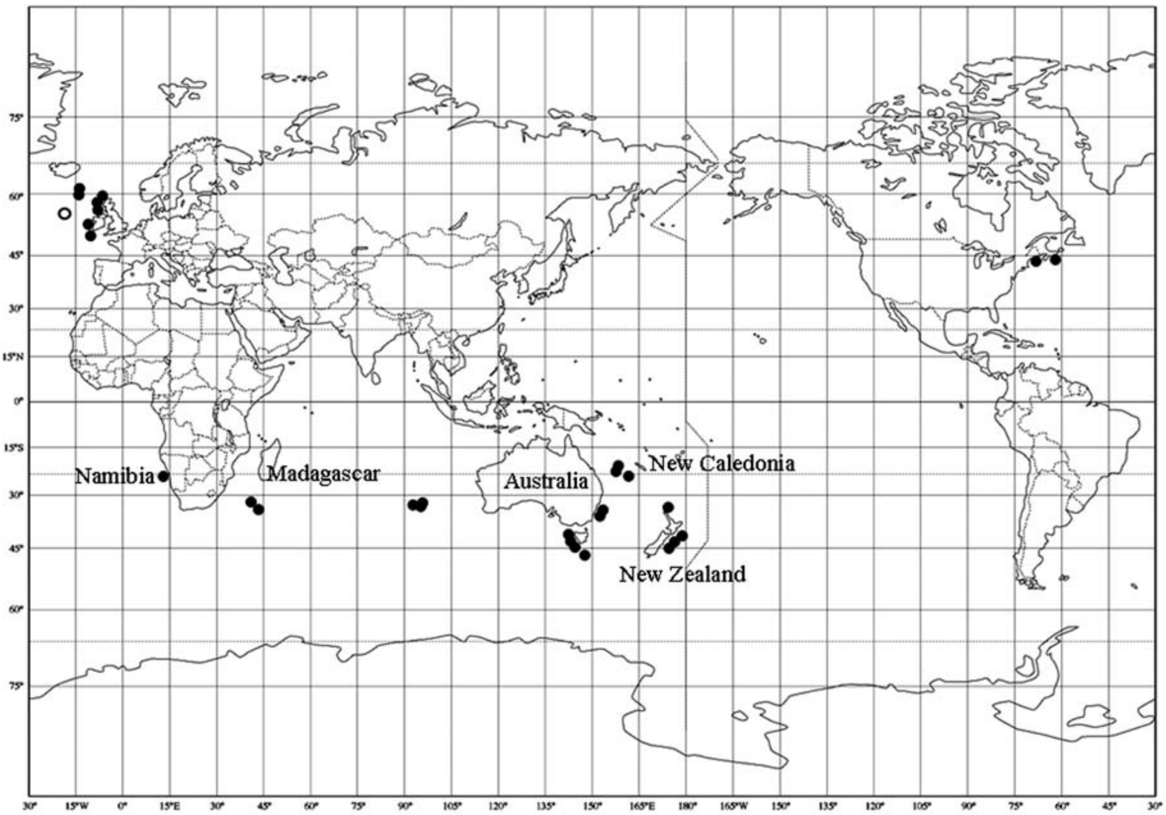

Figure 7. Geographical distribution of *Apristurus melanoasper*. Open circle indicates the type locality.

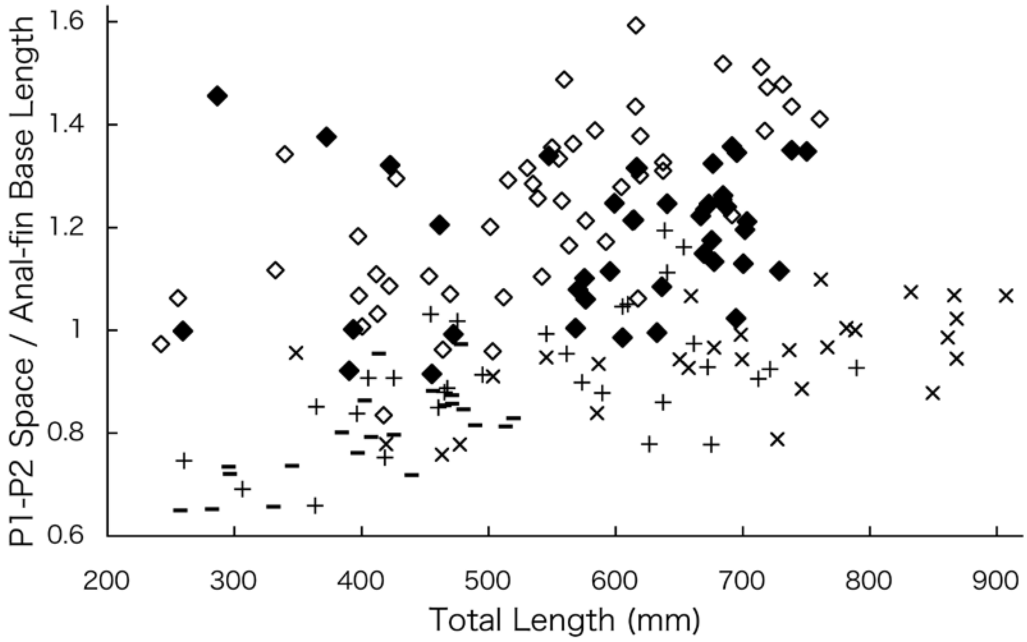

Figure 8. Ratio of anal-fin base length to P1–P2 space. *Apristurus melanoasper* (♦, present specimens; ◊, North Atlantic specimens); *A. exsanguis* (x); *A. parvipinnis* (–); *A. sinensis* (+).

much longer than the lower ones; P1–P2 space long, greater than anal-fin base length (ceratotrichia); pectoral fin small and slender with rather angular corners, tip not reaching 1/3 of P1–P2 space; anal fin short, high and triangular, base shorter than P1–P2 space; 19–23 intestinal spiral valves; 36–42 monospondylous vertebrae, 26–33 precaudal diplospondylous vertebrae; large dermal denticles (0.4–0.6 mm in width) giving a rough texture to body surface; no dermal denticles on tongue and palate; uniformly blackish brown coloration on body and fins. Therefore, these specimens are considered to belong to the same species of the 'brunneus group' of the genus *Apristurus* defined by Nakaya & Sato (1999).

The 'brunneus group' presently comprises the following 19 species; *Apristurus brunneus* (Gilbert, 1892), *A. canutus* Springer & Heemstra, 1979 *in* Springer (1979), *A. exsanguis* Sato, Nakaya & Stewart, 1999, *A. gibbosus* Meng, Chu & Li, 1985, *A. indicus* (Brauer, 1906), *A. internatus* Deng, Xiong & Zhan, 1988 (possibly a junior synonym of *A. gibbosus*: unpubl. data), *A. investigatoris* (Misra, 1962), *A. japonicus* Nakaya, 1975, *A. laurussonii* (Saemundsson, 1922), *A. macrorhynchus* (Tanaka, 1909), *A macrostomus* Chu, Meng & Li, 1985 *in* Meng, Chu & Li (1985), *A. melanoasper* Iglésias, Nakaya & Stehmann, 2004, *A. micropterygeus* Meng, Chu & Li, 1986 *in* Chu, Meng & Li (1986), *A. nasutus* de Buen, 1959, *A. parvipinnis* Springer & Heesmtra, 1979 *in* Springer (1979), *A. platyrhynchus* (Tanaka, 1909), *A. saldanha* (Barnard, 1925), *A. sibogae* (Weber, 1913) and *A. sinensis* Chu & Hu, 1981 *in* Chu, Meng, Hu & Li (1981).

Present specimens from the waters of Australia and New Zealand, Indian Ocean and eastern South Atlantic Ocean are typically characterised by dorsal fins of similar sizes, anterior position of first dorsal fin, a long P1–P2 space, short and slender pectoral fins, and rough skin related to the larger dermal denticles. Present specimens have first dorsal fin almost the same as second dorsal fin in size, but *Apristurus micropterygeus*, *A. parvipinnis* and *A. platyrhynchus* apparently have smaller first dorsal fins than second dorsal fins. Origin of the first dorsal fin is located clearly above pelvic-fin base in the present specimens, while those of *A. canutus*, *A. micropterygeus*, *A. platyrhynchus*, *A. parvipinnis*, *A. sibogae* and *A. sinensis* are located above posterior end or behind pelvic-fin base. Present specimens have a long P1–P2 space which is 0.9 times or more (mostly more than 1.0) than anal-fin base, while *Apristurus canutus*, *A. investigatoris*, *A. macrorhynchus*, *A. macrostomus*, *A. micropterygeus*, *A. platyrhynchus* and *A. sibogae* have a short P1–P2 space which is only 0.35–0.8 (mostly 0.4–0.7) times anal-fin base. Figure 8 shows the same ratio in the species with a longer P1–P2 space, and present specimens can be differentiated from *A. exsanguis*, *A. sinensis* and *A. parvipinnis*. Pectoral fins of present specimens are small and short, not reaching beyond anterior one third of P1–P2 space (Fig. 9A), while those of *Apristurus canutus*, *A. indicus*, *A. investigatoris*, *A. macrorhynchus*, *A. macrostomus*, *A. platyrhynchus* and *A. sibogae* are large and long, reaching halfway or beyond midpoint of P1–P2 space. Present specimens also have slender pectoral fins with almost parallel outer and inner margins, while *A. canutus*, *A. indicus*, *A. platyrhynchus*

Table 3. Frequency distribution of monospondylous vertebrae counts in available species of the 'brunneus group'.

number	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Present specimens				2	1	5	13	11	8	1						
acanutus			1													
brunneus						4	6	10	16	5	3					
canutus	3	3	4	4												
exsanguis								2	1	7	9	5	1		1	
gibbosus					2	1		2	3	6	1					
indicus							1									
japonicus										1	5	6	6	4	1	2
laurussonii									11	16	19	3				
macrorhynchus							1	3	1							
melanoasper				2	3	9	14	14	5		1					
nasutus			1	4	3	4	2									
parvipinnis					1	8	11	4								
platyrhynchus			1	2	13	8	5	3								
saldanha												1				
sinensis						1	1	1								
verweyi			1													

Table 4. Frequency distribution of precaudal diplospondylous vertebrae counts in available species of the 'brunneus group'.

number	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Present specimens		2	8	2	14	10	3	2	2												
canutus													1		1	3	1				
exsanguis						1	6	7	8	3	2										
gibbosus	2		1			5	4	3													
japonicus					1		4	5	7	4											
laurussonii					2	6	6	14	11	6	2										
macrorhynchus													2	2	1		1				
melanoasper		2	4	15	13	12	1	1													
nasutus		1	6	4	1																
parvipinnis											4	5									
platyrhynchus															1	3	6	5	1		1
saldanha										1											
sinensis					1	1			1												

(Fig. 9B) and *A. sibogae* have wider pectoral fins with a broader distal margin.

Figure 10 shows widths of dermal denticles in some available species. Present specimens are clearly different from *Apristurus gibbosus*, *A. japonicus*, *A. laurussonii*, *A. saldanha* and *A. sinensis* in having wider (larger) dermal denticles. Present specimens have 19–23 intestinal spiral valves, which is clearly different from those of *Apristurus brunneus*, *A. exsanguis*, *A. nasutus*, *A. saldanha* and *A. canutus* (Table 5). Number of monospondylous vertebrae is 36–42 for the present specimens, while that of *A. japonicus* and *A. canutus* are mainly out of this range (Table 3). Furthermore, present specimens have 26–33 precaudal diplospondylous vertebrae, but *A. parvipinnis*, *A. canutus*, *A. macrorhynchus* and *A. platyrhynchus* have larger numbers of precaudal diplospondylous vertebrae, i.e. 35–36, 37–41, 37–41 and 39–45, respectively (Table 4).

Table 5. Frequency distribution of spiral valve counts in available species of the 'brunneus group'.

number	12	13	14	15	16	17	18	19	20	21	22	23
Present specimens								5	9	5	10	5
acanutus							1					
brunneus				1	9	20	12	4				
canutus			2	1	6	3						
exsanguis	5	11	4	1								
gibbosus					1	2	4	3	3	1		
indicus						1						
japonicus						1	5	5	4			
laurussonii					3	25	38	18	9			
melanoasper								4	6	13	16	9
nasutus				8	3	2	3					
parvipinnis							5	5	5	6	1	
platyrhynchus					1	4	7	11	5			
saldanha		1										
sinensis						1	1	1				
verweyi						1						

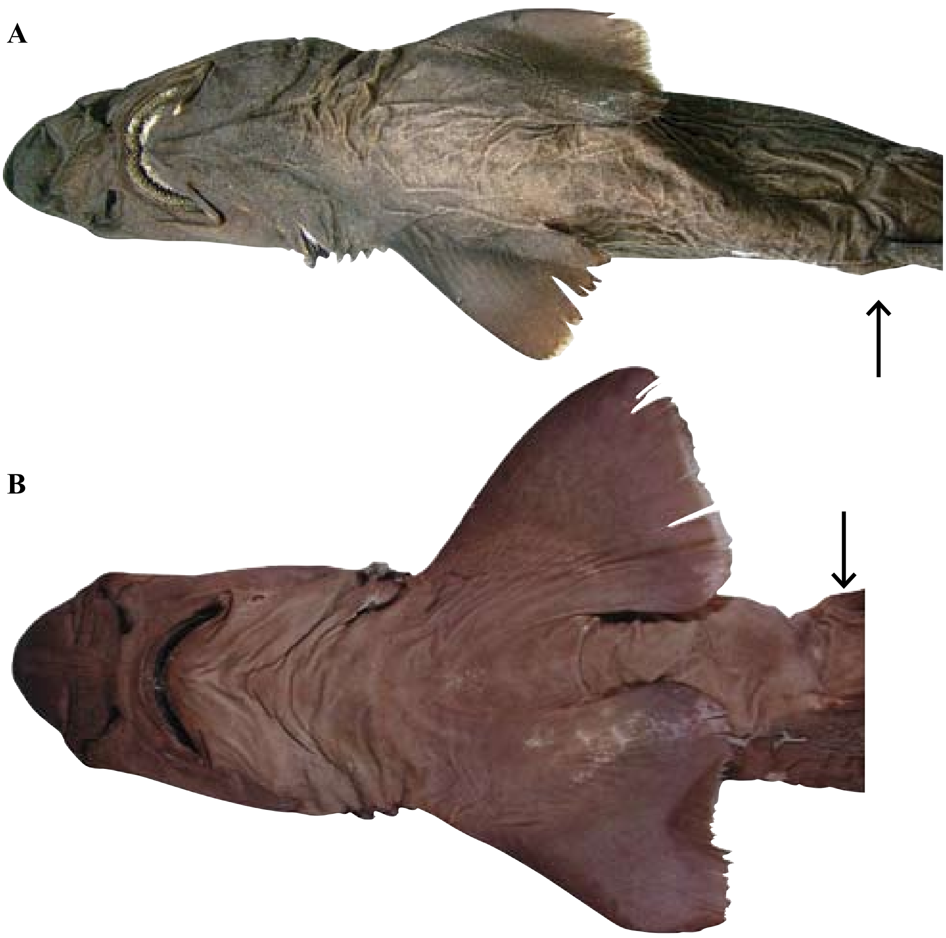

Figure 9. Ventral views of *Apristurus melanoasper* (A) and *A. platyrhynchus* (B), showing differences in pectoral fin shape and P1-P2 space in relation to pectoral fin size. A. Australian specimen, HUMZ 139936, male, 695.3 mm TL; B. TMFE 520, male, 739 mm TL. Arrow indicates origin of pelvic fin.

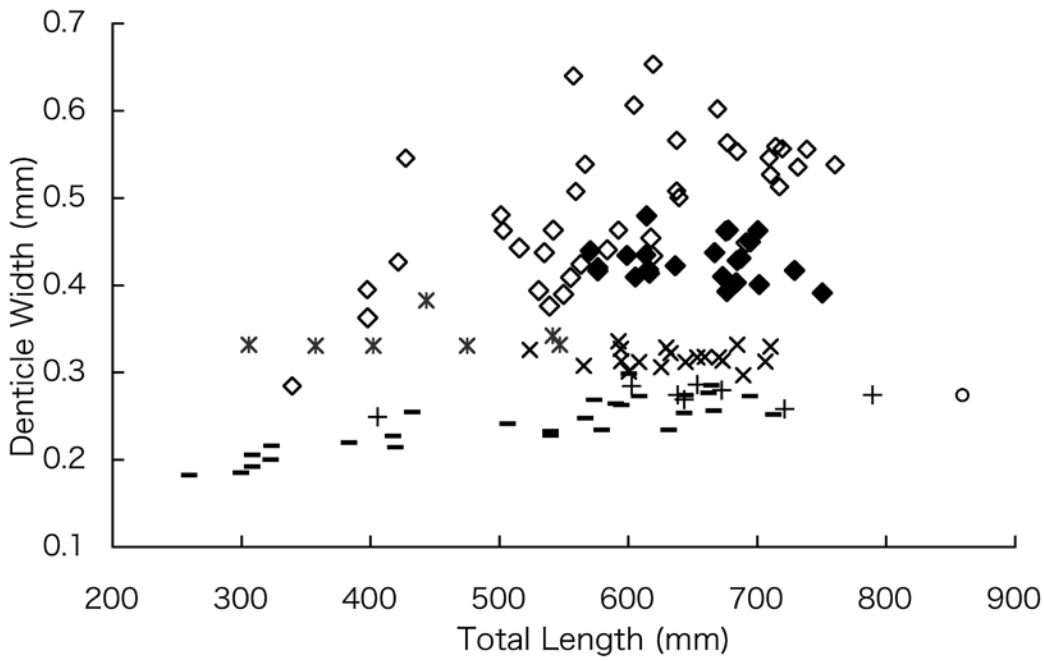

Figure 10. Width of dermal denticle. *Apristurus melanoasper* (♦, present specimens; ◊, North Atlantic specimens); *A. gibbosus* (*); *A. japonicus* (x); *A. laurussonii* (-); *A. sinensis* (+); *A. saldanha* (o).

As discussed above, present specimens are not identical with any other valid species of the genus, except for *Apristurus melanoasper*, which is presently known only from the North Atlantic Ocean. All the diagnostic characters of the present specimens mentioned above overlap with those of *A. melanoasper*, and no obvious specific difference was found between them. Therefore, the specimens from the waters of Australia and New Zealand, Indian Ocean and eastern South Atlantic Ocean are identified as *A. melanoasper* Iglésias, Nakaya & Stehmann, 2004. *Apristurus melanoasper* has the largest geographical distribution among the species of the genus *Apristurus*, ranging from the North Atlantic to the Indian and to the South Pacific Oceans through the South Atlantic. *Apristurus longicephalus* is also known to have a wide distribution from the western North Pacific to the western South Pacific and to the western Indian Ocean (Nakaya, unpublished data; Last & Stevens, 1994; Iglésias, Sellos & Nakaya, 2005). Such an extensive distribution of a species has not been recognised yet in the genus *Apristurus*, or even in the family Scyliorhinidae (Musick *et al*., 2004), and these facts may imply some taxonomic revision of the genus *Apristurus* is necessary.

Comparative materials.
A. acanutus Chu, Meng & Li, 1985: 2 specimens. SCSFRI D–172 (holotype), female 522 mm TL, South China Sea; SFC D161 (paratype), female 520 mm TL, South China Sea.
A. atlanticus (Koefoed, 1927): ZMUB 3203 (holotype), male 247 mm TL, off Canary Islands.
A. brunneus (Gilbert, 1892): 71 specimens. USNM 51708 (holotype), male 478 mm TL, off La Jolla, California; CAS 13425, CAS 15323–3, CAS 15323–4, CAS 15323–5, CAS 15325–1, CAS 15325–2, CAS 15383–2, CAS 40240, CAS 40241, CAS 40242 (2 specimens), CAS 40243 (2 specimens), CAS 40252 (4 specimens), CAS 56248 (4 specimens), CAS 58920, FSFL (Far Seas Fisheries Laboratory, Shimizu, Japan) 568–1, FSFL 568–2, FSFL 568–3, FSFL 568–4, FSFL 568–5, FSFL 568–6, HUMZ 105582, HUMZ 105583, HUMZ 105584, HUMZ 105585, HUMZ 105586, HUMZ 105587, HUMZ 105588, HUMZ 105589, HUMZ 105590, HUMZ 105592, HUMZ 105593, HUMZ 105594, HUMZ 105595, HUMZ 105598, HUMZ 105599, HUMZ 105600, HUMZ 105602, HUMZ 105605, HUMZ 105606, HUMZ 105607, HUMZ 105609, HUMZ 105610, HUMZ 105611, HUMZ 110327, HUMZ 30696, HUMZ 30697, HUMZ 30701, LACM W53–4(5), LACM 30378–1, LACM 30806–1 (2 specimens), LACM 30808–1, SIO 81–3, SIO 83–97, USNM 188033 (2 specimens) (non-types), 40 males and 30 females, 130–648 mm TL, California, U.S.A.
A. canutus Springer & Heemstra, 1979: 14 specimens. USNM 206176 (holotype), female 451 mm TL, Lesser Antilles; USNM 206180 (paratypes), 3 males and 1 female, 318–433 mm TL, Lesser Antilles; USNM 221293, 221294 (2 specimens), USNM 221295, USNM 221297, USNM 221299, USNM 221454, ZMB 31556 (non-types), 4 males and 5 females, 208–436 mm TL, Caribbean Sea.
A. exsanguis Sato, Nakaya & Stewart, 1999: 30 specimens. NMNZ P 21417 (holotype), male 862 mm TL, eastern Chatham Rise, New Zealand; NMNZ P 11406, NMNZ P 13143, NMNZ P 15064 (2 specimens), NMNZ

P 20257, NMNZ P 20341, NMNZ P 21455, NMNZ P 22072, NMNZ P 26833 (2 specimens), HUMZ 135345, HUMZ 135346, NSMT P 42809, NSMT P 42810, AMS I 35885–001, AMS I 35886–001 (paratypes), 11 males and 5 females, 349–869 mm TL; NMNZ P 11826, NMNZ P 12935, NMNZ P 22077, NMNZ P 24251, NMNZ P 24312, NMNZ P 26833 (2 specimens), NMNZ P 27100, NMNZ P 28795, NMNZ P 42769, NMNZ P 42807, NMNZ P 42808, HUMZ 65459 (non-types), 10 males and 3 females, 420–908 mm TL, New Zealand.

A. gibbosus Meng, Chu & Li, 1985: 13 specimens. SCSFRI D1121 (holotype), female 425 mm TL, South China Sea; SFC D–84, SFC D–1133 (paratypes), 2 females, 375 and 390 mm TL, South China Sea; SFC D–94, SFU e–1800097, SFC D–300, SFC D–2268, SFC D–339, SFC E–174, SFC D–700, HUMZ 145164, HUMZ 145166, HUMZ 145171, BSKU 23016, BSKU 23017, BSKU 23060, BSKU 26454, BSKU 26511, BSKU 26357, BSKU 28098, BSKU 28099, BSKU 28100, BSKU 28101, BSKU 28165, BSKU 33526 (non-types), 11 males and 11 females, 231–548 mm TL, East China Sea.

A. indicus (Brauer, 1906): 2 specimens. ZMB 22424 (lectotype), female 364 mm TL, western Indian Ocean off Somalia; ZMB 17411 (paralectotype), female, western Indian Ocean off Somalia.

A. internatus Deng, Xiong & Zhan, 1988: 2 specimens. ECSFI SH80D–0316 (holotype), female 419 mm TL, East China Sea; ECSFI E–1226 (paratype), male 403 mm TL, East China Sea.

A. investigatoris (Misra, 1959): ZSI Fi 627/2 (holotype), female 243 mm TL, Andaman Sea.

A. japonicus Nakaya, 1975: 27 specimens. HUMZ 40082 (holotype), male, 697 mm TL, Choshi, Japan; HUMZ 39961, HUMZ 40075, HUMZ 40076, HUMZ 40077, HUMZ 40078, HUMZ 40079, HUMZ 40080, HUMZ 40081 (paratypes), 7 males and 1 female, 626–711 mm TL, Choshi, Japan; HUMZ 164185, HUMZ 164186, HUMZ 176176, HUMZ 176177, HUMZ 176178, HUMZ 176179, HUMZ 176180, HUMZ 176181, HUMZ 176183, HUMZ 176184, HUMZ 176185, HUMZ 176197, HUMZ 176199, FUMT–P10157, FUMT–P10568, FUMT–P10571, FUMT–P10604, FUMT–P10605 (non-types), 7 males and 11 females, Pacific off northern Japan.

A. laurussonii (Saemundsson, 1922): 45 specimens. NHMR (no catalogue number, holotype), mature female 663 mm TL, off Vestmannaeyjar Island, Iceland, 560 m, 15 Jul 1915; MNHN 1987–0965, MNHN 1989–0680, MNHN 1999–0900, MNHN 1999–0904, MNHN 1999–0905, MNHN 1999–0906, MNHN 1999–0912, MNHN 1999–0915, MNHN 1999–0916, MNHN 1999–0917, MNHN 1999–0919, MNHN 1999–0920, MNHN 1999–0921, MNHN 1999–0922, MNHN 1999–0923, MNHN 1999–0924, MNHN 1999–0926, MNHN 1999–0928, MNHN 1999–0930, MNHN 1999–0931, MNHN 1999–0937, MNHN 2000–1745, MNHN 2000–1746, MNHN 2000–1748, MNHN 2000–1749, MNHN 2000–1750, MNHN 2000–1751, MNHN 2000–1752, MNHN 2000–1753, MNHN 2003–1070, HUMZ 156759, HUMZ 156760, HUMZ 156761, IOS Sm13, IOS 9008, IOS 9018, IOS 11543, ISH 51/1965, ISH 70/1965, ISH 23/1981 (3 specimens), ISH 109/1981, ISH 1052/1982 (non-types), 19 males and 25 females, 124–713 mm TL, North Atlantic Ocean.

A. macrorhynchus (Tanaka, 1909): 36 specimens. ZUMT 2153 (holotype), male 440 mm TL, Misaki, Japan; HUMZ 129580, HUMZ 142890, HUMZ 197806, HUMZ 197807, HUMZ 197808, HUMZ 197809, HUMZ 197810, HUMZ 197811, HUMZ 197812, HUMZ 197813, HUMZ 197814, HUMZ 197815, HUMZ 197816, HUMZ 197817, HUMZ 197818, HUMZ 197819, HUMZ 197820, HUMZ 197821, HUMZ 197822, HUMZ 197823, HUMZ 197824, HUMZ 197825, HUMZ 197826, HUMZ 197827, HUMZ 197828, HUMZ 197829, HUMZ 197830, HUMZ 197831, HUMZ 197832, HUMZ 197833, HUMZ 197834, HUMZ 197835, KPM-NI 10134, KPM-NI 3609, ZUMT 3467 (non-types), 23 males and 12 females, 188–674 mm TL, Japan.

A. macrostomus Chu, Meng & Li, 1985: SCSFRI D–807 (holotype), male 389 mm TL, South China Sea.

A. maderensis Cadenat & Maul, 1966: Holotype. MMF 18750, female 665 mm TL, Madeira.

A. melanoasper Iglésias, Nakaya & Stehmann, 2004: 53 specimens. MNHN 2000–1757 (holotype), mature male 718 mm TL, Lorien Bank, 54°21–22′ N, 19°28–44′ W, 1243–1260 m depth; MNHN 1999–0780, MNHN 1999–0782, MNHN 1999–0783, MNHN 2000–1754, MNHN 2000–1755, MNHN 2000–1756, MNHN 2000–1758, MNHN 2000–1759, MNHN 2000–1760, MNHN 2000–1761, MNHN 2000–1762, MNHN 2000–1763, MNHN 2000–1764, MNHN 2000–1765, MNHN 2000–1766, MNHN 2000–1767, MNHN 2000–1768, MNHN 2001–1111, ISH 26/1974, ISH 49/1974, ARC 8602997 (3 specimens), MCZ 125408, 13 males and 11 females, 340–761 mm TL (paratypes); MNHN 1999–0781, ISH 830/1974 (3 specimens), ISH 3411/1979 (4 specimens), ISH 3711/1979, ISH 3693/1979, ISH 3694/1979 (2 specimens), ISH 85/1981, ARC 8602997 (10 specimens), MCZ 125407, IOS 52106 (2 specimens), MHNLR 403, MHNLR 404, 22 males and 6 females, 243–638 mm TL, North Atlantic (non-types).

A. micropterygeus Meng, Chu & Li, 1986: SCSFRI E–1128 (holotype), male 381 mm TL, South China Sea.

A. nasutus de Buen, 1959: 22 specimens. MNHNC P 6502, MNHNC P 6503 (2 specimens), MNHNC P 6504, MNHNC P 6505, MNHNC P 6506 (2 specimens), MNHNC P 6507, MNHNC P 6508, MNHNC P 6509, MNHNC P 6510, MNHNC P 6511, MNHNC P 6512, USNM 221516, HUMZ 168122, HUMZ 189521, HUMZ 189522, HUMZ 189524, HUMZ 189525, HUMZ 189526, HUMZ 189527, HUMZ 189528, 12 males and 10 females, 171–596 mm TL, Chilean and Peruvian waters.

A. parvipinnis Springer & Heemstra, 1979: 29 specimens. USNM 206178 (holotype), male 472 mm TL, Gulf of Mexico; USNM 206179 (paratype), USNM 200969 (paratypes), 2 females, 403–466 mm TL, Gulf of Mexico; MCZ 40249, UF 27946, UF 39943 (2 specimens), UF

45231 (2 specimens), USNM 165557, USNM 201906 (2 specimens), USNM 221451, USNM 221487, USNM 221488, USNM 221489, USNM 221490, USNM 221496, USNM 221500, USNM 221502, USNM 221508 (2 specimens), USNM 221537, USNM 221639, USNM 221640 (3 specimens), ZMB 31555, 12 males and 13 females, 258–520 mm TL, Caribbean and Gulf of Mexico.

A. platyrhynchus (Tanaka, 1909): 35 specimens. BSKU 22337, BSKU 22788, TMFE 21, TMFE 22, TMFE 23, TMFE 40, TMFE 286, TMFE 287, TMFE 591, TMFE 592, BSKU 26866, BSKU 27062, BSKU 27063, BSKU 27064, BSKU 27065, BSKU 27594, BSKU 27597, BSKU 33521, BSKU 33522, BSKU 33523, BSKU 33524, BSKU 33525, BSKU 33972, HUMZ 103699, HUMZ 103700, HUMZ 145155, HUMZ 145156, HUMZ 145169, HUMZ 145157, HUMZ 145158, HUMZ 145159, HUMZ 145160, HUMZ 145162, HUMZ 145163, HUMZ 145170, 11 males and 24 females, 280–680 mm TL, Japan and East China Sea.

A. saldanha (Barnard, 1925): FAKU 44550, female 884 mm TL, South Africa.

A. sibogae (Weber, 1913): ZMA 111.076 (holotype), female 228 mm TL, Makassar Strait, Indonesia.

A. sinensis Chu & Hu, 1981: SCSFRI 99 (holotype), male, 426 mm TL, South China Sea; HUMZ 145161, HUMZ 145167, HUMZ 145168, 2 males and 1 female, 307–574 mm TL, East China Sea.

A. verweyi (Fowler, 1933): USNM 93135 (holotype), male 303 mm TL, Sibuko Bay, Borneo.

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Occurrence of the deep-water catsharks *Apristurus platyrhynchus* and *Apristurus pinguis* in the Indian and Western South Pacific Oceans (Carcharhiniformes: Scyliorhinidae)

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ABSTRACT.— This paper reports on the occurrences of two Northern Hemisphere species of the genus *Apristurus* from the western South Pacific and Indian oceans. *Apristurus platyrhynchus*, which was originally described from the Japanese waters, was collected from the Indian Ocean off Western Australia, the western South Pacific off Australia and Norfolk Ridge. *Apristurus pinguis*, which is previously known only from the East China Sea, was collected from waters off Tasmania and New South Wales, the West Australian Ridge in the Indian Ocean, and off the North Island of New Zealand. New biological data are also provided.

Key words. Chondrichthyes – Carcharhiniformes – Scyliorhinidae – *Apristurus platyrhynchus* – *Apristurus pinguis* – range extension – deepwater catshark – Indian and Western South Pacific Oceans

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INTRODUCTION

The genus *Apristurus* Garman, 1913 is one of the largest genera among the sharks, and are found globally on continental slopes, trenches, and submarine ridges, except for in polar areas, in depths of 400–2000 m. The genus is characterised by having a slender body, a long and flattened snout, a long anal fin, which is separated from the lower caudal fin by a notch, and the absence of distinct enlarged dermal denticles on the upper margin of the caudal fin. The genus has been reviewed by Springer (1966, 1979), Nakaya (1975, 1991), Compagno (1984, 1988) and Nakaya & Sato (1999). Forty-one species have been described and 32 of these are currently recognised as valid. However, with so many species, this genus is one of the most diverse and most taxonomically confusing genera among living sharks.

No *Apristurus* species from the waters around Australia and New Zealand had been formally reported prior to Paulin *et al*. (1989) and Last & Stevens (1994). Paulin *et al*. (1989) provided a simple key to the species of *Apristurus* in New Zealand waters, but they did not allocate any specific name to them. Last & Stevens (1994) also reported 8 species of *Apristurus* from Australia, but only identified one as a nominal species, *A. longicephalus* Nakaya, 1975, and treated the other 7 species as unidentified species (*Apristurus* sp. A–F). Recently, Sato *et al*. (1999) described *A. exsanguis* from New Zealand and Nakaya & Séret (1999) described *A. albisoma* from New Caledonia. However, the species from these waters have still not been taxonomically reviewed and formally named.

We have made an extensive taxonomic survey of the genus *Apristurus* from the Indian Ocean and the western South Pacific Ocean and in this paper we provide the first records of *Apristurus platyrhynchus* (Tanaka, 1909) and *Apristurus pinguis* Deng, Xiong & Zhan, 1983 from these waters.

METHODS

Morphometric measurements and meristic counts follow Nakaya *et al.* (2008). Vertebral counts were determined from radiographs. Egg capsule terminology follows Cox (1963) and Gomes & Carvalho (1995). Clasper terminology follows Compagno (1988). Anterior teeth in the 2nd–5th rows from the symphysis of both jaws were used for description. Dermal denticles were photographed by a scanning electron microscope (SEM) in the Okinawa Churaumi Aquarium. Sexual maturity stages follow Nakaya *et al*. (2008). Cephalic lateral lines follow Chu & Wen (1979). Institutional acronyms follow Leviton *et al*. (1985) and Eschmeyer (1998).

SYSTEMATICS

Apristurus platyrhynchus (Tanaka, 1909)

Figs 1–7; Table 1

Scyliorhinus platyrhynchus Tanaka, 1909: 4–6; Jordan; Tanaka & Snyder, 1913: 10.

Apristurus platyrhynchus Garman, 1913: 98; Tanaka, 1914: 24; Okada, 1938: 117; Matsubara, 1955: 108; Nakaya, 1975: 28–32, fig. 12; Springer, 1979: 26; Compagno, 1984: 278–279; Nakaya in Masuda *et al*., 1984: 4, pl. 335–B; Compagno, 1988: 170; Compagno, 1999: 478; Nakaya & Sato, 1999: 316; Nakaya & Séret, 1999: 307; Nakabo, 2000: 130; Nakaya & Sato, 2000: 223–229, figs 1–2; Nakabo, 2002: 130; Compagno, Dando & Fowler, 2005: 198–199, pl. 32.

Pentanchus verweyi Fowler, 1934: 237, fig. 2.

Apristurus verweyi Compagno, 1984: 287-288; Compagno, 1988: 170; Compagno, 1999: 478; Nakaya & Sato, 1999: 316; Nakaya & Séret, 1999: 307.

Pentanchus platyrhynchus Fowler, 1941: 57 (in part), not fig. 5.

Apristurus acanutus Chu, Meng & Li *in* Meng, Chu & Li, 1985: 46–47, fig. 3; Compagno, 1999: 478; Nakaya & Sato, 1999: 316; Nakaya & Séret, 1999: 307.

Apristurus sp. B: Last & Stevens, 1994: 169, 174, key fig. 24, pl. 19.

MATERIAL EXAMINED.— Australia (20 specimens): AMS I 20068–016, male 408 mm TL, east of Broken Bay, New South Wales, 33°27′ S, 152°09′ E, 886–895 m, 08 Dec 1977; AMS I 20920–020, female 285 mm TL, north-east of Raine Island, Queensland, 11°32′ S, 144°10′ E, 900 m, 12 Feb 1979; AMS I 21724–018, male 708 mm TL, east of Broken Bay, New South Wales, 33°39′ S, 152°06′ E, 1005 m, 06 Dec 1979; AMS I 24101–005, male 604 mm TL, off Sydney, New South Wales, 33°47′ S, 151°55′ E, 830 m, 25 July 1983; AMS I 24356–008, female 552 mm TL, off Shoalhaven Bight, New South Wales, 34°51′ S, 151°15′ E, 1043–1061 m, 26 Oct 1983; CSIRO H 913–01, male 666 mm TL, east of Sugarloaf Point, New South Wales, 32°20′ S, 153°02′ E, 905–960 m, 16 Feb 1987; CSIRO H 1201–02, female 426 mm TL, Houtman Albrolhos Islands, Western Australia, 29°05′ S, 113°41′ E, 880 m, Feb 1988; CSIRO H 1280–07, female 512 mm TL, east of Nowra, New South Wales, 34°52′ S, 151°15′ E, 981–990 m, 11 Apr 1984; CSIRO H 1286–03, female 548 mm TL, Marian Plateau, northeast of Whitsunday Group, Queensland, 18°53′ S, 150°25′ E, 1005–1013 m, 25 Nov 1985; CSIRO H 1343–01, male 669 mm TL, east of Nowra, New South Wales, 34°53′ S, 151°14′ E, 891–909 m, 11 Apr 1984; CSIRO H 1537–02, female 416 mm TL, east of Brush Island, New South Wales, 35°27′ S, 150°53′ E, 930–

Figure 1. *Apristurus platyrhynchus* Tanaka, 1909: A. lateral view of TMFE 520, adult male 711 mm TL, Japan; B. CSIRO H 913–01, adult male 666 mm TL, Australia; C. ventral view of head of CSIRO H 913–01. Scale bar = 5 cm.

950 m, 19 May 1988; CSIRO H 1543–01, female 507 mm TL, east of Brush Island, New South Wales, 35°26′ S, 150° 53′ E, 890–910 m, 19 May 1988; CSIRO H 2265–02, male 695 mm TL, west of Geraldton, Western Australia, 28°30′ S, 112°55′ E, 960 m, 29 Jan 1989; CSIRO H 2336–01, male 682 mm TL, CSIRO H 2336–02, female 553 mm TL, CSIRO H 2336–03, male 508 mm TL, CSIRO H 2336–04, female 430 mm TL, east of Tuncurry, New South Wales, 32°06′ S, 153°09′ E, 1025–1080 m, 04 May 1988; CSIRO H 2337–01, female 529 mm TL, east of Nowra, New South Wales, 34°51′ S, 151°17′ E, 995–1050 m, 10 May 1988; CSIRO H 2500–01, male 568 mm TL, east of Broken Bay, New South Wales, 33°33′ S, 152°09′ E, 1037–1049 m, 12 Feb 1986; FSFL ED 308, male 525 mm TL, Norfolk Ridge, 28°32′ S, 167°55′ E, 885 m, 18 Jan 1976.

DIAGNOSIS.— A species of *Apristurus* with the following characters: upper labial furrows much longer than the lowers; first dorsal fin much smaller than the second dorsal fin, originating clearly behind posterior end of pelvic-fin base; second dorsal-fin insertion well anterior to anal-fin insertion; abdomen short; P1–P2 space shorter than three fifths of anal-fin base length (ceratotrichia); pectoral-fin tip always posterior to midpoint of P1–P2 space; intestinal spiral valves 16–20; no enlarged dermal denticles along dorsal margin of caudal fin; body and fins uniformly light brown or grey to dark brown.

DESCRIPTION OF AUSTRALIAN SPECIMENS.— Proportional measurements and meristic counts are given in Table 1.

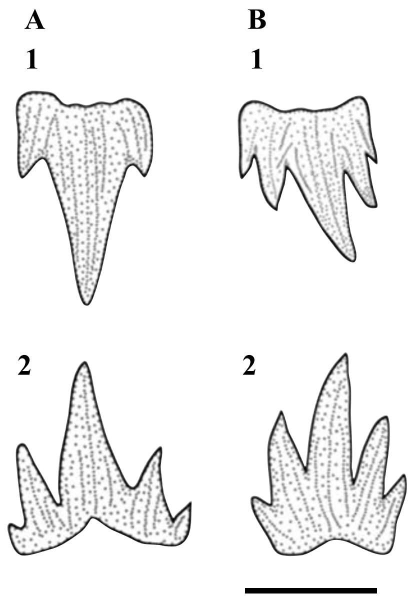

Figure 2. Teeth of *Apristurus platyrhynchus*: A. CSIRO H 2265–02, male 695 mm TL; B. CSIRO H 2336–02, female 553 mm TL; 1. anterior tooth on upper jaw; 2. anterior tooth on lower jaw. Scale bar = 1 mm.

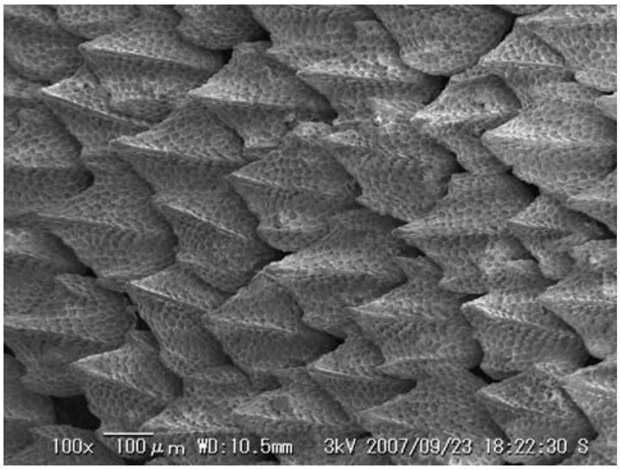

Figure 3. Dermal denticles of *Apristurus platyrhynchus*: CSIRO H 2265–02, male 695 mm TL. Scale bar = 100 µm.

Body cylindrical, slender and elongate (Fig. 1); abdomen short, P1–P2 space much longer than anal-fin base length and subequal to D1–D2 space, pectoral-fin tip reaching ¾ of P1–P2 space; caudal peduncle high, height about half of D1–D2 space. Head dorso-ventrally flattened, posterior part of body compressed laterally. Snout moderate in length; tip pointed. Pre-outer nostril length slightly greater than internarial width. Pre-oral length slightly less than pre-orbital length, about 1.4 times internarial width, slightly greater than mouth width and greater than interorbital width. Pre-orbital length about 1.5 times interorbital width, about 3 times orbit length. Internarial width subequal to orbit and nostril lengths. Nostril oblique, expanding obliquely inward from snout edge; length about half of pre-inner nostril length, about equal to internarial width and orbit length. Nostril–mouth space about half of internarial width. Mouth widely arched, with well developed labial furrows; upper labial furrow 1.5 times longer than the lower one. Upper labial furrow reaching beyond midpoint between mouth corner and posterior margin of nostril. Orbit moderate, with no

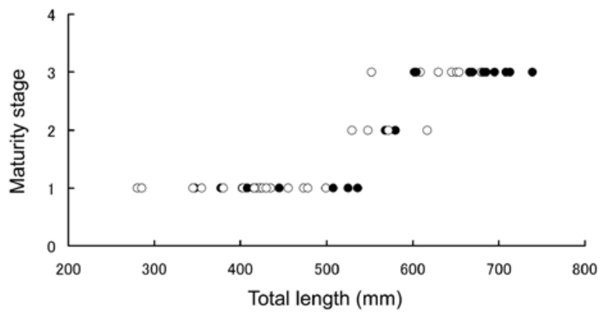

Figure 4. Maturity stages of *Apristurus platyrhynchus* from the western North Pacific Ocean (●) and Australia (○).

Table 1. Proportional measurements (%TL) and meristic counts of *Apristurus platyrhynchus*.

		Present specimens male (10), female (10)	*A. platyrhynchus* male (12), female (26)
1	Total length (mm)	285–708	280–739
3	PreD2-origin length	58.6–62.2	57.7–63.1
5	PreD1-origin length	45.5–49.3	46.5–51.5
6	PreP1 length	19.5–22.5	18.3–24.0
7	PreP2 length	35.7–39.4	36.3–40.8
9	Preanal length	47.6–52.8	46.9–52.7
10	Precaudal length	65.4–69.3	65.8–72.6
11	Pre-branchial length	16.7–19.9	16.3–20.6
13	Pre-orbital length	8.2–11.3	8.5–12.0
14	Pre-outer nostril length	3.8–5.9	4.0–6.0
15	Pre-inner nostril length	6.1–9.1	6.4–9.5
16	Pre-oral length	7.6–10.7	7.4–11.3
17	Head length	19.1–25.2	20.3–25.2
21	Mouth width	7.0–9.6	7.1–10.3
23	Internarial width	3.0–4.2	3.1–4.3
24	Upper labial furrow length	2.6–4.2	2.4–4.6
25	Lower labial furrow length	1.7–2.4	1.6–3.6
26	Orbit length	2.7–3.5	2.7–3.7
28	Nostril length	3.0–4.4	3.2–5.2
30	Interorbital width	5.6–7.6	5.1–7.5
31	1st gill height	1.6–2.7	1.0–3.4
32	3rd gill height	1.3–2.8	1.0–3.2
33	5th gill height	1.2–2.5	0.9–2.8
34	D1–D2 space	6.8–10.1	5.5–9.4
35	D1–D2 origins	12.1–14.9	10.4–12.8
36	D1–D2 insertions	13.7–16.5	11.5–15.2
37	P1–P2 space	6.9–10.2	6.8–11.1
38	P1 tip to P2 origin	1.1–3.9	1.2–5.6
39	P1–P2 origins	14.1–17.7	14.1–18.2
44	D1 base length	4.2–5.0	3.0–6.8
45	D1 height	1.1–1.9	1.2–2.4
46	D1 free lobe length	2.5–3.5	2.2–4.0
48	D2 base length	6.1–6.9	5.2–7.8
49	D2 height	2.1–3.3	2.2–3.6
50	D2 free lobe length	2.5–4.3	3.3–4.8
52	P1 anterior margin	11.0–14.1	11.1–14.3
57	P2 length	8.7–11.1	9.7–13.3
61	Anal base length (ceratotrichia)	15.9–18.9	16.1–20.6
65	Anal height (muscle)	2.7–6.2	4.0–5.7
68	Caudal length	30.5–32.8	29.0–33.5
74	Clasper outer length	1.6–5.1	1.1–5.7
	Tooth rows:		
	upper	68–86	62–85
	lower	69–87	64–85
	Vertebrae:		
	monospondylous	36–38	33–40
	precaudal diplospondylous	39–44	39–45
	Spiral valves	16–19	16–20

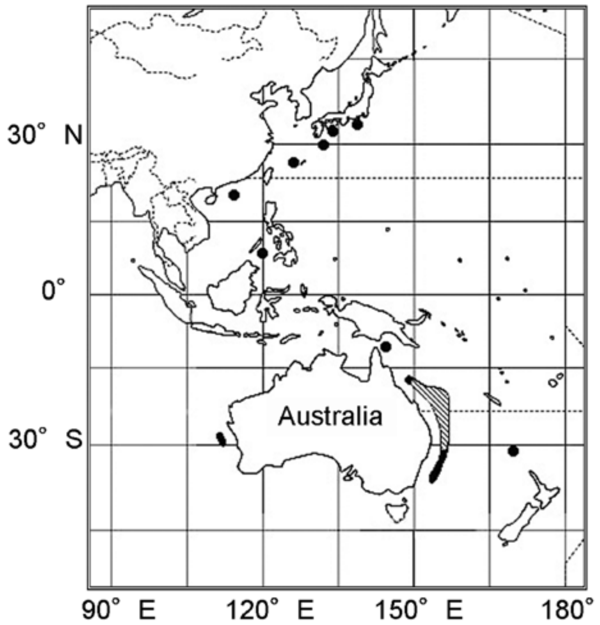

Figure 5. Distribution of *Apristurus platyrhynchus*: black area, present specimens; shaded area from Last & Stevens (1994).

indistinct subocular fold; orbit length about equal to internarial width, half of interorbital width. Spiracle very small placed slightly below level of horizontal axis of orbit. Five small gill slits present; 3rd gill slit above pectoral-fin origin; 5th gill slit smallest, above pectoral-fin base. Gill septa with projection, covered closely with dermal denticles.

Pectoral fin large, wide, sub-triangular; outer margin not parallel to inner margin; right and left fins separated by a space of half of mouth width. Pelvic fin moderate in size, its length subequal to pre-orbital length. Dorsal fins similar in shape. First dorsal fin much smaller than second dorsal fin; origin behind posterior end of pelvic-fin base; insertion behind anal-fin origin (ceratotrichia). Second dorsal-fin origin slightly posterior to mid anal-fin base; insertion always anterior to anal-fin insertion. Anal fin low, triangular, with a base much longer than P1 tip to P2 origin and P1–P2 space; apex clearly anterior to first dorsal-fin insertion; posterior margin straight; anal and caudal fins separated only by a notch. Caudal fin slender; ventral lobe high; apex of ventral lobe rather angular; subterminal notch distinct; terminal lobe moderate, about 1.8 times caudal terminal lobe height.

Intestinal spiral valves 16–19 (n=9). Monospondylous vertebrae 36–38 (n=11); precaudal diplospondylous vertebrae 39–44.

Teeth (Fig. 2) numerous and small, 68–86 rows on upper jaw, 69–87 rows on lower jaw; upper anterior and upper lateral teeth with a long robust central cusp and 1–2 short sharp lateral cusps on both sides of the central cusp; lower anterior and lower lateral teeth with a long robust central cusp, and one short and one minute lateral cusps on each sides of the central cusp.

Dermal denticles (Fig. 3) from dorso-lateral side of body small, overlapping each other; tricuspid, with a long ridged central cusp and shorter lateral cusps; outer surface of denticles completely structured by reticulations. No modified dermal denticles on the dorsal margin of the caudal fin. Dermal denticles densely present around the gill slits and on gill septa.

Clasper stout at base, tapering toward posterior tip; ventral and outer lateral sides covered with dermal denticles. Dorsal side of clasper naked and ventral and lateral sides covered with clasper denticles; clasper hooks absent; pseudosiphon slit-like in shape and deep; cover rhipidion vestigial; pseudopera not distinctively long; exorhipidion flat and simple in shape, with the posterior end free.

COLOUR (in alcohol).— Upper and lower surfaces of body and fins uniformly light brown or grey to dark brown; tongue and palate light brown; peritoneum light brown.

SIZE.— Males attain 713 mm TL, and females reach 654 mm TL. Claspers short and less than 1.7% TL in specimens <536 mm TL, which is ranked as maturity level 1 (immature: Nakaya *et al.*, 2008). Male of 568 mm TL has small but developing claspers (3.4% TL, maturity level 2). Males >602 mm TL have long, well developed claspers (4.9% TL, maturity level 3). Maturity in both sexes (Fig. 4) indicates that males <523 mm TL and females <536 mm TL are immature (maturity level 1), a 568 mm TL male and 523–553 mm TL females are adolescent (maturity level 2) and males >602 mm TL and females >609 mm TL are adult (maturity level 3).

DISTRIBUTION.— Japan (northward to Suruga Bay), East China Sea (Okinawa Trough), Philippines, South China Sea, and Australia (Norfolk Ridge, Queensland, New South Wales and Western Australia) (Fig. 5). Known from depths of 400–1080 m.

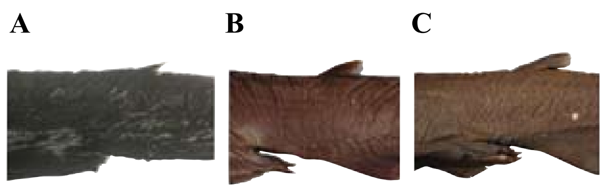

Figure 6. Shape of first dorsal fin: A. *A. micropterygeus*, SCSFRI E1128 (holotype), male 381 mm TL; B. *A. platyrhynchus* TMFE 520, male 711 mm TL, Japan; C. *A. platyrhynchus* CSIRO H 913–01, male 666 mm TL, Australia.

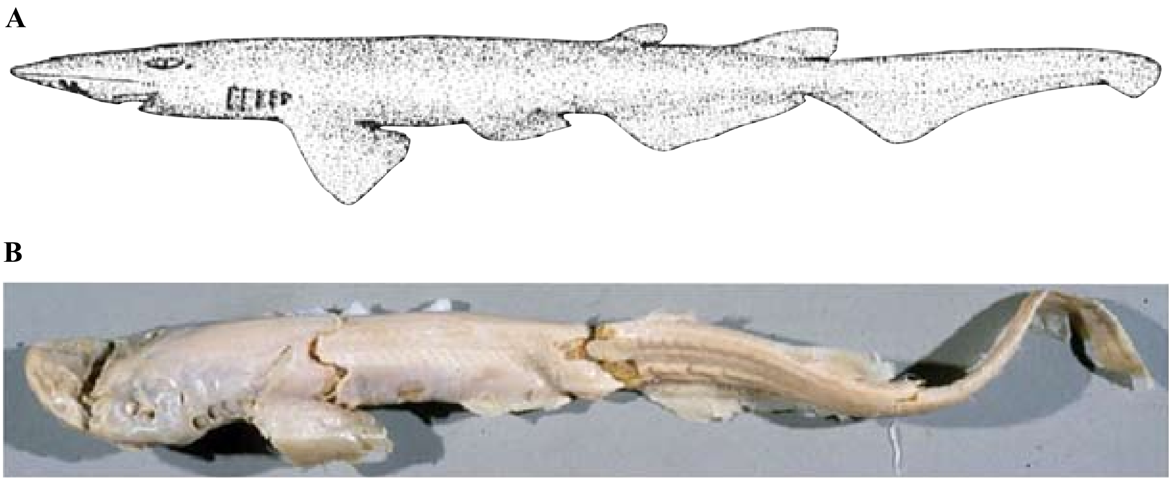

Figure 7. Holotype of *Apristurus sibogae*: ZMA 111076, female 228 mm TL: A., B. from Nakaya (1989).

REMARKS.— The present Australian specimens from the Indian Ocean and the western South Pacific Ocean belong to the 'brunneus group' of Nakaya & Sato (1999) due to a pre-outer nostril length that is shorter than the interorbital width, high spiral valve counts, an upper labial furrow that is longer than the lower furrow, and a discontinuous supraorbital sensory canal. The 'brunneus group' presently comprises the following 19 species: *A. brunneus* (Gilbert, 1892); *A. canutus* Springer & Heemstra *in* Springer, 1979; *A. exsanguis* Sato, Nakaya & Stewart, 1999; *A. gibbosus* Meng, Chu & Li, 1985; *A. indicus* (Brauer, 1906); *A. internatus* Deng, Xiong & Zhan, 1988; *A. investigatoris* (Misra, 1962); *A. japonicus* Nakaya, 1975; *A. laurussonii* (Saemundsson, 1922); *A. macrorhynchus* (Tanaka, 1909); *A. macrostomus* Meng, Chu & Li, 1985; *A. melanoasper* Iglésias, Nakaya & Stehmann, 2004; *A. micropterygeus* Meng, Chu & Li, 1986; *A. nasutus* de Buen, 1959; *A. parvipinnis* Springer & Heemstra *in* Springer, 1979; *A. platyrhynchus* (Tanaka, 1909); *A. saldanha* (Barnard, 1925); *A. sibogae* (Weber, 1913); *A. sinensis* Chu & Hu *in* Chu, Meng, Hu & Li, 1981.

The present Australian specimens agree with *A. micropterygeus*, *A. platyrhynchus* and *A. sibogae* in having the following characteristics in common: a pectoral-fin tip that reaches beyond the midpoint between the paired fin bases, a P1–P2 space that is shorter than the anal fin base (ceratotrichia), a low anal fin with a long base, and a first dorsal-fin origin located posterior to midpoint of the interspace between pelvic and anal fin bases.

The present Australian specimens are distinguishable from *A. micropterygeus* in having a brush-shaped first dorsal fin (vs. a narrow and sharply pointed first dorsal fin in *A. micropterygeus*) (Fig. 6), and from *A. sibogae* by second dorsal-fin insertion clearly anterior to anal-fin insertion (vs. posterior to anal-fin insertion in *A. sibogae*) Figs 1 and 7).

The present Australian materials agree well with the original description and with the specimens collected from the type locality and adjacent areas in meristic counts, proportional measurements and coloration (Fig. 1, Table 1). This paper provides the first record of *Apristurus platyrhynchus* from the South Pacific Ocean.

Apristurus pinguis Deng, Xiong & Zhan, 1983

Figs 8–19; Table 2

Apristurus pinguis Deng, Xiong & Zhan, 1983: 64, fig. 1; Compagno, 1988: 168; Compagno, 1999: 478; Nakaya & Sato, 1999: 316; Compagno, Dando & Fowler, 2005: 198–199, pl. 32.

Apristurus sp. E: Last & Stevens, 1994: 168, 177, key fig. 20, pl. 20; Compagno, Dando & Fowler, 2005: 204–205, pl. 33.

MATERIAL EXAMINED.— Australia (11 specimens): AMS I 24355–002/7, male 342 mm TL, off Shoalhaven, New South Wales, 34°54–56′ S, 151°15–17′ E, 1115–1150 m; AMS I 24644–001/2, male 335 mm TL, off Broken Bay, New South Wales, 33°28′ S, 152°14′ E, 1170–1200 m; AMS I 25095–006/1, female 446 mm TL, east of Woy Woy, Norah Head, New South Wales, 33°28–31′, 152°12–14′ E, 1171–1207 m; HUMZ 139929, male 637 mm TL, HUMZ 139945, female 546 mm TL, north-west of Point Hibbs, Tasmania, 42°25′ S, 144°39′ E, 1230–1242 m, 24 Mar 1988; HUMZ 139942, female 496 mm TL, west of Sandy Cape, Tasmania, 41°25–27′ S, 144°27–28′ E, 24 May 1986; HUMZ 139943, male 595 mm TL, west south-west of Cape Grim, Tasmania,

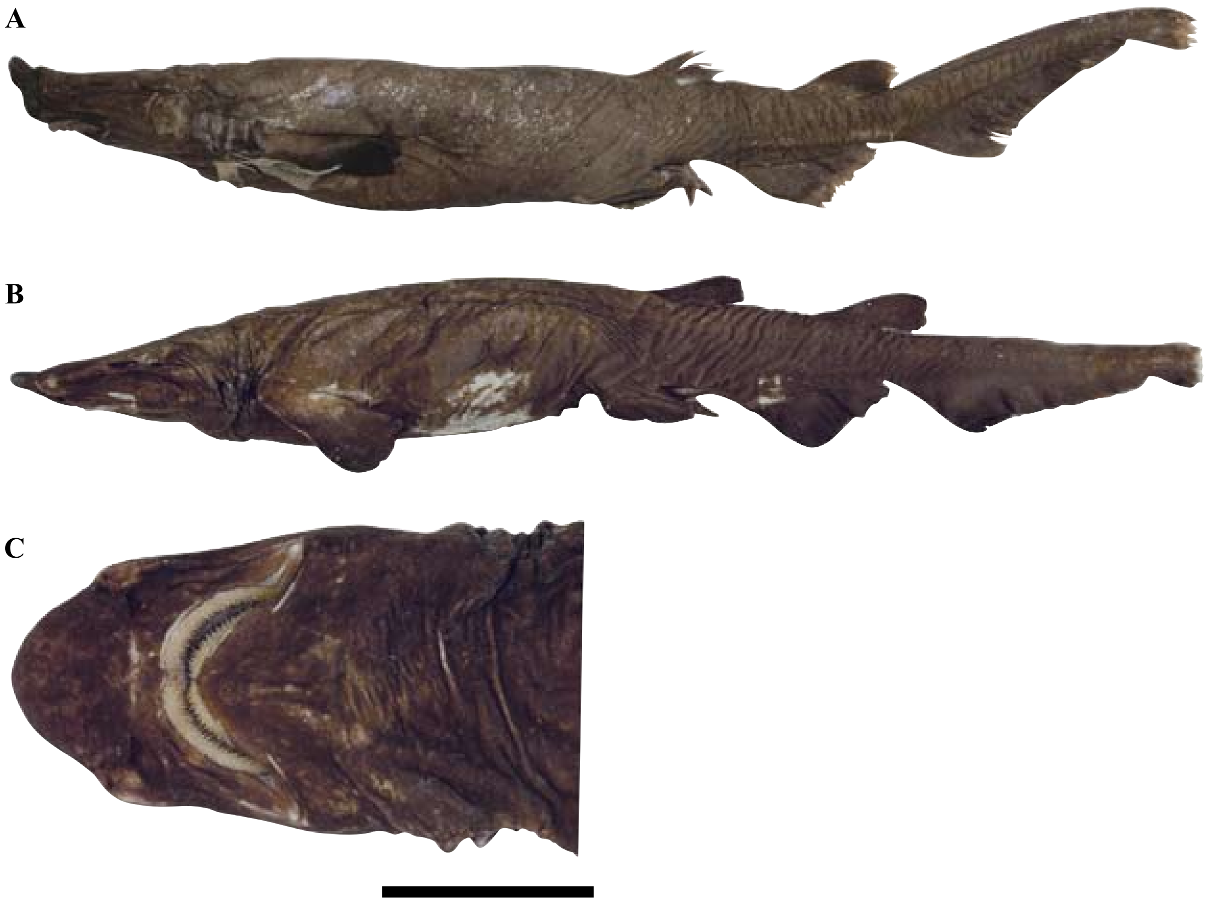

Figure 8. *Apristurus pinguis* Deng, Xiong & Zhan, 1983: A. lateral view of ECSFI SH80D–0312 (holotype), male 558 mm TL, East China Sea; B. lateral view of HUMZ 200708, male 590 mm TL, west of Sandy Cape, Tasmania; C. ventral view of head of HUMZ 200708. Scale bar = 5 cm.

40°54–56′ S, 143°39–41′ E, 1100–1105 m, 20 May 1988; HUMZ 139944, male, 573 mm TL, west of Trial Harbour, Tasmania, 41°57–58′ S, 144°28–30′ E, 1215–1275 m, 23 Mar 1988; HUMZ 200706, male 585 mm TL, west of Trial Harbour, Tasmania, 41°48–52′ S, 144°22–24′ E, 1288–1328 m, 25 May 1986; HUMZ 200707, male 611 mm TL, west of Trial Harbour, Tasmania, 41°57–58′ S, 144°28–29′ E, 1215–1275 m, 23 Mar 1988; HUMZ 200708, male 590 mm TL, west of Sandy Cape, Tasmania, 41°21–23′ S, 144°01–06′ E, 1225–1350 m, 11 Mar 1989. Eastern Indian Ocean (6 specimens): PPSIO uncatalogued (Nakaya No. 333), male 586 mm TL, 30°36′ S, 94°23′ E, 1400 m, 04 Apr 1979; PPSIO uncatalogued (Nakaya No. 334), female 488 mm TL, PPSIO uncatalogued (Nakaya No. 335), female 542 mm TL, 30°50′ S, 93°42′ E, 1250–1300 m, 30 Sep 1976; PPSIO uncatalogued (Nakaya No. 350), female 568 mm TL, 30°55′ S, 93°27′ E, 1150 m, 14 July 1976; PPSIO uncatalogued (Nakaya No. 360), male 652 mm TL, 28°29′ S, 98°11′ E, 1104–1300 m, Apr 1979; PPSIO uncatalogued (Nakaya No. 362), male 566 mm TL, 30°46′ S, 93°20′ E, 1260–1370 m, 26 Sep 1976. New Zealand (5 specimens): NMNZ P 24972, male 460 mm TL, Hikurangi Trough, 41°12′ S, 177°04′ E, 1450–1500 m; NMNZ P 25966, male 549 mm TL, North Chatham Rise, 42°43′ S, 179°12′ E, 1490–1503 m, 21 June 1990; NMNZ P 26253 (2 specimens), female 507 mm TL, female 531 mm TL, 41°14′S, 177°03′E, 1458 m, 02 Oct 1990; NMNZ P 28648, male 639 mm TL, Chatham Rise, 42°31′ S, 178°31′ E, 1452–1464 m, 16 June 1992.

DIAGNOSIS.— A species of *Apristurus* with the following characters: upper labial furrows equal to or slightly shorter than lowers; pre-orbital length relatively short; preP2 length relatively long; supraorbital sensory canal continuous; first dorsal fin slightly smaller than second dorsal fin; anal fin triangular in shape; dermal denticles tricuspid, overlapping each other; no enlarged dermal denticles along dorsal margin of caudal fin; intestinal spiral valves 7–11; mature at a size of about 500 mm TL; body and fins uniformly brown or blackish brown.

DESCRIPTION OF EASTERN INDIAN AND WESTERN SOUTH PACIFIC SPECIMENS.— Proportional measurements and meristic counts are given in Table 2.

Body cylindrical, robust and elongate (Fig. 8); abdomen long, P1–P2 space slightly longer than anal fin base length and subequal to P2–caudal space, pectoral fin tip not reaching anterior 1/3 of P1–P2 space; caudal peduncle high, height about equal to pre-outer nostril length. Head dorso-ventrally flattened, posterior part of body compressed laterally. Snout relatively short, broad; tip broadly rounded. Pre-outer nostril length subequal to internarial width. Pre-oral length slightly less than pre-orbital length, 1.4–2.0 times internarial width, less than mouth width and slightly less than interorbital width. Pre-orbital length subequal to interorbital width, 2.8–4.1 times orbit length. Internarial width subequal to caudal peduncle height. Supraorbital sensory canal continuous (Fig. 9). Nostril large, expanding obliquely inward from snout edge; length about half of pre-inner nostril length, subequal to orbit length. Nostril–mouth space about half of internarial width. Mouth shallowly arched, with well developed labial furrows; upper labial furrow subequal to, or shorter than the lower one. Upper labial furrow not reaching midpoint between mouth corner and posterior margin of nostril. Orbit relatively small; orbit length greater than half of internarial width, a little less than half of interorbital width. Spiracle small placed slightly below level of horizontal axis of orbit. Five small gill slits present; 4th gill slit above pectoral fin origin; 5th gill slit smallest, above pectoral fin base. Gill septa lacking projections, covered closely with dermal denticles.

Pectoral fin relatively small, rounded; right and left fins separated by a space about equal to mouth width. Pelvic fin moderate in size, its length subequal to pre-orbital length. Dorsal fins similar in shape. First dorsal fin slightly smaller than second dorsal fin; origin above pelvic fin base; insertion slightly before anal fin origin (ceratotrichia). Second dorsal-fin origin above mid anal fin base; insertion about above, or slightly anterior to anal fin insertion. Anal fin high, triangular, with a base a little shorter than P1–P2 space; apex slightly posterior to second dorsal-fin origin; posterior margin almost straight; anal and caudal fins separated only by a notch. Caudal fin slender; ventral lobe relatively high; apex of ventral lobe rather rounded; subterminal notch distinct; terminal lobe short, about equal to caudal terminal lobe height.

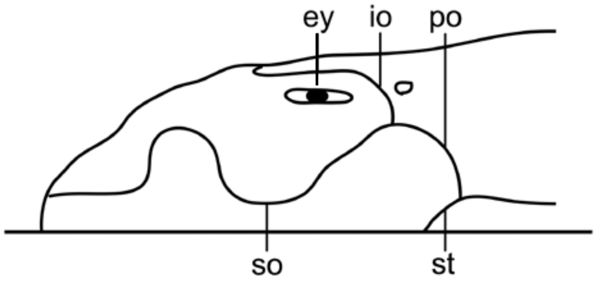

Figure 9. Sensory canal of head (right side) of *Apristurus pinguis*: HUMZ 139943, male 595 mm TL. Ey, eye; io, infraorbital canal; po, postorbital canal; so, supraorbital canal; st, supratemporal canal.

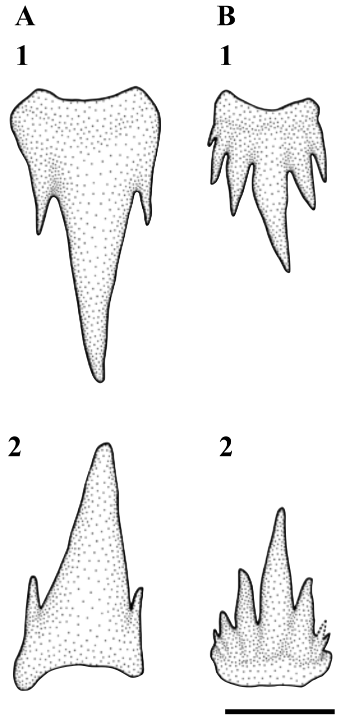

Figure 10. Teeth of *Apristurus pinguis*: A. HUMZ 139943, male 595 mm TL; B. HUMZ 139945, female 546 mm TL; 1. anterior tooth on upper jaw; 2. anterior tooth on lower jaw. Scale bar = 1 mm.

Intestinal spiral valves 8–11 (n=19). Monospondylous vertebrae 33–36 (n=17), precaudal diplospondylous vertebrae 25–29.

Teeth (Fig. 10) numerous and small, 52–70 rows on upper jaw, 50–66 rows on lower jaw; upper anterior and upper lateral teeth of male with a long robust central cusp and a short sharp lateral cusp on both sides of the central cusp;

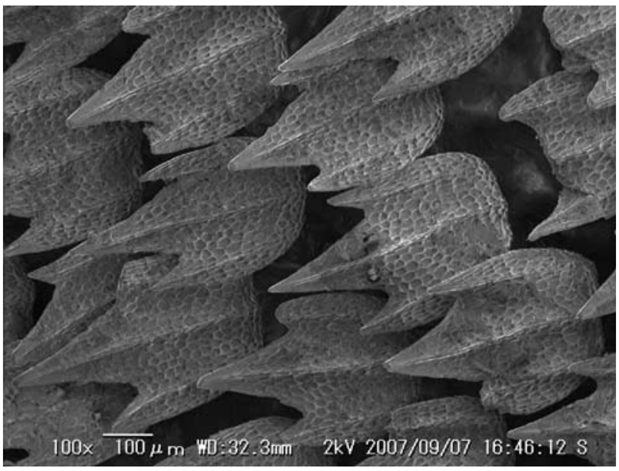

Figure 11. Dermal denticles of *Apristurus pinguis*: HUMZ 139945, female 546 mm TL. Scale bar = 100 µm.

Table 2. Proportional measurements (%TL) and meristic counts of *Apristurus pinguis*.

		Indian and western South Pacific male (15), female (7)	Holotype male
1	Total length (mm)	335–652	558
3	PreD2-origin length	62.0–68.0	64.3
5	PreD1-origin length	48.5–52.5	50.7
6	PreP1 length	20.7–23.4	21.5
7	PreP2 length	44.9–49.0	47.5
9	Preanal length	56.3–61.2	60.2
10	Precaudal length	68.8–75.6	70.4
11	Pre-branchial length	17.4–25.3	18.1
13	Pre-orbital length	8.2–10.8	8.8
14	Pre-outer nostril length	3.4–5.1	3.0
15	Pre-inner nostril length	4.4–7.4	4.8
16	Pre-oral length	6.0–8.9	6.2
17	Head length	21.4–23.9	21.9
21	Mouth width	9.0–11.8	–
23	Internarial width	3.9–5.2	4.6
24	Upper labial furrow length	1.9–3.5	2.9
25	Lower labial furrow length	2.5–3.5	3.2
26	Orbit length	2.4–3.3	2.9
28	Nostril length	2.3–3.5	2.3
30	Interorbital width	7.4–9.9	8.5
31	1st gill height	1.7–2.9	–
32	3rd gill height	1.7–3.3	–
33	5th gill height	1.0–2.2	–
34	D1–D2 space	5.9–10.4	8.2
35	D1–D2 origins	12.7–16.1	14.0
36	D1–D2 insertions	12.9–16.9	14.0
37	P1–P2 space	14.7–20.1	17.8
38	P1 tip to P2 origin	9.8–17.4	13.9
39	P1–P2 origins	20.2–28.7	24.9
44	D1 base length	5.7–8.4	–
45	D1 height	2.0–3.2	–
46	D1 free lobe length	2.2–3.9	–
48	D2 base length	5.8–8.0	–
49	D2 height	2.8–4.0	–
50	D2 free lobe length	3.1–5.3	–
52	P1 anterior margin	9.0–12.6	10.5
57	P2 length	8.9–11.7	–
61	Anal base length (ceratotrichia)	10.0–16.6	11.3
65	Anal height (muscle)	4.7–7.3	5.1
68	Caudal length	25.3–32.7	28.9
74	Clasper outer length	1.6–5.3	5.1
	Dermal denticle width (mm)	0.28–0.36	0.26
	Density of dermal denticles	35.7–62.7	–
	Tooth rows:		
	upper	52–70	61
	lower	50–66	56
	Vertebrae:		
	monospondylous	33–36	–
	precaudal diplospondylous	25–29	–
	Spiral valves	8–11	–

Figure 12. Egg capsule of *Apristurus pinguis* from HUMZ 139942, female 496 mm TL. Scale bar = 1 cm.

lower anterior teeth with a long robust central cusp and a short lateral cusp on both sides of the central cusp; lower lateral teeth with a long robust central cusp, and one short and one minute lateral cusps on symphysial side, and one short lateral cusp on outer side. Upper and lower teeth of females with a long robust central cusp and 2 or 3 short lateral cusps on both sides of the central cusp.

Dermal denticles (Fig. 11) from dorso-lateral side of body large, overlapping; tricuspid, with a long ridged central cusp and shorter lateral cups; outer surface of denticles completely structured by reticulations. No modified dermal denticles on the dorsal margin of the caudal fin. Dermal denticles densely present around the gill slits and on gill septa.

Clasper short and robust, tapering toward the tip; ventral and outer lateral sides densely covered by dermal denticles. Dorsal side of clasper naked except for exorhipidion. Clasper groove covered by rhipidions except for posterior one fifth. Pseudosiphon distinct as a narrow deep groove at postero-inner side of cover rhipidion.

Egg capsule from a female of 496 mm TL (HUMZ 139942, Fig. 12) is characterised by the following features: length 65.3 mm and width 24.4 mm; anterior and posterior end tapering; lacked tendrils; anterior margin of the capsule concave, with a short blunt horn of about 4 mm length at each corner; surface of the capsule lacked any

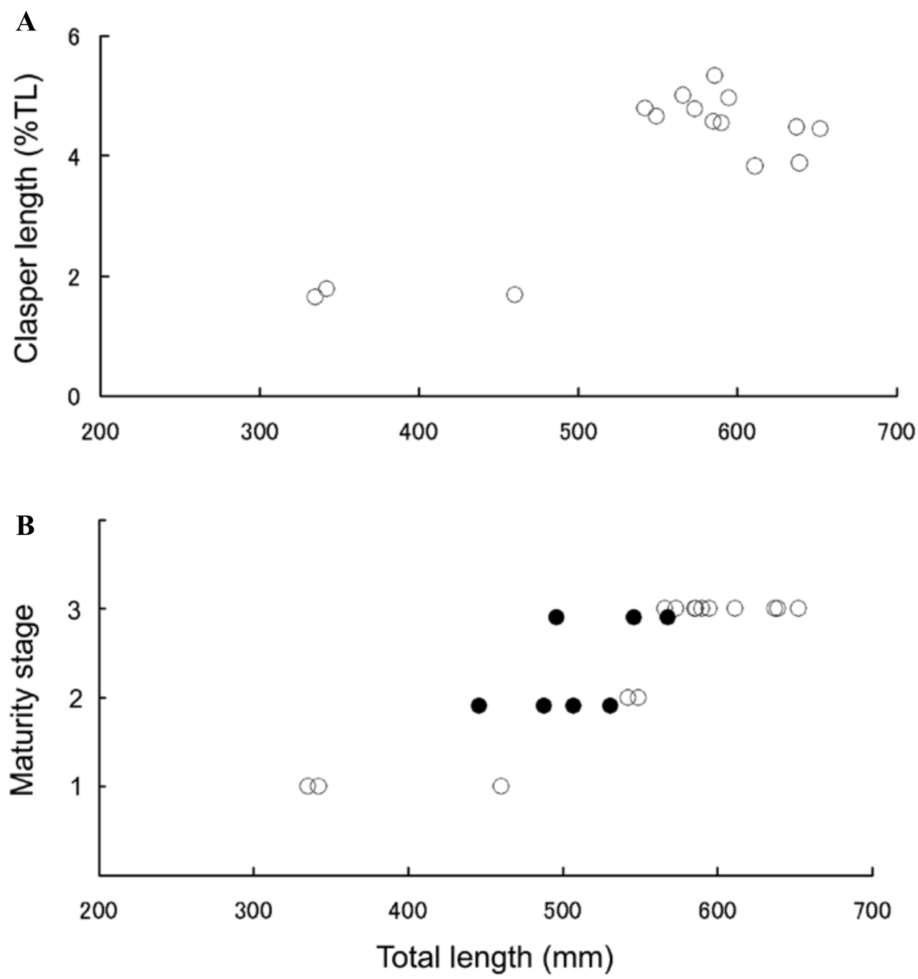

Figure 13. Clasper length (A) and sexual maturity stages (B) of *A. pinguis* from the Indian and the western South Pacific. Males (○), females (●).

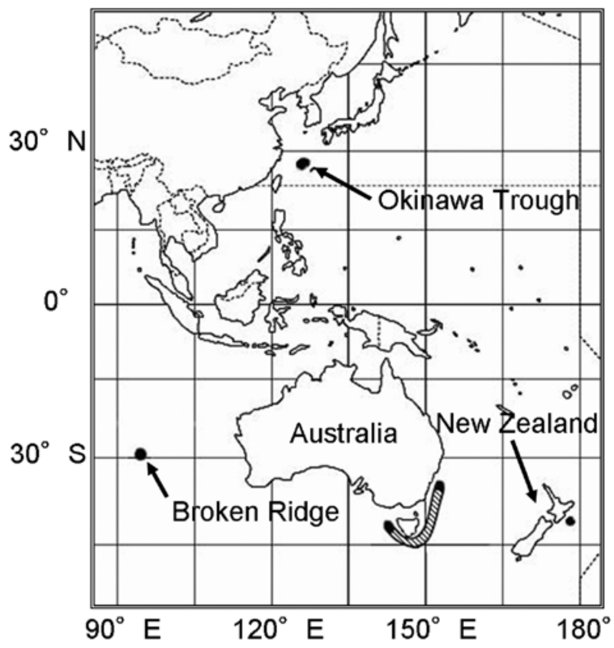

Figure 14. Distribution of *Apristurus pinguis*: black area, present specimens; shaded area from Last & Stevens (1994).

filaments, large number of longitudinal lines on surface of the capsule; lateral edge rounded; two respiratory fissures present as plugged grooves on anterior-left side and posterior-left side per surface of the capsule; capsule dark greenish brown in alcohol.

COLOUR (in alcohol).— Upper and lower surfaces of body and fins uniformly brown or blackish brown; tongue and palate black; peritoneum white.

SIZE.— Males attain 652 mm TL, and females reach 568 mm TL. Claspers (Fig. 13A) short and less than 2.0% TL in specimens <460 mm TL, which is ranked as maturity stage 1 (immature: Nakaya *et al*., 2008). Males of 542–549 mm TL have long but soft claspers (4.7–4.8% TL, maturity stage 2). Males >566 mm TL have long, well developed and hardened claspers (3.8–5.3% TL, maturity stage 3). Maturity in both sexes (Fig. 13B) indicates that males <460 mm TL are immature (maturity stage 1), males of 542–549 mm TL and females of 446–531 mm TL are adolescent (maturity stage 2), and males >566 mm TL and females >496 mm TL are adult (maturity stage 3). One female (HUMZ 139942, 496 mm TL) had a single egg case in the uterus.

SEXUAL DIMORPHISM.— Lateral cusps are more numerous in mature females than mature males. Teeth of mature males are apparently larger than those of mature females.

DISTRIBUTION.— East China Sea (Okinawa Trough), Australia (New South Wales and west coast of Tasmania), Broken Ridge and New Zealand (east of North Island) (Fig. 14). Possibly distributed continuously from New South Wales to Beachport in South Australia (Last & Stevens, 1994). Known from depths of 996–2057 m.

REMARKS.— The present specimens from the Indian Ocean and the western South Pacific Ocean belong to the ‘spongiceps group’ of Nakaya & Sato (1999) due to a pre-outer nostril length that is shorter than the interorbital width, low spiral valve counts, an upper labial furrow that is subequal to, or shorter than the lower furrow, and a continuous supraorbital sensory canal. The ‘spongiceps group’ presently comprises the following 11 species: *Apristurus albisoma* Nakaya & Séret, 1999; *A. aphyodes* Nakaya & Stehmann, 1998; *A. fedorovi* Dolganov, 1985; *A. kampae* Taylor, 1972; *A. manis* (Springer, 1979); *A. microps* (Gilchrist, 1922); *A. pinguis* Deng, Xiong & Zhan, 1983; *A. profundorum* (Goode & Bean, 1896); *A. riveri* Bigelow & Schroeder, 1944; *A. spongiceps* (Gilbert, 1905); and *A. stenseni* (Springer, 1979).

The present specimens are distinguished from *Apristurus fedorovi*, *A. kampae*, *A. manis*, and *A. stenseni* by the combination of the following characteristics: an angular anal fin (Fig. 15) and dense dermal denticles (35.7–62.7 in a 2×2 mm square, Fig. 16). The present specimens also differ from *A. spongiceps* in that they have dense (Fig. 16) and leaf-like dermal denticles (vs. thorn-like in *A. spongiceps*). Therefore, the present specimens are compared with the remaining six species, i.e., *A. albisoma*, *A. aphyodes*, *A. microps*, *A. pinguis*, *A. profundorum* and *A. riveri*.

The present specimens are distinguishable from *Apristurus aphyodes*, *A. microps* and *A. riveri* by having broader interorbital widths. For example, the ratio of orbit length in interorbital width, which decreases with growth, is 2.6–3.8 in the present specimens vs. 2.0–2.5 in *A. aphyodes*, 2.4–3.0 in *A. microps* and 1.9–2.9 in *A. riveri* (Fig. 17). The present specimens are further distinguishable from *A. riveri* in having a first dorsal fin slightly smaller than the second dorsal fin, height of first dorsal fin 0.7–0.9 times height of second dorsal fin (vs. 0.5–0.7 times in *A. riveri*). Moreover, the present specimens have 33–36 monospondylous vertebrae (30–32 in *A. riveri*), and are distinguishable from *A. aphyodes* by a darkish brown body coloration (whitish in *A. aphyodes*, Nakaya & Stehmann, 1998). The present specimens are similar to *A. albisoma*, *A. pinguis* and *A. profundorum* in having broad interorbital widths, but mature at about 500 mm TL and attain 652 mm TL (Fig. 18; vs. 550 and 755 mm TL in *A. profundorum*, respectively). This indicates that the present species attain a smaller size than *A. profundorum*. The present specimens are further separable from *A. profundorum* in having a shorter pre-orbital length and longer prepectoral length. The ratio of pre-orbital length in preP2 length indicates that they are distinguishable from *A. profundorum* (Fig. 19). The present specimens are

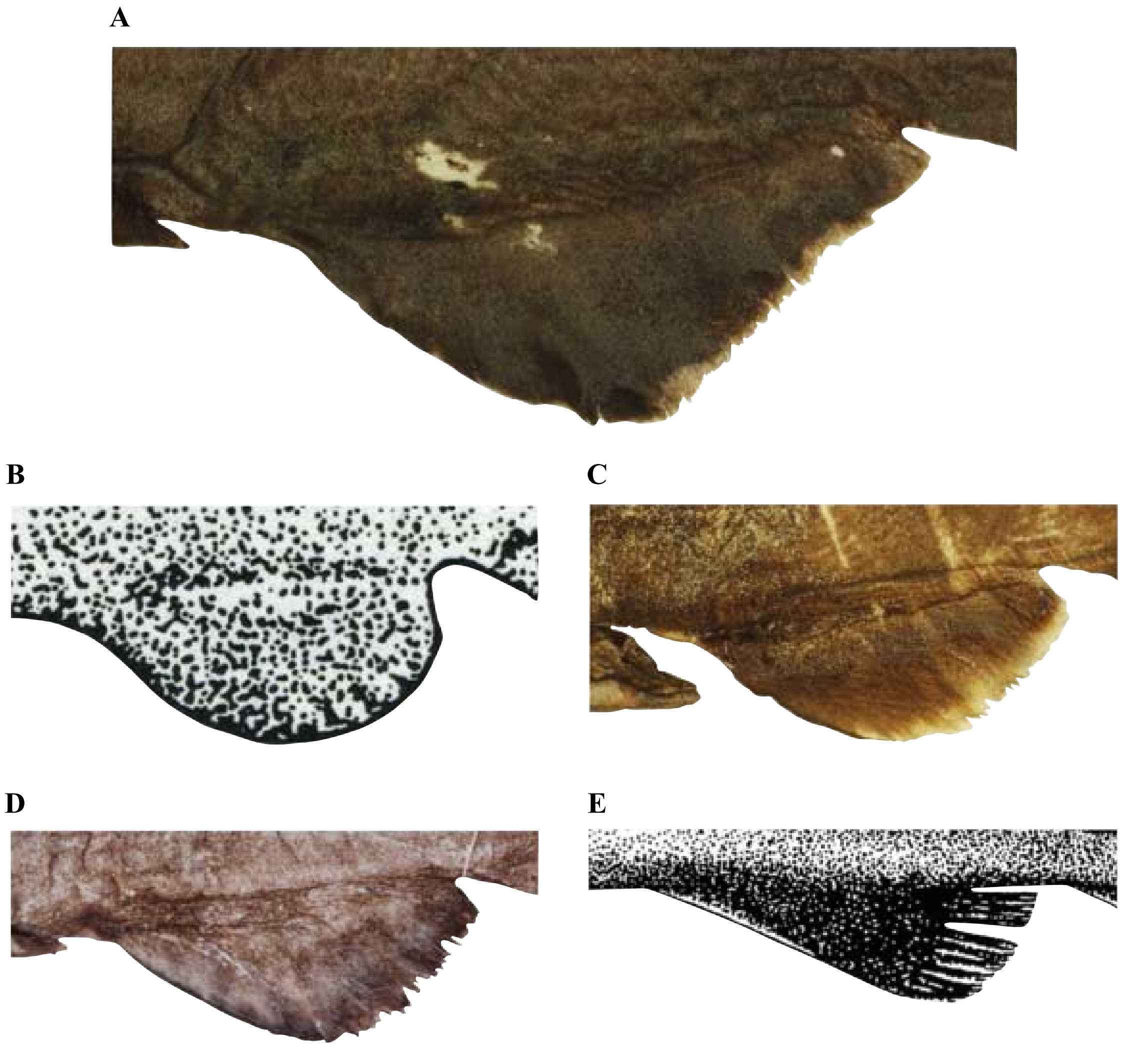

Figure 15. Shape of anal fin of A. *A. pinguis* HUMZ 200707, male 611 mm TL; B. *A. fedorovi*, ZIN 46980 (holotype), male 554 mm TL (from Dolganov, 1985); C. *A. kampae*, HUMZ 110336, male 584 mm TL; D. *A. manis*, MCZ 165122, male 741 mm TL; E. *A. stenseni*, ZMUC P 6146 (holotype), male 185 mm TL (from Springer, 1979).

similar to *A. albisoma* in meristic counts and proportional measurements, but they are distinguishable from *A. albisoma* in having a darkish brown body coloration (vs. whitish in *A. albisoma*, Nakaya & Séret, 1999). The present specimens are quite consistent with the holotype of *A. pinguis* and the specimens collected from the type locality in meristic counts, proportional measurements and coloration, and no specific differences were found. This paper provides the first records of *Apristurus pinguis* from the Indian Ocean and the western South Pacific Ocean.

Comparative material.

Apristurus acanutus Chu, Meng & Li, 1985: 2 specimens. SCSFRI D-0172 (holotype), female 522 mm TL, South China Sea, China; SFC D-0161 (paratype), female 520 mm TL, China.

Apristurus albisoma Nakaya & Séret, 1999: 21 specimens. MNHN 1997–3366 (holotype), male 573 mm TL, New Caledonia; MNHN 1997–3337, MNHN 1997–3350, MNHN 1997–3358, MNHN 1997–3359, MNHN 1997–3360, MNHN 1997–3361, MNHN 1997–3365, MNHN 1997–3368, MNHN 1997–3369, MNHN 1997–3370, MNHN 1997–3372, MNHN 1997–3373, MNHN 1997–3375, MNHN 1997–3376, MNHN 1997–3379–1, MNHN 1997–3379–2, MNHN 1997–3379–3, MNHN 1997–3380, MNHN 1997–3382, MNHN 1997–3383 (paratypes), 13 males and 7 females, 328–596 mm TL, off New Caledonia.

Apristurus aphyodes Nakaya & Stehmann, 1998: 25 specimens. ISH 71/1981 (holotype), male 538 mm TL, George Bligh Bank; BMNH 1998.1.22.1, HUMZ 152329, HUMZ 152330, ISH 24/1981, ISH 36/1981, ISH 49/1981, ISH 84/1981 (6 specimens), ISH 124/1981, ISH 138/1974 (2 specimens), ISH 184/1983 (2 specimens), ISH 187/1983, ISH 739/1974, ISH 807/1974, MNHN

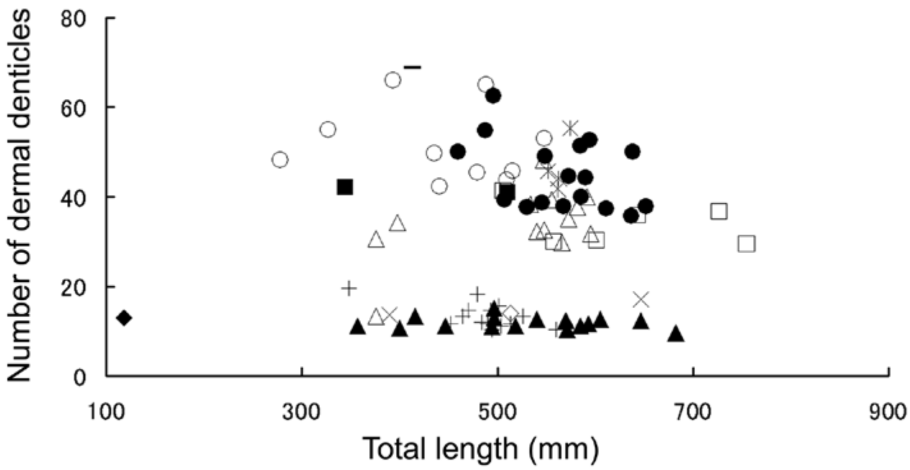

Figure 16. Number of dermal denticles in a 2×2 mm square. *A. pinguis* from the Indian and the western South Pacific (●) and from the East China Sea (○); *A. albisoma* (∆); *A. aphyodes* (■); *A. fedorovi* (▲); *A. kampae* (+); *A. manis* (×); *A. microps* (∗); *A. profundorum* (□); *A. spongiceps* (◊); *A. stenseni* (♦) and *A. riveri* (–).

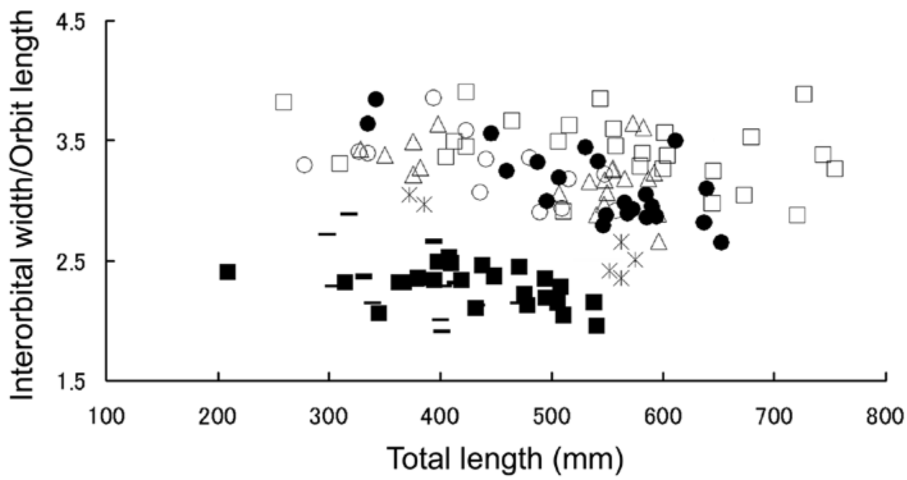

Figure 17. Ratio of orbit length in interorbirtal width: *A. pinguis* from the Indian and the western South Pacific (●) and from the East China Sea (○); *A. albisoma* (∆); *A. aphyodes* (■); *A. microps* (∗); *A. profundorum* (□) and *A. riveri* (–).

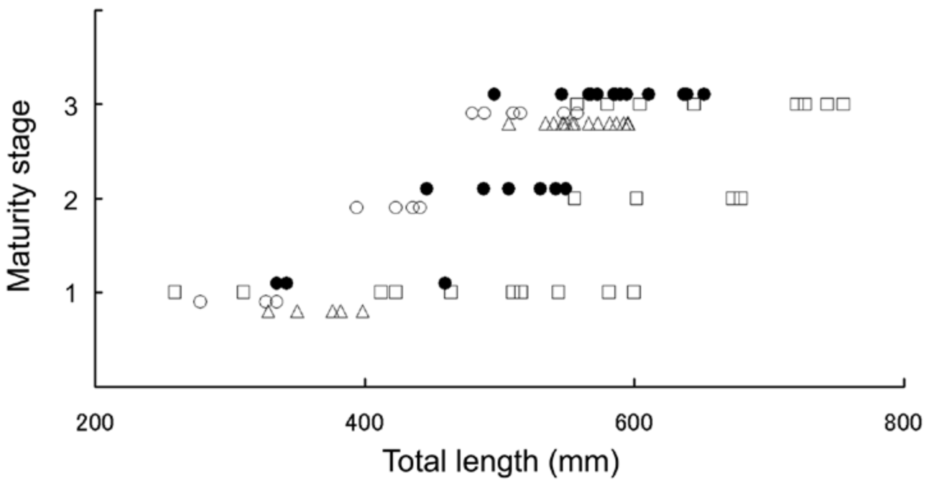

Figure 18. Sexual maturity stages: *A. pinguis* from the Indian and the western South Pacific (●) and from the East China Sea (○); *A. albisoma* (∆) and *A. profundorum* (□).

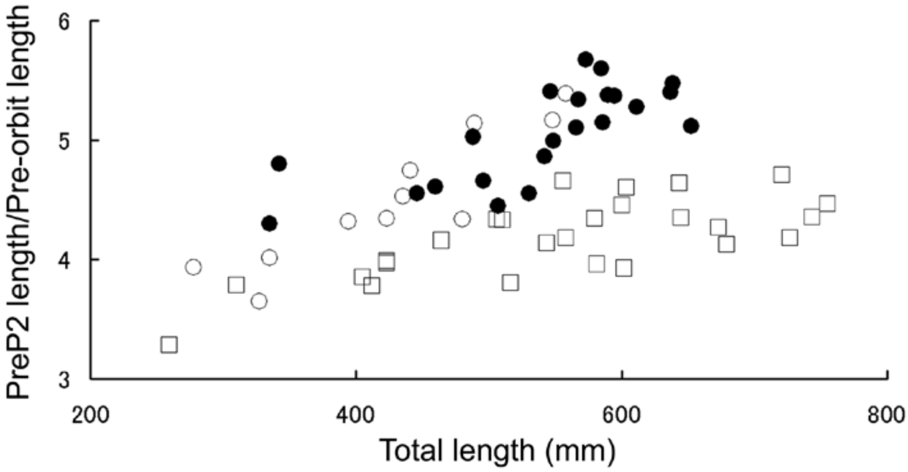

Figure 19. Ratio of pre-orbital length in preP2 length: *A. pinguis* from the Indian and the western South Pacific (●), from East China Sea (○) and *A. profundorum* (□).

1998–41, USNM 347837, ZIN N 51551, ZMUB 10171 (paratypes), 11 males and 13 females, 209–540 mm TL, Northeast Atlantic.

Apristurus fedorovi Dolganov, 1985: 55 specimens. ZIN 46980 (holotype), male 554 mm TL, off Iwate Pref., Japan; HUMZ 40073, HUMZ 40074, HUMZ 69163, HUMZ 72690, HUMZ 72716, HUMZ 72871, HUMZ 73030, HUMZ 74628, HUMZ 78038, HUMZ 78052, HUMZ 78064, HUMZ 78071, HUMZ 78100, HUMZ 78101, HUMZ 78105, HUMZ 78140, HUMZ 78174, HUMZ 78195, HUMZ 78196, HUMZ 78260, HUMZ 78276, HUMZ 78281, HUMZ 78316, HUMZ 78318, HUMZ 78333, HUMZ 78334, HUMZ 78374, HUMZ 78454, HUMZ 164184, HUMZ 176203, HUMZ 176204, HUMZ 176205, HUMZ 176206, HUMZ 176208, HUMZ 176211, HUMZ 176218, HUMZ 176219, HUMZ 176220, HUMZ 176221, HUMZ 176225, HUMZ 176229, HUMZ 176231, HUMZ 176236, HUMZ 176242, HUMZ 176243, HUMZ 176244, HUMZ 176245, HUMZ 176247, HUMZ 176249, HUMZ 176251, HUMZ 176252, HUMZ 176257, HUMZ 176258, HUMZ 176259 (non-types), 28 males and 26 females, 320–683 mm TL, off northern Japan.

Apristurus kampae Taylor, 1972: 46 specimens. SIO 70–248–5 (holotype), female 348 mm TL, Gulf of California, Mexico; CAS 38287, CAS 57935, HUMZ 105601, HUMZ 105603, HUMZ 105604, HUMZ 105608, HUMZ 110317, HUMZ 110318, HUMZ 110319, HUMZ 110320, HUMZ 110321, HUMZ 110322, HUMZ 110323, HUMZ 110324, HUMZ 110325, HUMZ 110326, HUMZ 110330, HUMZ 110331, HUMZ 110332, HUMZ 110333, HUMZ 110334, HUMZ 110335, HUMZ 110336, HUMZ 110337, HUMZ 167446, HUMZ 167571, HUMZ 167572, HUMZ 167770, HUMZ 167822, HUMZ 167823, HUMZ 167824, HUMZ 169864, HUMZ 174358, HUMZ 174359, HUMZ 174628, HUMZ 174707, HUMZ 174708, HUMZ 174709, HUMZ 175106, LACM 37449–1, SIO 70–299, SIO 71–190, SIO 88–98, SIO 88–99, SIO 88–100 (non-types), 27 males and 18 females, 198–584 mm TL, off California, off Galapagos Islands and off Peru.

Apristurus manis (Springer, 1979): 56 specimens. MCZ 38299 (holotype), female 390 mm TL, off Massachusetts, USA; MCZ 37416 (2 specimens), MCZ 37512, MCZ 37535 (paratypes), 3 males and 1 female, 227–255 mm TL, off Massachusetts; ARC 8601097, ARC 8602997, ISH 154/1974a, ISH 154/1974b, ISH 3412/1979, ISH 3449/1979, ISH 3696/1979, ISH 3712/1979, ISH 3713/1979 (2 specimens), MCZ 37407, MCZ 165118, MCZ 165122, MCZ 165144, uncatalogued (37 specimens) (non-types), 14 males and 37 females, 183–852 mm TL, North Atlantic.

Apristurus microps (Gilchrist, 1922): 6 specimens. FAKU 46061, FAKU 46063, FSFL EM 322, FSFL S 639, ISH 195/1967 (2 specimens), 5 males and 1 female, 372–575 mm TL, off South Africa.

Apristurus micropterygeus (Meng, Chu & Li, 1986): SCSFRI E–1128 (holotype), male 381 mm TL, South China Sea.

Apristurus pinguis Deng, Xiong & Zhan, 1983: 13 specimens. ECSFI SH80D-0312 (holotype), male 558 mm TL, East China Sea, China; HUMZ 145143, HUMZ 145144, HUMZ 145145, HUMZ 145146, HUMZ 145147, HUMZ 145148, HUMZ 145149, HUMZ 145150, HUMZ 148375, HUMZ 148376, HUMZ 148377, HUMZ 148378 (non-types), 7 males and 5 females, 278–548 mm TL, Okinawa Trough, East China Sea, Japan.

Apristurus platyrhynchus (Tanaka, 1909): Japan (12 specimens): BSKU 22337, BSKU 22788, 2 females, 345-355 mm TL, off Tosa, Kochi Pref., Japan, 960–985 m; TMFE 21, TMFE 22, TMFE 23, 3 females, 645–680 mm TL, Suruga Bay, Shizuoka Pref., Japan, TMFE 40, male 536 mm TL, Suruga Bay, off Hagachi Cape, Shizuoka Pref., Japan, 675–720 m, TMFE 286, TMFE 287, 2 females, 609–630 mm TL, off Heda, Shizuoka Pref., Japan, 625–750 m; TMFE 591, TMFE 592, male and female, 602–617 mm TL, off Omaezaki, Shizuoka Pref., Japan, 400–600 m; HUMZ 103699, HUMZ 103700, male and female, 484–528 mm TL, Kumano-Nada, Mie Pref., Japan. East China Sea (23 specimens): BSKU

26866, BSKU 27062, BSKU 27063, BSKU 27064, BSKU 27065, BSKU 27594, BSKU 27597, BSKU 33521, BSKU 33522, BSKU 33523, BSKU 33524, BSKU 33525, BSKU 33972, 7 males and 6 females, 280–499 mm TL, Okinawa Trough, Japan, 610–810 m; HUMZ 145155, HUMZ 145157, HUMZ 145158, HUMZ 145159, HUMZ 145160, HUMZ 145162, HUMZ 145163, HUMZ 145156, HUMZ 145169, HUMZ 145170, 1 male and 9 females, 304–592 mm TL, Okinawa Trough, Japan.

Apristurus profundorum (Goode & Bean, 1896): 27 specimens. USNM 35646, male 510 mm TL, off Delaware Bay in Gulf Stream; HUMZ 151216, HUMZ 151243, HUMZ 151244, HUMZ 151247, ISH 49/1981, ISH 697/1974, ISH 698/1974 (2 specimens), ISH 943/1973 (2 specimens), ISH 944/1973, ISH 945/1973, MCZ 58434, MCZ 158889, MCZ 162007 (3 specimens), MCZ 165125, ZMUB 16510, ZMUB 16511 (3 specimens), ZMUB 16512, ZMUB 16513, uncatalogued (2 specimens) (non-types), 10 males and 16 females, 259–755 mm TL, North Atlantic.

Apristurus riveri Bigelow & Schroeder, 1944: 17 specimens. MCZ 36092 (holotype), female 413 mm TL, off Northern Cuba; USNM 199395, USNM 199396, USNM 201760 (4 specimens), USNM 221526 (2 specimens), USNM 221528, USNM 221530, USNM 221531, USNM 221533 (2 specimens), USNM 221535, USNM 221536 (2 specimens) (non-types), 7 males and 9 females, 298–470 mm TL, Caribbean and Gulf of Mexico.

Apristurus sibogae (Weber, 1913): ZMA 111076 (holotype), female 228 mm TL, Makassar Strait, Indonesia.

Apristurus spongiceps (Gilbert, 1905): USNM 51590 (holotype), female 514 mm TL, off Bird Island, Hawaiian Islands, USA.

Apristurus stenseni (Springer, 1979): 13 specimens. ZMUC P 6146, male 185 mm TL, Gulf of Panama; HUMZ 138785, HUMZ 138786, ZMUC P 6147, ZMUC P 6148, ZMUC P 6159, ZMUC P 6162, ZMUC P 6164, ZMUC P 6166, ZMUC P 6167, ZMUC P 6173, ZMUC P 6182, ZMUC P 6189 (paratypes), 9 males and 2 females (1 specimen sex unknown), 118–228 mm TL, Gulf of Panama.

Apristurus verweyi (Fowler, 1933): 5 specimens. USNM 93135 (holotype), male 303 mm TL, Sibuko Bay, Borneo; HUMZ 105984, male 438 mm TL; HUMZ 105985, male 445 mm TL; ZUMT 3424, female 654 mm TL; TMFE 520, male 711 mm TL, Japan.

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A new species of deepwater catshark, *Apristurus ampliceps* sp. nov. (Chondrichthyes: Carcharhiniformes: Scyliorhinidae), from New Zealand and Australia

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ABSTRACT.— *Apristurus ampliceps* sp. nov. is described from the waters off New Zealand and Australia at depths of 800–1503 m. The description is based on 10 type specimens, which include immature and mature males and females, ranging from 656–836 mm TL. This new species is characterised by the following features: upper labial furrow about equal to, or slightly shorter than the lower one; pre-outer nostril length 4.5–6.6% TL; upper jaw semicircular; supraorbital sensory canal continuous; first dorsal fin slightly smaller, or equal to the second dorsal fin; anal fin rounded; dermal denticles narrow leaf-like and sparse in distribution; no enlarged dermal denticles along dorsal margin of caudal fin; spiral valves in the intestine 8–11; mature size 650–750 mm TL; body and fins uniformly brown or blackish brown.

Key words. Chondrichthyes– Carcharhiniformes – Scyliorhinidae – *Apristurus ampliceps* – new species – deepwater catshark – New Zealand – Australia

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INTRODUCTION

The genus *Apristurus* Garman, 1913 is one of the largest genera among the sharks, and are found globally on continental slopes, trenches, and submarine ridges except for in polar areas, in depths of 400–2000 m. This genus is characterised by having a slender body, a long and flattened snout, a long anal fin, which is separated from the lower caudal fin by a notch, and the absence of distinct enlarged dermal denticles on the upper margin of the caudal fin.

Currently 32 species are recognised as valid from the world oceans, and they are divided into three groups, i.e. the 'longicephalus group', the 'spongiceps group' and the 'brunneus group' (Nakaya & Sato, 1999). In the 'spongiceps group', 11 species are considered valid, and only *A. albisoma* Nakaya & Séret, 1999 has been described from the Indian and western South Pacific Oceans. However, some unnamed and undescribed species of the 'spongiceps group' have been reported from these regions by Paulin *et al*. (1989) and Last & Stevens (1994). In this paper we describe a new species of the genus *Apristurus* from Australia and New Zealand, referable to *Apristurus* sp. E of Paulin *et al*. (1989) and *Apristurus* sp. D of Last & Stevens (1994).

METHODS

Morphometric measurements and meristic counts follow Nakaya *et al.* (2008). Vertebral counts were determined from radiographs. Clasper terminology follows Compagno (1988). Anterior teeth in the 3rd–7th rows and lateral teeth in the 15th–19th rows from the symphyses of both jaws were used for the description. Dermal denticles and teeth were photographed by a scanning electron microscope (SEM) in the Okinawa Churaumi Aquarium. Definition of sexual maturity stages follows Nakaya *et al*. (2008). Institutional acronyms are those of Leviton *et al*. (1985) and Eschmeyer (1998).

Apristurus ampliceps sp. nov.

Figs. 1–14; Table 1

Apristurus sp. D: Last & Stevens, 1994: pp 168, 176, key fig. 19, pl. 20; Compagno, Dando & Fowler, 2005: p 204, pl. 33.
Apristurus sp. E: Paulin *et al*., 1989: p 22, key.

Holotype. NMNZ P 27063, mature male 826 mm TL, off Urry Bank, New Zealand, 44°56′ S, 174°06′ E, 1052–1105 m, 03 Nov 1990.

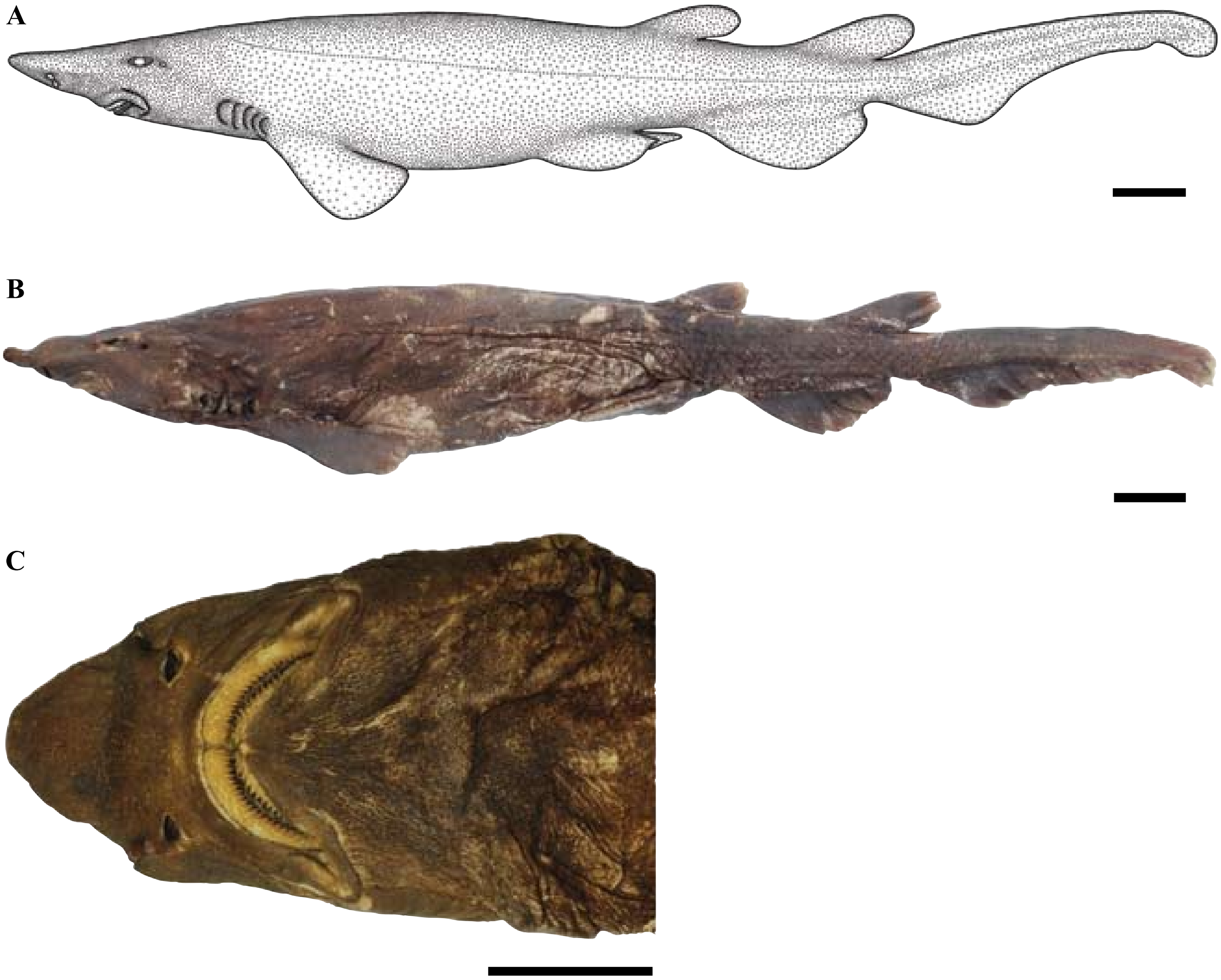

Figure 1. *Apristurus ampliceps* sp. nov., holotype, NMNZ P 27063, mature male 826 mm TL, off Urry Bank, New Zealand: A. lateral view (drawing); B. lateral view (photograph); C. ventral view of head. Scale bar = 5 cm.

Paratypes. 9 specimens. CSIRO H 559–01, male 765 mm TL, west of Cape Sorell, Tasmania, Australia, 42°11–16′ S, 144°36′ E, 1380–1440 m, 18 May 1986; CSIRO H 1009–05, male 821 mm TL, north-west of Sandy Cape, Tasmania, Australia, 41°12–16′ S, 143°56–58′ E, 1110–1190 m, 11 Aug 1987; CSIRO H 5128–01, female 695 mm TL, South Tasman Rise, Tasmania, Australia, 47°10′ S, 148°44–45′ E, 927–1005 m, 28 Feb 1998; HUMZ 135347, female 656 mm TL, off Urry Bank, New Zealand, 45°19′ S, 174°47′ E, 1055–1074 m, 04 Nov 1990; HUMZ 135349, male 780 mm TL, Chatham Rise, New Zealand, 44°52′ S, 174°53′ E, 871–883 m, 09 Nov 1991; HUMZ 139938, male 836 mm TL, west of Cape Sorell, Tasmania, Australia, 42°16–24′ S, 144°38–40′ E, 1130–1140 m, 22 Oct 1983; HUMZ 139939, male 801 mm TL, south-west of Port Davey, Tasmania, Australia, 43°31–32′ S, 145°32–34′ E, 1100–1140 m, 26 May 1988; HUMZ 139940, female 762 mm TL, Bass Strait, Victoria, Australia, 39°21–22′ S, 142°40–41′ E, 1120–1175 m, 04 Mar 1989; HUMZ 139941, female 729 mm TL, south-west of Macquarie Harbour, Tasmania, Australia, 42°50–52′ S, 144°51′ E, 1140–1145 m, 20 Mar 1989.

Other material. 17 specimens. NMNZ P 14865, male 527 mm TL, east of Canterbury Bight, New Zealand, 44°56′ S, 173°16′ E, 1130–1220 m, 29 Nov 1983; NMNZ P 16016, female 678 mm TL, Chatham Rise, New Zealand, 42°46′ S, 175°30′ E, 1196–1198 m, 22 July 1984; NMNZ P 17385, male 826 mm TL, Chatham Rise, New Zealand, 44°37′ S, 176°18′ E, 1019–1091 m, 07 May 1985; NMNZ P 18037, male 821 mm TL, between Chatham Rise and Bounty Trough, New Zealand, 44°21–23′ S, 178°02–03′ E, 1185 m, 09 Dec 1985; NMNZ P 20340, male 420 mm TL, north-east of Chatham Rise, New Zealand, 42°44′ S, 176°32′ E, 1198–1202 m, 11 July 1986; NMNZ P 23288, male 501 mm TL, north-east of Chatham Rise, New Zealand, 42°48′ S, 175°49′ E, 1153–1154 m, 10 Aug 1988; NMNZ P 23793, female 583 mm TL, north-east of Chatham Rise, New Zealand, 43°21′ S, 173°53′ E, 1220–1270 m, 20 Sep 1988; NMNZ P 24195, male 733 mm TL, Tasman Plateau, Tasmania, Australia, 47°12′ S, 147°48′

E, 1024–1030 m, 12 Jan 1989; NMNZ P 24951, male 469 mm TL, Hikurangi Trough, New Zealand, 41°10′ S, 176°50′ E, 1316–1429 m; NMNZ P 24953, female 578 mm TL, off Cape Turnagain, New Zealand, 40°30′ S, 177°14′ E, 1346–1436 m; NMNZ P 25907, male 522 mm TL, north of Chatham Rise, New Zealand, 42°36′ S, 179°14′ E, 1245–1384 m, 25 June 1990; NMNZ P 25966, male 855 mm TL, north of Chatham Rise, New Zealand, 42°43′ S, 179°12′ E, 1490–1503 m, 21 June 1990; NMNZ P 26214, male 404 mm TL, southern end of Hikurangi Trough, New Zealand, 42°52′ S, 174°14′ E, 1240–1295 m, 27 Sep 1990; NMNZ P 26258, female 796 mm TL, Hikurangi Trough, New Zealand, 40°03′ S, 177°48′ E, 1097–1165 m, 05 Oct 1990; NMNZ P 31228, male 822 mm TL, Chatham Rise, New Zealand, 44°28′ S, 179°24′ E, 995–1054 m, 12 May 1994; NMNZ P 31332, female 374 mm TL, NMNZ P 31862, female 741 mm TL, southern Louisville Ridge, New Zealand, 40°57′ S, 165°02′ E, 800–900 m, 02 Mar 1995.

DIAGNOSIS.— A species of *Apristurus* with the following characters: upper labial furrows about equal to, or slightly shorter than the lowers; pre-outer nostril length 4.5–6.6% TL; upper jaw semicircular; supraorbital sensory canal continuous; first dorsal fin slightly smaller than second dorsal fin; anal fin rounded in shape; dermal denticles narrow, leaf-like and sparse in distribution; no enlarged dermal denticles along dorsal margin of caudal fin; spiral valves in intestine 8–11; mature size 650–750 mm TL; body and fins uniformly brown or blackish brown.

DESCRIPTION.— (of the holotype, paratype descriptions are given in parentheses only when different). Proportional measurements and meristic counts are given in Table 1.

Body cylindrical, relatively stout and elongate (Fig. 1); abdomen long, P1–P2 space slightly longer than anal-fin base length and D1–D2 insertions, pectoral-fin tip not reaching anterior 1/3 of P1–P2 space; caudal peduncle high, height about half of interorbital width. Head dorso-

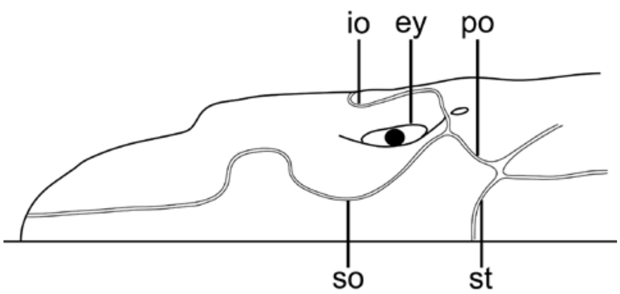

Figure 2. Sensory canal of head (right side) of *Apristurus ampliceps* sp. nov., paratype, HUMZ 139941, mature female 729 mm TL. ey = eye; io = infraorbital canal; po = postorbital canal; so = supraorbital canal; st = supratemporal canal.

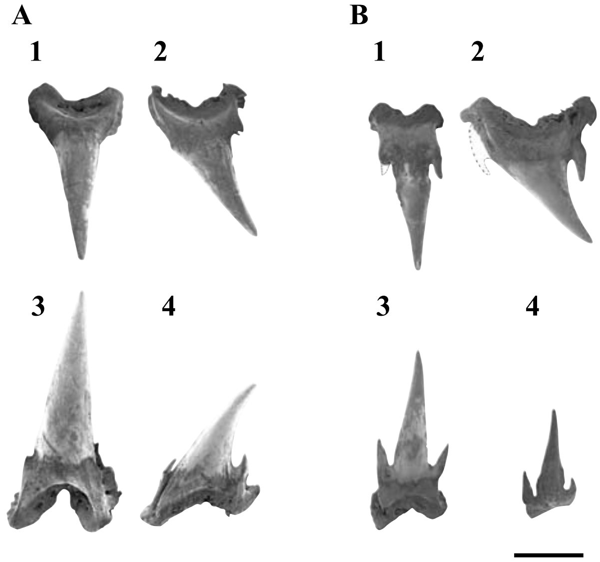

Figure 3. Teeth of *Apristurus ampliceps* sp. nov.: A. holotype, NMNZ P 27063, mature male 826 mm TL; B. paratype, HUMZ 139940, mature female 762 mm TL. 1: upper anterior tooth, 2: upper lateral tooth, 3: lower anterior tooth, 4: lower lateral tooth. Scale bar = 1 mm.

ventrally flattened, posterior part of body compressed laterally. Snout relatively long, broad; tip tapering evenly. Pre-outer nostril length slightly greater than internarial width. Pre-oral length slightly less than pre-orbital length, about 1.8 times internarial width, slightly less than mouth width and subequal to interorbital width. Pre-orbital length about 1.4 times interorbital width, about 4.2 times orbit length. Internarial width about 1.8 times orbit length, about 1.6 times nostril length. Supraorbital sensory canal continuous (Fig. 2). Nostril large, expanding obliquely inward from snout edge; nostril length about 0.4 times pre-inner nostril length, subequal to orbit length. Nostril-mouth space about 0.4 times internarial width. Mouth broadly arched, semicircular, with well developed labial furrows; upper labial furrows about equal to lowers, not reaching midpoint between mouth corner and posterior margin of nostril. Orbit relatively small; orbit length much greater than half of internarial width, slightly less than half of interorbital width. Spiracle small placed slightly below level of horizontal axis of orbit. Five small gill slits present; 4th gill slit above pectoral-fin origin; 5th gill slit smallest, above pectoral-fin base. Gill septa lacking projection, not covered with dermal denticles.

Pectoral fin relatively small, rounded; right and left fins separated by a space of about 3/4 of mouth width. Pelvic fin moderate in size; pelvic-fin length equal to pre-orbital length. Dorsal fins similar in shape. First dorsal fin slightly smaller than second dorsal fin; origin anterior to pelvic-fin insertion; insertion slightly anterior to anal-fin origin (ceratotrichia). Second dorsal-fin origin above mid anal-fin base; insertion posterior to anal-fin insertion. Anal fin relatively low, rounded, with a base longer than

Table 1. Proportional measurements (%TL) and meristic counts of the holotype of *Apristurus ampliceps* sp. nov. (NMNZ P 27063), paratypes (5 males and 4 females) and other material (11 males, 6 females).

		Holotype	Paratypes	Other material
1	Total length (mm)	826	656–836	374–855
3	PreD2-origin length	65.3	61.7–64.7	62.0–68.0
5	PreD1-origin length	50.2	48.1–51.1	48.5–52.5
6	PreP1 length	21.1	21.5–24.0	22.2–24.5
7	PreP2 length	44.9	43.3–47.1	41.8–45.6
9	Preanal length	58.1	54.7–59.7	54.0–59.9
10	Precaudal length	71.2	67.5–71.0	66.3–69.8
11	Pre-branchial length	19.2	19.8–22.2	18.7–21.2
13	Pre-orbital length	10.1	10.2–12.7	10.2–12.4
14	Pre-outer nostril length	4.6	4.7–6.6	4.5–6.4
15	Pre-inner nostril length	6.0	6.4–7.6	6.8–9.6
16	Pre-oral length	7.5	8.1–9.9	7.7–10.1
17	Head length	21.8	22.0–25.5	22.4–24.7
21	Mouth width	9.5	9.3–10.5	8.4–11.1
23	Internarial width	4.2	3.8–4.5	3.7–4.5
24	Upper labial furrow length	3.6	3.1–3.9	2.6–4.3
25	Lower labial furrow length	3.3	2.9–3.8	3.1–4.2
26	Orbit length	2.4	2.6–3.0	2.4–3.0
28	Nostril length	2.6	2.6–3.4	2.7–3.9
30	Interorbital width	7.4	7.4–8.3	7.4–9.1
31	1st gill height	2.0	1.5–2.3	–
32	3rd gill height	2.0	1.0–3.1	–
33	5th gill height	1.1	0.9–2.3	–
34	D1-D2 space	9.0	7.0–9.0	6.0–8.4
35	D1-D2 origins	14.6	11.0–15.1	12.6–14.6
36	D1-D2 insertions	15.4	13.3–15.4	12.6–15.4
37	P1-P2 space	17.6	13.2–16.1	11.1–16.1
38	P1 tip to P2 origin	12.0	7.5–10.6	7.2–12.3
39	P1–P2 origins	23.6	19.9–23.2	18.5–22.4
44	D1 base length	6.7	5.5–7.9	5.7–7.3
45	D1 height	2.7	2.3–2.9	2.3–3.0
46	D1 free lobe length	3.7	3.7–4.5	3.7–5.1
48	D2 base length	7.3	5.7–6.9	6.6–7.7
49	D2 height	3.2	2.9–3.6	2.9–3.9
50	D2 free lobe length	4.6	4.4–5.6	4.5–5.8
52	P1 anterior margin	12.3	11.2–12.7	9.7–13.0
57	P2 length	10.1	9.3–11.0	9.0–11.7
61	Anal base length (ceratotrichia)	12.8	10.8–13.7	9.9–13.6
65	Anal height (muscle)	5.4	4.7–5.7	4.1–5.7
68	Caudal length	28.4	28.2–32.3	30.0–33.9
74	Clasper outer length	4.7	4.2–5.6	1.2–5.1
	Tooth rows:			
	upper	63	57–70	54–70
	lower	62	50–62	52–64
	Vertebrae:			
	monospondylous	34	35–36	34–38
	precaudal diplospondylous	31	28–30	26–32
	Spiral valves	8	9–11	10–11

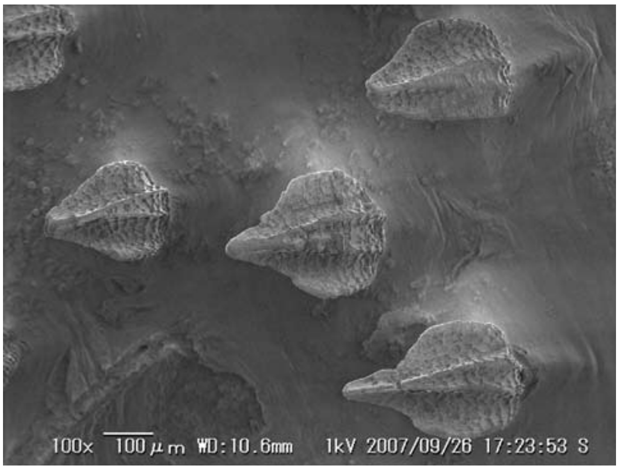

Figure 4. Dermal denticles of *Apristurus ampliceps* sp. nov., holotype, NMNZ P 27063, mature male 826 mm TL. Scale bar = 100 μm.

pelvic-fin length but shorter than P1–P2 space; anal and caudal fins only separated by a notch. Caudal fin slender; ventral lobe relatively high; apex of ventral lobe rounded; subterminal notch distinct; terminal lobe short, less than 2 times caudal terminal lobe height.

Intestinal spiral valves 8 (9–11). Monospondylous vertebrae 34 (35–36), precaudal diplospondylous vertebrae 31 (28–30).

Teeth (Fig. 3) numerous and large; 63 (57–70) rows on upper jaw, 62 (50–62) rows on lower jaw; upper anterior teeth with only a long robust central cusp; upper lateral teeth with a long, robust central cusp and one minute lateral cusp on outer side of the central cusp; lower anterior teeth with only a long robust central cusp; lower lateral teeth with a short sharp lateral cusp on both sides of the central cusp (anterior teeth on upper and lower jaws of females with a short sharp lateral cusp on both sides of the central cusp; lateral teeth of them with 1–2 lateral cusps on both sides of the central cusp).

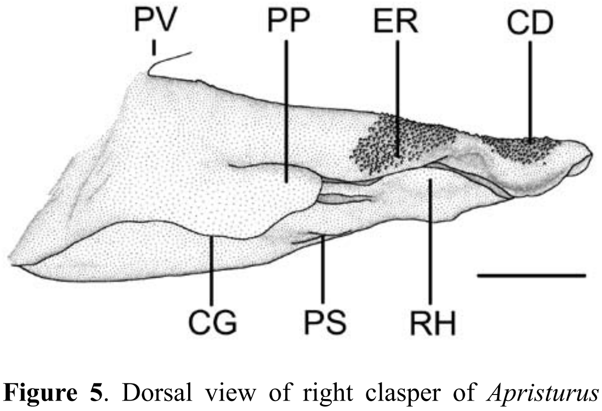

Figure 5. Dorsal view of right clasper of *Apristurus ampliceps* sp. nov., holotype, NMNZ P 27063, mature male 826 mm TL. CD = clasper denticles; CG = clasper groove; ER = exorhipidion; PP = pseudopera; PS = pseudosiphon; PV = pelvic fin; RH = rhipidion. Scale bar = 1 cm.

Dermal denticles (Fig. 4), from dorso-lateral side of body small, widely spaced, leaf-like in shape with a long ridged central cusp; outer surface of denticles completely structured by reticulations. No modified dermal denticles on the dorsal margin of the caudal fin.

Clasper (Fig. 5) short and robust, tapering toward the tip; ventral and outer lateral sides densely covered by dermal denticles. Dorsal side of clasper naked except for outer posterior half of exorhipidion. Clasper groove covered by rhipidion except for posterior one sixth. Pseudosiphon distinct as a narrow deep groove at postero-inner side of cover rhipidion.

COLOR (in alcohol).— Upper and lower surfaces of body and fins uniformly brown or blackish brown; tongue and palate blackish brown; peritoneum white.

SIZE.— Males and females attain at least 855 and 796 mm TL, respectively. Claspers (Fig. 6A) short and less than 2.0% TL in specimens <527 mm TL, which is ranked as maturity stage 1 (Fig. 6B, immature: Nakaya *et al.*, 2008). Males of 733–765 mm TL have long but soft claspers (3.9–4.2% TL, maturity stage 2). Males >780 mm TL have long, well developed and hardened claspers (3.6–5.6% TL, maturity stage 3). Males <527 mm TL and a 374 mm TL female are immature (Fig. 6B, maturity stage 1), males of 733–765 mm TL and females of 578–656 mm TL are adolescent (maturity stage 2), and males >780 mm TL and females >678 mm TL are adult (maturity stage 3).

SEXUAL DIMORPHISM.— Anterior teeth of mature males lack lateral cusp on both sides of the central cusp, but those of mature females have one small lateral cusp on both sides of the central cusp. Anterior teeth of mature males are apparently larger than those of mature females.

DISTRIBUTION.— Material examined from off west coast of Tasmania, east of New Zealand (including Chatham Rise), southern Louisville Ridge and Tasman Rise (Fig. 7). Possibly distributed also in southwestern Australia, off eastern Tasmania and west of New Zealand (Last & Stevens, 1994). Known from depths of 800–1503 m.

ETYMOLOGY.— The specific Latin name *ampliceps* is derived from its large (Latin: *amplus*) head (Latin: *caput*).

REMARKS.— *Apristurus ampliceps* sp. nov. belongs to the 'spongiceps group' of Nakaya & Sato (1999) in having a pre-outer nostril length shorter than interorbital width, a

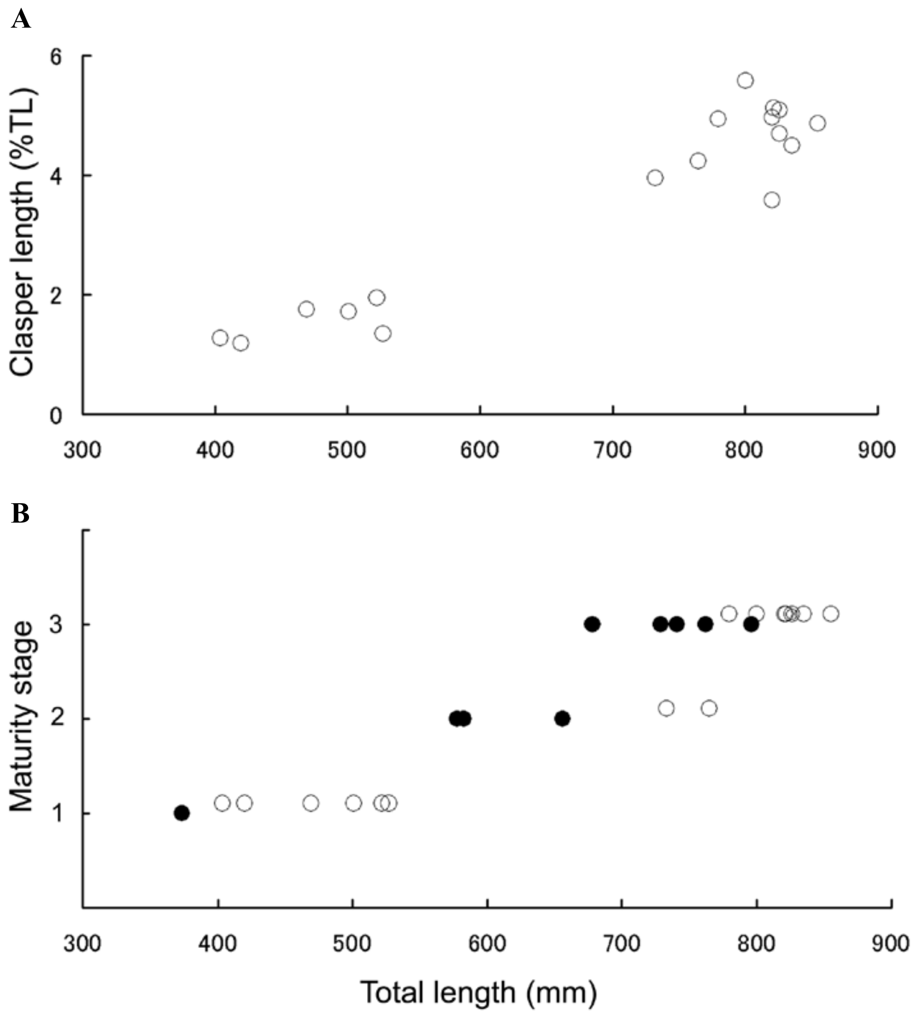

Figure 6. Clasper length (A) and sexual maturity stages (B) of *Apristurus ampliceps* sp. nov. Males (○) and females (●).

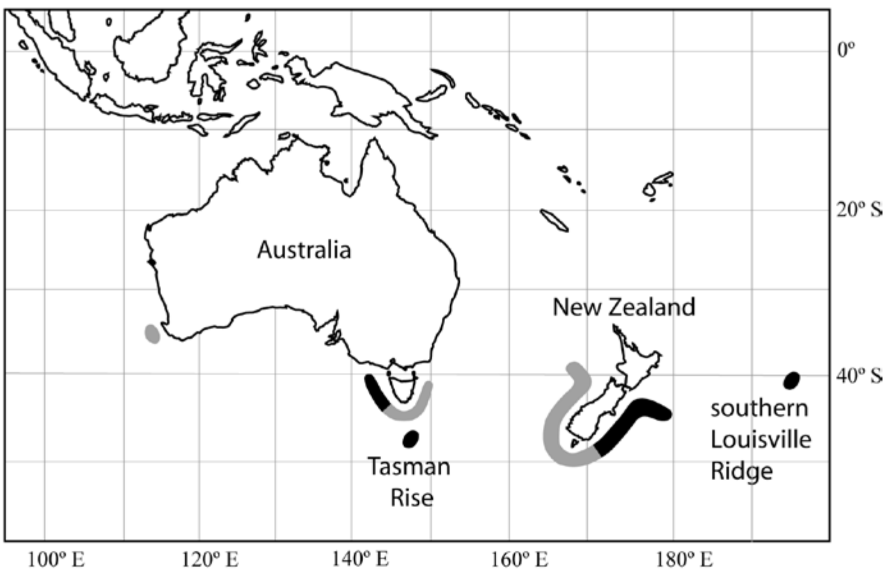

Figure 7. Distribution of *Apristurus ampliceps* sp. nov. in the Indian and western South Pacific Oceans. Black area, present specimens; grey area from Last & Stevens (1994).

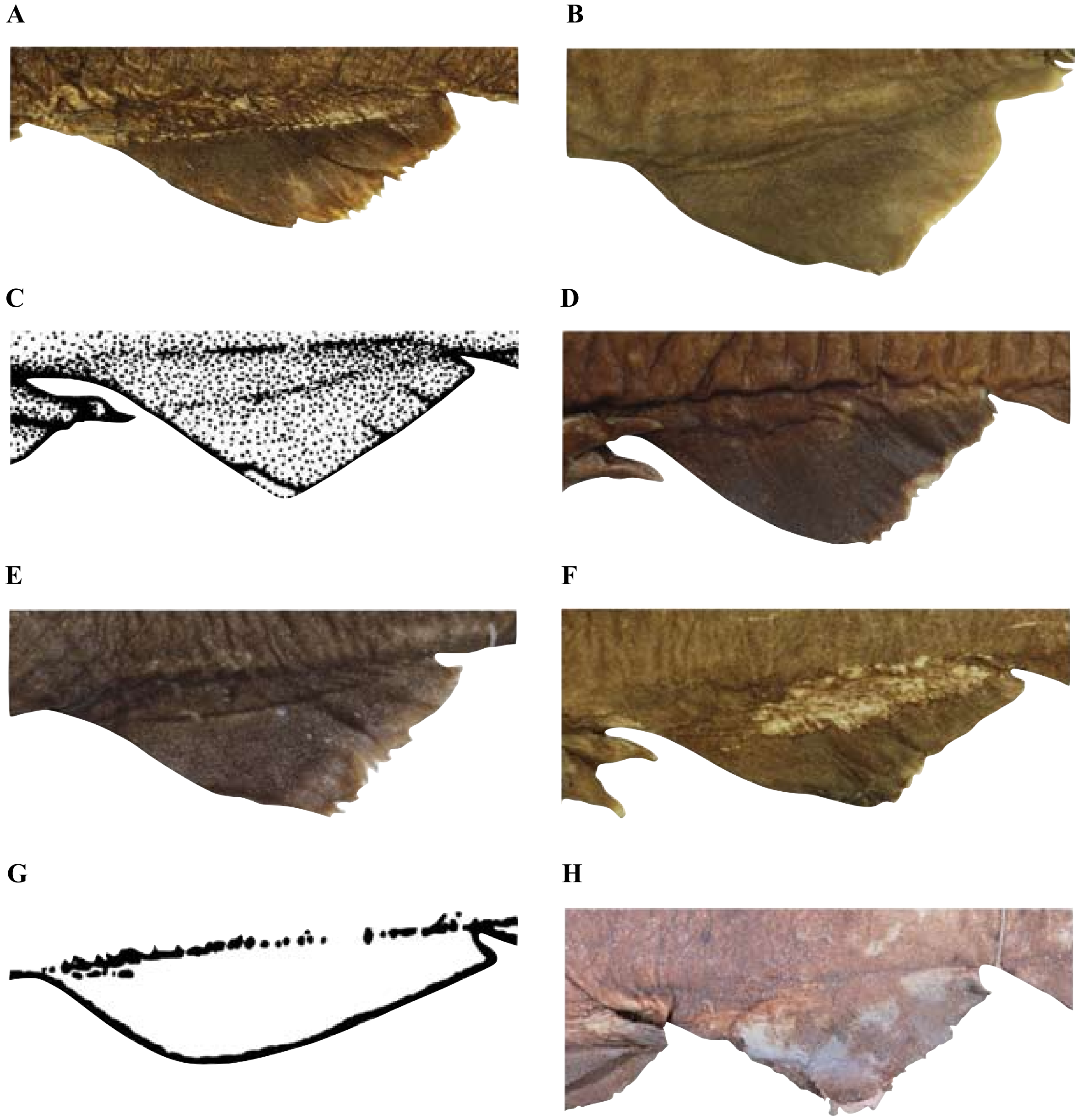

Figure 8. Shape of anal fin. A. *Apristurus ampliceps* sp. nov., holotype, NMNZ P 27063, mature male 826 mm TL; B. *A. albisoma*, holotype, MNHN 1997–3366, mature male 573 mm TL; C. *A. aphyodes*, paratype, HUMZ 152330, mature male 510 mm TL (from Nakaya & Stehmann, 1998); D. *A. microps*, FAKU 46061, mature male 563 mm TL; E. *A. pinguis*, holotype, ECSFI SH80D–0312, mature male 558 mm TL; F. *A. profundorum*, MCZ 165125, mature male 644 mm TL; G. *A. riveri*, holotype, MCZ 36092, mature female 413 mm TL (from Bigelow & Schroeder, 1944); H. *A. spongiceps*, holotype, USNM 51590, mature female 514 mm TL (right side).

low spiral valve count, upper labial furrows about equal to, or shorter than the lowers and a continuous supraorbital sensory canal. The 'spongiceps group' presently comprises the following 11 species: *A. albisoma* Nakaya & Séret, 1999; *A. aphyodes* Nakaya & Stehmann, 1998; *A. fedorovi* Dolganov, 1985; *A. kampae* Taylor, 1972; *A. manis* (Springer, 1979); *A. microps* (Gilchrist, 1922); *A. profundorum* (Goode & Bean, 1896); *A. riveri* Bigelow & Schroeder, 1944; *A. pinguis* Deng, Xiong & Zhan, 1983; *A. spongiceps* (Gilbert, 1905); *A. stenseni* (Springer, 1979).

Apristurus ampliceps sp. nov. is distinguished from *A. albisoma*, *A. aphyodes*, *A. microps, A. pinguis*, *A. profundorum* and *A. riveri* by a combination of the following characters: a rounded anal fin (Fig. 8) and sparse dermal denticles (10–18 in 2×2 mm square, Fig. 9). *Apristurus ampliceps* sp. nov. is clearly separated from *A. spongiceps* by its leaf-like dermal denticles (vs. hook-like in *A. spongiceps*) and a rounded anal fin (vs. triangular).

Therefore, *Apristurus ampliceps* sp. nov. is compared

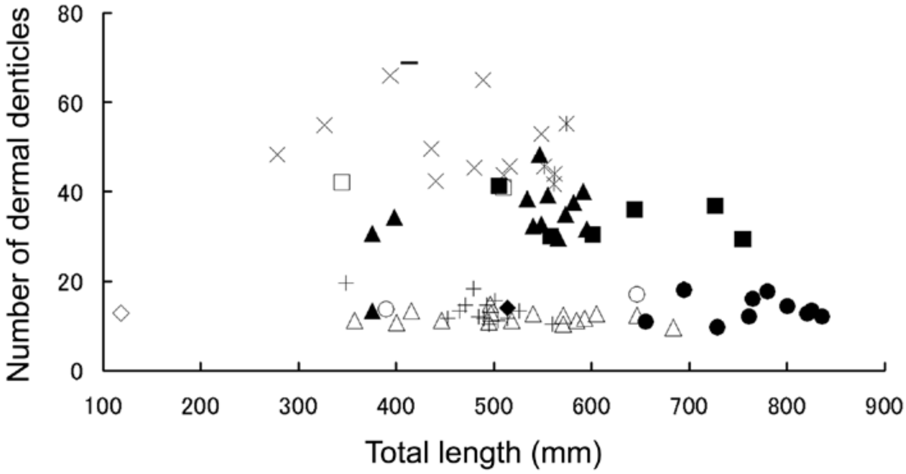

Figure 9. Number of dermal denticles in a 2×2 mm square. *Apristurus ampliceps* sp. nov. (●), *A. albisoma* (▲), *A. aphyodes* (□), *A. fedorovi* (Δ), *A. kampae* (+), *A. manis* (○), *A. microps* (∗), *A. pinguis* (×), *A. profundorum* (■), *A. spongiceps* (♦), *A. stenseni* (◊) and *A. riveri* (–).

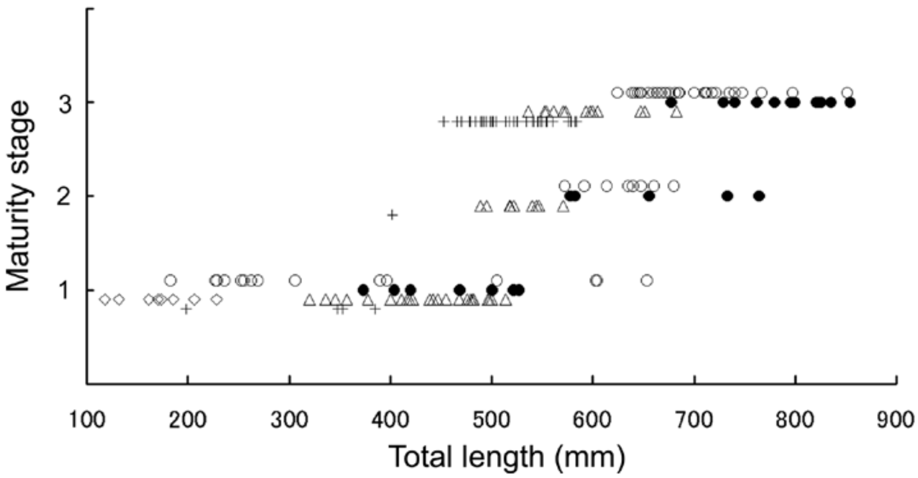

Figure 10. Sexual maturity stages of *Apristurus ampliceps* sp. nov. (●), *A. fedorovi* (Δ), *A. kampae* (+), *A. manis* (○) and *A. stenseni* (◊).

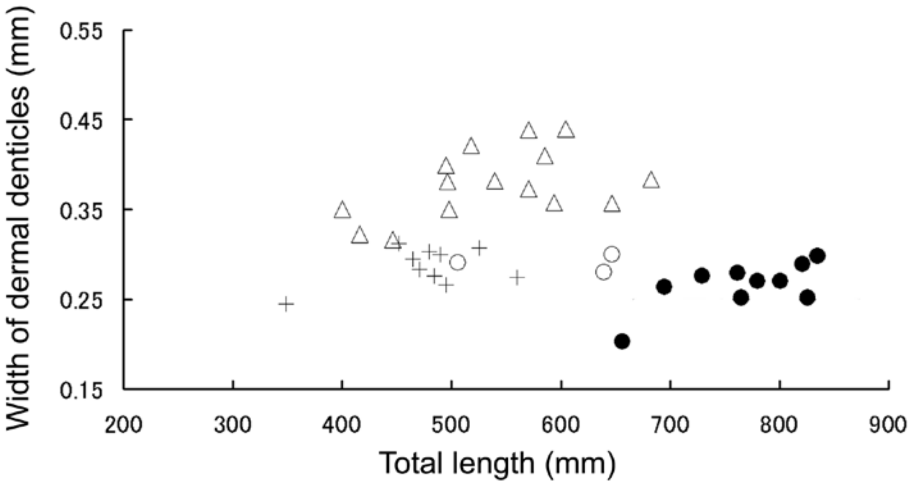

Figure 11. Width of dermal denticles in *Apristurus ampliceps* sp. nov. (●), *A. fedorovi* (Δ), *A. kampae* (+) and *A. manis* (○).

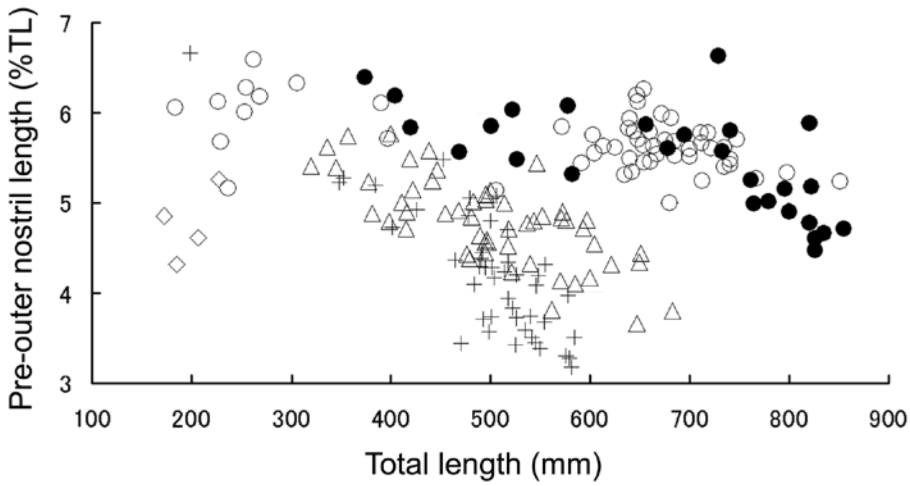

Figure 12. Ratio of pre-outer nostril length in *Apristurus ampliceps* sp. nov. (●), *A. fedorovi* (Δ), *A. kampae* (+), *A. manis* (○) and *A. stenseni* (◊).

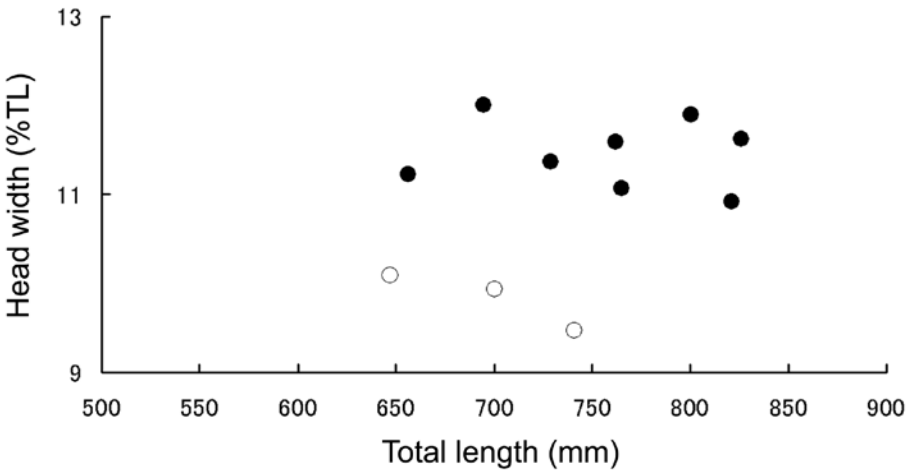

Figure 13. Ratio of head width in *Apristurus ampliceps* sp. nov. (●) and *A. manis* (○).

with the remaining four species, i.e. *A. fedorovi*, *A. kampae*, *A. manis* and *A. stenseni*. *Apristurus ampliceps* sp. nov. is apparently a larger species which matures at about 700 mm TL, and attains more than 850 mm TL, while in comparison *A. fedorovi* and *A. kampae* are relatively smaller species (550 and 683 mm TL in *A. fedorovi*, 400 and 582 mm TL in *A. kampae*, respectively, Fig. 10). Although *Apristurus ampliceps* sp. nov. is the largest in size in the 'spongiceps group', it has smaller dermal denticles, which are 0.20–0.30 mm in width (vs. 0.32–0.44 mm in *A. fedorovi*, Fig. 11). *Apristurus ampliceps* sp. nov. is also distinguishable from *A. fedorovi* and *A. kampae* by having relatively long pre-outer nostril length. The ratio of pre-outer nostril length to TL generally decreases with growth (Fig. 12). As highlighted in Fig. 12, *Apristurus ampliceps* sp. nov. is clearly different from *A. fedorovi* and *A. kampae* in relative pre-outer nostril length. *Apristurus ampliceps* sp. nov. cannot be directly compared with *A. stenseni*, because size ranges of the specimens do not overlap. The type specimens of *A. stenseni* (118–228 mm TL) have a pre-outer nostril length of 4.3–5.3% TL. However, *Apristurus ampliceps* sp. nov. and *A. stenseni* are clearly different, when ontogenetic changes of pre-outer nostril are considered. *Apristurus ampliceps* sp. nov. is separable from *A. manis* by having broad head, i.e. head width 10.9–12.0% TL (vs. 9.5–10.1% TL in *A. manis*, Fig. 13), but it should be noted only a few specimens were available for this measurement. However, this species is also distinguishable from *A. manis* by the shape of upper jaw, which is semicircular in *Apristurus ampliceps* sp. nov. vs. inverted U-shaped in *A. manis* (Fig. 14).

Comparative material.

Apristurus albisoma Nakaya & Séret, 1999: 21 specimens. MNHN 1997–3366 (holotype), male 573 mm

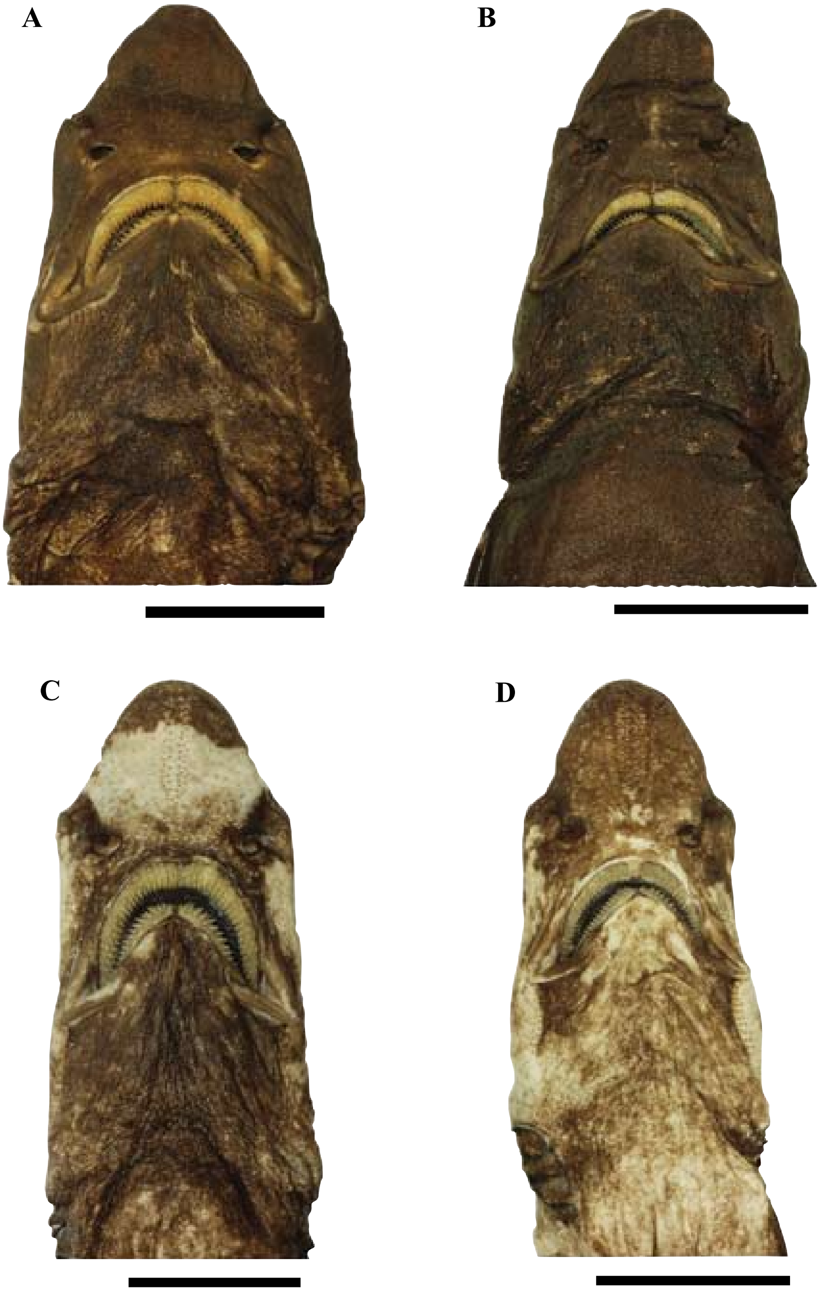

Figure 14. Shape of upper jaw. A. *Apristurus ampliceps* sp. nov., holotype, NMNZ P 27063, mature male 826 mm TL; B. *Apristurus ampliceps* sp. nov., paratype, HUMZ 139940, mature female 762 mm TL; C. *A. manis*, MCZ 165122, mature male 741 mm TL; D. *A. manis*, MCZ 165144, mature female 700 m TL. Scale bar = 5 cm.

TL, New Caledonia; MNHN 1997–3337, MNHN 1997–3350, MNHN 1997–3358, MNHN 1997–3359, MNHN 1997–3360, MNHN 1997–3361, MNHN 1997–3365, MNHN 1997–3368, MNHN 1997–3369, MNHN 1997–3370, MNHN 1997–3372, MNHN 1997–3373, MNHN 1997–3375, MNHN 1997–3376, MNHN 1997–3379–1 MNHN 1997–3379–2, MNHN 1997–3379–3, MNHN 1997–3380, MNHN 1997–3382, MNHN 1997–3383 (paratypes), 13 males and 7 females, 328–596 mm TL, off New Caledonia.

Apristurus aphyodes Nakaya & Stehmann, 1998: 25 specimens. ISH 71/1981 (holotype), male 538 mm TL, George Bligh Bank; BMNH 1998.1.22.1, HUMZ 152329, HUMZ 152330, ISH 24/1981, ISH 36/1981, ISH 49/1981, ISH 84/1981 (6 specimens), ISH 124/1981, ISH 138/1974 (2 specimens), ISH 739/1974, ISH 807/1974, ISH 184/1983 (2 specimens), ISH 187/1983, MNHN 1998–41, USNM 347837, ZIN N 51551, ZMUB 10171 (paratypes), 11 males and 13 females, 209–540 mm TL, Northeast Atlantic.

Apristurus fedorovi Dolganov, 1985: 55 specimens. ZIN 46980 (holotype), male 554 mm TL, off Iwate Pref., Japan; HUMZ 40073, HUMZ 40074, HUMZ 69163, HUMZ 72690, HUMZ 72716, HUMZ 72871, HUMZ

73030, HUMZ 74628, HUMZ 78038, HUMZ 78052, HUMZ 78064, HUMZ 78071, HUMZ 78100, HUMZ 78101, HUMZ 78105, HUMZ 78140, HUMZ 78174, HUMZ 78195, HUMZ 78196, HUMZ 78260, HUMZ 78276, HUMZ 78281, HUMZ 78316, HUMZ 78318, HUMZ 78333, HUMZ 78334, HUMZ 78374, HUMZ 78454, HUMZ 164184, HUMZ 176203, HUMZ 176204, HUMZ 176205, HUMZ 176206, HUMZ 176208, HUMZ 176211, HUMZ 176218, HUMZ 176219, HUMZ 176220, HUMZ 176221, HUMZ 176225, HUMZ 176229, HUMZ 176231, HUMZ 176236, HUMZ 176242, HUMZ 176243, HUMZ 176244, HUMZ 176245, HUMZ 176247, HUMZ 176249, HUMZ 176251, HUMZ 176252, HUMZ 176257, HUMZ 176258, HUMZ 176259 (non-types), 28 males and 26 females, 320–683 mm TL, off northern Japan.

Apristurus kampae Taylor, 1972: 46 specimens. SIO 70–248–5 (holotype), female 348 mm TL, Gulf of California, Mexico; CAS 38287, CAS 57935, HUMZ 105601, HUMZ 105603, HUMZ 105604, HUMZ 105608, HUMZ 110317, HUMZ 110318, HUMZ 110319, HUMZ 110320, HUMZ 110321, HUMZ 110322, HUMZ 110323, HUMZ 110324, HUMZ 110325, HUMZ 110326, HUMZ 110330, HUMZ 110331, HUMZ 110332, HUMZ 110333, HUMZ 110334, HUMZ 110335, HUMZ 110336, HUMZ 110337, HUMZ 167446, HUMZ 167571, HUMZ 167572, HUMZ 167770, HUMZ 167822, HUMZ 167823, HUMZ 167824, HUMZ 169864, HUMZ 174358, HUMZ 174359, HUMZ 174628, HUMZ 174707, HUMZ 174708, HUMZ 174709, HUMZ 175106, LACM 37449–1, SIO 70–299, SIO 71–190, SIO 88–98, SIO 88–99, SIO 88–100 (non-types), 27 males and 18 females, 198–584 mm TL, off California, off Galapagos Islands and off Peru.

Apristurus manis (Springer, 1979): 56 specimens. MCZ 38299 (holotype), female 390 mm TL, off Massachusetts, USA; MCZ 37416 (2 specimens), MCZ 37512, MCZ 37535 (paratypes), 3 males and 1 female, 227–255 mm TL, off Massachusetts; ARC 8601097, ARC 8602997, ISH 154/1974a, ISH 154/1974b, ISH 3412/1979, ISH 3449/1979, ISH 3696/1979, ISH 3712/1979, ISH 3713/1979 (2 specimens), MCZ 37407, MCZ 165118, MCZ 165122, MCZ 165144, uncatalogued (37 specimens) (non-types), 14 males and 37 females, 183–852 mm TL, North Atlantic.

Apristurus microps (Gilchrist, 1922): 6 specimens. FAKU 46061, FAKU 46063, FSFL EM 322, FSFL S 639, ISH 195/1967 (2 specimens), 5 males and 1 female, 372–575 mm TL, off South Africa.

Apristurus pinguis Deng, Xiong & Zhan, 1983: 13 specimens. ECSFI SH80D–0312 (holotype), male 558 mm TL, East China Sea, China; HUMZ 145143, HUMZ 145144, HUMZ 145145, HUMZ 145146, HUMZ 145147, HUMZ 145148, HUMZ 145149, HUMZ 145150, HUMZ 148375, HUMZ 148376, HUMZ 148377, HUMZ 148378 (non-types), 7 males and 5 females, 278–548 mm TL, Okinawa Trough, East China Sea, Japan.

Apristurus profundorum (Goode & Bean, 1896): 27 specimens. USNM 35646 (holotype), male 510 mm TL, off Delaware Bay in Gulf Stream; HUMZ 151216, HUMZ 151243, HUMZ 151244, HUMZ 151247, ISH 943/1973 (2 specimens), ISH 944/1973, ISH 945/1973, ISH 697/1974, ISH 698/1974 (2 specimens), ISH 49/1981, MCZ 58434, MCZ 158889, MCZ 162007 (3 specimens), MCZ 165125, ZMUB 16510, ZMUB 16511 (3 specimens), ZMUB 16512, ZMUB 16513, uncatalogued (2 specimens) (non-types), 10 males and 16 females, 259–755 mm TL, North Atlantic.

Apristurus riveri Bigelow & Schroeder, 1944: 17 specimens. MCZ 36092 (holotype), female 413 mm TL, off Northern Cuba; USNM 199395, USNM 199396, USNM 201760 (4 specimens), USNM 221526 (2 specimens), USNM 221528, USNM 221530, USNM 221531, USNM 221533 (2 specimens), USNM 221535, USNM 221536 (2 specimens) (non-types), 7 males and 9 females, 298–470 mm TL, Caribbean and Gulf of Mexico.

Apristurus spongiceps (Gilbert, 1905): USNM 51590 (holotype), female 514 mm TL, off Bird Island, Hawaiian Islands, USA.

Apristurus stenseni (Springer, 1979): 13 specimens. ZMUC P 6146 (holotype), male 185 mm TL, Gulf of Panama; ZMUC P 6147, ZMUC P 6148, ZMUC P 6156, ZMUC P 6159, ZMUC P 6162, ZMUC P 6164, ZMUC P 6166, ZMUC P 6167, ZMUC P 6173, ZMUC P 6182, ZMUC P 6186, ZMUC P 6189 (paratypes), 9 males and 2 females (1 specimen sex unknown), 118–228 mm TL, Gulf of Panama.

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Apristurus bucephalus sp. nov., a new deepwater catshark (Carcharhiniformes: Scyliorhinidae) from southwestern Australia

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ABSTRACT.— A new species of deepwater catshark, *Apristurus bucephalus* sp. nov., is described based on an large female specimen (675 mm TL) collected off Western Australia in depths of 1030–1140 m. It is characterised by a combination of the following features: a large and robust head, long pre-pectoral length, upper labial furrow slightly shorter than the lower furrow; pre-outer nostril length 4.0–4.1% TL; upper jaw shallowly arched or semicircular; anal fin triangular; dermal denticles weakly tricuspid and sparse in distribution; body and fins uniformly medium yellowish brown. Data is also provided for a second smaller female specimen (321 mm TL) which is highly likely to be the same species, but due to its much smaller size and given the high level of ontogenetic change in morphology in members of the genus *Apristurus*, it was not included as a type.

Key words. Scyliorhinidae – *Apristurus bucephalus* – deepwater catshark – new species – Australia

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INTRODUCTION

Last & Stevens (1994) identified 8 *Apristurus* species from Australian waters of which 7 were unidentifiable (i.e. *Apristurus* sp. A–G). In recent studies of the Australian species of *Apristurus*, four of these species have been provisionally synonymised with nominal species, i.e. *A. melanoasper* (= *A*. sp. C), *A. platyrhynchus* (= *A*. sp. B) and *A. pinguis* (= *A*. sp. E) (Kawauchi *et al*. 2008; Nakaya *et al*., 2008b), and provisionally with *A. sinensis* (= *A*. sp. A) (K. Nakaya, pers. comm.). Two of the remaining taxa, *A*. sp. D and *A*. sp. G, have now been formally described as new species in this series as *A. ampliceps* Sasahara, Sato & Nakaya, 2008 and *A. australis* Sato, Nakaya & Yorozu, 2008. The remaining species, i.e. the bighead catshark (*A*. sp. F *sensu* Last & Stevens, 1994), is known from only two specimens from the mid continental slope of southwestern Australia. This species is very similar to *Apristurus pinguis* (i.e. *Apristurus* sp. E of Last & Stevens, 1994), which has a wider geographic range in southern Australia, but differs in denticle morphology, and body and fin morphometrics. In this paper, the new species is formally described and compared closely with Australian material of *Apristurus pinguis*, and with the newly described *A. ampliceps*.

METHODS

Methods follow those illustrated and described in Nakaya *et al*. (2008a) in this series. In the table, the following abbreviations are used: P1, pectoral fin; P2, pelvic fin; D1, first dorsal fin; D2, second dorsal fin. A juvenile female specimen of the new species was not included in the type series due to some differences in morphology and distribution of denticles from the large holotype. Due to the lack of material of intermediate sizes, it was deemed more appropriate to exclude this specimen from the type series, but the data for this specimen is still presented in Table 1 and discussed in the Remarks section. Morphometrics were taken from the holotype (CSIRO H 2615–01) and the non-type specimen (CSIRO H 3111–06) of the new species and from 6 Australian specimens of *Apristurus pinguis* (Table 1). Vertebral counts were taken from radiographs of both specimens of the new species. Counts were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of ventral lobe of caudal fin) and caudal (centra of the caudal fin from ventral lobe origin) vertebrae. In the description, morphometric and meristic values are given for the holotype. Tooth counts were taken *in situ* from the non-type specimen (CSIRO H 3111–06); counts were not taken from the holotype as the jaw would need to be excised to enable counts to be made. Denticle counts follow the methodology described in Nakaya *et al*. (2008a), and are expressed as number of denticles in a 2 mm x 2 mm square. Specimens of the new species and comparative material are deposited in the Australian National Fish Collection, Hobart (CSIRO); their registration numbers are prefixed with this acronym.

Apristurus bucephalus sp. nov.

Figs 1–3; Table 1

Apristurus sp. F: Last & Stevens, 1994: pp 169, 178 (figured incorrectly); Compagno *et al*., 2005: p 205.

Holotype. CSIRO H 2615–01, female 675 mm TL, west of Mandurah, Western Australia, 32°33′ S, 114°25′ E, 1030–1140 m, 14 Feb 1991.
Other material. CSIRO H 3111–06, female 321 mm TL, southwest of Cape Leeuwin, Western Australia, 35°02′ S, 114°46′ E, 920–1100 m, 10 Jun 1992.

DIAGNOSIS.— A moderately-large species of *Apristurus* with the following characters: upper and lower labial furrows subequal in length; preorbital snout relatively short; head very robust, width (at mouth corners) 13.9% TL; mouth large, width 11.1% TL; orbit large, length 3.7% TL; prepectoral length and prepelvic length relatively long; first dorsal fin slightly smaller than second dorsal fin, its origin well forward of pelvic-fin insertion; anal fin tall, short based, triangular in shape; dermal denticles widely spaced, moderately large, deciduous, with long medial cusps; attaining at least 675 mm TL; body and fins uniformly medium yellowish brown; teeth in about 66 rows in upper jaw, about 55 rows in lower jaw; teeth of adult female with 5 cusps, 1 very long medial cusp, 2 much shorter inner lateral cusps, 2 much shorter outer lateral cusps situated anteriorly to inner lateral cusps; monospondylous vertebrae 35, diplospondylous precaudal vertebrae 26, total vertebrae about 108.

DESCRIPTION.— Body cylindrical, head dorso-ventrally flattened, posterior part of body compressed laterally; abdomen very long; pectoral–pelvic space 16.0% TL, pectoral tip to pelvic origin 1.5 times pectoral-fin width, 1.2 times pelvic-fin length; caudal peduncle height about half of preoral snout length. Snout relatively short; preorbital length about half of pre-branchial length; very broad; snout tip rounded. Pre-outer nostril length about half of pre-oral length, 0.9 times internarial width, 0.4 times interorbital width. Nostril large, expanded obliquely inward from snout edges; length about half of pre-inner nostril length, slightly smaller than orbit length. Nostril–mouth space about 2.8 in internarial width. Mouth shallowly arched, with well-developed labial furrows; upper furrow slightly shorter than lower furrow; upper labial furrow not reaching midpoint between mouth corner and posterior margin of nostril. Orbit large, length slightly less than internarial width, less than half interorbital width. Spiracle small, situated at about lower level of horizontal axis of eye. Five small gill slits; 5th opening smallest, located above pectoral-fin origin. Gill septa lacking projection, covered densely with dermal denticles.

Pectoral fins relatively small, rounded, subquadrangular in shape. Pelvic fins moderate in size, their length slightly greater than pre-orbital length. Dorsal fins similar in shape, subequal in size; first dorsal-fin origin over middle of pelvic-fin base, insertion above interspace between pelvic and anal fins; second dorsal-fin origin above middle of anal-fin base, its insertion above anal-fin insertion. Anal fin tall, broadly triangular, base much shorter than pectoral tip–pelvic origin space, posterior margin very slightly concave to nearly straight; apex slightly posterior to second dorsal-fin origin; separated from caudal fin by a notch. Caudal fin slender; ventral lobe relatively tall; apex of ventral lobe broadly triangular; subterminal notch distinct; terminal lobe short, about equal to caudal terminal lobe height.

Dermal denticles on dorsolateral side of body relatively large, broad-based, widely-spaced; elevated on short, slender pedicels; crowns almost upright, very narrow, weakly tricuspidate or unicuspidate, medial cusp very elongate, pointed; outer surface of crown reticulated, with a single low medial ridge. No modified dermal denticles on the dorsal margin of caudal fin; dermal denticles dense around the gill slits and on gill septa.

Teeth in upper and lower jaws numerous, small, with 5 cusps; in non-type specimen: about 66 rows in upper jaw, about 55 rows in lower jaw; tooth rows not counted in holotype. Upper and lower anterior teeth of holotype with 5 cusps; medial cusp strong, greatly enlarged, elongate, flanked either side by a single, short, narrowly-pointed inner lateral cusp (slightly shorter than half length of medial cusp); an additional outer lateral cusp on either side of tooth, angled slightly laterally, slightly shorter and positioned slightly anterior (rather than lateral) to inner lateral cusps.

Spiral valve counts not taken. Number of monospondylous vertebrae 35, diplospondylous precaudal vertebrae 26, precaudal vertebrae 61, total vertebrae about 108.

COLOUR.— When fresh: upper and lower surfaces of body uniformly medium yellowish brown; fins similar in colour basally and slightly darker brown distally; paler areas present on posterior portions of dorsal, anal and caudal fins where skin abraded away. A few large, asymmetric, blackish spots on body; one below first dorsal fin on left side (see Fig. 1a), one on dorsal head at anterior of right orbit, one medial to right orbit and one near right pelvic-fin base. Tongue and palate dark brown. Pupils pale greenish yellow, iris black.

SIZE.— Type specimen a female of 675 mm TL; one non-type specimen a female of 321 mm TL.

DISTRIBUTION.— Collected from off the mid continental slope off the south-west coast of Western Australia, from off Mandurah (32°33′ S, 114°25′ E) and south-west of Cape Leeuwin (35°02′ S, 114°46′ E), in 920–1140 m depth.

Figure 1. *Apristurus bucephalus* sp. nov., female holotype (CSIRO H 2615–01, 675 mm TL, fresh): A. lateral view; B. ventral view of head.

ETYMOLOGY.— Derived from the combination of the Latin *bu* (large) and the Greek *kephalis* (of the head) in allusion to its large, broad head. Vernacular: Bighead Catshark.

REMARKS.— *Apristurus bucephalus* belongs to the 'spongiceps group' of Nakaya & Sato (1999) due in part to a pre-outer nostril length that is much shorter than the interorbital width, and upper labial furrows subequal to, or shorter than, the lower labial furrows. The 'spongiceps group' presently comprises the following 12 species: *Apristurus albisoma* Nakaya & Séret, 1999; *A. ampliceps* Sasahara, Sato & Nakaya, 2008; *A. aphyodes* Nakaya & Stehmann, 1998; *A. fedorovi* Dolganov, 1985; *A. kampae* Taylor, 1972; *A. manis* (Springer, 1979); *A. microps* (Gilchrist, 1922); *A. pinguis* Deng, Xiong & Zhan, 1983; *A. profundorum* (Goode & Bean, 1896); *A. riveri* Bigelow & Schroeder, 1944; *A. spongiceps* (Gilbert, 1905) and *A. stenseni* (Springer, 1979).

Australian species *Apristurus bucephalus* and *A. pinguis* are clearly separable from *A. fedorovi*, *A. kampae*, *A. manis* and *A. stenseni* in the shape of the anal fin (Fig. 3; see Fig. 15 in Kawauchi *et al*., 2008). The new species differs from *A. albisoma*, *A. aphyodes*, *A. microps*, *A. pinguis*, *A. profundorum* and *A. riveri* in having more widely spaced dermal denticles (holotype with 9–16 denticles/4 mm^2 vs. usually >30 denticles/4 mm^2) that do not overlap, and which have weakly tricuspid crowns with very long medial cusps (vs. strongly overlapping with much shorter medial cusps). *Apristurus bucephalus* sp. nov. also differs markedly from *A. spongiceps* in having a long abdomen (vs. very short in *A. spongiceps*).

Of the 7 Australian *Apristurus* species, *A. bucephalus* is most similar to *A. pinguis* and *A. ampliceps*. The new species is clearly distinguishable from *A. pinguis* in having dermal denticles which are widely spaced and somewhat elevated (see Fig. 2; vs. overlapping and more flattened, see Fig. 11 in Kawauchi *et al*., 2008). The density of lateral trunk denticles (number per 2 mm x 2 mm square) in the juvenile non-type specimen (ca. 50

Table 1. Proportional measurements (as % TL) of the holotype (CSIRO H 2615–01) and non-type specimen (CSIRO H 3111–06) of *Apristurus bucephalus* sp. nov., and ranges for similar-size Australian specimens, one small (ca 320 mm TL) and 5 large (>500 mm TL), of *Apristurus pinguis*.

		A. bucephalus **sp. nov.**		***A. pinguis***		
				Large		Small
		Holotype	Non-type	Min.	Max.	
1	TL (mm)	675	321	521	695	325
2	PreD2-insertion length	71.3	70.2	69.9	72.9	68.0
3	PreD2-origin length	65.6	63.2	63.3	66.0	60.9
4	PreD1-insertion length	58.2	55.3	55.5	58.5	53.7
5	PreD1-origin length	53.2	49.1	49.6	53.0	47.2
6	PreP1 length	24.7	24.3	22.1	23.0	22.5
7	PreP2 length	47.0	44.9	45.8	48.8	43.7
8	Pre-vent length	50.8	48.3	49.4	53.0	48.0
9	Preanal length	60.1	54.2	58.1	62.2	56.9
10	Precaudal length	71.7	69.9	70.6	73.6	68.9
11	Pre-branchial length	20.6	19.0	17.8	19.6	18.1
12	Pre-spiracular length	13.8	14.1	13.1	14.6	13.2
13	Pre-orbital length	9.5	10.4	9.6	11.0	10.1
14	Pre-outer nostril	4.0	4.1	3.7	4.8	4.5
15	Pre-inner nostril	6.0	6.0	5.6	6.6	5.9
16	Pre-oral length	7.7	7.9	7.6	8.8	7.7
17	Head length	23.8	24.5	21.3	23.0	22.1
18	Head height	13.8	7.5	9.5	11.3	9.2
19	Head width (mouth corners)	13.9	14.1	10.7	12.5	12.6
20	Head width (max)	15.9	14.3	11.8	14.1	12.9
21	Mouth width	11.1	11.9	8.7	10.0	10.1
22	Mouth length	4.5	2.7	3.5	4.4	5.1
23	Internarial width	4.2	4.8	3.8	4.7	4.6
24	Upper labial furrow length	2.9	2.7	2.4	3.0	2.2
25	Lower labial furrow length	3.3	3.3	2.8	3.4	2.7
26	Orbit length	3.7	3.6	3.0	3.2	3.0
27	Orbit height	0.7	0.7	0.6	0.8	1.0
28	Nostril length	2.8	3.3	2.7	3.1	3.3
29	Nostril-mouth	1.5	2.1	2.1	2.3	2.0
30	Interorbital width	9.1	9.2	7.9	10.0	9.8
31	1st gill height	2.9	2.4	2.5	3.0	2.4
32	3rd gill height	3.3	2.8	2.6	3.3	2.7
33	5th gill height	2.4	1.8	2.0	2.4	1.8
34	D1–D2 space	7.0	7.9	7.5	9.6	7.8
35	D1–D2 origins	14.0	14.6	13.3	15.0	14.6
36	D1–D2 insertions	13.3	14.8	14.0	15.9	14.3
37	P1–P2 space	16.0	14.3	16.0	18.6	15.7
38	P1 tip to P2 origin	12.6	9.6	11.9	15.0	11.6
39	P1–P2 origins	23.6	21.3	23.1	26.4	23.4
40	P1–P2 insertions	25.1	23.1	24.0	27.3	24.0
41	P2–anal space	3.9	2.9	4.0	6.2	6.8
42	P2–anal origins	13.6	11.7	12.4	14.6	13.7
43	D1 length	9.1	9.3	7.6	9.6	9.6

Table 1. cont'd.

		A. bucephalus **sp. nov.**		***A. pinguis***		
				Large		Small
		Holotype	Non-type	Min.	Max.	
44	D1 base length	7.5	6.1	5.0	6.5	6.8
45	D1 height	3.7	2.5	2.2	3.0	2.5
46	D1 free lobe length	2.9	3.5	2.6	3.7	3.6
47	D2 length	8.4	10.2	8.8	10.8	9.9
48	D2 base length	6.5	6.9	6.0	7.0	6.8
49	D2 height	4.3	3.2	2.8	3.7	2.7
50	D2 free lobe length	3.2	4.0	3.5	4.7	3.8
51	P1 base length	8.2	7.8	7.6	8.2	6.7
52	P1 anterior margin	9.7	11.4	10.3	12.7	10.1
53	P1 posterior margin	7.5	5.4	6.1	7.3	5.9
54	P1 inner margin	4.2	4.0	3.4	4.1	4.5
55	P1 width	8.6	6.5	6.7	8.0	6.4
56	P2 anterior margin	6.0	4.6	4.8	7.2	5.0
57	P2 length	10.3	10.8	10.3	11.6	9.7
58	P2 base length	9.2	9.2	8.5	9.8	8.8
59	P2 posterior margin	6.9	6.7	5.6	6.8	6.3
60	P2 inner margin	3.0	2.1	2.4	3.3	2.6
61	Anal base length (ceratotrichia)	11.6	14.7	11.6	13.2	10.9
62	Anal base length (muscle)	12.6	16.2	13.1	14.8	12.5
63	Anal anterior margin	8.1	12.7	9.6	11.5	10.4
64	Anal posterior margin	7.9	8.6	6.8	9.4	6.7
65	Anal height (muscle)	6.1	6.3	6.0	7.1	6.0
66	Anal inner margin	1.3	–	0.9	1.7	0.9
67	Caudal peduncle height	4.4	4.1	4.1	4.4	4.4
68	Caudal length	28.6	30.2	26.6	29.5	30.5
69	Caudal height	8.2	8.3	9.1	9.4	8.3
70	Caudal preventral margin	9.5	11.0	10.9	12.5	10.5
71	Caudal postventral margin	17.4	16.7	14.3	17.2	15.7
72	Caudal terminal lobe height	2.6	3.2	2.4	3.0	3.1
73	Caudal terminal lobe length	4.5	5.8	4.8	6.0	6.7

denticles/4 mm^2) lies within that recorded for *A. pinguis* by Kawauchi *et al*. (2008; Fig. 16), i.e. 36–63 denticles/4 mm^2. In comparison, the holotype had a much lower density of denticles (9–16) than the juvenile non-type and of *A. pinguis*. This possibly suggests that the denticles of *A. bucephalus* are particularly deciduous, thus the density of denticles is likely to reduce significantly with size.

Since members of this genus show strong sexual and ontogenetic differences in some morphological characters, comparisons below are based on individuals of similar size and sex. The holotype of the new species differs from large specimens of *A. pinguis* (>500 mm TL, n=5) in the following characters: head larger, more robust, height 13.8 vs. 9.5–11.3% TL, width (maximum) 15.9 vs. 11.8–14.1% TL, width (at mouth corners) 13.9 vs. 10.7–12.5% TL; mouth large, width 11.1 vs. 8.7–10.0% TL; eye large, length 3.7 vs. 3.0–3.2% TL, 2.4 vs. 1.3–1.5 times nostril–mouth space; longer pre-pectoral length, 24.7 vs. 22.1–23.0% TL; slightly shorter first dorsal fin, base length 7.5 vs. 5.0–6.5% TL; and caudal-fin height 8.2 vs. 9.1–9.4% TL. Although much smaller, the non-type specimen also differed from a single available, similar-sized specimen of *A. pinguis* (CSIRO H 555–01) in having a larger, more robust head, length 24.5 vs. 22.1% TL, width (maximum) 14.3 vs. 12.9% TL, width

Figure 2. Lateral trunk denticles of *Apristurus bucephalus* sp. nov., holotype, CSIRO H 2615–01, female 675 mm TL.

(at mouth corners) 14.1 vs. 12.6% TL. It also differed in the following characters which were shown above to differ in adult specimens: longer prepectoral length (24.3 vs. 22.5% TL); mouth large, width 11.9 vs. 10.1% TL; orbit large, length 3.6 vs. 3.0% TL. In addition, the juvenile non-type *A. bucephalus* differed in having a shorter pelvic–anal space (2.9 vs. 6.8% TL), a larger anal fin (base length (muscle) 16.2 vs. 12.5% TL, anterior margin 12.7 vs. 10.4% TL) and a shorter pre-anal length (54.2 vs. 56.9% TL).

Apristurus bucephalus also differs from *A. pinguis* in tooth morphology. The upper and lower teeth of the large female holotype of the new species have 5 cusps consisting of a strong, very elongate medial cusp which is flanked on each side by 2 much shorter lateral cusps. The inner lateral cusps lie lateral to the medial cusp and the outer lateral cusps are situated slightly anterior to these. In comparison, the upper and lower teeth of large females of *A. pinguis* have a much shorter medial cusp flanked by 2 or 3 lateral cusps on each side; outer lateral cusps not positioned anteriorly to inner lateral cusps.

Figure 3. Anal fin of *Apristurus bucephalus* sp. nov., holotype, CSIRO H 2615–01, female 675 mm TL.

Apristurus bucephalus differs from the morphologically-similar *A. ampliceps* in anal-fin shape (broadly triangular vs. distinctly rounded in shape) and in the following morphometric characters (based on data for holotype of *A. bucephalus* and the types of *A. ampliceps* in Sasahara *et al*., 2008): a larger eye (orbit length 3.7 vs. 2.4–3.0% TL), first dorsal fin more posterior (pre-D1 origin length 53.2 vs. 48.1–51.1% TL), smaller pectoral fin (anterior margin 9.7 vs. 11.2–12.7% TL) and higher dorsal fins (D1 height 3.7 vs. 2.3–2.9% TL, D2 height 4.3 vs. 2.9–3.6% TL) with shorter free rear tips (D1 free lobe length 2.9 vs. 3.7–4.5% TL, D2 free lobe length 3.2 vs. 4.4–5.6% TL).

Comparative material.
Apristurus pinguis. Australia (7 specimens): CSIRO H 549–08, female 531 mm TL, west of Trial Harbour, Tasmania, 41°48’ S, 144°22’ E, 1288–1328 m, 25 May 1986; CSIRO H 555–01, immature male 325 mm TL, west of Cape Sorell, Tasmania, 42°18’ S, 144°36’ E, 1376–1404 m, 17 May 1986; CSIRO H 1526–02, female 521 mm TL, CSIRO H 1526–03, female 537 mm TL, north-west of Point Hibbs, Tasmania, 42°26’ S, 144°39’ E, 1230–1242 m, 24 Mar 1988; CSIRO H 3110–01, female 695 mm TL, southwest of Cape Leeuwin, Western Australia, 35°04’ S, 114°49’ E, 990–1050 m, 09 June 1992; CSIRO H 5342–02, immature male 408 mm TL, southwest Indian Ocean, 858–1455 m, 31 Oct 1999; CSIRO H 6645–01, female 521 mm TL, west of Sandy Cape, Tasmania, 41°23’ S, 144°06’ E, 1225–1350 m, 11 Mar 1989.

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Apristurus australis sp. nov., a new long-snout catshark (Chondrichthyes: Carcharhiniformes: Scyliorhinidae) from Australia

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ABSTRACT.— A new long-snout catshark, *Apristurus australis* sp. nov. is described based on 29 type specimens collected from the coasts around Australia at depths of 486–1035 m. This species is a member of the 'longicephalus group' having a conspicuously elongated prenarial snout, but differs from other species of this group by the following features: first dorsal-fin origin just above or slightly anterior to pelvic-fin insertion; first dorsal-fin height 2/3 of that of second dorsal-fin; anterior teeth with 5 or more cusps; upper and lower jaws with 50–64 and 48–68 tooth rows, respectively; lower spiral valve counts (8–9); pale greyish to light brown body often with white margins on fins and paler ventrally. This species is distributed off the west and east coasts of Australia.

Key words. Chondrichthyes – Carcharhiniformes – Scyliorhinidae – *Apristurus australis* – new species – deep-sea catshark – Australia

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INTRODUCTION

The genus *Apristurus* Garman, 1913 comprises a group of deep-sea demersal catsharks found globally on continental slopes and submarine elevations in the world oceans at 400–2000 m depth. This genus is the most speciose genera of living sharks, containing 41 nominal species, with 32 of these currently recognised as valid. Compagno (1988) mentioned the presence of a few undescribed species of long-snout *Apristurus* from Australia and New Zealand. Later, Last & Stevens (1994) reported *A. longicephalus* and seven other unnamed species (sp. A–G) from Australian waters. However, no other taxonomic work has been done on the Australian species of the genus since their reports. Nakaya & Sato (1999) subdivided species of the genus *Apristurus* into 3 phenetic species groups, i.e. 'longicephalus', 'spongiceps' and 'brunneus' groups. Later, each of these three phenetic groups were recognised as monophyletic by the phylogenetic studies of Sato (2000) and Iglésias *et al.* (2005), and these studies further revealed that the 'longicephalus + spongiceps group' and the 'brunneus group' are in sister relationships. The 'longicephalus group' is typically characterised by a remarkably elongated prenarial snout which is much longer than interorbital width. Two nominal species, *Apristurus herklotsi* and *A. longicephalus*, are recognised as belonging to this group.

Since examining specimens in AMS and CSIRO, present authors KS and KN have long noticed the presence of a species similar to *A. herklotsi* in the waters of Australia, possessing a quite elongated prenarial snout, its length is distinctively longer than its interorbital width. Here we describe this as a new species in the 'longicephalus group' of the genus *Apristurus*.

METHODS

Morphometric measurements and meristic counts follow Nakaya *et al*. (2008). Vertebral counts were determined from radiographs. Terminology of clasper follows Compagno (1988), and that of the egg capsule follows Cox (1963). Dermal denticles were collected from the dorsolateral side of the body below the first dorsal fin. Anterior right teeth in 3rd–5th rows and lateral teeth in 13th–15th rows from the symphysis of both jaws were used for the description. Dermal denticles and teeth were photographed by scanning electron microscope (KEYENCE VE-8800) at Okinawa Churaumi Aquarium. Definition of sexual maturity stages follows Nakaya *et al*. (2008). Institutional acronyms follow Leviton *et al*. (1985) and Eschmeyer (1998).

Apristurus australis sp. nov.

Figs. 1–7; Tables 1–2

Apristurus sp. G: Last & Stevens, 1994: pp 168, 179, key fig. 11, fig. 26.7, pl. 19; Compagno *et al*., 2005: p 205, pl. 33.

Holotype. CSIRO H 953–07, male 616 mm TL, east of Sydney, New South Wales, 33°44–43′ S, 151°53–54′ E, 486–509 m, 18 Dec 1985.

Paratypes. 28 specimens. AMS I 20068–016, female 250 mm TL, east of Broken Bay, New South Wales, 33°27–25′ S, 152°09–11′ E, 895 m, 08 Dec 1977; AMS I 20452–020, male 292 mm TL, off Broken Bay, New South Wales, 33°32–38′ S, 152°00–04′ E, 822 m, 19 Aug 1975; AMS I 24037–007(1), female 586 mm TL, AMS I 24037–007(2), female 501 mm TL, AMS I 24037-007(3), male 272 mm TL, AMS I 24037–007(4), male 357 mm TL, east of Sydney, New South Wales, 33°44–47′ S, 151°55′ E, 825–850 m; CSIRO H 616–01, male 535 mm TL, CSIRO H 616–04, male 530 mm TL, CSIRO H 616–05, male 558 mm TL, CSIRO H 1287–01, male 528 mm TL, CSIRO H 1287–04, female 521 mm TL, north-east of Whitsunday Group, Queensland, 19°00′ S, 150°37′ E, 751–752 m, 24 Nov 1985; CSIRO H 860–02, female 531 mm TL, east of St. Patrick's Head, Tasmania, 41°36′ S, 148°41′ E, 900–930 m, 06 Aug 1987; CSIRO H 1201–09, female 555 mm TL, Houtman Abrolhos Islands, Western Australia, 29°05′ S, 113°41′ E, 880 m, Feb 1988; CSIRO H 1228–01, male 467 mm TL, CSIRO H 1228–02, male 543 mm TL, east of St Patricks Head, Tasmania, 41°38′ S, 148°42′ E, 980–1020 m, 07 Aug 1987; CSIRO H 1229–01, female 575 mm TL, CSIRO H 1229–02, male 575 mm TL, east of Nowra, New South Wales, 34°53′ S, 151°14′ E, 891–909 m, 11 Apr 1984; CSIRO H 1240–01, female 560 mm TL, west of Lihou Reef and Cays, Queensland, 17°03′ S, 150°51′ E, 606–610 m, 06 Dec 1985; CSIRO H 1285–02, female 504 mm TL, north of Lihou Reef & Cays, Queensland, 16°54′ S, 151°31′ E, 880 m, 06 Dec 1985; CSIRO H 1286–02, male 542 mm TL, north-east of Whitsunday group, Queensland, 18°54′ S, 150°25′ E, 1005–1013 m, 25 Nov 1985; CSIRO H 1539–02, female 528 mm TL, east of Brush Island, New South Wales, 35°26′ S, 150°54′ E, 900–921 m, 19 May 1988; CSIRO T 459, female 562 mm TL, off Bicheno, Tasmania, ca. 42° S, 148° E, 1000 m, 26 Jul 1982; HUMZ 139946, female 530 mm TL, HUMZ 139947, male 574 mm TL, HUMZ 139948, male 560 mm TL, HUMZ 139949, female 499 mm TL, New South Wales, 33°50–49′ S, 151°57–14′ E, 960–1025 m, 03 May 1988; HUMZ 139950, female 499.5 mm TL, Western Australia, 41°40–42′ S, 148°42′ E 1000–1035 m, 20 Apr 1989; HUMZ 139951, male 339.5 mm TL, Tasmania, 41°37–38′ S, 148°42′ E, 940–942 m, 22 Apr 1989.

DIAGNOSIS.— A species of *Apristurus* with the following characters: prenarial snout flattened, apparently longer than interorbital width; upper labial furrows much longer than the lowers; pectoral fin widely expanding posteriorly, its outer margin a little longer than P1–P2 space; abdomen short, P1–P2 space narrower than preorbital length or anal fin base length; first dorsal-fin origin just above or slightly anterior to pelvic-fin insertion; 50–64 and 48–68 tooth rows on upper and lower jaws; teeth including anterior teeth with 5 or more cusps; egg capsule lacking coiled tendrils on anterior and posterior ends, posterior end tapering toward tip; color in alcohol uniformly pale brownish to light greyish, sometimes light yellowish brown; dorsal side of body a little darker than ventral side.

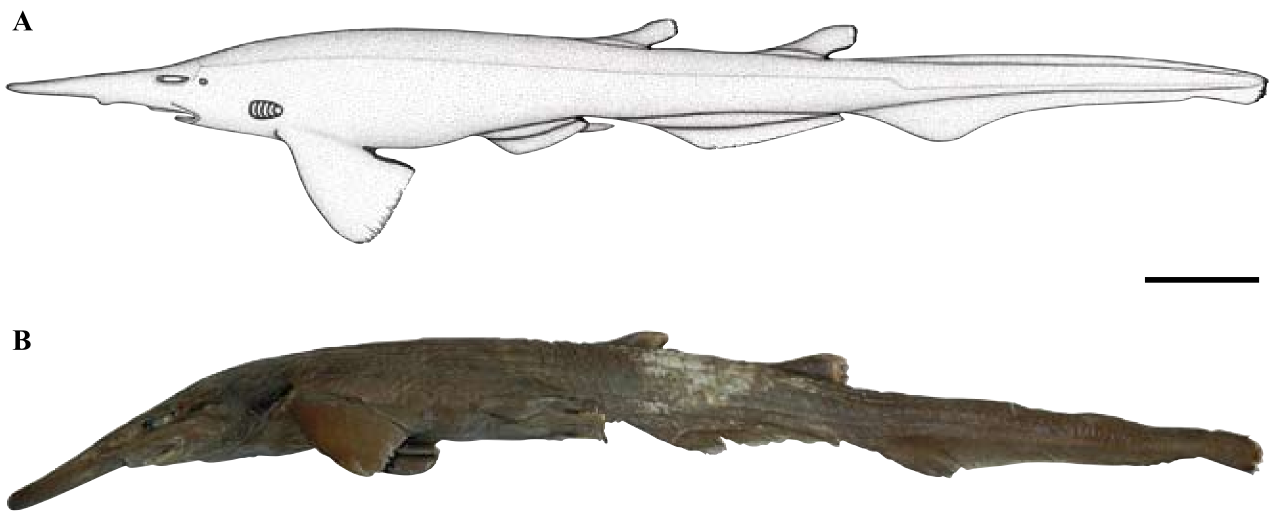

Figure 1. *Apristurus australis* sp. nov., holotype CSIRO H 953–07 (mature male 616 mm TL): A. lateral view (drawing); B. lateral view (photograph). Scale bar = 50 mm.

Figure 2. Head of *Apristurus australis* sp. nov., holotype CSIRO H 953–07 (mature male 616 mm TL): A. ventral view; B. dorsal view. Scale bar = 10 mm.

DESCRIPTION OF THE HOLOTYPE.— (paratype descriptions are given in parentheses when different. Egg capsule is described based on that from a paratype). Proportional measurements and counts are given in Table 1.

Body anterior to pelvic fins slender and cylindrical; height and width of body at the middle point of P1–P2 space almost equal. Abdomen narrow; P1–P2 space less than pre-orbital length or anal fin base, but greater than prenarial snout. Posterior part of body compressed laterally (Fig. 1); its width about half of its height. Snout extremely long and flattened dorso-ventrally (Fig. 2), pre-outer nostril length greater than mouth width, and slightly shorter than 3 times internarial width. Pre-oral length about 4 times internarial width or 3 times mouth length, and more than twice interorbital width. Pre-orbital length longer than twice interorbital width, about 4 times orbit length. Nostril relatively large, expanding obliquely inward from snout edge; nostril length subequal to internarial width, and equal to or slightly smaller than orbit length. Mouth broadly arched, about twice mouth height (2.5 times in immature males and female specimens); mouth length subequal to upper labial furrow (a little smaller in females). Upper labial furrows long, about 1.5 times lower furrows. Orbit large, its length slightly greater than nostril length or half of interorbital width. Subocular fold present, but not distinctive. Spiracle small, located just behind eye and below horizontal axis of eye. Five small gill slits (often their form modified in each specimen); edges of gill septa and gill slits blackish; 5th gill slit smallest situated above pectoral-fin base. Gill septa covered with numerous dermal denticles except posterior margins, normally without posteriorly projecting medial lobe.

Pectoral fin large, broad, expanding laterally (less expansion in females); anterior margin equal to or slightly longer than P1–P2 space; its posterior tip extending beyond middle position of P1–P2 origins. Pelvic-fin origin located at mid point between pectoral-fin insertion and anal-fin origin. Pelvic fin small, low, length slightly less than P1–P2 space. Anal fin low, its height subequal to nostril length, base length equal to or greater than P1–P2 origins; its outline rounded and very long-based; its origin very close to pelvic-fin insertion (separated by a notch in female). First dorsal fin located above pelvic–anal interspace; its origin almost above or slightly anterior to pelvic-fin insertion. First dorsal fin small, its height subequal to 2/3 second dorsal-fin height. Anterior margins of dorsal fins slightly rounded. D1–D2 space smaller than anterior margin of second dorsal fin. Second dorsal-fin insertion apparently anterior to anal-fin insertion, its height equal to 1.5 times D1 height or body width at second dorsal fin. Caudal fin long, without distinctively enlarged modified denticles on dorsal edge;

Table 1. Proportional measurements (%TL) and meristic counts of the holotype (CSIRO H953-07) and paratypes (14 males and 14 females) of *Apristurus australis* sp. nov.

		Holotype	Paratypes
1	Total length (mm)	616	250–628
3	PreD2-origin length	58.4	54.8–61.0
5	PreD1-origin length	46.0	43.3–50.3
6	PreP1 length	21.6	21.8–25.0
7	PreP2 length	36.6	36.4–40.5
9	Preanal length	51.0	45.2–52.0
10	Precaudal length	66.4	60.8–67.8
11	Pre-branchial length	19.6	19.3–23.4
13	Pre-orbital length	11.4	11.1–13.5
14	Pre-outer nostril length	7.3	6.7–8.8
15	Pre-inner nostril length	9.2	9.1–11.0
16	Pre-oral length	10.8	9.4–13.0
17	Head length	22.2	21.0–25.6
21	Mouth width	7.2	5.2–8.0
23	Internarial width	2.8	2.6–3.4
24	Upper labial furrow length	3.2	3.0–4.2
25	Lower labial furrow length	2.8	2.1–3.1
26	Orbit length	2.9	2.2–3.4
28	Nostril length	2.8	2.5–3.2
30	Interorbital width	5.7	4.4–6.3
31	1st gill height	1.5	0.9–2.0
32	3rd gill height	1.7	1.2–2.3
33	5th gill height	1.3	1.0–1.7
34	D1–D2 space	7.6	5.5–9.3
35	D1–D2 origins	13.6	10.2–13.0
36	D1–D2 insertions	14.0	9.2–14.1
37	P1–P2 space	7.6	6.0–11.8
38	P1 tip to P2 origin	3.8	2.3–6.1
39	P1–P2 origins	15.1	13.0–19.5
44	D1 base length	5.5	3.3–5.7
45	D1 height	9.9	1.3–1.7
46	D1 free lobe length	2.1	1.9–3.6
48	D2 base length	6.1	4.0–6.3
49	D2 height	2.5	2.1–2.6
50	D2 free lobe length	2.3	2.9–5.0
52	P1 anterior margin	9.9	9.3–12.1
57	P2 length	9.3	7.5–10.0
61	Anal base length (ceratotrichia)	15.8	13.8–17.2
65	Anal height (muscle)	2.8	2.1–3.9
68	Caudal length	33.6	32.2–37.7
74	Clasper outer length	4.3	1.2–5.3
	Tooth rows:		
	upper	54	50–64
	lower	57	48–68
	Vertebrae:		
	monospondylous	33	32–34
	precaudal diplospondylous	36	31–36
	Spiral valves		8–9

Table 2. Comparison of number of tooth cusps in *Apristurus australis* sp. nov. and *A. herklotsi*.

Teeth	Anterior	Lateral
Mature male		
A. australis	5-6	7-8
A. herklotsi	3-5	5
Female & immature		
A. australis	6-7	8-9
A. herklotsi	5	6-7

ventral lobe high and its apex rather rounded. Caudal peduncle height twice its width.

Intestinal spiral valves (8–9). Monospondylous vertebrae 33 (32–34), and precaudal diplospondylous vertebrae 36 (31–36).

Tooth rows on upper jaw 54 (50–64), on lower jaw 57 (48–68). Teeth on upper jaw (Fig. 3) possessing 5 or more cusps, usually with 2–1–2 arrangement; 3rd tooth from the symphysis with long, sharp and robust central cusp, about 3–4 times longer than its adjacent cusp; teeth of 13th lateral position posteriorly projecting, not asymmetric form in numbers of cusps and their size. Tooth on lower jaw (Fig. 3) with 5–8 cusps; anterior 3rd–5th teeth from the symphysis wide based; lateral 13–15th tooth with numerous cusps in maple leaf-like outline, its central cusp not conspicuously elongated, lateral cusps not asymmetric, cusp arrangement 4–1–3 (anterior teeth

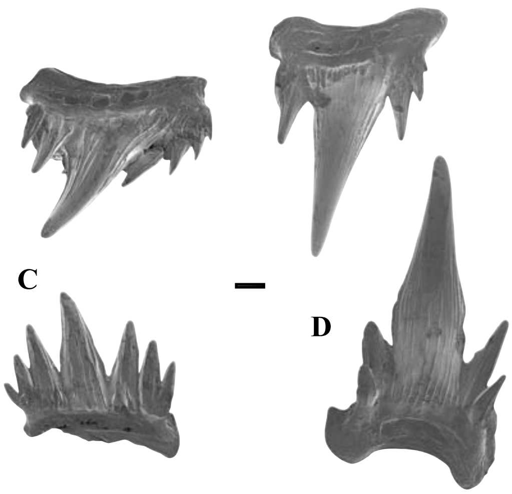

Figure 3. Teeth of *Apristurus australis* sp. nov., holotype CSIRO H 953–07 (mature male 616 mm TL): A. upper right 13th; B. upper right 5th; C. lower right 15th; D. lower right 3rd. Scale bar = 0.2 mm.

Figure 4. Egg capsules: A. *Apristurus australis* sp. nov., paratype HUMZ 139946 (female 530 mm TL); B. *A. herklotsi*, HUMZ 170421 (female 482 mm TL). Scale bar = 10 mm.

in female usually 6 cusps or more, 8 or more in lateral teeth on upper and lower jaws). Central cusp of anterior teeth apparently longer than the lateral cusps, but that of lateral teeth relatively short, shorter than twice its adjacent cusps or a little longer than its adjacent cusps. Number of tooth cusps on lower jaw usually more than those on upper jaw when compared at same position.

Egg capsule (from a paratype) taken from 530 mm TL specimen (HUMZ 139946, Fig. 4A) 78.6 mm long and 17.2 mm wide in a narrow cylindrical shape, without coiled tendrils on anterior and posterior ends; anterior margin of the capsule rounded without projection at each corner; weak neckline constriction located at about one fifth of capsule; lateral edges flanged, fused at posterior end; posterior tip forming narrow tubule tapering toward its end. Surface of egg capsule relatively smooth to touch, no striation recognised. Colour brownish, eggs taken from oviduct covered with fibrous substance entirely. Respiratory slits at anterior-left and posterior-left side of the capsule, posterior one covered by thin membrane extended from edge.

Denticles from dorsolateral side of body (Fig. 5) closely spaced, overlapping, leaf-like in shape with 3 cusps; each cusp sharp and pointed with weak ridges on its dorsal surface; outer surface of denticles completely structured by reticulations. No modified or enlarged dermal denticles on the dorsal margin of caudal fin.

Clasper (Fig. 6A) moderately narrow, tapering toward the tip; ventral side of clasper and surface of exorhipidion densely covered by dermal denticles; dorsal side of clasper almost naked including rhipidions. Clasper groove entirely covered by rhipidions except for posterior one sixth. Pseudosiphon distinct, a narrow, deep groove opening at postero-inner side of cover rhipidion; its aperture melanised and forming an oval concavity. Cover rhipidion thick and distinctive, covering almost entire rhipidion dorsally. Rhipidion moderately small, convex

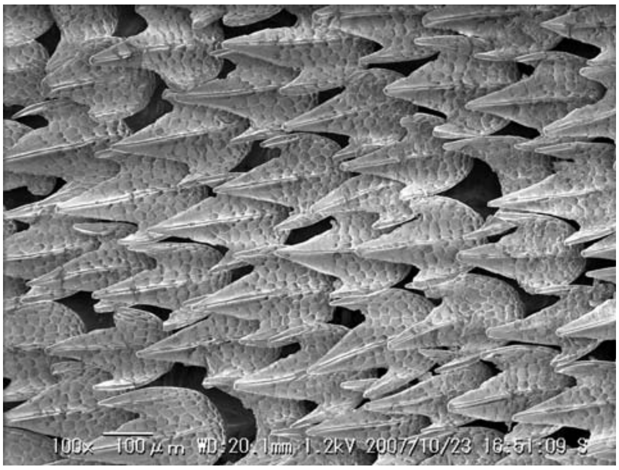

Figure 5. Dermal denticles of *Apristurus australis* sp. nov., holotype CSIRO H 953–07 (male 616 mm TL). Scale bar = 0.1 mm.

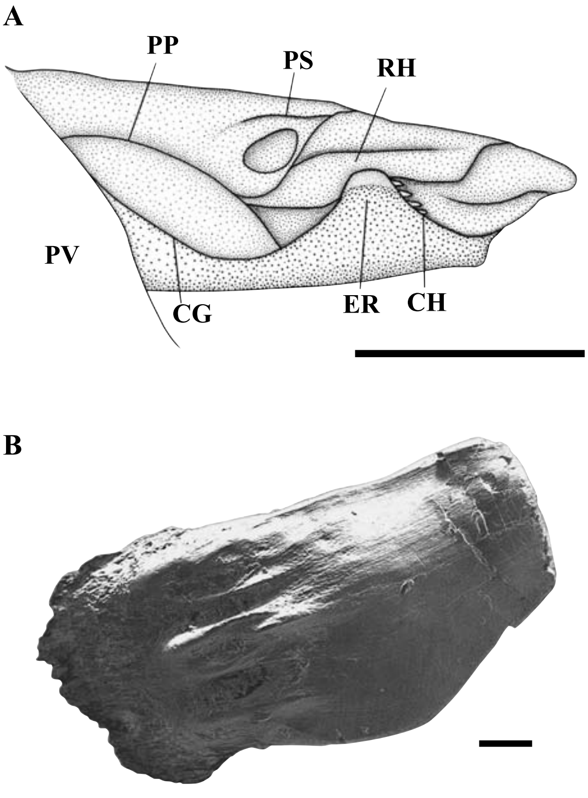

Figure 6. A. Dorsal view of left clasper of *Apristurus australis* sp. nov., holotype CSIRO H 953–07 (male 616 mm TL); B. Enlarged SEM image of a clasper hook from right clasper, scale bar = 0.1 mm. CG = clasper groove; CH = clasper hooks; ER = exorhipidion; PP = pseudopera; PS = pseudosiphon; PV = pelvic fin; RH = rhipidion, scale bar = 10 mm.

at about mid length. Distinct clasper hooks present along the antero-inner margin of the exorhipidion; a clasper hook taken from the right clasper (Fig. 6B) almost flat plate-like in shape, 0.99 mm long, 0.52 mm wide, with smooth posterior edge.

COLOUR (in alcohol).— Colour in alcohol uniformly pale brownish to light greyish (sometimes light yellowish brown); dorsal side of body a little darker than ventral side. Margins of dorsal pectoral, pelvic, anal and caudal fins without naked areas and slightly darker coloured. Axils of dorsal, pectoral and pelvic fins naked with blackish coloration. Paratypes from Queensland typically having darker dorsal and paler ventral sides of body, and paler pectoral, pelvic, dorsal and caudal fin margins. Inside of buccal cavity dark brownish without denticles.

SEXUAL DIMORPHISM.— Space between pectoral fins slightly narrower in mature males; pelvic fin a little anteriorly located and P2–anal fin space greater (P2 and anal fins separated by a notch in females); first dorsal fin in males almost above pelvic insertion (apparently in front of pelvic-fin insertion); relatively less cusps with a robust central cusp on teeth in mature male; deeper arch of mouth in mature males.

DISTRIBUTION.— Widely distributed along the coasts off Australia from off northern Queensland to southern Tasmania and Western Australia in depths of 486–1035 m.

SIZE.— Males and females attain at least 600 mm TL, and the maximum size recorded in this study is 616 mm TL. Males maturing at 450–500 mm TL based on clasper condition. Females maturing at 450–550 mm TL based on gonad development.

ETYMOLOGY.— The specific Latin name *australis* (southern) is derived after its geographic distribution, currently found only from southern hemisphere around Australia.

REMARKS.— *Apristurus australis* sp. nov. belongs to the 'longicephalus group' of *Apristurus* suggested by Nakaya & Sato (1999) in possessing conspicuously long pre-outer nostril length which is much greater than the interorbital width. The 'longicephalus group' was composed of 7 nominal species, *A. abbreviatus* Deng, Xiong & Zhan, 1985, *A. brevicaudatus* Chu, Meng & Li, 1986, *A. herklotsi* (Fowler, 1934), *A. longianalis* Chu, Meng & Li, 1986, *A. longicaudatus* Li, Meng & Chu, 1986 (*in* Chu, Meng & Li, 1986), *A. longicephalus* Nakaya, 1975 and *A. xenolepis* Meng, Chu & Li, 1985, but Nakaya (1991) recognised only 2 species *A. herklotsi* and *A. longicephalus* as valid. Among the 'longicephalus group', *Apristurus australis* sp. nov., which is the third species in the group, is morphologically closer to *A. herklotsi* from the western North Pacific by possessing higher tooth row counts of 50–64 on upper and 48–68

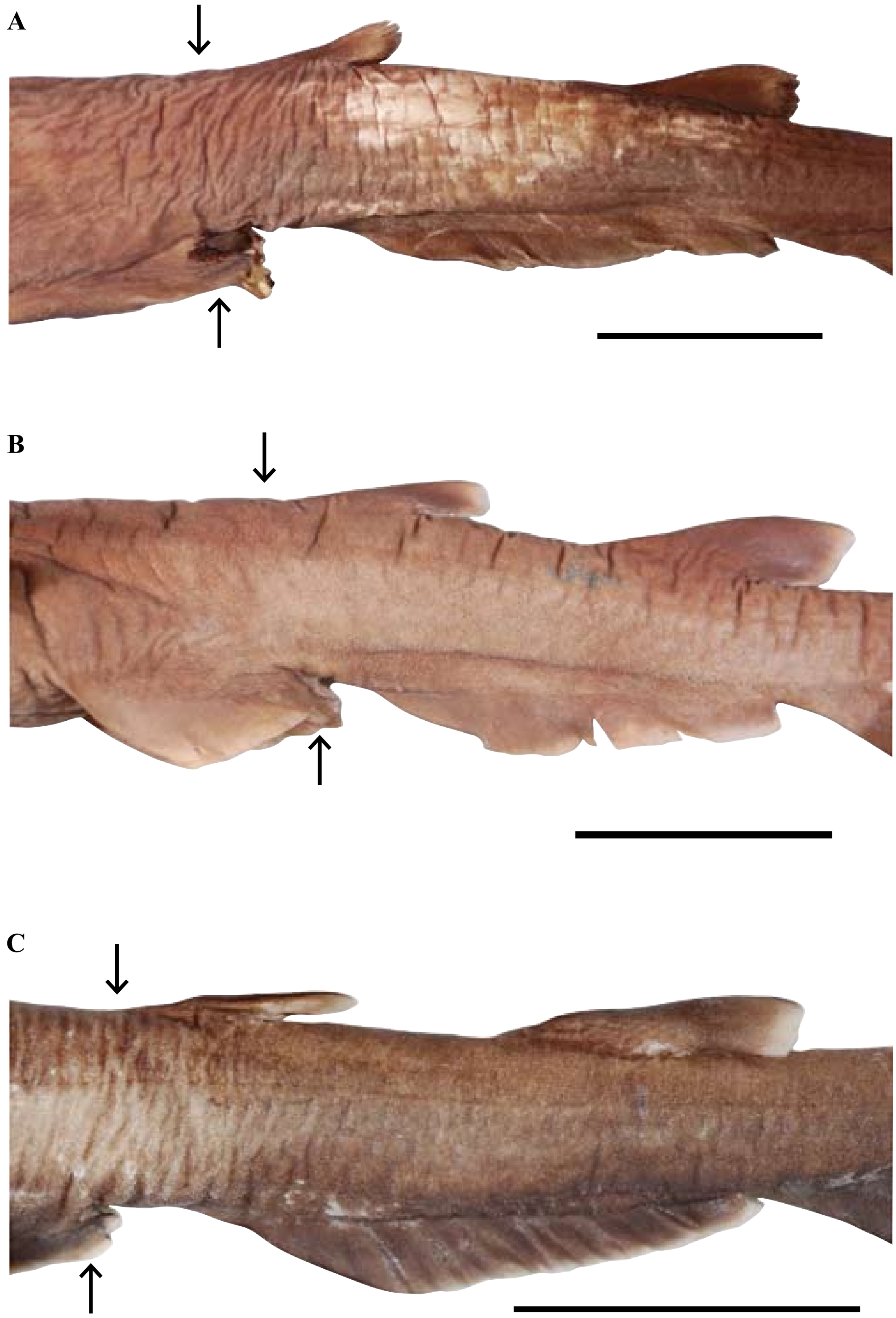

Figure 7. Positions of first dorsal-fin origin and pelvic-fin insertion (arrows): A. *Apristurus australis* sp. nov., holotype CSIRO H 953–07 (mature male 616 mm TL); B. *Apristurus australis* sp. nov., paratype CSIRO T 459 (mature female 562 mm TL); C. *Apristurus herklotsi*, HUMZ 170421 (mature female 482 mm TL). Scale bar = 50 mm.

on lower jaws (vs. 47–56 and 49–61 in *A. herklotsi*, 36–49 and 31–44 in *A. longicephalus*), counts of spiral valves 8–9 (vs. 10–11 in *A. herklotsi* and 13–17 in *A. longicephalus*), short duodenum of intestine (vs. very long in *A. longicephalus*).

Although *Apristurus australis* sp. nov. is very similar to *A. herklotsi* in proportion and counts, this species differs from the latter species in several morphological features as follows. *Apristurus australis* sp. nov. is distinguishable from *A. herklotsi* in the position of the first dorsal fin, i.e. first dorsal-fin origin located almost above (in mature males, Fig. 7A) or slightly before pelvic-fin insertion (in juveniles and females) (Fig. 7B), while the origin is located apparently behind pelvic-fin insertion in *A. herklotsi* regardless of sex (Fig. 7C). These two species are separable by the comparative sizes of the first and second dorsal fins. The first dorsal-fin height is about 2/3 of that of second dorsal fin in *A. australis* sp. nov. (Fig. 7A, B), while it is half or less in *A. herklotsi* (Fig. 7C), indicating *A. herklotsi* has much smaller first dorsal fin than *A. australis* sp. nov. They can be further distinguished by the tooth morphology (Table 2), even though sexual dimorphism is recognised. In mature males, anterior teeth on both jaws usually have 5 or more cusps in *A. australis* sp. nov., while 3–5 weak lateral cusps are present in *A. herklotsi*. Lateral teeth of mature males have 7–8 cusps in *A. australis* sp. nov. (vs. at most 5 cusps with a prominent central cusp in *A. herklotsi*). In females and immature specimens, anterior and lateral teeth have 6–7 and 8–9 cusps, respectively in *A. australis* sp. nov. (vs. 5 and 6–7 cusps in *A. herklotsi*). The central cusps of lateral teeth are subequal to twice the size of adjacent lateral cusps (in male) or slightly longer than adjacent lateral cusps (in females) in *A. australis* sp. nov. (vs. much longer than twice adjacent lateral cusps in *A. herklotsi*). As shown above, *A. australis* sp. nov. has more distinct lateral cusps and relatively shorter central cusps than *A. herklotsi*. *Apristurus australis* sp. nov. is also different from *A. herklotsi* in some biological features. *Apristurus australis* sp. nov. matures at about 450–500 mm TL in males and 450–550 mm TL in females, while *A. herklotsi* matures at lengths smaller than 400 mm TL in males and 450 mm TL in females. Together with the facts that the largest specimen examined is 616 mm for *A. australis* sp. nov. and 520 mm TL for *A. herklotsi*, *A. australis* sp. nov. is considered to be a larger species than *A. herklotsi*. An egg capsule of *A. australis* sp. nov. is 79.2 mm long and 17.6 mm wide (Fig. 4A), and this is much larger than that of *A. herklotsi* (55.7 mm long and 15.6 mm wide, Fig. 4B). This may also indicate that *A. australis* sp. nov. is a larger species than *A. herklotsi*. In addition, its length/width ratio of egg capsule is 5.08 in *A. australis* sp. nov., while it is 3.57 in *A. herklotsi*, indicating that the present new species has more slender egg capsules than *A. herklotsi*.

Last & Stevens (1994) noted the presence of two populations in this species, i.e. northern and southern forms, which are distinct from each other in colour patterns. We examined those specimens from both regions, but no valid difference was found between the two forms in proportions and counts. In addition, intermediate forms in colour pattern were found among present specimens. Therefore, we conclude the two forms noted by Last & Stevens (1994) are intraspecific variations in *A. australis* sp. nov. As discussed above, *A. australis* sp. nov. can be distinguished from the closest species, *A. herklotsi*, and is described here as a new species of the genus *Apristurus*.

Comparative material.
Apristurus abbreviatus Deng, Xiong & Zhan, 1985: 6 specimens: ECSFI (East China Sea Fisheries Institute) E-1547 (holotype), male 430 mm TL, East China Sea; ECSFI E-1000, ECSFI E-1001, ECSFI E-1417, ECSFI E-1548, ECSFI E-1597 (paratypes), 2 males and 3 females, 311–407 mm TL, East China Sea.
Apristurus brevicaudatus Chu, Meng & Li, 1986: 3 specimens: SCSFRI (South China Sea Fisheries Institute) D-1125 (holotype), male 397 mm TL, South China Sea; SFC D-32, SFC D-1126 (paratypes), 2 males, 412–419 mm TL, South China Sea.
Apristurus herklotsi (Fowler, 1934): 26 specimens: USNM 93134 (holotype), female 326 mm TL, Cagayan Island, Jolo Sea, Philippines; BSKU 23109, BSKU 23110, BSKU 26647, BSKU 27598, BSKU 27882, FUMT-P 10142, FUMT-P 10143, FUMT-P 10444, HUMZ 170382, HUMZ 170415, HUMZ 170416, HUMZ 170417, HUMZ 170418, HUMZ 170420, HUMZ 170421, HUMZ 170442, HUMZ 170448, HUMZ 170492, HUMZ 170499, HUMZ 170932, HUMZ 185159, HUMZ 185160, HUMZ 185161, HUMZ 185162, HUMZ 185169 (non-types), 13 males and 12 females, 268–520 mm TL, Okinawa Trough and Taiwan.
Apristurus longianalis Chu, Meng & Li, 1986: 2 specimens: SCSFRI S-6530 (holotype), female 366 mm TL, South China Sea; SFC D-571 (paratype), female 359 mm TL, South China Sea.
Apristurus longicaudatus Li, Meng & Chu, 1986 *in* Chu, Meng & Li, 1986: 2 specimens: SCSFRI D-811 (holotype), male 324 mm TL, South China Sea; SFC-564 (paratype), male 330 mm TL, South China Sea.
Apristurus longicephalus Nakaya, 1975: 38 specimens: HUMZ 42399 (holotype), male, 367 mm TL, Tosa Bay, Shikoku, Japan; BSKU 22338, BSKU 23012, BSKU 26455, BSKU 26512, BSKU 26648, BSKU 26649, BSKU 26650, BSKU 26651, BSKU 26867, BSKU 26868, BSKU 27596, BSKU 28096, BSKU 28097, BSKU 28166, BSKU 33518, BSKU 33519, BSKU 33520, BSKU 33999, BSKU 34000, HUMZ 145151, HUMZ 145153, HUMZ 145154, HUMZ 191310, HUMZ 193669, HUMZ 194156, HUMZ 194157, HUMZ 194158, HUMZ 194159, HUMZ 194161, HUMZ 194265, HUMZ 194266, PPSIO (6 uncatalogued specimens) (paratypes), 237–585 mm TL, 14 males, 14 females and 9 unsexed specimens, Okinawa Trough, Indonesia and west of Madagascar.
Apristurus xenolepis Meng, Chu & Li, 1985: SCSFRI D-42 (holotype), female 415 mm TL, South China Sea.

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Bythaelurus incanus sp. nov., a new deepwater catshark (Carcharhiniformes: Scyliorhinidae) from northwestern Australia

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ABSTRACT.— *Bythaelurus incanus*, a new species belonging to a rare genus of deepwater catsharks, is described based on a single specimen collected from the Ashmore Terrace, off northwestern Australia in about 1000 m depth. It complies closely with the definition of Compagno's recently elevated subgenus of the genus *Halaelurus*. *Bythaelurus incanus* differs from most of its congeners in morphometrics and colour, being uniformly plain coloured both dorsally and ventrally rather than spotted and blotched, weakly saddled or paler ventrally, and in denticle and tooth morphologies.

Key words. Scyliorhinidae – *Bythaelurus incanus* – deepwater catshark – new species – Australia

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INTRODUCTION

Members of the subgenus *Bythaelurus* Compagno, 1988, were initially assigned to the genus *Halaelurus* (Compagno, 1984). Compagno (2005) elevated the group to genus level, presumably based on the combination of characters used to define his subgenus. He listed seven members of the group: *Bythaelurus alcockii* (Garman, 1913), *B. canescens* (Günther, 1878), *B. clevai* (Séret, 1987), *B. dawsoni* (Springer, 1971), *B. hispidus* (Alcock, 1891), *B. immaculatus* (Chu & Meng *in* Chu, Meng, Hu & Li, 1982), *B. lutarius* (Springer & D'Aubrey, 1972), of which *B. alcockii* is considered questionable. Compagno *et al*. (2005) provided short descriptions of these species and included two extra undescribed species: a new species from the Galapagos Islands (as *B.* sp. B) and an Australian species previously identified by Last & Stevens (1994) as *B.* sp. A. The new Australian species is formally named and described below based on a single specimen collected off northwestern Australia.

METHODS

Morphometric methods generally followed a widely adopted scheme for elasmobranchs (Compagno, 1984, 2001), but focused on direct rather than horizontal measurements. The holotype was measured in full (Table 1) and meristics were taken from radiographs. Meristics were obtained separately for total, trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and caudal (centra of the caudal fin) vertebrae. The holotype is deposited in the Australian National Fish Collection, Hobart (CSIRO).

Bythaelurus incanus sp. nov.

Figs 1, 2; Table 1

Halaelurus sp. A: Last & Stevens, 1994: pp 171, 202, key fig. 53, fig. 26.30, pl. 18; Compagno *et al*., 2005: p 215, pl. 35.

Holotype. CSIRO H 1204–02, juvenile male 454 mm TL, south of Roti Island, Ashmore Terrace, Western Australia, 13°06′ S, 122°18′ E, 900–1000 m, Jan 1988.

DIAGNOSIS.— A *Bythaelurus* with the following combination of characters: head short and broad, width 13.5% TL, length 19.1% TL; snout short, broadly rounded, length 2.5 in head length; anterior nasal flaps triangular; mouth large, width 10.3% TL, length 4.6% TL; labial furrows short, confined to mouth corners; roof of mouth with small papillae; abdomen elongate, pectoral–pelvic space 2.8 times length of pectoral-fin anterior margin, 1.7 times interdorsal space; predorsal distance about 42% TL, 10.9 times eye length; anal-caudal distance 6.3% TL; first dorsal-fin origin slightly behind origin of pelvic fin; second dorsal-fin origin well behind anal-fin mid-base; anal-fin base length 1.2 times second dorsal-fin base length, subequal to interdorsal space; flank denticles weakly tricuspidate, crowns very slender, their length more than twice their width;

Figure 1. *Bythaelurus incanus* sp. nov., juvenile male holotype (CSIRO H 1204–02, 454 mm TL): A. dorsal view; B. lateral view.

teeth minute with mainly 4 small cusps, central pair longer than those adjacent, about 100 rows in each jaw; flank denticles upright, weakly tricuspidate; about 93 precaudal centra before upper caudal-fin origin; body uniformly greyish brown.

DESCRIPTION.— Body robust, flabby, depressed anteriorly, somewhat tadpole shaped; arched above pectoral fins; belly slightly expanded, tapering strongly behind first dorsal fin. Head strongly depressed, short and broad, length 19.1%, width 13.5% TL; widest just forward of 1st gill slit; broadly parabolic in dorsoventral view, bluntly pointed in lateral view; lateral angle of suborbital shelf well defined; supraorbital crest thin; gill slits dorsolateral; last two slits over pectoral-fin base, slightly closer together than slits 1–3; slits decreasing progressively in length from first to fifth. Snout broadly rounded, length 2.93 in head length. Eye dorsolateral, slit-like, length 1.67 in snout; suborbital groove well-developed, slightly longer than eye; orbito-spiracular groove continuous; interorbital width 1.31 times snout length, 2.23 in head length. Spiracle very small, suboval, well separated from eye; dorsolateral on head, length 14.1 in interorbital width. Anterior nasal flap expanded laterally, triangular, partly overlapping outer lobe but not reaching mouth, posterior margin usually entire; internarial width subequal to length of nasal cavity. Mouth long and broad, width 2.23 times length; roof of mouth and tongue pleated and weakly papillose; labial furrows rudimentary; postoral grooves absent. Jaw teeth minute, villiform, recurved slightly medially, in oblique rows; mainly with 4 sharp cusps; near symphysis central pair longest, outer medial cusp longer than lateral cusp; near angle of jaw central pair only slightly longer than lateral cusps; cusps with basal grooves.

Flank denticles very small, bristly, erect, weakly tricuspidate; well separated, not imbricate, similar in size; crowns narrow (length more than twice width) with a well-developed median ridge, lateral ridges absent; their apices elongate and narrowly pointed; denticles along dorsal caudal margin densely packed, smaller than those adjacent; denticles on belly broader, denser, smaller than those of flank, lacking median ridge on crown.

First dorsal fin tall, strongly raked, preceded by a deep groove; anterior margin long, weakly convex; apex narrowly rounded; posterior margin short, truncate; free rear tip obtusely angular; inner margin long, straight, obliquely upright; smaller than second dorsal fin; origin slightly behind origin of pelvic fin; pre-first dorsal length 42.4% TL. Second dorsal fin tall, strongly raked, preceded by a deep groove that extends to first dorsal fin; anterior margin long, weakly convex; apex narrowly rounded; posterior margin truncate (much longer than in first dorsal fin); free rear tip obtusely angular; inner margin short, straight, obliquely upright; pre-second dorsal length 58.8% TL; origin well behind anal-fin mid-base, insertion well behind free rear tip of anal fin. Anal fin larger than second dorsal fin (base longer but height of fin less); anterior margin long, weakly convex; apex broadly rounded; posterior margin weakly concave; free rear tip narrowly angular; inner margin short, weakly concave; anal-fin length 2.02 times pelvic–anal space. Pectoral

Table 1. Morphometric data for the holotype of *Bythaelurus incanus* sp. nov. (CSIRO H 1204–02). Measurements expressed as a percentage of total length.

Total length (mm)	454	Caudal peduncle width	1.8
Precaudal length	71.8	Pectoral fin - anterior margin	13.0
Pre-second dorsal length	58.8	Pectoral fin - base length	5.6
Pre-first dorsal length	42.4	Pectoral fin - height	8.9
Head length	19.1	Pectoral fin - inner margin	5.2
Prebranchial length	16.5	Pectoral fin - posterior margin	8.8
Prespiracular length	12.0	Pelvic fin - length	9.9
Preorbital length (horizontal)	5.1	Pelvic fin - anterior margin	6.1
Preorbital length (direct)	6.5	Pelvic fin - base length	7.3
Preoral length	5.3	Pelvic fin - height	4.5
Prenarial length	3.6	Pelvic fin - inner margin	3.3
Prepectoral length	20.1	Pelvic fin - posterior margin	6.1
Prepelvic length	40.3	First dorsal fin - length	8.7
Snout–vent length	43.2	First dorsal fin - anterior margin	8.5
Preanal length	52.6	First dorsal fin - base length	5.8
Interdorsal space	10.1	First dorsal fin - height	3.3
Dorsal–caudal space	5.5	First dorsal fin - inner margin	2.9
Pectoral–pelvic space	17.1	First dorsal fin - posterior margin	2.5
Pelvic–anal space	5.9	Second dorsal fin - length	11.1
Anal–caudal space	6.3	Second dorsal fin - anterior margin	11.2
Eye length	3.9	Second dorsal fin - base length	8.4
Eye height	0.4	Second dorsal fin - height	4.5
Interorbital width	8.6	Second dorsal fin - inner margin	2.3
Nostril width	2.7	Second dorsal fin - posterior margin	3.7
Internarial space	3.0	Anal fin - length	11.9
Anterior nasal flap length	2.4	Anal fin - anterior margin	9.1
Spiracle length	0.6	Anal fin - base length	9.7
Eye–spiracle space	1.5	Anal fin - height	3.4
Mouth length	4.6	Anal fin - inner margin	1.9
Mouth width	10.3	Anal fin - posterior margin	5.2
Upper labial furrow length	0.5	Caudal fin - dorsal caudal margin	26.6
Lower labial furrow length	0.4	Caudal fin - preventral caudal margin	11.9
First gill slit height	1.9	Caudal fin - upper postventral margin	12.9
Fifth gill slit height	1.0	Caudal fin - subterminal margin	5.2
Head height	7.0	Caudal fin - terminal margin	4.8
Trunk height	6.6	Caudal fin - terminal lobe	4.7
Caudal peduncle height	3.4	Second dorsal origin-anal fin origin	5.1
Head width	13.5	Second dorsal insertion-anal fin insertion	3.9
Trunk width	11.5		

fin large, lobe-like; anterior margin weakly convex, its length 13.0% TL; apex narrowly rounded; posterior margin almost straight; free tip broadly rounded; inner margin weakly convex. Pelvic fin small, length 9.9% of TL; anterior margin almost straight, apex broadly rounded; posterior margin weakly concave; free rear tip narrowly angular; inner margin almost straight. Claspers not developed, slightly depressed, not reaching beyond cloaca. Caudal fin large, elongate, with a low dorsal lobe and a weak ventral lobe; terminal lobe well developed, narrow, broadest distally, its posterior margin weakly concave; origin of dorsal lobe well forward of apex of ventral lobe; origin of ventral lobe indistinct, fleshy part of lobe originating just posterior to origin of dorsal lobe

Figure 2. Ventral view of head of *Bythaelurus incanus* sp. nov., juvenile male holotype (CSIRO H 1204–02, 454 mm TL).

but extending further anteriorly as a low scaly ridge almost to second dorsal fin.

Teeth in upper jaw about 99; in lower jaw about 101. Monospondylous centra 46; precaudal centra about 93 (to upper caudal origin); total centra about 142.

COLOUR.— Preserved specimen: Body almost entirely uniformly greyish brown (a few white blotches on belly); fins slightly darker dusky grey; mouth and teeth white.

SIZE.— Based on an immature male 454 mm TL.

DISTRIBUTION.— Known from the holotype which was taken on the mid-continental slope off the Ashmore Terrace, Western Australia (13°06′ S, 122°18′ E), in 900–1000 m.

ETYMOLOGY.— Derived from the Latin *incanus* (quite grey) in allusion to body and fin coloration. Vernacular: Dusky Catshark.

REMARKS.— Compagno (2005) lists six valid nominal species of *Bythaelurus*, and a dubious species, *B. alcockii*, and suggests that at least another two undescribed species have been identified. In another publication (Compagno *et al*., 2005), these species are figured and discussed. One of these undescribed species, *B. incanus* (as *B*. sp. A) was first identified in a recent guide to Australian sharks and rays (Last & Stevens, 1994). *Bythaelurus incanus* differs from most of its congeners in colour, being uniformly plain coloured both dorsally and ventrally, rather than spotted and blotched, weakly saddled or paler ventrally. Of the other species, *Bythaelurus immaculatus* from the western North Pacific is most similar to *B. incanus*. It shares a plain coloration with *B. incanus* but differs slightly in morphometrics, and based on figures of *B. immaculatus* in Compagno (1984), it appears to have broader denticles (length much less than twice their width vs. more than twice width) and more tooth cusps (a large central cusp and 4 much smaller lateral cusps vs. mainly 4 cusps of which the central pair are much larger than those adjacent). Based on Chu *et al*. (1982) description of the male holotype and two female paratypes, *B. immaculatus* also has a longer snout–vent length (exceeding tail length vs. more than 1.3 in tail length), snout subequal to eye length (vs. horizontal snout length 1.3 times eye length), interdorsal space almost twice base of first dorsal fin (vs. about 1.7 times), and pectoral–pelvic space 2.4–2.5 times (vs. 1.7 times) interdorsal space. *Bythaelurus canescens*, from the southeastern Pacific, is also mainly plain coloured but differs from *B. incanus* in having a pectoral–pelvic space 1.2–1.5 (vs. 2.8) times the length of the anterior margin of the pectoral fins, and the anal-fin base slightly shorter than (vs. subequal to) the interdorsal space. Compagno's (1984) figure of *B. canescens* also displays a more robust shark with a deeper and longer head, less evenly rounded snout, and a much shorter and deeper caudal peduncle.

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New swellsharks (*Cephaloscyllium*: Scyliorhinidae) from the Indo–Australian region

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ABSTRACT.— Four new species of swellsharks, *Cephaloscyllium cooki* sp. nov., *C. pictum* sp. nov., *C. speccum* sp. nov. and *C. signourum* sp. nov., are described based on material from the lower continental shelves and upper continental slopes of the Indo–Australian region. *Cephaloscyllium cooki* (eastern Indonesia and northwestern Australia) can be readily distinguished from all other nominal *Cephaloscyllium* species by a combination of its coloration and small maximum size. *Cephaloscyllium pictum* (eastern Indonesia), *C. speccum* (northwestern Australia) and *C. signourum* (northeastern Australia) belong to a species complex that is characterised by a strong, variegated colour pattern, and members can be distinguished from one another by morphometry and unique combinations of body and fin coloration in adults and juveniles.

Key words. Scyliorhinidae – *Cephaloscyllium cooki* – *Cephaloscyllium pictum* – *Cephaloscyllium speccum* – *Cephaloscyllium signourum* – new species – swellshark – Australia – Indonesia – Indo–West Pacific

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INTRODUCTION

The deep continental-slope fish faunas off tropical Indo–Australia have been surveyed opportunistically since the expedition of the R.V. *Siboga* (Weber, 1913). The trawling survey 'JETINDOFISH' investigated mainly the continental shelf of the Java and Arafura Seas between 20 and 250 m depth (Gloerfelt-Tarp & Kailola, 1984). However, in the late 1970's and 1980's, several cruises were undertaken in northwestern Australian waters to assess local scampi resources (CSIRO, unpublished data). In 1991, the French–Indonesian exploratory cruise 'KARUBAR' sampled the deep waters of the Banda and Arafura Seas using the Indonesian navy vessel 'Baruna Jaya I'. The aims of the cruise were to survey the bathyal fauna and make an assessment of biological resources of this area using an approach adopted for the MUSORSTOM cruises performed jointly by the Office de la Recherche Scientifique et Technique d'Outre-Mer (ORSTOM) and the Muséum National d'Histoire Naturelle (MNHN) in the Indo–Pacific, mainly the Philippines and New Caledonia (Séret, 1997). Material from this survey has been complemented by a survey of chondrichthyans marketed in eastern Indonesia (White *et al*., 2006). Concurrent deepwater surveys by government and commercial trawlers were underway off tropical eastern Australia (Last, unpublished data). Together, these surveys unearthed several new chondrichthyan species and provided important insights into the biodiversity of the region.

Amongst the groups for which several new species were collected, were swellsharks of the genus *Cephaloscyllium*. Members of this group are speciose in the Indo–West Pacific and most have narrow geographic ranges (see Compagno *et al*., 2005). Four species have been recorded from tropical Indo–Australia (Last & Stevens, 1994, White *et al*., 2006). Three of these are undescribed and the fourth has been tentatively identified as *C. fasciatum* Chan, 1966 (Last & Stevens, 1994). One of these new taxa, *C*. sp. E (*sensu* Last & Stevens, 1994), was thought to have a patchy distribution off eastern and western Australia (Last & Stevens, 1994; Compagno *et al*., 2005) and off eastern Indonesia (White *et al*., 2006). More recent studies have shown that the two regional forms of these strikingly variegated catsharks represent two distinct species. A fifth species, also undescribed, is known on the basis of 7 individuals collected near Tanimbar island in the western Arafura Sea by Australian vessels and during the KARUBAR survey from 1987–1991. The colour pattern of this catshark, which is dominated by dark bars and saddles lined with white lines and spots, is unlike any other known species of *Cephaloscyllium*. This species, along with the three variegated swellsharks, are described in this paper.

METHODS

Morphometric characters were selected to facilitate comparisons of the four new *Cephaloscyllium* species. Our methods generally followed a widely adopted scheme for elasmobranchs (Compagno, 1984, 2001), and focused on direct rather than horizontal measurements. The holotype and paratype(s) of the new species were all measured in full (Tables 1 and 2). Meristics were taken from radiographs of all type specimens of the four new species. Meristics were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and caudal (centra of the caudal fin) vertebrae. In the description, morphometric and meristic values for the holotype are given first followed in parentheses by the ranges of the paratype(s). Type specimens are deposited in the Australian National Fish Collection, Hobart (CSIRO), and ichthyological collections of the Muséum National d'Histoire Naturelle, Paris (MNHN), Museum Zoologicum Bogoriense, Jakarta (MZB), the Museum and Art Gallery of the Northern Territory, Darwin (NTM), the Queensland Museum, Brisbane (QM) and the Western Australian Museum, Perth (WAM); their registration numbers are prefixed with these acronyms.

Cephaloscyllium cooki sp. nov.

Figs 1–2; Table 1

Holotype. NTM S 13147–022, adult male 293 mm TL, Arafura Sea, Northern Territory, 09°46′ S, 130°25′ E, 255 m, 09 Dec 1990.
Paratypes. 6 specimens. CSIRO H 6638–02, female 242 mm TL, collected with holotype; NTM S 12288–038, female 286 mm TL, east of Evans Shoals, Arafura Sea, Northern Territory, ca. 10° S, 129° E, 270–300 m, 15 Sep 1987; NTM S 13147–016, female 284 mm TL, collected with holotype; MNHN 2007–1927, adolescent male 295 mm TL, off Tanimbar Island, Indonesia, 08°01′ S, 132°51′ E, 271–273 m, 29 Oct 1991; MNHN 2007–1928, female 242 mm TL, off Tanimbar Island, Indonesia, 09°23′ S, 131°09′ E, 246–275 m, 04 Nov 1991; MNHN 2007–1929, juvenile male 227 mm TL, off Tanimbar Island, Indonesia, 09°26′ S, 131°13′ E, 223–225 m, 04 Nov 1991.

DIAGNOSIS.— A small *Cephaloscyllium* with the following combination of characters: body relatively robust, head height 10.5–14.2% TL, trunk width 17.1–21.7% TL; first dorsal-fin origin over centre or posterior half of pelvic-fin base; prenarial length 4.9–5.5% TL; preorbital snout length 1.3–1.6 times prenarial length, 2.5–3.1 in prepectoral length, 5.5–6.6 in prepelvic length; short snout-vent length, 45.4–49.3% TL; nostrils wide, width 3.0–3.4% TL; wide eye–spiracle space, 1.0–1.2% TL; small pectoral fin, height 9.4–10.2% TL, posterior margin 8.9–9.8% TL; low anal fin, 2.8–3.4% TL; long caudal peduncle, anal–caudal space 6.3–6.9% TL; teeth near symphysis of upper jaw mainly with 3 cusps; flank denticles mainly weakly tricuspidate; no greatly enlarged denticles on back; adult clasper very long, outer length to at least 10% TL, almost reaching anal fin, interspace 0.9–1.0% TL; 101–106 vertebral centra; low tooth count, 48–62 teeth in each jaw; upper half of body, tail and caudal fin with 8 dark, white-edged saddles; and undersurface mainly uniform greyish, snout darkest.

DESCRIPTION.— Body moderately robust anteriorly, belly expanded, tapering gradually behind first dorsal fin. Head strongly depressed, short and moderately broad, length 22.9 (21.8–22.8)%, head width 13.8 (14.6–16.9)% of TL; widest just forward of 1st gill slit; narrowly parabolic in dorsoventral view, bluntly pointed in lateral view; lateral angle of suborbital shelf moderately well-defined; supraorbital crest thin; gill slits lateral; last two slits over pectoral-fin base, closer together than slits 1–3; first three subequal in length, last two decreasingly smaller. Snout tip moderately rounded, length 3.19 (2.71–3.17) in head length. Eyes dorsolateral, slit-like, length 1.71 (1.59–2.19) in snout; suborbital groove well-developed, slightly longer than eye; orbito–spiracular groove weak, formed by suborbital ridge and lateral extension of supraorbital crest; interorbital width 0.78 (0.80–0.81) of snout, 2.47 (2.18–2.90) in head length. Spiracle very small, subcircular to suboval, very close to mid level of eye, dorsolaterally on head, length 20.07 (11.52–17.39) in interorbital width. Anterior nasal flap expanded laterally, partly overlapping outer lobe but not reaching mouth, posterior margin notched or crenulated; internarial width subequal to nostril width. Mouth relatively long and narrow, width 2.23 (2.32–3.52) times length; roof of mouth and tongue weakly papillose; labial furrows absent; postoral groove short, deep, concave (extending ventrolaterally from each corner of mouth). Upper jaw teeth in adult male holotype small, mainly with 3 cusps (small lateral knobs on some teeth), similar in both jaws; most pronounced near symphysis, considerably longer than lateral cusps near mouth corners; medial teeth with greatly extended central cusp, about 3–4 times longer than those adjacent; in females, lateral cusps about a third or more of central cusp; symphysial groove of upper jaw deep. Lower jaw teeth in holotype smaller at symphysis in both sexes. Flank denticles of adult male weakly tricuspidate (lateral cusps blunt or sometimes not obvious), small, semi-upright, not or weakly imbricate, widely spaced; crown with a well-developed median ridge, apices pungent; females similar, more upright, crown with better developed lateral cusps and weak longitudinal ridges on lateral margins; no greatly enlarged denticles on body surface or fins. First dorsal fin not strongly raked, apex narrowly rounded with posterior margin truncated (convex in one paratype); much larger than second dorsal fin; origin over posterior half of pelvic-fin base (further forward in female paratypes), pre-first dorsal length 47.6 (49.4–52.2)% TL. Second dorsal fin low, subtriangular, pre-

Figure 1. *Cephaloscyllium cooki* sp. nov. holotype (NTM S 13147–022, adult male 293 mm TL): A. dorsal view; B. lateral view.

second dorsal length 62.5 (63.6–66.4)% TL; anterior and posterior margins almost straight, apex broadly rounded; origin well behind anal-fin origin, insertion almost over anal insertion (sometimes posterior). Anal fin similar in shape to second dorsal fin, but slightly larger. Pectoral fins relatively small, anterior margin 16.2 (12.8–15.8)% TL; anterior margin strongly convex, apices somewhat angular, posterior margin almost truncate, inner margin straight or weakly convex, free tip bluntly angular. Pelvic fins relatively small, length 11.4 (10.9–11.9)% of TL; anal-fin length 0.87 (1.01–1.12) times pelvic–anal space. Claspers cylindrical, very elongate, almost reaching anal-fin origin, ventral surface covered with denticles; pelvic fins united to dorsobasal surface of clasper, incomplete apron joining claspers just posterior to cloaca. Teeth in upper jaw 48 (50–61); in lower jaw 51 (49–62). Monospondylous vertebrae 37 (37–40); precaudal 70 (67–72); total 103 (101–106).

COLOUR.— Preserved specimens: Upper surface and sides above level of pectoral-fin medium greyish brown with 8 darker, white-edged saddles that extend ventrally to or almost to mid-flank; saddles mostly edged with white lines or spots (often well separated) with additional spots centrally; dorsal snout with variable fine white spots; mouth white. Six saddles on body; first saddle crescentic, extending across interorbit from posterior half of eye and directed posteriorly (greatest thickness subequal to combined eye and spiracle length), continuing ventrally below mid eye to suborbital ridge; second saddle originating slightly in advance of first gill slit, somewhat recurved posteriorly near dorsal midline (incomplete in paratype NTM S 13147–016b), similar in width to first saddle; third saddle originating above base of pectoral fin, irregular in shape, also recurved, horizontal length at midline slightly larger than first two saddles (NTM S 13147–016a with a posterolateral extension on flanks); fourth saddle originating over mid-abdomen, becoming narrower on flanks in paratypes; broad saddles beneath each dorsal fin, extending onto anterior base of fins. Caudal fin with two short saddles, without white internal spotting; first saddle barely reaching lateral midline, origin over ventral origin of caudal fin; second saddle slightly larger, insertion almost over caudal notch; dark v-shaped marking on posterior terminal lobe, extending along posterior margin of terminal lobe with its apex directed anteriorly; paler markings on ventral lobe. Dorsal surface of each pectoral fin mostly dark greyish, scantily marked with white spots (MNHN paratypes with large central blotch). Undersurface of body and pectoral, pelvic and anal fins uniformly pale greyish; darker grey on tip of preoral snout; claspers uniformly pale greyish.

SIZE.— Type material ranges from 227–295 mm TL. Holotype is an adult male of 293 mm TL.

DISTRIBUTION.— Known from the Arafura Sea off northwestern Australia (Evans Shoals, ca. 10° S, 129°

Table 1. Morphometric data for the holotype of *Cephaloscyllium cooki* sp. nov. (NTM 13147–022) with ranges provided for 6 paratypes. Measurements expressed as a percentage of total length.

	C. cooki **sp. nov.**		
		Paratypes	
	Holotype	Min.	Max.
Total length (mm)	293	242	286
Precaudal length	76.3	77.3	78.5
Pre-second dorsal length	62.5	63.6	66.4
Pre-first dorsal length	47.6	49.4	52.2
Head length	22.9	21.8	22.8
Pre-branchial length	17.5	17.9	18.5
Pre-spiracular length	11.4	12.1	12.6
Preorbital length (horizontal)	6.1	6.0	6.7
Preorbital length (direct)	7.2	7.1	8.3
Preoral length	4.4	4.2	4.8
Prenarial length	5.5	4.9	5.3
Pre-pectoral length	22.3	20.7	21.3
Pre-pelvic length	42.7	46.1	47.0
Pre-vent length	45.4	48.8	49.3
Pre-anal length	60.4	60.7	62.9
Interdorsal space	8.3	7.4	8.8
Dorsal–caudal space	8.9	6.8	8.7
Pectoral–pelvic space	16.7	19.8	20.5
Pelvic–anal space	12.1	8.5	9.5
Anal–caudal space	6.9	6.3	6.6
Eye length	4.2	3.8	4.5
Interorbital width	9.2	8.9	10.3
Nostril width	3.0	3.0	3.4
Internarial space	3.5	2.6	3.0
Anterior nasal flap length	1.7	1.3	2.0
Spiracle length	0.5	0.6	0.8
Eye–spiracle space	1.0	1.0	1.2
Mouth length	4.7	3.4	4.9
Mouth width	10.6	11.2	12.0
First gill slit height	2.0	2.2	2.3
Fifth gill slit height	1.0	1.4	1.5
Head height	10.6	10.5	14.2
Trunk height	13.2	12.6	16.4
Caudal peduncle height	2.9	3.1	3.4
Head width	13.8	14.6	16.9
Trunk width	17.1	17.3	21.7
Caudal peduncle width	3.1	2.9	3.3
Pectoral fin - length	14.4	12.6	14.1
Pectoral fin - anterior margin	16.2	12.8	15.8
Pectoral fin - base	7.8	8.3	9.2
Pectoral fin - height	9.6	9.4	10.2
Pectoral fin - inner margin	6.7	5.0	5.5
Pectoral fin - posterior margin	9.8	8.9	9.7

Table 1. cont'd.

	C. cooki sp. nov.		
		Paratypes	
	Holotype	Min.	Max.
Pelvic fin - length	11.4	10.9	11.9
Pelvic fin - anterior margin	6.9	5.7	6.9
Pelvic fin - base length	7.3	6.7	8.0
Pelvic fin - height	5.1	4.6	5.0
Pelvic fin - inner margin	5.7	3.5	4.5
Pelvic fin - posterior margin	7.5	6.0	7.2
Clasper outer length	10.0	–	–
Clasper inner length	14.6	–	–
Clasper base width	1.9	–	–
First dorsal fin - length	9.7	10.0	10.6
First dorsal fin - anterior margin	9.8	9.1	10.1
First dorsal fin - base length	7.0	7.1	7.4
First dorsal fin - height	4.7	4.3	5.3
First dorsal fin - inner margin	2.7	3.1	3.2
First dorsal fin - posterior margin	4.3	4.0	4.4
Second dorsal fin - length	9.2	8.6	8.6
Second dorsal fin - anterior margin	6.7	6.0	6.8
Second dorsal fin - base length	6.5	5.7	5.9
Second dorsal fin - height	3.0	2.8	3.0
Second dorsal fin - inner margin	3.4	2.7	3.0
Second dorsal fin - posterior margin	3.5	2.9	3.4
Anal fin - length	10.6	9.2	9.6
Anal fin - anterior margin	7.9	7.2	7.6
Anal fin - base length	7.8	6.5	7.6
Anal fin - height	3.3	2.8	3.4
Anal fin - inner margin	3.1	2.5	2.9
Anal fin - posterior margin	4.2	3.2	4.0
Caudal fin - dorsal margin	23.4	22.4	22.8
Caudal fin - preventral margin	10.8	10.2	11.1
Caudal fin - lower postventral margin	2.2	1.9	2.8
Caudal fin - upper postventral margin	8.0	6.7	8.9
Caudal fin - subterminal margin	5.4	4.0	4.1
Caudal fin - terminal margin	5.3	5.2	5.7
Caudal fin - terminal lobe length	8.0	6.6	7.3
Second dorsal origin–anal origin	1.4	2.0	2.8
Second dorsal insertion–anal insertion	0.4	0.7	1.4

E) and off Tanimbar Island, eastern Indonesia (08°01′ S, 132°51′ E, 09°26′ S, 131°13′ E), in 223–300 m.

ETYMOLOGY.— Named in honour of the late Sid Cook whose energy, dedication and contribution to shark conservation is sadly missed. Vernacular: Cook's Swellshark.

REMARKS.— The colour pattern of this catshark is unique within the genus *Cephaloscyllium* but not unique within the family. *Galeus boardmani* (Whitley, 1928) from subtropical and temperate Australia also has a somewhat similar, distinctive pattern of dark, pale-edged saddles and bars. Three other species are known from the tropical southeastern Indian Ocean: *C. fasciatum*

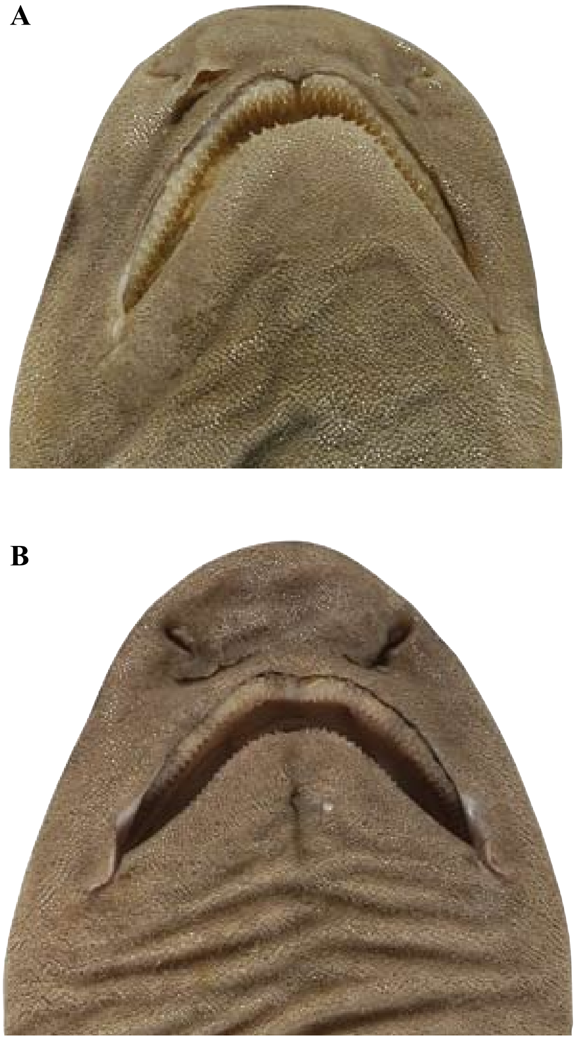

Figure 2. Ventral view of head of *Cephaloscyllium cooki* sp. nov.: A. holotype NTM S 13147–022 (adult male 293 mm TL); B. paratype NTM S 12288–038 (female 286 mm TL).

Chan, 1966 from off Vietnam, China and northwestern Australia; and two undescribed species (treated below) with variegated colour patterns that have been confused with *C.* sp. E (Last & Stevens, 1994, White *et al*., 2006). *Cephaloscyllium fasciatum* (*sensu* Last & Stevens, 1994), another small species also maturing at about 36 cm, has a variable pattern of narrow rings and open saddle-like markings. Apart from colour, the two variegated *Cephaloscyllium* species differ from *C. cooki* in their relative dorsal-fin positions, head shapes, and pelvic-fin sizes (see treatments for these species below). Most other members of the genus, except *C. silasi* (Talwar, 1974) and *C. fasciatum*, the males of which attain maturity by about 36 cm TL (Compagno *et al*., 2005), are large (adults attaining well over 50 cm and often over 100 cm). The colour pattern of *C. silasi* consists of dark blotches and saddles and its head is much broader than *C. cooki*.

Cephaloscyllium pictum sp. nov.

Figs 3–4, Table 2

Cephaloscyllium sp. E: White *et al*., 2006: pp 176, 177, fig.

Holotype. MZB 15502, adult male 649 mm TL, Tanjung Luar fish landing site, Lombok, Indonesia, 08°45′ S, 116°35′ E, 12 July 2004.
Paratypes. 4 specimens. CSIRO H 5875–01, female 632 mm TL, CSIRO H 5875–02, adult male 643 mm TL, Tanjung Luar fish landing site, Lombok, Indonesia, 08°45′ S, 116°35′ E, 26 Mar 2002; CSIRO H 5889–01, adult male 643 mm TL, Kedonganan fish landing site, Bali, Indonesia, 08°45′ S, 115°10′ E, July 2002; CSIRO H 6128–07, adult male 580 mm TL, Kedonganan fish landing site, Bali, Indonesia, 08°45′ S, 115°10′ E, 12 Oct 2002.

DIAGNOSIS.— A medium-sized *Cephaloscyllium* with the following combination of characters: head height 8.7–12.1% TL, trunk width 12.8–16.8% TL; first dorsal-fin origin over centre of pelvic-fin base; prenarial length 3.1–4.0% TL; preorbital snout length 1.8–2.1 times prenarial length, 3.1–3.5 in prepectoral length, 6.5–7.1 in prepelvic length; long snout-vent length, 49.5–50.7% TL; nostril width 2.5–2.9% TL; narrow eye–spiracle space, 0.5–0.7% TL; medium-sized pectoral fin, height 11.8–13.2% TL, posterior margin 9.8–12.1% TL; tall anal fin, 3.5–4.7% TL; anal–caudal space 5.5–6.6% TL; precaudal length 77–78% TL; interdorsal space 8.3–8.9% TL; teeth near symphysis of upper jaw with 3–5 cusps; flank denticles unicuspidate or weakly tricuspidate; no greatly enlarged denticles on back; adult clasper long, outer length 7–8% TL, terminating well short of anal fin, interspace 1.6–1.8% TL; 110–117 vertebral centra; moderate tooth count, 58–78 teeth in each jaw; upper half of body very dark, with a weak variegated pattern of spots and blotches, saddles absent or barely detectable; dorsal fins mostly dark variegated; large, blackish blotch over gills; dark, anteriorly directed, v-shaped marking on posterior margin of terminal lobe of caudal fin; pelvic-fin upper surface with a well-defined, blackish median blotch; no dark saddle extending onto caudal peduncle above origin of ventral lobe of caudal fin; ventral surface piebald with a speckled snout; and coloration of juvenile unknown.

DESCRIPTION.— Body moderately robust anteriorly, belly expanded, tapering gradually behind first dorsal fin. Head strongly depressed, short and moderately broad, length 22.7 (22.3–23.9)% TL, head width 14.1 (adult male paratypes 13.9–15.5, female paratype 17.0)% TL; widest just forward of 1st gill slit; narrowly parabolic in dorsoventral view (more broadly parabolic in female paratype), bluntly pointed in lateral view; lateral angle of suborbital shelf moderately well-defined; supraorbital crest thin; gill slits lateral; last two slits mostly over pectoral-fin base, slightly closer together than slits 1–3;

Figure 3. *Cephaloscyllium pictum* sp. nov. holotype (MZB 15502, adult male 649 mm TL): A. dorsal view (fresh); B. lateral view.

first four slits subequal in length, fifth much smaller. Snout tip bluntly pointed, length 3.21 (3.25–3.50) in head length. Eyes dorsolateral, slit-like, length 1.42 (1.42–1.59) in snout; suborbital groove well-developed, longer than eye; orbito–spiracular groove well developed, formed by suborbital ridge and lateral extension of supraorbital crest; interorbital width 0.86 (0.77–0.84) of snout, 2.75 (2.63–2.85) in head length. Spiracle very small, subcircular to suboval, close to mid level of eye, dorsolateral on head, length 10.53 (9.90–13.82) in interorbital width. Anterior nasal flap expanded laterally, partly overlapping outer lobe but not reaching mouth, posterior margin mostly irregular (sometimes weakly notched); internarial width subequal to nostril width. Mouth relatively long and narrow, width 2.00 (2.01–2.41) times length; roof of mouth and tongue strongly papillose; labial furrows absent; postoral groove short, deep, concave (extending ventrolaterally from each corner of mouth). Upper jaw teeth in adult male holotype small, recurved medially, with 3 cusps and basal grooves; lateral cusps minute or rudimentary (barely distinguishable to the naked eye); central cusps greatly extended near symphysis, only slightly longer than lateral cusps near mouth corners; symphysial groove deep. Lower jaw teeth in adult male holotype slightly smaller than those near symphysis of upper jaw, recurved anterolaterally; lateral cusps of posterior teeth more strongly defined than those anteriorly. Upper jaw teeth in female paratype with 3–5 cusps, those near symphysis with central cusp about twice size of lateral cusps; central cusp relatively much shorter than in adult males; central cusp near angle of jaw barely longer than those laterally. Flank denticles of adult male small, semi-erect, unicuspidate or weakly tricuspidate, widely spaced, weakly imbricate, apex broadly pointed; variable in size (some denticles more than twice the size of those adjacent); crown with a well-developed median ridge, lateral ridges not obvious; denticles of female also variable in shape, but with crowns slightly larger, more imbricate and with better developed medial and lateral ridges; no greatly enlarged denticles on mid surface of body or fins. First dorsal fin strongly raked, apex narrowly rounded with posterior margin mostly truncated (more broadly rounded in CSIRO H 5875–02); much larger than second dorsal fin; origin over mid-base of pelvic-fin, pre-first dorsal length 52.5 (49.8–52.1)% TL. Second dorsal fin low, raked (subtriangular in most paratypes), pre-second dorsal length 67.3 (66.0–67.1)% TL; anterior margin slightly convex, apex broadly rounded, posterior margin weakly concave, free rear tip angular (occasionally extended); origin slightly behind anal-fin origin, insertion almost over anal insertion (slightly posterior in female paratype). Anal fin much larger, relatively taller than second dorsal fin. Pectoral fins relatively small, anterior margin 15.3 (14.8–16.5)% TL; anterior margin moderately convex, apices narrowly rounded, posterior margin truncate to weakly convex,

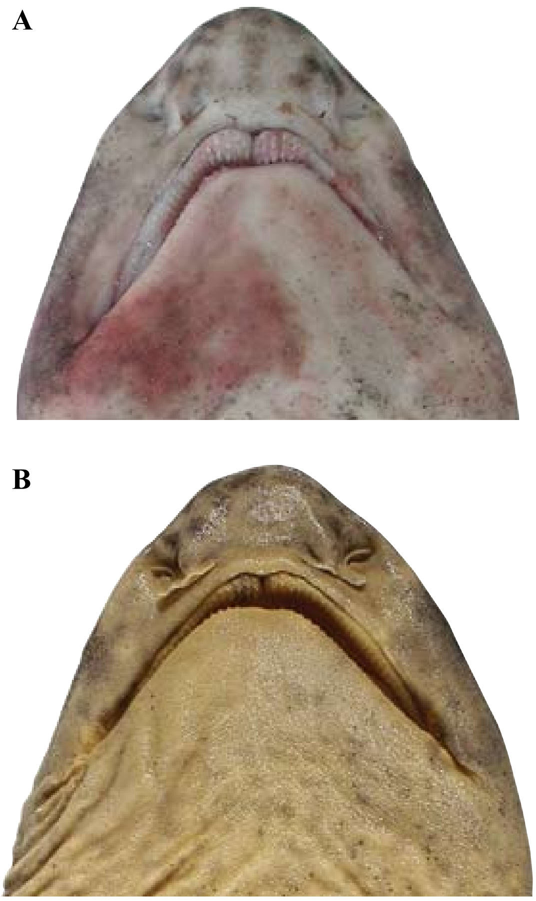

Figure 4. Ventral view of head of *Cephaloscyllium pictum* sp. nov.: A. holotype MZB 15502 (adult male 649 mm TL); B. paratype CSIRO H 5875–01 (female 632 mm TL).

inner margin weakly convex, free tip broadly rounded. Pelvic fins relatively small, length 10.8 (10.4–12.2)% of TL; anal-fin length 0.85 (0.78–1.10) times pelvic–anal space. Claspers cylindrical, elongate; apices well short of anal-fin origin; ventral surface covered with denticles; pelvic fins united to dorsobasal surface of clasper, incomplete apron joining claspers just posterior to cloaca. Caudal fin with a distinct ventral lobe; terminal lobe well developed, posterior margin truncate to strongly convex. Teeth in upper jaw 69 (58–78); in lower jaw 71 (59–77). Monospondylous vertebrae 41 (41–42); precaudal 74 (73–80); total 114 (110–117).

COLOUR.— Preserved specimens: Upper surface strongly variegated, predominantly dark; pattern irregular, consisting of a combination of pale, dark and greyish spots and blotches; dark broad bars and saddles typical of most *Cephaloscyllium* species not obvious; sharply but irregularly defined from much paler ventral surface near lateral angle of head and below gill slits to pectoral-fin origin; similarly demarcated from pectoral-fin insertion to pelvic-fin origin; spots and blotches not well defined on holotype, mainly consisting of irregular pale blotches and darker spots on predorsal body; variegated pattern somewhat better defined on postdorsal tail; large blackish bars beneath eye and around gill slits; other male paratypes either similar to holotype or with additional fine, regular-sized white spots; female paratype similar to holotype, with a greater abundance of blackish blotches and spots. Ventral surface yellowish with expansive coverage of greyish blotches in holotype (variable in paratypes but usually evident at least on abdomen); snout with distinct black and white speckling from angle of jaws forward; suborbital bar evident on ventral surface; ventral half of tail with light and dark blotches; no median dark stripe on belly; mouth pale. Dorsal fins variegated but mostly dark; anterior half of first dorsal fin with a dark irregular marking; second dorsal fin similar to first dorsal, anterior dark marking less obvious. Caudal fin strongly variegated, irregular bars through anterior and postmedial fin; distinct dark, anteriorly directed, v-shaped marking on posterior margin of terminal lobe. Anal fin mostly pale; usually with a distinct dark anterior marking, its edge poorly defined (less evident in CSIRO H 6128–07). Pectoral-fin upper surface similar in tone to dorsal surface of body, sometimes with additional, diffuse-edged white spots; ventral surface much paler, darker blotches most evident near fin margins. Pelvic-fin upper surface variegated, with a well-defined, blackish median blotch; ventral surface also variegated, somewhat paler. Claspers greyish dorsally, slightly paler ventrally; smooth tissue at apex whitish with a darker proximal band.

SIZE.— Type material ranges from 580 to 649 mm TL. Largest female and male recorded had lengths of 701 and 717 mm TL, respectively, and males mature by 580 mm TL (White, 2007).

DISTRIBUTION.— Known only from several locations in eastern Indonesia, i.e. Bali, Lombok. The types were obtained from fish markets so no depth information is available.

ETYMOLOGY.— From the Latin *pictus* (paint) in allusion to the coloration which has a somewhat painted appearance. Vernacular: Painted Swellshark.

REMARKS.— *Cephaloscyllium pictum* was tentatively identified as *C.* sp. E (White *et al*., 2006) based on its similarity to forms described from Australia. Genetic evidence supports its non-conspecificity with Australian forms (Ward *et al*., 2008) and there are subtle differences in their morphology. However, the three forms identified as *C.* sp. E are very similar in morphometrics and meristics. Most of the shape differences are masked by ontogenetic and sexual variation, which cannot be fully understood at this time due to the small collections of material for study. However, the variegated coloration in each of the forms has some obvious consistencies that help to distinguish species. Also, while the juvenile of *C. pictum* is unknown, the two Australian species have juveniles with markedly different colour patterns. In summary, adults of *C. pictum* differ from its Australian relatives in having a very dark, almost black, base colour (rather than greyish, or yellowish) with little evidence of darker saddles (saddles evident), the dorsal fins are mostly dark (rather than mostly pale), the pelvic-fin upper surface has a well-defined, blackish median blotch (usually absent), and the ventral surface piebald with a strongly speckled pattern on the snout. It differs from the Australian forms in precaudal length (77.1–78.4% TL, mean 78.0% TL vs. 72.5–77.7% TL, mean 76.7% TL in the Australian species), anal–caudal space 5.5–6.6% TL, mean 6.1% TL vs. 4.5–6.1% TL, mean 5.4% TL), dorsal caudal margin (20.8–23.9% TL, mean 21.8% TL vs. 22.1–26.4% TL, mean 23.3% TL, and prepectoral length 3.1–3.5 (mean 3.3) vs. 2.6–3.1 (2.9) times preorbital snout length. Other differences between theses taxa are discussed in treatments below.

Within the genus, only *C. ventriosum* (Garman, 1880) from the eastern Pacific has a strongly variegated colour pattern. *Cephaloscyllium pictum* is smaller (adult males 58–65 cm) whereas adult males of *C. ventriosum* are about 82–85 cm (Compagno, 1984). The colour pattern also differs between the species. *Cephaloscyllium ventriosum* is more strongly spotted and its anterior nasal flaps apparently reach the mouth (vs. terminating before mouth) (Compagno, 1984).

Cephaloscyllium signourum sp. nov.

Figs 5–7, Table 2

Cephaloscyllium sp. E (in part): Last & Stevens, 1994: pp 171, 196, key fig. 52, fig. 26.24, pl. 23; Compagno *et al.*, 2005: pp 221, 222, pl. 36; Compagno & Niem, 1998: pp 1282, 1285, fig. 14.

? *Cephaloscyllium* sp. n.: Séret, 1994, Chondrichthyan Fishes of New Caledonia. Chondros 5(3): 7.

Holotype. QM I 25956, female 741 mm TL, off Lihou Reefs, Queensland, 17°20′ S, 152°00′ E, 600–700 m.
Paratype. QM I 20641, immature female 236 mm TL, east of Murray Isles, Queensland, 09°53′ S, 144°23′ E, 480 m, 28 May 1985.
Other material. MNHN 1997–3430, male 837 mm TL, northern Norfolk Ridge, New Caledonia, 23°39′ S, 168°00′ E, 318 m, 13 Feb 1990. MNHN 1997–3431, male 559 mm TL, New Caledonia, 22°32′ S, 166°26′ E, 586 m, 14 May 1993; MNHN 1997–3432, female 898 mm TL, New Caledonia, 22°46′ S, 167°16′ E, 419–427 m, 12 January 1992; MNHN 1997–3433, female 878 mm TL, off Erromango Is., Vanuatu, 18°53′ S, 168°57′ E, 440 m, 24 September 1994; MNHN 2004–2661, male 850 mm TL, northern Norfolk Ridge, New Caledonia, 23°44′ S, 168°17′ E, 377–401 m, 31 Oct 2003.

DIAGNOSIS.— A medium-sized *Cephaloscyllium* with the following combination of characters (based on the holotype): head height 7.5% TL, trunk width 16.3% TL; first dorsal-fin origin over anterior pelvic-fin base; prenarial length 3.6% TL; preorbital snout length 2.0 times prenarial length, 3.0 in prepectoral length, 6.6 in prepelvic length; long snout-vent length, 51.7% TL; nostril width 2.7% TL; narrow eye–spiracle space, 0.5% TL; medium-sized pectoral fin, height 12.8% TL, posterior margin 11.9% TL; tall anal fin, 4.0% TL; anal–caudal space 5.0% TL; precaudal length 76% TL; interdorsal space 6.6% TL; teeth near symphysis of upper jaw with 3 well-developed cusps; flank denticles mostly unicuspidate; no greatly enlarged denticles on back; adult clasper unknown; 115–116 vertebral centra; high tooth count, 84 and 97 teeth in upper and lower jaws, respectively; upper half of body medium brown, with a variegated pattern that is not clearly demarcated from the ventral surface; 10 dark saddles evident on body and tail; dorsal fins pale variegated; no dark blotch over gills; dark, anteriorly directed, V-shaped marking on posterior margin of terminal lobe of caudal fin; pectoral-fin upper surface with a dark brown central blotch; well-developed saddle centred over ventral origin of caudal fin; ventral surface uniformly greyish or white; juvenile pale with dark transverse markings appearing as narrow bars and hollow saddles, and markings between spiracles not separated into two unconnected pseudo-ocelli.

DESCRIPTION.— Body moderately robust anteriorly, belly little expanded, tapering gradually behind first dorsal fin. Head very strongly depressed, short and very broad, length 23.4 (20.8 in small juvenile paratype)% TL, head width 15.9 (16.2)% TL; widest just forward of 1st gill slit; broadly parabolic in dorsoventral view, bluntly pointed in lateral view; lateral angle of suborbital shelf poorly defined; supraorbital crest thick; gill slits lateral; last 2–3 slits over pectoral-fin base, closer together than slits 1–3; first three subequal in length, last two decreasingly smaller. Snout broadly rounded, length 3.21 (2.68) in head length. Eyes dorsolateral, slit-like, length 1.43 (2.13) in snout; suborbital groove well-developed, slightly longer than eye (barely evident in paratype); orbito–spiracular groove weak, formed by suborbital ridge and lateral extension of supraorbital crest; interorbital width 0.81 (0.82) of snout, 2.60 (2.21) in head length. Spiracle very small (minute in paratype), subcircular, very close to mid level of eye, dorsolateral on head, length 15.42 (14.22) in interorbital width. Anterior nasal flap expanded laterally, fully overlapping outer lobe but not reaching mouth, posterior margin strongly notched; internarial width subequal to nostril width. Mouth short and broad, width 2.18 (2.66) times length; roof of mouth and tongue strongly papillose; lower labial furrow rudimentary in holotype, absent in paratype; postoral groove short, deep, concave (extending ventrolaterally from each corner of mouth). Upper jaw teeth in holotype small, recurved medially, with basal grooves and mainly with 3 cusps; lateral cusps well-developed, about a third height of central cusp near symphysis; central cusp about twice length of longest lateral cusp near angle of jaw; teeth near angle of jaw

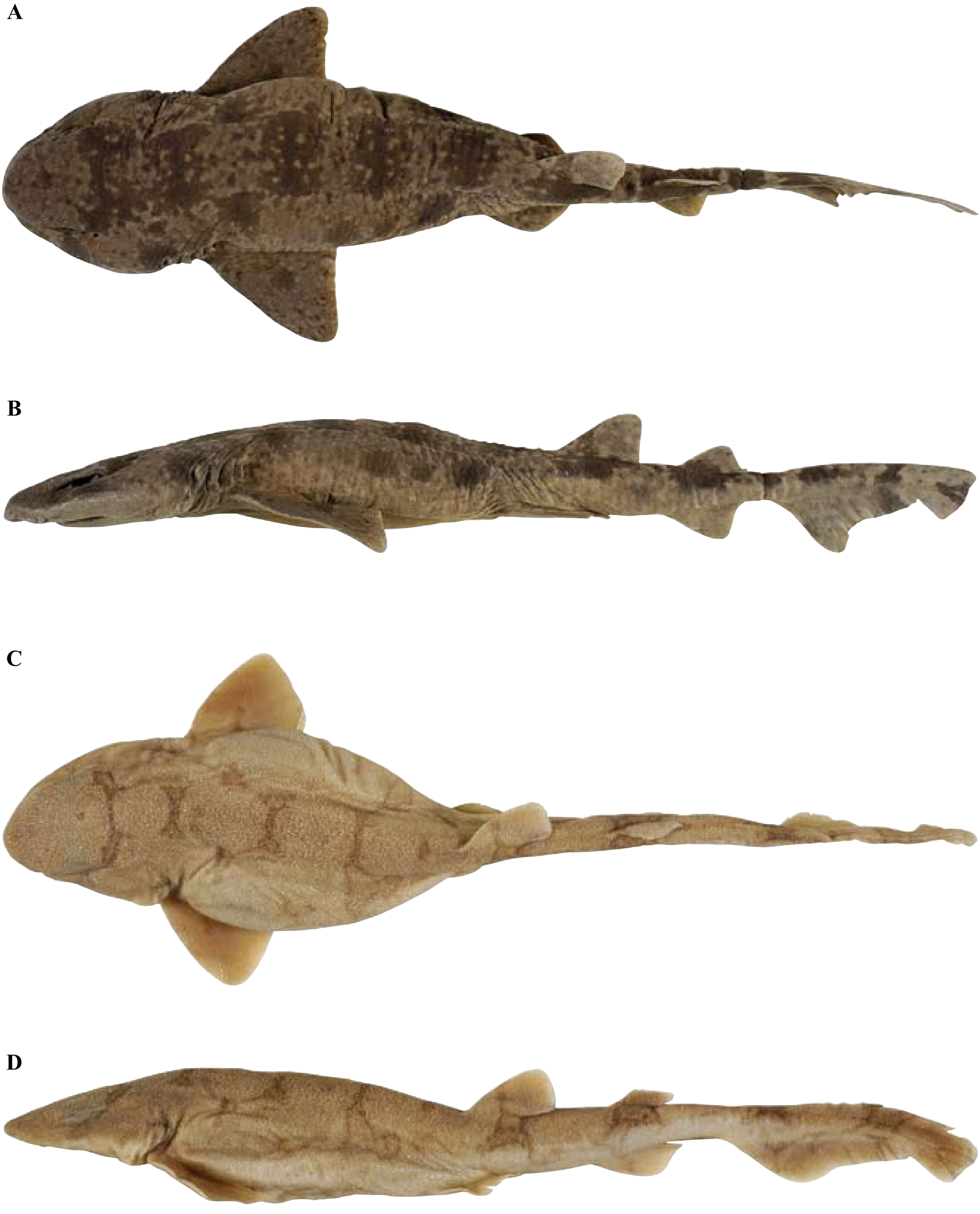

Figure 5. *Cephaloscyllium signourum* sp. nov.: A. dorsal view, B. lateral view of holotype (QM I 25956, female 741 mm TL); C. dorsal view, D. lateral view of juvenile paratype (QM I 20641, female 236 mm TL).

Figure 6. Ventral view of head of *Cephaloscyllium signourum* sp. nov. holotype (QM I 25956, female 741 mm TL).

often with 1 to 2 additional cusplets; symphysial groove narrow. Lower jaw teeth in holotype similar to those of upper jaw, not recurved anterolaterally; lateral cusps almost as long as central cusp near angle of jaw; about 5 rows of small teeth at symphysis of lower jaw, much smaller than those adjacent (teeth in both jaws of juvenile paratype mainly with narrow pungent central cusp; central cusps distinctly short and blunt towards angle of lower jaw). Flank denticles of holotype small, semi-erect, mainly unicuspidate (rarely tricuspidate), closely spaced, imbricate; variable in size; crown broad, with blunt apex; crown with a well-developed median ridge, lateral ridges indistinct; denticles of juvenile paratype slender, erect, weakly tricuspidate or unicuspidate, apex pungent, not imbricate; no greatly enlarged denticles on mid surface of body or fins in either adult holotype or juvenile paratype. First dorsal fin not strongly raked (more so in paratype), apex narrowly rounded with posterior margin truncated; much larger than second dorsal fin; origin over anterior half of pelvic-fin base, pre-first dorsal length 52.5 (45.8)% TL. Second dorsal fin very low, elongate, pre-second dorsal length 65.6 (61.0)% TL; anterior margin moderately convex, apex broadly rounded, posterior margin weakly convex with an extended free rear tip in holotype (not extended in paratype); origin well behind anal-fin origin, insertion over anal insertion. Anal fin much larger, deeper than second dorsal fin. Pectoral fins moderately sized, anterior margin 15.7 (12.8)% TL; anterior margin strongly convex, apices narrowly rounded, posterior margin almost truncate, inner margin weakly convex, free tip broadly rounded. Pelvic fins relatively small, length 11.7 (10.5)% TL; anal-fin length 1.32 (1.35) times pelvic–anal space. Caudal fin with a distinct ventral lobe (weak in paratype); terminal lobe well developed, posterior margin almost truncate. In holotype, teeth in upper jaw 84; in lower jaw 97. Monospondylous vertebrae 45 (42); precaudal 77 (78); total 115 (116).

COLOUR.— Preserved specimens: Upper surface strongly variegated, not predominantly dark, medium-brown; pattern irregular, consisting of a combination of 10, indistinct, dark saddles and pale, dark and greyish spots and blotches; not clearly defined from ventral surface; 5 vague, dark brown, irregular predorsal saddles, some of these with lateral extensions; saddles sometimes containing irregular-shaped yellowish spots; interorbital saddle extending from hind margin of eye and centred over spiracle, suborbital extension similar in width to eye and covering most of subocular shelf; no obvious dark bar over gill slits; well developed subdorsal saddles; saddle below first dorsal fin extending to lateral midline and posteriorly to free rear tip of fin, barely extending onto fin base; saddle below second dorsal fin elongate, originating forward of fin origin and extending almost to its free rear tip, extending ventrally to lateral midline; well-developed saddle at base of caudal fin, its midpoint above origin of ventral lobe of fin. Ventral surface almost uniformly dark grey, without distinct darker spots and blotches; snout similar to belly, without speckling; no median dark stripe on belly; mouth pale. Dorsal fins variegated but mostly pale; anterior third of first dorsal fin with a weak dark marking; second dorsal fin similar to first dorsal, dark marking confined to fin base. Caudal fin strongly variegated, with two dark bars, anteriormost bar better developed than posterior bar; distinct dark, anteriorly directed, V-shaped marking on posterior margin of terminal lobe. Anal fin uniformly greyish, without dark markings. Pectoral-fin upper surface similar in tone to dorsal surface of body, with a vague central dark brown blotch (sometimes with indistinct marginal spots); ventral surface uniformly greyish. Pelvic-fin upper surface variegated, without a median blotch; ventral surface uniformly greyish. <u>In juvenile paratype</u>: pale yellowish dorsally with dark, narrow bars and hollow saddles in similar positions to adult; interorbital bar represented as a posteriorly curved line separating two weak ocelli; other markings also represented as sharply demarcated lines with clearer areas between; ventral margins of subdorsal saddles sharply defined near lateral midline; bars on caudal fin represented as well-defined lines with paler areas between; V-shaped marking on terminal lobe of caudal fin hollow; darker, laterally directed streak near median base of pectoral fin; darker markings barely penetrating dorsal fins. Pelvic and anal fins mostly plain. Ventral surface almost uniformly white.

SIZE.— The type specimens are a large female 741 mm TL and a juvenile female 236 mm TL. If proven conspecific with the types, an 898 mm TL female from New Caledonia may be the largest representative of this species in collections; based on a specimen from Fiji, it may obtain a metre or more.

DISTRIBUTION.— Type material collected off Murray Isles (ca. 09° S) and Lihou Reef (ca. 17° S) off northeastern Queensland in depths of 480–700 m. Possibly also occurs in nearby Oceania, off the islands of New Caledonia, Fiji and Vanuatu.

Figure 7. Fresh specimen of *Cephaloscyllium* cf *signourum* caught in a *Nautilus* trap off Ovalau Island, Fiji in 350 m depth. Image supplied by Noby Dehm (Ovalau Watersports, Fiji).

ETYMOLOGY.— From the combination of the Latin *signum* (flag) and the Greek *oura* (tail) in allusion to the distinctive flag-like dark marking on the terminal lobe of the caudal fin. Vernacular: Flagtail Swellshark.

REMARKS.— The speckled swellshark, *C.* sp. E, was recognised by Last & Stevens (1994) based on a few individuals from small distributional pockets off northern Western Australia and Queensland. In the Australian region, demersal elasmobranchs rarely have disjunct and restricted distributions in two ocean basins (Last & Séret, 1999), so the conspecificity of these populations initially seemed questionable. More recent research has shown that these swellshark populations are of separate species. They are very similar in morphometrics and meristics but there are subtle differences in coloration, particularly of the juveniles. Juveniles of *C. signourum* are largely pale with dark transverse markings appearing as narrow bars and hollow saddles, rather than having a complex pattern of ocellate markings, spots and streaks. The anteriormost marking in young *C. signourum*, which crosses the dorsal surface almost level with the spiracles, consists of two narrow distal loops connected by a thin line. In the western species, this marking is divided in two larger, subcircular ‘pseudo-ocelli’ comprised of streaks and spots that are not connected dorsally. Based on the limited material available, adults of *C. signourum* appear to have: the first dorsal fin situated further forward with respect to the pelvic fin, a solid, dark V-shaped marking on posterior margin of terminal lobe of caudal fin (rather than absent but instead with irregular dark specks), the pectoral-fin upper surface with a dark brown central blotch (otherwise absent), and a well-developed saddle at the caudal-fin base with its midpoint (rather than its origin) over the ventral caudal lobe. Additional, larger specimens collected from Fiji (>1000 mm TL, K. Hoppen, pers. comm.), New Caledonia (MNHN 1997–3430, male 837 mm TL, MNHN 1997–3431, male 559 mm TL, MNHN 1997–3432, female 898 mm TL, MNHN 2004–2661, male 850 mm TL), and Vanuatu (MNHN 1997–3433, 878 mm TL), are similar to *C. signourum* in colour. The Vanuatu and New Caledonian specimens are also similar to *C. signourum* in vertebral counts, but differ in morphometrics and need to be compared more closely to Australian material to positively determine their identity. Another regional form recorded by E. Clark and J. Garrick is close to this species and belongs in this subgroup of variegated swellsharks.

Cephaloscyllium speccum sp. nov.

Figs 8–9, Table 2

Cephaloscyllium sp. E (in part): Last & Stevens, 1994: pp 171, 196, key fig. 52, fig. 26.24, pl. 23; Compagno *et al.*, 2005: pp 221, 222, pl. 36; Compagno & Niem, 1998: pp 1282, 1285, fig. 14.

Holotype. WAM P 31317–001, adult male 680 mm TL, Rowley Shoals, Western Australia, 17°35′ S, 118°55′ E, 150 m, 24 May 1997.

Paratypes. 6 specimens. CSIRO CA 4109, adult male 636 mm TL, Rowley Shoals, Western Australia, 17°37′ S, 118°44′ E, 396–399 m, 03 Feb 1984; CSIRO H 1210–01, female 694 mm TL, southwest of Ashmore Reef, Western Australia, 14°01′ S, 122°08′ E, 443 m, Jan 1988; CSIRO H 1634–01, immature male 416 mm TL, Rowley Shoals, Western Australia, 17°17′ S, 118°58′ E, 455 m, 02 Sep 1988; CSIRO H 1636–01, immature male 330 mm TL, Rowley Shoals, Western Australia, 17°49′ S, 118°29′ E, 410 m, 24 Aug 1988; CSIRO H 2027–01, female 494 mm TL, Rowley Shoals, Western Australia, 16°54′ S, 120°25′ E, 396 m, 12 Apr 1989; WAM P 28272–001, female 425 mm TL, Rowley Shoals, Western Australia, 16°41′ S, 120°35′ E, 400 m, 05 Feb 1984.

DIAGNOSIS.— A medium-sized *Cephaloscyllium* with the following combination of characters: head height 7.8–12.5% TL, trunk width 13.0–16.8% TL; first dorsal-fin origin mostly over posterior of pelvic-fin base; prenarial length 3.6–4.9% TL; preorbital snout length 1.5–2.0 times prenarial length, 2.6–3.1 in prepectoral length, 5.9–7.1 in prepelvic length; long snout-vent length, 47.4–51.1% TL; nostril width 2.2–2.7% TL; narrow eye–spiracle space, 0.4–1.0% TL; medium-sized pectoral fin, height 8.9–13.8% TL, posterior margin 8.5–13.3% TL; tall anal fin, 3.2–4.4% TL; anal–caudal space 4.5–6.1% TL; precaudal length 76–78% TL; interdorsal space 6.5–8.6% TL; teeth with 3–5 cusps; flank denticles unicuspidate or weakly tricuspidate; no greatly enlarged denticles on back; adult clasper long, outer length about 7% TL, well short of anal fin, interspace about 1.9% TL; 111–115 vertebral centra; relatively high tooth count, 69–97 teeth in each jaw; upper half of body pale, with a strongly variegated pattern that is well-demarcated from the ventral surface; 8 dark saddles evident on body and caudal fin; dorsal fins pale variegated; no dark blotch over gills; no distinct V-shaped marking on posterior margin of terminal lobe of caudal fin; pectoral and pelvic-fin upper surfaces lacking a dark central blotch; no dark saddle extending onto caudal peduncle above origin of ventral lobe of caudal fin; ventral surface uniformly pale; and juvenile pale with dark lines and spots forming rosettes and linear saddle markings, and markings between spiracles separated into two unconnected pseudo-ocelli.

DESCRIPTION.— Body moderately robust anteriorly, belly expanded, tapering gradually behind first dorsal fin. Head strongly depressed, short and moderately broad, length 23.8 (20.6–24.6)% TL, head width 15.1 (14.4–17.5)% TL; widest just forward of 1st gill slit; narrowly to broadly parabolic in dorsoventral view, bluntly pointed in lateral view; lateral angle of suborbital shelf moderately well-defined; supraorbital crest thin; gill slits lateral; last two slits over pectoral-fin base, slightly closer together than slits 1–3; first three slits subequal in length, last two becoming decreasingly smaller. Snout tip bluntly pointed, length 3.44 (2.73–3.35) in head length. Eyes dorsolateral, slit-like, length 1.48 (1.49–2.10) in snout; suborbital groove usually weakly developed, slightly longer than eye; orbito–spiracular groove weak, formed by suborbital ridge and lateral extension of supraorbital crest; interorbital width 0.78 (0.79–0.93) of snout, 2.67 (2.23–2.79) in head length. Spiracle very small, subcircular to suboval, mostly above mid level of eye, dorsolateral on head, length 13.15 (11.53–17.62) in interorbital width. Anterior nasal flap expanded laterally, overlapping outer lobe but not reaching mouth, posterior margin weakly notched or irregular; internarial width slightly larger than nostril width. Mouth relatively long and narrow, width 2.17 (2.06–2.78) times length; roof of mouth and tongue strongly papillose; labial furrows absent; postoral groove short, deep, concave (extending ventrolaterally from each corner of mouth). Upper jaw teeth in adult male holotype prominent, recurved medially, with basal grooves; mainly with 3 cusps near symphysis but with increasing regularity of additional 1–2 cusplets towards corner of mouth; lateral cusps easily visible to the naked eye; central cusps elongate near symphysis, about 3–4 times longer than longest lateral cusp, about 2–3 times longer near mouth corner; symphysial groove deep. Lower jaw teeth in adult male holotype only slightly smaller than those near symphysis of upper jaw, recurved anterolaterally; lateral cusps of posterior teeth not more strongly defined than those anteriorly; symphysial teeth damaged, probably slightly smaller than those adjacent. Upper jaw teeth in female paratype (CSIRO H 1210–01) with mainly 5 cusps, those near symphysis with central cusp about 2–3 times size of lateral cusps; central cusp distinctly shorter than in adult male; central cusp near angle of jaw more robust and about twice length of lateral cusps. Teeth of smallest juvenile (CSIRO H 1636–01) distinctly tricuspid in both jaws, cusps pungent. Flank denticles of adult male holotype small, semi-erect, mainly unicuspidate (sometimes very weakly tricuspidate), widely spaced, weakly imbricate, apex broadly pointed; variable in size; crown with a well-developed median ridge, lateral ridges not obvious. Denticles of female (CSIRO H 1210–01) non-erectile, mainly unicuspidate (sometimes weakly tricuspidate); crowns broad, undulate, sub-rhomboidal with prominent median ridge, well-defined lateral ridges; more strongly imbricate than in male; no greatly enlarged denticles on mid surface of body or fins. Denticles of smallest juvenile (CSIRO H 1636–01) weakly tricuspidate, erect, non-imbricate, widely spaced, variable in shape, crown narrow with pungent tips. First dorsal fin raked (more so in juvenile paratypes), apex narrowly rounded with posterior margin truncated (convex in juveniles); much larger than second dorsal fin; origin mostly over posterior half of pelvic-fin base (further forward in CSIRO H 2027–01), pre-first dorsal length 52.1 (48.3–53.1)% TL. Second dorsal fin very low, subtriangular in adults (more elongate in juveniles), pre-second dorsal length 66.2 (63.3–67.7)% TL; anterior margin almost straight, apex broadly rounded, posterior margin deeply concave basally, free rear tip usually extended; origin behind

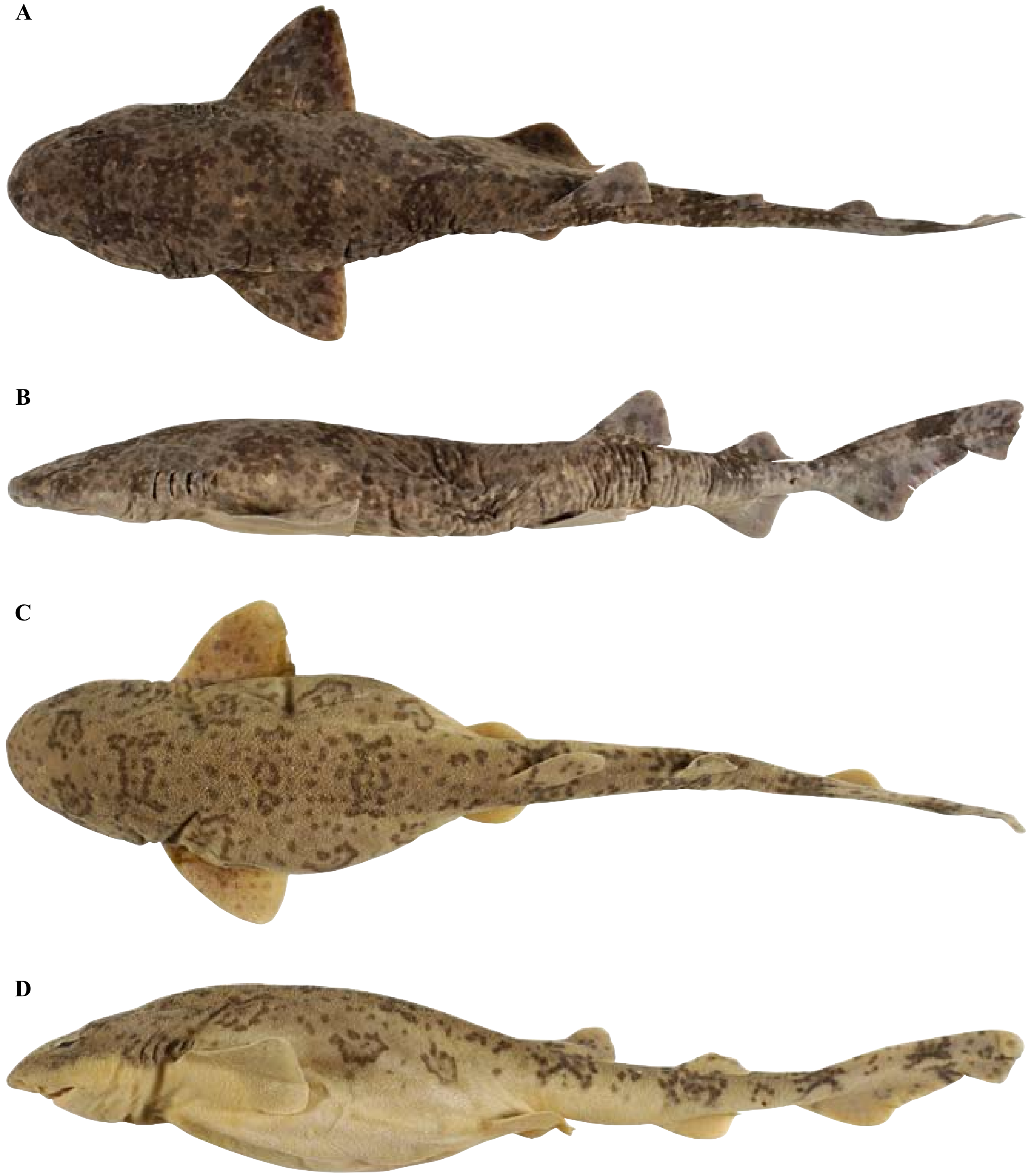

Figure 8. *Cephaloscyllium speccum* sp. nov.: A. dorsal view, B. lateral view of holotype (WAM P 31317–001, adult male 680 mm TL); C. dorsal view, D. lateral view of juvenile paratype (CSIRO H 1636–01, male 330 mm TL).

anal-fin origin, insertion almost over anal insertion. Anal fin similar in shape to second dorsal but slightly larger (usually relatively deeper). Pectoral fins moderately sized, anterior margin 15.0 (12.5–17.4)% TL; anterior margin strongly convex, apices narrowly rounded, posterior margin almost truncate (sometimes concave), inner margin straight or weakly convex, free tip bluntly angular to broadly rounded. Pelvic fins relatively small, length 11.9 (10.1–12.0)% TL; anal-fin length 0.94 (0.85–1.30) times pelvic–anal space. Claspers cylindrical, elongate, well short of anal-fin origin, ventral surface covered with denticles; pelvic fins united to dorsobasal surface of clasper, incomplete apron joining claspers just posterior to cloaca. Caudal fin with a distinct ventral

A

B

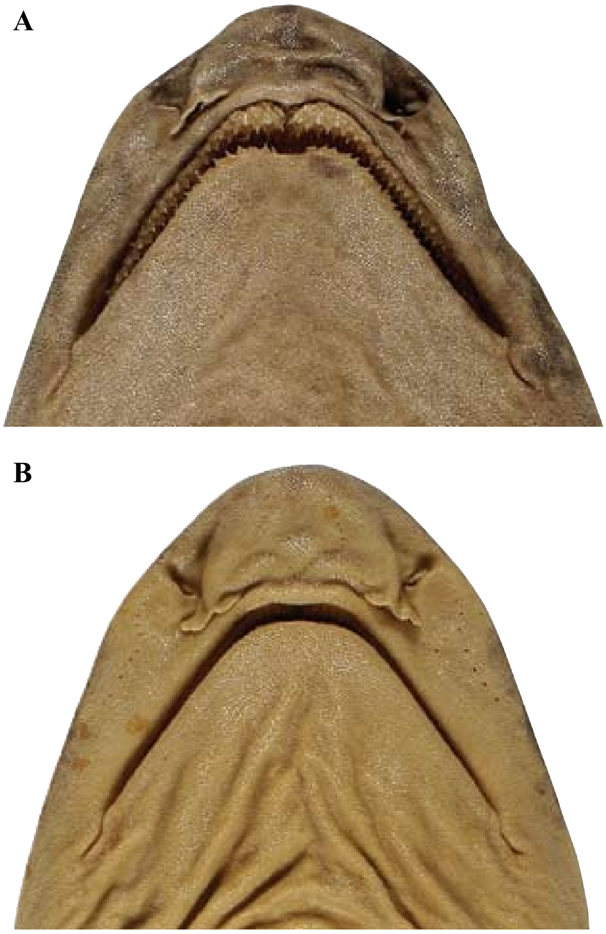

Figure 9. Ventral view of head of *Cephaloscyllium speccum* sp. nov.: A. holotype WAM P 31317–001 (adult male 680 mm TL); B. paratype CSIRO H 1210–01 (female, 694 mm TL).

lobe; terminal lobe well developed, posterior margin truncate to biconvex. Teeth in upper jaw 73 (69–84 in two paratypes); in lower jaw 77 (74–97 in two paratypes). Monospondylous vertebrae 43 (42–45); precaudal 75 (74–78); total 114 (111–115).

COLOUR.— Preserved specimens: Upper surface strongly variegated, not predominantly dark, medium-brown; pattern irregular, consisting of a combination of indistinct saddles and pale, dark and greyish spots and blotches; usually well defined from ventral surface; 4 vague, dark brown, irregular predorsal saddles, some of these with lateral extensions; saddles usually containing irregular-shaped yellowish spots; interorbital saddle broken at midline, forming two irregular shaped dark brown blotches between spiracles, suborbital extension similar in width to eye and covering most of subocular shelf; no obvious dark bar over gill slits; no obvious dark saddle above origin of pelvic fin; well developed subdorsal saddles; saddle below first dorsal fin extending to slightly below lateral midline and posteriorly to just behind insertion of fin, barely extending onto anterior fin base; saddle below second dorsal fin not elongate, originating forward of fin origin and extending to near its insertion, extending ventrally to well below lateral midline; no well developed precaudal saddle. Ventral surface almost uniformly pale grey, slightly darker on snout, with few darker spots and paler patches (paratypes white or almost uniformly pale yellow); no median dark stripe on belly; mouth pale. Dorsal fins greyish, variegated (paratypes mostly paler variegated); anterior basal third of first dorsal fin with a weak, irregular dark marking; second dorsal fin similar to first dorsal. Caudal fin strongly variegated, two dark bars; posterior bar slightly posterior of upper caudal lobe, better developed than anterior bar; anterior bar originating above origin of ventral lobe of caudal fin; no distinct dark, V-shaped marking on posterior margin of terminal lobe (with irregular dark blotches and streaks). Anal fin almost uniformly greyish or yellowish, without dark markings. Pectoral-fin upper surface similar in tone to dorsal surface of body, without a dark symmetrical blotch; ventral surface uniformly greyish or yellowish. Pelvic-fin upper surface variegated (sometimes almost uniformly pale), without a median blotch; ventral surface uniformly pale greyish or yellowish. In smallest juvenile paratype (CSIRO H 1636–01): more uniformly pale yellowish dorsally with darker brown lines and spots; saddles and blotches of adult evident as irregular rosettes and transverse linear saddle markings; most markings formed through coalesced spots with a semi-mitotic appearance; snout and interspaces between primary markings with scattering of small irregular dark spots (no obvious white spots); markings in similar positions to those of adults; weak evidence of a 5th predorsal saddle (missing in adults); fins relatively weakly or sparsely spotted.

SIZE.— Type material ranges from 330 to 694 mm TL. Males mature by 636 mm TL.

DISTRIBUTION.— Known only from the outer continental shelf and upper continental slope of northwestern Australia between Rowley Shoals (17°49′ S, 118°29′ E) and Ashmore Reef (14°01′ S, 122°08′ E) in depths of 150–455 m.

ETYMOLOGY.— From the Latin combination of *specca* (speckled) in allusion to the speckling of dark brown spots and blotches that dominate the colour pattern. Vernacular: Speckled Swellshark.

REMARKS.— Colour pattern is very important for distinguishing *Cephaloscyllium* species and formed the basis of the main key to the group (Compagno, 1984). The coloration of *C. speccum* is unlike any other variegated member of the genus, and this is best demonstrated in juveniles which have an elaborate arrangement of pseudo-ocelli on the back and sides which solidify to form weak saddles and bands in adults. Differences between *C. speccum* and its eastern Australian congener, *C. signourum*, have been discussed earlier. Geograph-

Table 2. Morphometric data for the holotype of *Cephaloscyllium pictum* sp. nov. (MZB 15502), *Cephaloscyllium signourum* sp. nov. (QM I 25956) and *Cephaloscyllium speccum* sp. nov. (WAM P 31317–001), with ranges provided for the paratype(s). Measurements expressed as a percentage of total length.

	C. pictum			***C. signourum***		***C. speccum***		
		n=4					n=7	
	Holotype	Min.	Max.	Holotype	Paratype	Holotype	Min.	Max.
Total length (mm)	649	580	643	741	236	680	330	694
Precaudal length	78.0	77.1	78.4	76.3	72.5	77.1	75.8	77.7
Pre-second dorsal length	67.3	66.0	67.1	65.6	61.0	66.2	63.3	67.7
Pre-first dorsal length	52.5	49.8	52.1	52.5	45.8	52.1	48.3	53.1
Head length	22.7	22.3	23.9	23.4	20.8	23.8	20.6	24.6
Pre-branchial length	18.4	17.5	19.4	19.1	16.9	18.8	17.4	19.1
Pre-spiracular length	11.6	10.8	12.1	11.8	12.0	11.3	10.7	12.1
Preorbital length (horizontal)	6.0	5.4	6.1	6.0	7.0	5.7	5.5	6.2
Preorbital length (direct)	7.1	6.5	7.1	7.3	7.8	6.9	6.8	7.9
Preoral length	4.9	3.9	4.7	4.2	4.9	4.1	3.8	4.7
Prenarial length	3.7	3.1	4.0	3.6	4.5	3.6	3.7	4.9
Pre-pectoral length	22.4	21.8	22.9	21.9	18.2	21.7	19.5	22.3
Pre-pelvic length	48.5	46.2	46.7	48.3	42.8	48.4	44.5	48.4
Pre-vent length	50.7	49.5	50.4	51.7	46.8	50.7	47.4	51.1
Pre-anal length	64.7	62.9	65.0	63.7	56.8	64.1	61.4	65.0
Interdorsal space	8.5	8.3	8.9	6.6	8.5	7.2	6.5	8.6
Dorsal–caudal space	6.1	5.6	7.4	5.6	8.6	5.8	5.3	7.7
Pectoral–pelvic space	19.4	18.8	20.6	19.2	18.0	20.9	17.2	20.3
Pelvic–anal space	10.9	9.0	11.9	7.2	8.1	10.4	7.9	11.3
Anal–caudal space	5.5	5.7	6.6	5.0	5.7	5.2	4.5	6.1
Eye length	5.0	4.5	4.8	5.1	3.6	4.7	3.8	4.8
Interorbital width	8.2	8.3	8.7	9.0	9.4	8.9	8.2	9.3
Nostril width	2.5	2.6	2.9	2.7	3.0	2.5	2.2	2.7
Internarial space	2.9	2.6	3.3	3.1	3.0	2.9	2.8	3.3
Anterior nasal flap length	1.4	1.1	1.4	1.2	1.6	1.2	1.1	1.6
Spiracle length	0.8	0.6	0.9	0.6	0.7	0.7	0.5	0.7
Eye–spiracle space	0.5	0.5	0.7	0.5	0.7	0.4	0.6	1.0
Mouth length	5.2	4.4	5.6	6.1	3.8	5.3	3.9	5.3
Mouth width	10.3	10.4	11.9	13.4	10.2	11.6	10.8	12.1
First gill slit height	2.0	1.6	2.0	2.6	1.8	2.5	1.7	2.4
Fifth gill slit height	1.5	1.2	1.6	1.7	0.9	1.5	1.3	1.6
Head height	10.7	8.7	12.1	7.5	8.3	8.7	7.8	12.5
Trunk height	12.2	10.5	14.0	7.9	9.0	9.6	8.2	15.8
Caudal peduncle height	2.7	2.4	2.9	2.4	3.3	2.8	2.6	3.4
Head width	14.1	13.9	17.0	15.9	16.2	15.1	14.4	17.5
Trunk width	14.4	12.8	16.8	16.3	20.1	14.3	13.0	16.8
Caudal peduncle width	2.6	2.3	2.7	2.2	2.5	2.1	2.1	3.0
Pectoral fin - length	12.7	13.0	14.3	13.4	12.9	13.6	12.5	13.8
Pectoral fin - anterior margin	15.3	14.8	16.5	15.7	12.8	15.0	12.5	17.4
Pectoral fin - base	8.9	8.2	9.4	8.9	8.9	8.7	8.3	9.1
Pectoral fin - height	12.5	11.8	13.2	12.8	9.5	12.0	8.9	13.8
Pectoral fin - inner margin	4.9	5.1	5.7	5.0	4.5	5.2	4.3	5.9
Pectoral fin - posterior margin	11.7	9.8	12.1	11.9	9.0	10.9	8.5	13.3

Table 2. cont'd.

	C. pictum			*C. signourum*		*C. speccum*		
		n=4					n=7	
	Holotype	Min.	Max.	Holotype	Paratype	Holotype	Min.	Max.
Pelvic fin - length	10.8	10.4	12.2	11.7	10.5	11.9	10.1	12.0
Pelvic fin - anterior margin	6.5	6.4	7.1	7.2	5.4	6.9	6.0	7.1
Pelvic fin - base length	7.7	8.0	9.3	9.6	8.0	7.8	6.7	8.8
Pelvic fin - height	5.3	4.0	5.3	3.9	4.3	5.2	4.0	5.9
Pelvic fin - inner margin	4.2	3.5	3.8	2.4	3.2	4.3	2.5	4.7
Pelvic fin - posterior margin	6.5	5.8	7.6	6.1	5.8	6.9	5.9	7.3
Clasper outer length	7.7	7.1	7.7	–	–	7.2	–	–
Clasper inner length	11.2	10.5	11.9	–	–	10.5	–	–
Clasper base width	1.4	1.6	1.7	–	–	1.4	–	–
First dorsal fin - length	9.4	9.9	10.4	10.3	9.9	10.3	9.2	10.1
First dorsal fin - anterior margin	10.1	9.3	10.5	10.8	9.5	10.3	9.0	10.7
First dorsal fin - base length	7.1	6.7	7.6	7.7	7.3	7.5	6.3	7.3
First dorsal fin - height	5.9	5.1	5.9	5.6	4.9	5.7	4.3	5.6
First dorsal fin - inner margin	2.6	2.7	3.3	2.8	3.5	3.2	2.7	3.4
First dorsal fin - posterior margin	5.3	3.9	5.3	5.0	4.0	5.1	3.7	5.2
Second dorsal fin - length	7.7	7.4	8.4	7.9	8.3	8.4	7.7	9.1
Second dorsal fin - anterior margin	6.3	5.9	7.0	5.9	6.3	6.2	6.1	7.0
Second dorsal fin - base length	5.0	4.9	5.3	5.0	6.2	5.2	4.8	6.1
Second dorsal fin - height	3.3	3.1	3.5	3.1	2.5	3.4	2.5	3.6
Second dorsal fin - inner margin	2.8	2.6	3.3	3.0	2.8	3.3	2.8	3.3
Second dorsal fin - posterior margin	3.6	2.8	3.8	3.2	2.6	4.0	2.9	3.9
Anal fin - length	9.3	9.2	10.6	9.5	10.9	9.8	9.6	10.3
Anal fin - anterior margin	8.1	8.1	9.4	8.0	8.3	8.0	7.4	8.7
Anal fin - base length	6.8	6.6	7.6	7.1	8.1	7.1	7.0	7.4
Anal fin - height	4.7	3.5	4.5	4.0	3.3	4.4	3.2	4.3
Anal fin - inner margin	2.7	2.4	3.3	2.8	2.6	2.9	2.5	3.1
Anal fin - posterior margin	4.2	3.0	4.1	4.2	3.6	4.3	3.4	4.5
Caudal fin - dorsal margin	21.6	20.8	23.9	23.2	26.4	22.6	22.1	24.3
Caudal fin - preventral margin	10.3	10.5	11.3	10.6	11.2	10.2	10.2	11.5
Caudal fin - lower postventral margin	2.9	2.6	3.1	3.0	3.0	3.2	2.3	3.8
Caudal fin - upper postventral margin	8.6	6.2	8.2	8.4	8.3	7.3	7.1	8.6
Caudal fin - subterminal margin	4.0	3.7	4.6	4.0	5.0	4.3	3.7	4.5
Caudal fin - terminal margin	6.2	5.2	6.3	6.2	5.0	6.1	5.2	7.3
Caudal fin - terminal lobe length	7.1	6.4	7.3	7.2	7.3	7.2	7.2	7.8
Second dorsal origin–anal origin	2.1	1.7	2.4	1.5	2.2	1.6	1.6	2.2
Second dorsal insertion–anal insertion	0.4	0.2	0.4	0.2	0.3	0.3	0.2	0.3

ically, *C. speccum* occurs close to *C. pictum*. Both occur in the tropical eastern Indian Ocean off eastern Indonesia. *Cephaloscyllium* speccum is much paler on the fins and body, has obvious dark saddles on the dorsal surface (indistinct in *C. pictum*), lacks a dark v-shaped marking on the terminal lobe of the caudal fin (present); and the ventral snout is uniform in colour (rather than with distinct black and white speckling).

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Cephaloscyllium albipinnum sp. nov., a new swellshark (Carcharhiniformes: Scyliorhinidae) from southeastern Australia

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ABSTRACT.— A new species of swellshark, *Cephaloscyllium albipinnum* sp. nov., is described based on material from the outer continental shelf and upper continental slope of southeastern Australia. *Cephaloscyllium albipinnum* has a parapatric distribution with another large swellshark, *C. laticeps*. These species can be distinguished by a combination of coloration and meristics. *Cephaloscyllium albipinnum*, which belongs to a subgroup of swellsharks with a colour pattern dominated by dark dorsal saddles and blotches (rather than being strongly mottled or variegated), has an egg case with a smooth surface. In comparison, the egg cases of *C. laticeps* are unique within the genus in possessing a series of thick transverse ridges. Other Australian saddled swellsharks have narrower saddles with larger interspaces, as well as subtle differences in body shape. A deepwater swellshark from New Zealand, *C. isabella*, also has well defined saddle-like markings but differs from Australian species in having a distinctive stellate saddle between the spiracles, and larger and more widely spaced denticles.

Key words. Scyliorhinidae – *Cephaloscyllium albipinnum* – swellshark – new species – Australia

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INTRODUCTION

Last & Stevens (1994) identified 7 *Cephaloscyllium* species from Australian waters of which 5 were considered to be undescribed. One of these species, known as the whitefin swellshark (*C.* sp. A *sensu* Last & Stevens), occurs off southeastern Australia where it is parapatric with an abundant inshore species, *C. laticeps* (Duméril, 1853). *Cephaloscyllium* sp. A was taken during the first deepwater fishery resource surveys off southern Australia but was mistaken as a variant of *C. laticeps* (Last & Harris, 1981). It was subsequently misidentified and figured as *C. nascione* Whitley, 1932 by Compagno (1984) and May & Maxwell (1986), which presumably led to its inclusion as that species in an Australian Pisces checklist (Paxton *et al.*, 1989). *Cephaloscyllium nascione* is now considered to be a junior synonym of *C. laticeps* (Last & Stevens, 1994, Hoese *et al.*, 2006). Whitley's (1932) swellshark, which was named *C. isabella nascione*, was thought to be a subspecies of the New Zealand swellshark, *C. isabellum* (Bonnaterre, 1788). However, the New Zealand species differs from all Australian swellsharks in colour pattern and denticle morphology.

Cephaloscyllium sp. A is a common bycatch in trawl fisheries of southeastern Australia. New South Wales catches, thought to be of *C.* sp. A but probably of *C.* sp. C *sensu* Last & Stevens, declined by more than 30% over a 20 year period (Barratt & Kyne, 2003). *Cephaloscyllium* sp. A has been rated as near threatened by the IUCN (Barratt & Kyne, 2003), and despite confusion with *C.* sp. C., this rating is probably appropriate. This new species is formally described and compared closely with *C. laticeps*, *C. isabellum* and *C. umbratile* Jordan & Fowler, 1903.

METHODS

Morphometric characters were selected to facilitate comparisons of the new *Cephaloscyllium* species with the sympatric *C. laticeps*. Our methods generally followed a widely adopted scheme for elasmobranchs (Compagno, 1984, 2001), but focused on direct rather than horizontal measurements. The holotype (CSIRO H 5314–11) and 6 paratypes (CSIRO CA 58, CSIRO CA 4500, CSIRO H 1328–01, CSIRO H 1328–02, CSIRO H 3866–01 and CSIRO H 5940–01) of the new species, 8 specimens of *C. laticeps* (CSIRO CA 4501, CSIRO H 1264–13, CSIRO H 1330–01, CSIRO H 1333–01, CSIRO H 2649–01, CSIRO H 3547–01, CSIRO H 3574–01 and CSIRO H 3850–05) and two specimens of

C. isabellum (NMNZ P 5454 and NMNZ P 20991) were measured in full (Table 1). Meristics were taken from radiographs of the holotype and 12 paratypes (CSIRO CA 58, CSIRO CA 4498, CSIRO CA 4500, CSIRO H 985–04, CSIRO H 1328–01, CSIRO H 1328–02, CSIRO H 1329–01, CSIRO H 3579–01, CSIRO H 3704–03, CSIRO H 3704–04, CSIRO H 3866–01 and CSIRO H 5940–01) of the new species, 9 specimens of *C. laticeps* (CSIRO CA 4501, CSIRO H 1264–12, CSIRO H 1332–01, CSIRO H 1333–01, CSIRO H 1334–01, CSIRO H 1339–01, CSIRO H 2341–01, CSIRO H 2649–01 and CSIRO H 3547–01) and 4 specimens of *C. isabellum* (NMNZ P 5454, NMNZ P 20971, NMNZ P 20978 and NMNZ P 20991). Meristics were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and caudal (centra of the caudal fin) vertebrae. In the description, morphometric and meristic values for the holotype are given first followed in parentheses by the ranges of the measured paratypes. Morphometric methods for egg cases follow those described by Ebert *et al*. (2006) and are presented for both the new species and *C. laticeps* (see Table 2). Type specimens and comparative material are deposited in the Australian National Fish Collection, Hobart (CSIRO), and ichthyological collections of the South Australian Museum (SAMA) and Museum of New Zealand, Te Papa Tongarewa (NMNZ); their registration numbers are prefixed with these acronyms.

Cephaloscyllium albipinnum sp. nov.

Figs 1, 2, 3a; Table 1, 2

Cephaloscyllium sp. A: Last & Stevens, 1994: pp 170, 192, key fig. 44, fig. 26.20, pl. 23; Compagno *et al.*, 2005: pp 219, 220, pl. 36.

Cephaloscyllium nascione: Gomon *et al.*, 1994: pp 136, 137, figs 104, 105.

Holotype. CSIRO H 5314–11, adult male 1013 mm TL, east of Maria Island, Tasmania, 42°38′ S, 148°26′ E, 445–463 m, 01 May 2000.

Paratypes. 15 specimens. CSIRO CA 58, immature male 638 mm TL, north-east of Flinders Island, Tasmania, 39°27′ S, 148°33′ E, 240–300 m, 28 Nov 1976; CSIRO CA 4498, female 421 mm TL, CSIRO CA 4499, female 475 mm TL, Australia, 21 Jan 1986; CSIRO CA 4500, female 590 mm TL, east of Maria Island, Tasmania, 42°39′ S, 148°25′ E, 462–480 m, 17 Apr 1984; CSIRO H 985–04, female 446 mm TL, east of Maria Island, Tasmania, 42°40′ S, 148°24′ E, 428–460 m, 30 Oct 1984; CSIRO H 1328–01, immature male 737 mm TL, CSIRO H 1328–02, female 619 mm TL, west of Cape Sorell, Tasmania, 42°10′ S, 144°43′ E, 546–548 m, 17 July 1983; CSIRO H 1329–01, immature male 700 mm TL, south-west of King Island, Tasmania, 40°34′ S, 143°29′ E, 480–510 m, 12 Oct 1983; CSIRO H 1331–01, female 587 mm TL, off Strahan, Tasmania, Jan 1976; CSIRO H 3579–01, female 271 mm TL, east of Disaster Bay, New South Wales, 37°17′ S, 150°19′ E, 139–141 m, 30 Nov 1993; CSIRO H 3704–03, female 245 mm TL, CSIRO H 3704–04, female 223 mm TL, east of Disaster Bay, New South Wales, 37°19′ S, 150°18′ E, 139–143 m, 08 Aug 1994; CSIRO H 3866–01, female 1025 mm TL, east of Green Cape, Tasmania, 37°12′ S, 150°20′ E, 126–135 m, 23 Nov 1994; CSIRO H 5940–01, female 632 mm TL, west of Point Hibbs, Tasmania, 42°40′ S, 144°45′ E, 460 m, 21 Aug 2002; CSIRO T 1310, female 231 mm TL, off Port Davey, Tasmania, 146 m, Jan 1979. Egg cases. CSIRO T 1953, egg case, east of Maria Island, Tasmania, 80 m, 24 Sep 1979; CSIRO T 1959, two egg cases, east of Schouten Island, Tasmania, 120 m; CSIRO H 6623–01, egg case, south of Tasman Island, Tasmania, ca. 43° S, ca. 148° E, 30 Oct 2002.

Other material. CSIRO C 4786, immature male 762 mm TL, east of Batemans Bay, New South Wales, 35°39′ S, 150°45′ E, 350–400 m, 30 Aug 1976; CSIRO CA 3325, adult male ca. 950 mm TL, Great Australian Bight, Western Australia, 33°17′ S, 128°23′ E, 310–320 m, 03 Dec 1981; CSIRO H 986–01, immature male 574 mm TL, east of Maria Island, Tasmania, 42°39′ S, 148°26′ E, 460–480 m, 15 June 1984; CSIRO H 1327–01, female 774 mm TL, west of Cape Sorell, Tasmania, 42°13′ S, 144°44′ E, 554–612 m, 06 July 1983; CSIRO H 1337–01, juvenile male 370 mm TL, west of Kangaroo Island, South Australia, 36°01′ S, 135°44′ E, 365–409 m, 27 Nov 1984; CSIRO H 3588–01, adult male ca. 895 mm TL, east of Green Cape, New South Wales, 37°19′ S, 150°18′ E, 135–139 m, 18 June 1993; CSIRO H 3850–01, juvenile male 339 mm TL, CSIRO H 3850–02, juvenile male 336 mm TL, east of Disaster Bay, New South Wales, 37°16′ S, 150°19′ E, 139–145 m, 18 Sep 1994; CSIRO H 5929–01, female ca. 938 mm TL, east of Maria Island, Tasmania, 42°40′ S, 148°30′ E, 460 m, 23 Oct 2002.

DIAGNOSIS.— A large *Cephaloscyllium* with the following combination of characters: head height 8.6–13.5% TL, trunk width 16.1–23.8% TL; first dorsal-fin origin usually forward of mid pelvic-fin base; prenarial length 4.5–5.1% TL; preorbital snout length 1.4–1.7 times prenarial length, 2.5–3.1 in prepectoral length, 6.3–6.9 in prepelvic length; long snout-vent length, 48.1–52.4% TL; nostril width 2.4–2.7% TL; wide eye–spiracle space, 1.0–1.4% TL; large pectoral fin, height 12.6–13.6% TL, posterior margin length 12.0–13.6% TL; tall anal fin, height 3.8–4.4% TL; anal–caudal space 4.0–5.6% SL; precaudal length 74–78% TL; interdorsal space 6.3–7.6% TL; teeth near symphysis of upper jaw with 3–5 cusps; flank denticles mainly weakly tricuspidate; no greatly enlarged denticles on back; adult clasper long, to 8.8% TL, almost reaching anal fin, interspace about 4.4 in anal-fin base; 121–126 vertebral centra; high tooth count, 90–116 teeth in each jaw; upper half of body with strong pattern of saddles and blotches; 9–10 dark, transverse dorsal markings on body and tail, interspaces between them narrow; interspiracular saddle subequal to eye and spiracle length; large circular blotch over and

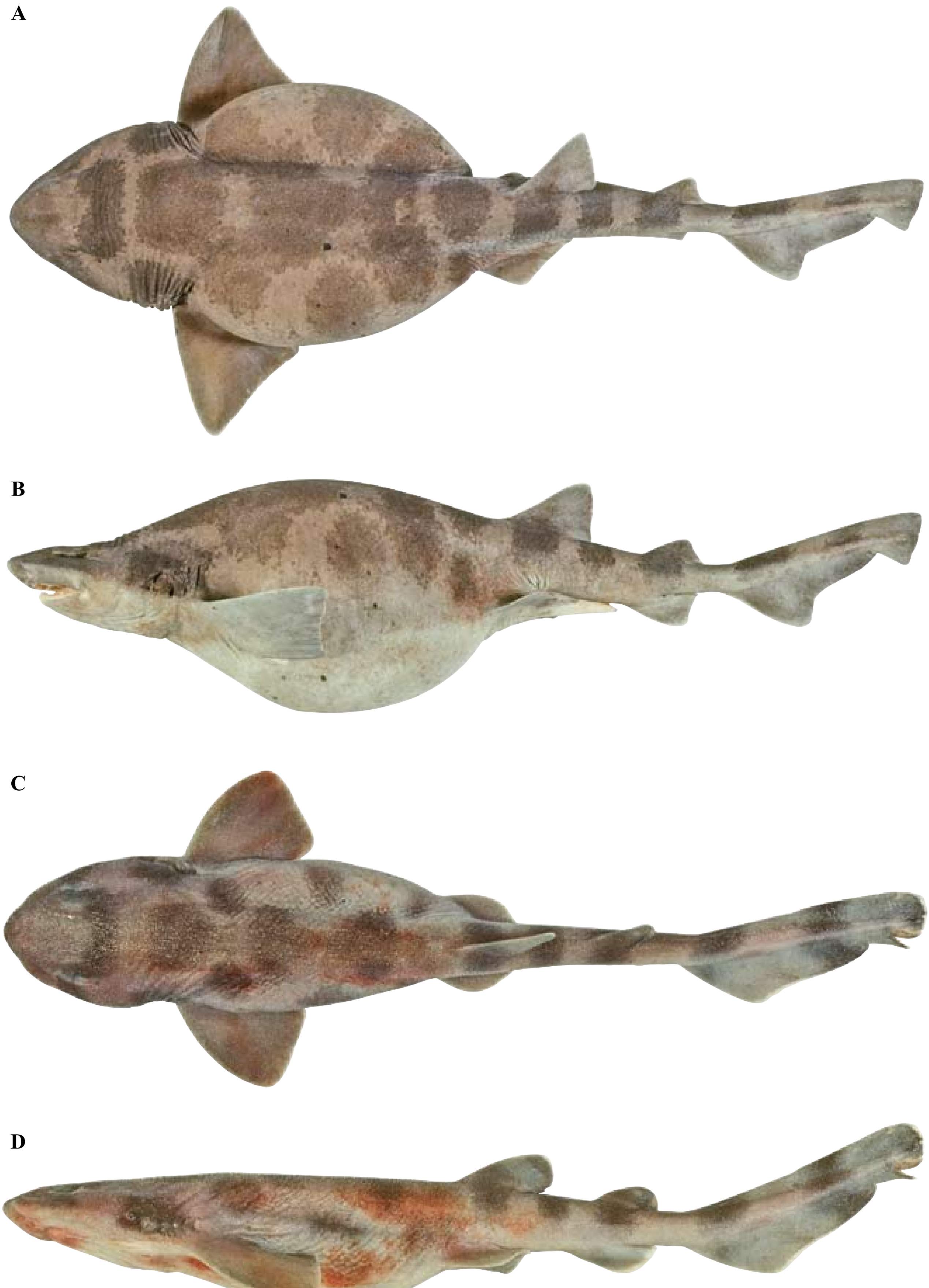

Figure 1. *Cephaloscyllium albipinnum* sp. nov.: A. dorsal view, B. lateral view of holotype (CSIRO H 5314–11, adult male 1013 mm TL); C. dorsal view, D. lateral view of juvenile paratype (CSIRO H 3579–01, female 271 mm TL).

above gill slits; and fins with variably developed, narrow pale margins.

DESCRIPTION.— Body robust anteriorly, belly often greatly expanded, tapering gradually behind first dorsal fin. Head strongly depressed, short and very broad, length 23.2 (21.5–23.6)%, width 17.9 (16.9–18.7)% TL; widest just forward of 1st gill slit; broadly parabolic in dorsoventral view, bluntly pointed in lateral view; lateral angle of suborbital shelf usually weakly defined; supraorbital crest thick; gill slits dorsolateral; last two slits over pectoral-fin base (third gill slit over pectoral-fin origin in some paratypes), slightly closer together than slits 1–3; first three slits subequal in length, last two decreasingly smaller (fourth gill slit only slightly smaller than third in smallest whole paratype, CSIRO T 1310). Snout moderately rounded to bluntly pointed, length 3.24 (2.91–3.14) in head length. Eye dorsolateral, slit-like, length 2.13 (1.77–2.33) in snout; suborbital groove well-developed, much longer than eye; orbito-spiracular groove usually discontinuous; interorbital width 0.89 (0.80–0.91) of snout, 2.87 (2.33–2.70) in head length. Spiracle very small, subcircular to suboval, well separated from eye; dorsolateral on head, length 16.0 (14.3–21.6) in interorbital width. Anterior nasal flap expanded laterally, overlapping outer lobe but not reaching mouth, posterior margin usually entire, sometimes weakly fringed; internarial width slightly larger than nostril width. Mouth relatively long and broad, width 2.07 (2.10–2.93) times length; roof of mouth and tongue usually papillose; labial furrows absent; postoral groove short, deep, straight or concave (extending ventrolaterally from each corner of mouth). Upper jaw teeth of adult male holotype small, recurved medially, with 3 cusps and basal grooves; first pair of lateral cusps well-developed, sometimes with additional 1–2 rudimentary lateral cusplets; central cusps not greatly extended near symphysis, much longer than lateral cusps near mouth corners; symphysial groove deep. Lower jaw teeth in adult male holotype subequal in size to those near symphysis of upper jaw, recurved medially; lateral cusps of posterior teeth not better defined than those anteriorly; 6 rows or so at symphysis greatly reduced, about a quarter size of those adjacent. Teeth in upper jaw of largest female paratype (CSIRO H 3866–01) usually with 3 main cusps, often with 1–2 short cusplets on each side; central cusp near symphysis only slightly larger than lateral cusps, only slightly smaller than central cusp of adult male; central cusp near angle of jaw barely longer than those laterally. Flank denticles of adult male very small, semi-erect, usually weakly tricuspidate, apices broadly pointed; well separated, not imbricate, reasonably similar in size; crown with a well-developed median ridge, lateral ridges short and obvious; denticles of adult female (CSIRO H 3866–01) also similarly sized, subequal to male holotype; crowns of female with much better developed medial and lateral ridges; denticles of smallest juvenile paratype (CSIRO T 1310) hirsute, slender, upright, pungent, not imbricate, well separated, those on midline of back not enlarged, similar in size to those on sides; no greatly enlarged denticles on mid surface of body or fins. First dorsal fin raked slightly, apex bluntly rounded (more narrowly rounded in smaller paratypes), posterior margin truncate (slightly convex in smallest paratypes); much larger than second dorsal fin; origin usually slightly to well forward of mid pelvic-fin base, pre-first dorsal length 50.9 (48.3–51.8)% TL. Second dorsal fin low, weakly subtriangular, pre-second dorsal length 66.8 (63.6–67.2)% TL; anterior margin almost straight, apex broadly rounded, posterior margin moderately concave (variable in paratypes, weakly concave to weakly convex); origin well behind anal-fin origin, insertion almost over anal-fin insertion. Anal fin distinctly larger than second dorsal fin, taller, apex broadly rounded in juvenile CSIRO T 1310 (usually more narrowly rounded in adults). Pectoral fins moderately large, anterior margin moderately convex, its length 15.7 (15.4–16.3)% TL; apices narrowly rounded, posterior margin weakly concave to truncate, inner margin mostly convex, free tip bluntly angular to narrowly rounded; anal-fin length 0.94 (0.97–1.31) times pelvic–anal space.

A

B

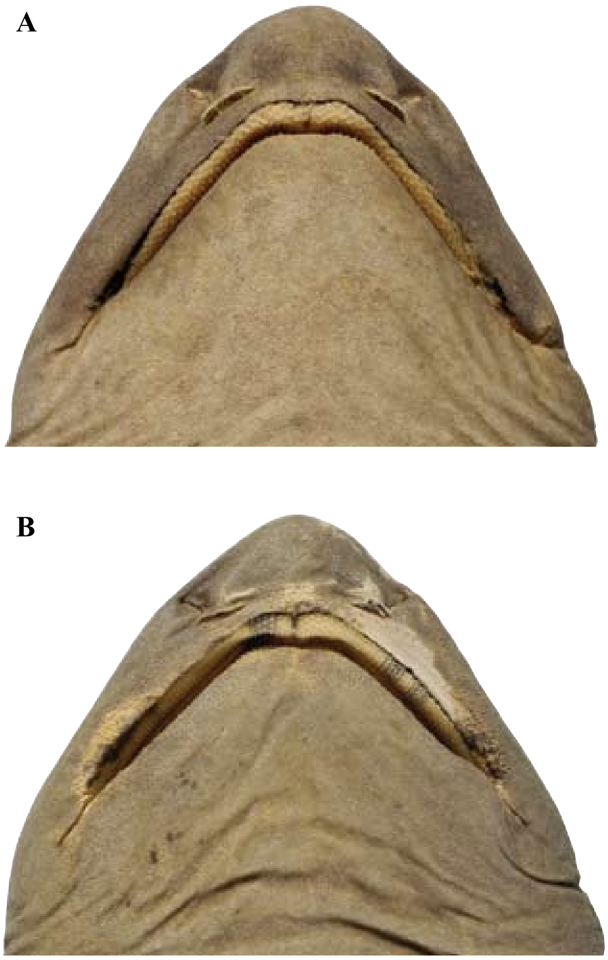

Figure 2. Ventral view of head of *Cephaloscyllium albipinnum* sp. nov.: A. holotype CSIRO H 5314–11 (adult male 1013 mm TL); B. paratype CSIRO H 3866–01 (adult female 1025 mm TL).

Table 1. Morphometric data for the holotype of *Cephaloscyllium albipinnum* sp. nov. (CSIRO H 5314-11), with ranges provided for the 6 measured paratypes, and ranges provided for *C. isabellum* and *C. laticeps*. Measurements expressed as a percentage of total length.

	C. albipinnum **sp. nov.**			***C. isabellum***		***C. laticeps***	
	Holotype	Paratypes		(n=2)		(n=8)	
		Min.	Max.	Min.	Max.	Min.	Max.
Total length (mm)	1013	590	1025	469	652	360	874
Precaudal length	77.4	74.3	77.7	76.8	79.0	76.3	78.9
Pre-second dorsal length	66.8	63.6	67.2	65.5	67.5	63.6	67.9
Pre-first dorsal length	50.9	48.3	51.8	50.7	52.3	48.9	51.2
Head length	23.2	21.5	23.6	21.2	22.3	20.6	23.0
Pre-branchial length	19.2	17.9	18.9	17.7	18.2	17.3	18.8
Pre-spiracular length	11.7	11.2	11.8	11.4	11.4	10.3	11.6
Preorbital length (horizontal)	6.2	5.6	6.4	5.6	6.2	5.0	5.9
Preorbital length (direct)	7.2	7.2	7.7	7.4	7.6	6.8	7.5
Preoral length	4.2	3.6	4.2	4.0	4.3	3.6	4.2
Prenarial length	4.7	4.5	5.1	4.7	4.7	4.4	4.7
Pre-pectoral length	21.8	19.0	22.2	19.9	20.2	18.9	21.7
Pre-pelvic length	49.1	45.9	49.2	46.0	46.8	43.8	46.7
Pre-vent length	52.1	48.1	52.4	50.7	50.9	47.2	50.2
Pre-anal length	64.9	60.8	64.2	62.7	65.4	60.9	64.9
Interdorsal space	7.6	6.3	7.6	6.8	7.6	6.7	8.7
Dorsal–caudal space	5.3	4.8	6.0	6.0	6.0	5.0	7.2
Pectoral–pelvic space	21.0	17.7	22.3	17.2	19.5	15.6	20.3
Pelvic–anal space	9.9	7.5	9.9	8.6	10.0	7.1	10.8
Anal–caudal space	4.4	4.0	5.6	5.0	5.5	4.1	5.2
Eye length	3.4	3.2	4.1	3.3	3.8	3.2	3.7
Interorbital width	8.1	8.1	9.6	8.8	9.1	7.7	9.4
Nostril width	2.5	2.4	2.7	2.5	3.1	2.3	3.1
Internarial space	3.3	3.1	3.8	3.0	3.0	2.9	3.2
Anterior nasal flap length	1.2	0.9	1.3	1.3	1.3	0.9	1.4
Spiracle length	0.5	0.4	0.6	0.8	0.8	0.4	0.9
Eye–spiracle space	1.4	1.0	1.2	0.8	1.2	0.8	1.2
Mouth length	6.3	4.7	6.2	4.7	4.8	3.8	5.1
Mouth width	13.0	11.8	14.1	10.2	11.4	10.5	12.9
First gill slit height	3.2	2.3	3.3	2.2	2.5	1.7	2.6
Fifth gill slit height	2.0	1.5	2.0	1.3	1.9	1.3	1.7
Head height	13.0	8.6	13.5	9.7	12.0	9.3	11.6
Trunk height	18.3	9.5	15.8	11.4	11.8	8.8	15.4
Caudal peduncle height	2.9	2.7	3.0	2.7	3.0	2.7	3.7
Head width	17.9	16.9	18.7	14.3	15.8	15.3	18.0
Trunk width	23.0	16.1	23.8	14.2	15.4	13.9	21.3
Caudal peduncle width	2.8	2.3	2.6	2.8	2.9	2.6	3.2
Pectoral fin - length	14.9	14.3	15.4	15.3	15.4	15.5	17.9
Pectoral fin - anterior margin	15.7	15.4	16.3	15.4	15.8	15.7	18.8
Pectoral fin - base	10.4	9.5	11.0	9.6	10.5	9.7	11.7
Pectoral fin - height	13.6	12.6	13.6	13.1	13.3	12.9	15.2
Pectoral fin - inner margin	5.3	5.3	5.8	5.7	5.9	5.5	7.0
Pectoral fin - posterior margin	13.1	12.0	13.6	12.2	13.1	12.4	14.9

Table 1. cont'd

	C. albipinnum sp. nov.			*C. isabellum*		*C. laticeps*	
	Holotype	Paratypes		(n=2)		(n=8)	
		Min.	Max.	Min.	Max.	Min.	Max.
Pelvic fin - length	12.1	10.1	11.8	12.1	12.6	10.8	14.1
Pelvic fin - anterior margin	6.5	5.9	6.9	7.3	7.9	6.3	8.1
Pelvic fin - base length	7.7	6.5	8.7	8.5	8.6	7.3	10.7
Pelvic fin - height	6.5	5.0	6.5	6.0	6.2	5.4	6.8
Pelvic fin - inner margin	4.7	3.0	4.5	4.0	4.2	2.7	5.3
Pelvic fin - posterior margin	8.0	6.8	8.4	6.8	6.9	7.0	9.3
Clasper outer length	8.8	0.0	0.0	9.7	9.7	8.3	9.3
Clasper inner length	12.1	0.0	0.0	13.4	13.4	14.0	14.2
Clasper base width	2.0	0.0	0.0	2.1	2.1	2.0	2.1
First dorsal fin - length	11.2	10.5	11.8	10.4	10.6	10.7	12.1
First dorsal fin - anterior margin	11.3	10.9	12.5	10.4	10.6	10.7	12.0
First dorsal fin - base length	8.5	7.9	9.1	7.6	8.1	8.2	9.7
First dorsal fin - height	7.1	6.3	7.1	5.9	6.1	5.4	6.7
First dorsal fin - inner margin	2.5	2.2	3.0	2.6	3.2	2.2	2.8
First dorsal fin - posterior margin	6.8	5.7	6.8	5.2	5.5	5.7	7.2
Second dorsal fin - length	8.1	7.6	8.4	8.3	8.6	8.0	9.4
Second dorsal fin - anterior margin	6.2	5.4	7.1	6.4	6.8	6.3	7.8
Second dorsal fin - base length	5.2	5.0	5.8	5.6	5.8	5.5	7.0
Second dorsal fin - height	3.1	2.7	3.4	3.3	3.3	3.1	3.7
Second dorsal fin - inner margin	2.9	2.4	2.7	2.9	2.9	2.5	2.9
Second dorsal fin - posterior margin	4.0	3.1	3.8	3.4	3.7	3.3	4.6
Anal fin - length	9.3	9.3	10.4	10.0	10.1	10.1	11.5
Anal fin - anterior margin	8.3	7.3	8.5	9.0	9.3	9.2	10.1
Anal fin - base length	6.5	6.8	7.9	7.3	7.8	7.7	9.3
Anal fin - height	4.4	3.8	4.4	3.9	4.0	3.6	4.6
Anal fin - inner margin	2.9	2.4	2.8	2.5	2.8	2.4	2.9
Anal fin - posterior margin	4.8	3.9	4.9	3.5	3.8	3.2	5.0
Caudal fin - dorsal margin	22.5	22.1	25.3	21.2	23.0	20.7	23.4
Caudal fin - preventral margin	10.4	9.2	10.7	10.9	11.4	11.4	12.6
Caudal fin - lower postventral margin	3.3	2.6	3.5	2.6	3.3	2.6	3.3
Caudal fin - upper postventral margin	7.9	7.9	9.7	7.7	7.7	6.0	7.2
Caudal fin - subterminal margin	3.9	3.2	5.1	4.0	4.5	3.9	5.5
Caudal fin - terminal margin	6.0	5.7	6.6	6.5	7.0	5.6	7.8
Caudal fin - terminal lobe length	6.6	6.6	7.8	7.1	8.1	6.4	8.6
Second dorsal origin–anal origin	1.1	1.1	2.6	1.7	2.1	2.0	3.2
Second dorsal insertion–anal insertion	0.6	0.2	0.9	0.4	0.8	0.3	1.1

Pelvic fins small, length 12.1 (10.1–11.8)% TL. Claspers cylindrical, elongate, robust, almost reaching anal-fin origin, ventral surface covered with denticles; pelvic fins united to dorsobasal surface of clasper, incomplete apron joining claspers just posterior to cloaca. Caudal fin large, with a distinct ventral lobe; terminal lobe well developed, deep, its posterior margin truncate to moderately convex (narrow and broadly rounded in smallest paratype). Teeth in upper jaw about 115 (90–116); in lower jaw about 109 (97–110). Monospondylous vertebrae 48 (45–48 in 11 paratypes); precaudal 81 (79–82); total 126 (121–126).

EGG CASES.— Eggs cases large (98–116 mm in length, excluding horns), smooth, glossy, without transverse or longitudinal striations or ridges; not constricted; somewhat flattened, height 21.2–26.7% ECL, posterior

Table 2. Morphometric data for egg cases of *Cephaloscyllium albipinnum* sp. nov. and *C. laticeps*. Measurements expressed as a percentage of egg case length (ECL).

	C. albipinnum **sp. nov.**			***C. laticeps***		
	n=4			n=3		
	Mean	Min.	Max.	Mean	Min.	Max.
Egg case length (mm)	103.7	98.2	115.9	127.1	125.7	129.8
Posterior case width	44.5	38.5	50.6	39.0	37.3	40.9
Anterior case width	32.4	28.3	37.7	25.4	24.7	26.0
Anterior border width	28.3	25.1	32.7	21.7	20.9	22.5
Posterior border width	12.3	9.6	16.5	3.9	3.1	4.7
Egg case height	23.7	21.2	26.7	23.2	21.8	24.3

width 38.5–50.6% ECL; lateral flanges extending entire length of egg case, thick, rounded (not T-shaped). Anterior border nearly straight, broad; anterior horns relatively short, curved strongly inwards but not touching; tendrils long, wiry, tightly coiled. Posterior border much narrower, concave, width 2.0–2.6 in anterior border width; posterior horns moderately long, curved strongly inwards, overlapping; tendrils very long, wiry, highly convoluted, tightly coiled. Egg cases, in alcohol, are uniformly pale yellowish in colour.

COLOUR.— Preserved specimens: Upper surface and sides above level of pectoral-fin medium greyish brown with multiple darker, greyish brown saddles and blotches; coloration not variegated with white and dark markings; saddles not edged with paler lines or spots. Nine to ten darker cross-markings on body and caudal fin; a broad, weakly crescentic interspiracular saddle (greatest thickness subequal to combined eye and spiracle length); suborbital bar similar in colour, disjunct from interspiracular saddle, expanded ventrally (width at edge of head greater than interspiracular saddle); four additional, large predorsal markings on midline, weakly separated from each other and sometimes partly coalesced in large adults; first blotch on midline usually largest, centred over gill slits and anterior pectoral fin; second blotch on midline mostly over inner margin of pectoral fin and extending posteriorly; third blotch on midline before dorsal-fin origin; broad saddle situated between second and third blotches, sometimes connected to second blotch; enlarged lateral blotch over posterior base of pectoral fin, sometimes connected to first and second medial blotches at their basal extremities; enlarged blotch over gill slits, delineated ventrally by paler ventral coloration, extending well above dorsal extremities of gill slits to above eye level; two diffuse-edged blotches on sides, at mid belly and above pelvic-fin origin. Two to three saddles in region of dorsal fins; broad saddles below each dorsal fin, their width subequal to fin bases; sometimes with an additional interdorsal saddle, its origin near insertion of first dorsal fin; saddles penetrating onto bases of dorsal fins, more extreme in second dorsal fin than first. Caudal fin with two well-developed bars; first bar originating just behind origin of dorsal lobe; posterior bar inserted just anterior to insertion of ventral caudal lobe, extending further ventrally than anterior bar; indistinct dark terminal marking on terminal lobe. All fins with variably developed narrow pale margins, usually most pronounced on posterior upper margin of pectoral fin, lower lobe of caudal fin, and posterior margins of pelvic and anal fins; usually thinner but well pronounced on dorsal-fin margins of juveniles. Pectoral and pelvic-fin dorsal surfaces and anal fin similar to dorsal surface of body, becoming slightly darker away from fin base; ventral surface of pectoral and pelvic fins paler than dorsal surface, sometimes with a darker posterior region. Ventral surface of body dark in adults, slightly paler than dorsal surface (sometimes with light and dark blotches; juveniles distinctly paler, often almost white). Claspers mostly whitish, with some greyish areas; mouth mostly

A

B

Figure 3. Egg case: A. *Cephaloscyllium albipinnum* sp. nov. (CSIRO H 6623–01); B. *Cephaloscyllium laticeps* (CSIRO T 1679–05).

Figure 4. *Cephaloscyllium laticeps:* A. dorsal view, B. lateral view of adult (CSIRO H 1264–13, adult female 820 mm TL); C. dorsal view, D. lateral view of juvenile (CSIRO H 5926–01, juvenile male 370 mm TL).

Figure 5. Dorsal view of: A. *Cephaloscyllium isabellum* (NMNZ P 5454, adult male 652 mm TL); B. *Cephaloscyllium umbratile* (CSIRO H 6295–22, immature male 330 mm TL).

pale, occasionally with enlarged black blotches. Colour pattern of small juveniles (CSIRO T 1310 and CSIRO H 3579–01) almost symmetric, more regular and better defined than in adults.

SIZE.— Material examined ranges from 198–1025 mm TL for females and 336–1013 mm TL for males. Smallest adult male ca. 895 mm TL and largest immature male 762 mm TL.

DISTRIBUTION.— Known from the outer continental shelf and upper continental slope of southeastern Australia from off Batemans Bay, New South Wales (35°39′ S, 150°45′ E) westward to the Great Australian Bight, Western Australia (33°17′ S, 128°23′ E), including Tasmania south to at least Maria Island (42°40′ S, 148°25′ E) on the east coast and Point Hibbs off the west coast (42°40′ S, 144°45′ E), at depths of 126–554 m.

ETYMOLOGY.— Derived from the combination of the Latin *albi* (white) and *pinna* (fin) in allusion to the distinctive white fin margins. Vernacular: Whitefin Swellshark.

REMARKS.— *Cephaloscyllium albipinnum* differs markedly from other nominal Australian species of the genus *Cephaloscyllium* in colour pattern. Unlike new species treated earlier in this series (Last *et al*., 2008), *C. speccum* Last, Séret & White, 2008 and *C. signourum* Last, Séret & White, 2008, which both have a strongly variegated pattern, *C. albipinnum* has a strong pattern of plain dark blotches and saddles. *Cephaloscyllium cooki*, a small member of the genus attaining only about 300 mm TL, also has saddle-like markings but these are white edged. Another dwarf species, *C. fasciatum*, has fine, dark, linear markings. *Cephaloscyllium albipinnum*, and a parapatric congener *C. laticeps*, are the two largest Australian species, both attaining 1 m or more in length. However, the coloration of *C. laticeps* is more strongly variegated, denticles on the juveniles are larger, and its egg cases have well-developed transverse ridges (otherwise with smooth surfaces). The genetic barcode of *C. albipinnum* differs from those species that have been analysed, i.e. *C. fasciatum*, *C. laticeps*, *C. pictum*, *C. speccum* and *C.* sp. C (Ward *et al*., submitted).

A New Zealand species, *C. isabellum*, and a western North Pacific species, *C. umbratile*, also have very different colour patterns to *C. albipinnum* (see Fig. 5). *Cephaloscyllium isabellum* has less extensive subdorsal saddle-like markings and the interspiracular saddle terminating in a broad narrow bar with a lateral extension above and behind the gill slits. These saddle-like markings are much less well defined and narrower than in juveniles and adults of *C. albipinnum*. Juveniles of *C. isabellum* have larger and more widely spaced denticles on the back and males mature at a smaller size (650 mm vs. >850 mm TL in *C. albipinnum*). The juveniles of *C. umbratile* have 3 primary predorsal saddles (vs. 4–5 in *C. albipinnum*) that are weakly demarcated from their pale interspaces by lighter borders (vs. not demarcated), no distinct blotch over the gill slits (vs. present), and denser denticles.

Comparative material.
Cephaloscyllium isabellum: 4 specimens. NMNZ P 5454, adult male 652 mm TL, north of D'Urville Island, New Zealand, 40°24′ S, 174°26′ E, 110 m, 12 May 1971; NMNZ P 20971, female 240 mm TL, east of Chatham Islands, New Zealand, 43°27′ S, 176°27′ E, 140–155 m, 26 May 1987; NMNZ P 20978, immature male 259 mm TL, east of Chatham Islands, New Zealand, 43°38′ S, 175°51′ E, 234–245 m, 25 May 1987; NMNZ P 20991, female 469 mm TL, east of Chatham Islands, New Zealand, 43°39′ S, 175°53′ E, 220–248m, 24 May 1987.
Cephaloscyllium laticeps: 16 specimens. CSIRO CA 4501, female 564 mm TL, Australia; CSIRO H 1264–12, adult male 796 mm TL, CSIRO H 1264–13, pregnant female 820 mm TL, north of Maria Island, Tasmania, 42°33′ S, 148°15′ E, 81–82 m, 07 Apr 1988; CSIRO H 1330–01, adult male 806 mm TL, west of Cape Grim, Tasmania, 40°47′ S, 144°16′ E, 93 m, 21 Feb 1979; CSIRO H 1332–01, female 368 mm TL, Tasmania; CSIRO H 1333–01, immature male 360 mm TL, east coast of Tasmania, 20 June 1978; CSIRO H 1334–01, female 293 mm TL, Frederick Henry Bay, Tasmania, 42°54′ S, 147°36′ E, 14 m, 21 July 1983; CSIRO H 1339–01, immature male 305 mm TL, west of Tasman Island, Tasmania, 43°17′ S, 147°50′ E, 101–121 m, 02 Dec 1983; CSIRO H 2341–01, female 473 mm TL, Bathurst Harbour entrance, Tasmania, Oct 1988; CSIRO H 2649–01, female 422 mm TL, north of Maria Island, Tasmania, 42°32′ S, 148°12′ E, 530 m, 13 July 1990; CSIRO H 3547–01, adult male 874 mm TL, east of Lakes Entrance, Victoria, 37°56′ S, 148°12′ E, 42 m, 30 July 1993; CSIRO H 3574–01, female 422 mm TL, Bass Strait, Victoria, 38°36′ S, 148°22′ E, 106–118 m, 28 July 1993; CSIRO H 3850–05, immature male 546 mm TL, east of Disaster Bay, New South Wales, 37°16′ S, 150°19′ E, 139–145 m, 18 Sep 1994; CSIRO H 5926–01, immature male 370 mm TL, North Bruny Island, Tasmania, 43°03′ S, 147°22′ E, 21 m, 25 Sep 2002; CSIRO T 1701–01, female 198 mm TL, southern Tasmania, 02 Feb 1980; SAMA A 1761, immature male 195 mm TL, out of Anxious Bay, South Australia, 27 Feb 1981. Egg cases. CSIRO T 1425, 2 egg cases, Bruny Island, Tasmania, ca. 43°17′ S, 147°18′ E, 15 m, 17 Aug 1983; CSIRO T 1679–05, egg case, off Triabunna, Tasmania, ca. 42°30' S, 148° E, 15 Feb 1981; CSIRO T 1960, egg case, off Tamar River mouth, Tasmania.
Cephaloscyllium umbratile: 3 specimens. CSIRO H 6295–22, immature male 330 mm TL, Tashi fish market, Taiwan, 24 May 2005; CSIRO H 5611–04, immature male 205 mm TL, CSIRO H 5611–08, immature male 300 mm TL, Tashi fish market, Taiwan, 01 Aug 2000.

ACKNOWLEDGEMENTS

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Two new saddled swellsharks (*Cephaloscyllium*: Scyliorhinidae) from eastern Australia

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ABSTRACT.— Two new saddled swellsharks, *Cephaloscyllium variegatum* sp. nov. and *C. zebrum* sp. nov., are described from the outer continental shelf and upper continental slope of eastern Australia. These species differ from each other, and from another closely related Australian species *C. albipinnum*, in the number and width of transverse, saddle-like markings on their dorsal surface. *Cephaloscyllium variegatum* and *C. zebrum*, which can also be distinguished by a combination of morphology and meristics, both occur off Queensland but only *C. variegatum* occurs in temperate seas off New South Wales. The colour pattern of juveniles of *C. variegatum* consists of fine dark spots rather than broad saddles typical of adults.

Key words. Scyliorhinidae – *Cephaloscyllium variegatum* – *Cephaloscyllium zebrum* – swellshark – new species – Australia

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INTRODUCTION

Last & Stevens (1994) identified 7 *Cephaloscyllium* species from Australian waters of which 5 appeared to be undescribed. This is the third paper in this series on new species of catsharks from the genus *Cephaloscyllium* with four new species from Australian waters described in the two previous papers: *C. cooki*, *C. signourum* and *C. speccum* (Last *et al*., 2008a), and *C. albipinnum* (Last *et al*., 2008b). The 3 remaining undescribed saddled swellsharks, *C*. sp. B, *C*. sp. C, and *C*. sp. D (*sensu* Last & Stevens, 1994), all occur off eastern Australia. *Cephaloscyllium* sp. C occurs off New South Wales and southern Queensland, where trawling effort has been high. As a consequence, it has been rated as near threatened by the IUCN (Barratt & Kyne, 2003). Further investigation of *C*. sp. B and *C*. sp. C has revealed that they most likely represent a single, variable species. *Cephaloscyllium* sp. D is only known from two individuals collected off northern Queensland. The two new species are formally described and compared with other Australian *Cephaloscyllium* species.

METHODS

Morphometric characters were selected to facilitate comparisons of the two new species of *Cephaloscyllium* with other members of this genus from Australia and adjacent regions. Our methods generally followed a widely adopted scheme for elasmobranchs (Compagno, 1984, 2001), but focused on direct rather than horizontal measurements. For *C*. sp. C, the holotype (CSIRO H 3714–01) and four paratypes (CSIRO H 975–01, CSIRO H 3428–01, CSIRO H 3715–01 and CSIRO H 3855–01) were measured in full (Table 1). For *C*. sp. D, the holotype (CSIRO H 1323–02) and paratype (CSIRO H 1323–03) were measured in full (Table 2). Meristics were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and caudal (centra of the caudal fin) vertebrae. These were extracted from radiographs of the holotype and 8 paratypes (AMS I 15970–014, AMS I 15970–015, AMS I 29536–002, CSIRO H 975–01, CSIRO H 3428–01, CSIRO H 3715–01, CSIRO H 3855–01 and QM I 22238) of *C*. sp. C and from both types of *C*. sp. D. Tooth counts for *C*. sp. C were taken from four paratypes (CSIRO H 3428–01, CSIRO H 3855–01, CSIRO H 4759–02 and CSIRO H 4759–03), and from the holotype (CSIRO H 1323–02) and paratype (CSIRO H 1323–03) of *C*. sp. D. In the species descriptions, morphometric and meristic values for the holotype are given first followed in parentheses by the ranges of the measured paratype(s). Morphometric methods for egg cases follow those described by Ebert *et al*. (2006) and are presented for *C*. sp. C and a second species tentatively identified as *C. signourum* (see Table 2). Type specimens are deposited in the Australian National Fish Collection, Hobart (CSIRO), and the ichthyological collections of the Australian Museum, Sydney (AMS) and the Queensland Museum, Brisbane (QM); their registration numbers are prefixed with these acronyms.

Cephaloscyllium variegatum sp. nov.

Figs 1–4; Tables 1, 2

?*Cephaloscyllium* sp. B: Last & Stevens, 1994: pp 170, 193, key fig. 45, fig. 26.21, pl. 24; Compagno *et al.*, 2005: p 220, pl. 36; Compagno & Niem, 1998: pp 1281, 1285, fig. 12.

Cephaloscyllium sp. C: Last & Stevens, 1994: pp 171, 194, key fig 51, fig. 26.22, pl. 24; Compagno *et al.*, 2005: pp 220, 221, pl. 36; Compagno & Niem, 1998: pp 1282, 1285, fig. 13.

Holotype. CSIRO H 3714–01, adult male 683 mm TL, east of Newcastle, New South Wales, 32°58′ S, 152°13′ E, 132–134 m, 30 Mar 1994.

Paratypes. 10 specimens. CSIRO CA 3322, female 167 mm TL, off Sydney, New South Wales, 33°42′ S, 151°51′ E, 296–300 m, 25 Jan 1982; CSIRO H 975–01, adult male 654 mm TL, east of Shoalhaven Heads, New South Wales, 34°52′ S, 151°05′ E, 140–162 m, 18 Apr 1985; CSIRO H 3428–01, adult male 671 mm TL, east of Wollongong, New South Wales, 34°24′ S, 151°09′ E, 135–137 m, 16 Mar 1993; CSIRO H 3715–01, female 692 mm TL, east of Newcastle, New South Wales, 32°57′ S, 152°16′ E, 137 m, 30 Mar 1994; CSIRO H 3855–01, adult male 687 mm TL, east of Batemans Bay, New South Wales, 35°41′ S, 150°26′ E, 114 m, 25 May 1994; CSIRO H 4684–01, female 237 mm TL, CSIRO H 4684–02, juvenile male 252 mm TL, east of Sydney, New South Wales, 33°49′ S, 151°55′ E, 369–386 m, 30 May 1996; CSIRO H 4759–01, juvenile male 242 mm TL, CSIRO H 4759–02, juvenile male 300 mm TL, CSIRO H 4759–03, female 291 mm TL, east of Sydney, New South Wales, 33°40′ S, 151°54′ E, 380–390 m, 17 Sep 1996; AMS I 15970–014, female 595 mm TL, AMS I 15970–015, juvenile male 577 mm TL, north-east of Sydney, New South Wales, 33°43′ S, 151°54′ E, 494 m, 15 Apr 1971; AMS I 29536–002, female 314 mm TL, east of Batemans Bay, New South Wales, 35°43′ S, 150°38′ E, 329 m, 02 Aug 1977; AMS I 41114–004, 2 specimens, female 319 mm TL, female 346 mm TL, off Tathra, New South Wales, 36°31′ S, 150°19′ E, 293–366 m, 09 June 2001; QM I 21985, female 170 mm TL, east of Capricorn Group, 23°15′ S, 153°45′ E, 415 m, 06 Sep 1983; QM I 22238, female 244 mm TL, between Noosa, Queensland (26°27′ S, 153°06′ E) and Point Danger, New South Wales (28°07′ S, 153°29′ E), 12 June 1983. Egg cases: CSIRO B 2253, two egg cases, Coffs Harbour, New South Wales, 30°20′ S, 153°08′ E, 23 Aug 1954.

Other material. New South Wales: CSIRO CA 3323, female 166 mm TL, off Sydney, 33°42′ S, 151°51′ E, 296–300 m, 25 Jan 1982; CSIRO H 3580–01, adult male 630 mm TL, east of Newcastle, 32°58′ S, 152°17′ E, 134–137 m, 14 Oct 1993; CSIRO H 4755–01, juvenile male 240 mm TL, CSIRO H 4755–02, female 232 mm TL, east of Sydney, 33°44′ S, 151°51′ E, 380–388 m, 23 May 1996; AMS I 35420–001, female 402 mm TL, north-east of Coffs Harbour, 30°31′ S, 153°28′ E, 283 m, 12 Aug 1993. Queensland: CSIRO CA 3324, juvenile male 301 mm TL, between Moreton Bay and New South Wales Border, ca. 28° S, 400 m, 28 July 1982; CSIRO H 451, adult male 720 mm TL, south of Saumarez Plateau, 22°52′ S, 152°42′ E, 225–282 m, 19 Nov 1985; CSIRO H 947–09, juvenile male 349 mm TL, Saumarez Plateau, 22°56′ S, 154°21′ E, 590–606 m, 17 Nov 1985; CSIRO H 1338–01, juvenile male 342 mm TL, north-east of Rockhampton, 20°23′ S, 152°57′ E, 508–511 m, 22 Nov 1985; CSIRO H 1340–01, subadult male 558 mm TL, Townsville Trough, 18°10′ S, 147°13′ E, 240–248 m, 08 Dec 1985; CSIRO H 5635–10, adult male 669 mm TL, CSIRO H 5635–11, female 735 mm TL, CSIRO H 5635–12, subadult male, east of Rockingham Bay, 18°08′ S, 147°09′ E, 223–248 m, 19–21 Aug 2000.

DIAGNOSIS.— A medium-sized *Cephaloscyllium* with the following combination of characters: head height 9.4–10.5% TL, trunk width 14.5–17.1% TL; first dorsal-fin origin over or slightly behind mid pelvic-fin base; prenarial length 4.4–5.0% TL; preorbital snout length 1.5–1.7 times prenarial length, 2.9–3.3 in prepectoral length, 6.4–7.2 in prepelvic length; long snout-vent length, 50.5–52.9% TL; nostril width 2.4–2.6% TL; wide eye–spiracle space, 0.8–1.3% TL; large pectoral fin, height 12.9–13.2% TL, posterior margin length 10.4–12.1% TL; anal fin height 3.5–4.1% TL; anal–caudal space 4.5–5.7% SL; precaudal length 76–78% TL; interdorsal space 6.5–8.0% TL; teeth near symphysis of upper jaw with 3–7 cusps; flank denticles mainly unicuspidate; no greatly enlarged denticles on back; adult clasper long, to 8.1% TL, almost reaching anal fin, interspace about 5.4 in anal-fin base; 116–124 vertebral centra; 68–82 teeth in each jaw; colour pattern variable, adults and juveniles dissimilar; adults with 11 distinct or indistinct dark saddle-like markings on body and tail; juveniles without saddles, instead with fine blackish spots; predorsal saddles not much wider than interspaces between them; interspiracular saddle width subequal to eye length; no obvious dark blotch over gill slits; fleshy portion of caudal fin appearing as a pale stripe, well demarcated from darker areas above and below.

DESCRIPTION.— Body robust anteriorly, belly variably expanded, tapering gradually behind first dorsal fin. Head strongly depressed, short and moderately broad, length 22.4 (22.4–23.6)% TL, width 16.1 (12.9–15.5)% TL; widest just forward of 1st gill slit; parabolic in dorsoventral view, narrowly rounded in lateral view (more pointed in juvenile paratypes); lateral angle of suborbital shelf evident; supraorbital crest thick; gill slits lateral; last two slits over pectoral-fin base (third gill slit over pectoral-fin origin in smaller paratypes), usually slightly closer together than slits 1–3; first three slits subequal in length, last two decreasingly smaller. Snout tip bluntly pointed, length 2.98 (3.11–3.24) in head length. Eyes dorsolateral, slit-like, length 1.94 (2.08–2.31) in snout; suborbital groove usually well-developed (feeble or absent in smaller paratypes), longer than eye; orbito-spiracular groove usually continuous; interorbital width

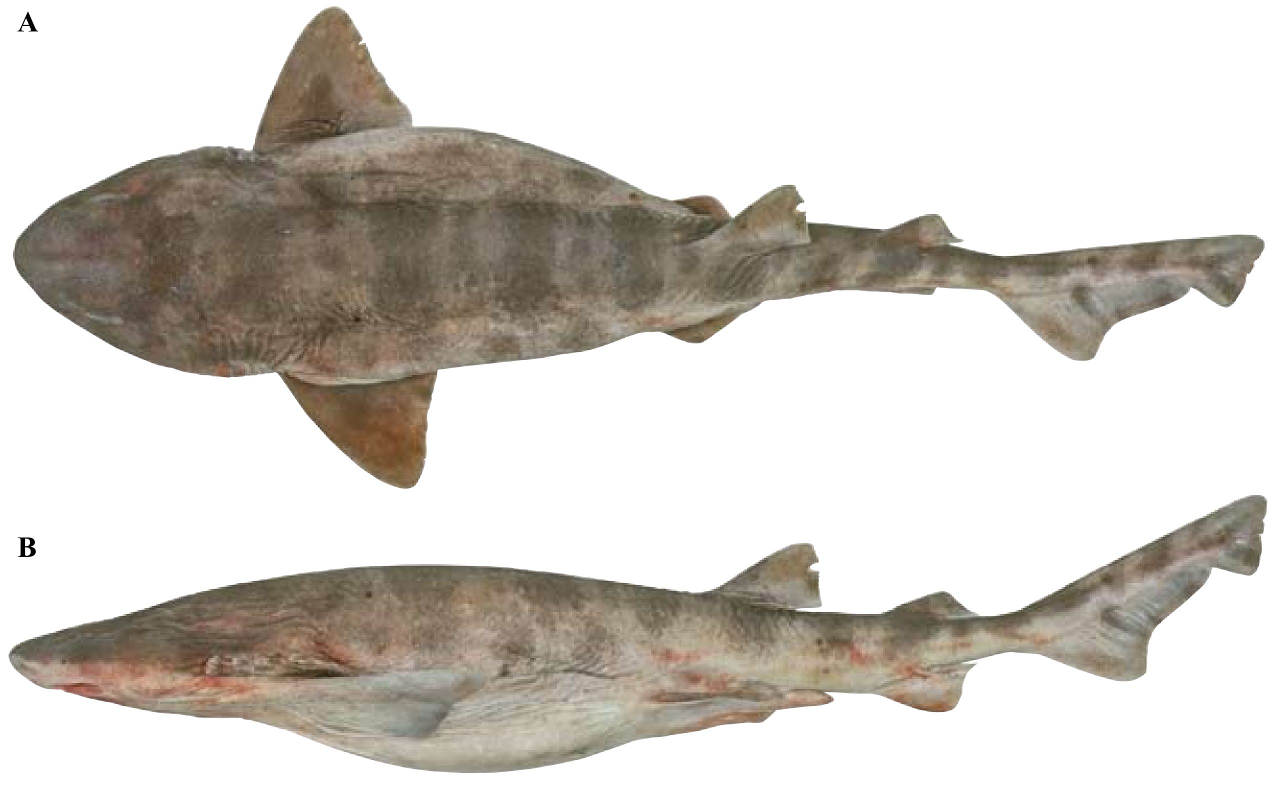

Figure 1. *Cephaloscyllium variegatum* sp. nov. holotype (CSIRO H 3714–01, adult male 683 mm TL): A. dorsal view; B. lateral view.

0.86 (0.81–0.93) of snout, 2.56 (2.56–2.90) in head length. Spiracle very small (minute, barely evident in smallest paratypes), length 26.0 (13.7–21.7) in interorbital width; subcircular to suboval, close to eye, dorsolateral on head. Anterior nasal flap expanded laterally, overlapping outer lobe but not reaching mouth, posterior margin usually entire or weakly notched, sometimes weakly fringed; internarial width slightly larger than nostril width. Mouth relatively long and not broad, width 2.12 (1.62–2.02) times length; roof of mouth and tongue usually papillose; labial furrows absent; postoral groove short, deep, concave (extending ventrolaterally from each corner of mouth). Teeth in upper jaw of adult male holotype small, recurved medially, with basal grooves; with 3 cusps near symphysis, usually with additional minute cusplet towards angle of jaw; central cusps robust, broad; cusps extended near symphysis, much longer than lateral cusps near mouth corners; symphysial groove deep; mouth firmly closed, with symphysial teeth of lower jaw obscure (in additional male paratype CSIRO H 3855–01 central cusps similar to those on either side of symphysis of upper jaw, recurved anterolaterally; lateral cusps of posterior teeth slightly smaller than those anteriorly; 6 rows or so at symphysis greatly reduced, about a third size of those adjacent). Teeth in upper jaw of largest female paratype (CSIRO H 3715–01) usually with 3 cusps, often with 1–2 short cusplets on each side, more cusplets near angle of mouth; central cusps only much smaller than in adult male. Flank denticles of adult male holotype very small, not erect, elevated slightly; mostly unicuspidate, sometimes with weak lateral cusplets; close together, sometimes imbricate, apices very broadly pointed, often blunt; very variable in size; crowns with a well-developed median ridge, lateral ridges not obvious; denticles of adult female (CSIRO H 3715–01) also similarly sized, subequal to male holotype, often with supplementary anterior ridges; denticles of smallest juvenile paratype (CSIRO CA 3322), slender, weakly tricuspidate, erect, pungent, not imbricate, well separated, those on midline of back not enlarged, only slightly larger than those on sides; no greatly enlarged denticles on mid surface of body or fins. First dorsal fin raked slightly, apex narrowly rounded, posterior margin truncate (sometimes slightly convex in smallest paratypes), free rear tip angular in adults; much larger than second dorsal fin; origin about over or slightly behind mid pelvic-fin base, pre-first dorsal length 51.5 (52.8–54.0)% TL. Second dorsal fin low, weakly subtriangular, pre-second dorsal length 66.9 (66.7–67.9)% TL; anterior margin almost straight (more convex in smaller paratypes), apex broadly rounded, posterior margin weakly concave (straight to slightly convex in juveniles); origin well behind anal-fin origin (slightly behind in some juveniles), insertion almost over anal-fin insertion. Anal fin distinctly larger, taller than second dorsal fin; apex broadly rounded. Pectoral fins of moderate size, anterior margin 14.6 (14.3–15.6)% TL; anterior margin moderately convex, apices narrowly rounded, posterior margin weakly concave to truncate,

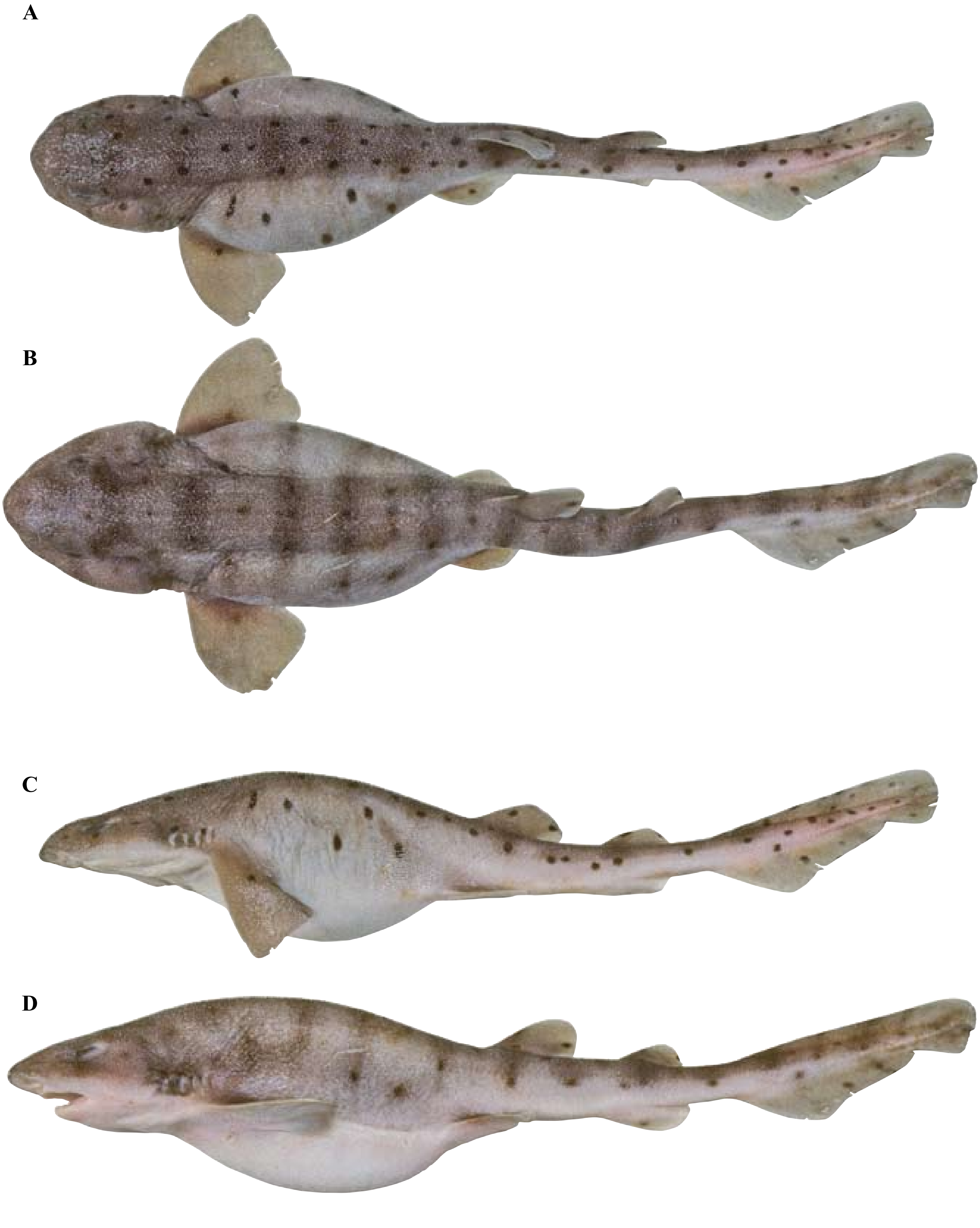

Figure 2. *Cephaloscyllium variegatum* sp. nov.: A. dorsal view of paratype CSIRO H 4684–01 (female 237 mm TL); B. dorsal view of paratype CSIRO H 4684–02 (juvenile male 252 mm TL); C. lateral view of paratype CSIRO H 4684–01 (female 237 mm TL); D. lateral view of paratype CSIRO H 4684–02 (juvenile male 252 mm TL).

inner margin mostly convex, free rear tip broadly rounded. Pelvic fins small, length 11.3 (11.5–11.9)% TL; anal-fin length 1.11 (0.89–1.63) times pelvic–anal space. Claspers subconical, elongate, not robust, tips usually well short of anal-fin origin, ventral surface covered with denticles; pelvic fins united to dorsobasal surface of clasper, incomplete apron joining claspers just posterior to cloaca. Caudal fin with a distinct ventral lobe; terminal lobe well developed, deep, its posterior margin truncate to strongly convex. Teeth in upper jaw of 4 paratypes 68–82; in lower jaw 68–80. Monospondylous centra 45 (44–47, mainly 44–45); precaudal 77 (76–80, mainly 78–80); total 117 (116–124).

EGG CASES.— Eggs cases large (71 mm in length from anterior to posterior, excluding horns), smooth, glossy, without transverse or longitudinal striations or ridges; no constricted waist section; somewhat flattened, height 27.2–27.8% ECL, posterior width 56.0–56.8% ECL; lateral flanges extending entire length of egg case, thick, rounded (not T-shaped). Anterior border nearly straight, broad; anterior horns moderately long, curved strongly inwards; tendrils long, wiry, tightly coiled. Posterior border narrower, concave, width 1.7–1.9 in anterior border width; posterior horns moderately long, curved strongly inwards, overlapping; tendrils long, wiry, tightly coiled. Egg cases (in alcohol) uniformly golden brown.

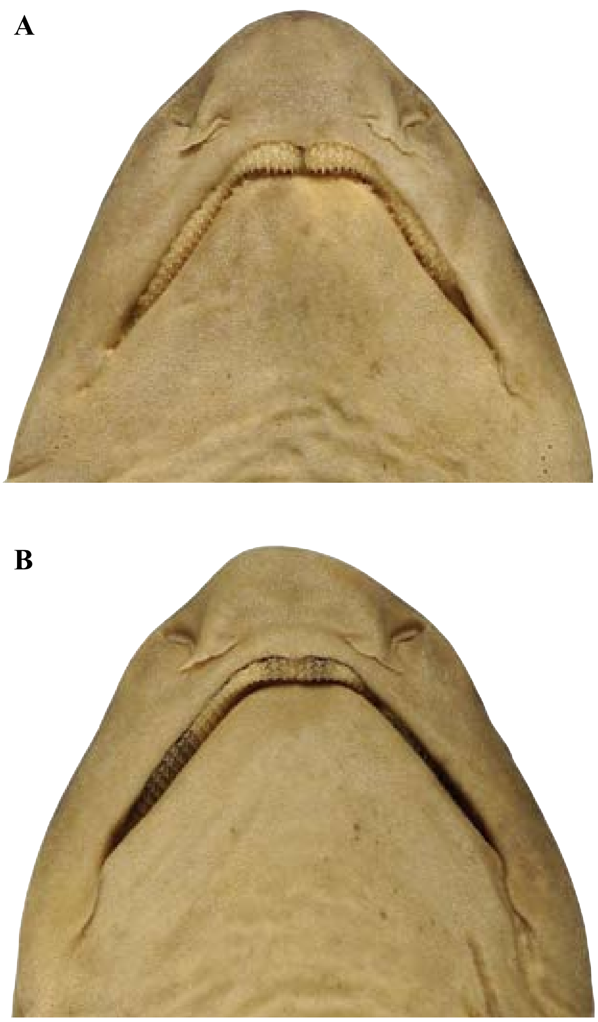

Figure 3. Ventral view of head of *Cephaloscyllium variegatum* sp. nov.: A. holotype (CSIRO H 3714–01, adult male 683 mm TL); B. paratype (CSIRO H 3715–01, female 692 mm TL).

COLOUR.— Preserved specimens: Colour pattern intraspecifically and ontogenetically variable. Adults medium to dark brown dorsally with about 11 weak saddles, yellowish ventrally; light and dark tones along lateral margin of head strongly demarcated, interface between them extending through ventral tips of gill slits to pectoral-fin origin; suborbital bar weak, usually obscure; no obvious black blotch over gill slits. Predorsal saddles 5, often indistinct, primarily dark brownish; separated by slightly narrower, less distinct, interstitial bars; interspiracular saddle well defined, occasionally weakly crescentic, width subequal to eye length; 2nd saddle over level of last gill slits; 3rd saddle over inner margin of pectoral fin; 4th saddle over abdomen; 5th saddle over pelvic-fin origin; all saddles extending to lateral midline or slightly below. Six saddles on precaudal tail; broad saddles beneath each dorsal-fin base; dark blotch usually at origin of first dorsal fin; interdorsal saddle subequal in width to subdorsal saddles; precaudal saddle usually present. Caudal fin usually with two, distinct, slightly darker, irregular bars; bars just behind origin of dorsal caudal-fin origin, and forward of subterminal notch; sometimes with irregular darker markings near posterior margin of terminal lobe and on upper lobe of fin; fleshy portion of fin appearing as a pale stripe, well demarcated from darker lobes above and below. Dorsal fins dark greyish brown, markings irregular. Pectoral and pelvic-fin upper surfaces almost uniformly dark brown, paler yellowish or white ventrally. Anal fin usually much paler than second dorsal fin, uniform yellowish or pale brownish. Ventral surface of body pale, usually uniformly creamish or yellowish, often with a few, small, darker flecks and blotches; claspers yellowish; mouth almost white. **Juvenile specimens:** Juvenile coloration variable; pattern dominate by sharply defined brownish black spots when smaller than about 240 mm TL. Smallest whole paratypes (CSIRO CA 3322, female 167 mm TL and QM I 21985, female 170 mm TL) strongly spotted without evidence of bars or saddles; spots sharply defined, partly

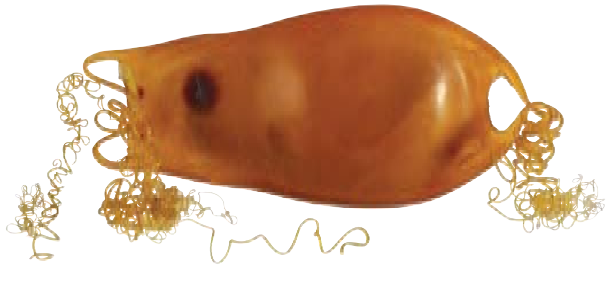

Figure 4. Egg case of *Cephaloscyllium variegatum* sp. nov. (CSIRO B 2253).

symmetrical in distribution, roughly equidistant, their diameter about half nostril width; spots distributed over back and sides including dorsal, caudal and pectoral fins; single medial spot at base of pectoral fin; a small spot near mid anterior and posterior margins of both dorsal fins. Specimen (CSIRO H 4684–01, female 237 mm TL) has both well-defined black spots and weakly developed, dusky precaudal saddles; 2 individuals (CSIRO H 4684–02, juvenile male 252 mm TL, and CSIRO H 4759–01, juvenile male 242 mm TL) have weakly defined spots but progressively developing transverse saddles; paratypes (CSIRO H 4759–02, juvenile male 300 mm TL and CSIRO H 4759–03, female 291 mm TL) without evidence of spots, saddles well defined (but less pronounced than in some other barred *Cephaloscyllium* species). Largest juvenile paratypes with white ventral surfaces; tone sharply demarcated from darker areas above; pale stripe on caudal fin well defined.

SIZE.— Largest females and males examined were 740 and 720 mm TL, respectively. Smallest mature male 630 mm TL. Smallest free-swimming specimen examined 170 mm TL.

DISTRIBUTION.— Occurs off eastern Australia from off Rockingham Bay, Queensland (18°08′ S, 147°09′ E), south to Tathra, New South Wales (36°31′ S, 150°19′ E), on the outer continental shelf and upper slope at depths of 114–606 m.

ETYMOLOGY.— Derived from the Latin *variegatus* (various) in allusion to the strong intraspecific and ontogenetic variability in colour pattern and morphology amongst the specimens examined. Vernacular: Saddled Swellshark.

REMARKS.— *Cephaloscyllium variegatum* is reasonably similar in colour pattern to its more temperate relative *C. albipinnum*. Both species have a colour pattern dominated by dark saddles, but in *C. variegatum* these markings are more intraspecifically variable and less regular. Also, the saddle markings and blotches (when evident) on adult *C. variegatum* are smaller, more widely separated and less well defined, the suborbital bar is less distinct, there is no obvious broad bar at the base and middle of the caudal fin, and the pale ventral half of the tail extends onto the fleshy portion of the caudal fin as a whitish stripe (cf. ventral half of tail not sharply demarcated from the dorsal half in *C. albipinnum*). Also, a large blotch covering the gills and the flank immediately above in *C. albipinnum* is absent in *C. variegatum*. Saddles, which are also present in small juveniles of *C. albipinnum*, are replaced by small blackish spots in juveniles of *C. variegatum*. These spots fade at about 250 mm TL and the saddle-like markings begin to develop. Other species of *Cephaloscyllium* have ontogenetically variable colour patterns. The juveniles of *C. sarawakensis* Yano, Ahmad & Gambang, 2005 have a dense pattern of ocellate spots that are lost with growth (Yano *et al*., 2005). The *Cephaloscyllium* species also differ slightly in morphometrics and meristics. *Cephaloscyllium variegatum* has fewer teeth (68–82 vs. 90–116 in each jaw), and a narrower trunk (14.5–17.1% vs. 16.1–23.8% TL), and a shorter posterior pectoral fin margin (10.4–12.1% vs. 12.0–13.6% TL). The colour pattern is very different to all other Australian swellsharks, and a New Zealand species, *C. isabellum*. Also, the denticles of *C. variegatum* are much smaller than in *C. isabellum*.

A narrow-bodied swellshark described as *C*. sp. B (Last & Stevens, 1994), collected primarily from Queensland, appears to be a morph of *C. variegatum* (see Fig. 5). These forms seem to grade into each other morphometrically and their vertebral counts were similar (based on non-types CSIRO H 1338–01, CSIRO H 947–09, CSIRO H 1340–01, CSIRO H 5635–10, CSIRO H 5635–12, CSIRO CA 3324): monospondylous centra 43–46 vs. 44–47 in the types of *C. variegatum*; precaudal 74–82 vs. 76–80; total 114–122 vs. 116–124. However, as some uncertainties still exist, specimens attributed to *C*. sp. B were excluded from the type series of *C. variegatum*.

The two *Cephaloscyllium* egg cases collected from Queensland (ca. 22° S; Fig. 6) differ from those of the known eastern Australian swellsharks, *C. albipinnum*, *C. laticeps* and *C. variegatum*. They had an ECL of ca. 82 and ca. 88 mm (Table 2), which is larger than those recorded for *C. variegatum* (ca. 71 mm), and smaller than those recorded for *C. albipinnum* (98–116 mm) and *C. laticeps* (126–130 mm). They are smooth-walled and lack the transverse ridges that are diagnostic of the egg cases of *C. laticeps*. These egg cases are much flatter than those of *C. variegatum* (egg case height 22.2 vs. 27.2–27.8% ECL) and have a much narrower posterior border than those of *C. albipinnum* (posterior border width 6.5–7.4 vs. 9.6–16.5% ECL). Three species of *Cephaloscyllium* species are known to occur off Queensland, i.e. *C. signourum*, *C. variegatum* and another new species treated below (as *C*. sp. D *sensu* Last & Stevens, 1994). As mentioned, the unidentified egg cases are distinct from those of *C. variegatum*. The egg cases of *C. albipinnum*, *C. laticeps* and *C. variegatum* have lengths (ECL) 7.7–10.2 in maternal total length (based on the sizes of adult females). If the unidentified Queensland egg cases came from a female of *C*. sp. D, which only attains ca. 430 mm TL, the ECL would be an unlikely 4.9–5.3 in maternal total length. In contrast, *C. signourum*, which attains ca. 800 mm TL, is the more likely candidate (i.e. ECL of egg cases of this size 9.1–9.8 in maternal total length). There is one other remote possibility. If *C*. sp. B as illustrated by Last & Stevens (1994) turns out to be a valid taxon, the egg cases could be of this species.

Figure 5. *Cephaloscyllium variegatum* sp. nov. Queensland specimen (CSIRO H 5635–10, adult male 669 mm TL): A. dorsal view; B. lateral view.

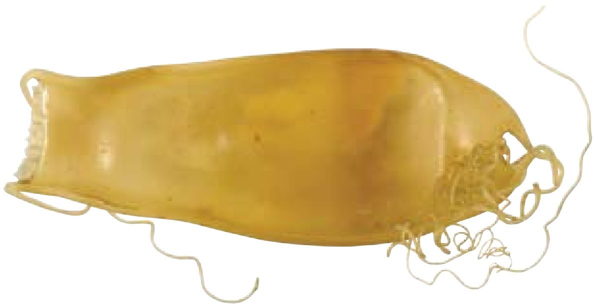

Figure 6. Egg case of *Cephaloscyllium signourum*? (CSIRO H 579–02).

Cephaloscyllium zebrum sp. nov.

Figs 7–8; Table 1

Cephaloscyllium sp. D: Last & Stevens, 1994: pp 170, 195, key fig. 41,fig. 26.23, pl. 23; Compagno *et al.*, 2005: p 221, pl. 36; Compagno & Niem, 1998: pp 1281, 1285, fig. 11.

Holotype. CSIRO H 1323–02, adult male 445 mm TL, east of Flinders Reef, Queensland, 17°32′ S, 149°34′ E, 444–454 m, 03 Dec 1985.
Paratype. CSIRO H 1323–03, female 435 mm TL, collected with holotype.

DIAGNOSIS.— A small *Cephaloscyllium* with the following combination of characters: head height 10.2–11.1% TL, trunk narrow, width 14.7–15.7% TL; first dorsal-fin origin slightly behind mid pelvic-fin base; prenarial length 4.4–4.8% TL; preorbital snout length 1.5 times prenarial length, 2.8–2.9 in prepectoral length, about 6.3 in prepelvic length; snout-vent length, 49.4–50.3% TL; nostril width 2.2–2.4% TL; wide eye–spiracle space, 1.1–1.3% TL; pectoral fin, height 11.3–12.1% TL, posterior margin length 10.6–11.6% TL; anal fin height 3.2–3.3% TL; anal–caudal space about 5.4% TL; precaudal length 75–76% TL; interdorsal space 6.2–7.7% TL; teeth near symphysis of upper jaw usually with 3–5 cusps; flank denticles unicuspidate or weakly tricuspidate; no greatly enlarged denticles on back; adult clasper long, to 8.2% TL, almost reaching anal fin, interspace about 3.9 in anal-fin base; 110–111 vertebral centra; low tooth count, 59–62 teeth in each jaw; upper half pale with 31–34 narrow, saddle-like bars on body and tail; interspaces between bars broad, about 1.5 times width of adjacent bar; large blotches absent.

DESCRIPTION.— Body moderately robust anteriorly, belly greatly expanded, tapering gradually behind first dorsal fin. Head strongly depressed, arched posteriorly, short and broad, length 22.0 (22.8)% TL, width 14.1 (15.3)% TL; widest just forward of 1st gill slit; broadly parabolic in dorsoventral view, bluntly pointed in lateral view; lateral angle of suborbital shelf usually weakly defined; supraorbital crest thin; gill slits lateral; last two slits over pectoral-fin base, third gill slit almost over pectoral-fin origin, slightly closer together than slits 1–3; first three slits subequal in length, last two decreasingly smaller. Snout tip moderately rounded to bluntly pointed, length 3.01 (3.05) in head length. Eyes dorsolateral, slit-like, length 2.19 (1.78) in snout; suborbital groove well-developed, slightly longer than eye; orbito-spiracular groove continuous; interorbital width 0.87 (0.88) of snout, 2.63 (2.68) in head length. Spiracle very small,

Table 1. Morphometric data for the holotype of *Cephaloscyllium variegatum* sp. nov. (CSIRO H 3714-01) and *C. zebrum* sp. nov. (CSIRO H 1323-02), with ranges provided for the measured paratype(s). Measurements expressed as a percentage of total length.

	C. variegatum **sp. nov.**			***C. zebrum*** **sp. nov.**	
	Holotype	Paratypes		Holotype	Paratype
		Min.	Max.		
Total length (mm)	683	654	692	445	435
Precaudal length	77.7	76.6	78.2	75.7	74.9
Pre-second dorsal length	66.9	66.7	67.9	63.8	63.2
Pre-first dorsal length	51.5	52.8	54.0	49.3	51.3
Head length	22.4	22.4	23.6	22.0	22.8
Pre-branchial length	18.7	18.0	19.0	18.3	18.8
Pre-spiracular length	11.7	10.8	11.8	11.8	12.1
Preorbital length (horizontal)	6.1	5.9	6.8	7.0	6.3
Preorbital length (direct)	7.5	6.9	7.6	7.3	7.5
Preoral length	4.4	3.6	4.3	4.6	4.8
Prenarial length	4.5	4.4	5.0	4.8	4.4
Pre-pectoral length	23.1	21.6	22.7	20.7	21.8
Pre-pelvic length	49.0	47.1	49.9	45.8	47.3
Pre-vent length	52.1	50.5	52.9	49.4	50.3
Pre-anal length	64.7	63.5	64.8	61.6	61.4
Interdorsal space	7.5	6.5	8.0	7.7	6.2
Dorsal–caudal space	5.8	4.8	6.6	6.5	6.3
Pectoral–pelvic space	20.2	18.4	21.6	17.5	18.7
Pelvic–anal space	8.8	6.4	10.5	10.0	6.7
Anal–caudal space	5.2	4.5	5.7	5.4	5.4
Eye length	3.9	3.1	3.5	3.3	4.2
Interorbital width	8.7	8.0	9.0	8.4	8.5
Nostril width	2.5	2.4	2.6	2.2	2.4
Internarial space	3.8	2.9	3.5	3.0	2.9
Anterior nasal flap length	1.3	1.0	1.3	1.1	1.1
Spiracle length	0.3	0.4	0.6	0.6	0.6
Eye–spiracle space	1.0	0.8	1.3	1.3	1.1
Mouth length	5.1	5.1	6.0	5.7	5.5
Mouth width	10.8	9.3	11.2	10.2	10.5
First gill slit height	2.4	2.2	3.0	2.5	2.4
Fifth gill slit height	1.2	1.5	1.6	1.5	1.6
Head height	10.2	9.4	10.5	11.1	10.2
Trunk height	10.5	10.1	12.3	13.4	11.5
Caudal peduncle height	2.7	2.8	3.1	2.7	2.8
Head width	16.1	12.9	15.5	14.1	15.3
Trunk width	17.1	14.5	16.6	15.7	14.7
Caudal peduncle width	3.0	2.0	2.7	2.3	2.8
Pectoral fin - length	13.3	13.7	14.1	14.5	15.4
Pectoral fin - anterior margin	14.6	14.3	15.6	15.6	16.1
Pectoral fin - base	9.2	9.0	10.1	8.8	8.2
Pectoral fin - height	11.9	10.9	13.2	11.3	12.1
Pectoral fin - inner margin	4.8	4.5	5.5	6.1	6.5
Pectoral fin - posterior margin	11.4	10.4	12.1	10.6	11.6

Table 1. cont'd.

	C. variegatum sp. nov.			***C. zebrum*** sp. nov.	
	Holotype	Paratypes		Holotype	Paratype
		Min.	Max.		
Pelvic fin - length	11.3	11.5	11.9	12.3	12.6
Pelvic fin - anterior margin	6.6	6.2	7.1	6.5	6.9
Pelvic fin - base length	6.7	7.2	8.6	6.8	8.3
Pelvic fin - height	6.4	5.1	6.2	5.0	4.9
Pelvic fin - inner margin	4.7	3.5	4.8	5.3	4.3
Pelvic fin - posterior margin	6.7	6.2	8.0	7.7	7.1
Clasper outer length	7.5	7.4	8.1	8.2	-
Clasper inner length	11.4	11.0	12.3	11.9	-
Clasper base width	1.8	1.6	1.7	1.6	-
First dorsal fin - length	11.1	9.5	10.6	10.1	10.3
First dorsal fin - anterior margin	11.2	9.3	10.9	10.2	9.8
First dorsal fin - base length	8.6	7.2	8.3	7.3	7.1
First dorsal fin - height	5.6	5.1	6.1	4.8	4.6
First dorsal fin - inner margin	2.9	2.4	3.4	2.7	3.2
First dorsal fin - posterior margin	5.1	4.8	5.6	4.3	4.8
Second dorsal fin - length	8.3	7.8	7.9	7.7	8.1
Second dorsal fin - anterior margin	6.1	5.8	5.9	5.4	5.8
Second dorsal fin - base length	5.7	5.1	5.3	4.7	5.5
Second dorsal fin - height	3.1	2.7	3.2	2.2	2.5
Second dorsal fin - inner margin	2.9	2.6	3.0	2.8	3.1
Second dorsal fin - posterior margin	3.3	3.1	3.6	3.2	3.2
Anal fin - length	9.8	9.3	10.4	9.1	9.9
Anal fin - anterior margin	7.9	7.2	8.8	6.8	7.6
Anal fin - base length	7.3	6.5	8.0	6.8	7.2
Anal fin - height	4.1	3.5	4.1	3.3	3.2
Anal fin - inner margin	2.6	2.5	3.0	2.7	2.9
Anal fin - posterior margin	4.1	3.9	4.3	3.8	4.2
Caudal fin - dorsal margin	22.2	21.6	23.3	23.9	24.7
Caudal fin - preventral margin	10.5	9.9	10.7	10.9	10.1
Caudal fin - lower postventral margin	3.2	2.7	3.3	2.5	3.1
Caudal fin - upper postventral margin	7.2	7.2	8.0	8.1	9.5
Caudal fin - subterminal margin	3.8	3.6	4.3	4.1	4.3
Caudal fin - terminal margin	6.3	5.3	7.5	5.8	6.8
Caudal fin - terminal lobe length	7.1	6.2	8.0	6.9	7.9
Second dorsal origin–anal origin	1.7	1.2	2.5	1.5	0.8
Second dorsal insertion–anal insertion	0.3	0.2	0.4	0.4	0.4

subcircular, close to eye, dorsolateral on head, length 13.78 (15.09) in interorbital width. Anterior nasal flap expanded laterally, usually overlapping outer lobe but not reaching mouth, posterior margin usually entire or weakly fringed; internarial width slightly larger than nostril width. Mouth relatively long and narrow, width 1.80 (1.90) times length; roof of mouth and tongue papillose; labial furrows absent; postoral groove short, deep, concave (extending ventrolaterally from each corner of mouth). Upper jaw teeth of adult male holotype small, recurved medially, usually with 3 cusps and weak basal grooves, lateral cusps well-developed, sometimes with an additional lateral cusplet; central cusps not greatly extended near symphysis, slightly longer than lateral cusps near mouth corners; symphysial groove deep. Lower jaw teeth of holotype subequal in size to those near symphysis

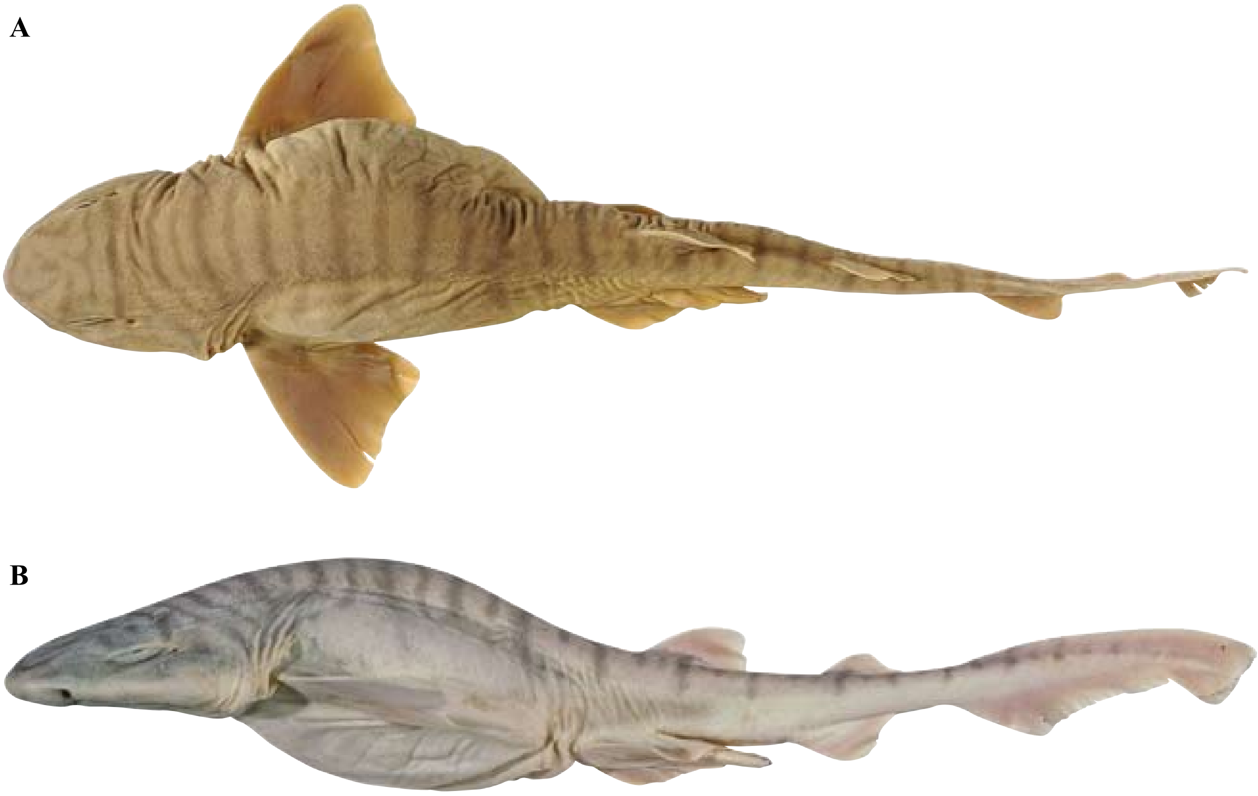

Figure 7. *Cephaloscyllium zebrum* sp. nov. holotype (CSIRO H 1323–02, adult male 445 mm TL): A. dorsal view (preserved); B. lateral view (fresh).

Table 2. Morphometric data for the egg cases of both *Cephaloscyllium variegatum* sp. nov. and *C. signourum*?. Measurements expressed as a percentage of egg case length (ECL).

	C. variegatum **sp. nov.**		***C. signourum?***	
	n=2		n=2	
	Min.	Max.	Min.	Max.
Egg case length (mm)	71.1	71.5	81.7	87.8
Posterior case width	56.0	56.8	41.9	43.7
Anterior case width	34.6	35.3	26.5	30.4
Anterior border width	28.2	28.6	21.4	24.8
Posterior border width	14.8	17.2	6.5	7.4
Egg case height	27.2	27.8	22.2	22.2

of upper jaw, recurved anterolaterally; lateral cusps of posterior teeth not better defined than those anteriorly; 3 or so rows at symphysis greatly reduced, about a third size of those adjacent. Upper jaw teeth of female paratype (CSIRO H 1323–03) usually with 5 cusps, outer cusplets small or rudimentary; those near symphysis with central cusp much larger than lateral cusps; central cusps of female and male of similar size; teeth near jaw angle with better developed lateral cusps in upper jaw than in lower jaw (lateral cusps often rudimentary in lower jaw). Flank denticles of adult male very small, not erect, dense, weakly imbricate; usually weakly tricuspidate with broadly pointed apices; variable in size; crowns with a well-developed median ridge, lateral ridges short and elevated slightly; denticles of adult female (CSIRO H 1323–03) unicuspidate or weakly tricuspidate, variable in size and subequal to male holotype. First dorsal fin raked slightly, apex narrowly rounded, posterior margin upright and truncate; much larger than second dorsal fin; origin slightly behind mid pelvic-fin base (further forward in female paratype), pre-first dorsal-fin length 49.3 (51.3)% TL. Second dorsal fin very low, elongate, pre-second dorsal-fin length 63.8 (63.2)% TL; anterior margin weakly convex, apex broadly rounded, posterior margin concave; origin well behind anal-fin origin (slightly behind in female paratype), insertion almost over anal-fin insertion. Anal fin distinctly larger, taller, apex broadly rounded, posterior margin concave. Pectoral fins moderately large, anterior margin 15.6 (16.1)% TL; anterior margin moderately convex, apices narrowly rounded, posterior margin weakly concave, inner margin mostly convex, free rear tip somewhat angular. Pelvic fins small, length 12.3 (12.6)% TL; anal-fin length 0.92 (1.47) times pelvic–anal space. Clasper slender, elongate, not robust, almost reaching anal-fin origin, ventral surface covered with denticles; pelvic fins united to dorsobasal surface of clasper, incomplete apron joining claspers just posterior to cloaca. Caudal fin of moderate size, with

A

B

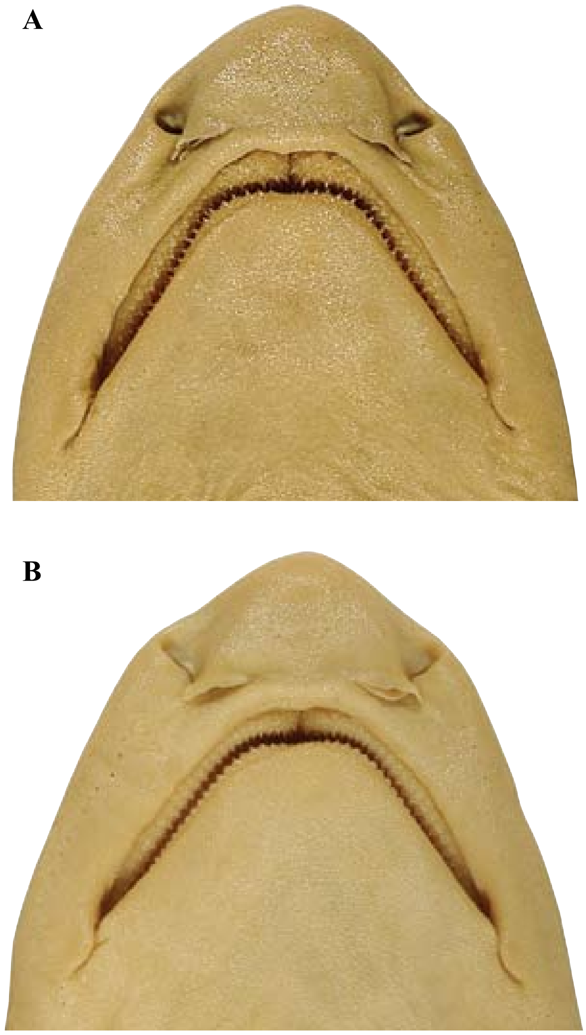

Figure 8. Ventral view of head of *Cephaloscyllium zebrum* sp. nov.: A. holotype CSIRO H 1323–02 (adult male 445 mm TL); B. paratype CSIRO H 1323–03 (female 435 mm TL).

a distinct ventral lobe; terminal lobe well developed, posterior margin almost truncate. Teeth in upper jaw 62 (61); in lower jaw 59 (62). Monospondylous vertebrae 40 (40); precaudal 72 (71); total 110 (111).

COLOUR.— Preserved specimens: Body pale yellowish, slightly darker dorsally; with about 31–34 darker brown, transverse, saddle-like bars on upper surface of body and caudal fin; dark and light coloration on head strongly demarcated laterally, extending above its lateral margin and above gill slits; gill membranes yellowish, without a dark blotch-like marking; bars narrow, almost equally spaced, interspaces about 1.5 times width of adjacent bar; dorsal prespiracular head with irregular, dark bars and lines, extending to snout tip. Primary predorsal bars 15–16; interspiracular bar well developed, its origin largely over eye–spiracle interspace; some predorsal bars indistinct (weak interstitial bars on interspace near dorsal fin of female paratype); anterior bars extending to upper margin of gill slits, barely to lateral midline posteriorly. About 9–10 primary bars on precaudal tail; sometimes with fainter interstitial bars; primary bars at origin, insertion and midpoint of each dorsal fin; 1–2 interdorsal bars; 2 postdorsal bars. Caudal fin with 3–5 primary bars, most pronounced anteriorly, bars absent on posterior half of fin; ventral half of fin and terminal lobe uniformly pale. Subdorsal bars extending on to fins just above their bases, remainder of dorsal fins uniformly pale. Ventral surfaces of body, mouth and claspers, and pectoral, pelvic and anal fins, uniformly pale.

SIZE.— Known only from the two type specimens, the adult male holotype (445 mm TL) and female paratype (435 mm TL).

DISTRIBUTION.— Both types were taken near Flinders Reef in Queensland (17°32′ S, 149°34′ E) on the upper continental slope at depths of 444–454 m.

ETYMOLOGY.— Derived from the Amharic *zebra* (striped equine of Africa) in allusion to the colour pattern of narrow bars on the dorsal and lateral surfaces of the head and body. Vernacular: Narrowbar Swellshark.

REMARKS.— The colour pattern of multiple narrow, saddle-like bars on the back is unique within the genus. *Cephaloscyllium zebrum* also differs from other saddled Australian *Cephaloscyllium* species, *C. variegatum* and *C. albipinnum*, in morphometrics and meristics. *Cephaloscyllium zebrum* has fewer vertebral centra (total 110–111 vs. 116–126 combined for the other species), fewer teeth (total 59–62 vs. 68–116 in each jaw), narrower nostrils (nostril width 2.2–2.4% vs. 2.4–2.7% TL), smaller pectoral fin (height 11.3–12.1% vs. 12.6–13.6% TL), and a lower anal fin (height 3.2–3.3% vs. 3.5–4.4% TL). It may occur sympatrically with *C. variegatum* as both have been collected from similar regions off Queensland.

Comparative material.
Cephaloscyllium signourum? Egg cases: CSIRO H 579–02, egg case, Swain Reefs, Queensland, 21°31′ S, 152°58′ E, 239–247 m, 20 Nov 1985; CSIRO H 3465–01, egg case, Saumarez Reef, Queensland, 22°09′ S, 153°29′ E, 325–344 m, 19 Nov 1985.

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Cephaloscyllium hiscosellum sp. nov., a new swellshark (Carcharhiniformes: Scyliorhinidae) from northwestern Australia

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ABSTRACT.— A new species of swellshark, *Cephaloscyllium hiscosellum* sp. nov., is described based on material from the upper continental slope of northwestern Australia. *Cephaloscyllium hiscosellum* is clearly separable from all other Australian members of this genus by its distinctive colour pattern which consists of a series of dark brown lines which form a pattern of open saddle-like markings and reticulations. This species is similar in appearance to *C. fasciatum* from Vietnam and China but can be distinguished by a combination of coloration, morphometrics and meristics.

Key words. Scyliorhinidae – *Cephaloscyllium hiscosellum* – swellshark – new species – Australia

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INTRODUCTION

Last & Stevens (1994) identified 7 *Cephaloscyllium* species from Australian waters, consisting of 5 considered to be undescribed species (*C*. sp. A–E) and two nominal species (*C. fasciatum* and *C. laticeps*). This is the fourth paper in this series on new species of swellsharks of the genus *Cephaloscyllium* with 6 new species from Australian waters described in the three previous papers: *C. albipinnum* (Last *et al*., 2008a), *C. cooki*, *C. signourum* and *C. speccum* (Last *et al*., 2008b), and *C. variegatum* and *C. zebrum* (Last & White, 2008). Although the three previous papers have provided formal descriptions of the undescribed species first identified by Last & Stevens (1994), further examination of Australian specimens of *C. fasciatum* Chan, 1966 revealed that they are clearly separable from the type specimens of this species and represent a new taxon. *Cephaloscyllium fasciatum* was described based on 5 specimens collected from off Cape Bantagan in Vietnam in depths of 205–315 m by Chan (1966). Schaaf-Da Silva & Ebert (2008) provided a redescription of *C. fasciatum* based on the holotype and one paratype. This species has a distinctive colour pattern of dark brown lines which form loops, open-centred saddles, reticulations and circles which clearly distinguishes it from other members of the genus *Cephaloscyllium*. Australian specimens have a similar colour pattern which distinguishes it from other Australian *Cephaloscyllium* species, but are clearly separable from the true *C. fasciatum*. This new species is formally described and compared closely with type specimens of *C. fasciatum*.

METHODS

Morphometrical characters were selected to facilitate comparisons of the new *Cephaloscyllium* species with *C. fasciatum*. Our methods generally followed a widely adopted scheme for elasmobranchs (Compagno, 1984, 2001), but focused on direct rather than horizontal measurements. The holotype (CSIRO H 2590–07) and 7 paratypes (CSIRO CA 3299, CSIRO CA 4483, CSIRO CA 4484, CSIRO H 822–06, CSIRO H 822–07, CSIRO H 1341–01 and CSIRO H 1341–02) of the new species and the holotype (BMNH 1965.8.11.1) and one paratype (BMNH 1965.8.11.5) of *C. fasciatum* were measured in full (Table 1). Meristics were taken from radiographs of the holotype and 8 paratypes (CSIRO CA 3299, CSIRO CA 3300, CSIRO CA 4483, CSIRO CA 4484, CSIRO H 822–06, CSIRO H 822–07, CSIRO H 1341–01 and CSIRO H 1342–01) of the new species and the holotype and a single paratype (BMNH 1965.8.11.5) of *C. fasciatum*. Meristics were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and caudal (centra of the caudal fin) vertebrae. Tooth counts were taken *in situ* from 3 paratypes (CSIRO CA 4484, CSIRO H 1342–01 and CSIRO H 6419–01). In the description, morphometric and meristic values for the holotype are given first followed in parentheses by the ranges of the measured paratypes. Type specimens and comparative material are deposited in the Australian National Fish Collection, Hobart (CSIRO), and ichthyological collections of the Natural History Museum, London (BMNH), Stanford University (SU; now housed at California Academy of Sciences, CAS) and the Western Australian Museum (WAM); their registration numbers are prefixed with these acronyms.

Cephaloscyllium hiscosellum sp. nov.

Figs 1–3; Table 1

Cephaloscyllium fasciatum (northwestern Australia population): Compagno, 1984: pp 296–298; Last & Stevens, 1994: pp 170, 197, key fig. 40, fig. 26.25, pl. 23; Compagno & Niem, 1998: pp 1281, 1289; Compagno *et al*., 2005: p 216.

Holotype. CSIRO H 2590–07, adult male 458 mm TL, west of Leander Point, Western Australia, 29°15′ S, 113°56′ E, 320–325 m, 06 Feb 1991.
Paratypes. 18 specimens. CSIRO CA 3299, adolescent male 356 mm TL, CSIRO CA 3300, female 311 mm TL, south-west of Rowley Shoals, Western Australia, 18°55′ S, 117°00′ E, 300–306 m, 13 Apr 1982; CSIRO CA 4073, female 313 mm TL, south-west of Rowley Shoals, Western Australia, 18°53′ S, 117°08′ E, 296–300 m, 17 Aug 1983; CSIRO CA 4483, female 318 mm TL, north-east of Monte Bello Islands, Western Australia, 19°00′ S, 116°09′ E, 348 m, 30 Jan 1984; CSIRO CA 4484, female 336 mm TL, south-west of Rowley Shoals, Western Australia, 18°31′ S, 117°29′ E, 446–452 m, 01 Feb 1984; CSIRO H 822–06, adolescent male 391 mm TL, CSIRO H 822–07, female 256 mm TL, CSIRO H 822–08, immature male 135 mm TL, south-west of Shark Bay, Western Australia, 27°03′ S, 112°40′ E, 402 m, 27 Oct 1986; CSIRO H 1341–01, female 329 mm TL, north-east of Monte Bello Islands, Western Australia, 19°00′ S, 116°09′ E, 348 m, 30 Jan 1984; CSIRO H 1342–01, adolescent male 364 mm TL, north of Dampier Archipelago, Western Australia, 19°06′ S, 116°11′ E, 294–296 m, 30 Jan 1984; CSIRO H 6419–01, adult male 463 mm TL, north-west of Shark Bay, Western Australia, 24°35′ S, 112°15′ E, 402–406 m, 23 Apr 2006; WAM P 28270–001, 316 mm TL, off Port Hedland, Western Australia, 18°46′ S, 117°08′ E, 350 m, 31 Jan 1984; WAM P 30421–002 (5 specimens), 332–520 mm TL, south-west of Shark Bay, Western Australia, 27°33′ S, 112°54′ E, 380–420 m, 26 Apr 1990; WAM P 30584–003, 320 mm TL, north of Dampier Archipelago, Western Australia, 19°05′ S, 116°12′ E, 294–296 m, 26 Apr 1990.

DIAGNOSIS.— A small *Cephaloscyllium* with the following combination of characters: head height 8.9–13.1% TL, trunk width 12.9–19.1% TL; first dorsal-fin origin usually over mid pelvic-fin base; prenarial length 4.5–5.2% TL; preorbital snout length 1.4–1.6 times prenarial length, 2.6–3.1 in prepectoral length, 5.9–6.7 in prepelvic length; long snout-vent length, 46.2–51.2% TL; nostril width 2.5–3.1% TL; wide eye–spiracle space, 0.8–1.2% TL; moderate-sized pectoral fin, height 8.7–12.2% TL, posterior margin length 7.4–11.4% TL; relatively low anal fin, height 2.8–3.7% TL; anal–caudal space 5.4–6.5% TL; precaudal length 76.4–79.2% TL; interdorsal space 7.4–9.6% TL; teeth near symphysis of upper jaw with 3–5 cusps; flank denticles mainly unicuspidate; no greatly enlarged denticles on back; adult clasper long, to 9.3% TL, reaching anal-fin origin; 100–108 vertebral centra; low tooth count, between 45 and 63 teeth in each jaw; dorsal surface with a striking pattern of dark brown, open-centred saddles.

DESCRIPTION.— Body robust anteriorly, belly often greatly expanded, tapering gradually behind first dorsal fin. Head strongly depressed, short and relatively broad, length 22.1 (21.1–22.1)% TL, width 15.4 (13.0–14.9)% TL; widest just forward of 1st gill slit; broadly parabolic in dorsoventral view, bluntly pointed to narrowly rounded in lateral view; lateral angle of suborbital shelf usually weakly defined; supraorbital crest thin; gill slits dorsolateral; last two slits over pectoral-fin base (third gill slit over pectoral-fin origin in some paratypes), usually slightly closer together than slits 1–3; first three slits subequal in length, last two decreasingly smaller (fourth gill slit only slightly smaller than third in some paratypes). Snout tip moderately rounded to bluntly pointed, length 2.75 (2.93–3.17) in head length. Eye dorsolateral, slit-like, length 2.18 (1.70–2.15) in snout; suborbital groove well-developed, slightly longer than eye; orbito-spiracular groove usually discontinuous; interorbital width 1.13 (1.04–1.25) of snout, 2.42 (2.34–3.00) in head length. Spiracle very small, subcircular to suboval, well separated from eye; dorsolateral on head, length 11.8 (8.8–21.7) in interorbital width. Anterior nasal flap expanded laterally, overlapping outer lobe but not reaching mouth, posterior margin weakly notched (fringed laterally in some paratypes); internarial width slightly larger than nostril width.

Mouth relatively long and broad, strongly arched (weakly arched to broadly rounded in female paratype CSIRO H 1341–01) width 2.06 (2.19–2.59) times length; roof of mouth and tongue papillose (very weakly in some paratypes); labial furrows absent; postoral groove short, deep, nearly straight or concave (extending ventrolaterally from each corner of mouth). Upper jaw teeth of adult male holotype small, recurved medially, with 3 cusps; first pair of lateral cusps well-developed, sometimes with additional 1–2 rudimentary lateral cusplets; central cusp on teeth near symphysis slightly longer than those adjacent; symphysial groove deep. Lower jaw teeth in adult male holotype subequal in size to those near symphysis of upper jaw, recurved medially; lateral cusps of posterior teeth not better defined than those anteriorly; 4 rows or so at symphysis greatly reduced, about a quarter size of those adjacent; no symphysial groove. Teeth in

Figure 1. *Cephaloscyllium hiscosellum* sp. nov., adult male holotype (CSIRO H 2590–07, 458 mm TL): A. dorsal view; B. lateral view.

upper jaw of female paratype (CSIRO H 1341–01) much smaller than in similar sized males; similar shape to those of adult male; usually with 3 main cusps, often with 1–2 (mainly 1) short cusplets on each side.

Flank denticles of adult male very small, usually unicuspidate (rarely very weakly tricuspidate), apices narrowly pointed; barely overlapping, reasonably similar in size; crown with a very strong median ridge, no lateral ridges; denticles of female paratype (CSIRO H 1341–01) also similarly sized; crowns of female with obvious lateral ridges; no greatly enlarged denticles on mid surface of body or fins.

First dorsal fin strongly raked, anterior margin weakly to moderately convex, apex rounded (bluntly angular in some paratypes), posterior margin truncate; much larger than second dorsal fin; origin over mid pelvic-fin base (slightly more posterior to almost over pelvic-fin insertion in some paratypes), pre-first dorsal length 52.1 (47.1–52.2)% TL. Second dorsal fin low, weakly subtriangular, pre-second dorsal length 64.8 (62.7–68.2)% TL; anterior margin almost straight to weakly convex, apex broadly rounded, posterior margin almost straight to moderately concave; origin slightly behind anal-fin origin; insertion almost over anal-fin insertion. Anal fin distinctly larger than second dorsal fin, taller, apex broadly rounded. Pectoral fin moderate-sized, anterior margin weakly to moderately convex, its length 16.0 (12.8–15.8)% TL; apex narrowly rounded (moderately rounded in some paratypes); posterior margin weakly concave to truncate; inner margin weakly convex, free tip bluntly angular to narrowly rounded; anal-fin length 1.26 (0.67–1.33) times pelvic–anal space. Pelvic fin small, length 11.6 (10.0–13.2)% TL. Claspers almost cylindrical, elongate, relatively slender, extending past anal-fin origin (terminates well anterior to anal-fin origin in smaller adult male paratypes), ventral surface covered with denticles; pelvic fins united to dorsobasal surface of clasper, incomplete apron joining claspers just posterior to cloaca. Caudal fin moderately large, with a distinct ventral lobe; terminal lobe well developed,

Table 1. Morphometric data for the holotype of *Cephaloscyllium hiscosellum* sp. nov. (CSIRO H 2590–07), with ranges provided for the measured paratypes, and the holotype (BMNH 1965.8.11.1) and one paratype (BMNH 1965.8.11.5) of *C. fasciatum*. Measurements expressed as a percentage of total length.

	C. hiscosellum **sp. nov.**			***C. fasciatum***	
	Holotype	Paratypes			
		Min.	Max.	Holotype	Paratype
Total length (mm)	458	256	391	421	224
Precaudal length	77.5	76.4	79.2	78.4	74.1
Pre-second dorsal length	64.8	62.7	68.2	67.6	60.1
Pre-first dorsal length	52.1	47.1	52.2	53.2	45.8
Head length	22.1	21.1	22.1	18.4	20.0
Pre-branchial length	18.6	17.1	18.1	14.2	16.5
Pre-spiracular length	12.0	10.9	11.9	10.5	11.9
Preorbital length (horizontal)	6.4	6.0	6.5	5.5	5.7
Preorbital length (direct)	8.0	6.7	7.4	–	–
Preoral length	4.4	3.8	4.7	3.5	4.6
Prenarial length	5.2	4.5	5.1	–	–
Pre-pectoral length	21.1	20.2	21.8	17.1	20.1
Pre-pelvic length	47.8	43.1	46.3	44.6	44.1
Pre-vent length	51.2	46.2	50.6	48.9	43.4
Pre-anal length	62.9	59.0	65.7	–	–
Interdorsal space	7.4	7.7	9.6	7.1	8.0
Dorsal–caudal space	6.8	6.6	8.3	6.5	9.7
Pectoral–pelvic space	20.0	16.9	19.5	20.7	18.2
Pelvic–anal space	8.7	8.3	13.6	8.5	9.2
Anal–caudal space	5.8	5.4	6.5	5.3	5.8
Eye length	3.7	3.4	4.3	3.6	4.9
Interorbital width	9.1	7.1	9.1	8.0	8.4
Nostril width	2.6	2.5	3.1	2.5	2.9
Internarial space	3.5	2.7	3.3	2.7	3.2
Anterior nasal flap length	1.6	1.1	1.4	1.4	1.6
Spiracle length	0.8	0.4	0.9	0.9	0.5
Eye–spiracle space	0.9	0.8	1.2	1.0	0.6
Mouth length	5.1	4.2	5.0	5.5	6.2
Mouth width	10.4	9.7	11.3	11.8	10.5
First gill slit height	2.2	1.7	2.0	2.1	1.8
Fifth gill slit height	1.5	1.2	1.7	1.3	0.8
Head height	13.1	8.9	10.7	7.7	8.5
Trunk height	15.1	9.4	12.5	8.8	7.4
Caudal peduncle height	2.8	2.5	3.4	3.0	3.3
Head width	15.4	13.0	14.9	14.9	12.6
Trunk width	19.1	12.9	17.0	5.0	5.8
Caudal peduncle width	2.6	2.1	3.1	3.6	1.9
Pectoral fin - length	14.3	12.4	14.4	12.0	12.1
Pectoral fin - anterior margin	16.0	12.8	15.8	14.4	12.9
Pectoral fin - base	9.3	7.8	9.1	7.6	7.7
Pectoral fin - height	12.2	8.7	10.6	10.1	8.0
Pectoral fin - inner margin	5.2	4.4	6.3	4.9	5.4
Pectoral fin - posterior margin	11.4	7.4	10.0	9.5	7.3

Table 1. cont'd.

	C. hiscosellum sp. nov.			***C. fasciatum***	
	Holotype	Paratypes			
		Min.	Max.	Holotype	Paratype
Pelvic fin - length	11.6	10.0	13.2	9.5	10.6
Pelvic fin - anterior margin	6.4	6.2	7.3	6.0	7.5
Pelvic fin - base length	6.6	6.6	9.3	7.5	7.3
Pelvic fin - height	5.6	4.5	5.6	2.9	3.6
Pelvic fin - inner margin	5.6	2.9	5.2	3.0	3.1
Pelvic fin - posterior margin	6.2	5.1	7.5	4.7	5.1
Clasper outer length	9.3	7.3	8.3	–	–
Clasper inner length	12.9	11.5	12.4	–	–
Clasper base width	1.9	1.5	1.9	–	–
First dorsal fin - length	10.5	9.1	10.8	9.7	9.4
First dorsal fin - anterior margin	10.5	8.2	10.5	9.8	9.4
First dorsal fin - base length	7.8	7.1	8.3	7.4	6.9
First dorsal fin - height	5.1	3.9	5.0	4.9	4.6
First dorsal fin - inner margin	2.9	2.0	3.3	2.5	3.1
First dorsal fin - posterior margin	4.7	3.1	4.5	4.3	3.3
Second dorsal fin - length	8.3	6.8	8.8	7.5	7.5
Second dorsal fin - anterior margin	6.2	5.1	7.2	5.9	5.9
Second dorsal fin - base length	5.4	4.3	6.0	5.0	4.9
Second dorsal fin - height	2.7	2.3	2.7	2.2	2.1
Second dorsal fin - inner margin	3.0	2.4	3.0	2.8	3.6
Second dorsal fin - posterior margin	3.6	2.7	3.5	2.7	2.5
Anal fin - length	10.9	8.8	11.0	9.8	10.3
Anal fin - anterior margin	8.5	6.2	8.6	7.8	8.2
Anal fin - base length	8.1	6.5	8.4	7.3	6.8
Anal fin - height	3.7	2.8	3.5	2.7	3.2
Anal fin - inner margin	2.9	2.2	3.1	2.6	2.7
Anal fin - posterior margin	4.0	3.0	3.7	2.4	2.7
Caudal fin - dorsal margin	22.9	20.8	23.4	23.4	22.5
Caudal fin - preventral margin	10.9	8.7	11.7	9.8	10.5
Caudal fin - lower postventral margin	3.1	2.4	3.4	–	–
Caudal fin - upper postventral margin	7.1	6.1	8.5	–	–
Caudal fin - subterminal margin	5.0	3.5	5.0	4.2	4.8
Caudal fin - terminal margin	5.0	4.5	5.4	5.5	4.8
Caudal fin - terminal lobe length	7.3	5.9	7.1	6.8	6.0
Second dorsal origin–anal origin	2.4	1.6	3.1	1.4	1.9
Second dorsal insertion–anal insertion	0.3	0.2	1.0	0.4	0.0

deep, its posterior margin truncate to moderately convex (sometimes weakly notched near centre).

Teeth in upper jaw about 49–63; in lower jaw about 45–60 (n=3). Monospondylous vertebrae 37 (37–39 in 8 paratypes); precaudal 71 (69–75); total 103 (100–108).

EGG CASES.— Eggs cases (based on Fig. 3, specimen not retained) smooth, without transverse or longitudinal striations or ridges; not constricted; lateral flanges extending along entire length of egg case. Anterior border nearly straight, broad; anterior horns relatively short, curved strongly inwards. Posterior border much narrower, concave; posterior horns moderately long, curved strongly inwards, overlapping; tendrils long, tightly coiled. Uniformly pale yellowish in colour.

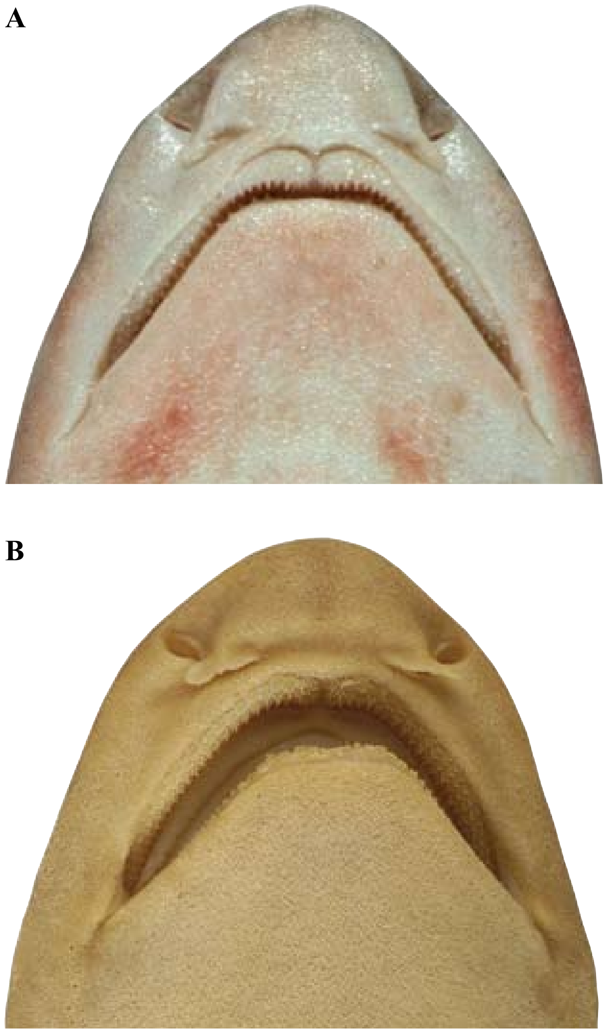

Figure 2. Ventral view of head of *Cephaloscyllium hiscosellum* sp. nov.: A. adult male holotype (CSIRO H 2590–07, 458 mm TL); B. female paratype (CSIRO CA 4484, female 336 mm TL).

COLOUR.— Preserved holotype: Dorsal and lateral surfaces light to medium brown, with a series of narrow, dark brown, pale-edged, open centred saddles. Head light to medium brown, with three, dark-brownish saddles; two dark bars originating on ventrolateral margin below eyes converging at level of lower margin of eye, weakly evident on eyelid; two closed saddles across interorbital and interspiracular regions, both posteriorly concave towards dorsal midline; third saddle above gill slits, open centred, diverging above 3rd gill slit. Predorsal body with 2 open-centred saddles; first saddle over pectoral-fin inner margin; second saddle midway between pectoral and pelvic fins, posterior dark bar of saddle near dorsal midline open-centred; right lateral side with a short, dark bar above pectoral fin base. Open-centred saddles over origins and insertions of both dorsal fins; saddle at dorsal caudal-fin origin. Caudal fin with three saddles above level of vertebral column; first saddle closed, slightly posterior to origin; second saddle closed at mid-dorsal caudal margin; third saddle open centred, slightly posterior to second dorsal; short, dark brown stripe at mid-caudal terminal margin; web of ventral lobe with 2 poorly-defined, dark brown bars. First dorsal fin similar in colour to body, with a dark V-shaped margin extending from mid-anterior margin to slightly posterior of apex. Second dorsal fin with a dark central, vertical bar joining open-centred saddle below insertion of fin. Pectoral and pelvic fins uniformly medium brown dorsally, margins slightly pale yellowish; yellowish brown ventrally; no dark markings. Anal fin uniformly pale yellowish. Ventral surface of body, portion of tail below lateral midline and claspers uniformly pale yellowish. **Preserved paratypes:** Colour pattern of paratypes similar to holotype overall, but with variations in number and positions of bars and saddles. Dorsal surface of head and body of paratype (CSIRO H 1342–01) with numerous poorly-defined, pale yellowish spots between saddles. Head of some paratypes with the first two saddles open centred. Pectoral fin dorsal surfaces of some paratypes with a dark brownish ring (sometimes reduced as a spot) or bar near its centre.

SIZE.— Material examined ranged from 256–520 mm TL for females and 135–463 mm TL for males. Males adolescent 356–391 mm TL, mature at 458–463 mm TL.

DISTRIBUTION.— Known from the upper continental slope of north-west Western Australia from west of Leander Point (29°15′ S, 113°56′ E) to south-west of Rowley Shoals (18°31′ S, 117°25′ E), at depths of 294–420 m.

ETYMOLOGY.— Derived from the combination of the Latin *hisco* (open) and *sella* (saddle) in allusion to the distinctive open-centred saddle-like markings which dominate the colour pattern of this species. Vernacular: Australian Reticulate Swellshark.

REMARKS.— *Cephaloscyllium hiscosellum* is clearly separable from other Australian species of *Cephaloscyllium* by its distinctive colour pattern. Unlike other Australian species, *C. hiscosellum* has a colour pattern dominated by dark brown lines forming a series of open saddle-like markings and narrow rings on the dorsal and lateral surfaces of the body and fins, and without spots. *Cephaloscyllium hiscosellum* attains a much smaller size than most other Australian species, i.e. 520 mm TL vs. >720 mm TL, with the exception of the similar-sized *C. zebrum* Last & White, 2008 (maximum size 445 mm TL) and the considerably smaller *C. cooki* Last, Séret & White, 2008 (maximum size 295 mm TL). *Cephaloscyllium hiscosellum* also has a lower number of vertebrae (total centra 100–108) than other Australian species (total centra 110–128), with the exception of *C. cooki* (total centra 103–106).

Figure 3. Egg case of *Cephaloscyllium hiscosellum* sp. nov. (not retained) containing late-term embryo.

Figure 4. *Cephaloscyllium fasciatum* female holotype BMNH 1965.8.11.1 (421 mm TL): A. dorsal view; B. lateral view. Photograph by P.R. Last.

Cephaloscyllium hiscosellum was previously considered to be conspecific with *C. fasciatum*, which was described by Chan (1966) off Vietnam and China. These two species are superficially very similar, but differ in meristics, colour and subtly in morphometrics. The new species differs from *C. fasciatum* in having a lower number of vertebrae (monospondylous centra 37–39 vs. 45; precaudal centra 69–75 vs. 77–78; total centra 100–108 vs. 118–120). The difference in monospondylous counts between these two species is notable, particularly when considering that intraspecific variation in monospondylous centra counts is typically very low (usually less than 3 centra) in members of this genus (see Last *et al*., 2008a, 2008b; Last & White, 2008).

The colour pattern also differs subtly between the two species. Larger specimens of *C. fasciatum* (Fig. 4) have dark spots on the dorsal and lateral surfaces as well as the dark brown lines forming open saddle-like markings, while all type specimens of *C. hiscosellum* lack such dark spots (as do juveniles of *C. fasciatum*). Both species possess two dark brown lines extending ventrally from the lower level of the eye to the lateral margin of head. However, *C. fasciatum* possesses dark brown lines (sometimes forming an incomplete ring) extending from anterior of eye forward to about level of nostrils, while all specimens examined of *C. hiscosellum* lack any lines or rings anterior of eyes (Figs 1 vs. 4). The types of *C. fasciatum* also possess a relatively dark ring in the centre of the dorsal surface of each pectoral fin which is lacking in *C. hiscosellum* (except in paratype CSIRO CA 4484 which possesses a small ring near the mid-base of each pectoral fin and paratype CSIRO H 822–07 which has several minute rings on the dorsal fins). The underside of the head and abdomen in *C. hiscosellum* is uniformly pale, compared to lightly spotted in *C. fasciatum*.

Cephaloscyllium hiscosellum was found to show relatively high levels of intraspecific variation in some measurements, e.g. pre-second dorsal length 62.7–68.2% TL, pre-first dorsal length 47.1–52.2% TL, snout-vent length 46.2–51.2% TL, pre-anal length 59.0–65.7% TL, pelvic–anal space 8.3–13.6% TL, pectoral-fin posterior margin 7.4–11.4% TL. This new species differs from *C. fasciatum* in having: a shorter mouth (mouth length 4.2–5.1 vs. 5.5–6.2% TL), slightly less depressed head and body (head height 8.9–13.1 vs. 7.7–8.5% TL; trunk height 9.4–15.1 vs. 7.4–8.8% TL), a taller pelvic fin (pelvic-fin height 4.5–5.6 vs. 2.9–3.6% TL), a slightly taller second dorsal fin (second dorsal-fin height 2.3–2.7 vs. 2.1–2.2% TL) and anal posterior margin 3.0–4.0 vs. 2.4–2.7% TL. Although the measurements in Table 1 also suggest that *C. hiscosellum* has a longer head and snout (head length 21.1–22.1 vs. 18.4–20.0% TL, prebranchial length 17.1–18.6 vs. 14.2–16.5% TL, preorbital length (horizontal) 6.0–6.5 vs. 5.5–5.7% TL), these differences are likely the result of different morphometric techniques. The measurements taken by Schaaf-Da Silva & Ebert (2008) were taken horizontally compared to taken directly in this study. This would have resulted in slightly longer measurements in the current study.

Comparative material.
Cephaloscyllium fasciatum. BMNH 1965.8.11.1 (holotype), female 421 mm TL, BMNH 1965.8.11.2 (paratype), juvenile male 246 mm TL, BMNH 1965.8.11.3 (paratype), juvenile male 236 mm TL, BMNH 1965.8.11.4 (paratype), juvenile male 232 mm TL; BMNH 1965.8.11.5 (paratype), juvenile female, 224 mm TL, off Cape Bantagan, Vietnam, 15°55.7′ N, 109°18.5′ E, 205–315 m, 16 Sep 1963; SU 34041, female 111 mm TL, Hainan, China Sea, China.

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Resurrection of the genus *Figaro* Whitley (Carcharhiniformes: Scyliorhinidae) with the description of a new species from northeastern Australia

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ABSTRACT.— The scyliorhinid genus-level taxon *Figaro* is resurrected based on a combination of characters, including: presence of dorsal caudal and preventral caudal crests of enlarged denticles; inner margins of pelvic fins united over the claspers of adult males to form a partial 'apron'; claspers of adult males tapering distally; anal fin terminating just behind level of origin of second dorsal fin; relatively short pectoral and caudal fins; elongate, well-defined caudal peduncle; pectoral–pelvic interspace long (exceeding anal-fin length in males, approximately equal to anal-fin length in females). *Figaro boardmani* Whitley is the type species of the genus, and a second, narrow-ranging species, *F. striatus* sp. nov., from northeastern Australia is described. The new species differs subtly from *F. boardmani* in a number of morphological characters and colour pattern, including the relative width of the characteristic saddles adorning its dorsal surface. *Figaro boardmani* is a widespread species with a distribution encompassing much of the southern Australian coastline. Regional variability exists in morphology and coloration of *F. boardmani* and a closer examination is required to gain a better understanding of variation within these forms. Australasian scyliorhinids require further study to characterise the relationships of species of *Galeus*, *Parmaturus* and *Figaro*.

Key words. Scyliorhinidae – *Figaro striatus* – *Figaro boardmani* – sawtail shark – new species – Australia.

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INTRODUCTION

The genus *Galeus* was proposed by Rafinesque (1810) with subsequent type designation of *G. melastomus* (Fowler, 1908). Although multiple species were described as *Galeus* by Rafinesque, *G. melastomus* was the only species for which a description was provided; the other three species, *Galeus vulpecula*, *G. mustelus* and *G. catulus*, although "identifiable" (Orkin, 1952), were mentioned in name only without references to characters. *Figaro*, a new subgenus of *Pristiurus* (= *Galeus*), was proposed by Whitley (1928) for a new Australian catshark (as *Pristiurus* (*Figaro*) *boardmani*), collected from near Montague Island (New South Wales) in 70–80 fathoms. The subgenus was based on the additional crest of enlarged denticles on the caudal peduncle and preventral caudal margin which is otherwise typically absent in *Galeus* (Compagno, 1984). The exception is *G. murinus* (Collett, 1904) which may belong in *Parmaturus*. Whitley (1939) later elevated *Figaro* to generic level, but Fowler (1936, 1941) and Bigelow & Schroeder (1948) have since placed it, and *Pristiurus*, in the synonymy of *Galeus*. Springer (1966) recognised *Figaro* without comment, but later (1979) placed it in synonymy with *Galeus*. Chu *et al*. (1983) resurrected *Figaro* for *Pristiurus boardmani*, *Dichichthys melanobranchius* Chan, 1966 (= *Parmaturus melanobranchius*) and *Figaro piceus* Chu, Meng & Liu, 1983 (= *Parmaturus melanobranchius*), defining the genus primarily by its preventral caudal denticle crest. Compagno (1984) and others have since considered *Figaro* to be a subgenus of *Galeus*.

Exploratory surveys of the continental slope of northeastern Australia in the mid 1980s revealed a large number of new and rare shark and ray species. Last & Stevens (1994) identified 3 *Galeus* species from Australian waters, of which two were thought to be undescribed: *G.* sp. A and *G.* sp. B. *Galeus* sp. A was described as *G. gracilis* by Compagno & Stevens (1993). *Galeus* sp. B *sensu* Last & Stevens, 1994) was superficially similar to *G. boardmani* but had a different colour pattern.

This paper revalidates and diagnoses the genus *Figaro*, providing a formal description of *Galeus* sp. B in *Figaro*, and comparing it with *Figaro boardmani*.

METHODS

Morphometric characters were selected to facilitate comparisons of the new *Figaro* species with the other Australian species. Our methods generally followed a widely adopted scheme for elasmobranchs (Compagno, 1984, 2001) with modifications as they appear in Compagno & Stevens (1993), but focused on direct rather than horizontal measurements. The posterior extent of the dorsal and ventral caudal-peduncle is defined as the anterior origin of the crest of enlarged denticles preceding the caudal fin origin and insertion respectively. The holotype (CSIRO H 1312–01) and 5 paratypes (CSIRO H 1310–01, CSIRO H 1310–02, CSIRO H 1311–01, CSIRO H 1312–02 and CSIRO H 1312–03) of the new species, and 6 specimens of *Figaro boardmani* (CSIRO CA 3200, CSIRO H 2692–04, CSIRO H 2692–05, CSIRO H 2692–06, CSIRO H 2692–07 and CSIRO H 3845–01) were measured in full (Table 1). A subset of characters was also measured for additional specimens to enable more detailed comparison between species. Meristics were taken from radiographs of the holotype and 6 paratypes (CSIRO H 1310–01, CSIRO H 1310–02, CSIRO H 1311–01, CSIRO H 1311–02, CSIRO H 1312–03 and CSIRO H 1312–05) of the new species and 10 specimens of *F. boardmani* (CSIRO CA 70, CSIRO CA 501, CSIRO CA 503, CSIRO CA 504, CSIRO CA 3200, CSIRO H 866–03, CSIRO H 866–04, CSIRO H 2692–06, CSIRO H 3684–03 and CSIRO H 3846–01). Meristics were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and caudal (centra of the caudal fin) vertebrae. In the description, morphometric and meristic values for the holotype are given first, followed in parentheses by the ranges of the measured paratypes. Teeth counts were taken *in situ* from two paratypes (CSIRO H 1310–01 and CSIRO H 1313–01) by excising the mouth corners to expose both jaws. Type specimens and comparative material are deposited in the Australian National Fish Collection, Hobart (CSIRO) and the Australian Museum, Sydney (AMS); their registration numbers are prefixed with these acronyms.

Figaro Whitley, 1928

Figaro (as a subgenus of *Pristiurus*) Whitley, 1928: 238 Type by original designation.

DEFINITION.— A firm-bodied scyliorhinid catshark with the following combination of characters: crest of enlarged denticles on anterior dorsal and ventral caudal-fin margins; inner margins of pelvic fins fused over claspers of adult males to form a partial 'apron'; free rear tip of pelvic fins of adult males distorted dorsoventrally to partially encompass the claspers; claspers having a progressive taper toward the tip; anal fin terminating just behind vertical axis at origin of the second dorsal fin; relatively short pectoral and caudal fins; a well defined caudal peduncle; and pectoral–pelvic space long (exceeding anal-fin length in males, approximately equal to anal-fin length in females).

REMARKS.— *Figaro boardmani* and the new species differ markedly from typical species of *Galeus* (Springer, 1979; Compagno, 1988), including the type species *Galeus melastomus* Rafinesque, in several morphological features. *Figaro* is closely aligned with *Asymbolus*, sharing several morphological characters, including: having the inner margins of pelvic fins united over the claspers to form an 'apron' (although less developed in *Figaro*); claspers having a progressive taper toward the tip; relatively short pectoral and caudal fins; and a long caudal peduncle, pectoral–pelvic interspace, and abdomen (Compagno, 1988), but differing in having both supracaudal and preventral caudal margin with enlarged denticles forming prominent crests (absent in *Asymbolus*). We resurrected *Figaro* to now include *F. boardmani* and a newly described species, *F. striatus*, within this genus based on the definition above. *Galeus* differs from *Figaro* in several morphological characters, including: inner margins of pelvic fins not fused (vs. fused) over claspers of adult males to form a partial 'apron' (Compagno 1988, Compagno & Stevens 1993); no prominent crest of enlarged denticles (vs. crest present) on the preventral caudal margin (except in *Galeus murinus*, discussed below); relatively larger pectoral, anal and caudal fins (Compagno 1984); claspers typically narrow centrally (rather than tapered), broadly expanded posteriorly (Compagno 1988); and anal fin almost confluent with caudal fin (vs. fins well separated with a long caudal peduncle). Species of *Parmaturus* also possess a preventral caudal crest of enlarged denticles, but are generally softer bodied, more or less uniform in colour (rather than strongly patterned), and have a velvety feeling when touched (Springer 1979). One species of *Galeus*, *G. murinus*, also possesses a preventral caudal crest of enlarged denticles and its current allocation needs further investigation. It remains the only *Galeus* species possessing this character state and may belong in *Parmaturus*. A review of the relationships of the Australasian scyliorhinids, particularly *Asymbolus*, *Galeus*, *Parmaturus* and *Figaro*, is required. Characters provided in the generic definition above list the main distinguishing features of the group. However, these are not exhaustive, and additional characters requiring a more thorough examination appear to further differentiate *Figaro* from other scyliorhinids.

Figaro striatus sp. nov.

Figs 1–3; Table 1

Galeus sp. B: Last & Stevens, 1994: pp 170, 200, key fig. 37, fig. 26.28, pl. 18; Compagno *et al*., 2005: pp 231, 232, pl. 38.

Holotype. CSIRO H 1312–01, adult male 421 mm TL, south of Saumarez Reef, Saumarez Plateau, Queensland, 22°42′ S, 154°05′ E, 416–419 m, 17 Nov 1985.

Paratypes. 10 specimens. CSIRO H 1310–01, adult male 398 mm TL, CSIRO H 1310–02, adult male 386 mm TL, south of Saumarez Reef, Queensland, 22°35′ S, 153°40′ E, 314–319 m, 16 Nov 1985; CSIRO H 1311–01, adult male 399 mm TL, CSIRO H 1311–02, adult male 381 mm TL, east of Whitsunday Group, Marian Plateau, Queensland, 19°29′ S, 150°17′ E, 324–328 m, 15 Nov 1985; CSIRO H 1312–02, female 330 mm TL, CSIRO H 1312–03, female 369 mm TL, CSIRO H 1312–04, female 313 mm TL, CSIRO H 1312–05, juvenile male 289 mm TL, collected with holotype; CSIRO H 1313–01, adult male 389 mm TL, CSIRO H 1313–02, adult male 381 mm TL, east of Hinchinbrook Island, Townsville Trough, Queensland, 18°37′ S, 148°05′ E, 300 m, 08 Dec 1985.

DIAGNOSIS.— A very small species of catshark with the following combination of characters: head narrowly parabolic in dorsoventral view, short 17.2–19.6% TL; eye small, length 3.4–3.9% TL, 1.73–2.03 in snout, located dorsolaterally; labial furrows well developed, extending well beyond corners of mouth, lower furrow slightly longer than upper; first dorsal fin slightly smaller than second dorsal fin; pelvic fins small, slender, length 8.8–11.3% TL; posterior portion strongly directed posterodorsally (forming a small lobe, partly enveloping proximo-lateral margin of clasper); inner margin strongly convex, forming a partial apron and connected to clasper dorsomedially near its base, soft tissue connecting insertions of pelvic fins weak, not forming a prominent apron overlying ventral surface of tail; anal-fin base much longer than second dorsal fin, base 9.9–10.9% TL, 2.4–6.0 times anal–caudal space; caudal peduncle long, anal–caudal space 1.6–4.2% TL; crest of enlarged denticles on anterior dorsal caudal-fin margin extending from about over origin of ventral caudal-fin lobe to almost mid-length of dorsal caudal-fin margin; crest of enlarged denticles originating at mid-point of caudal peduncle, extending to elevated part of ventral lobe; males mature at about 380 mm TL; colour of preserved material pale brown dorsally, with dark saddles and bars, lighter ventrally; about 4 larger saddles pre-dorsally; saddles present below and between dorsal fins and extending onto caudal, rarely larger than eye diameter; larger saddles pale edged, separated by narrower, less distinct bars; saddles rarely extending below the lateral midline; monospondylous vertebrae 35–38; precaudal 85–93; total 140–149.

DESCRIPTION.— Body very slender, tapering gradually behind first dorsal fin; abdomen not expanded; caudal peduncle elongate. Head moderately depressed, short and relatively narrow, length 17.8 (17.2–19.6)%, width 9.5 (8.7–10.8)% TL; widest just forward of 1st gill slit; narrowly parabolic in dorsoventral view; lateral angle of suborbital shelf relatively well defined (weakly defined in some paratypes); supraorbital crest absent; gill slits lateral; last slit over pectoral-fin base, 4th slit at level of pectoral-fin origin, slightly closer together than slits 1–3; first slit largest (subequal in smallest paratype CSIRO H 1312–05); slits becoming smaller posteriorly. Snout narrowly rounded (tip somewhat pointed in some paratypes), bluntly pointed in lateral view, length 2.56 (2.58–2.89) in head length. Eye very slightly dorsolateral, slit-like, length 2.03 (1.73–1.92) in snout; suborbital groove well-developed, becoming very shallow posteriorly, about equal to eye length; orbito-spiracular groove weak and shallow (sometimes indistinct); interorbital width 0.94 (1.04–1.12) of snout, 2.73 (2.45–2.79) in head length. Spiracle very small, suboval, separated from eye by about its length; slightly dorsolateral on head, length 8.2 (7.6–12.1) in interorbital width. Anterior nasal flap expanded laterally, overlapping outer lobe but not reaching mouth; posterior margin transverse, usually entire, straight to weakly concave; internarial width much smaller than nostril width.

Mouth long, angular, rounded (shorter and more broadly rounded in female paratypes), width 2.25 (2.37–2.92) times length; roof of mouth and tongue usually papillose; labial furrows well developed, lower furrow slightly longer than upper; postoral groove absent. Upper jaw teeth of adult male holotype small; central cusp and 2–4 (usually 3) lateral cusplets on either side, mesial edge usually with 2 short, acute cusplets, lateral edge with single cusplet; central cusp much longer than adjacent cusplets, elongate, pungent, recurved lingually, with prominent anterior ridges on their basal third; 1 to 2 very short teeth at symphysis, about half length of those adjacent, teeth beside symphysis only slightly larger than those laterally in jaw; no symphysial groove. Lower jaw teeth of adult male holotype mainly with central cusp and 4 cusplets; central cusp subequal in length to those of upper jaw teeth; lateral cusplets very short. Teeth in upper jaw of female paratype (CSIRO H 1312–03) with central cusp and 3–5 (mainly 5) lateral cusplets; two medial cusplets usually longer than those laterally; central cusp less well pronounced than in adult male; one very short symphysial tooth. Teeth in lower jaw of female paratype with a central cusp and 3–5 (mainly 4) lateral cusplets; similar in size to those of upper jaw; recurved at symphysis of lower jaw; central cusps at symphysis shorter than those on adjacent teeth.

Flank denticles of adult male very small, uniform in size, dense, strongly imbricate, unicuspidate or weakly tricuspidate, pedicels short; crowns suboval, not upright, with very long pungent central cusp; lateral cusps forming a weak angle or absent; median cusp with a

Figure 1. *Figaro striatus* sp. nov., holotype CSIRO H 1312–01 (adult male, 421 mm TL), preserved: A. lateral view; B. dorsal view.

Figure 2. Lateral view of *Figaro striatus* sp. nov., paratype CSIRO H 1311–02 (adult male 381 mm TL), fresh.

prominent longitudinal ridge; no obvious ridge laterally on crown. Flank denticles of adult female similar to male but with more prominent lateral cusps; lateral cusps short, variable, forming an obtuse angle to short and pointed. Holotype with a low crest of enlarged denticles along dorsal caudal-fin margin; crest consisting of a band of small median denticles bordered by greatly enlarged, posterolaterally directed spine-like denticles (their width subequal to length of normal flank denticles); spine-like denticles dense, regular in size and shape; crest extending from slightly forward (to above) origin of ventral caudal-fin lobe to about mid-length of dorsal caudal-fin margin; lateral denticles on posterior part of crest directed posteroventrally, merging with smaller denticles of caudal fin. A similar ventral crest originating at mid-point of caudal peduncle, extending to elevated part of ventral lobe of enlarged denticles at origin of caudal-fin ventral lobe; crest low, shorter than dorsal crest, with similar posterolaterally directed, spine-like denticles along its lateral margin.

First dorsal fin strongly raked, anterior margin nearly straight to weakly convex (recurved distally), apex narrowly rounded, posterior margin weakly concave and almost upright, free rear tip short and narrowly pointed (sometimes longer in paratypes), inner margin very short and straight; slightly smaller than second dorsal fin; origin at about level of pelvic-fin insertion (slightly more anterior in female and juvenile male paratypes), pre-first dorsal length 43.8 (41.5–42.7)% TL. Second dorsal similar in shape, slightly longer based than first dorsal fin, pre-second dorsal length 63.3 (62.0–63.9)% TL; anterior margin nearly straight to weakly convex, apex narrowly rounded, posterior margin moderately concave (weakly concave in some paratypes) and upright, free rear tip relatively short and pointed, inner margin short and straight; origin well anterior to anal-fin insertion, insertion posterior to anal-fin rear tip. Anal fin much longer based than second dorsal fin, anterior margin weakly convex to nearly straight, apex broadly angular, posterior margin weakly concave, free rear tip narrowly pointed, inner margin very short; anal-fin length 0.88 (0.96–1.25) times pelvic–anal space. Pectoral fin small, lobate, its anterior margin 9.3 (8.6–9.8)% TL; anterior margin weakly convex, apex rounded, posterior margin weakly concave to nearly straight (sometimes

Table 1. Morphometric data for the holotype of *Figaro striatus* sp. nov. (CSIRO H 1312–01), with ranges and means provided for the 5 measured paratypes, and ranges provided for *F. boardmani*. Measurements expressed as a percentage of total length.

	F. striatus **sp. nov.**				***F. boardmani***		
	Holotype	Paratypes			(n=6)		
		Min.	Max.	Mean	Min.	Max.	Mean
Total length (mm)	421	330	399		382	527	
Precaudal length	72.4	71.4	74.7	73.1	72.9	77.0	75.1
Pre-second dorsal length	63.3	62.0	63.9	63.0	63.1	65.9	64.3
Pre-first dorsal length	43.8	41.5	42.7	42.2	43.3	46.5	44.8
Head length	17.8	17.2	19.6	18.0	17.6	19.3	18.4
Pre-branchial length	14.1	13.1	14.7	13.6	12.7	14.6	14.0
Pre-spiracular length	10.2	9.5	10.6	9.9	10.0	11.4	10.7
Preorbital length (horizontal)	6.2	5.3	6.2	5.8	6.1	6.8	6.5
Preorbital length (direct)	6.9	6.4	6.8	6.6	6.2	7.0	6.7
Preoral length	5.4	5.6	6.4	6.1	3.5	6.2	5.6
Prenarial length	3.7	3.8	4.1	3.9	3.8	4.5	4.0
Pre-pectoral length	16.9	16.4	18.4	17.2	16.1	18.7	17.6
Pre-pelvic length	37.3	36.4	37.9	37.0	36.3	38.9	37.3
Pre-vent length	39.1	38.1	40.4	39.2	39.0	41.4	40.1
Pre-anal length	56.1	52.9	55.9	54.7	55.3	58.2	56.5
Interdorsal space	14.6	15.0	16.2	15.5	14.2	16.2	14.9
Dorsal–caudal space	3.8	3.0	4.9	3.9	3.0	5.9	4.7
Pectoral–pelvic space	15.5	14.6	16.4	15.6	13.5	16.6	15.8
Pelvic–anal space	12.8	10.0	12.8	11.6	11.3	13.4	12.6
Anal–caudal space	1.6	2.1	4.2	3.3	1.5	4.5	2.9
Eye length	3.4	3.5	3.9	3.7	3.4	4.2	3.9
Interorbital width	6.5	6.9	7.2	7.0	6.3	6.7	6.5
Nostril width	2.6	2.3	2.8	2.6	2.2	2.8	2.6
Internarial space	1.5	1.4	1.8	1.6	1.6	2.4	1.9
Anterior nasal flap length	1.2	1.0	1.2	1.1	0.9	1.2	1.1
Spiracle length	0.8	0.6	0.9	0.7	0.6	1.0	0.8
Eye–spiracle space	0.7	0.4	0.9	0.7	0.5	0.9	0.7
Mouth length	2.8	2.4	2.7	2.6	2.5	3.5	3.0
Mouth width	6.4	6.4	7.1	6.7	6.4	6.8	6.7
First gill slit height	1.6	1.3	1.8	1.5	1.4	1.8	1.6
Fifth gill slit height	1.0	0.7	1.2	1.0	1.0	1.4	1.2
Head height	7.7	6.4	7.7	7.1	7.2	8.7	8.0
Trunk height	8.6	7.6	8.7	8.0	7.9	10.5	8.8
Caudal peduncle height	3.6	3.1	3.8	3.4	3.4	3.9	3.6
Head width	9.5	8.7	10.8	9.9	9.4	10.8	10.0
Trunk width	8.9	7.2	9.0	8.1	7.8	9.8	8.7
Caudal peduncle width	2.9	2.6	3.0	2.8	2.1	3.0	2.5
Pectoral fin - length	9.2	8.5	10.5	9.4	9.2	10.4	9.6
Pectoral fin - anterior margin	9.3	8.6	9.8	9.4	9.4	10.8	9.9
Pectoral fin - base	4.8	5.0	5.6	5.3	4.9	5.3	5.1
Pectoral fin - height	7.7	6.2	7.5	7.0	6.1	8.4	7.2
Pectoral fin - inner margin	6.0	5.8	6.6	6.1	6.3	7.0	6.5
Pectoral fin - posterior margin	8.6	7.5	9.4	8.3	8.2	9.3	8.8

Table 1. cont'd.

	F. striatus sp. nov.				*F. boardmani*		
	Holotype	Paratypes			(n=6)		
		Min.	Max.	Mean	Min.	Max.	Mean
Pelvic fin - length	8.8	9.4	11.3	10.2	8.2	10.4	9.4
Pelvic fin - anterior margin	3.9	3.7	4.1	4.0	4.3	4.8	4.6
Pelvic fin - base length	6.1	6.4	7.8	7.0	6.1	7.1	6.5
Pelvic fin - height	2.7	2.2	3.1	2.5	3.1	3.7	3.4
Pelvic fin - inner margin	3.8	3.5	4.1	3.9	3.4	4.3	3.9
Pelvic fin - posterior margin	5.9	6.0	8.1	7.0	7.0	8.0	7.4
Clasper outer length	5.7	5.8	6.5	6.2	5.6	6.7	6.3
Clasper inner length	10.6	10.8	11.4	11.0	9.7	11.7	11.0
Clasper base width	1.5	1.4	1.5	1.4	1.2	1.5	1.4
First dorsal fin - length	7.0	7.2	8.0	7.6	7.4	7.9	7.5
First dorsal fin - anterior margin	7.1	7.2	7.5	7.4	7.3	8.0	7.6
First dorsal fin - base length	4.9	5.0	5.7	5.4	4.8	5.6	5.3
First dorsal fin - height	3.9	3.6	4.5	3.9	3.9	4.3	4.1
First dorsal fin - inner margin	2.0	1.8	2.3	2.0	1.9	2.5	2.2
First dorsal fin - posterior margin	3.4	3.4	4.3	3.8	3.7	4.5	4.1
Second dorsal fin - length	8.0	8.3	8.6	8.5	8.2	8.9	8.5
Second dorsal fin - anterior margin	7.8	7.8	8.6	8.0	8.0	8.6	8.4
Second dorsal fin - base length	6.0	6.2	6.4	6.3	5.9	6.3	6.1
Second dorsal fin - height	4.0	3.9	4.4	4.1	4.2	4.7	4.4
Second dorsal fin - inner margin	2.2	2.2	2.4	2.3	2.2	2.7	2.4
Second dorsal fin - posterior margin	3.8	3.7	4.4	4.2	4.4	5.1	4.8
Anal fin - length	11.3	11.6	12.5	12.1	11.3	12.6	12.0
Anal fin - anterior margin	7.3	5.5	7.2	6.2	6.9	7.5	7.2
Anal fin - base length	9.9	10.2	10.9	10.5	9.1	10.8	10.1
Anal fin - height	3.2	2.9	3.6	3.2	3.2	3.7	3.5
Anal fin - inner margin	1.5	1.4	1.8	1.6	1.7	1.9	1.9
Anal fin - posterior margin	6.1	6.2	7.7	7.3	6.1	7.8	6.9
Caudal fin - dorsal margin	25.2	26.3	28.4	27.1	23.7	27.1	25.2
Caudal fin - preventral margin	15.5	14.6	17.8	15.8	13.8	16.5	15.1
Caudal fin - lower postventral margin	2.6	2.4	4.0	3.2	2.3	3.4	2.9
Caudal fin - upper postventral margin	9.1	8.8	9.7	9.3	7.4	10.2	8.8
Caudal fin - subterminal margin	4.4	3.8	5.2	4.4	4.0	4.4	4.2
Caudal fin - terminal margin	4.3	4.1	4.9	4.4	4.5	5.2	4.8
Caudal fin - terminal lobe length	6.4	5.9	7.0	6.4	6.1	6.6	6.3
Second dorsal origin–anal origin	6.7	7.0	8.7	7.7	6.9	8.0	7.3
Second dorsal insertion–anal insertion	2.9	2.6	3.3	3.0	2.3	3.2	3.0

with undulations), free tip broadly rounded, inner margin convex. Pelvic fins small, slender, length 8.8 (9.4–11.3)% TL; anterior margin straight; apex broadly rounded; in adult males, posterior margin notched, straight to weakly convex anteriorly and centrally, posterior portion strongly directed posterodorsally (forming a small lobe, partly enveloping proximo-lateral margin of clasper); free rear tip usually angular; inner margin strongly convex, forming a partial apron and connected to clasper dorsomedially near its base, soft tissue connecting insertions of pelvic fins weak, not forming a prominent apron overlying ventral surface of tail. Pelvic fin in females with posterior margin, straight anteriorly with a weak posterior concavity; free rear tip narrowly pointed; inner margin elongate, straight to weakly convex. Claspers elongate, tapering, subrectangular in cross-

Figure 3. Ventral view of head of *Figaro striatus* sp. nov., holotype, CSIRO H 1312–01 (adult male 421 mm TL, preserved).

section, pointed distally, reaching to beyond first dorsal-fin free rear tip, ventral surface covered with denticles (tip usually naked). Caudal fin small, with weak but distinct ventral lobe; terminal lobe well developed, deep, double convex with a weak median indentation (variable in paratypes); subterminal notch shallow. Teeth (based on two paratypes) in upper jaw about 65; in lower jaw about 61–65. Monospondylous vertebrae 38 (35–38 in 6 paratypes); precaudal 93 (85–93); about total 148 (140–149).

COLOUR.— Preserved, based on holotype: Head and body pale yellowish brown with a series of distinct, darker saddles; saddles edged with narrow pale lines. Head pale yellowish brown dorsally, without distinct markings forward of spiracles; a broad, darker brown, pale-edged saddle originating at level of second gill slit, extending forward medially almost to level of spiracles on midline, evident over gill slits; some pale blotches posterior to spiracle, extending onto saddle. Trunk with 3 darker brown, pale-edged saddles, extending below lateral midline but not to ventral surface; first saddle situated above pectoral-fin inner margin, broadest medially; second saddle situated midway between paired fins, broadest medially; third saddle situated above anterior third of pelvic-fin base, narrower than first two saddles, less well-defined below lateral midline; indistinct dark bars between saddles, variably developed, not distinctly pale-edged. Subdorsal saddles pale-edged, below dorsal-fin bases, barely evident below lateral midline. Interdorsal region with 3 darker, pale-edged saddles, barely evident below lateral midline; first originating at first dorsal-fin free rear tip; second saddle much broader than other two interdorsal saddles, above anal-fin origin; third saddle similar to first, located over mid anal-fin base; weak darker bars present between saddles. Postdorsal tail and caudal fin with four dark saddles, diffuse edged, no pale margins, barely evident below lateral midline; first saddle originating at second dorsal-fin free rear tip, second saddle originating above ventral caudal-fin origin; third saddle less distinct, situated above caudal-fin ventral lobe; fourth saddle broad, situated at about mid length of dorsal caudal margin; two weak, somewhat indistinct darker bars, either side of first saddle. Dorsal fins dusky basally, paler distally and on posterior margin. Dorsal surfaces of paired fins mostly dusky, free rear tip somewhat paler. Ventral surface of head and body pale yellowish; paler tonal areas on head extending slightly onto lateral surface; pale tonal area extending up to lateral midline posterior of pelvic-fin origin; paired fins similar in colour basally, slightly darker on most of fin web, paler distally; anal fin and ventral caudal lobe similar in colour to ventral body; claspers pale yellowish. **When fresh:** (based on CSIRO H 1311–02) saddles dark brown, interspaces, lateral and ventral surfaces white to pale grey.

SIZE.— Material examined ranges from 313–369 mm TL for females and 289–421 mm TL for males. Males reach maturity at about 380 mm TL.

DISTRIBUTION.— Material examined was collected from the upper continental slope of Queensland, Australia, from off Townsville (18°37′ S, 148°05′ E) south to Saumarez Plateau (22°42′ S, 154°05′ E) at depths of

300–419 m. Last & Stevens (1994) recorded this species slightly further south off Rockhampton (ca. 23°24′ S).

ETYMOLOGY.— Derived from the Latin *striatus* (striped) in allusion to the striped colour patterning of this species. Vernacular: Northern Sawtail Shark.

REMARKS.— *Figaro striatus* differs markedly from its larger relative *F. boardmani*, which reaches about 610 mm TL, in colour pattern and in some morphometric characters. Differences between *F. striatus* and *F. boardmani* in morphometry are evident when comparing specimens of similar size (i.e. adults and large juveniles of *F. striatus*, of maximum size of 421 mm TL, with specimens of *F. boardmani* <425 mm TL), rather than only comparing the largest adults of each species. As the morphometrics of *F. boardmani* differ slightly between geographic localities (unpubl. data), we confined comparisons to material from nearby New South Wales (i.e. the type locality). *Figaro striatus* differs in having relatively smaller eyes (3.4–3.9, mean 3.6% TL (n=6) vs. 3.7–4.2, mean 3.9% TL (n=4) in specimens <425 mm TL, and 3.4–3.9, mean 3.7% TL in specimens >425 mm TL (n=2) in *F. boardmani*), shorter upper labial furrows (1.0–1.5, mean 1.3% TL vs. 1.6–2.5, mean 1.8% TL in specimens <425 mm TL, 1.4–1.5, mean 1.4% TL in specimens >425 mm TL), a relatively shorter pelvic-fin anterior margin (3.7–4.1, mean 4.0% TL vs. 4.5–4.8, mean 4.7% TL in specimens <425 mm TL, 4.3 % TL in specimens >425 mm TL), and possibly a slightly longer second dorsal-fin base (6.0–6.4, mean 6.3% TL vs. 5.9–6.2, mean 6.1% TL in specimens <425 mm TL, 6.0–6.3, mean 6.2% TL in specimens >425 mm TL). *Figaro striatus* also differs from *F. boardmani* in colour pattern, having narrower saddles, their width (longitudinal measurement) along the dorsal midline generally less than the eye length (vs. generally greater than the eye length), saddles rarely extending ventrally below the lateral midline (vs. often extending beyond the lateral midline), in having a narrower saddle on the head (width along dorsal midline 2.1–3.6, mean 2.8% TL (n=6) vs. 4.9–5.6, mean 5.3% TL (n=6)), a wider interspace between the cranial saddle and first trunk saddle (width at dorsal midline 6.4–8.9, mean 7.4% TL vs. 4.1–6.1, mean 5.6% TL), a narrower first trunk saddle (width at dorsal midline 2.3–3.4, mean 2.8% TL vs. 4.0–6.1, mean 4.9% TL), and a narrower saddle below the first dorsal fin (width at dorsal-fin base 4.4–5.2, mean 4.8% TL vs. 5.3–7.0, mean 6.0% TL).

Figaro boardmani as it is currently recognised, ranges from Noosa, Queensland, along the southern Australian coast, including Tasmania, to Carnarvon, Western Australia. Material examined during this study from outside New South Wales exhibited minor geographically based intraspecific variation. Regional variability was reported by Whitley (1939) who noted that specimens of *F. boardmani* collected from the Great Australian Bight had fainter dorsal saddles and recognised this form as a subspecies. Further examination of *F. boardmani* is required to gain an understanding of the intraspecific or interspecific variability within these forms.

Additional exploration is required of the poorly studied deeper waters of northeastern Australia to document the biodiversity of the continental slopes and numerous submarine plateaus of the region. Such an exercise would complement recent inshore surveys in the Great Barrier Reef and would fill gaps in our knowledge of the fauna from this biogeographically important region. Additional specimens and tissue samples are needed of the genera *Asymbolus*, *Figaro*, *Galeus* and *Parmaturus* to assist in determining their interrelationships.

Comparative material.
Figaro boardmani. New South Wales (20 specimens): AMS I 31163–008 (3 specimens), females 361–380 mm TL; CSIRO CA 70, female 521 mm TL; CSIRO CA 82, female 278 mm TL; CSIRO CA 501, juvenile male 470 mm TL; CSIRO CA 503, adult male 539 mm TL; CSIRO CA 504, female 536 mm TL; CSIRO CA 3200, adult male 464 mm TL; CSIRO H 866–03, female 514 mm TL; CSIRO H 866–04, adult male 514 mm TL; CSIRO H 2692–04, adult male 414 mm TL; CSIRO H 2692–05, adult male 396 mm TL; CSIRO H 2692–06, adult male 382 mm TL; CSIRO H 2692–07 adult male 404 mm TL; CSIRO H 3684–02, adult male 526 mm TL; CSIRO H 3684–03, female 551 mm TL; CSIRO H 3845–01, female 527 mm TL; CSIRO H 3846–01, female 522 mm TL; CSIRO H 3847–01, adult male 466 mm TL.

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Description of two new species of gummy sharks, genus *Mustelus* (Carcharhiniformes: Triakidae), from Australian waters

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ABSTRACT.— Two new species of the genus *Mustelus* Linck, 1790 (Carcharhiniformes: Triakidae) are described from Australia. These species belong to a large subgroup of *Mustelus* species which have an upper jaw skeleton consisting of undivided palatoquadrates and upper labial furrows much longer than lower furrows. *Mustelus stevensi* sp. nov. and *Mustelus walkeri* sp. nov. are described based on material collected from the outer continental shelf and upper slopes off northwestern and northeastern Australia, respectively. They are similar morphologically to each other and to *M. antarcticus* from southern Australia but can be separated based on a combination of morphological and meristic characters, size, colour, and distribution of buccopharyngeal denticles on the floor and palate of the mouth.

Key words. Triakidae – *Mustelus stevensi* – *Mustelus walkeri* – new species – gummy sharks – Australia

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INTRODUCTION

The genus *Mustelus* was proposed by Linck, 1790 for *Squalus mustelus* Linnaeus, 1758, and consists of 26 described species (Eschmeyer, 2008). Some members of this genus are an important food resource in a number of countries, for example, *M. antarcticus* Günther, 1870 in southern Australia and *M. manazo* Bleeker, 1854 in Japan and Taiwan (Last & Stevens, 1994; Compagno *et al*., 2005a). *Mustelus* is one of the largest genera of sharks, but is also one of the most systematically troublesome groups (Compagno, 1988). Last & Stevens (1994) identified 3 species of *Mustelus* from Australian seas, *M. antarcticus*, *M*. sp. A and *M*. sp. B, and provided evidence of meristic differences between forms of *M*. sp. B from northeastern and northwestern Australia. *Mustelus* sp. A has since been described as *M. ravidus* White & Last, 2006, and belongs to a small subgroup of *Mustelus* which are characterised by having an upper jaw skeleton with each palatoquadrate subdivided near its symphysis, resulting in a short medial segment on each side (White & Last, 2006). In contrast, *M. antarcticus* (southern Australia) and *M*. sp. B (northeastern and northwestern Australia) belong to a larger subgroup which have undivided palatoquadrates and include the morphologically similar Indo–West Pacific species *M. lenticulatus* Phillipps, 1932 and *M. manazo*.

Gardner & Ward (2002) examined the taxonomic affinities of Australian and New Zealand *Mustelus* species using mainly a molecular approach, and concluded that the northeastern specimens of *M*. sp. B are referable to *M. antarcticus* and the northwestern specimens are probably a another species. More recent comparisons of specimens of *M*. sp. B from northeastern and northwestern Australia provided strong evidence that these two populations refer to separate taxa, and are also distinct from *M. antarcticus*. This conclusion is also supported in the results of an extensive tagging program on *M. antarcticus* (Walker, 2007) which provided evidence that populations of this species extend north to Jervis Bay (New South Wales) but not into Queensland waters. There is an important fishery for *M. antarcticus* in southern Australia and although stocks have reduced markedly, they are currently considered to be harvested at a sustainable level (Pribac *et al*., 2005). However, it is critical that the extent of the distribution of this important commercial species is properly understood.

This paper provides a formal description of both the northwestern and northeastern Australian forms of *M*. sp. B, and provides detailed comparisons of these two new species with *M. antarcticus*.

METHODS

Morphometric characters were selected to enable morphological and meristic comparisons with other similar *Mustelus* species. The holotype (CSIRO H 1035–

13) and 5 paratypes (CSIRO CA 3371, CSIRO H 4031–93, CSIRO H 4631–02, CSIRO H 4649–02 and CSIRO H 4650–01) of *M. stevensi* and the holotype (CSIRO H 460–02) and 5 paratypes (CSIRO H 459–02, CSIRO H 2469–01, CSIRO H 2471–01, CSIRO H 2471–02 and CSIRO H 3643–20) of *M. walkeri* were measured in full (Table 1). In the description, morphometric and meristic values for the holotype are given first followed in parentheses by the ranges of the paratypes. The measurements used follow the FAO system of Compagno (1984, 2001). The angle of the ventral caudal lobe was also determined as described in Heemstra (1997). The distribution of buccopharyngeal denticles on the palate and floor of the mouth was also recorded for both species because this pattern was shown by Heemstra (1997) to exhibit little intraspecific variation and be diagnostic for members of this genus. Meristics were taken from radiographs of the holotype and 9 of the 14 paratypes of *M. stevensi*, and of the holotype and all paratypes of *M. walkeri*. Vertebral counts were obtained separately for trunk (monospondylous centra), precaudal (monospondylous + diplospondylous centra to origin of upper lobe of the caudal fin) and caudal (centra of the caudal fin) regions. Morphology of the palatine processes of the palatoquadrate was also obtained from some of the radiographs. Tooth row counts were taken *in situ* from the dissected mouth of one paratype of each species (CSIRO H 3599–03 and CSIRO H 2469–02).

Type specimens are deposited in the ichthyological collections of the Australian National Fish Collection, Hobart (CSIRO) and the Queensland Museum (QM); their registration numbers are prefixed with these acronyms.

Mustelus stevensi sp. nov.

Figs 1, 2, 5a; Table 1

Mustelus sp. B (in part - western form): Last & Stevens, 1994: pp 206, 214, 215, key fig. 16, fig. 27.8, pl. 28; Compagno *et al.*, 2005a: 277, 278, pl. 46; Compagno & Niem, 1998: pp 1300, 1301, fig. 14.

Mustelus manazo: Gloerfelt-Tarp & Kailola, 1984: p 13.

Holotype. CSIRO H 1035–13, adult male 611 mm TL, north of Dampier Archipelago, Western Australia, 19°08′ S 116°54′ E, 196–198 m, 24 Oct 1986.

Paratypes. 14 specimens: CSIRO CA 3317, adult male 603 mm TL, south-west of Rowley Shoals, Western Australia, 18°55′ S 117°00′ E, 300–306 m, 13 Apr 1982; CSIRO CA 3369, adult male 582 mm TL, CSIRO CA 3370, female 762 mm TL, south-west of Rowley Shoals, Western Australia, 19°09′ S 116°54′ E, 180–190 m, 01 Oct 1982; CSIRO CA 3371, female 1034 mm TL, north of Dampier Archipelago, Western Australia, 19°25′ S 116°40′ E, 121–124 m, 22 Nov 1982; CSIRO H 822–14, adult male 705 mm TL, south-west of Shark Bay, Western Australia, 27°03′ S 112°40′ E, 402 m, 27 Oct 1986; CSIRO H 1370–01, female 518 mm TL, north-west of Monte Bello Islands, Western Australia, 20°06′ S 115°02′ E, 176–180 m, 12 Oct 1986; CSIRO H 2356–02, adult male 718 mm TL, south-west of Shark Bay, Western Australia, 26°44′ S 112°19′ E, 735 m, 28 Dec 1989; CSIRO H 3599–02, adult male 689 mm TL, CSIRO H 3599–03, adult male 686 mm TL, south-west of Shark Bay, Western Australia, 27°03′ S 112°43′ E, 303–333 m, 03 Feb 1991; CSIRO H 4031–93, adult male 919 mm TL, north of Cape Lambert, Western Australia, 18°57′ S 117°14′ E, 248–253 m, 30 Aug 1995; CSIRO H 4074–15, juvenile male 278 mm TL, north of Cape Lambert, Western Australia, 18°53′ S 117°27′ E, 206–208 m, 30 Aug 1995; CSIRO H 4631–02, adult male 692 mm TL, north of Dampier Archipelago, Western Australia, 19°11′ S 116°35′ E, 196–200 m, 11 Aug 1997; CSIRO H 4649–02, adult male 617 mm TL, north of Nickol Bay, Western Australia, 19°06′ S 117°01′ E, 187–196 m, 09 Aug 1997; CSIRO H 4650–01, female 711 mm TL, west of Monte Bello Islands, Western Australia, 20°24′ S 114°53′ E, 163–175 m, 13 Aug 1997.

Other material. 14 specimens: CSIRO CA 4069, juvenile male 291 mm TL, south-west of Rowley Shoals, Western Australia, 18°52′ S 117°10′ E, 296–300 m, 17 Aug 1983; CSIRO CA 4475, juvenile male 247 mm TL, north-west of Dampier Archipelago, Western Australia, 19°05′ S 116°10′ E, 294–296 m, 30 Jan 1984; CSIRO CA 4479, juvenile male 271 mm TL, north-east of Monte Bello Islands, Western Australia, 19°21′ S 115°42′ E, 306–308 m, 29 Jan 1984; CSIRO H 822–01, head only, south-west of Shark Bay, Western Australia, 27°03′ S 112°40′ E, 402 m, 27 Oct 1986; CSIRO H 1035–19, juvenile male 440 mm TL, CSIRO H 1035–20, adult male 618 mm TL, collected with holotype; CSIRO H 1505–07, adolescent male 522 mm TL, north of Nickol Bay, Western Australia, 19°07′ S 117°04′ E, 177–184 m, 05 Oct 1988; CSIRO H 3599–01, adult male 582 mm TL, south-west of Shark Bay, Western Australia, 27°03′ S 112°43′ E, 303–333 m, 03 Feb 1991; CSIRO H 4074–16, adult male 624 mm TL, north of Cape Lambert, Western Australia, 18°53′ S 117°27′ E, 206–208 m, 30 Aug 1995; CSIRO H 4649–06, adult male 583 mm TL, CSIRO H 4649–07, adult male 647 mm TL, CSIRO H 4649–08, adult male 593 mm TL, CSIRO H 4649–09, juvenile male 328 mm TL, north of Nickol Bay, Western Australia, 19°06′ S 117°01′ E, 187–196 m, 09 Aug 1997; CSIRO H 6571–03, adult male 770 mm TL, north-west of Cape Leveque, Western Australia, 14°59′ S 121°39′ E, 205–211 m, 26 Jun 2007.

DIAGNOSIS.— A relatively large *Mustelus* with the following combination of characters: dorsal fins moderately tall, posterior margin mostly upright distally, first dorsal-fin base length 1.6–2.1 times anal–caudal space; buccopharyngeal denticles covering entire palate and floor of mouth; claspers of adult males long, slender, strongly depressed, inner length about 8–11% TL, reaching to level of second dorsal-fin origin; lower edge of spiracle usually level with lower edge of eye; anal-fin insertion slightly anterior to its apex; teeth in about 72/75 rows; precaudal vertebral centra 76–80,

Figure 1. *Mustelus stevensi* sp. nov., holotype (CSIRO H 1035–13, adult male, 611 mm TL): A. lateral view (fresh); B. ventral head view (preserved).

monospondylous centra 33–35; light yellowish grey dorsally with numerous small, diffuse-edged white spots arranged in staggered, irregular rows on postspiracular head and body; light and dark tonal coloration not well demarcated; dorsal fins of juveniles (<400 mm TL) with bases and inner lobe whitish and strongly contrasted to distal part of fin; caudal fin of juveniles not distinctly white-edged.

DESCRIPTION.— Body elongate and slender (less so in most paratypes), trunk weakly compressed, subtriangular in cross-section at first dorsal-fin base; length of trunk from fifth gill slits to vent 1.27 in holotype (1.14–1.45 in paratypes) times head length; second dorsal-fin origin to anal-fin origin 2.25 (2.25–2.86) in second dorsal-fin origin to pelvic-fin midpoint; anal–caudal space 9.46 (8.37–9.96) in preanal length; predorsal ridge weak, extending forward to about in line with posterior gill slits; interdorsal ridge low (better defined than predorsal ridge), present before second dorsal-fin origin; postdorsal ridge low (similar to interdorsal ridge); lateral line forming a weak ridge, indistinct anteriorly, extending from over gill slits to beneath second dorsal fin. Caudal peduncle slender, cylindrically-tapering, without lateral keels; height 1.39 (1.05–1.23) in width at upper caudal-fin origin, 4.64 (4.32–5.15) in dorsal–caudal space. Precaudal pits absent.

Head short, length 0.85 (0.77–0.99) in pectoral–pelvic space; narrow (broader on most paratypes), moderately depressed, roughly trapezoidal in cross-section at eyes; outline of prespiracular head in lateral view convex over eye, concave on midsnout, elevated and straight or convex over gills; post-oral head almost straight; parabolic in dorsoventral view; preoral snout moderate, 1.46 (1.23–1.37) in mouth width. Snout bluntly pointed in lateral view, convex below, concave above; tip narrowly rounded in dorsoventral view, without shallow indentations anterior to nostrils. Eyes large and elongate-oval in shape, eye length 6.19 (6.20–7.86) in head length; slightly dorsolateral on head; lower edges slightly medial to lateral margin of head in dorsal view; fleshy subocular ridges strong; external opening with prominent posterior notch, no anterior notch; nictitating lower eyelids external; subocular pouches deep, entirely scaled with secondary lower eyelids. Spiracles small, oblique, slit-like or oval, their length only slightly less than eye to spiracle space, lower edge level or just above lower edge of eye. Third and fourth gill slits tallest, fifth shortest; first gill slit much taller than fifth, height of fifth 0.77 (0.74–0.91) height of first; height of first 10.17 (7.91–12.40) in head length, 0.61 (0.54–0.99) of eye length. Anterior margin of gill slits undulate or slightly convex; top of fifth gill slit more dorsolateral than top of first; upper margin of gill slits slightly above lower edges of eyes; gill filaments not visible externally. Nostrils with large oval

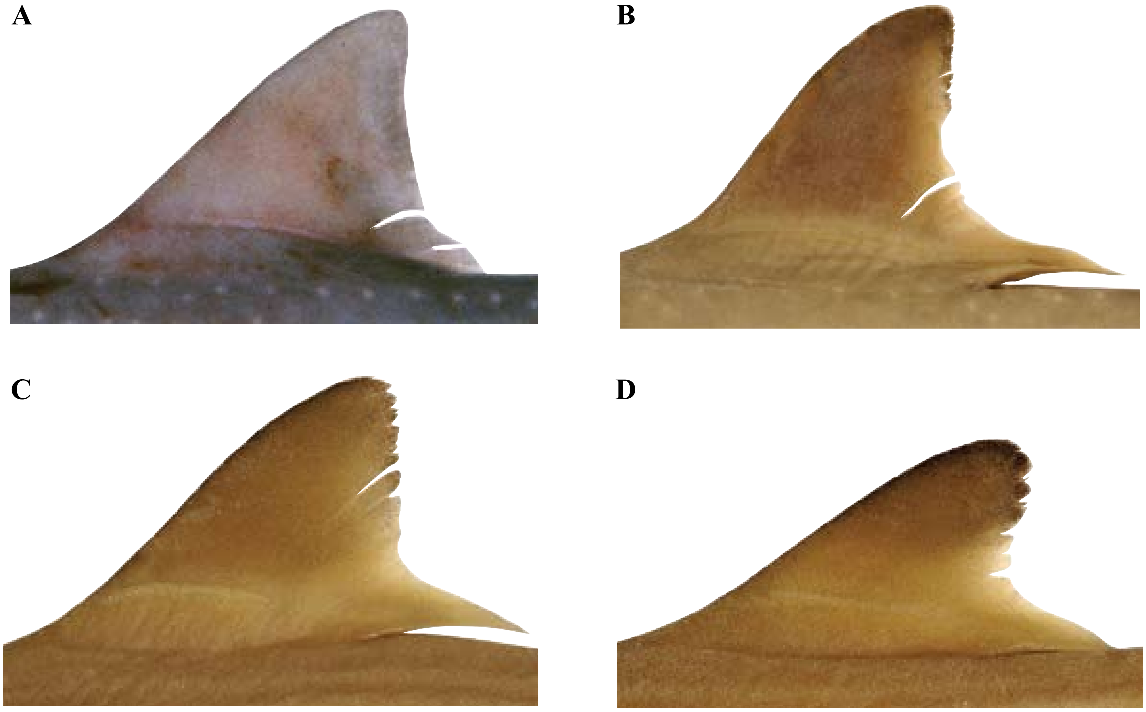

Figure 2. First (A, C) and second (B, D) dorsal fins of *Mustelus stevensi* sp. nov.: A. (fresh), B. (preserved) holotype, CSIRO H 1035–13 (adult male, 611 mm TL); C., D. juvenile paratype, CSIRO H 4074–15 (male 278 mm TL).

to crescentic incurrent apertures, lacking posterolateral keels; well in front of mouth; width 1.75 (1.43–1.68) in internarial space, 1.83 (1.47–1.72) in eye length, 1.11 (0.83–1.47) in first gill slit height; excurrent apertures small, suboval; anterior nasal flaps with broadly rounded apices, prominent mesonarial flaps, small posterior nasal flaps; anterior nasal aperture bluntly angular anteriorly, forming a mostly sharp depression.

Mouth very strongly arched; width 4.24 (3.84–3.88) in head length; length 1.81 (1.95–2.23) in width; tongue large, almost flat, narrowly rounded apically, filling floor of mouth; buccal papillae absent, buccopharyngeal denticles covering entire palate and floor of mouth; labial furrows elongate; upper furrows longer than lower furrows, length 1.67 (1.27–1.60) times length of lower furrows, 0.94 (0.85–1.00) in nostril length; anterior tip of uppers slightly forward of mid-eye, extending well forward of corners of mouth; palatine processes of the palatoquadrates not subdivided at symphysis, no separate medial segment on each side. Teeth relatively symmetrical between jaws, quincuncial, with a low, lingual cusp (slightly more pronounced near symphysis than near corner of mouth), no cusplets; no apparent sexual heterodonty or difference between jaws; no notch or toothless space at symphysis; exposed evenly around centre of lower jaw when mouth closed, tooth bands not visible from margin of lower jaw towards corners; in 72/75 rows (one adult male paratype, CSIRO H 3599–03); formula is 36 + 36 in upper jaw, 38 + 37 in lower jaw.

Lateral trunk denticles below first dorsal fin very small and densely imbricated, variable in size and shape; crowns broadly oval, weakly pointed distally, apices bluntly angular to narrowly rounded, with a weak anterior ridge, surface flat posteriorly; crown length subequal or only slightly longer than its width. Narrow naked areas at insertions of pectoral and pelvic fins.

First dorsal fin tall and subfalcate (subtriangular in large paratypes); anterior margin weakly convex; apex narrowly pointed; posterior margin concave, upright distally, strongly concave near junction with inner lobe, directed posteroventrally from top to bottom; free rear tip acutely pointed; inner margin strongly concave; origin slightly posterior to insertion of pectoral fins; free rear tip slightly anterior to pelvic-fin origins (well anterior in some paratypes); insertion below fin apex (well behind in most paratypes); first dorsal-fin base 1.77 (1.48–1.87) in interdorsal space, 1.52 (1.28–1.65) in dorsal caudal-fin margin; fin height 1.43 (1.25–1.58) in base length; inner margin 2.07 (2.25–2.34) in height, 2.96 (2.92–3.60) in base length. Second dorsal fin moderately tall and upright, apically narrow and weakly falcate; smaller than first dorsal fin, height 0.74 (0.62–0.75) of first dorsal-fin height, base length 0.81 (0.73–0.88) of first dorsal-fin base length; anterior margin slightly convex; apex narrowly rounded (much broader in some paratypes); posterior margin deeply concave, directed slightly dorsoposteriorly from bottom to top (more upright in large paratypes); free rear tip acutely pointed, terminating well anterior to anal-fin free rear tip and well in front of upper caudal-fin origin; inner margin straight or slightly concave; origin separated from pelvic-fin insertions by a space about 2.27 (1.75–2.70) times pelvic-fin base; insertion slightly posterior to fin apex; second dorsal-fin base length 1.06 (0.91–1.09) in dorsal–caudal space; fin height 1.57 (1.59–1.84) in base length; inner margin 2.17 (1.99–2.37) in height, 3.40 (3.29–4.00) in base length.

Anal fin low, apically narrow, weakly falcate, much smaller than second dorsal fin; height 0.49 (0.53–0.59) in second dorsal-fin height, base length 0.68 (0.66–0.73) times second dorsal-fin base length; anterior margin weakly convex; apex narrowly rounded; posterior margin deeply notched, slanting posteroventrally from base; free rear tip narrow, acutely pointed, well in front of lower caudal-fin origin; inner margin nearly straight; origin well behind second dorsal-fin origin, by 0.57 (0.45–0.50) of second dorsal-fin base; insertion slightly anterior to fin apex, well behind second dorsal-fin insertion; anal-fin base length 1.01 (0.89–1.10) in anal–caudal space; fin height 2.19 (1.99–2.27) in base length; inner margin 1.20 (1.35–1.50) in height, 2.63 (2.68–3.22) in base length; preanal ridges low, sometimes indistinct.

Pectoral fins not falcate; slightly larger in area than first dorsal fin; anterior margin broadly convex, 1.39 (1.10–1.31) times posterior margin; base narrow; apex narrowly rounded, above free rear tip when fin is elevated and adpressed to body (slightly behind in some paratypes); posterior margin moderately concave; free rear tips broadly angular; inner margins strongly convex; origin under fourth gill slit. Pelvic fins narrowly subtriangular; area much greater than anal-fin area; anterior margin straight to slightly convex, 0.52 (0.51–0.55) pectoral-fin anterior margin; apex angular; posterior margin broadly concave; free rear tip pointed (more so in some paratypes); inner margins nearly straight or weakly concave. Claspers of adult males strongly depressed, very long, slender, nearly straight for most of outer margin length and strongly tapering to tip; extending well behind pelvic-fin free rear tips, to mostly below origin of second dorsal fin; glans moderately short, length more than one third of clasper outer margin; covered laterally and ventrally with small denticles, mostly naked dorsally.

Caudal fin asymmetrical, upper lobe narrow; terminal lobe enlarged, ventral lobe prominent; dorsal caudal margin moderately long, 4.31 (3.91–4.41) in precaudal length, weakly double convex, mesially concave, without lateral undulations; preventral margin moderately convex, 2.70 (2.54–2.81) in dorsal caudal margin, apex narrowly rounded; lower postventral margin short, nearly straight; upper postventral margin weakly convex, notch between these forming angle of 120 (102–118°); subterminal notch narrow, short; subterminal margin almost straight, terminal margin moderately concave (variable in paratypes from concave to almost straight), lobe formed by these margins bluntly angular; subterminal margin 1.52 (1.69–1.96) in terminal margin; tip of caudal fin bluntly pointed, terminal lobe length 2.40 (2.14–2.37) in dorsal caudal margin.

Total vertebral centra 123 (120–128), precaudal centra 77 (76–80), monospondylous precaudal centra 34 (33–35), diplospondylous precaudal centra 43 (41–45).

COLOUR.— Preserved specimens: Light yellowish grey above, slightly paler below; covered in small, regular sized, diffuse-edge white spots; darker areas above merging gradually with pale area below on sides of body; interface not more pronounced on head. Spots largely absent from prespiracular head and below midline of trunk, in 2–3 staggered, horizontal rows along trunk from about level of pectoral-fin base to second dorsal fin (mainly just below base of first dorsal fin and along lateral line); no spots on fins; about 1–2 mm in diameter on average in specimens <700 mm TL, up to 3.0 mm in diameter in largest adults. First dorsal fin medium greyish brown, posterior margin with narrow dusky or blackish markings distally, basal half of margin pale; second dorsal fin similar, dusky or blackish marking extending more anteriorly onto distal third of fin tip, paler basal edge thin; caudal fin almost uniformly greyish, dusky near apex of fin, margin of terminal lobe almost white, not usually sharply demarcated from area adjacent; anal fin uniformly pale grey, without dark markings; pectoral fins uniformly yellowish grey, part of fin above and below radials slightly darker greyish brown; pelvic fins uniformly pale yellowish (sometimes central part of fin darker greyish brown). Ventral surface uniformly yellowish white, claspers uniformly pale yellowish or white. Juvenile male paratype CSIRO H 4074–15 (278 mm TL) without spots; proximal anterior margin of first dorsal fin narrowly black-edged, not becoming broader near apex, distal posterior margin more broadly black-edged, junction with inner lobe white-edged, inner lobe and fin base white and strongly contrasted with distal part of fin; second dorsal fin similar to first, black edge along posterior margin confined to its distal half but central distal part of fin dusky, inner lobe and fin base white and strongly contrasted with distal part of fin; caudal fin almost uniformly coloured with weak dusky blotch on outer central third of fin, posterior margins not distinctly white-edged.

SIZE.— Material examined ranged from 518–1034 mm TL for females and 247–919 mm TL for males; mature males 582–919 mm TL, adolescent male 522 mm TL.

DISTRIBUTION.— Known from the continental shelf and upper slope of northwestern Australia from south-west of Shark Bay (27°03′ S, 112°40′ E) to north-west of Cape Leveque (14°59′ S, 121°39′ E), at depths of 121–402 m (one specimen collected from 735 m).

ETYMOLOGY.— The epithet acknowledges the pioneering efforts of Dr John Stevens (CSIRO) who has dedicated a lifetime to researching sharks around the world, and who has contributed greatly to our knowledge of sharks and rays in Australia. Vernacular: Western Spotted Gummy Shark.

REMARKS.— Compagno (1984, 1988) noted that members of the genus *Mustelus* are unusually difficult to separate from one another because morphological and meristic characters used to distinguish species typically overlap and some characters can vary greatly intraspecifically. On a molecular level, *Mustelus* species are also very conservative with very few interspecific differences in comparison to other sharks and rays (see e.g. Ward *et al.*, 2008). *Mustelus stevensi* belongs to a subgroup of white-spotted Indo–Pacific species which includes *M. antarcticus* from southern Australia, *M. lenticulatus* from New Zealand and *M. manazo* from Japan and Taiwan.

Mustelus stevensi is clearly separable from *M. lenticulatus* of similar size, differing in the following characters: fewer vertebrae (33–35 vs. 38–39 monospondylous centra, 76–80 vs. 93–97 precaudal centra, 120–128 vs. 141–145 total centra), first dorsal fin slightly further forward (pre-first dorsal length 25.5–26.3 vs. 27.6–27.9% TL), dorsal fins well separated (interdorsal space 21.3–23.3 vs. 18.4–19.0% TL), shorter pectoral-fin inner margins (length 7.0–7.3 vs. 8.1–8.6% TL), a smaller caudal fin (preventral margin 8.4–8.9 vs. 9.4–9.7% TL, caudal fork width 4.9–5.2 vs. 6.4–6.7% TL, caudal fork length 7.4–8.1 vs. 9.3–10.2% TL), and dorsal and lateral surfaces yellowish grey with very small, weakly differentiated white spots (vs. greyish with small, strongly differentiated white spots in *M. lenticulatus*).

Mustelus stevensi is morphologically very similar to *M. manazo*, but differs in the following characters: dorsal and lateral surfaces yellowish grey with very small, weakly differentiated white spots (vs. greyish with medium-small, strongly differentiated white spots), tail slightly broader (tail width 5.6–7.0 vs. 5.2–5.5% TL), slightly shorter pectoral-fin inner margin (7.0–7.3 vs. 7.5–8.2% TL), and nostrils slightly further apart (internarial space 2.8–3.2 vs. 2.4–2.7% TL, 2.19–2.55 vs. 2.84–3.21 in pectoral-fin inner margin). Recent DNA barcoding results showed that while there were few interspecific differences between specimens of *M. antarcticus*, *M. lenticulatus* and *M. stevensi*, specimens of *M. manazo* formed a distinct clade from these species (B. Ward, CSIRO, unpubl. data).

Mustelus stevensi is clearly separable from *M. antarcticus* and differs in the following characters: buccopharyngeal denticles covering entire floor and palate of mouth (vs. denticles restricted to the anterior third to half of the floor and palate), a slightly narrower caudal-fin upper lobe (caudal fork width 4.9–5.2 vs. 5.2–6.0% TL), first dorsal fin slightly larger and more strongly raked (anterior margin 13.0–15.0 [mean 14.1] vs. 12.3–13.4 [mean 12.7]% TL, height 8.5–10.1 vs. 7.2–8.5% TL), anal fin shorter (length 9.0–9.9 vs. 10.3–10.8% TL, base 6.9–7.6 vs. 8.0–8.5% TL), caudal peduncle slightly lower (height 2.2–2.4 vs. 2.6–2.7% TL, 3.6–4.6 vs. 2.8–3.3 in first dorsal-fin height), smaller size (maximum size 103 vs. 185 cm TL, males mature at 61 vs. 93–97 cm TL), dorsal and lateral surfaces yellowish grey with white spotting (vs. slightly darker greyish with white spotting) and snout narrowly rounded (vs. more broadly rounded). *Mustelus stevensi* also typically occurs in much deeper waters than *M. antarcticus* (>120 vs. usually <80 m depth).

Some notable sexual dimorphism was evident in the measured specimens of *M. stevensi*, with females having more posteriorly located pelvic fins than adult males (prepelvic length 46.6–46.8 vs. 43.8–45.4% TL, pre-vent length 48.1–48.5 vs. 45.4–46.5% TL, pectoral–pelvic space 25.5–26.0 vs. 21.4–25.1% TL, pelvic–anal space 13.8–13.9 vs. 15.5–16.6% TL), and slightly larger pelvic fins (height 6.8–6.9 vs. 5.8–6.2% TL). It should also be noted that the holotype of *M. stevensi* has a slightly narrower head than the paratypes (9.5 vs. 10.1–11.1% TL).

Mustelus walkeri sp. nov.

Figs 3, 4, 5b; Table 1

Mustelus sp. B (in part - eastern form): Last & Stevens, 1994: pp 206, 214, 215, key fig. 16, fig. 27.8, pl. 28; Compagno *et al.*, 2005a: pp 277, 278, pl. 46; Compagno & Niem, 1998: pp 1300, 1301, fig. 14.

Mustelus antarcticus (in part): Daley *et al.*, 2002: p 52.

Holotype. CSIRO H 460–02, adult male 926 mm TL, north-east of Hinchinbrook Island, Queensland, 17°57′ S 147°02′ E, 298–306 m, 11 Jan 1986.

Paratypes. 16 specimens: CSIRO H 459–02, adult male 926 mm TL, north-east of Hinchinbrook Island, Queensland, 17°57′ S 147°03′ E, 300 m, 11 Jan 1986; CSIRO H 632–02, adult male 855 mm TL, north-east of Hinchinbrook Island, Queensland, 17°58′ S 147°03′ E, 302–308 m, 11 Jan 1986; CSIRO H 705–01, juvenile male 427 mm TL, south of Saumarez Reef, Queensland, 21°51′ S 153°59′ E, 400–403 m, 20 Nov 1985; CSIRO H 1310–04, juvenile male 327 mm TL, CSIRO H 1310–05, juvenile male 365 mm TL, CSIRO H 1310–06, female 314 mm TL, south of Saumarez Reef, Queensland, 22°35′ S 153°40′ E, 314–319 m, 16 Nov 1985; CSIRO H 1362–01, female 366 mm TL, CSIRO H 1362–02, juvenile male 415 mm TL, north-east of Hinchinbrook Island, Queensland, 17°56′ S 147°07′ E, 400–402 m, 29 Nov 1985; CSIRO H 1367–01, female 455 mm TL, north-east of Hinchinbrook Island, Queensland, 17°58′ S 147°01′ E, 212 m, 09 Dec 1985; CSIRO H 2468–01, adult male 902 mm TL, north-east of Hinchinbrook Island, Queensland, 17°57′ S 147°02′ E, 298–306 m, 11 Jan 1986; CSIRO H 2469–01, adult male 919 mm TL, CSIRO H 2469–02, adult male 918 mm TL, north-east of Hinchinbrook Island, Queensland, 17°58′ S 147°01′ E, 260–264 m, 10 Jan 1986; CSIRO H 2471–01, early adolescent male 707 mm TL, CSIRO H 2471–02, adult male 912 mm TL, north-east of Hinchinbrook Island, Queensland, 17°56′ S 146°58′ E, 218–220 m, 09 Jan 1986; CSIRO H 3643–20, female 1113 mm TL, north-east of Hinchinbrook Island, Queensland, 17°55′ S 146°57′ E, 227–249 m, 30 Nov 1993; QM I 38198, female 992 mm TL, east of Rockingham Bay, Queensland, 18°06′ S, 147°09′ E), 266–239 m, 30 Nov 1993.

Other material. 8 specimens: CSIRO H 457–02, adult male 912 mm TL, CSIRO H 457–03, adult male 868 mm TL, north-east of Hinchinbrook Island, Queensland, 17°57′ S 147°04′ E, 300 m, 10 Jan 1986; CSIRO H 1363–01, juvenile male 356 mm TL, CSIRO H 2255–01, female 949 mm TL, Saumarez Plateau, Queensland, 22°53′ S 152°42′ E, 225–282 m, 19 Nov 1985; CSIRO H 2469–03, adult male 912 mm TL, north-east of Hinchinbrook Island, Queensland, 17°58′ S 147°01′ E, 260–264 m, 10 Jan 1986; CSIRO H 2473–01, adult male 942 mm TL, north-east of Hinchinbrook Island, Queensland, 17°58′ S 147°02′ E, 260–264 m, 10 Jan 1986; CSIRO H 2721–01, female 1116 mm TL, north-east of Hinchinbrook Island, Queensland, 17°58′ S 146°59′ E, 224–228 m, 09 Jan 1986; CSIRO H 5754–01, adult male 810 mm TL, west of Moreton Island, Queensland, 27°18′ S 153°31′ E, 52 m, 15 Oct 2001.

DIAGNOSIS.— A relatively large *Mustelus* with the following combination of characters: dorsal fins tall, posterior margin directed posteroventrally from top to bottom and not upright distally, first dorsal-fin base 1.6–2.0 times anal–caudal space; buccopharyngeal denticles covering entire palate and floor of mouth; claspers of adult males long, slender, strongly depressed, inner length about 9–10% TL, extending to just anterior of the second dorsal-fin origin; lower edge of spiracle usually close to level of mid-eye; anal-fin insertion usually over its apex; teeth in about 69/73 rows; precaudal vertebral centra 78–94, monospondylous centra 35–39; pale greyish dorsally with numerous small, often indistinct, semi-regular, diffuse-edged white spots on postspiracular head and body; light and dark tonal coloration well demarcated on head below eye and onto middle of first gill slit, intergill membranes much darker dorsally than ventrally; dorsal fins of juveniles (<400 mm TL) with bases and inner lobe not strongly contrasted to distal part of fin, inner lobe pale-edged; caudal fin of juveniles with distinctive whitish posterior margins.

DESCRIPTION.— Body elongate and moderately robust to slender, trunk weakly compressed, subtriangular in cross-section at first dorsal-fin base; length of trunk from fifth gill slits to vent 1.22 in holotype (1.23–1.42 in paratypes) times head length; second dorsal-fin origin to anal-fin origin 2.67 (2.58–3.75) in second dorsal-fin origin to pelvic-fin midpoint; anal–caudal space 8.55 (7.87–10.07) in preanal length; predorsal ridge weak, variable, usually extending forward to about in line with posterior gill slits; interdorsal ridge distinct, low (better defined than predorsal ridge), present before second dorsal-fin origin; postdorsal ridge well defined (similar to interdorsal ridge); lateral line forming a weak ridge, indistinct anteriorly, extending from over gill slits to beneath second dorsal fin. Caudal peduncle slender, cylindrically-tapering, without lateral keels; height 1.42 (1.18–1.48) in width at upper caudal-fin origin, 4.42 (3.96–4.42) in dorsal–caudal space. Precaudal pits absent.

Head short, length 0.89 (0.86–0.88) in pectoral–pelvic space; narrow, moderately depressed, roughly trapezoidal in cross-section at eyes; outline of prespiracular head in lateral view convex over eye, concave on midsnout, elevated and straight or convex over gills; post-oral head almost straight; parabolic in dorsoventral view; preoral snout moderate, 1.31 (1.14–1.37) in mouth width. Snout bluntly pointed in lateral view, convex below, concave above; tip narrowly rounded in dorsoventral view, without shallow indentations anterior to nostrils. Eyes large and elongate-oval in shape, eye length 7.16 (6.38–7.83) in head length; slightly dorsolateral on head; lower edges slightly medial to lateral margin of head in dorsal view; fleshy subocular ridges strong; external opening with prominent posterior notch, no anterior notch; nictitating lower eyelids external; subocular pouches deep, entirely scaled with secondary lower eyelids. Spiracles small, oblique to almost horizontal, mainly slit-like, their length only slightly less than eye to spiracle space, lower edge close to level of mid-eye. Third and fourth gill slits usually tallest, fifth shortest; first gill slit much taller than fifth, height of fifth 0.95 (0.76–0.89) of first; height of first 10.87 (7.61–10.23) in head, 0.66 (0.69–0.96) of eye length. Anterior margin of gill slits weakly undulate; top of fifth gill slit slightly more dorsolateral than top of first; upper margin of gill slits slightly above lower edges of eyes; gill filaments not visible externally. Nostrils with large suboval to crescentic incurrent apertures, lacking posterolateral keels; well in front of mouth; width 1.66 (1.50–1.66) in internarial space, 1.64 (1.49–1.63) in eye length, 1.08 (1.11–1.48) in first gill slit height; excurrent apertures small, narrowly oval; anterior nasal flaps with broadly rounded apices, prominent mesonarial flaps, small posterior nasal flaps; anterior nasal aperture bluntly angular anteriorly, forming a gradual depression.

Mouth very strongly arched; width 4.03 (3.52–3.98) in head length; length 2.08 (1.90–2.55) in width; tongue large, almost flat, narrowly rounded apically, filling floor of mouth; buccal papillae absent, buccopharyngeal denticles covering entire palate and floor of mouth; labial furrows elongate; upper furrows longer than lower furrows, length 1.39 (1.36–1.68) times length of lower furrows, 0.89 (0.78–1.05) in nostril length; anterior tip of uppers slightly forward of mid-eye, extending well forward of corners of mouth; palatine processes of the palatoquadrates not subdivided at symphysis, no separate medial segment on each side. Teeth (based on adult male paratype CSIRO H 2469–02) relatively symmetrical

Table 1. Morphometric data for the holotype of *Mustelus stevensi* sp. nov. (CSIRO H 1035–13) and *M. walkeri* sp. nov. (CSIRO H 460–02), with ranges provided for the measured paratypes. Measurements expressed as a percentage of total length.

	M. stevensi **sp. nov.**				***M. walkeri*** **sp. nov.**			
	Holotype	Paratypes			Holotype	Paratypes		
		Min.	Max.	Mean		Min.	Max.	Mean
Total length (mm)	611	617	1034		926	707	1113	
Pre-second dorsal length	60.4	59.5	61.4	60.1	59.9	58.7	61.7	59.9
Pre-first dorsal length	25.7	25.5	26.3	25.9	26.3	25.3	26.1	25.6
Head length	20.1	18.4	20.7	19.4	19.8	19.0	19.5	19.3
Prebranchial length	17.0	16.0	17.5	16.6	17.2	16.1	16.8	16.4
Prespiracular length	11.6	10.2	11.9	10.9	11.3	10.3	11.2	10.8
Preorbital length	7.7	7.1	8.1	7.5	7.8	7.1	7.7	7.4
Prepectoral length	20.7	19.1	20.5	19.7	19.8	19.0	19.6	19.3
Prepelvic length	45.0	43.8	46.8	45.5	44.4	43.1	46.5	44.1
Snout–vent length	46.5	45.4	48.5	46.9	45.8	44.6	48.1	45.4
Preanal length	65.5	63.9	66.0	64.8	63.9	62.5	66.4	63.9
Interdorsal space	22.0	21.3	23.3	22.0	22.5	21.4	23.2	22.4
Dorsal–caudal space	10.7	9.6	11.6	10.4	10.6	9.9	11.0	10.5
Pectoral–pelvic space	24.2	21.4	26.0	24.6	23.1	22.3	23.2	22.9
Pelvic–anal space	16.0	13.8	16.6	15.1	15.0	14.6	16.3	15.5
Anal–caudal space	6.9	6.6	7.7	7.0	7.5	6.6	7.9	7.2
Pelvic–caudal space	29.1	27.5	29.9	28.9	29.7	27.8	30.8	29.6
Prenarial length	5.2	4.6	5.4	4.9	5.1	4.6	5.1	4.9
Preoral length	7.1	6.3	7.5	6.7	6.7	6.2	6.9	6.5
Eye length	3.3	2.5	3.2	3.0	2.9	2.5	3.1	2.8
First gill slit height	2.0	1.7	2.5	2.2	1.9	2.0	2.6	2.4
Fifth gill slit height	1.5	1.6	2.0	1.8	1.8	1.7	2.1	1.9
Pectoral fin - anterior margin	13.6	13.2	14.4	13.6	12.5	12.2	14.2	12.9
Pectoral fin - base length	3.9	4.2	4.8	4.6	4.0	3.8	4.8	4.1
Pectoral fin - posterior margin	9.8	10.0	12.5	11.0	9.8	9.9	11.2	10.4
Pectoral fin - inner margin	7.0	7.0	7.3	7.2	6.9	6.6	7.7	7.0
Caudal fin - dorsal margin	18.8	18.5	20.4	19.3	18.9	18.3	20.7	19.7
Caudal fin - preventral margin	8.9	8.4	8.9	8.7	8.9	7.9	9.2	8.5
Caudal fin - upper postventral margin	6.7	6.0	7.3	6.7	8.1	6.7	8.2	7.6
Caudal fin - lower postventral margin	2.2	1.9	2.3	2.0	2.6	2.0	2.7	2.3
Caudal fin - fork width	5.1	4.9	5.2	5.0	5.0	4.7	5.5	5.1
Caudal fin - fork length	8.1	7.4	8.1	7.7	7.3	7.0	8.4	7.6
Caudal fin - subterminal margin length	4.2	3.6	4.2	4.0	3.4	3.4	4.2	3.8
Caudal fin - subterminal margin width	3.1	2.7	3.3	3.0	2.9	2.7	3.2	3.0
Caudal fin - terminal margin length	6.4	6.9	7.4	7.1	6.7	6.8	7.1	7.0
Caudal fin - terminal lobe length	7.9	8.0	8.7	8.4	7.8	7.8	8.5	8.2
First dorsal fin - length	16.8	15.7	18.4	16.6	15.9	15.5	17.2	16.3
First dorsal fin - anterior margin	14.4	13.0	15.0	14.0	12.9	13.1	15.0	14.0
First dorsal fin - base length	12.4	12.1	14.5	12.8	12.5	12.2	13.2	12.7
First dorsal fin - height	8.7	8.5	10.1	9.1	8.4	7.5	9.4	8.3
First dorsal fin - inner margin	4.2	3.7	4.3	4.0	3.7	3.3	4.1	3.7
First dorsal fin - posterior margin	9.3	9.0	11.5	10.3	10.4	9.4	10.5	9.8

Table 1. cont'd.

	M. stevensi **sp. nov.**				***M. walkeri*** **sp. nov.**			
	Holotype	Paratypes			Holotype	Paratypes		
		Min.	Max.	Mean		Min.	Max.	Mean
Second dorsal fin - length	13.1	12.7	13.8	13.2	13.1	12.4	13.6	12.9
Second dorsal fin - anterior margin	10.8	10.5	11.7	11.1	10.6	10.8	11.4	11.1
Second dorsal fin - base length	10.1	10.2	10.7	10.5	10.7	9.8	10.8	10.3
Second dorsal fin - height	6.4	5.5	6.6	6.2	5.5	5.6	6.7	6.1
Second dorsal fin - inner margin	3.0	2.7	3.2	2.9	2.5	2.4	2.9	2.7
Second dorsal fin - posterior margin	7.3	6.1	7.7	6.9	7.2	6.6	7.3	7.0
Pelvic fin - length	9.9	9.4	10.4	10.0	9.0	9.3	9.9	9.6
Pelvic fin - anterior margin	7.1	6.7	7.6	7.2	6.2	6.5	7.7	6.9
Pelvic fin - height	6.2	5.8	6.9	6.3	5.6	5.8	6.3	6.0
Pelvic fin - inner margin	4.7	4.5	5.4	4.9	4.5	4.4	5.1	4.8
Pelvic fin - posterior margin	6.3	5.9	7.5	6.5	6.0	5.8	6.7	6.2
Anal fin - length	9.3	9.0	9.9	9.6	9.5	9.5	9.8	9.7
Anal fin - anterior margin	7.7	7.9	8.6	8.1	8.1	7.6	8.2	7.9
Anal fin - base length	6.9	7.0	7.6	7.3	7.6	7.1	7.8	7.4
Anal fin - height	3.1	3.3	3.6	3.5	3.3	3.1	3.6	3.3
Anal fin - inner margin	2.6	2.2	2.7	2.5	1.9	2.0	2.4	2.2
Anal fin - posterior margin	3.3	3.5	3.9	3.7	3.7	3.4	4.1	3.7
Head height	7.4	8.0	9.1	8.6	8.7	8.3	9.1	8.6
Trunk height	8.2	8.8	10.1	9.4	9.0	8.9	9.4	9.1
Abdomen height	8.8	8.4	9.7	9.0	9.2	8.8	9.5	9.2
Tail height	5.8	5.6	6.9	6.1	6.2	5.9	6.8	6.3
Caudal peduncle height	2.3	2.2	2.4	2.3	2.4	2.3	2.7	2.5
Pelvic midpoint-first dorsal insertion	9.0	8.9	10.2	9.7	9.4	7.7	9.5	8.6
Pelvic midpoint-second dorsal origin	12.9	10.9	13.1	12.0	12.3	12.4	14.0	13.2
Second dorsal origin-anal origin	5.7	4.6	5.4	5.0	4.6	3.6	4.9	4.2
Second dorsal insertion-anal insertion	2.4	1.4	2.1	1.8	1.4	1.3	1.6	1.4
Mouth length	2.7	2.5	2.7	2.5	2.5	2.2	2.6	2.5
Mouth width	4.8	5.0	5.5	5.2	5.1	5.0	5.6	5.3
Upper labial furrow length	1.9	1.7	2.3	2.0	2.0	1.8	2.2	2.0
Lower labial furrow length	1.2	1.3	1.5	1.4	1.4	1.3	1.4	1.3
Nostril width	1.8	1.7	2.1	1.9	1.8	1.7	1.9	1.8
Internarial space	3.2	2.8	3.0	2.9	2.9	2.7	3.0	2.8
Clasper inner length	10.3	8.1	11.2	9.9	9.1	9.5	9.9	9.7
Clasper base width	1.5	1.2	1.5	1.3	1.3	0.8	1.5	1.2
Interorbital space	6.0	6.3	6.8	6.6	6.6	5.9	6.3	6.1
Head width	9.5	10.1	11.1	10.4	10.4	9.4	10.6	10.0
Trunk width	8.4	8.3	9.6	9.0	9.0	8.7	10.1	9.2
Abdomen width	6.7	7.6	9.5	8.3	8.0	6.8	8.4	7.9
Tail width	5.9	5.6	7.0	6.1	6.2	5.3	6.7	6.0
Caudal peduncle width	1.7	1.9	2.2	2.0	1.7	1.6	2.1	1.9

A

B

Figure 3. *Mustelus walkeri* sp. nov., holotype (CSIRO H 460–02, adult male, 926 mm TL, preserved): A. lateral view; B. ventral head view.

between jaws, quincuncial, with an indistinct lingual cusp, no cusplets; no apparent sexual heterodonty or difference between jaws; no notch or toothless space at symphysis; exposed evenly around centre of lower jaw when mouth closed, tooth bands not visible from margin of lower jaw towards corners; in 69/73 rows (one paratype, CSIRO H 2469–02); formula is 34 + 35 in upper jaw, 36 + 37 in lower jaw.

Lateral trunk denticles below first dorsal fin minute, very dense, strongly imbricated, variable in size and shape; crowns broadly oval to subcircular, not elevated, very weakly pointed distally or with irregular margins, apices mostly rounded or very weakly pointed; weak ridges at anterior base of crown sometimes present (usually indistinct); crown length subequal or only slightly longer than its width. Narrow naked areas at insertions of pectoral and pelvic fins.

First dorsal fin subtriangular; anterior margin weakly convex; apex narrowly pointed; posterior margin straight distally, with a strong concavity near junction with inner lobe, directed posteroventrally from top to bottom; free rear tip acutely pointed; inner margin strongly concave; origin above or slightly posterior to insertion of pectoral fins; free rear tip well anterior to pelvic-fin origins; insertion well posterior to fin apex; first dorsal-fin base 1.80 (1.67–1.90) in interdorsal space, 1.52 (1.38–1.65) in dorsal caudal-fin margin; fin height 1.48 (1.34–1.62) in base length; inner margin 2.28 (2.11–2.43) in height, 3.38 (3.10–3.80) in base length. Second dorsal fin moderately tall and upright, not falcate; smaller than first dorsal fin, height 0.65 (0.70–0.76) of first dorsal-fin height, base length 0.86 (0.77–0.85) of first dorsal-fin base length; anterior margin weakly convex; apex rounded, variable; posterior margin deeply concave at junction with inner margin, almost straight distally, almost subvertical; free rear tip acutely pointed, terminating slightly anterior to anal-fin free rear tip and well in front of upper caudal-fin origin; inner margin straight or slightly concave; origin separated from pelvic-fin insertions by a space about 2.27 (2.00–3.10) times pelvic-fin base; insertion distinctly posterior to fin apex; second dorsal-fin base length 0.99 (0.97–1.11) in dorsal–caudal space; fin height 1.96 (1.45–1.89) in base length; inner margin 2.19 (2.15–2.38) in height, 4.29 (3.32–4.31) in base length.

Anal fin low, sometimes weakly falcate, much smaller than second dorsal fin; height 0.61 (0.46–0.59) in second dorsal-fin height, base length 0.71 (0.66–0.75) times second dorsal-fin base length; anterior margin weakly convex; apex narrowly rounded; posterior margin deeply notched, slanting posteroventrally from base; free rear tip narrow, acutely pointed, well in front of lower caudal-fin

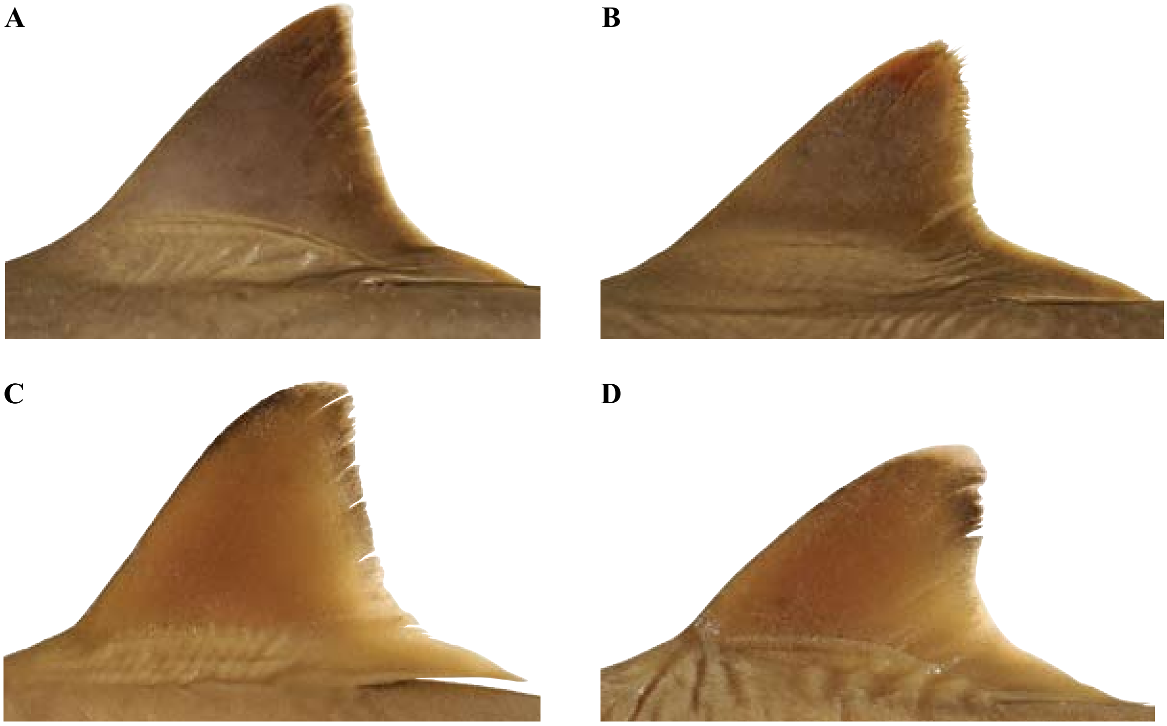

Figure 4. First (A, C) and second (B, D) dorsal fins of *Mustelus walkeri* sp. nov.: A., B. holotype, CSIRO H 460–02 (adult male, 926 mm TL); C., D. juvenile paratype, CSIRO H 1310–06 (female 314 mm TL).

origin; inner margin nearly straight or weakly concave; origin well behind second dorsal-fin origin, by 0.43 (0.37–0.45) of second dorsal-fin base; insertion mainly over fin apex (slightly posterior in some paratypes), well behind second dorsal-fin insertion; anal-fin base length 0.99 (0.92–1.11) in anal–caudal space; fin height 2.26 (2.00–2.34) in base length; inner margin 1.72 (1.32–1.63) in height, 3.90 (2.97–3.81) in base length; preanal ridges low, sometimes indistinct.

Pectoral fins not falcate; slightly larger in area than first dorsal fin; anterior margin broadly convex, 1.28 (1.15–1.29) times posterior margin; base narrow; apex moderately rounded (more narrowly rounded in some paratypes), well behind free rear tip when fin is elevated and adpressed to body; posterior margin moderately concave; free rear tips broadly angular; inner margins strongly convex; origin mainly between third and fourth gill slit. Pelvic fins narrowly subtriangular; area much greater than anal-fin area; anterior margin straight to slightly convex, 0.50 (0.52–0.55) pectoral-fin anterior margin; apex angular; posterior margin broadly concave; free rear tip narrowly pointed; inner margins nearly straight or weakly concave. Claspers of adult males strongly depressed, very long, slender, nearly straight for most of outer margin length and strongly tapering to tip; extending well behind pelvic-fin free rear tips, to mostly just forward of origin of second dorsal fin; glans moderately short, length more than one third of clasper outer margin; covered laterally and ventrally with small denticles, mostly naked dorsally.

Caudal fin asymmetrical, upper lobe narrow; terminal lobe enlarged, ventral lobe prominent; dorsal caudal margin moderately long, 4.30 (3.86–4.48) in precaudal length, weakly double convex, mesially concave, without lateral undulations; preventral margin moderately convex, 2.75 (2.54–2.96) in dorsal caudal margin, apex narrowly rounded; lower postventral margin short, nearly straight; upper postventral margin weakly convex, notch between these forming angle of 103 (100–110°); subterminal notch narrow, short; subterminal margin almost straight, terminal margin weakly to moderately concave, lobe formed by these margins bluntly angular; subterminal margin 1.96 (1.64–2.04) in terminal margin; tip of caudal fin bluntly pointed, terminal lobe length 2.41 (2.34–2.51) in dorsal caudal margin.

Total vertebral centra 136 (129–143), precaudal centra 90 (78–94), monospondylous precaudal centra 39 (35–39), diplospondylous precaudal centra 51 (41–57).

COLOUR.— Preserved specimens: Adults almost uniformly pale greyish above, paler ventrally; covered in small, often indistinct, semi-regular, diffuse-edge white spots; darker areas above merging gradually with pale area below on sides of body; interface (waterline) much more pronounced on head; waterline extending along ventrolateral margin of head well below eye and usually onto middle of first gill slit; intergill membranes usually darker dorsally than ventrally. Spots largely absent from prespiracular head and below lateral line, in scattered or weak, indistinct rows along trunk from about level of

A

B

Figure 5. Caudal fin of juvenile of: A. *Mustelus stevensi* sp. nov., paratype (CSIRO H 4074–15, male 278 mm TL); B. *Mustelus walkeri* sp. nov., paratype (CSIRO H 1310–06, female 314 mm TL).

pectoral-fin base to second dorsal fin (mainly just below base of first dorsal fin and along lateral line); no spots on fins; mostly less than 2 mm in diameter on average in specimens <700 mm TL, up to 3 mm in diameter in largest adults. First dorsal fin greyish brown, somewhat dusky, without distinct markings, posterior margin with a narrow semi-translucent edge; second dorsal fin similar, slightly darker near apex; caudal fin almost uniformly greyish brown, somewhat dusky, posterior margins narrowly white-edged, sharply demarcated from area adjacent; anal fin uniformly pale greyish brown, without dark markings; pectoral fins uniformly greyish brown dorsally, much paler yellowish ventrally, posterior margins narrowly white-edged; pelvic fins similar to pectoral fins. Ventral surface uniformly yellowish white, claspers uniformly pale yellowish or white. Juveniles <400 mm TL with less distinct white spots, slightly more brownish grey; dorsal fins with more distinct dusky distal edges. In female paratype CSIRO H 1310–06 (314 mm TL), proximal anterior margin of first dorsal fin narrowly black-edged, becoming broader near apex, distal posterior margin broadly black-edged to its junction with inner lobe, inner lobe distinctly paler, almost white-edged; second dorsal fin similar to first, black edge along posterior margin confined to its distal half; caudal fin almost uniformly coloured with weak dusky central blotch on subterminal lobe, posterior margins distinctly whitish.

SIZE.— Material examined ranged from 314–1116 mm TL for females and 327–942 mm TL for males; mature males 855–942 mm TL, adolescent male 707 mm TL.

DISTRIBUTION.— Known from the upper continental slope of northeastern Australia from off Hinchinbrook Island (17°55′ S, 146°57′ E) to Moreton Island (27°18′ S, 153°31′ E) in Queensland, at depths of 52–403 m (recorded inshore to 120 m depth in Last & Stevens, 1994).

ETYMOLOGY.— The species name is in acknowledgement of the pioneering efforts of Terry Walker (Department of Primary Industries, Victoria) who has dedicated a lifetime to the ecology and fisheries management of Australian chondrichthyans, most notably school and gummy sharks. Vernacular: Eastern Spotted Gummy Shark.

REMARKS.— *Mustelus walkeri* sp. nov. belongs to a subgroup of white-spotted Indo–Pacific species that includes *M. antarcticus*, *M. lenticulatus*, *M. manazo* and *M. stevensi*.

Mustelus walkeri is clearly separable from *M. lenticulatus* from New Zealand, differing in the following characters: first dorsal fin slightly further forward (pre first dorsal length 25.3–26.3 vs. 27.6–27.9% TL), dorsal fins well separated (interdorsal space 21.4–23.2 vs. 18.4–19.0% TL), a longer pelvic–anal space (14.6–16.3 vs. 13.6–14.3% TL), longer anal–caudal space (6.6–7.9 vs. 6.4–6.5% TL), a smaller caudal fin (preventral margin 7.9–9.2 vs. 9.4–9.7% TL, caudal fork width 4.7–5.5 vs. 6.4–6.7% TL, caudal fork length 7.0–8.4 vs. 9.3–10.2% TL), smaller pelvic fins (anterior margin 6.2–7.7 vs. 7.9–8.0% TL, posterior margin 5.8–6.7 vs. 7.1–7.2% TL), pelvic mid-point to second dorsal-fin origin 12.3–14.0 vs. 10.3–10.5% TL, and dorsal and lateral surfaces pale grey with very small, weakly differentiated white spots (vs. greyish with small, strongly differentiated white spots).

Mustelus walkeri can be separated from *M. manazo* based on the following characters that are most evident in males: dorsal and lateral surfaces greyish with very small, not strongly differentiated white spots (vs. greyish with strongly differentiated medium-small white spots), pelvic fins slightly further forward (prepelvic length in males 43.1–44.4 vs. 44.6–46.8% TL, pelvic–caudal space in males 29.7–30.8 vs. 27.5–29.4% TL), shorter pre-vent length (44.6–45.8 vs. 46.0–48.2% TL in males), slightly smaller pectoral fin (in males, anterior margin 12.2–12.8 vs. 13.5–14.5% TL, base 3.8–4.0 vs. 4.1–4.8% TL), slightly smaller pelvic fins (in males, anterior margin 6.2–6.9 vs. 7.2–8.2% TL), and head and body slightly more robust (head height 8.3–9.1 vs. 7.5–8.2% TL, trunk height 8.9–9.4 vs. 8.1–8.7% TL).

Mustelus walkeri is clearly separable from *M. antarcticus* and differs in the following characters: buccopharyngeal denticles covering entire floor and palate of mouth (vs. denticles restricted to the anterior third to half of the floor and palate), snout narrowly rounded (vs. more broadly rounded), males with a slightly shorter pre-vent length (44.6–45.8 vs. 45.8–47.1% TL), anal fin smaller (length 9.5–9.8 vs. 10.3–10.8% TL, anterior margin 7.6–8.2 vs.

8.2–8.9% TL, inner margin 1.9–2.4 vs. 2.5–2.7% TL), slightly shorter pelvic-fin inner margin (4.4–5.1 vs. 5.2–6.3% TL), dorsal and lateral surfaces pale greyish with white spotting (vs. slightly darker greyish with white spotting), and gill slits darker dorsally and paler ventrally but without strong demarcation between light and dark tones (vs. gill slits mostly dark with waterline distinct at their lower margin). *Mustelus walkeri* also typically occurs in much deeper waters than *M. antarcticus* (>120 vs. usually <80 m depth).

Mustelus walkeri is clearly separable from *M. stevensi* by a combination of the following characters: slightly more vertebrae (total centra 129–143 vs. 120–128, monospondylous centra 35–39 vs. 33–35), males maturing at a larger size (early adolescent at 71 cm TL vs. fully mature at ca. 58 cm TL), light and dark tonal areas on the head clearly demarcated as a distinct waterline (vs. tonal areas not clearly defined, diffuse), lower edge of spiracles close to level of mid-eye on horizontal axis (vs. at level of lower eye), first dorsal fin subtriangular with posterior margin directed posteroventrally from top to bottom (vs. upright and subfalcate with posterior margin almost vertical), insertion of first dorsal fin well posterior to fin apex (vs. almost level with fin apex), second dorsal-fin apex rounded (vs. narrowly rounded), anal-fin insertion mostly over fin apex (vs. slightly anterior), pectoral-fin apex moderately rounded (vs. narrowly rounded) and dorsal fins of juveniles without distinct whitish areas at their bases (vs. inner lobe and fin bases distinctly whitish, strongly demarcated from distal portion of fins) and posterior margins of caudal fin distinctly white-edged (vs. not distinctly white-edged, Fig. 5).

The buccopharyngeal denticles were show by Heemstra (1997) to be particularly useful for discriminating certain species within the genus *Mustelus* while showing little intraspecific variation. In this study, it was found that *M. stevensi* and *M. walkeri* have the entire roof and palate of the mouth covered in fine buccopharyngeal denticles (as with *M. manazo*) compared to *M. antarcticus* which has the buccopharyngeal denticles restricted to the anterior third to half of the floor and palate.

Notable sexual dimorphism was evident in the measured specimens of *M. walkeri*, with the one large female paratype measured having more posteriorly located pelvic fins than adult males (prepelvic length 46.5 vs. 43.1–44.4% TL, pre-vent length 48.1 vs. 44.6–45.8% TL, pelvic–caudal space 30.8 vs. 27.8–29.7% TL).

A more detailed revision of the white-spotted *Mustelus* species occurring in the Indo–West Pacific is required, including full skeletal examinations. The large differences in reproductive biology, sizes at maturity, parasitic fauna and genetic variation of specimens of *Mustelus manazo* from Japan and Taiwan (Chen *et al*., 2001; Yamaguchi *et al*., 1997, 2000) should be examined in more detail to elucidate whether more than one taxa is involved. Additional white-spotted species from Indonesia and the Philippines (identified as *M.* cf *manazo* by White *et al*., 2006 and Compagno *et al*., 2005b, respectively) also need further examination.

Comparative material.
Mustelus antarcticus: Southern Australia: CSIRO C 4693, adolescent male 755 mm TL; CSIRO C 4892, juvenile male 540 mm TL; CSIRO C 4904, female 785 mm TL; CSIRO H 2501–01, adolescent male 690 mm TL; CSIRO H 2501–02, adolescent male 672 mm TL; CSIRO H 2501–03, female 698 mm TL; CSIRO H 4109–01, adult male 1127 mm TL; 10 unregistered specimens (not retained, southern Western Australia) from which buccopharyngeal denticle patterns were taken.
Mustelus lenticulatus: New Zealand: CSIRO H 5551–01, juvenile male 515 mm TL; CSIRO H 5551–02, juvenile male 480 mm TL.
Mustelus manazo: Taiwan: CSIRO H 6292–23, female 506 mm TL; CSIRO H 6293–33, adult male 723 mm TL; CSIRO H 6293–34, adult male 616 mm TL; CSIRO H 6293–35, adult male 707 mm TL; CSIRO H 6294–32, female 867 mm TL.

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Glyphis garricki sp. nov., a new species of river shark (Carcharhiniformes: Carcharhinidae) from northern Australia and Papua New Guinea, with a redescription of *Glyphis glyphis* (Müller & Henle, 1839)

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ABSTRACT.— *Glyphis garricki* sp. nov. (formerly *Glyphis* sp. C) is formally named and described based on 16 specimens collected from heavy tidal zones and rivers in northern Australia (Western Australia and Northern Territory) and Papua New Guinea. *Glyphis garricki* differs from its congeners by a combination of dentition, vertebral counts, morphometrics and coloration. It is compared closely to the morphologically similar *Glyphis glyphis* (formerly *Glyphis* sp. A) that has a similar range. Comparison of the stuffed holotype of *Carcharias (Prionodon) glyphis* with specimens of *Glyphis* sp. A from northern Australia and Papua New Guinea suggests that they are conspecific, and a redescription of *Glyphis glyphis* is provided based on all of these specimens.

Key words. Carcharhinidae – *Glyphis garricki* – *Glyphis glyphis* – new species – northern Australia – Papua New Guinea

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INTRODUCTION

The genus *Glyphis* was proposed by Agassiz (1843) for a living species of carcharhinid shark (Family Carcharhinidae), *Carcharias (Prionodon) glyphis*, which had been described by Müller & Henle (1839) from a single stuffed specimen without locality but with distinctive spear-shaped (hastate) lower anterior teeth, small eyes and a large second dorsal fin. Agassiz also described a new British Eocene fossil species, *G. hastalis*, from isolated teeth but didn't name a type species for his new genus while specifying that it contained both the living and fossil species. *Glyphis* takes *C. (P.) glyphis* as type species by absolute tautonymy.

Glyphis was seldom used by subsequent authors and was occasionally misinterpreted as being based only on the fossil *G. hastalis* or as being a senior synonym of the blue shark genus *Prionace* Cantor, 1849. A detailed account of the nomenclatural history of *Glyphis* can be found in Compagno (1979, 1988, 2003). Compagno (1979) noted that *Glyphis* had as type-species the living *Carcharias (Prionodon) glyphis* by absolute tautonymy, and initially placed *Glyphis* in synonymy of *Carcharhinus* Blainville, 1816. Garrick (1982, 1985) revised *Carcharhinus* and excluded *C. (P.) glyphis* and a second similar species, *C. (P.) gangeticus* Müller & Henle 1839 (from the Ganges River in India), from *Carcharhinus* without assigning them to a separate genus. Garrick noted that these two species were close to each other, but that *Carcharias murrayi* Günther, 1883 (from the Indus River delta of Pakistan) and *Carcharias siamensis* Steindachner, 1896 (from the Irrawaddy River delta of Myanmar) were also similar species. Compagno (1984) revived *Glyphis* as a genus for *C.(P.) glyphis* and *C.(P.) gangeticus*, but noted that there were additional species represented by specimens from Borneo, New Guinea and Queensland (Australia) reported by Prof. J.A.F. Garrick (pers. comm., to senior author). Compagno (1984) proposed the name 'river sharks' for *Glyphis* species because the Ganges shark and other species were associated with tropical rivers including deltas in the Indo–West Pacific.

Compagno (2005) recognised three nominal species in the genus *Glyphis*: *G. gangeticus*, *G. glyphis* and *G. siamensis*, plus two or three undescribed species. More recently, Compagno *et al*. (2005), recognised six species, *G. gangeticus* from India and possibly Pakistan, *G. glyphis* from Papua New Guinea and possibly the Bay of Bengal, *G. siamensis* from Burma, *G.* sp. A [*sensu* Last & Stevens, 1994] from northern Australia, *G.* sp. B [*sensu* Compagno & Niem, 1998] from Borneo, and

G. sp. C [*sensu* Compagno & Niem, 1998] from northern Australia and New Guinea. Compagno *et al*. (2005) provided a character table for *Glyphis* species and noted that *G*. sp. A may be the same as *G. glyphis* with similarly large teeth and low tooth counts, but differences in dentition were possibly due to changes with growth.

The present account reviews the species of *Glyphis* from Australia and provides a formal name and description of *Glyphis* sp. C as *G. garricki* sp. nov. after its discoverer, Prof. J. A. F. Garrick. Collection of a series of *Glyphis* sp. A from Australia and Papua New Guinea and comparison with the stuffed holotype of *Carcharias (Prionodon) glyphis* suggests that these represent a single species, *G. glyphis*.

METHODS

Terminology for morphology follows Compagno (1973, 1979, 1988, 2001, 2003), Compagno & Springer (1971), Compagno *et al*. (2005) and Taylor *et al*. (1983). Measurement terminology is from Compagno (1984, 2001, 2003) who assigned names and abbreviations to measurements often indicated by descriptive phrases (example: snout to upper caudal origin = precaudal length = PRC). Dentitional terms are modified from Compagno (1970, 1979, 1988, 2001, 2003). Vertebral terminology, method of counting and vertebral ratios follow Springer & Garrick (1964) and Compagno (1970, 1979, 1988, 2003), including 'A' ratio (length of penultimate monospondylous precaudal centrum/ length of first diplospondylous precaudal centrum x 100) and 'B' ratio (length/width of penultimate monospondylous precaudal centrum x 100).

The holotype and 6 paratypes of *Glyphis garricki* were measured in full (Table 1), and the holotype and 8 other specimens of *G. glyphis* were also measured in full (Table 3). Morphometric and meristic values for the holotype are followed in parentheses by the ranges of the paratypes in the descriptive section. Meristics were taken from radiographs or by dissection of the holotype and 7 paratypes, 3 additional specimens and 4 other specimens (one from Taniuchi *et al*., 1991; LWF–E–227, LWF–E–294, WAM P 32597–001) of *Glyphis garricki* and from the holotype (caudal fin only) and 8 other specimens of *G. glyphis*. Counts were obtained separately for trunk (monospondylous), precaudal (monospondylous + diplospondylous to origin of upper lobe of caudal fin) and caudal (centra of the caudal fin) vertebrae (Tables 2 and 4). Tooth row counts were taken in situ, from radiographs or from excised jaws.

Specimens, including types, are referred to by the following prefixes for their registration numbers: CSIRO, Australian National Fish Collection, Hobart; KTG, field numbers, Darwin Initiative Sabah elasmobranch program and SMEC, Sabah Museum, Kota Kinabalu, Sabah, Malaysia; LWF, L.W. Filewood field numbers for specimens collected in Papua New Guinea; MNHN, Museum National d'Histoire Naturelle, Paris; NMW, Naturhistorisches Museum, Vienna; NTM, Museum and Art Gallery of the Northern Territory, Darwin, Australia; SAM, South African Museum, Cape Town; QM, Queensland Museum, Brisbane, Australia; WAM, Western Australian Museum, Perth, Australia; ZMB, Zoologisches Museum, Humboldt Universitat, Berlin, Germany; ZSI, Zoological Survey of India, Calcutta.

FAMILY CARCHARHINIDAE Jordan & Evermann, 1896

Genus *Glyphis* Agassiz, 1843

Type species. *Carcharias (Prionodon) glyphis* Müller & Henle, 1839, by absolute tautonymy.

SPECIES.— *Glyphis* includes at least five species: *G. garricki* Compagno, White & Last, 2008; *G. gangeticus* (Müller & Henle, 1839); *G. glyphis* (Müller & Henle, 1839); *G. siamensis* (Steindachner, 1896); and *G*. sp. B [*sensu* Compagno & Niem, 1998]. *Carcharias murrayi* Günther 1883 (from the Indus River delta of Pakistan) is a possible synonym of *G. gangeticus* or a distinct species but its holotype, a stuffed specimen in the collection of the Natural History Museum, is possibly lost (O. Crimmen, J. Macclaine, pers. comm.) and could not be located during a search for it in 2007.

Glyphis garricki sp. nov.

Figs 1–6, 13b; Tables 1 and 2

Glyphis sp. C: Compagno & Niem, 1998: pp 1318, 1360, fig. 23; Thorburn & Morgan, 2004: pp 1–8, figs 2–4; Compagno *et al*., 2005: pp 312, 313, pl. 55.

Holotype. CSIRO H 5262–01, female 670 mm TL, East Alligator River, Kakadu National Park, Northern Territory, 12°07′ S, 132°38′ E, 09 Jun 1999.

Paratypes. 8 specimens: CSIRO H 6173–01 (jaws), female 1770 mm TL, northeast of entrance to Cambridge Gulf, Western Australia, 14°42′ S, 128°34′ E, 22 Oct 2003; CSIRO H 6635–01 (jaws), adult male ca. 1450 mm TL, South Alligator River, 3 km downstream from 12º39′ S, 132º29′ E, 11 m depth, jaws, 10 May 1996; SAM uncatalogued (previously WAM P 32600–001) (chondrocranium, jaws, pelvic fin skeleton, pectoral girdle), juvenile female 1350 mm TL, King Sound, Western Australia, ca. 17°13′ S, 123°40′ E, 09 June 2003; WAM P 32598–001, juvenile male 906 mm TL, Doctors Creek, Derby, Western Australia, 17°13′ S, 123°40′ E, 07 Jun 2003; WAM P 32599–001, female 957 mm TL, Doctors Creek, Derby, Western Australia, 17°13′ S, 123°40′ E, 06

Jun 2003; WAM P 32600–001 (3 specimens), adult male 1418 mm TL, juvenile male 1191 mm TL, juvenile male 1022 mm TL, King Sound, Western Australia, ca. 17°13′ S, 123°40′ E, 09 June 2003.

Other material. 7 specimens: LWF–E227, juvenile male 720 mm TL, LWF–E294, juvenile male 720 mm TL, New Guinea (specimens lost but radiographs, drawings and photos provided by Prof. J.A.F. Garrick); LWF–E217 (jaws, supplied by P. Kailola), adult male ca. 1500–1700 mm TL, LWF–E219 (jaws, supplied by J.A.F. Garrick), Port Romilly, New Guinea, 07°40′ S, 144°50′ E, 12 Mar 1966; LWF–E473 (jaws, supplied by P. Kailola), 1020 mm TL, Baimuru, New Guinea, 07°33′ S, 144°51′ E, 28 Mar 1974; WAM P 32597–001, (deformed) adolescent male 994 mm TL, Doctors Creek, Derby, Western Australia, 17°13′ S, 123°40′ E, 2002. Also, data on specimen not seen but reported by Taniuchi et al. (1991), juvenile female 1314 mm TL, 100 km up from the mouth of the Adelaide River, Northern Territory, Australia, 13°00′ S, 131°15′ E, 26 May 1989.

DIAGNOSIS.— A species of *Glyphis* with an elongated snout, more flattened in lateral view than *Glyphis glyphis*. Closest distance from mouth to nostril about 1.5 times nostril width. Lips not concealing teeth when mouth is closed. Upper symphysis about an eye diameter in front of anterior eye margin. Lower anterior teeth with smooth proximal cusps and hastate, serrated, edged tips but without cusplets. Anteroposterior tooth row counts 15–17/14–17; total tooth row counts 31–34/30–35, or 62–68. Interdorsal space 16.1–21.2% TL. Anterior margins of pectoral fins weakly convex, pectoral length 12.9–13.8% TL. Pelvic fin anterior margins 7.6–9.1% TL and 35–46% of pectoral anterior margin, height 6.9–8.1% TL. First dorsal fin triangular, with nearly straight posterior margin; free rear tip well anterior to pelvic origins; length 16.7–18.7% TL. Second dorsal fin length 10.2–12.5% TL, anterior margin 8.6–9.9% TL, base 6.6–8.4% of total length and 1.0–1.4 times second dorsal fin height; height 5.8–6.9% TL and 58–66% of first dorsal fin height. Anal fin height 4.6–5.3% TL and 72–84% of second dorsal height, base 83–98% of second dorsal-fin base. Caudal-fin subterminal margin deeply concave. Total vertebral counts 137–151; monospondylous precaudal counts 44–50 and 31–34% of total counts; diplospondylous precaudal counts 28–34 and 20–24% of total counts; diplospondylous caudal counts 61–70 and 44–48% of total counts; precaudal counts 73–83 and 52–56% of total counts. Watermark boundary more than eye diameter below eye, visible below eyes on ventral view of head; watermark boundary sharply defined and jagged along trunk in young, about nostril width above pelvic-fin bases. No discrete blackish blotch at base of dorsal pectoral-fin; pectoral fin without a blackish blotch at ventral tip. Anal fin with a light distal web. Terminal caudal lobe with narrow black tip and terminal margin, ventral caudal lobe with black apical blotch.

DESCRIPTION.— Body stout, trunk subcircular and almost pear-shaped in section at first dorsal-fin base, length of trunk from fifth gill slits to vent 1.13 (1.16–1.24) times head length. Predorsal, interdorsal and postdorsal ridges absent from midline of back, lateral ridges absent from body. Caudal peduncle stout, rounded-hexagonal in section at second dorsal-fin insertion, postdorsal and postventral spaces flattened and often with a shallow median groove anteriorly, lateral surfaces subangular and with a broad, low, inconspicuous lateral ridge on each side at middle of the peduncle that extends anteriorly to the pelvic-fin midbases and posteriorly onto the caudal-fin base; height of caudal peduncle at 2nd dorsal-fin insertion 1.21 (1.07–1.24) times its width, 1.80 (1.63–2.03) times in dorsal–caudal space. Precaudal pits present; upper pit a shallow, subtriangular depression, not arcuate and crescentic; lower pit rudimentary, essentially a dimple at the lower caudal-fin origin.

Head length to 5th gill opening 0.83 (0.85–0.94) times in pectoral–pelvic space. Head broad and flattened, ellipsoidal-lenticular in shape in cross-section at eyes. Outline of head in lateral view undulated dorsally, nearly straight on snout, weakly convex above eye (accentuated in holotype as snout is slightly shriveled), moderately concave at nape and convex above gills, convex ventrally along lower jaws and beneath gills. In dorsoventral view, head anteriorly rounded and U-shaped (slightly more angular in holotype), with gill septa expanded outwards. Snout short, preoral snout length 0.65 (0.67–0.72) times mouth width; tip broadly rounded in dorsoventral view and with a weak angle at nostrils but not noticeably indented anterior to nostrils; snout very bluntly pointed in lateral view, weakly convex above and below.

External eye opening of fleshy orbit without anterior or posterior notches, circular in shape, with height 1.06 (0.83–1.09) in eye length. Eyes very small, length 23.23 (23.25–30.88) in head length; situated slightly dorsolateral and slightly above head rim, with lower edges crossing horizontal head rim in dorsal view; subocular ridges absent. Nictitating lower eyelids internal, with deep subocular pouches and secondary lower eyelids fused to upper eyelids.

Spiracles absent. First three gill slits subequal in height, fourth and fifth increasingly smaller, fifth about 0.92 (0.78–0.81) of height of third; height of third about 6.41 (5.37–6.51) in head length and 3.63 (4.32–5.50) times eye length. Margins of first four gill slits straight, posterior margins irregular; fifth weakly concave. Gill filaments not visible from outside. Upper end of highest gill opening about level with upper edge of eye. Gill-raker papillae absent from gill arches.

Nostrils with very large oval incurrent apertures; prominent triangular anterior nasal flaps with bluntly pointed tips, mesonarial flaps absent, small suboval excurrent apertures, posterior nasal flaps absent; well in front of mouth; width 3.11 (3.38–3.63) in internarial

Table 1. Proportional dimensions as percentages of total length for the holotype (CSIRO H 5262–01) and 6 paratypes of *Glyphis garricki* sp. nov. Ranges for the 6 paratypes are also provided.

	CSIRO H 5262–01	WAM P 32598–001	WAM P 32599–001	WAM P 32600–001	WAM P 32600–001	SAM uncat.	WAM P 32600–001	Min.	Max.
TL (mm)	670	906	957	1022	1191	1350	1418	906	1418
PCL	74.6	74.9	74.4	74.1	74.4	74.5	75.0	74.1	75.0
PRN	5.4	4.8	4.6	4.4	4.6	–	4.4	4.4	4.8
POR	7.3	7.7	7.6	7.3	7.1	7.1	7.0	7.0	7.7
POB	8.4	7.2	7.3	6.8	7.0	6.5	6.9	6.5	7.3
PGI	20.7	20.2	20.0	19.7	20.2	–	19.7	19.7	20.2
HDL	25.5	24.0	24.5	24.0	24.6	–	24.1	24.0	24.6
PP1	23.7	24.5	24.0	22.5	24.0	–	23.1	22.5	24.5
PP2	50.9	50.7	50.6	49.1	50.1	51.2	50.0	49.1	51.2
SVL	54.2	53.8	54.3	52.4	53.2	54.1	52.4	52.4	54.3
PAL	60.7	62.7	61.4	61.5	61.5	62.5	61.6	61.4	62.7
PD1	30.3	30.8	31.1	30.3	30.6	30.8	30.0	30.0	31.1
PD2	59.3	61.3	61.0	60.4	60.9	61.6	61.1	60.4	61.6
IDS	16.1	19.7	19.5	19.2	19.0	19.3	21.2	19.0	21.2
DCS	7.2	7.5	6.5	7.2	7.5	6.5	7.3	6.5	7.5
PPS	21.1	21.0	22.3	20.3	23.1	21.9	22.4	20.3	23.1
PAS	4.8	6.1	5.7	6.1	6.3	6.0	7.3	5.7	7.3
ACS	5.7	5.8	6.0	6.2	5.6	5.6	6.0	5.6	6.2
EYL	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.8	1.0
EYH	1.0	1.0	1.1	0.9	0.8	0.7	0.8	0.7	1.1
INO	11.3	11.8	12.1	11.5	11.5	11.2	11.6	11.2	12.1
NOW	2.3	1.9	2.0	1.9	1.9	1.7	1.9	1.7	2.0
INW	7.0	6.7	6.8	6.4	6.4	6.2	6.4	6.2	6.8
ANF	0.6	0.6	0.7	0.6	0.7	0.7	0.7	0.6	0.7
MOL	5.0	5.6	5.6	5.1	5.4	5.8	5.3	5.1	5.8
MOW	11.2	10.7	10.7	10.7	10.6	10.5	10.4	10.4	10.7
ULA	0.4	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.6
LLA	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
GS1	3.9	4.1	3.6	3.8	3.1	3.8	3.6	3.1	4.1
GS2	4.0	4.4	3.8	3.9	3.3	3.9	4.1	3.3	4.4
GS3	4.0	4.5	4.2	4.0	3.8	4.1	4.5	3.8	4.5
GS4	3.8	4.2	4.1	3.9	3.7	4.0	4.3	3.7	4.3
GS5	3.6	3.6	3.4	3.2	3.1	3.2	3.6	3.1	3.6
HDH	13.8	13.9	15.0	15.5	14.4	14.7	14.3	13.9	15.5
HDW	14.3	13.2	14.5	13.5	13.2	13.9	13.0	13.0	14.5
TRH	14.8	17.0	16.2	17.0	16.8	17.1	17.2	16.2	17.2
TRW	12.4	13.1	15.9	15.0	14.8	15.2	12.9	12.9	15.9
CPH	4.0	3.9	4.0	3.7	3.9	3.9	3.6	3.6	4.0
CPW	3.3	3.3	3.3	3.5	3.2	3.1	3.0	3.0	3.5
P1L	13.2	13.0	13.7	13.2	12.9	13.8	13.0	12.9	13.8
P1A	19.6	20.5	22.1	20.8	22.4	22.2	21.6	20.5	22.4
P1B	7.2	7.1	8.3	7.9	7.5	8.1	7.5	7.1	8.3

Table 1. cont'd.

	CSIRO H 5262–01	WAM P 32598–001	WAM P 32599–001	WAM P 32600–001	WAM P 32600–001	SAM uncat.	WAM P 32600–001	Min.	Max.
P1H	17.7	19.2	20.2	19.3	20.1	20.4	18.5	18.5	20.4
P1I	6.7	6.4	6.7	6.4	6.3	6.1	6.2	6.1	6.7
P1P	15.6	18.2	19.6	18.8	19.2	19.1	18.9	18.2	19.6
P2L	10.6	9.8	10.2	9.2	9.6	9.6	9.2	9.2	10.2
P2A	9.0	8.6	9.1	8.1	8.2	8.1	7.6	7.6	9.1
P2B	6.7	6.8	6.8	5.8	6.7	6.7	5.4	5.4	6.8
P2H	7.4	7.5	8.1	7.3	6.9	8.1	7.0	6.9	8.1
P2I	3.9	3.6	3.9	3.7	3.5	3.7	4.8	3.5	4.8
P2P	7.7	8.3	8.2	7.9	8.0	7.8	7.4	7.4	8.3
CLO	–	1.7	–	2.0	2.4	–	6.6	1.7	6.6
CLI	–	3.7	–	3.5	4.5	–	9.0	3.5	9.0
CLB	–	0.9	–	0.7	1.1	–	1.5	0.7	1.5
D1L	18.7	17.0	17.7	17.1	17.2	17.4	16.7	16.7	17.7
D1A	13.9	13.9	15.2	13.9	14.4	14.3	14.3	13.9	15.2
D1B	13.3	11.9	12.6	11.9	12.3	12.9	12.2	11.9	12.9
D1H	9.4	9.7	10.6	9.6	10.8	10.5	10.6	9.6	10.8
D1I	5.7	5.6	5.3	5.4	5.4	4.9	5.3	4.9	5.6
D1P	11.5	11.2	12.5	11.7	13.3	13.1	13.1	11.2	13.3
D2L	12.5	10.9	11.1	10.4	10.9	10.2	10.5	10.2	11.1
D2A	9.8	9.0	9.9	8.6	9.1	8.6	8.8	8.6	9.9
D2B	8.4	7.1	7.3	6.8	7.1	6.6	7.0	6.6	7.3
D2H	6.0	6.5	6.7	5.8	6.9	6.1	6.1	5.8	6.9
D2I	4.0	4.2	4.1	4.0	4.3	3.8	3.8	3.8	4.3
D2P	7.4	8.0	8.1	7.7	8.1	7.8	7.0	7.0	8.1
ANL	10.9	9.4	10.3	9.4	9.2	9.4	9.3	9.2	10.3
ANA	9.1	8.4	8.8	8.3	8.3	8.0	8.5	8.0	8.8
ANB	7.0	6.0	6.6	6.4	6.4	6.4	6.6	6.0	6.6
ANH	5.0	5.3	5.1	4.6	5.0	4.7	4.7	4.6	5.3
ANI	3.9	3.5	3.7	3.4	3.5	3.3	3.1	3.1	3.7
ANP	5.7	5.9	5.8	5.6	5.9	5.8	5.5	5.5	5.9
CDM	25.2	24.6	24.8	25.0	25.2	24.4	24.3	24.3	25.2
CPV	12.7	13.4	13.9	13.0	13.9	13.4	13.7	13.0	13.9
CPL	5.7	7.0	7.4	7.1	7.9	6.8	7.3	6.8	7.9
CPU	12.0	13.4	12.5	13.1	12.9	13.3	13.6	12.5	13.6
CST	4.2	4.0	3.7	4.0	3.8	3.8	3.8	3.7	4.0
CTR	6.8	7.3	6.7	7.1	7.4	7.0	7.0	6.7	7.4
CTL	7.9	8.3	8.1	8.2	8.3	8.2	7.9	7.9	8.3
CFL	9.1	8.9	9.0	8.2	8.5	–	8.2	8.2	9.0
DPI	6.7	7.0	6.4	6.1	6.3	–	6.8	6.1	7.0
DPO	13.1	15.1	13.6	14.2	13.1	–	12.9	12.9	15.1
PDI	9.2	11.8	10.6	11.9	10.8	–	10.8	10.6	11.9
PDO	5.9	5.8	7.4	6.8	7.0	–	8.8	5.8	8.8
DAO	2.1	1.6	1.3	1.5	1.4	0.8	1.0	0.8	1.6
DAI	0.4	1.3	0.5	0.7	0.9	0.6	0.7	0.5	1.3

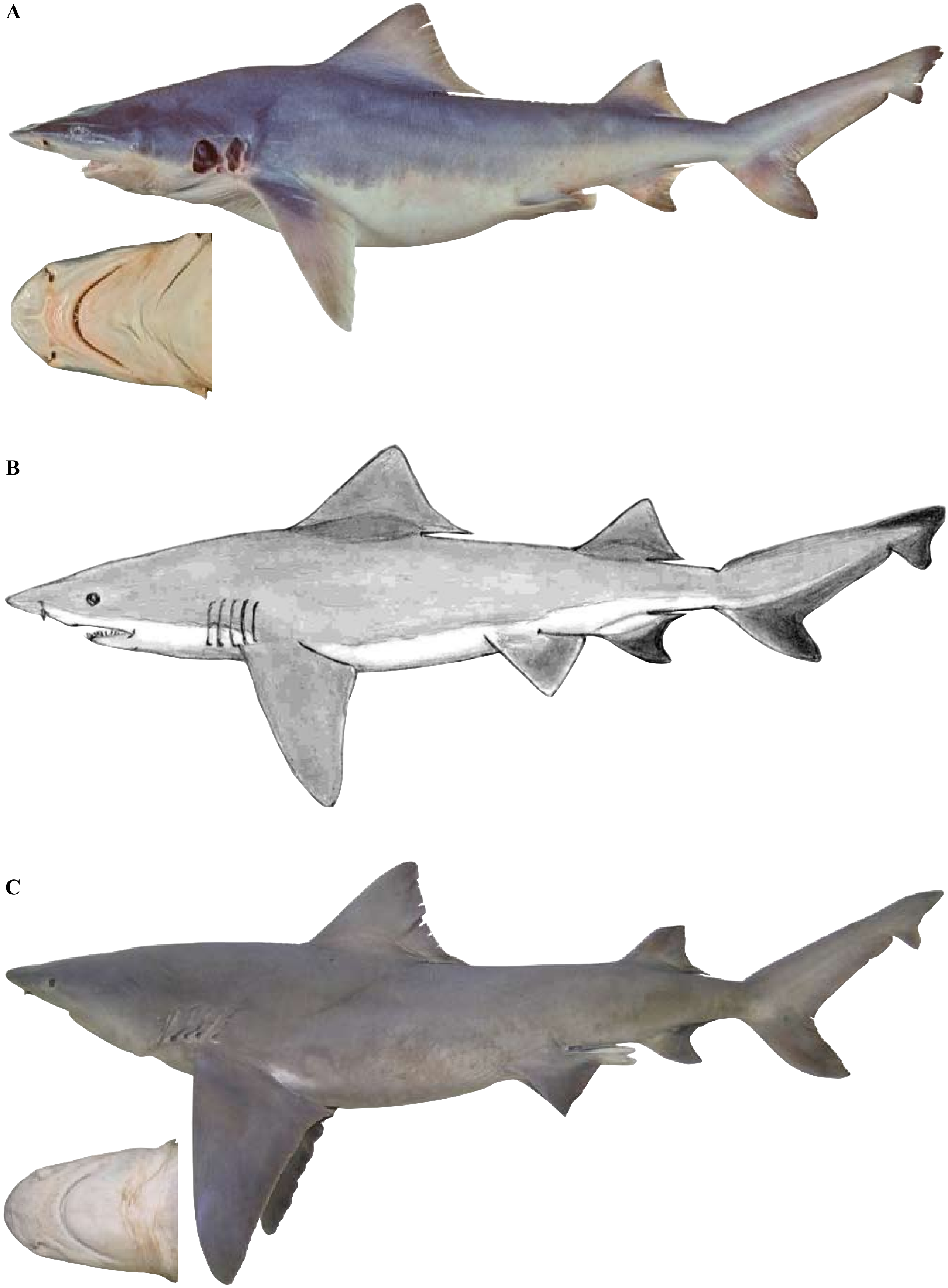

Figure 1. Whole lateral view and ventral view of head of *Glyphis garricki* sp. nov.: A. fresh holotype CSIRO H 5262–01 (female 670 mm TL); B. illustration of preserved holotype (by L.J.V. Compagno); C. preserved paratype WAM P 32600–001 (adult male 1418 mm TL).

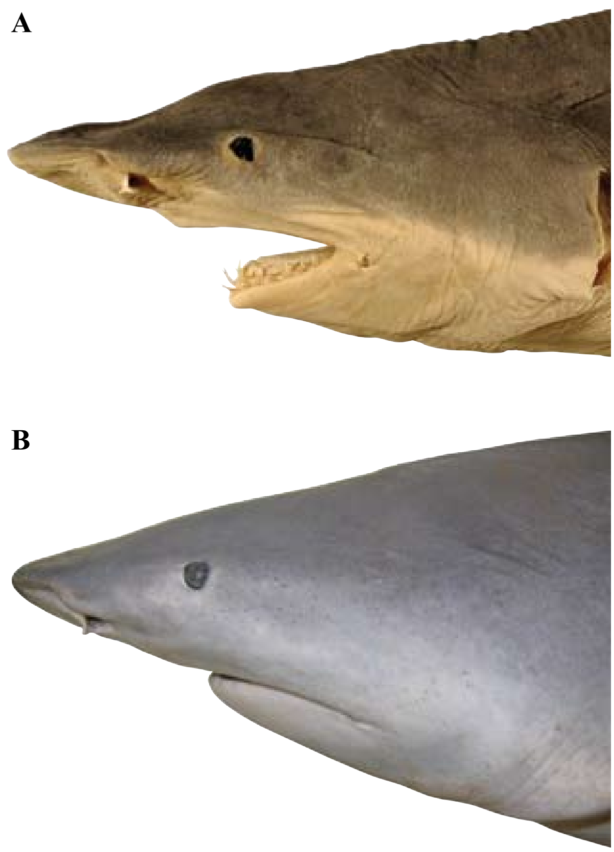

Figure 2. Lateral view of head of *Glyphis garricki* sp. nov.: A. preserved holotype CSIRO H 5262–01 (female 670 mm TL); B. preserved paratype WAM P 32600–001 (adult male 1418 mm TL).

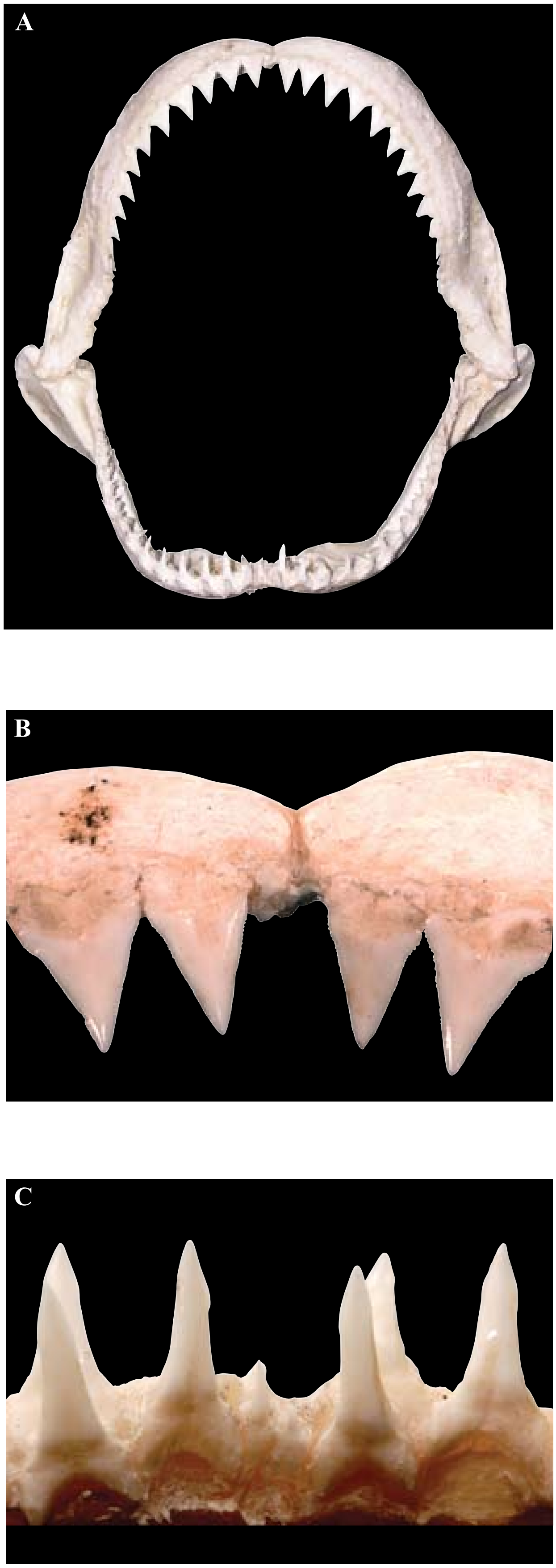

Figure 3. A. jaws, B. central upper teeth, and C. central lower teeth of *Glyphis garricki* sp. nov. (CSIRO H 6173–01, female 1770 mm TL).

width, 0.49 (0.42–0.53) in eye length, 1.76 (2.01–2.42) in longest gill-opening.

Mouth broadly arched and large; margin of lower jaw less convex near symphysis; width 2.27 (2.24–2.33) in head length; mouth length 2.27 (1.80–2.09) in mouth width. Lips not concealing teeth when mouth is closed (teeth totally obscure or only slightly visible in large paratypes). Tongue large, flat and broadly rounded, filling floor of mouth. Maxillary valve narrow, width slightly less than eye diameter, strongly papillose. No large buccal papillae on floor or roof of mouth behind maxillary valve. Palate, floor of mouth and gill arches covered with buccopharyngeal denticles. Labial furrows short, uppers 1.26 (2.05–3.19) times as long as lowers, lowers concealed by overlapping upper lip; anterior ends of uppers far behind eyes by distance about 40–45% of mouth width. Labial cartilages appear to be absent.

Teeth relatively few, in 34 in holotype (31–34, n=15)/34 (30–35) rows or 68 (62–67) total rows (both jaws), 1–2/2–3 series functional. Teeth not arranged in diagonal files, no toothless spaces at symphysis. Teeth highly

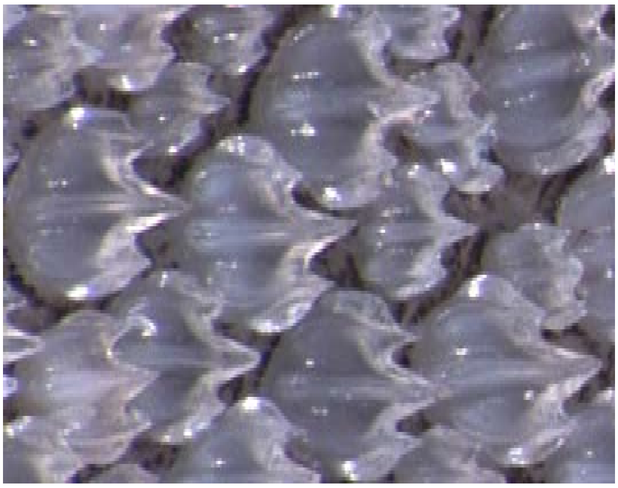

Figure 4. Cusps of the flank denticles of *Glyphis garricki* sp. nov., paratype WAM P 32598–001 (juvenile male 906 mm TL).

differentiated in upper and lower jaws and along jaws, tooth row groups include upper and lower medials (M), anteriorised lower symphysials (AS), and anteriors (A), laterals (L), and posteriors (P) in both jaws. Tooth formula (n=16): upper jaw 17 (15–16) + 1 (1–2) + 16 (15–16); lower jaw 17 (15–16) + 1 (1–2) + 16 (14–16). Upper teeth with tall, broad, flat, triangular, blade-like, erect to semi-oblique cusps (except posteriors), distal and mesial edges serrated (except for most posteriors); unnotched mesial edges; slightly arched roots. Lower teeth with narrow, tall, erect, slightly hooked (anteriorised symphysial and anteriors) to straight cusps; first few anterior teeth of large specimens hastate with serrated cutting edges usually confined to spear-like tips (not obvious in small specimens, including holotype); no cusplets; low mesial and distal shoulders or blades (except in posteriors).

Lateral trunk denticles of juvenile male (WAM P 32598–001) small, imbricate, transversely oval, with 3 short, stout cusps; crowns about as wide as long, with 3 prominent longitudinal ridges (medial ridge stronger and more pronounced) that extend entire length of crown onto cusps; medial cusp short but strong, shorter than rest of crown, flanked by a pair of slightly shorter lateral cusps.

Pectoral fins large (relatively larger in adult male paratype), weakly falcate; anterior margin slightly convex, apices very narrowly rounded; posterior margin weakly concave (more so in adult male paratype); free rear tip broadly rounded, inner margin strongly convex; base broad about 60% of fin length; length from origin to rear tip 1.48 (1.58–1.73) times in anterior margin length; much greater in area than first dorsal fin; origin varying from about under third to under fourth gill slits; fin apex about opposite inner margin when fin is elevated and appressed to body.

Pelvic fins triangular and not falcate; length of anterior margin 0.46 (0.35–0.42) of pectoral-fin anterior margin; area about 1.5 times that of anal fin; anterior margin nearly straight and slightly concave near base; apices very narrowly rounded; posterior margin nearly straight or slightly convex; free rear tip bluntly rounded, inner margin nearly straight with a basal convexity in holotype; posterior margin, rear tip and inner margin forming a broad triangle with an ~60° apex. Claspers of adult male paratype (WAM P 32600–01, 1418 mm TL) short, relatively broad, moderately stout, not tapering sharply distally, outer length 6.6% TL, base width 22.3% of outer length; clasper glans extending to about half of clasper outer length.

First dorsal fin apically narrow and broadly triangular, not falcate; angle of apex about 80 to 90°; anterior margin broadly convex (weakly concave basally); apex narrowly subangular; posterior margin distally straight and basally moderately concave; free rear tip acutely pointed, inner margin concave to almost straight; origin slightly forward of insertion of pectoral-fin bases (over insertion in larger paratypes), midpoint of base 2.0 (1.9–2.3) times closer to pectoral insertions than pelvic origins; free rear tip just anterior to pelvic-fin origins (by about 10% of first dorsal-fin inner margin length); posterior margin arcing posteroventrally from apex; insertion well behind level of dorsal-fin apex by about 70% of inner margin length. First dorsal fin base 1.21 (1.49–1.74) in interdorsal space, 1.89 (1.89–2.10) in dorsal caudal margin; height 1.41

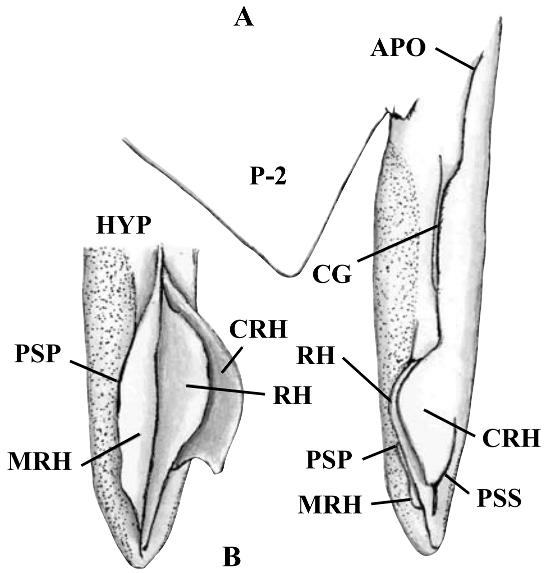

Figure 5. Clasper (left) of *Glyphis garricki* sp. nov., adult male paratype (WAM P 32600–001, 1418 mm TL): A. entire clasper; B. glans dilated. APO, apopyle; CG, clasper groove; CRH, cover rhipidion; HP, hypopyle; MRH, mesorhipidion; P-2, pelvic fin; PSP, pseudopera; PSS, pseudosiphon; RH, rhipidion.

Figure 6. Freshly caught specimen of *Glyphis garricki* sp. nov. (specimen not retained) highlighting fresh coloration.

(1.14–1.24) in base; inner margin 1.65 (1.73–2.16) in height, 2.33 (2.11–2.65) in base.

Second dorsal fin apically narrow, subtriangular; height 0.64 (0.58–0.66) times first dorsal-fin height, base 0.63 (0.51–0.60) times first dorsal-fin base; anterior margin weakly convex (more so in larger paratypes); apex narrowly subangular; posterior margin convex distally and basally concave; free rear tip acutely pointed, inner margin nearly straight; origin well behind pelvic-fin insertions and about opposite pelvic-fin free rear tips (slightly behind in larger paratypes); rear tip about opposite or slightly behind anal-fin free rear tip, in front of upper caudal-fin origin by 0.25 (0.22–0.40) times its inner margin; posterior margin curving posteroventrally from apex (almost upright in some paratypes); insertion slightly behind fin apex in holotype. Second dorsal fin base 0.85 (0.89–1.06) in dorsal–caudal space; height 1.40 (1.03–1.17) in base; inner margin 1.49 (1.46–1.64) in height, 2.09 (1.68–1.84) in base.

Anal fin apically narrow and semi-falcate; height 0.84 (0.72–0.81) times second dorsal-fin height, base length 0.83 (0.83–0.98) times second dorsal-fin base; anterior margin indented basally and distally broadly convex; apex bluntly pointed; posterior margin deeply notched at about a right angle; free rear tip acutely pointed, inner margin slightly concave; origin slightly behind second dorsal-fin origin by about a third inner margin length; insertion slightly behind second dorsal-fin insertion, slightly in front of fin apex; free rear tip in front of lower caudal-fin origin by about half of its inner margin length; posterior margin slanting anterodorsally and then abruptly posterodorsally. Anal-fin base expanded anteriorly as very short preanal ridges (obscure), less than a quarter length of rest of base. Anal-fin base 0.81 (0.87–0.97) in anal–caudal space; height 1.39 (1.13–1.40) in base; inner margin 1.30 (1.34–1.54) in height, 1.81 (1.70–2.16) in base.

Caudal fin narrow-lobed and asymmetrical, with short terminal lobe and prominent, long, narrowly expanded, weakly falcate ventral lobe (more erect in adult males); dorsal caudal margin proximally and distally convex, and slightly concave just anterior to subterminal notch, with prominent lateral undulations; preventral margin strongly convex (less so in largest paratypes), tip of ventral caudal-fin lobe bluntly pointed; lower postventral margin strongly convex; upper postventral margin nearly straight except for convex section at subterminal notch; notch between postventral margins deep, forming about a 90° angle (angle greater in larger paratypes); subterminal notch a narrow, deep slot; subterminal margin slightly concave to almost straight, terminal margin irregular and deeply concave, lobe formed by these margins narrowly rounded or bluntly pointed, tip of tail narrowly rounded. Length of dorsal caudal margin 2.96 (2.95–3.09) in precaudal length, preventral caudal margin 1.98 (1.77–1.92) in dorsal caudal margin, terminal lobe from caudal tip to subterminal notch about 3.19 (2.97–3.07) in dorsal caudal margin, subterminal margin length 1.60 (1.78–1.92) in terminal margin.

Vertebral counts listed in Table 2. Counts of total vertebral centra (TC) 148 (137–151, n=14), precaudal centra (PC) 79 (73–81, n=13), monospondylous precaudal (MP) centra 47 (44–50, n=12), diplospondylous precaudal (DP) centra 32 (28–34, n=12), diplospondylous caudal (DC) centra 69 (61–70, n=13); MP centra 31.8 (30.6–33.8)%, DP centra 21.6 (20.0–23.6)%, and DC centra 46.6 (43.9–47.9)% of TC centra. Ratios of DP/MP centra 0.68 (0.62–0.77), DC/MP centra 1.47 (1.30–1.50), ‘A’ ratio 129.8–147.3 (n=3), ‘B’ ratio 91.4–96.9 (n=3). Transition between MP and DP centra about over pelvic bases and, in holotype, 4 centra posterior to pelvic girdle. Last few MP centra before MP–DP transition not enlarged and not forming a ‘stutter zone’ of alternating long and short centra.

COLOUR.— When fresh and in preservative: uniformly medium slate-grey on dorsal surface of sides of head, trunk and tail, abruptly whitish on lower lateral and ventral surfaces. Demarcation of light and dark

Table 2. Vertebral counts and ratios for the holotype (CSIRO H 5262–01) and 6 paratypes *Glyphis garricki* sp. nov. Ranges for the 7 radiographed types and for 7 additional specimens are also provided.

	CSIRO H 5262–01	CSIRO H 6173–01	WAM P 32598–001	WAM P 32599–001	WAM P 32600–001	WAM P 32600–001	SAM uncat.	WAM P 32600–001	Types Min.	Types Max.	Other specimens Min.	Other specimens Max.
TL (mm)	670	1770	906	957	1022	1191	1350	1418				
Vertebrae:												
MP	47	–	46	–	47	–	47	47	46	47	44	50
DP	32	–	33	–	31	–	32	34	31	34	28	34
DC	69	66	68	–	64	–	69	70	64	70	61	69
PC	79	73	79	–	78	–	79	81	73	81	73	83
TC	148	139	147	147	142	147	148	151	139	151	137	148
%MP	31.8	–	31.3	–	33.1	–	31.8	31.1	31.1	33.1	30.6	33.8
%DP	21.6	–	22.4	–	21.8	–	21.6	22.5	21.6	22.5	20.0	23.6
%DC	46.6	–	46.3	–	45.1	–	46.6	46.4	45.1	46.6	43.9	47.9
%PC	53.4	–	53.7	–	54.9	–	53.4	53.6	53.4	54.9	52.1	56.1
DP/MP	0.7	–	0.7	–	0.7	–	0.7	0.7	0.7	0.7	0.6	0.8
DC/MP	1.5	–	1.5	–	1.4	–	1.5	1.5	1.4	1.5	1.3	1.5
A ratio	147.3	–	–	–	–	–	–	–	–	–	129.8	143.1
B ratio	96.9	–	–	–	–	–	–	–	–	–	91.4	96.5

surfaces (waterline) of head strong, well below eye (by at least an eye height) and at level of nostrils, extending to well below middle of gill slits, terminating on membrane of fifth gill opening; dark area below eye visible ventrally between nostril and corner of mouth; waterline irregular, jagged along abdomen to origin of pelvic fin (distance between origin of pelvic fin and waterline about a nostril width or less); waterline directed posterodorsally above pelvic-fin base, extending along tail mid-laterally; pale area continuing onto base of caudal fin, apparent as a pale marking along the upper lobe to the origin of the terminal lobe; waterline on larger paratypes less distinct, ventral coloration dusky in WAM paratypes. Dorsal fins similar to each other and dorsal surface of body, sometimes paler centrally, usually with a slightly darker posterior margin. Caudal fin with darker markings ventrally; upper lobe greyish dorsally, with prominent black tip and posterior margin of terminal lobe; upper postventral margin darker grey with a narrow black posterior margin; ventral lobe mostly dark, almost blackish posteriorly, with a narrow black posterior margin, anterior base and margin pale (less contrasted in larger paratypes). Anal fin pale basally and anteriorly, with a large distal blackish blotch (dusky in larger paratypes); free rear tip mostly pale. Pelvic-fin dorsal surfaces mostly dusky, with pale margins; ventral surfaces with pale base and dusky on distal web (dark areas covering more than half of fin). Pectoral-fin dorsal surfaces uniformly dusky; continuous on basal area and flank (without a dark basal blotch); posterior margin slightly paler; basal anterior margin pale; ventral surfaces with pale base and dusky on distal web, without black blotch near apex. Mouth white; eye pupil black; a more or less conspicuous narrow light ring around eyes. Claspers of adult male paratype (WAM P 32600–001, intact adult male) uniformly greyish dorsally, pale ventrally.

SIZE.— Type specimens range in length from 670–1770 mm TL, while the largest specimen captured was a 2510 mm TL post partum female (R. Pillans, pers. comm.). Two male paratypes were adult at 1418 mm TL (WAM P 32600–001) and ca. 1450 mm TL (CSIRO H 6635–01); 5 specimens (720–1191 mm TL) were immature. One male specimen (WAM P 32597–001) is adolescent at only 994 mm TL, but this deformed specimen shows severe fusing of vertebrae and spinal curvature (see Thorburn & Morgan, 2004) and is thus not directly comparable to the "normal" type specimens. A female paratype (CSIRO H 6173–01, 1770 mm TL, jaws only retained) was mature; one female paratype (SAM uncatalogued) was immature at 1350 mm TL. The smallest specimen was the female holotype (CSIRO H 5262–01) at 670 mm TL which had no evidence of an umbilical scar.

DISTRIBUTION.— Known from scattered localities off northern Australia and New Guinea (Fig. 12). In Western Australia, recorded from King Sound (17°20′ S, 123°34′

E) and Doctors Creek (17°13′ S, 123°40′ E) near Derby in salinities 32 and 36.6. In Northern Territory, recorded from the Adelaide and West, East and South Alligator Rivers (Larson, 2000) in salinities of 6 to 26.

ETYMOLOGY.— Named after Prof. J.A.F. Garrick of Victoria University, Wellington, New Zealand, for his revisions of the Carcharhinidae (Garrick, 1982) and who discovered this species in the form of two newborn males from Papua New Guinea and supplied radiographs, morphometrics, drawings and other details of these specimens (since lost) to the senior author. Vernacular: Northern River Shark.

Glyphis glyphis (Müller & Henle, 1839)

Figs 7–11, 13c; Tables 3 and 4

Glyphis sp. A: Last & Stevens, 1994: pp 222, 259, 260, key figs 6 and 8, fig. 29.23, pl. 29; Compagno & Niem, 1998: pp 1318, 1360, fig. 24; Daley *et al*., 2002: p 311, pl. 55; Peverell *et al*., 2006: pp 53–68, figs 2–4, 6.

Glyphis sp. A [? = *G. glyphis*]: Compagno *et al*., 2005: p 311, pl. 55.

Holotype. ZMB 5265, stuffed specimen, juvenile female 1023 mm TL, locality unknown but probably Indian Ocean (photos, morphometrics and radiographs of tail from Dr. H. Paepke).

Other material. 15 specimens: CSIRO H 5261–01, juvenile male 770 mm TL, East Alligator River, Kakadu National Park, Northern Territory, 12°12′ S, 132°47′ E, 1–3.5 m, 10 Jun 1999; CSIRO H 5756–01, juvenile male 631 mm TL, Marrakai Creek, Adelaide River, Northern Territory, 12°41′ S, 131°20′ E, 28 Nov 2001; NTM S 15097–001, juvenile male 792 mm TL, Brooks Creek, South Alligator River, Kakadu National Park, Northern Territory, 12°12′ S, 132°24′ E, 04 Jun 1999; NTM S 15351–001, female 678 mm TL, Marrakai Creek, Adelaide River system, Kakadu National Park, Northern Territory, 12°41′ S, 131°20′ E, 11 Sep 2001; NTM S 15508–001, female 595 mm TL, NTM S 15508–002, juvenile male 590 mm TL, Adelaide River system, Kakadu National Park, Northern Territory, 12°37′ S, 132°47′ E, 16 Nov 2002; NTM S 16217–001, adolescent male 1447 mm TL, Wenlock River, Cape York Peninsula, Queensland, 12°03′ S, 141°55′ E, 01 Feb 2006; QM I 19719, juvenile male 745 mm TL, 17 km upstream from Bizant River mouth, Princess Charlotte Bay, Queensland, 14°33′ S, 144°05′ E, 23 Mar 1982; QM I 36881, female 1095 mm TL, QM I 36882, juvenile male 705 mm TL, QM I 36883, juvenile male 867 mm TL, QM I 36884, juvenile male 723 mm TL, QM I 36885, 770 mm TL, Gloughs Landing, Wenlock River, Queensland, 12°45′ S, 142°59′ E, 28 Apr 2005; LWF–E218 (jaws), juvenile female ca. 1600–1800 mm, Port Romilly, New Guinea, 07°40′ S, 144°50′ E, 12 Mar 1966; LWF–E405B (jaws, supplied by Kailola), ca. 1700–1800 mm, Alligator Island, Fly River, New Guinea, 07°19′ S, 141°11′ E.

DIAGNOSIS.— A species of *Glyphis* with a short and broadly wedge-shaped snout as seen in lateral view. Closest distance from mouth to nostril 1.8–2.1 times nostril width. Lips usually concealing teeth when mouth is closed. Upper symphysis above or just in front of anterior eye margin. Lower anterior teeth with entire, weakly serrated edges in young, smooth basally in adults and subadults, tips not hastate in young but prominently so in adults; lower anterior teeth with low mesial and distal cusplets in young, absent in adults and subadults. Anteroposterior tooth row counts 13–14/13–14; total tooth row counts 26–29/27–29, or 53–58. Interdorsal space 14.5–18.4% TL. Anterior margins of pectoral fins strongly convex, pectoral length 11.3–14.0% TL. Pelvic-fin anterior margin 7.0–9.0% TL and 36–45% of pectoral-fin anterior margin, pelvic-fin height 4.7–8.0% TL. First dorsal fin semifalcate, with concave posterior margin, free rear tip well anterior to about opposite pelvic-fin origins; length 16.2–19.6% TL. Second dorsal-fin length 9.8–13.0% TL, anterior margin 7.0–10.7% TL, base 6.5–8.9% TL and 1.1–1.5 times second dorsal-fin height, height 5.8–6.9% TL and 70–84% of first dorsal height. Anal fin height 3.0–5.4% of total length and 53–90% of second dorsal-fin height, base 81–91% of second dorsal-fin base. Caudal fin subterminal margin straight or weakly concave. Total vertebral counts 213–222; monospondylous precaudal counts 69–73 and 32–34% of total counts; diplospondylous precaudal counts 50–54 and 23–25% of total counts; diplospondylous caudal counts 89–99 and 42–45% of total counts; precaudal counts 123–124 and 55–58% of total counts. Watermark boundary just below eye and not visible below eyes on ventral view of head; watermark boundary sharply defined and regular along trunk in young, about twice nostril width above pelvic-fin bases. No discrete blackish blotch at base of dorsal pectoral-fin; pectoral-fin tip with a black blotch ventrally. Anal fin with a dusky to blackish distal web. Terminal caudal lobe with narrow black tip, ventral caudal lobe with black apical blotch.

DESCRIPTION.— Body stout, trunk subcircular and almost pear-shaped in section at first dorsal-fin base, length of trunk from fifth gill slits to vent 1.11 (0.99–1.16) times head length. Predorsal, interdorsal and postdorsal ridges absent from midline of back, lateral ridges absent from body. Caudal peduncle stout, rounded-weakly hexagonal in section at second dorsal-fin insertion, postdorsal and postventral spaces flattened and often with a shallow median groove anteriorly, lateral surfaces subangular and with a broad, very low, inconspicuous lateral ridge on each side at middle of the peduncle that extends anteriorly to the pelvic-fin midbases and posteriorly onto the caudal-fin base; height of caudal peduncle at 2nd dorsal-fin insertion 1.21 (1.14–1.25) times its width, 1.97 (1.20–1.61) times in dorsal–caudal space. Precaudal pits present; upper pit a pronounced, subtriangular depression, not arcuate and crescentic; lower pit rudimentary, essentially a dimple at

Table 3. Proportional dimensions as percentages of total length for the holotype (ZMB 5265) and 8 additional specimens of *Glyphis glyphis.* Ranges for the 8 additional specimens are also provided.

	ZMB 5265	CSIRO H 5261–01	CSIRO H 5756–01	NTM S 15508–001	NTM S 15508–002	NTM S 15097–001	NTM S 15351–001	NTM S 16217–001	QM I 19719	Min.	Max.
TL	1023	770	631	595	590	792	678	1447	754	590	1447
PCL	76.7	73.5	73.7	74.3	73.1	73.9	74.3	74.1	72.9	72.9	74.3
PRN	3.7	4.3	4.5	4.7	4.5	4.3	4.6	3.8	3.3	3.3	4.7
POR	2.8	6.9	7.1	7.6	7.2	6.9	7.9	6.5	7.2	6.5	7.9
POB	5.9	7.0	7.5	7.4	7.5	7.2	7.5	6.3	7.2	6.3	7.5
PGI	15.5	20.5	20.4	20.6	20.3	20.4	21.5	20.4	20.4	20.3	21.5
HDL	26.0	25.1	24.0	24.8	24.4	24.9	25.9	25.2	25.2	24.0	25.9
PP1	23.0	22.3	22.8	22.5	22.7	22.5	23.5	22.8	24.1	22.3	24.1
PP2	51.8	49.7	49.6	49.4	47.8	49.2	50.6	50.5	47.2	47.2	50.6
SVL	54.7	52.1	51.8	52.4	51.0	51.9	53.2	53.0	50.1	50.1	53.2
PAL	64.1	60.9	60.5	60.0	59.8	60.6	61.2	61.7	60.2	59.8	61.7
PD1	31.3	29.2	30.0	30.1	28.8	30.1	30.5	29.6	29.7	28.8	30.5
PD2	63.8	59.1	59.6	58.5	58.3	58.8	59.4	60.8	58.6	58.3	60.8
IDS	20.8	17.1	18.0	14.5	16.1	16.9	16.4	18.4	16.3	14.5	18.4
DCS	6.7	6.7	6.3	6.8	6.5	6.8	6.5	6.1	6.5	6.1	6.8
PPS	20.7	21.0	22.5	20.2	20.0	19.8	20.9	20.0	17.2	17.2	22.5
PAS	7.6	5.5	5.8	5.2	6.6	6.3	5.4	6.0	4.6	4.6	6.6
ACS	7.3	5.3	5.0	4.5	5.4	5.2	5.1	5.1	5.0	4.5	5.4
EYL	1.0	1.1	1.1	1.2	1.1	0.9	1.1	0.8	1.2	0.8	1.2
EYH	1.0	1.2	1.1	1.2	1.2	1.1	1.3	0.9	1.2	0.9	1.3
INO	8.6	10.9	10.8	10.9	10.9	11.2	11.7	11.2	11.0	10.8	11.7
NOW	1.5	1.9	1.8	2.1	2.0	1.9	2.0	1.8	2.0	1.8	2.1
INW	5.2	6.4	6.0	6.1	6.1	6.4	6.6	6.2	6.4	6.0	6.6
ANF	0.3	0.6	0.5	0.6	0.5	0.7	0.8	0.7	0.8	0.5	0.8
MOL	5.1	5.3	5.3	5.5	5.4	5.7	6.1	5.8	6.0	5.3	6.1
MOW	9.8	10.7	10.2	10.2	10.8	10.6	10.5	10.4	10.2	10.2	10.8
ULA	–	0.5	0.4	0.4	0.5	0.5	0.4	0.5	0.7	0.4	0.7
LLA	–	0.5	0.4	0.4	0.6	0.5	0.6	0.6	0.4	0.4	0.6
GS1	4.6	4.0	3.8	3.7	3.6	3.8	3.7	4.1	3.6	3.6	4.1
GS2	4.4	4.0	3.7	3.8	3.9	3.8	3.7	3.9	3.3	3.3	4.0
GS3	4.4	3.8	3.5	3.6	3.8	4.0	3.8	3.7	3.4	3.4	4.0
GS4	3.8	3.8	3.4	3.5	3.8	3.9	3.7	3.7	3.3	3.3	3.9
GS5	3.2	3.3	3.2	2.9	3.1	3.3	3.2	3.3	2.8	2.8	3.3
HDH	–	14.0	12.6	13.1	13.9	13.8	13.4	13.2	6.2	6.2	14.0
HDW	–	13.8	13.1	13.2	14.1	14.6	14.0	15.8	11.7	11.7	15.8
TRH	7.6	15.3	13.5	13.9	14.8	14.2	13.7	14.4	14.7	13.5	15.3
TRW	7.0	13.2	12.8	12.7	13.2	13.1	13.4	13.9	11.0	11.0	13.9
CPH	3.4	4.5	4.2	4.5	4.5	4.6	4.1	4.3	5.4	4.1	5.4
CPW	2.8	3.6	3.5	3.7	3.7	3.8	3.5	3.6	4.8	3.5	4.8
P1L	11.3	14.0	12.1	12.9	12.2	13.6	12.6	14.0	13.8	12.1	14.0
P1A	19.7	18.7	17.6	17.5	17.6	18.4	19.3	22.2	20.6	17.5	22.2
P1B	7.9	8.1	7.1	7.2	6.9	7.7	7.6	7.6	7.8	6.9	8.1

Table 3. cont'd.

	ZMB 5265	CSIRO H 5261–01	CSIRO H 5756–01	NTM S 15508–001	NTM S 15508–002	NTM S 15097–001	NTM S 15351–001	NTM S 16217–001	QM I 19719	Min.	Max.
P1H	15.8	17.5	15.6	14.9	15.0	16.7	17.9	20.8	18.2	14.9	20.8
P1I	5.0	6.9	5.9	6.3	5.7	6.7	6.0	7.9	6.2	5.7	7.9
P1P	15.1	15.5	13.8	13.4	14.2	15.4	16.4	20.8	18.0	13.4	20.8
P2L	7.1	10.3	9.5	10.1	9.7	10.1	9.6	10.2	9.9	9.5	10.3
P2A	7.0	8.3	7.6	7.8	7.8	8.0	7.7	8.3	9.0	7.6	9.0
P2B	4.6	6.1	5.8	6.0	6.3	6.1	6.5	6.6	6.0	5.8	6.6
P2H	4.7	8.0	6.9	7.2	7.3	6.6	7.3	7.9	7.2	6.6	8.0
P2I	4.0	4.3	3.6	4.5	3.7	4.1	3.4	4.0	4.4	3.4	4.5
P2P	5.0	8.5	7.0	7.3	7.4	7.5	8.0	8.1	7.3	7.0	8.5
CLO	–	–	–	–	–	–	–	–	2.5	2.5	2.5
CLI	–	–	–	–	–	–	–	–	5.3	5.3	5.3
CLB	–	–	–	–	–	–	–	–	0.9	0.9	0.9
D1L	16.2	18.7	16.9	18.6	18.3	18.1	17.9	18.5	19.6	16.9	19.6
D1A	12.3	14.3	12.8	13.6	14.3	13.7	13.6	14.8	15.0	12.8	15.0
D1B	12.2	13.3	12.1	13.4	13.1	13.2	12.6	13.0	13.9	12.1	13.9
D1H	6.8	9.1	8.3	8.9	9.0	9.0	8.7	10.3	9.8	8.3	10.3
D1I	4.4	5.6	5.0	5.3	5.0	5.0	5.3	5.6	5.2	5.0	5.6
D1P	7.8	11.3	10.2	10.7	11.0	12.1	10.6	11.8	13.0	10.2	13.0
D2L	9.8	12.6	11.8	13.0	11.9	11.7	11.5	11.3	12.6	11.3	13.0
D2A	7.2	9.7	9.4	10.1	9.4	9.9	10.0	9.0	10.7	9.0	10.7
D2B	6.5	8.6	8.3	8.9	8.1	8.2	8.0	7.3	8.5	7.3	8.9
D2H	5.8	6.4	5.5	5.9	6.0	6.3	6.7	7.0	6.9	5.5	7.0
D2I	3.2	4.1	3.5	4.2	4.0	3.7	3.4	4.2	4.1	3.4	4.2
D2P	6.1	7.8	6.5	7.4	7.0	8.0	7.3	8.2	7.7	6.5	8.2
ANL	7.6	11.1	10.5	11.1	10.7	10.6	11.0	10.2	10.3	10.2	11.1
ANA	7.0	8.9	8.9	9.1	8.7	9.0	9.8	8.5	9.4	8.5	9.8
ANB	5.5	7.2	6.9	7.2	7.1	6.8	7.3	6.5	7.0	6.5	7.3
ANH	3.0	5.4	4.7	5.3	5.2	5.0	5.3	5.3	5.3	4.7	5.4
ANI	2.8	4.1	3.5	3.9	3.8	4.0	3.9	3.9	4.1	3.5	4.1
ANP	3.0	6.7	5.7	6.6	6.7	5.8	5.8	6.3	5.7	5.7	6.7
CDM	23.9	25.8	26.1	26.3	26.6	26.3	25.5	25.9	25.9	25.5	26.6
CPV	10.8	12.8	12.2	12.4	12.2	13.1	12.9	13.4	13.0	12.2	13.4
CPL	5.1	6.1	5.2	4.4	4.9	5.5	6.3	6.7	5.4	4.4	6.7
CPU	11.5	12.6	13.8	14.5	14.4	14.0	12.9	14.6	14.1	12.6	14.6
CST	2.4	2.7	3.0	3.0	3.1	2.6	3.0	2.8	2.8	2.6	3.1
CTR	5.6	7.5	6.7	6.5	6.5	6.8	6.8	7.0	7.0	6.5	7.5
CTL	6.7	7.7	7.3	7.6	7.6	7.3	7.6	7.5	7.7	7.3	7.7
CFL	7.2	8.9	9.3	9.3	9.0	9.3	9.2	8.5	8.2	8.2	9.3
DPI	–	5.9	7.4	6.1	6.5	5.0	6.4	6.0	5.3	5.0	7.4
DPO	–	13.7	13.7	14.6	12.1	14.1	13.4	13.6	11.9	11.9	14.6
PDI	–	10.0	10.7	9.5	9.4	10.1	10.6	10.8	10.1	9.4	10.8
PDO	–	6.5	7.4	5.3	6.4	6.4	5.8	6.8	8.0	5.3	8.0
DAO	–	1.9	1.6	2.2	2.4	2.7	2.4	1.8	2.0	1.6	2.7
DAI	–	0.6	0.5	0.5	0.8	1.6	1.5	0.7	–	0.5	1.6

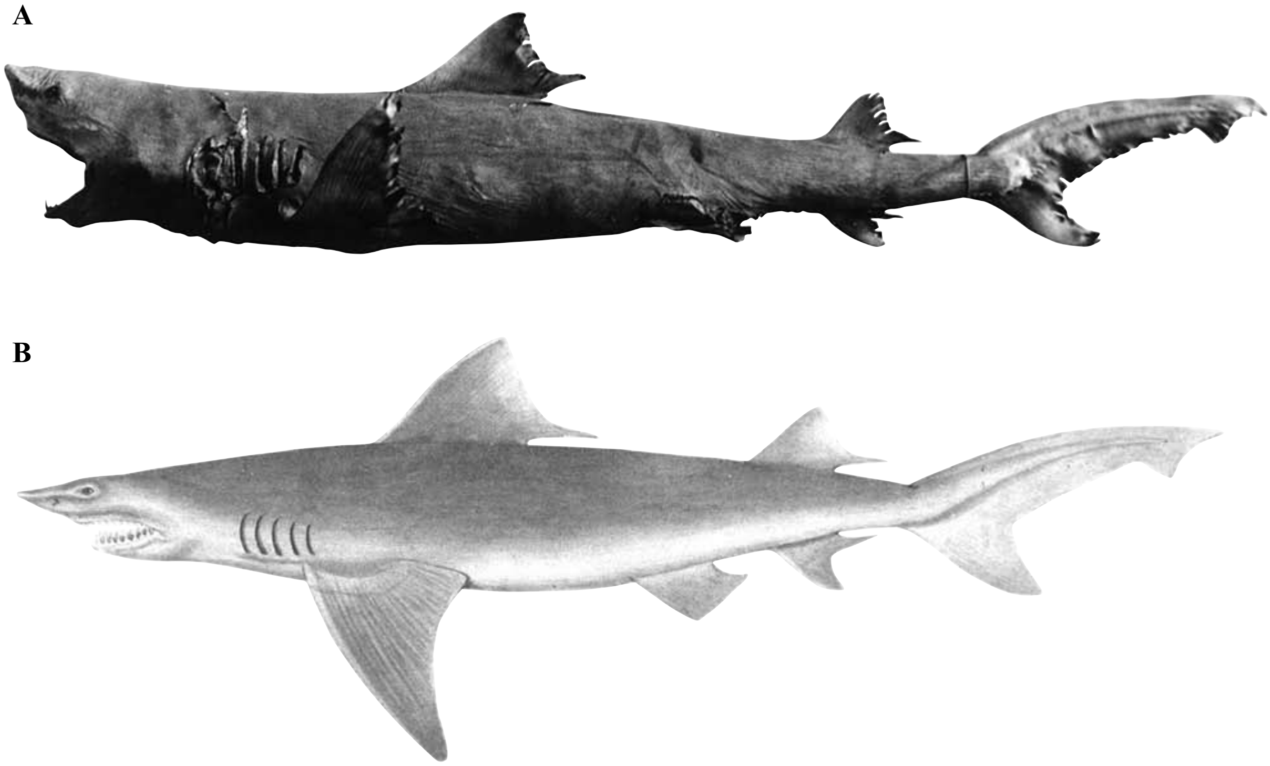

Figure 7. Whole lateral view of the holotype of *Glyphis glyphis* (ZMB 5265, (immature female 1023 mm TL): A. image of stuffed holotype; B. original illustration by Müller & Henle.

the lower caudal-fin origin.

Head length to 5th gill opening 0.80 (0.68–0.94) times in pectoral–pelvic space. Head broad and flattened, ellipsoidal-lenticular in shape in cross-section at eyes. Outline of head in lateral view undulated dorsally, slightly concave at midsnout (more pronounced in smaller specimens), weakly convex above eye, moderately concave at nape, weakly convex above gills and progressively elevated towards first dorsal fin; convex ventrally along lower jaws and beneath gills. In dorsoventral view, head anteriorly bluntly rounded and U-shaped, with gill septa expanded outwards. Snout short, preoral snout length 0.29 (0.63–0.75) times mouth width; tip broadly rounded in dorsoventral view and with a weak angle at nostrils but not noticeably indented anterior to nostrils; snout bluntly pointed in lateral view, weakly convex above and below.

External eye opening of fleshy orbit without anterior or posterior notches, circular in shape, with height 0.80–1.03 in eye length. Eyes small, length 26.60 (21.02–30.77) times in head length; situated slightly dorsolateral and slightly above head rim, with lower edges crossing horizontal head rim in dorsal view; subocular ridges absent. Nictitating lower eyelids internal, with deep subocular pouches and secondary lower eyelids fused to upper eyelids.

Spiracles absent. First four gill slits subequal in height, first opening usually much larger, fifth smallest, fifth about 0.73 (0.81–0.90) of height of third; height of third about 5.91 (6.28–7.31) in head length, 4.50 (2.89–4.52) times eye length. Margins of first four gill slits slightly convex, posterior margin irregular; fifth weakly concave; upper edges of gill slits 2–4 most elevated; upper end of highest gill opening about level with upper edge of eye. Gill filaments not visible from outside. Gill-raker papillae absent from gill arches.

Nostrils with large, mostly narrowly oval incurrent apertures; prominent triangular anterior nasal flaps with bluntly pointed tips, mesonarial flaps absent, small suboval excurrent apertures, posterior nasal flaps absent; well in front of mouth; width 3.53 (2.94–3.49) in internarial width, 0.67 (0.47–0.63) in eye length, 3.00 (1.73–2.11) in longest gill-opening.

Mouth very broadly arched and large; width 2.66 (2.26–2.47) in head length; mouth length 1.92 (1.71–2.02) in mouth width. Lips usually concealing teeth when mouth is closed (occasionally teeth of upper jaw near symphysis visible distally). Tongue large, flat and broadly rounded, filling floor of mouth. Maxillary valve narrow, width slightly less than eye diameter, strongly papillose. No large buccal papillae on floor or roof of mouth behind maxillary valve. Palate, floor of mouth and gill arches

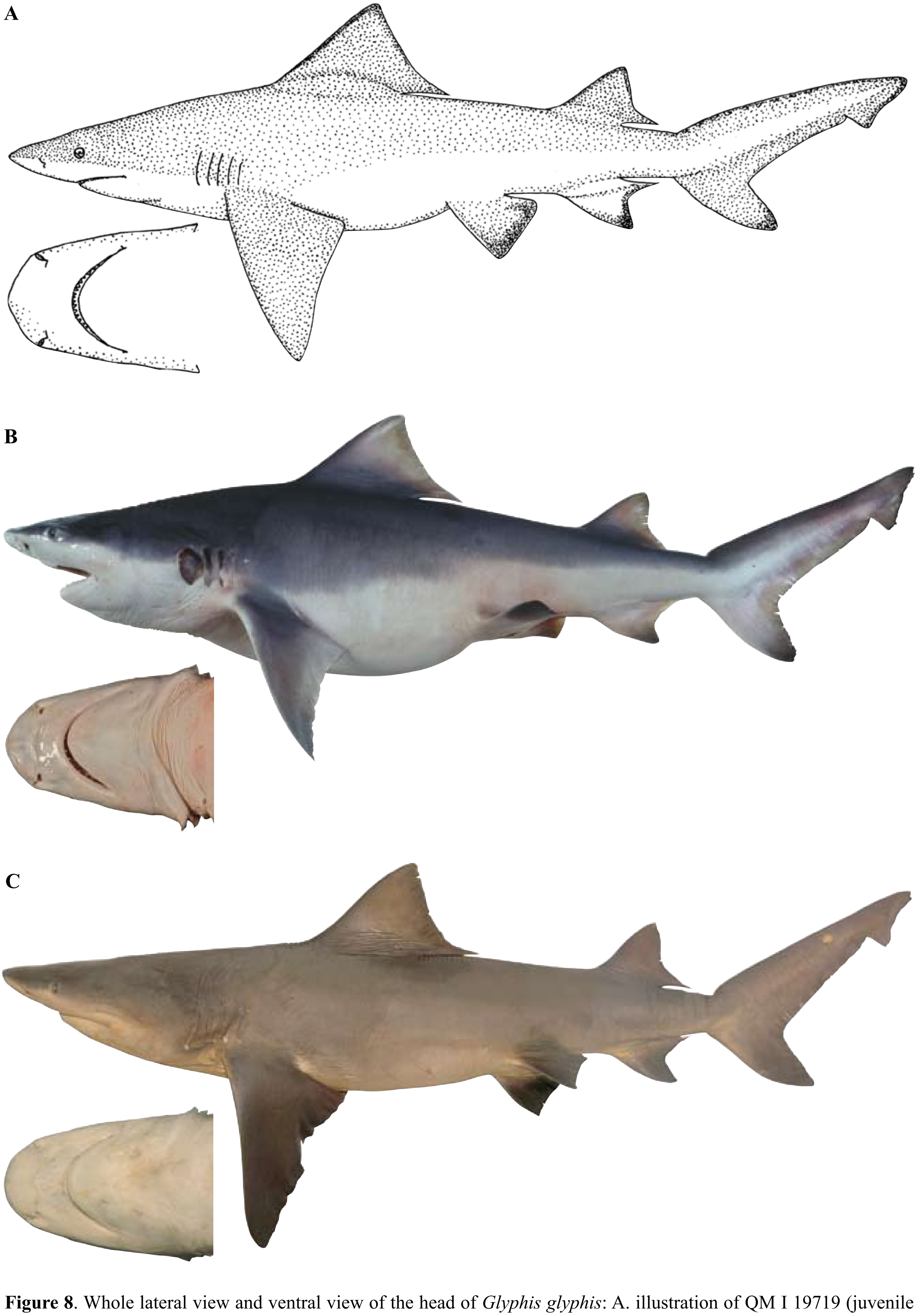

Figure 8. Whole lateral view and ventral view of the head of *Glyphis glyphis*: A. illustration of QM I 19719 (juvenile male 745 mm TL; by L.J.V. Compagno); B. fresh specimen CSIRO H 5261–01 (juvenile male 770 mm TL); C. preserved specimen NTM S 16217–001 (adolescent male 1447 mm TL).

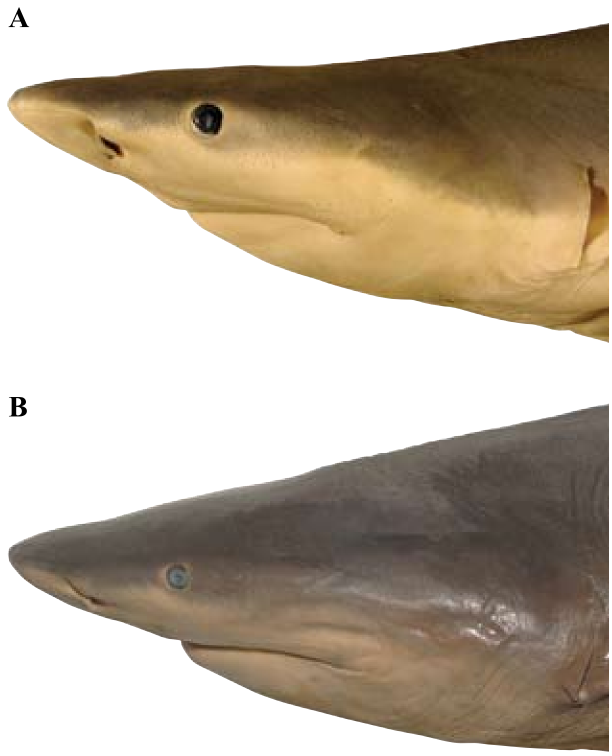

Figure 9. Lateral view of the head of *Glyphis glyphis*: A. preserved specimen NTM S 15351–001 (juvenile female 678 mm TL); B. preserved specimen NTM S 16217–001 (adolescent male 1447 mm TL).

covered with buccopharyngeal denticles. Labial furrows short, uppers (0.66–1.67) times as long as lowers, lowers concealed by overlapping upper lip; anterior ends of uppers far behind eyes by distance about 40–50% of mouth width. Labial cartilages appear to be absent.

Teeth relatively few, in 27 in holotype (26–29, n=4)/27 (27–29) rows or 54 (53–58) total rows (both jaws). Teeth not arranged in diagonal files, no toothless spaces at symphysis. Teeth highly differentiated in upper and lower jaws and along jaws, tooth row groups include upper and lower medials (M), anteriorised lower symphysials (AS), and anteriors (A), laterals (L), and posteriors (P) in both jaws. Tooth formula (n=5): upper jaw (13–14) + 1 (0–1) + 13 (13–14); lower jaw (13) + 1 (1–2) + 13 (13–14). Upper teeth with tall, broad, flat, triangular, blade-like, erect to semi-oblique cusps (except posteriors), distal and mesial edges serrated (except for most posteriors); unnotched mesial edges; slightly arched roots. Lower teeth with narrow, tall, erect, slightly hooked (anteriorised symphysial and anteriors) to straight cusps; first few anterior teeth of large specimens hastate with serrated cutting edges confined to spear-like tips (not obvious in small specimens); sometimes with very small cusplets on crown foot; low mesial and distal shoulders or blades (except in posteriors).

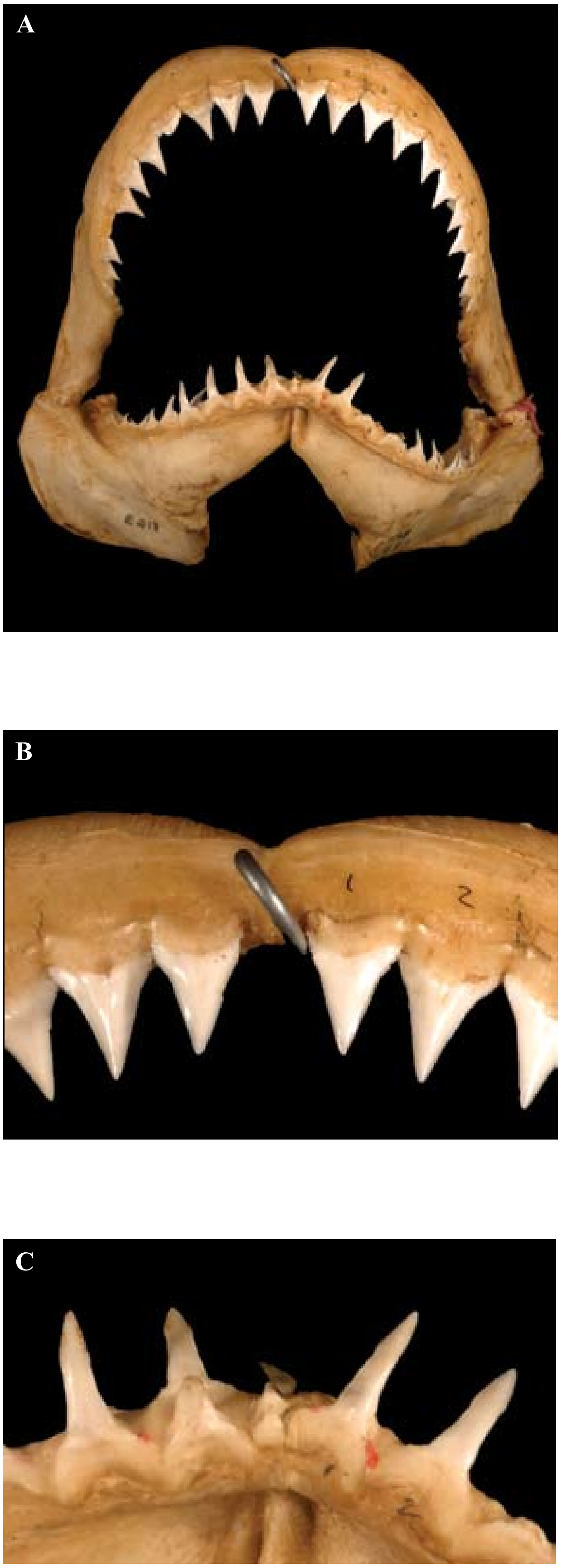

Figure 10. A. jaws, B. central upper teeth, and C. central lower teeth of *Glyphis glyphis* (LWF E 218, immature female 1600–1800 mm TL).

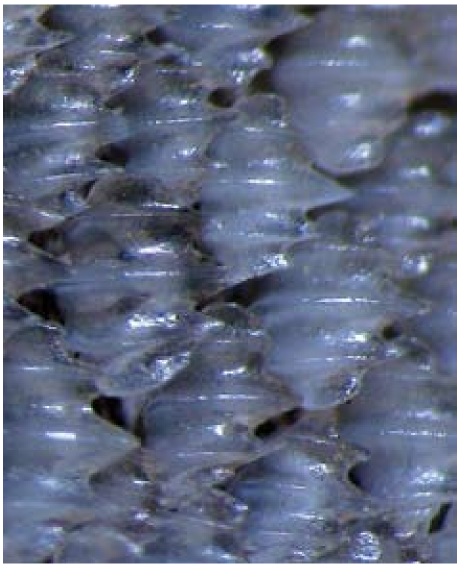

Figure 11. Cusps of the flank denticles of *Glyphis glyphis* (NTM S 16217–001, adolescent male 1447 mm TL).

Lateral trunk denticles of adolescent male (NTM S 16217–001) small, imbricate, transversely oval, with 3 (sometimes 5) short, stout cusps; crowns slightly wider than long, with 3 prominent longitudinal ridges that extend entire length of crown onto cusps; medial cusp short but strong, shorter than rest of crown, flanked by a pair of slightly shorter lateral cusps, and sometimes a second pair of much shorter lateral cusps.

Pectoral fins large (relatively larger in NTM S 16217–001, subadult male, 1447 mm TL), weakly falcate; anterior margin strongly convex, apices very narrowly rounded (bluntly pointed in NTM S 16217–001); posterior margin strongly concave; free rear tip broadly rounded, inner margin strongly convex; base broad about 60% of fin length; length from origin to rear tip 1.74 (1.33–1.58) in anterior margin length; much greater in area than first dorsal fin; origin varying from between gill slits 2 and 4 (mainly between 3 and 4); fin apex about opposite inner margin when fin is elevated and appressed to body.

Pelvic fins triangular and not falcate; length of anterior margins 0.36 (0.38–0.45) of pectoral–fin anterior margins; area less than 1.5 times that of anal fin; anterior margin straight to weakly convex and slightly concave near base; apices broadly pointed to narrowly rounded; posterior margin nearly straight to weakly convex distally; free rear tip bluntly rounded, inner margin nearly straight (males with a prominent distal convexity); posterior margin, rear tip and inner margin forming a broad triangle with an ~60° apex. Claspers of adult males not examined.

First dorsal fin apically narrow and broadly triangular, semi-falcate; angle of apex about 80 to 90°; anterior margin broadly convex (weakly concave basally); apex very narrowly rounded to acute; posterior margin concave; free rear tip acutely pointed, inner margin concave to almost straight; origin over or slightly forward of insertion of pectoral-fin bases, midpoint of base 1.8–2.8 times closer to pectoral insertions than pelvic origins; free rear tip just anterior to pelvic-fin origins (by about a quarter of first dorsal-fin inner margin length); posterior margin arcing posteroventrally from apex; insertion well behind level of dorsal-fin apex by about a quarter of inner margin length. First dorsal-fin base 1.70 (1.08–1.49) in interdorsal space, 1.95 (1.86–2.15) in dorsal caudal margin; height 1.79 (1.27–1.51) in base length; inner margin 1.56 (1.64–1.90) in height, 2.78 (2.35–2.69) in base length.

Second dorsal fin apically narrow, subtriangular; height 0.84 (0.67–0.77) times first dorsal-fin height, base 0.54 (0.56–0.68) times first dorsal-fin base; anterior margin concave basally, becoming broadly convex distally; apex narrowly rounded; posterior margin deeply concave; free rear tip acutely pointed, inner margin nearly straight; origin well behind pelvic-fin insertions and mostly slightly behind pelvic-fin free rear tips; rear tip over or slightly forward of anal-fin free rear tip, in front of upper caudal-fin origin by 0.1–0.4 times its inner margin length; posterior margin curving posteroventrally from apex; insertion slightly behind fin apex. Second dorsal-fin base 1.03 (0.76–0.84) in dorsal–caudal space; height 1.14 (1.05–1.51) in base; inner margin 1.79 (1.42–1.94) in height, 2.03 (1.75–2.32) in base.

Anal fin apically narrow and semi-falcate; height 0.53 (0.77–0.90) times second dorsal-fin height, base length 0.84 (0.81–0.91) times second dorsal-fin base; anterior margin indented basally and distally broadly convex; apex bluntly pointed; posterior margin deeply notched at more than a right angle; free rear tip acutely pointed, inner margin slightly concave or straight; origin slightly to well behind second dorsal-fin origin; insertion opposite or slightly behind second dorsal-fin insertion, slightly in front of fin apex; free rear tip in front of lower caudal-fin origin by about half of its inner margin length; posterior margin slanting anterodorsally and then abruptly posterodorsally. Anal fin base expanded anteriorly as very short preanal ridges (obscure), less than a quarter length of rest of base. Anal-fin base 1.34 (0.62–0.79) in anal–caudal space; height 1.81 (1.22–1.48) in base; inner margin 1.07 (1.23–1.38) in height, 1.93 (1.68–2.01) in base.

Caudal fin narrow-lobed and asymmetrical, with short terminal lobe and prominent, long, narrowly expanded, lobate ventral lobe; dorsal caudal margin proximally and distally convex, and slightly concave just anterior to subterminal notch, with prominent lateral undulations; preventral margin strongly convex (more so in NTM S 16217–001), tip of ventral caudal-fin lobe narrowly rounded; lower postventral margin nearly straight; upper

Table 4. Vertebral counts and ratios for the holotype (ZMB 5265) and 8 specimens of *Glyphis glyphis*.

	ZMB 5265	CSIRO H 5261–01	CSIRO H 5756–01	NTM S 15508–001	NTM S 15508–002	NTM S 15097–001	NTM S 15351–001	NTM S 16217–001	QM I 19719	Min.	Max.
Vertebrae:											
MP	–	71	69	71	70	70	73	–	70	69	73
DP	–	53	54	53	54	53	50	–	54	50	54
DC	90	89	94	94	93	99	91	90	93	89	99
PC	–	124	123	124	124	123	123	123	124	123	124
TC	–	213	217	218	217	222	214	213	217	213	222
%MP	–	33.3	31.8	32.6	32.3	31.5	34.1	–	32.3	31.5	34.1
%DP	–	24.9	24.9	24.3	24.9	23.9	23.4	–	24.9	23.4	24.9
%DC	–	41.8	43.3	43.1	42.9	44.6	42.5	–	42.9	41.8	44.6
%PC	–	58.2	56.7	56.9	57.1	55.4	57.5	–	57.1	55.4	58.2
DP/MP	–	0.7	0.8	0.7	0.8	0.8	0.7	–	0.8	0.7	0.8
DC/MP	–	1.3	1.4	1.3	1.3	1.4	1.2	–	1.3	1.2	1.4
A ratio	–	113.6	115.9	108.4	106.3	128.7	109.5	–	128.2	106.3	128.7
B ratio	–	60.0	57.4	53.7	51.2	60.1	56.9	–	60.2	51.2	60.2

postventral margin nearly straight except for convex section at subterminal notch; notch between postventral margins deep, forming about a 90° angle; subterminal notch a narrow, deep slot; subterminal margin slightly concave to nearly straight, terminal margin irregular and weakly concave to almost straight, lobe formed by these margins bluntly rounded, tip of tail narrowly rounded. Length of dorsal caudal margin 3.22 (2.75–2.92) in precaudal length, preventral caudal margin 2.22 (1.93–2.18) in dorsal caudal margin, terminal lobe from caudal tip to subterminal notch about 3.54 (3.34–3.60) in dorsal caudal margin, subterminal margin length 2.28 (2.11–2.76) times in terminal margin.

Vertebral counts listed in Table 4. Counts of total vertebral centra (TC) 213–222 (n=8), precaudal centra (PC) 123–124 (n=8), monospondylous precaudal (MP) centra 69–73 (n=7), diplospondylous precaudal (DP) centra 50–54 (n=7), diplospondylous caudal (DC) centra 90 (89–99, n=8); MP centra 31.5–34.1%, DP centra 23.4–24.9%, and DC centra 41.8–44.6% of TC centra. Ratios of DP/MP centra 0.68–0.78, DC/MP centra 1.25–1.41, 'A' ratio 106.3–128.7 (n=7), 'B' ratio 51.2–60.2 (n=7). Transition between MP and DP centra about over pelvic bases and about 2–8 (n=6) centra posterior to pelvic girdle. Last few MP centra before MP–DP transition not enlarged and not forming a 'stutter zone' of alternating long and short centra.

COLOUR.— When fresh and in preservative: uniformly slate-grey on dorsal surface of sides of head, trunk and tail, abruptly whitish on lower lateral and ventral surfaces. Demarcation of light and dark surfaces (waterline) of head strong, extending along side of head at about level of lower margin of eye but dipping slightly at eye (by much less than eye height), extending to middle of gill slits in small juveniles (almost to ventral edge of gill slits in NTM S 16217–001), terminating on membrane of fifth gill opening; no dark area below eye visible ventrally; waterline on sides almost entire in juveniles, not jagged (less well defined in larger individuals); waterline directed posteriorly above pelvic-fin base (slightly half body depth from pelvic-fin origin), extending along tail almost mid-laterally; pale area continuing onto base of caudal fin, apparent as a pale marking along the upper lobe to the origin of the terminal lobe. Dorsal fins similar to each other and dorsal surface of body, sometimes paler centrally, usually with a slightly darker posterior margin (less so on larger specimens). Caudal fin with darker markings ventrally; upper lobe greyish dorsally, with narrow black tip and posterior margin of terminal lobe narrowly black; upper postventral margin darker grey with a narrow black posterior margin; ventral lobe dusky with distal half of lobe almost black, anterior base and margin pale (less contrasted in larger specimens). Anal fin pale basally and anteriorly, with a large distal blackish marking (less pronounced in NTM S 16217–001); free rear tip mostly pale. Pelvic-fin dorsal surfaces mostly dusky, with base and basal anterior margin pale; ventral surfaces with pale base and dusky to blackish on distal web (more pronounced in smallest individual CSIRO H 5756–10), dark areas covering more than half of fin. Pectoral-fin dorsal surfaces uniformly greyish; continuous on basal area and flank (without a dark basal blotch); anterior margin pale (most pronounced basally); ventral surfaces with pale base, slightly darker on web with blackish blotch near apex extending to further along the posterior margin to anterior margin. Mouth white; eye pupil black; a more or less conspicuous narrow light ring around eyes.

SIZE.— Specimens examined ranged in length from 590–ca. 1800 mm TL. The largest whole specimen captured was a 1750 mm TL female of unknown maturity (R. Pillans, pers. comm.), but the large sets of jaws from this species examined by the senior author indicates that they are likely attaining well over 2 m and possibly up to 3 m TL. One male examined was adolescent at 1447 mm TL; all other males examined (590–867 mm TL) were juveniles. The two smallest specimens examined (NTM S 15508–001, –002, 590 and 595 mm TL) possessed reasonably fresh umbilical scars, suggesting a length at birth in this species of around 590 mm.

DISTRIBUTION.— Known from scattered localities off northern Australia and New Guinea (Fig. 12). In Queensland, recorded from the Bizant (14°33′ S, 144°05′ E) and Wenlock Rivers (12°03′ S, 141°55′ E; 12°45′ S, 142°59′ E) in relatively fresh water. In Northern Territory, recorded from the Adelaide and East and South Alligator Rivers in relatively fresh water. In New Guinea, specimens recorded from close to Port Romilly (07°40′ S, 144°50′ E) and Fly River (07°19′ S, 141°11′ E).

VERNACULAR.— Speartooth Shark.

REMARKS.— Detailed examination of the stuffed holotype of *Carcharias (Prionodon) glyphis* (ZMB 5265) by the senior author and comparison with Australian and Papua New Guinea specimens of *G*. sp. A [*sensu* Last & Stevens, 1994] suggest that they represent a single species, *G. glyphis*. The caudal vertebral count for the holotype of *G. glyphis* (90, the only vertebrae still present in the specimen) lies within that recorded for 8 other specimens examined (89–99). This high caudal vertebral count clearly distinguished this specimen from *G. garricki*, which has much lower caudal counts (61–70, n=14). The lower anterior teeth of the holotype of *G. glyphis*, and of large Australian and Papua New Guinea specimens, have their cutting edges confined to the spear-like tips, which distinguishes these from *G. gangeticus* from India and Pakistan which have lower teeth with entire cutting edges, not confined only to the tip. They are also clearly separable from *G. gangeticus* in the following features: lower tooth counts (upper jaw with 26–29 vs. 30–37 teeth; lower jaw 27–29 vs. 31–34 teeth), shorter interdorsal space (14.5–18.4 vs. 19.2–20.1% TL), a taller second dorsal fin (height 5.8–6.9 vs. 4.3–5.0% TL, 70–84 vs. 50–60% of first dorsal-fin height). The 8 specimens from Australia and Papua New Guinea that were radiographed had higher vertebral counts than *G. siamensis* from Myanmar, i.e. total centra 213–222 vs. 209 and precaudal centra 123–124 vs. 117. Thus, *G*. sp. A from Australia and Papua New Guinea is synonomised with *G. glyphis*.

Glyphis garricki is clearly separable from its congeners by a combination of coloration, meristics and morphometrics. Vertebral counts clearly separate the known species of *Glyphis*. *Glyphis garricki* differs from other *Glyphis* species in having the lowest vertebral counts, i.e. total count 137–151 vs. 169–222 and caudal centra 61–70 vs. 82–99. *Glyphis gangeticus* has similarly low precaudal vertebral counts to *G. garricki* (precaudal centra 80 and 73–81 vs. 108–124 in *G. glyphis*, *G. siamensis* and *G*. sp. B) but they are clearly separable based on caudal vertebrae counts (89 vs. 73–81, respectively). Peverell *et al*. (2006) provided vertebral counts from 6 additional specimens of *G. glyphis* (total centra 204–208, precaudal centra 118–123) which are slightly lower than that recorded in this study and are possibly the result of missing end vertebrae on the caudal fin tip.

Glyphis garricki has often been confused with *G. glyphis* throughout their similar ranges, which is due in part to the paucity of specimens and the nomenclatural problems. *Glyphis garricki* is clearly separable from *G. glyphis* in the following meristic characters: total vertebral centra (137–151 vs. 213–222), precaudal centra (73–81 vs. 123–124), monospondylous centra (44–50 vs. 69–73), caudal centra (61–70 vs. 89–99), 'B' ratio (91–97 vs. 51–60) and tooth counts (upper jaw 31–34 vs. 26–29; lower jaw 30–35 vs. 27–29). They are very similar morphologically, but *Glyphis garricki* and *G. glyphis* differ in the following morphometric features (comparisons below do not include the measurements of the stuffed holotype of *G. glyphis*): shorter lower labial furrows (lower labial furrow length 0.2–0.3 vs. 0.4–0.6% TL, 7.1–11.0 vs. 3.2–5.0 in nostril width), anal–caudal space (5.6–6.2 vs. 4.5–5.4% TL), head height (13.8–15.5 vs. 6.2–14.0), snout more bluntly pointed in lateral view, nostrils with larger incurrent apertures, lips not concealing teeth (vs. usually concealing teeth), anterior margin only slightly convex (vs. strongly convex), first dorsal fin not falcate and with a nearly straight posterior margin (vs. semi-falcate and with a concave posterior margin), anal-fin posterior margin deeply notched at about a right angle (vs. more than a right angle), caudal-fin lower postventral margin strongly convex (vs. nearly straight) and caudal-fin terminal margin deeply concave (vs. weakly concave to almost straight).

Glyphis garricki can be clearly distinguished from *G. glyphis* in the following coloration characteristics: watermark boundary (between light and dark tonal areas) more than an eye diameter below eye (vs. just below

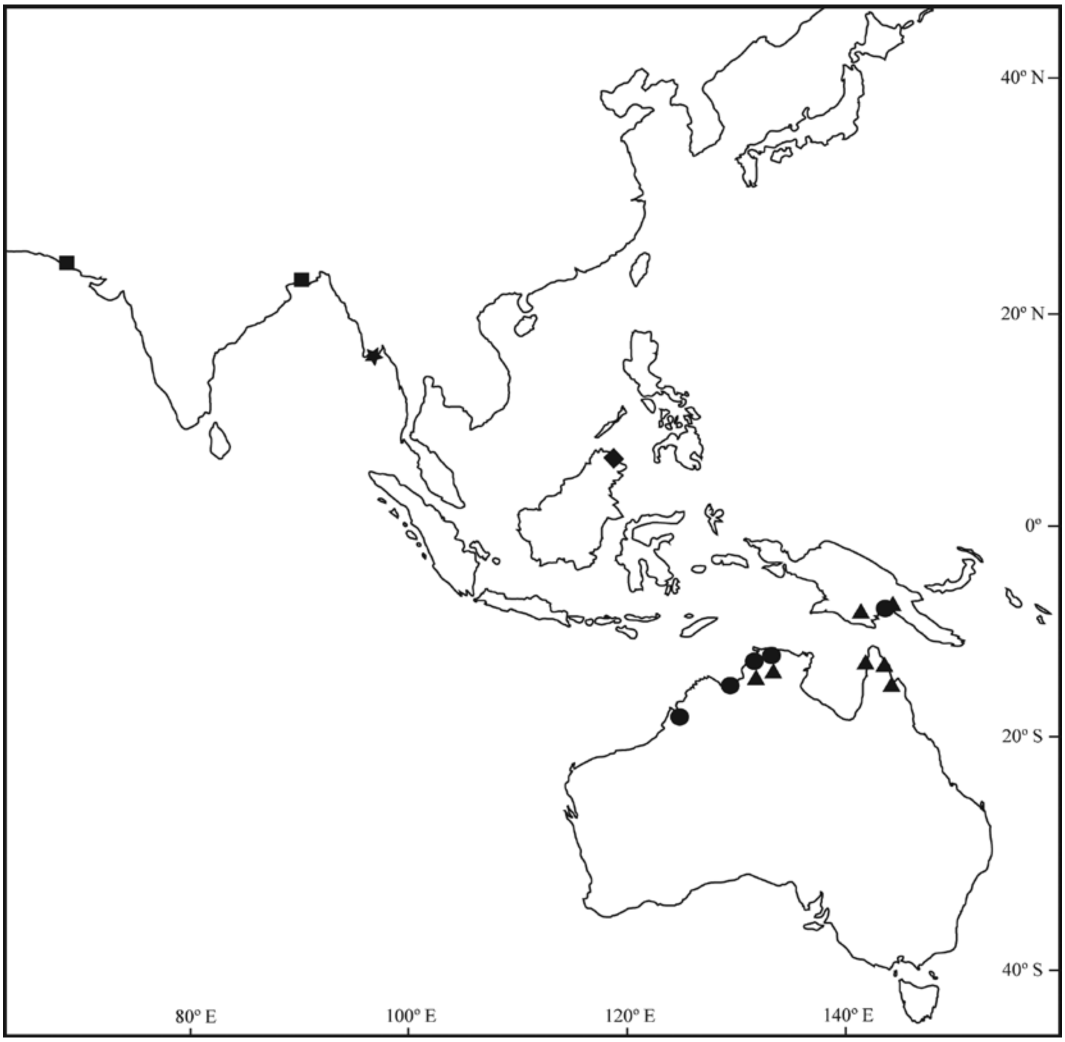

Figure 12. Map showing the collection localities of specimens of the known species of *Glyphis*: *G. gangeticus* (square), *G. garricki* (circle), *G. glyphis* (triangle), *G. siamensis* (star) and *G.* sp. B (diamond).

in *G. glyphis*) and visible below eyes on ventral view of head (vs. not visible below eyes on ventral view of head), watermark boundary sharply defined and jagged along trunk in young (vs. sharply defined and regular along trunk) and about a nostril width above pelvic-fin bases (vs. twice nostril width above pelvic-fin bases), no blackish blotch present on ventral tip of pectoral fins (vs. blackish blotch present on ventral tips), and anal fin with a pale distal web (vs. distal web dusky to blackish).

Comparative material.

Glyphis gangeticus: ZSI 8067, newborn female 610 mm TL, Hooghly River, West Bengal, India; MNHN 1141 (syntype), juvenile free-living male 561 mm TL, "Bengal"; ZMB 4474 (syntype), adult male 1850 mm TL, according to Müller & Henle (1839) "Im Ganges, 60 Stunden oberhalb des Meers bei Hougly gefangen." (In the Ganges, captured in the Hooghly River 60 leagues above the sea, if correct possibly near the city of Navadwip at ca. 23º24′ N, 88º22′ E) photos and measurements contributed by Dr. H. Paepke of the Humboldt Museum, Berlin. ZMB 4474 was considered as lost (Garrick, 1982, 1985, Compagno, 1984, 1988) but was later rediscovered (Paepke & Schmidt, 1988).

Glyphis siamensis: NMW 61379, juvenile male 630 mm TL, Irrawaddy River mouth, Rangoon, Myanmar, photos, radiographs and measurements contributed by Dr. Ernst Mikschi, Vienna Museum.

Glyphis sp. B [*sensu* Compagno & Niem, 1998 and Compagno *et al*., 2005]: CSIRO H 5784–01, juvenile male 517 mm TL, Kampong Abai, Kinabatangan River, Sabah, Malaysia, Mar. 1999; NMW 61401, female 627 mm TL, Borneo, no further locality data; KTG 1/28597 (SMEC–323), female 778 mm TL, KTG 4/28597, female 538 mm TL, KTG 5/28597, female 582 mm TL, KTG 6/28597 (SMEC–328), female 566 mm TL, KTG 7/28597, female 505 mm TL, KTG 8/13697 juvenile male 575 mm TL, KTG 9/17797, juvenile male 667 mm TL, KTG 10/17797, juvenile male 632 mm TL, KTG 11/17797 (SMEC–358), juvenile male 600 mm TL,

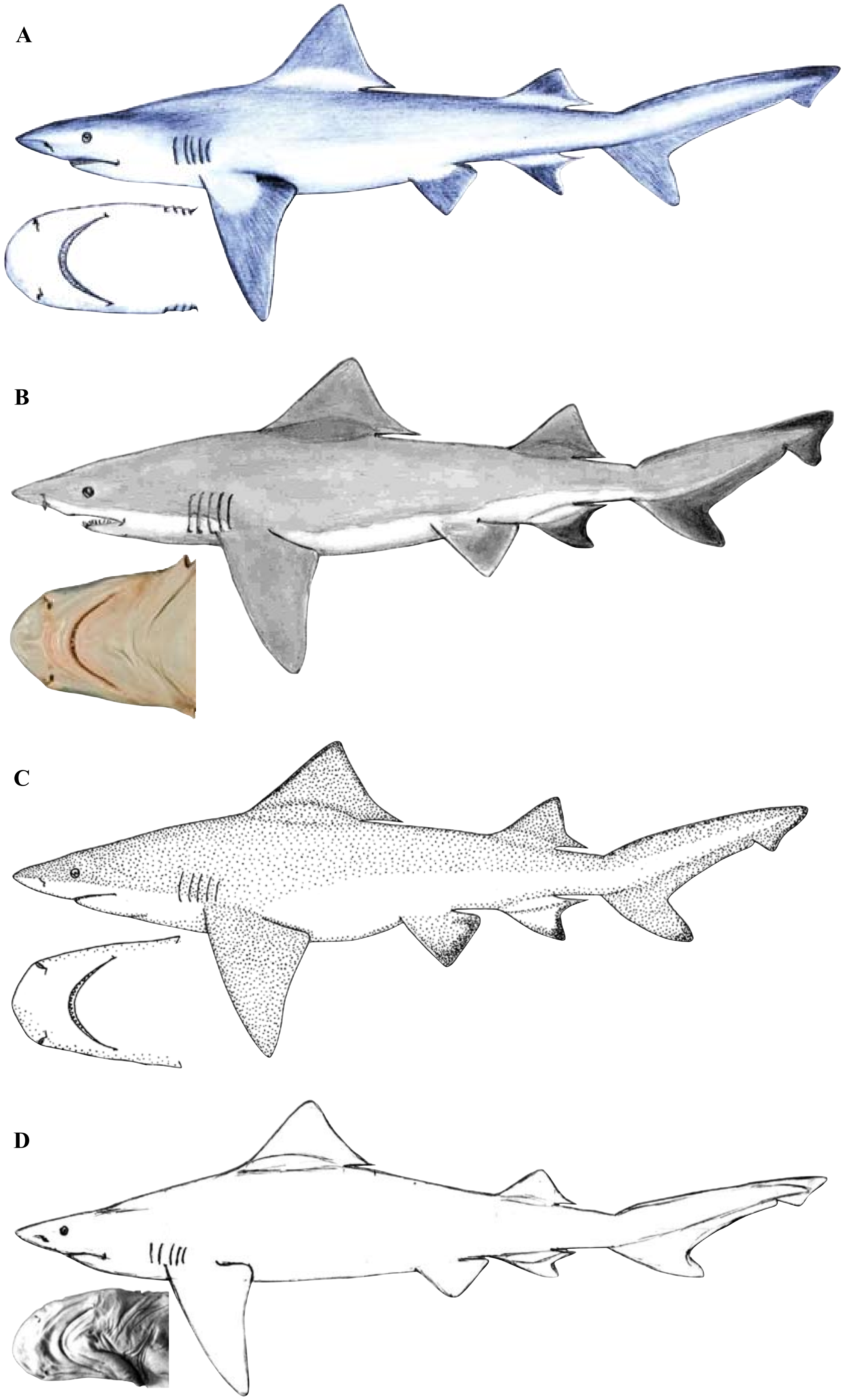

Figure 13. Comparative lateral and ventral head views of nominal *Glyphis* species: A. *G. gangeticus* (MNHN 1141, juvenile male syntype 561 mm TL); B. *G. garricki* sp. nov. (CSIRO H 5262–01, female holotype 670 mm TL); C. *G. glyphis* (QM I 19719, juvenile male 745 mm TL); D. *G. siamensis* (NMW 61379, immature male 630 mm TL).

KTG 12/17797, juvenile male 606 mm TL, Kampong Abai, Kinabatangan River, Sabah, Malaysia, 05°41′ N, 118°23′ E.

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A new species of wedgefish, *Rhynchobatus palpebratus* sp. nov. (Rhynchobatoidei: Rhynchobatidae), from the Indo–West Pacific

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ABSTRACT.— A new wedgefish, *Rhynchobatus palpebratus* sp. nov., is described based on specimens collected off northern Australia and the Andaman Sea off Thailand. It is a medium-sized species, males adult at 103 cm TL. *Rhynchobatus palpebratus* differs from other species of *Rhynchobatus* in having a distinctive eye-brow like marking on the orbital membranes, as well as other more subtle aspects of its colour pattern, and in a combination of morphometrics and meristics. Several regional variations exist in wedgefishes currently identified as *R. laevis* and additional valid species may exist in the Indo–West Pacific.

Key words. Rhynchobatidae – *Rhynchobatus palpebratus* – Eyebrow Wedgefish – new species – Australia

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INTRODUCTION

The genus *Rhynchobatus* Müller & Henle, 1837 comprises at least seven species of large shark-like batoids in the monotypic Family Rhynchobatidae according to the classification of McEachran *et al*. (1996). The monotypic genus *Rhina* Bloch & Schneider, 1801 and *Rhina ancylostoma* Bloch & Schneider, 1801 has been removed to a separate Family Rhinidae as a suprafamilial group, the suborder Rhinoidei. *Rhynchobatus* species are widespread and common in inshore tropical continental shelf waters of the Eastern Atlantic, Indian Ocean and Western Pacific. Following FAO usage (Stehmann, 1981; Compagno & Last, 1999), *Rhynchobatus* species are termed 'wedgefishes' because of their distinctive wedge-shaped discs and snouts; other names include giant guitarfishes, white-spotted guitarfishes, shovelnose rays, and, significantly, sharkfin guitarfishes.

Wedgefishes are commonly caught as bycatch of demersal inshore fisheries wherever they occur and are important commercially for their excellent flesh and very valuable fins which are traditionally and currently important in the oriental sharkfin trade. The intense and increasing fisheries pressure on wedgefishes and minimal biological data on any of the species makes for concern about their conservation status. However, currently none of the species in the family are protected and fisheries and habitat modification and degradation are mostly out of control in their home ranges. In southern Africa and tropical Australia, wedgefishes have been sought as game fishes by sports anglers because of their great size and strength, and powerful response when hooked.

The genus *Rhynchobatus* includes species of great size, with the Western Indian Ocean *Rhynchobatus djiddensis* (Forsskål, 1775) and the Eastern Atlantic *R. luebberti* Ehrenbaum, 1914 attaining a length of 3 m, and in the former species a weight of 227 kg. Three other *Rhynchobatus* species, *R. australiae* Whitley, 1939, possibly *R. laevis*, and definitely *R*. sp. 2 of Compagno & Last (1999), grow to 2 to 3 m total length, although *R*. sp. 1 of Compagno & Last (1999) may not exceed a 1 m in length.

Müller & Henle (1837, 1841) recognised only a single species in their genus *Rhynchobatus*, *R. laevis* (Bloch & Schneider, 1801). Eleven nominal species and a subspecies have been referred to *Rhynchobatus* by various authors, but only two, the West African *R. luebberti*, and the Indo–West Pacific *R. djiddensis*, were generally recognised as valid in the 20th Century, and most of these species were synonymised with *R. djiddensis* (Garman, 1913; Fowler, 1941; Bigelow & Schroeder, 1953).

This paper describes a new, small, boldly marked species of *Rhynchobatus* from the central Western Pacific, the Eyebrow Wedgefish, as part of a revision of the genus *Rhynchobatus* begun by the senior author in the 1960's.

Systematics of *Rhynchobatus* for the FAO Western Central Pacific area was briefly summarised by Compagno & Last (1999) who included a key to the species. The present account amplifies the systematics of *Rhynchobatus* with particular emphasis on the Australian species.

METHODS

External measurements of *Rhynchobatus* specimens are based on the batoid measurements of Bigelow & Schroeder (1953), Hubbs & Ishiyama (1968), Compagno & Roberts (1982), Compagno & Randall (1987), and Randall & Compagno (1995), and the shark measurements of Compagno (1984, 2001). Terminology for enlarged dermal denticles or thorns is based on that of Hubbs & Ishiyama (1968). Pectoral fin and cranial terminology follows Compagno (1988, 1999, 2001 and 2003).

Vertebrae, pectoral-fin radials and crania were examined and counted from radiographs mostly taken on industrial and medical X-ray machines using a variety of film types. In *Rhynchobatus*, as in other living batoids, the vertebral column is more differentiated than in sharks. Just behind the cranium a group of vertebrae are fused to form a large cervical synarcual (Garman, 1913; Compagno, 1973, 1988, 1999, 2003) containing from 25 to 34 segments. The synarcual has an anterior centrum-free region of 13 to 21 segments and a posterior region with 11 to 16 embedded centra. The number of synarcual segments is determined by counting the synarcual centra and the corresponding spinal nerve foramina and canals in the anterior centrum-free region on high-resolution radiographs that are properly exposed. It was not possible to count the centrum-free region in some specimens, particularly newborn and poorly calcified individuals, although synarcual centra could be seen in these specimens. Posterior to the synarcual, the vertebral column can be divided into monospondylous precaudal (MP) centra in the trunk, diplospondylous precaudal (DP) centra in the precaudal tail, and diplospondylous caudal (DC) centra in the caudal fin. The MP centra have very long ribs which are reduced posteriorly before the transition to DP centra, in which the centra suddenly become smaller and two per myomere. The DC centra have strongly expanded neural and haemal arches modified as pterygiophores for the caudal fin but, for purposes of consistency, counts are delimited anteriorly at the upper caudal-fin origin as in sharks (Springer & Garrick, 1964). Counts presented here include the numbers of centra in the synarcual, and the MP centra, DP centra, DC centra, total free centra and total centra; centrum-free segments and total segments were not included as some of these counts proved difficult.

In *Rhynchobatus*, as in most modern elasmobranchs or neoselachians (Compagno, 1973, 1977, 1988, 1999, 2003), there are three basal cartilages to the pectoral-fin skeleton, the anterior propterygium, intermediate mesopterygium and posterior metapterygium, that bear most of the pectoral-fin radials. In addition, *Rhynchobatus* and various other batoids have a space between the mesopterygium and metapterygium where `neopterygial' radials articulate directly with the synarcual. The propterygium of *Rhynchobatus* is a single, unsegmented cartilage with a front end that terminates behind the nasal capsules. Anterior to the propterygium there are one to 8 free propterygial radials that are located in the horizontal head rim and suggest that a segmented propterygial axis, such as that present in other batoids, may have been lost in *Rhynchobatus*. The propterygium itself has 16 to 26 radials, the mesopterygium 5 to 7 radials, the neopterygial space on the scapulocoracoid 4 to 6 radials and the metapterygium 21 to 29 radials. Counts presented include free, propterygial, mesopterygial, neopterygial, metapterygial, total basal radials (excluding free radials) and total radials.

Chondroneurocrania or braincases were examined by radiography and by extraction of the crania of fresh specimens by maceration in hot water (Compagno, 1988, 2003). Cranial morphology of the new *Rhynchobatus* species is not considered in detail here but we note that *Rhynchobatus* species differ in the shape of their rostral appendixes and by the position of the anterior ends of the antorbital cartilages relative to the anterior ends of the nasal capsules.

Features of the group are outlined, but these results will be reported in more detail in future studies. Proportional dimensions as percentages of total length are given in Table 1. Vertebral counts and ratios, pectoral-fin radial counts, and tooth row counts are given in Table 2. Material is deposited in the Australian National Fish Collection, Hobart (CSIRO).

ORDER RAJIFORMES

SUBORDER RHYNCHOBATOIDEI

DEFINITION.— (Modified and expanded from Compagno, 1973, 1977 and Compagno & Last, 1999): Batoid fishes with a very long, acutely angular, flattened snout (broadly triangular in dorsal view) and prepectoral head, preorbital length greater than width of snout at eyes; snout not formed into a rostral saw. Head flat, eyes not extending much above level of interorbital. Spiracles with two dermal folds on posterior margins. Nostrils on underside of snout, very large, narrow, diagonal with posteriorly bent excurrent apertures that are not widely expanded laterally; distance between outer margins of incurrent apertures less than twice mouth width; nostril width slightly greater than internarial space; anterior nasal flaps small, separate from each other, inner margin ending well laterally to medial ends of excurrent apertures, accessory posterior nasal flap extending medially to the lateral edge of the excurrent aperture. Nostrils close to mouth but entirely separate from it, with no nasoral grooves. Mouth shallowly arched, labial furrows and folds well developed on upper and lower jaws, labial cartilages present but small. Margins of jaws weakly undulated, with jaw cartilages and dental bands forming a prominent knob in the lower jaw and a corresponding depression in the upper jaw. Teeth not greatly enlarged and without ridges on crowns.

Body stocky but flattened, back not strongly arched and trunk depressed at first dorsal-fin origin. Tail very stout, long, shark-like and depressed, lenticular in section with strong lateral ridges that extend from pelvic-fin bases to caudal base. No pectoral or caudal electric organs.

Skin of body and fins almost entirely covered with very small shark-like denticles with flat crowns. Small inconspicuous thorns present on supraorbital crests around eyes, and in two species also on the midline of preorbital snout. A mid-dorsal row of small and inconspicuous thorns in front of first dorsal fin and on the interdorsal space between dorsal-fin bases, but absent from dorso–caudal space. Small inconspicuous patches of scapular thorns present on the scapular region. Males without rows of enlarged specialised malar or alar spines on the dorsolateral surfaces of the pectoral fins. No caudal stinging spine on dorsal surface of tail.

Trunk, head and pectoral fins forming a small pectoral disc but pectorals not extending to level of nasal capsules. Pectoral fins very low, small and angular, height less than their base lengths. Origins of pectoral fins separated from prepectoral snout by a shallow indentation. Pectoral-fin propterygia short and unsegmented, behind nasal capsules and antorbital cartilages, with free propterygial radials present anterior to propterygium. Pectoral and pelvic-fin bases separated by a pectoral–pelvic space shorter than pelvic base lengths.

Pelvic-fin origins well anterior to the pectoral-fin free rear tips, separated by less than length of pectoral-fin inner margins. Pelvic fins not laterally expanded and not divided into distinct anterior and posterior lobes. Lateral prepelvic processes present on the pelvic girdle, but no medial process.

Claspers greatly elongated, slender, with a small glans with pseudosiphon and pseudopera, and a small clasper spine similar to those of squaloid sharks. Clasper skeleton shark-like, with long dorsal and ventral marginal cartilages, simple dorsal and ventral terminal cartilages, an accessory terminal T3 cartilage to support the clasper spine, and a large ventral covering piece situated on the underside of the clasper.

Two large, high, more or less falcate, shark-like dorsal fins present, with more or less attenuated free rear tips and no dorsal-fin spines. First dorsal fin variably slightly larger to much larger than second dorsal fin and with length greater than interdorsal space. First dorsal-fin base over the tail-base with origin over or anterior to pelvic fin bases.

Caudal fin distinctly asymmetrical, with a short but prominent ventral lobe that is much shorter than dorsal lobe; postdorsal and postventral margins defining a deeply concave fork. Caudal fin vertebral axis raised at a low angle above body axis.

Chondroneurocranium with a long, stout, narrow, tapering rostrum with wing-like or barb-like rostral appendices at rostral node. Rostral length exceeding nasobasal length. Rostrum partially enclosing narrow, tubular precerebral cavity and roofing it dorsally; rostral nerves not enclosed in the rostrum. Nasal capsules expanded laterally, with internasal septum broad, depressed, and widely separating the capsules; nasal capsules extending ventrally to internasal septum between them. Nasal capsules with short angular projections on their anterior margins. Antorbital cartilages small, not distally expanded and fanlike, articulating with posterolateral condyles on the nasal capsules, directed posteriorly and ending well anterior to the pectoral fin propterygia, with anterior projections that may extend anterior to the nasal capsules or end opposite or well behind their anterior margins. Anterior fontanelle not delimited anteriorly by a transverse ridge, longitudinally elongated, oval, and extending anteriorly as the dorsal aperture of the precerebral cavity. Cranial roof with a small parietal fenestra that ends far posterior to the anterior fontanelle; no frontal fontanelle or epiphysial foramen. Orbits with the preorbital processes strongly developed but low and the postorbital processes small, low and prominent. Supraorbital crests present, strong and complete. Orbital wall with a discrete ventral angle where it merges with basal plate, but no suborbital shelves. Basal plate with an internal carotid foramina present on its midline. Basal plate flat and without a basal angle or condyles for palatoquadrate articulations. Otic capsules with sphenopterotic ridges not expanded rearwards. Occipital condyles small, ventral in position, not excerted, and not covering the occiput.

Cervicothoracic synarcual long and extending posterior to the pectoral girdle and its articulation with the suprascapulae, not formed anteriorly into a collar-like sheath for the spinal cord but with a trough-like ventral projection that fits between the occipital condyles. No thoracolumbar synarcual. Superscapulae articulating with the posterodorsal edge of the synarcual but not forming sockets or condyles, the superscapulae in the form of deeply forked plates with the scapular articulations in the forks.

Hyobranchial skeleton with hypobranchials often separate from each other and from the basibranchial copula. Basihyoid slender but usually well developed; the basibranchial copula without a forked anterior projection.

Development ovoviviparous (aplacental viviparous), but mode of reproduction otherwise poorly known.

Dorsal surface yellowish, brownish, greyish brown, or greenish, sometimes blackish; white ventrally; dorsal surface with small to large whitish spots; sometimes with dark orbito-spiracular markings; usually with a pair of black pectoral ocelli on the pectoral-fin bases, often surrounded with white spots.

FAMILY RHYNCHOBATIDAE Garman, 1913

Subfamily Rhynchobatinae (Family Rhinobatidae) Garman, 1913: p 226. Family Rhynchobatidae; Bigelow & Schroeder, 1953: p 44. Type genus: *Rhynchobatus* Müller & Henle, 1837.

DEFINITION.— As per the suborder.

Genus ***Rhynchobatus*** Müller & Henle, 1837

Genus *Rhynchobatus* Müller & Henle, 1837: p 116 (Type species: "*R. laevis*" by monotypy, equivalent to *Rhinobatus laevis* Bloch & Schneider, 1801).

Genus *Rhynchobatis* Müller & Henle, 1841: p 111 (emended spelling of *Rhynchobatus* Müller & Henle, 1837).

DEFINITION.— As per the suborder.

SPECIES.— The following nominal species have been placed in this genus by various writers including Dumeril (1865), Günther (1870), Garman (1913), Fowler (1936, 1941, 1969), Bigelow & Schroeder (1953), Stehmann (1981) and Compagno & Last (1999): *Raja djiddensis* Forsskål, 1775; *Rhinobatus laevis* Bloch & Schneider, 1801; *Rhinobatus laevissimus* Blainville, 1816; *Rhinobatus duhameli* Blainville, 1825; *Rhinobates rueppelli* Swainson, 1838; *Rhinobatus jaram* Montrouzier, 1856; *Rhynchobatus luebberti* Ehrenbaum, 1914, *Rhynchobatus atlanticus* Regan, 1915; *Rhinobatos albomaculatus* Norman, 1930; *Rhinobatos irvinei* Norman, 1931; and *Rhynchobatus yentinensis* Wang, 1933. In addition, *Rhynchobatus djiddensis australiae* was proposed by Whitley (1939) as an Australian subspecies of *R. djiddensis* (described from the Red Sea).

A detailed consideration of the nomenclature and systematics of *Rhynchobatus* will be presented elsewhere, but 7 species are recognised here and assigned tentative ranges: 1). *Rhynchobatus australiae* Whitley, 1939, originally described from New South Wales but now known to be more wide-ranging in Australia; more recent records from Thailand (Gulf of Thailand), Philippines, Singapore, Taiwan and Indonesia; a similar form occurs off Mozambique and in the Gulf of Aden. 2). *Rhynchobatus djiddensis* (Forsskål, 1775), possibly including *Rhinobates rueppelli* Swainson, 1838 (no types), originally described from Jeddah in the Red Sea but known from the western Indian Ocean, ranging from the southeastern coast of South Africa (Western Cape to KwaZulu-Natal), Mozambique and the Red Sea (Gulf of Suez, Egypt, and Jeddah, Saudi Arabia); numerous nominal records of *R. djiddensis* from the Indo–West Pacific (Garman, 1913; Fowler, 1941) cannot be confirmed because adequate descriptions, illustrations, and voucher specimens are generally not available. 3). *Rhynchobatus laevis* (Bloch & Schneider, 1801), originally described from Tranquebar, India (no types) and possibly including *R. yentinensis* Wang, 1933 (described from Yenching, Wenchow, China) from Zanzibar, the Arabian Sea, Oman, the Persian Gulf, India, Sri Lanka, Bangladesh and west to probably Indonesia, China, Japan and Australia; may be a species complex or chain of subspecies. 4). *Rhynchobatus luebberti* Ehrenbaum, 1914, including *R. atlanticus* Regan, 1915 as a junior synonym; from tropical West Africa from Mauritania to Congo and Cabinda, Angola. 5). *Rhynchobatus* sp. 1 (Compagno & Last, 1999), an undescribed species only known from Singapore and Java (Indonesia). 6). *Rhynchobatus* sp. 2 (Compagno & Last, 1999), an undescribed species that is found in the Western Pacific, Philippines, Thailand (Gulf of Thailand), Sarawak (Borneo, Malaysia), Singapore, and Java (Indonesia). 7). *Rhynchobatus palpebratus* sp. nov., a small, distinctive species from Australia and Thailand; possibly closely related to *R. laevis* and sympatric with an Australian form of *R. laevis*.

Other nominal species of *Rhynchobatus* are treated as follows: 1). *Nomen nudum*: *Rhinobatus laevississimus* Blainville, 1816, possibly based on *Rhinobatus laevis* Bloch & Schneider, 1801. 2). *Species dubia* within *Rhynchobatus*: *Rhinobatus duhameli* Blainville, 1825 (no types) and *Rhinobatus jaram* Montrouzier, 1856 (no types). 3). Species of *Rhinobatos*: *Rhinobatos albomaculatus* Norman, 1930 and *Rhinobatos irvinei* Norman, 1931, from West Africa. These were erroneously placed in *Rhynchobatus* by Bigelow & Schroeder (1953) because of damaged caudal fins on their holotypes that superficially resembled the shark-like caudal fins of *Rhynchobatus*. The senior author examined the holotypes of *R. albomaculatus* and *R. irvinei* in the Natural History Museum, London and his findings support their exclusion from *Rhynchobatus*.

Rhynchobatus palpebratus sp. nov.

Figs 1–4; Tables 1 and 2

Holotype. CSIRO H 3384–01, adult male 1025 mm TL, north-west of Wessel Islands, Arafura Sea, Northern Territory, 10°11′ S, 137°17′ E, 50 m, 09 Feb 1993.
Paratypes. 6 specimens (455–768 mm TL): CSIRO

C 2291, female 495 mm TL, Exmouth Gulf, Western Australia, ca. 22° S, 114° E, 1954; CSIRO CA 2373, female 455 mm TL, north of Groote Eylandt, Northern Territory, ca. 13° S, 136° E, 28 Jun 1981; CSIRO H 2376–08, female 512 mm TL, off Cairns, Queensland, 16°54′ S, 145°47′ E, 5 m, 14 Aug 1989; CSIRO H 3322–01, juvenile male 768 mm TL, west of Weipa, Gulf of Carpentaria, Queensland, 12°35′ S, 141°00′ E, 41 m, 22 Jan 1993; CSIRO H 3340–01, female 697 mm TL, west of Weipa, Gulf of Carpentaria, Queensland, 12°37′ S, 140°46′ E, 60 m, 30 Jan 1993; CSIRO H 4927–01, female 581 mm TL, market near Trang, Andaman Sea, Thailand, 08 Dec 1993.

DIAGNOSIS.— A *Rhynchobatus* with a long and narrowly pointed snout, not bottle-shaped or broadly wedge-shaped; preoral snout 17–22% of total length. Eyes small, lengths 3.7–4.0 in preorbital snout; interorbital space 2.6–2.8 in preorbital snout. Mouth hardly bowed, with a strong indentation on upper jaw near symphysis and strong protuberance on lower jaw. Tooth rows in upper jaw about 52; no spines on dorsal snout. Supraorbital spines very small, spines in mid-dorsal row similarly small; single weak row of small scapular spines on each side. Enlarged dorsal spines light-coloured. Origin of first dorsal fin over origin of pelvic fin; predorsal length 43–48% of total length. Colour pattern yellowish grey with white spots on pectoral disc and tail; pectoral disc with a prominent white anterior margin; black eye-brow like markings on orbital membrane; large, sharp-edged, black ocelli on pectoral-fin bases and sometimes behind spiracles. Propterygial radials 3–7 + 20–23 = 25–29, mesopterygial radials 3–5 + 5–7 = 9–12, metapterygial radials 24–28, total radials 62–65. Vertebrae: 12–14 synarcual centra, 25–35 monospondylous precaudal centra, 61–72 diplospondylous precaudal vertebrae, 35–44 caudal centra, 130–139 free centra, 144–152 total centra.

DESCRIPTION.— Body moderately robust; snout in front of eyes angular, obtusely wedge-shaped, with angle of about 50° (paratype CSIRO H 3322–01). Margins of anterior half of snout nearly straight to weakly concave, then becoming somewhat convex between eyes and origins of pectoral fins. Preorbital length about 3.2 in holotype (3.2–3.3 in paratypes) times interorbital width. Preoral length 3.1 (3.1–3.4) times mouth width. Disc (combined head-pectoral fins) width across pectoral-fin apices 83% (74–79%) of disc length from snout tip to pectoral-fin free rear tips. Head greatly depressed, trowel-shaped, disc thickness 1.5 (1.2–1.5) times in interorbital space; length from snout tip to fifth gill slits 3.6 (3.1–3.4) times in total length; surface between eyes and spiracles flat. Head-trunk length from snout tip to vent 72% (77–89%) length of tail from vent to caudal tip. Tail depressed, rounded dorsally and ventrally but angular laterally, tapering evenly from pelvic-fin insertions. Width of tail at first dorsal-fin insertions 2.2 (1.5–1.9) times interspiracular distance. Lateral keels of tail extended as the thick angular lateral edge on precaudal tail, extending forward to first dorsal insertion, strongly differentiated on caudal fin.

Horizontal eye (eyeball) diameter about 67% (70–72%) of interspiracular width, distance from anterior margin of orbit to posterior margin of spiracle 93% (86–94%) of interspiracular width; greatest dimension of spiracles 56% (44–52%) of horizontal eye diameter, their apertures transversely situated. Distance between spiracle and orbit about half horizontal eye diameter. Anterior margin of spiracle with a strong valve, posterior margin with two vertical spiracular folds; outer fold slightly higher and larger than the inner fold.

First through fourth gill slits subequal in length, the fifth distinctly shorter. Third gill slit 2.1 (2.2–2.8) in internarial width, 2.4 (2.5–3.3) times in nostril length, 1.4 (1.3–1.6) times length of fifth gill slit.

Nostrils forming about 45° angle with body axis, anterior ends more lateral. Nasal cavity fully open, without dividing flaps; aperture straight anterolaterally, curved posteromedially to form a hook. Anterior nasal flap narrow, low, anterolateral on nasal aperture, inserted near midlength of nasal aperture; anterior process short, rounded, about twice as long as wide, separated by a deep notch from wider posteromedial section. Posterolateral nasal flap low, narrow and elongated, weakly lobate; originating just behind lateral edge of incurrent aperture, extending posteriorly to about midlength of nasal aperture. Posterior nasal flap low, relatively short-based; joined to posterolateral flap at about anterior third of its length, junction concealed beneath posterolateral nasal flap; inserted at midlength of nostril. Nostril width 1.2 (1.2) times in internarial width.

Mouth opening slightly arcuate, weakly undulating to nearly straight laterally; strong medial depression on upper jaw corresponding to a very prominent hump at symphysis of lower jaw; much weaker corresponding depressions and humps laterally. Labial folds and furrows well-developed at corners of mouth. Lateral to labial folds are shallow pockets, surrounding jaws as a series of low folds and depressions, especially prominent on lower jaw. Roof of mouth behind tooth bands with a maxillary valve, narrowest medially but broader laterally; extending across entire width of mouth, with an essentially smooth edge. Teeth in serial rows about 52 in upper jaw of holotype.

Dermal denticles covering virtually all of body surface; on dorsal surface minute, closely packed but not overlapping each other, no obvious skin exposed between them; above eyes, denticles slightly smaller than those on interorbit; a subtriangular patch of enlarged denticles present in front of eyes, length of patch about half length of eye; denticles of ventral surface subequal in size to those of dorsal surface. Dorsal denticles with very low, slender

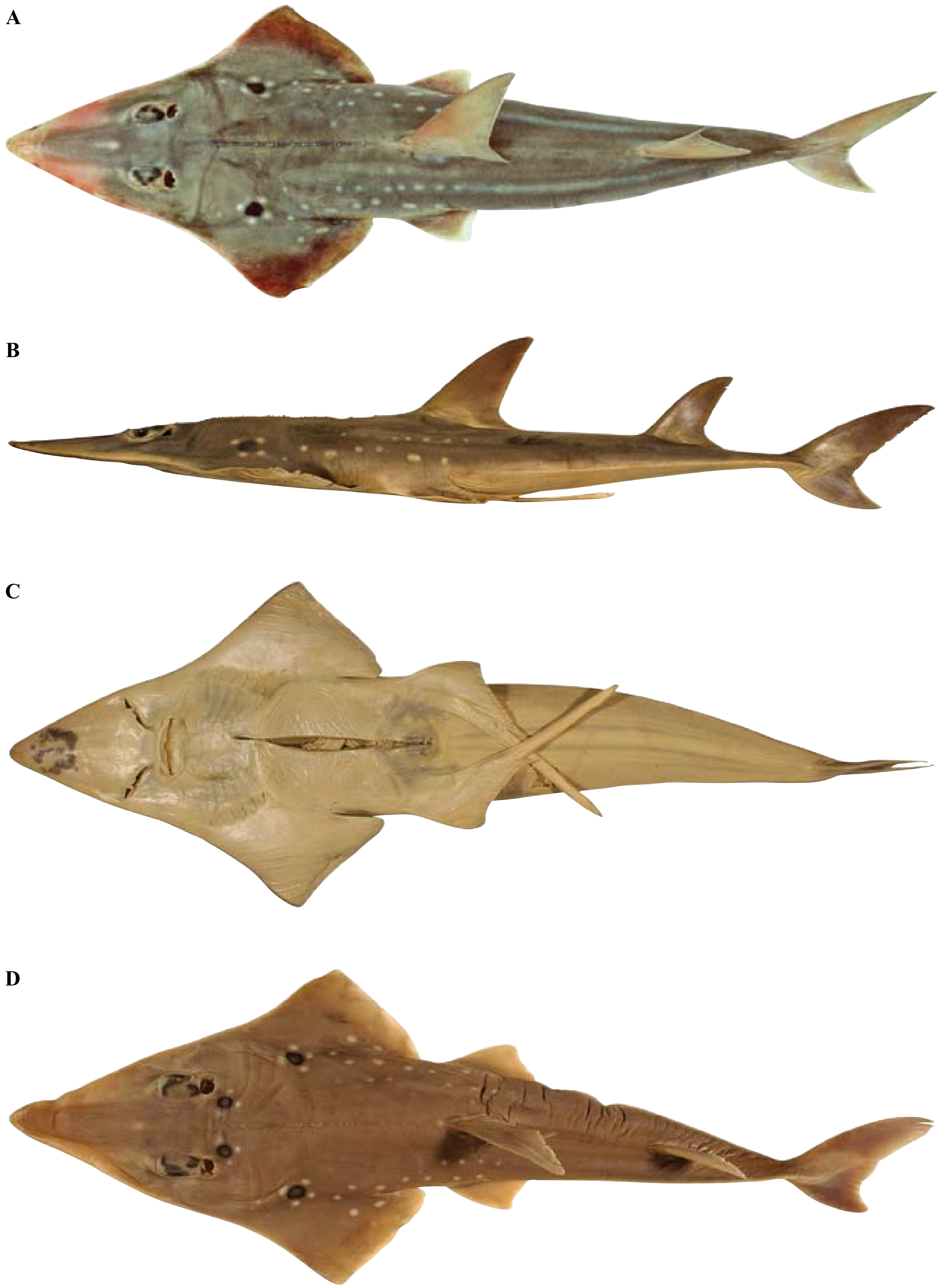

Figure 1. *Rhynchobatus palpebratus* sp. nov.: A. dorsal view (fresh), B. lateral view (preserved), C. ventral view (preserved) of adult male holotype (CSIRO H 3384–01, 1025 mm TL); D. dorsal view of female paratype (CSIRO CA 2373, 455 mm TL, preserved).

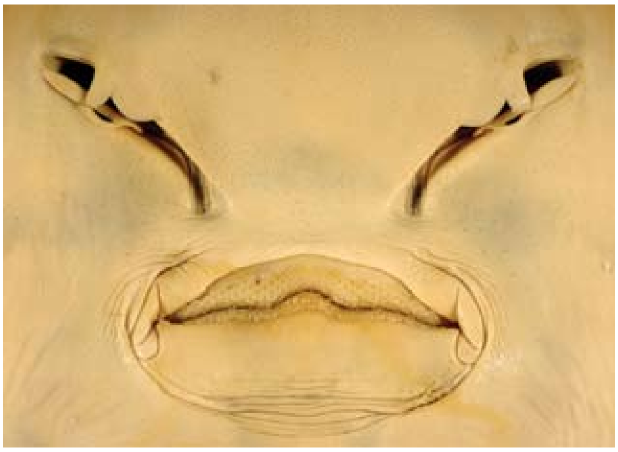

Figure 2. View of oronasal region of *Rhynchobatus palpebratus* sp. nov., adult male holotype (CSIRO H 3384–01, 1025 mm TL).

pedicels and flat crowns; crowns on trunk flattened, broad, subcircular, irregularly rounded anteriorly, unicuspidate or weakly tricuspidate posteriorly (posterior medial cusp weak in juvenile paratypes), usually with low medial and lateral ridges. Ventral denticles usually lacking cusps.

Small variable-sized thorns (enlarged denticles) present on dorsal surface of body and tail; present on orbital margin, along dorsal midline, and in scapular region; no rostral thorns; those between nuchal and scapular regions largest. Thorns on midline smooth, narrow, pearl-like (smallest paratypes with weak ridges anteriorly); semi-oblique to upright, bases partially embedded in skin; largest thorns tilted slightly, seed shaped or keel like; largest surrounded by a narrow naked perimeter and/or a broad patch of variably enlarged peripheral denticles; peripheral denticles with three well-developed longitudinal ridges on crown, terminating in three short cusps. Orbit with continuous series of variably sized thorns; series extending along inner margin of orbit from anterior mid-eye to posterior margin of spiracle; mostly in a single row, approximately 27 on each side in holotype; row usually at least partly interrupted medial to spiracle (vaguely subdivided into orbital and spiracular groups of thorns). Mid-dorsal series of thorns present before first dorsal fin (predorsal series) and between dorsal fins (interdorsal series); absent behind second dorsal fin. Predorsal thorns on a low dermal ridge in a single row, extending from anterior nuchal region to end of free rear tip of pectoral fin; more densely arranged forward of pectoral insertions; 41 thorns of variable sizes in holotype. Interdorsal thorns on poorly defined dermal ridge, extending in a single row from free rear tip of first dorsal fin to about an eye diameter anterior to second dorsal-fin origin; usually much smaller than predorsal thorns, 25 in holotype (smaller paratypes with fewer, widely spaced thorns along interdorsal midline). Two short patches (rows) of scapular thorns on each side of disc in holotype; positioned just forward of level of apices of pectoral fins; midlateral rows with five thorns, length about 3/4 of eye diameter; lateral patches very short, with one thorn (lateral patches absent in all paratypes).

Dorsal fins similar in shape, shark-like, with strongly convex anterior margins (shallowly concave at base), narrowly pointed apexes, deeply concave posterior margins, sharply acute free rear tips, and straight inner margins. Inner margins of first dorsal fin 79% (64–79%) of its base length. First dorsal fin considerably larger than second; origin about over origins of pelvic fins; free rear tip opposite or slightly forward of free rear tips of pelvic fin. Interdorsal space 2.5 (2.1–2.5) length of first dorsal base. Interdorsal space about 3.4 (3.0–3.3) times length of second dorsal-fin base.

Caudal fin rather short, its dorsal margin 5.6 (5.9–6.4) in total length, subequal to interdorsal space. Dorsal caudal-fin margin strongly convex, except at origin where it is slightly concave; tip narrowly pointed, angular. Preventral caudal margin strongly convex, except at ventral origin where it is concave; ventral lobe long, strong, angular (shorter and less well-defined in smaller paratypes). Lower postventral margin short, concave, 2.7 (2.3–3.4) in length of upper. Upper postventral margin weakly concave (more deeply concave in paratypes). Caudal axis raised slightly, forming a shallow angle to body axis.

Pectoral fins originating at about spiracles, with weakly convex anterior margins; apices broadly pointed, posterior margins almost straight, becoming more convex near free rear tips; free rear tips narrowly rounded, extending about 71% (67–82%) of distance from pectoral-fin insertions to pelvic-fin origins; inner margins straight to convex.

Pelvic fins with weakly convex anterior margins, broadly pointed apices, concave posterior margins, elongate free rear tips, and straight to slightly concave inner margins; inner margin very long, 1.6 (1.1–1.6) times lengths of pelvic bases; fin bases 1.2 (0.7–1.1) in distance between pectoral-fin insertions and pelvic-fin origins (pectoral–pelvic space); height of pelvic fins about 2.1 (2.0–2.4) in their lengths. Distance between pelvic-fin insertions longer than pelvic-fin base length. Vent with well-developed, extended lips, not connected with pelvic-fin inner margins.

Clasper very elongate, slender, weakly expanded distally at glans, extending to origin of second dorsal fin (adult male holotype).

Vertebral column with 144 (147–152) total centra; 14 (12–14) synarcual segments, 34 (25–35) monospondylous centra, 95 (95–99) precaudal centra, 35 (36–44) caudal centra, 130 (135–139) free centra. Total synarcual segments 9.7% (8.2–9.3)%; monospondylous 23.6% (16.4–23.5)%; diplospondylous precaudal centra 42.4%

Table 1. Morphometric data for the holotype and 5 paratypes of *Rhynchobatus palpebratus* sp. nov. (CSIRO H 3384–01), with ranges and means provided for all measured types. Measurements expressed as a percentage of total length.

	H 3384–01	CA 2373	H 2376–08	H 3322–01	H 3340–01	H 4927–01	Min.	Max.	Mean
TOT – Total length (mm)	1025	455	512	768	697	581	455	1025	673
FOR – Fork length	90.2	91.4	92.0	91.4	91.5	92.3	90.2	92.3	91.5
PCL – Precaudal length	82.5	82.9	83.2	82.3	83.2	84.3	82.3	84.3	83.1
PD2 – Pre-second dorsal length	66.0	68.1	68.0	67.1	67.1	69.9	66.0	69.9	67.7
PD1 – Pre-first dorsal length	42.8	48.0	46.9	44.1	44.5	47.6	42.8	48.0	45.7
PP2 – Prepelvic length	42.7	46.1	44.8	41.8	43.8	44.8	41.8	46.1	44.0
SVL – Snout–vent length	42.0	47.2	45.8	43.4	43.9	46.6	42.0	47.2	44.8
PSP – Prespiracular length	18.4	22.0	22.2	19.5	20.2	21.8	18.4	22.2	20.7
PG1 – Prebranchial length	24.2	28.4	28.2	25.0	25.9	27.6	24.2	28.4	26.6
HDL – Head length	28.1	32.7	32.4	29.0	30.0	32.3	28.1	32.7	30.7
POB – Preorbital length (direct)	14.7	17.8	18.1	15.6	16.1	17.9	14.7	18.1	16.7
POR – Preoral length	17.3	21.2	21.6	18.5	19.3	21.0	17.3	21.6	19.8
PRN – Prenarial length	13.8	16.7	16.5	14.6	15.1	16.4	13.8	16.7	15.5
IDS – Interdorsal space	17.2	14.6	15.2	17.1	16.5	16.3	14.6	17.2	16.2
DCS – Dorsal–caudal space	11.0	10.1	10.0	10.6	11.1	10.2	10.0	11.1	10.5
PPS – Pectoral–pelvic space	6.5	6.3	4.6	5.8	6.1	4.6	4.6	6.5	5.6
PCS – Pelvic–caudal space	35.5	31.0	33.2	36.0	33.5	33.1	31.0	36.0	33.7
PDS – Pelvic–dorsal space	0.1	1.1	0.8	1.0	1.1	1.3	0.1	1.3	0.9
DW – Disc width	33.7	34.1	34.0	32.7	33.1	33.5	32.7	34.1	33.5
DL – Disc length	40.6	45.9	45.7	41.4	42.5	45.0	40.6	45.9	43.5
DT – Disc thickness	7.0	6.9	7.4	7.4	7.2	6.9	6.9	7.4	7.1
Snout – greatest width	30.6	35.7	36.1	32.1	33.6	34.9	30.6	36.1	33.8
SWB – Snout width at base	13.4	16.0	15.7	13.9	14.4	15.4	13.4	16.0	14.8
COL – Corneal/eye length	1.7	2.9	2.5	1.9	1.7	2.3	1.7	2.9	2.2
COH – Corneal/eye height	1.0	1.4	1.3	1.0	1.1	1.2	1.0	1.4	1.2
EYL – Eye (eyeball) length	3.7	4.7	4.7	4.0	4.3	4.6	3.7	4.7	4.4
EYH – Eye (eyeball) height	2.6	2.9	2.8	2.6	2.7	2.6	2.6	2.9	2.7
INO – Interorbital space	4.6	5.5	5.5	4.8	5.0	5.4	4.6	5.5	5.1
SPL – Spiracle length	1.4	1.9	1.4	1.3	1.4	1.6	1.3	1.9	1.5
SPH – Spiracle height	2.1	2.2	2.4	2.0	2.1	2.1	2.0	2.4	2.1
ESL – Eye–spiracle space	5.2	6.2	5.9	5.3	5.5	5.6	5.2	6.2	5.6
INS – Interspiracular space	5.6	6.7	6.5	5.8	6.0	6.5	5.6	6.7	6.2
NOW – Nostril width	4.4	5.3	5.4	4.6	4.8	5.0	4.4	5.4	4.9
INW – Internarial space	3.8	4.5	4.3	3.8	4.0	4.3	3.8	4.5	4.1
ANF – Anterior nasal flap length	0.8	1.0	0.8	0.9	0.8	0.7	0.7	1.0	0.8
NSE – Nostril to snout edge	1.3	1.4	1.3	1.3	1.4	1.5	1.3	1.5	1.3
MOL – Mouth length	0.6	0.8	0.7	0.7	0.6	0.5	0.5	0.8	0.7
MOW – Mouth width	5.6	6.7	6.4	5.8	5.9	6.2	5.6	6.7	6.1
ULA – Upper labial furrow length	1.4	1.1	0.9	1.0	1.1	1.0	0.9	1.4	1.1
LLA – Lower labial furrow length	0.7	0.9	0.9	0.8	0.9	0.9	0.7	0.9	0.8
GS1 – First gill slit height	1.8	1.5	1.6	1.6	1.6	1.8	1.5	1.8	1.7
GS2 – Second gill slit height	1.8	1.6	1.7	1.7	1.7	1.9	1.6	1.9	1.7
GS3 – Third gill slit height	1.8	1.6	1.8	1.7	1.7	2.0	1.6	2.0	1.8

Table 1. cont'd.

	H 3384–01	CA 2373	H 2376–08	H 3322–01	H 3340–01	H 4927–01	Min.	Max.	Mean
GS4 – Fourth gill slit height	1.8	1.8	1.8	1.7	1.8	1.8	1.7	1.8	1.8
GS5 – Fifth gill slit height	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
ING1 – Intergill	13.3	14.6	14.5	13.0	13.3	13.7	13.0	14.6	13.7
Inter 5th gill	10.0	10.7	10.4	9.7	9.6	10.0	9.6	10.7	10.1
HDH – Head height	6.6	7.4	6.1	7.0	7.0	7.2	6.1	7.4	6.9
TRH – Trunk height	7.1	6.3	6.5	7.9	8.0	7.1	6.3	8.0	7.1
TRW – Trunk width	14.1	13.8	12.2	13.4	13.1	13.6	12.2	14.1	13.4
ABH – Abdomen height	6.9	6.1	6.7	7.0	6.9	7.3	6.1	7.3	6.8
ABW – Abdomen width	12.0	10.2	10.3	–	11.6	11.1	–	12.0	9.2
CPH – Caudal peduncle height	1.6	1.7	1.7	1.6	1.7	1.7	1.6	1.7	1.7
CPW – Caudal peduncle width	3.7	3.1	3.6	3.5	3.2	3.7	3.1	3.7	3.5
VNL – Vent length	2.7	2.5	2.2	2.6	2.3	2.4	2.2	2.7	2.4
TFL – Tail fold length	37.3	33.2	33.8	37.7	37.6	36.7	33.2	37.7	36.0
P1L – Pectoral-fin length	19.2	19.3	18.2	19.4	19.1	20.2	18.2	20.2	19.2
P1A – Pectoral-fin anterior margin	12.9	12.1	10.9	12.7	12.7	13.5	10.9	13.5	12.5
P1B – Pectoral-fin base	14.4	15.2	15.1	15.0	14.8	16.1	14.4	16.1	15.1
P1H – Pectoral-fin height	10.7	11.5	11.6	11.0	10.4	10.8	10.4	11.6	11.0
P1P – Pectoral-fin posterior margin	13.0	13.6	12.9	13.0	13.1	13.0	12.9	13.6	13.1
P1I – Pectoral-fin inner margin	4.6	4.2	3.8	4.4	4.7	4.8	3.8	4.8	4.4
P2L – Pelvic-fin length	13.8	13.5	12.2	13.5	13.2	13.0	12.2	13.8	13.2
P2A – Pelvic-fin anterior margin	7.7	8.5	7.4	8.1	7.9	7.6	7.4	8.5	7.9
P2B – Pelvic-fin base	5.4	6.7	6.2	6.3	5.3	5.4	5.3	6.7	5.9
P2H – Pelvic-fin height	6.7	5.6	5.3	6.7	6.6	6.1	5.3	6.7	6.2
P2P – Pelvic-fin posterior margin length	10.0	7.7	7.9	8.2	9.1	8.5	7.7	10.0	8.6
P2I – Pelvic-fin inner margin length	8.9	8.7	6.6	9.1	7.9	8.7	6.6	9.1	8.3
P2S – Pelvic-fin span	18.2	17.3	18.5	32.4	19.2	17.9	17.3	32.4	20.6
CLO – Clasper outer length	13.1	–	–	5.6	–	–	5.6	13.1	9.3
CLI – Clasper inner length	19.6	–	–	11.1	–	–	11.1	19.6	15.4
CLB – Clasper base width	1.5	–	–	0.8	–	–	0.8	1.5	1.1
D1L – First dorsal-fin length	12.2	11.6	11.5	12.4	11.9	12.1	11.5	12.4	11.9
D1A – First dorsal-fin anterior margin	15.3	14.4	14.6	15.8	14.8	14.9	14.4	15.8	15.0
D1B – First dorsal-fin base	6.9	6.5	7.2	6.9	6.9	7.0	6.5	7.2	6.9
D1H – First dorsal-fin height	10.4	10.4	10.3	9.9	10.0	8.7	8.7	10.4	9.9
D1P – First dorsal-fin posterior margin	10.6	10.4	9.4	10.2	10.0	8.4	8.4	10.6	9.8
D1I – First dorsal-fin inner margin	5.4	5.1	4.6	5.4	5.2	5.3	4.6	5.4	5.2
D2L – Second dorsal-fin length	9.7	9.4	8.7	9.8	9.4	9.3	8.7	9.8	9.4
D2A – Second dorsal-fin anterior margin	12.7	11.5	11.1	12.4	11.2	11.7	11.1	12.7	11.7
D2B – Second dorsal-fin base	5.1	4.9	5.0	5.2	5.0	4.9	4.9	5.2	5.0
D2H – Second dorsal-fin height	7.6	7.4	7.3	7.5	7.3	6.9	6.9	7.6	7.3
D2P – Second dorsal-fin posterior margin	7.2	7.3	6.9	6.8	6.9	6.0	6.0	7.3	6.8
D2I – Second dorsal-fin inner margin	4.6	4.7	4.2	4.7	4.5	4.6	4.2	4.7	4.5
CDM – Dorsal caudal margin	17.8	16.7	16.2	17.0	16.3	15.7	15.7	17.8	16.6
CPV – Preventral caudal margin	12.1	10.7	10.9	11.4	10.8	10.0	10.0	12.1	11.0
CPL – Lower postventral caudal margin	4.3	3.1	3.4	4.2	4.1	3.6	3.1	4.3	3.8

Table 2. Vertebral and pectoral-fin radial counts for the holotype (CSIRO H 3384–01) and paratypes of *Rhynchobatus palpebratus* sp. nov., with number counted, ranges, means and standard deviation provided for all types. Pectoral-fin radials are taken from the left side only.

	H 3384–01	C 2291	CA 2373	H 2376–08	H 3322–01	H 3340–01	H 4927–01	N	Min.	Max.	Mean	St. dev.
Vertebrae:												
SYS – synarcual segments	14	14	12	13	12	13	13	7	12	14	13.0	0.8
SYC+MP – monospondylous centra	34	28	27	25	32	35	25	7	25	35	29.4	4.2
DP – diplospondylous centra	61	68	71	72	67	62	70	7	61	72	67.3	4.3
DC – caudal centra	35	40	37	42	36	39	44	7	35	44	39.0	3.3
PCC – precaudal centra	95	96	98	97	99	97	95	7	95	99	96.7	1.5
DP+DC – total diplospondylous centra	96	108	108	114	103	101	114	7	96	114	106.3	6.7
TC – total free centra	130	136	135	139	135	136	139	7	130	139	135.7	3.0
TS – total centra	144	150	147	152	147	149	152	7	144	152	148.7	2.9
Pectoral-fin radials:												
FRA – free radials before propterygium	6	6	5	4	6	6	5	7	4	6	5.5	0.8
PRO – propterygials	22	23	20	22	22	22	23	7	20	23	21.8	1.0
MES – mesopterygials	4	5	4	4	3	4	5	7	3	5	4.0	0.6
NEO – neopterygials	6	6	6	6	7	6	6	7	6	7	6.2	0.4
MET – metapterygials	26	–	–	28	25	26	–	4	25	28	26.3	1.3
TR – total basal radials	64	–	–	64	63	64	–	4	63	64	63.8	0.5

(41.6–48.3)%, and precaudal free centra 66.0% (62.5–67.3)% of total centra count. Total attached pectoral radials 62–64 (62–65): 6 (3–7) free radials before propterygium, 22 (20–23) propterygials, 4 (3–5) mesopterygials, 6 (5–7) neopterygials, 26 (24–28) metapterygials, 56–58 (56–60) total basal radials (excluding free radials).

COLOUR.— Preserved specimens: Dorsal surface of body dark yellowish to greyish, with well-defined black pectoral spots (and often with spots and markings around eye and spiracle) and sparse, diffuse-edged white spots. Ventral surface almost uniformly yellowish or white. Snout with sharply-defined whitish or yellowish borders dorsally, broadest anteriorly; dorsal surface with dark median stripe and broad pale areas laterally, greatest width of pale area subequal to width of stripe (light areas most conspicuous in holotype and more or less faded in paratypes); elongated white marking on midline of forehead over the anterior fontanelle; preorbital area usually with pale markings; ventral snout pale with pair of small black marginal spots on snout tip, a large, irregular blackish blotch on front of snout in holotype. Dorsal surface of each eyeball with two curved black bars, highlighted anteriorly, posteriorly, and laterally with whitish areas. Margin of spiracle and spiracular folds pale. Disc with 1–2 pairs of black spots on either side of disc; main pectoral-fin spot large (subequal to or larger than eye), sharp-edged, usually surrounded by 4 almost equally spaced, diffuse-edged white spots (sometimes weakly ocellate in small specimens, e.g. CSIRO CA 2373); pectoral spot rarely with a smaller anterolateral black spot and additional white spots (i.e. CSIRO H 2376–08); pair of smaller black spots with three accompanying white spots often located posteromedially to the spiracles. Dorsal surface of pectoral fins with sparse coverage of small pale spots; spots not densely arranged in rows on posterior web of fin; subdorsal trunk with 2–4 rows of similar white spots, commencing just forward of pectoral-fin insertion and extending to just forward or just behind free rear tip of first dorsal fin; fins pale ventrally, except for dusky markings on anterior margins. Postpelvic tail without spots. Dorsal-fin bases pale, contrasting sharply with darker outer web; extreme edges of posterior margin of fins pale; caudal fin similar, with pale base, dark webs and light postventral margin. Pelvic fins similar to trunk dorsally, with dark base, paler web, and white anterior and posterior margins; uniformly pale ventrally; claspers almost uniformly pale, with a faint dusky stripe dorsally.

SIZE.— Material examined ranges from 455–1025 mm TL; largest specimen an adult male.

DISTRIBUTION.— Not well defined. Northern Australia from Exmouth Gulf (Western Australia) to Cairns (Queensland), including throughout the Arafura

Figure 3. Orbito-spiracular and nuchal region of *Rhynchobatus palpebratus* sp. nov., adult male holotype (CSIRO H 3384–01, 1025 mm TL).

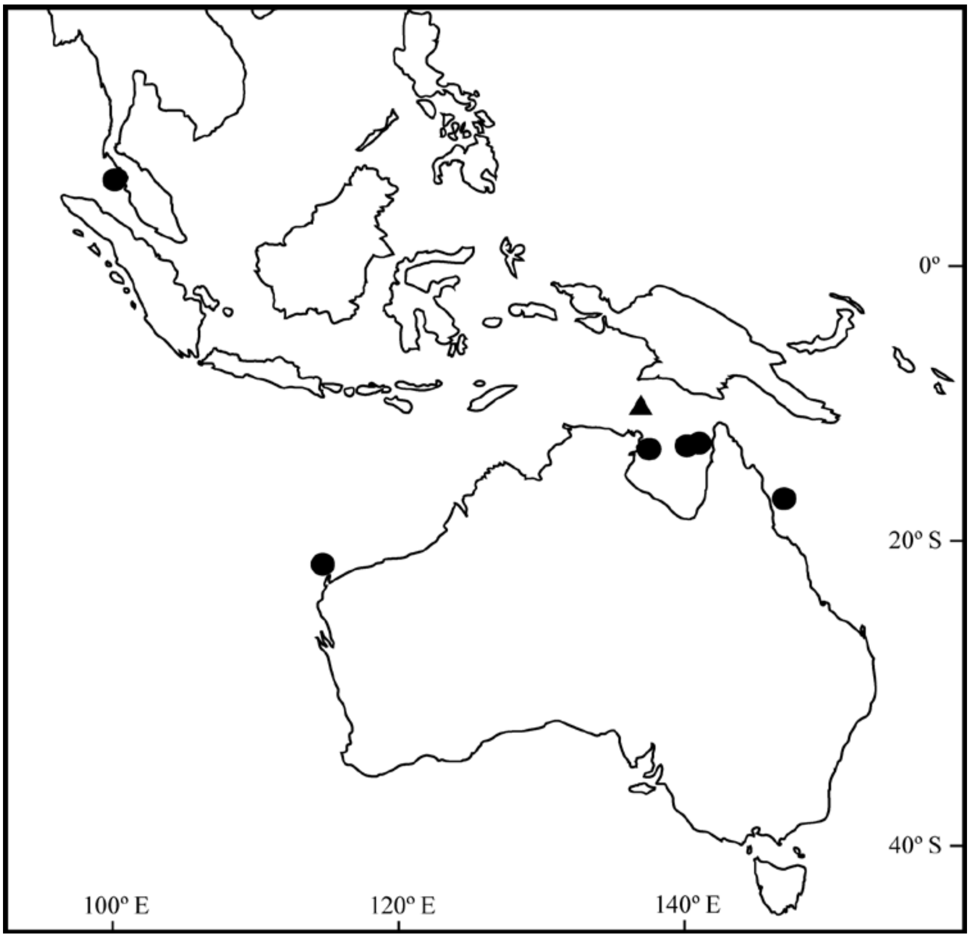

Figure 4. Map showing the collection localities of the type specimens of *Rhynchobatus palpebratus* sp. nov.: holotype (triangle) and paratypes (circles).

Sea (Northern Territory) and Gulf of Carpentaria (Fig. 4). A single record from the Andaman Sea suggests that it may be more widespread in the central Western Pacific. Probably mainly coastal; Australian depth records 5–61 m.

ETYMOLOGY.— Derived from the Latin *palpebra* (eyelid) in reference to the dark, eyebrow-like marking on the supraorbital membrane. Vernacular: Eyebrow Wedgefish.

REMARKS.— *Rhynchobatus palpebratus* differs from the only currently recognised Australian wedgefish, *R. australiae* Whitley, 1939, in its unique dark eyebrow-markings on the eyes, and bold light markings on the eyes and snout; in having a snout that is narrowly wedge-shaped (but not distinctly bottle-shaped or constricted near its tip); a more forwardly positioned first dorsal fin (origin about opposite pelvic-fin origins or slightly anterior to them by distance not exceeding 0.8% TL in front of or 1.2% TL behind them vs. origin behind pelvic-fin origins by a distance about 1.5–2.5% of total length); an almost circular black spot in pectoral ocellus (vs. spot usually elongate-oval in *R. australiae*); fewer attached propterygial radials (20–23 vs. 28–32); and fewer total free vertebral centra (130–139 vs. 152–153) and total vertebral centra (144–152 vs. 165–166).

Another wedgefish, which has been discovered recently in Australian seas, has been provisionally identified as *Rhynchobatus laevis* (Bloch & Schneider, 1801). Some variability exists within regional forms presently assigned to *R. laevis* and more research is needed to assess their validity. Unlike *R. palpebratus*, Australian populations of *R. laevis* have a plain coloured snout (not distinctively bicoloured with a dark medial band and whitish lateral bands), lack an eye-brow-like marking near the eyes, and have more precaudal centra (106–111 vs. 95–99 in *R. palbebratus*), total free vertebral centra (vs. 144–149 vs. 130–139) and total centra (156–165 vs. 144–152).

Comparative material.
Rhynchobatus australiae: 3 specimens: AMS IA 4959 (holotype), female 1300 mm TL; CSIRO H 1058–01, juvenile male 735 mm TL; CSIRO H 3323–01, female 998 mm TL.
Rhynchobatus cf *laevis*: 4 specimens: CSIRO C 2802, juvenile male 423 mm TL; CSIRO H 1474–03, juvenile male 606 mm TL; CSIRO H 2491–01, female 861 mm TL; CSIRO H 4051–01, juvenile male 796 mm TL.

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New species of numbfishes from Australia, with a key to Australian electric rays of the genus *Narcine* Henle, 1834 (Chondrichthyes: Torpediniformes: Narcinidae)

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ABSTRACT.— Two new species of electric rays of the genus *Narcine* Henle, 1834 are described from the Australian continental shelf and upper continental slope, and are compared with all valid and undescribed species of this genus. *Narcine ornata* sp. nov. is known from material mostly from the Gulf of Carpentaria, but also from specimens collected in the Timor and Arafura Seas, occurring off the Northern Territory, northwestern Queensland, and Western Australia. *Narcine ornata* sp. nov. is distinguished by its unique and elaborate dorsal coloration, composed of dark brown, large and medium-sized spots that are variously fused and elongated, and which are surrounded by smaller spots on most of dorsal surface including snout and tail region. Among species of *Narcine*, *N. ornata* sp. nov. is most similar to *N. westraliensis* in general features. *Narcine nelsoni* sp. nov. is described from abundant material collected from primarily two localities off northeastern Queensland. It is distinguished from congeners on the basis of a unique combination of characters, including an extremely elongated tail (tail length as measured from cloaca much longer than disc width or length), a much wider than long nasal curtain, a uniform light brown dorsal coloration devoid of spots and markings, and a low and ridge-like lateral tail fold. *Narcine nelsoni* sp. nov. closely resembles the predominantly Australian species *N. tasmaniensis* Richardson, 1841 and *N. lasti* Carvalho & Séret, 2002 in overall morphology, but is further distinguished from them in proportional measurements of the disc, interdorsal distance, and tooth row counts. A key to identify all Australian species of *Narcine* is provided.

Key words. Narcinidae – *Narcine* – *Narcine ornata* – *Narcine nelsoni* – Australia – Indo-West Pacific – new species – taxonomy – identification

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INTRODUCTION

Electric rays of the genus *Narcine* Henle, 1834 ("numbfishes" or "lesser" electric rays) are small to medium-sized batoids that are relatively common components of the inshore marine fauna. Species of *Narcine* have their greatest diversity in the vast tropical Indo–West Pacific region, with upwards of 15 species currently recognised, and where species identification may be problematical, especially concerning material from the Gulf of Tonkin and from the Indian sub-continent, and in relation to specimens usually attributed to the morphologically similar species *N. maculata* (Shaw, 1804) and *N. lingula* Richardson, 1846 (Carvalho, 1999; Carvalho *et al.*, 1999). Numbfishes occur circumglobally in warm to warm-temperate continental shelf and upper continental slope regions, but are absent from regions with a manifest cold-water influx, such as along western Africa in the Eastern Atlantic Ocean.

Narcine is hypothesised to be monophyletic on the basis of derived neurocranial and branchial arch characters (see below). Carvalho (1999) reviewed the genus and recognised a total of 20 species, including 9 species which were deemed to be new at that time. Subsequent publications have increased the diversity of *Narcine*; presently, out of 32 nominal species available in the genus, at least 16 are considered valid and some 3 new forms, in addition to the ones described below, still await formal description (Carvalho, 1999, 2001; Carvalho & Séret, 2002; Carvalho *et al*., 2002a, b; Carvalho & Randall, 2003; Carvalho, unpubl. data). Three new species of *Narcine* from Australia were treated, but not named, by Last & Stevens (1994), Carvalho (1999) and Carvalho *et al*. (1999). The description of one of these species, distributed from Western Australia to southeastern Indonesia, has been published elsewhere (Carvalho & Séret, 2002). The remaining two new species from Australia are described in the present paper; a key to identify all five Australian species of *Narcine* is also provided.

METHODS

Measurements were obtained with electronic calipers in a straight line, point-to-point, to the nearest tenth of a millimeter, except when specimens were large (approx. 150 mm or more), in which the aid of a steel ruler or tape measure was employed. Measurements are according to Carvalho (1999, 2001) and are expressed as proportions of total length (% of TL) to facilitate direct comparisons. Measurements are further defined in the Appendix. Meristics also follow Carvalho (1999, 2001) and were taken directly from radiographs (and are also presented in the Appendix). Note that the position of the pelvic girdle was employed to divide the vertebral column into trunk and precaudal centra (discerning the monospondylous/diplospondylous transition was not always possible from radiographs). Radial elements of the pectoral and dorsal fins that are joined at base but radiate outward in a bifid fashion were counted as two separate elements. Tooth counts were taken under stereomicroscope and follow the method outlined by Stehmann (1978). Only exposed tooth rows were counted, i.e. rows visible on tooth bands when the mouth is closed (radiography or dissection would be necessary to count internal tooth rows due to the strength with which the mouth is closed). Comparative material of all species of *Narcine* was used for the present description (listed in Carvalho, 1999). Institutional abbreviations follow Leviton *et al.* (1985). Terminology generally follows Carvalho (1999, 2001).

SYSTEMATIC ACCOUNTS

GENUS *NARCINE* HENLE, 1834

DIAGNOSIS.— Narcinid electric rays distinguished from the other extant genera of the family (*Discopyge* Heckel, 1846, *Benthobatis* Alcock, 1898 and *Diplobatis* Bigelow & Schroeder, 1948) by the following unique combination of external features: joint nasal curtain with straight posterior margin, without median posterior flap (present in *Discopyge*); pelvic fins separated posteriorly, not joined to form "apron" (present in *Discopyge*); eyes functional and clearly visible externally anterior to spiracles, usually about same size or slightly larger or smaller than spiracles (eyes not readily visible externally in *Benthobatis*); nostrils not subdivided into two distinct compartments by bridge of stiff integument between dorsal nasal curtain and ventral nasal flaps (nostrils fully divided in *Diplobatis*); claspers adjoined lateroexternally to pelvic fins, not covered and concealed dorsally by pelvic fins (condition in *Diplobatis* and some species of *Benthobatis*); both lower and upper tooth bands exposed externally when mouth is closed (tooth bands not readily exposed in *Diplobatis* and *Benthobatis*); lateral tail folds or ridges on lateral aspect of tail generally well developed, extending from level of first dorsal fin posteriorly to caudal peduncle (rudimentary lateral tail folds in *Benthobatis*). The following anatomical features were hypothesised as supporting the monophyly of *Narcine* by Carvalho (1999): fused and paired hypobranchial plates with sinuous external margins, articulating with ceratobranchials 2–4; separate facio-palatine foramen present within the orbit; conspicuous heart-shaped basibranchial copula that bears a well-developed, slender posterior process; lack of contact between ceratohyal and the first hypobranchial.

Narcine ornata sp. nov.

Figs 1–6, Tables 1–2

Narcine westraliensis: Gloerfelt-Tarp & Kailola, 1984: p 36 (misidentification, photograph); Sainsbury *et al*., 1985: pp 44, 330 (misidentification, brief description, listed, photograph); Allen & Swainston, 1988: p 26 (in part, misidentification, illustration); Paxton *et al*., 1989: p 61 (in part, misidentification).

Narcine sp. A: Last & Stevens, 1994: pp 374, 375, key fig. 1, fig. 39.1, pl. 67 (identification, description, distribution, illustrated in colour); Compagno *et al*., 1999: p 1407 (listed); Carvalho *et al*., 1999: pp 1435, 1437, 1441 (identification, brief description, distribution, illustrated).

Narcine sp.: Allen, 1997: p 46 (brief account, illustration).

Narcine sp. nov. A: Carvalho, 1999: pp 209–218, figs 72–76, tabs. 28–29 (identification, description, distribution, illustrated, colour photographs); Carvalho & Séret, 2002: p 405 (comparisons with *Narcine lasti*, originally described therein).

Holotype. CSIRO H 3646–02, 186 mm TL adult male, Gulf of Carpentaria, 12°58′ S, 139°10′ E, 56 m, FRV *Southern Surveyor*, SS 7/93/21, G. Yearsley, 01 Nov 1993 (Figs 1, 2a).

Paratypes. (6 specimens, 169–237 mm TL): Queensland: AMS I 15557–015, 204 mm TL adult female, Gulf of Carpentaria, 12°37′ S, 140°57′ E, 61.2 m (34 fathoms), 29 Apr 1964; CSIRO CA 2273, 194 mm TL adult male, Arafura Sea, west of Prince of Wales Island, 10°44′ S, 139°55′ E, 58 m, FRV *Soela*, SO 2/81/28, prawn trawl, 13 June 1981; CSIRO H 1115–01, 212 mm TL adult male, Arafura Sea, North of Gulf of Carpentaria, 10°38′ S, 139°46′ E, 53 m, FRV *Kulasi*, Sta. 2 (Shot 1), P. Kailola, 06 Nov 1987; CSIRO H 3646–05, 169 mm TL adolescent or adult female, collected with holotype (Fig. 2b); QM I 27854, 237 mm TL adult female, Gulf of Carpentaria, 14°30′ S, 139°42′ E, 59 m, CSIRO cruise no. SS 3/90, Sta. 75, J. Johnson, 07 Dec 1990 (Fig. 5); QM I 28005, 223 mm TL adult female, Gulf of Carpentaria, 13°31′ S, 137°32′ E, 48 m, CSIRO cruise no. SS 3/90, Sta. 99, J. Johnson, 12 Dec 1990.

Other material: (22 specimens, 115–241 mm TL) Queensland: CSIRO H 1116–01, 194 mm TL adult female, Arafura Sea, 10°36′ S, 140°01′ E, 54 m, FRV Kulasi, Sta. 3/4 (Shot 6), P. Kailola, 05 Nov 1987; QM I 11150, 194 mm TL adult male, Gulf of Carpentaria, 16°58′ S, 140°57′ E, MV *Laakanuki*, Sta. 26; QM I 23187 (2 specimens), 241 and 240 mm TL adult females, Gulf

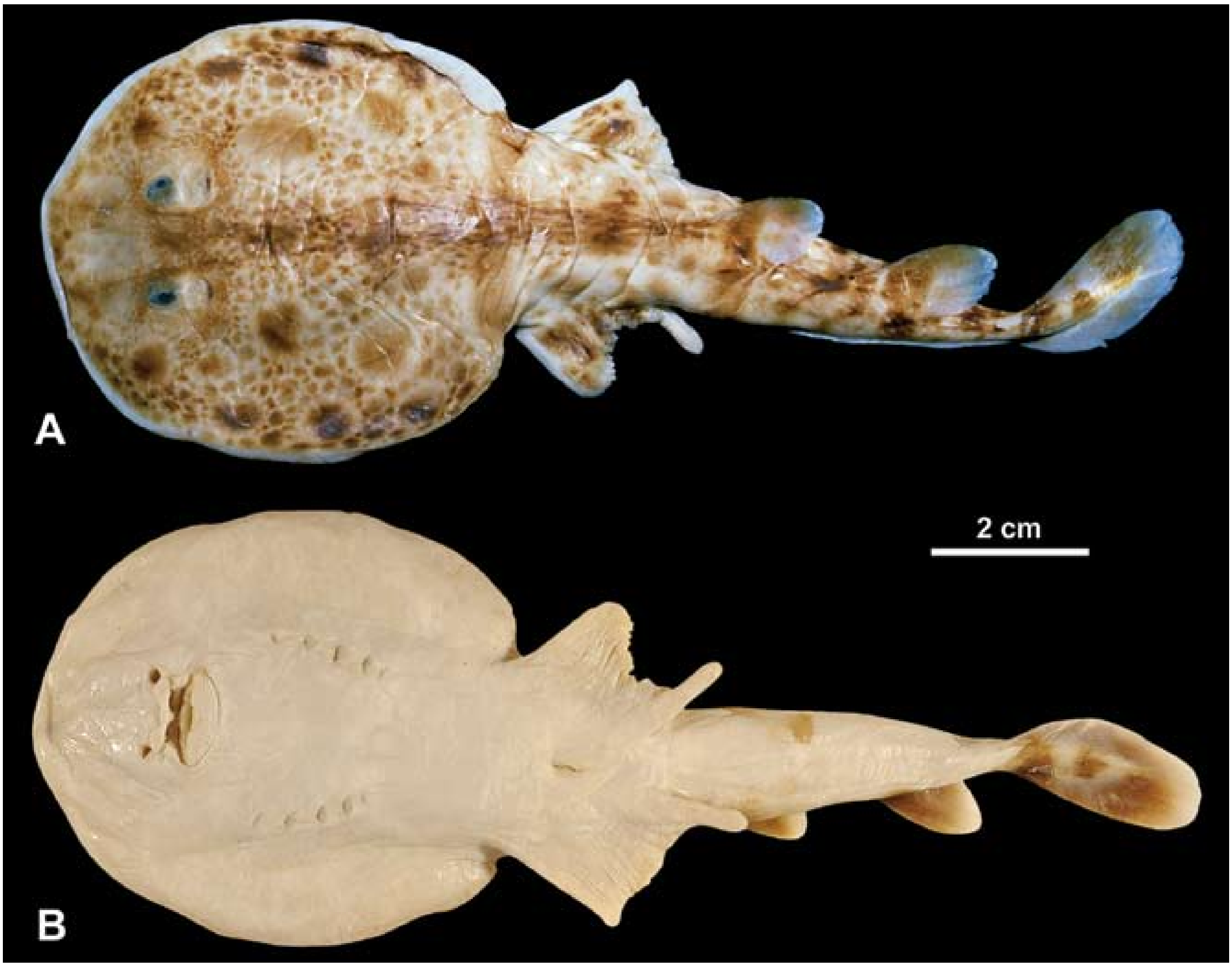

Figure 1. Holotype of *Narcine ornata* sp. nov. in dorsal (A) and ventral (B) views (CSIRO H 3646–02, 186 mm TL adult male, Gulf of Carpentaria, fresh). Caudal fin is downturned in ventral view.

of Carpentaria, ca. 16° S, 140° E, "Q.F.S.", 19 Oct 1983 (Fig. 3); QM I 25766, 197 mm TL adult male, Gulf of Carpentaria, 10°37′ S, 140°08′ E, 52 m, P. Kailola, 5 Nov 1987; QM I 27918, 155 mm TL juvenile female, Gulf of Carpentaria, 11°59′ S, 139°42′ E, 57 m, J. Johnson, 08 Dec 1990. Northern Territory: CSIRO H 773–01, 166 mm TL adolescent or adult male, Arafura Sea, north of Cape Wessel, Wessel Island Group, 09°48′ S, 136°57′ E, 80 m, *Chin Wei 1*, 28 Mar 1987 (Fig. 4b); CSIRO C 4079, 220 mm TL adult male, Gulf of Carpentaria, 13°30′ S, 137°04′ E, 04 Sep 1963; NTM S 11680–012, 161 mm TL juvenile male, Arafura Sea, north of Cape Wessel, 10°30′ S, 136°21′ E, 56–57 m, Sta. WH 85–4, W. Houston, 9 Mar 1985; NTM S 12262–003, 177 mm TL adolescent or adult male, Arafura Sea, north-east of Goulburn Island, 10°20′ S, 134°29′ E, 59 m, NT Fisheries Obs., Sta. BAG 8706A; NTM S 12264–003, 184 mm TL adolescent or adult male, Arafura Sea, north-east of Goulburn Island, 10°21′ S, 134°24′ E, 59 m, NT Fisheries Observers, Sta. BAG 8706C, 12 June 1987; NTM S 12269–003, 115 mm TL juvenile male, Arafura Sea, north of Goulburn Island, 10°19′ S, 133°30′ E, 80 m, NT Fisheries Observers, Sta. BAG 8706H, 20 June 1987; NTM S 12924–001 (2 specimens), 214 mm TL adult male, 123 mm TL juvenile male, Arafura Sea, 09°43′ S, 133°25′ E, 105 m, Sta. RW 90–25, R. Williams, 14 Nov 1990; NTM S 12983–002, 170 mm TL adolescent male, Arafura Sea, 10°18′ S, 132°50′ E, 68 m, Sta. HL 90–55, H. Larson, 01 Nov 1990; NTM S 13347–002, 123 mm TL juvenile male, Arafura Sea, 09°39′ S, 133°19′ E, 115 m, 14 Nov 1990; NTM S 13576–008 (2 specimens), 228 and 215 mm TL adult females, Arafura Sea, 09°46′ S, 133°45′ E, Sta. RW 92–64, R. Williams, 19 Oct 1992. Western Australia: AMS I 21634–002, ca. 200 mm TL adult female, Timor Sea, 11°42′ S, 127°29′ E, 132 m, RV *Courageous*, J. Paxton, 2 June 1979; NTM S 13329–001 (2 specimens), 178 and 173 mm TL adolescent males, Timor Sea, 12°47′ S, 128°16′ E, 99 m, NT Fisheries Observers, Shot 199, 07 Dec 1990 (Fig. 4a); NTM S 13400–001, 204 mm TL adult female, Timor Sea, 12°05′ S, 126°59′ E, 87 m, NT Fisheries, Shot 173.

DIAGNOSIS.— A species of *Narcine* distinguished from all congeners by its uniquely derived dorsal colour

Figure 2. Dorsal coloration in (A) freshly collected holotype (CSIRO H 3646–02, 186 mm TL adult male), and (B) paratype (CSIRO H 3646–05, 169 mm TL adolescent or adult female) of *Narcine ornata* sp. nov.

pattern, composed of dark brown, large and medium-sized spots (generally larger than interorbital distance) that are variously fused and elongated, which are surrounded by smaller spots (smaller than eye-diameter) on most of dorsal surface including snout and tail region.

DESCRIPTION.— Measurements and counts are presented in Tables 1 and 2, respectively. Disc generally oval, slightly longer than wide on average (disc length is 36.5–44.0% TL [mean 40.2%], disc width is 30.4–42.8% TL [mean 36.9%]). In well-preserved or fresh specimens disc slightly overlaps origin of pelvic fins posteriorly, but in most preserved specimens disc ends posteriorly at level of origin of pelvic fins. Disc adjoins directly to side of trunk, not leaving any distinguishable free lobe posteriorly. Snout region circular anteriorly, not angled or acute; preorbital snout length reaching 7.5–11.6% TL. Preorbital snout region about one-fourth to one-fifth of disc length. Electric organs externally not markedly distinguished in dorsal or ventral views (slightly more conspicuous in ventral view). Electric organs extend anteriorly from level of anterior margins of eyes, and ventrally at level of nostrils, and continue posteriorly on disc to between four-fifths and five-sixths of disc length. Electric organs much longer than wide; electric organ length varies from 12.9–24.8% TL, electric organ width varies from 5.4–10.2% TL. Gill slits semi-circular, very small, and relatively close together; gill-slits situated closer to mid-line progressively from first to last gill-slit. Distance between last gill-slits and length of branchial basket almost equal. Spiracles begin adjacent to posterior aspect of eyes; spiracles without strongly elevated rims. Eyes just slightly longer than spiracles on average; spiracles about as wide as long. Spiracles very circular posteriorly.

Nasal curtain relatively long in well-preserved or fresh specimens, covering the upper tooth band almost entirely. Nasal curtain with circular posterior margin that is wider than area between nostrils. Ampullary pores on nasal curtain continue posteriorly to level of posterior margin of nostrils, which is close to nasal curtain mid-length. Nostrils small, circular and with slightly elevated borders. Prenasal snout length just inferior to preorbital snout length. Mouth wider than internarial distance (6.0–8.1% TL vs. 1.8–4.1% TL, respectively). Upper tooth band slightly wider than lower tooth band, both fairly circular in outline with exposed portions wider than long, however lower tooth band may be sub-triangular in some specimens. Teeth in 12–17/9–18 exposed vertical rows

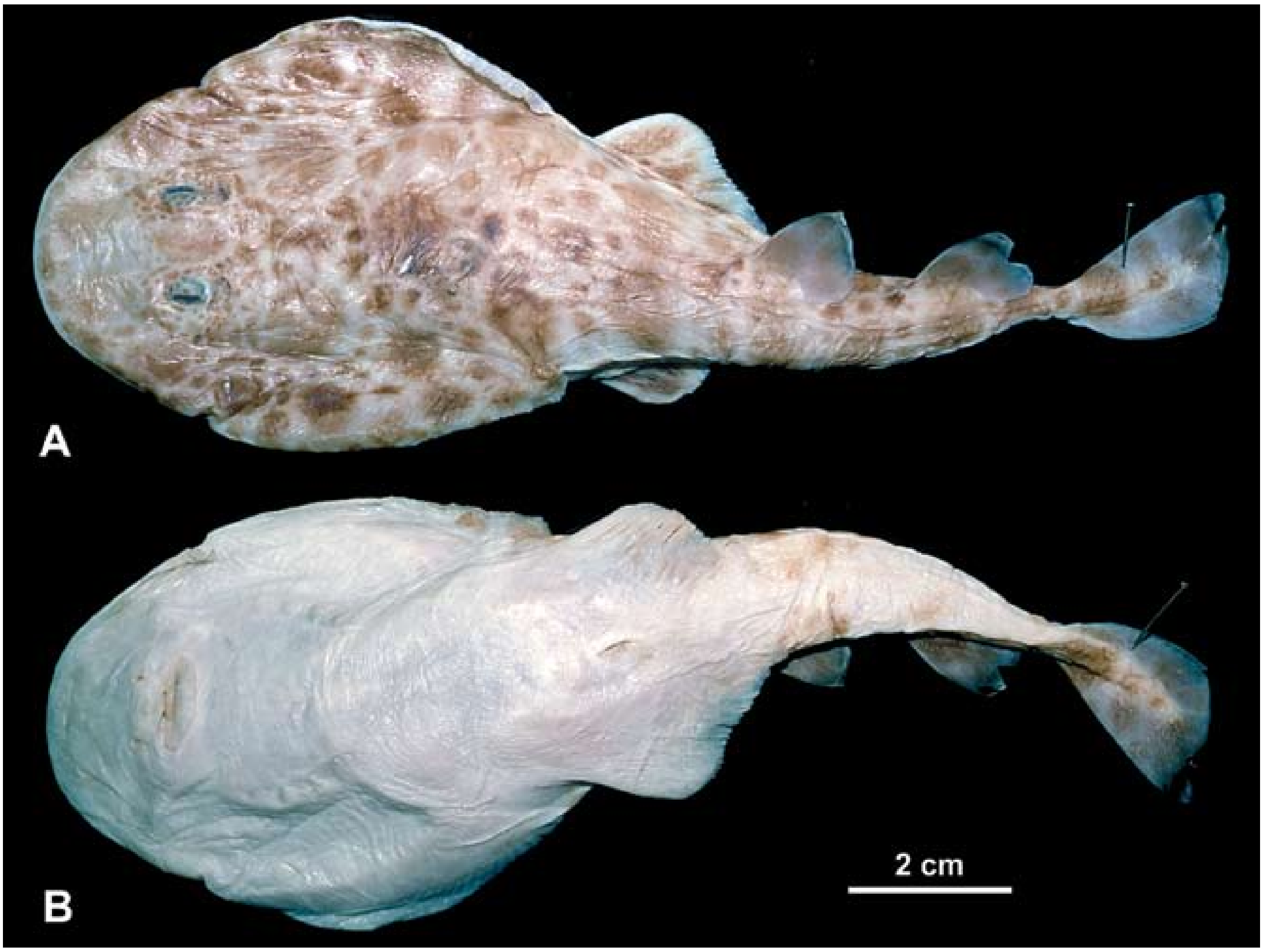

Figure 3. Dorsal (A) and ventral (B) depiction of *Narcine ornata* sp. nov. (QM I 23187, 241 mm TL adult female, Gulf of Carpentaria). Caudal fin is downturned in B.

in adults and adolescents (one specimen had an unusual count of 13/18, accounting for the high extreme of lower tooth rows, which would otherwise be 14). Teeth with small cusps generally, especially on exposed rows; teeth on inner-most rows with slightly more extended cusps; adult males with longer cusps than adult females of similar size. Crowns small, diamond-shaped, wider than long, closely set in quincunx arrangement.

Pelvic fins not very prominent, wider than long, with posterior lobes longer than anterior lobes. Posteriorly, pelvic fin has a very small free lobe. Pelvic fins extend from level of posterior insertion of pectoral fins to underneath level of origin of first dorsal fin on tail. Pelvic fins not greatly rounded or blunt at lateral corners. Claspers relatively thin, attached to pelvic fins without leaving a significant free lobe. Claspers in mature males project posteriorly beyond pelvic fins to about one-fifth of their total length as measured from cloaca, reaching to level of mid first dorsal fin base. Tail long, longer than disc length, and distinctively occupying from 49.5–58.4% TL as measured from cloaca to posterior tip of tail. Tail relatively broad at base (compared to disc width, tail width 14.1–22.0% TL vs. 30.4–42.8% TL), sub-circular in cross-section. Lateral tail fold not as prominent as observed in *N. westraliensis*, beginning just posterior to first dorsal fin base and extending caudally to insert on lower aspect of lateral caudal peduncle. Lateral tail fold commences as a slight ridge, barely noticeable, and is more difficult to detect in dried and distorted specimens. Dorsal fins about equal in height and length of base, first dorsal appearing only slightly taller, second dorsal slightly more slanted. Dorsal fins relatively rounded at apex in most specimens, sub-acute in larger adults. Dorsal fins with rounded to more or less straight posterior margins, and with small free lobe posteriorly (sometimes more pronounced on second dorsal fin). First dorsal fin originates dorsally on tail at level of small free lobe of pelvic fins or dorsal to posterior pelvic fin base. Distance between dorsal fins about equal to distance between second dorsal and caudal fins (means of 6.8 and 6.9% TL, respectively). Caudal fin generally low, not reaching one-half of dorsal fin height (applying to both upper and lower lobes of caudal fin when measured separately). Caudal fin long, with rounded, continuous posterior margin; lower caudal fin lobe beginning anterior to upper caudal fin lobe in some larger specimens.

Table 1. Measurements for *Narcine ornata* sp. nov. N is number of specimens from which means and standard deviations (SD) were extracted. All measurements, except TL, are expressed as percentages of TL. See 'Appendix' for abbreviations. Holotype: CSIRO H 3646–02.

	Holotype	Paratypes	All specimens	N	Mean	SD
TL (mm)	186	169 – 237	155 – 241	24	–	–
DW (%)	38.7	30.7 – 41.0	30.4 – 42.8	24	36.9	3.7
DL (%)	40.3	37.6 – 43.0	36.5 – 44.0	24	40.2	2.2
PBS (%)	10.0	8.6 – 9.6	7.5 – 11.6	24	9.5	0.9
POS (%)	13.5	12.0 – 12.9	12.0 – 14.0	24	12.7	0.6
PNS (%)	9.6	8.3 – 9.0	7.2 – 9.8	24	8.5	0.7
SDW (%)	28.0	27.0 – 30.7	22.1 – 30.7	24	25.8	2.4
IOD (%)	6.0	5.6 – 7.0	4.7 – 7.5	24	5.9	0.7
EL (%)	2.8	2.8 – 3.6	2.3 – 3.9	24	3	0.4
ISD (%)	6.0	5.7 – 7.1	4.6 – 7.1	24	6.2	0.6
SPL (%)	2.4	1.9 – 2.9	1.5 – 3.0	24	2.2	0.3
SPW (%)	2.6	2.2 – 2.8	2.0 – 3.7	24	2.5	0.3
MW (%)	8.0	5.9 – 7.2	6.0 – 8.1	24	7.1	0.6
UTB (%)	2.1	2.0 – 3.2	2.0 – 3.4	24	2.6	0.3
LTB (%)	1.9	1.6 – 2.5	1.5 – 3.0	24	2	0.4
NCW (%)	6.1	4.5 – 5.3	4.1 – 6.6	24	5.1	0.6
NCL (%)	2.7	1.8 – 4.1	1.8 – 4.1	24	2.7	0.7
DBN (%)	5.4	2.5 – 5.2	1.9 – 6.0	24	4.5	0.9
FGO (%)	14.5	10.2 – 12.1	10.2 – 14.5	24	11.8	1.1
LGO (%)	10.1	7.2 – 10.7	7.2 – 10.7	24	8.6	1.0
BBL (%)	9.4	7.7 – 10.5	6.9 – 10.5	24	8.5	0.9
PFL (%)	17.2	16.0 – 19.2	13.7 – 19.3	24	17.3	1.6
PFW (%)	29.6	22.3 – 29.6	20.8 – 31.9	24	28	2.9
AMP (%)	12.6	9.9 – 16.7	7.5 – 16.9	24	10.6	1.9
PMP (%)	12.4	10.0 – 15.2	9.2 – 17.8	24	13.2	2.4
TW (%)	16.6	14.2 – 19.8	14.1 – 22.0	24	17.2	2.1
HFD (%)	8.4	8.2 – 9.5	8.2 – 11.5	24	9.5	1
LFD (%)	7.5	6.6 – 8.0	5.6 – 9.0	24	7.3	1
HSD (%)	8.8	8.0 – 9.0	7.1 – 11.1	24	9.2	1
LSD (%)	8.2	7.2 – 9.4	5.7 – 9.5	24	7.9	0.9
LDC (%)	14.9	13.2 – 16.1	6.1 – 16.7	24	14.5	2
LVC (%)	14.9	12.3 – 15.3	6.6 – 16.5	24	13.9	2.1
HDC (%)	3.8	3.3 – 3.9	2.9 – 4.5	24	3.7	0.4
HVC (%)	3.1	2.8 – 3.7	2.6 – 4.4	24	3.3	0.4
HC (%)	8.0	7.0 – 8.7	6.9 – 11.4	24	8.6	1.1
DBD (%)	6.2	5.0 – 9.3	4.4 – 9.3	24	6.8	1.3
SDC (%)	6.1	5.2 – 7.0	4.8 – 8.8	24	6.9	1.1
SCL (%)	43.0	41.5 – 43.8	39.2 – 45.6	24	42.3	1.5
CLC (%)	52.7	50.0 – 53.8	49.5 – 58.4	24	53.3	2
SFD (%)	58.6	49.5 – 56.1	48.8 – 58.6	24	53.7	2.6
EOL (%)	18.8	12.9 – 23.7	12.9 – 24.8	24	20.8	2.8
EOW (%)	8.1	5.8 – 8.8	5.4 – 10.2	24	7.1	1.2
CL (%)	10.2	12.0 – 13.3	10.2 – 15.2	12	13	1.5

Table 2. Counts for *Narcine ornata* sp. nov. A) QM I 23187–001 (241 mm TL); B) QM I 23187–001 (240 mm TL); C) QM I 25766; D) QM I 27918 (paratype); E) NTM S 13576–008 (228 mm TL); F) NTM S 13576–008 (215 mm TL); G) NTM S 13400–001; H) NTM S 12924–001; I) NTM S 13329–001; J) NTM S 11680–012; K) NTM S 12983–002; L) NTM S 12262–003; M) NTM S 12264–003. Dashes represent counts not available in radiographs. See 'Appendix' for abbreviations.

	A	B	C	D	E	F	G	H	I	J	K	L	M	RANGE
PRO	15	15	15	14	15	–	15	15	15	15	15	15	17	14–17
MES	6	7	7	7	8	8	8	8	8	6	8	6	6	6–9
MET	9	7	7	8	6	9	9	9	8	7	6	6	6	6–9
TPR	30	29	29	28	29	–	32	32	31	28	29	27	29	27–32
PVR	17	19	19	16	16	14	17	16	17	15	17	15	14	14–19
FDR	9	9	9	7	–	7	8	7	7	–	8	6	7	6–9
SDR	11	9	9	8	–	9	–	8	11	–	8	–	8	8–11
DCR	28	28	28	25	23	21	24	31	22	24	25	26	27	21–31
VCR	32	32	32	31	27	27	31	32	30	29	31	26	29	26–32
TCR	60	60	60	56	50	48	55	63	52	53	56	52	56	48–63
TC	16	17	17	17	15	16	16	16	18	16	17	17	16	15–18
PC	58	63	63	59	59	64	67	61	59	61	63	63	61	58–67
CC	26	30	30	26	26	23	26	28	29	24	26	24	26	23–30
TV	100	110	110	102	100	103	109	105	106	101	106	104	103	100–110
R	7	5	5	6	6	6	5	6	5	6	6	5	6	5–7

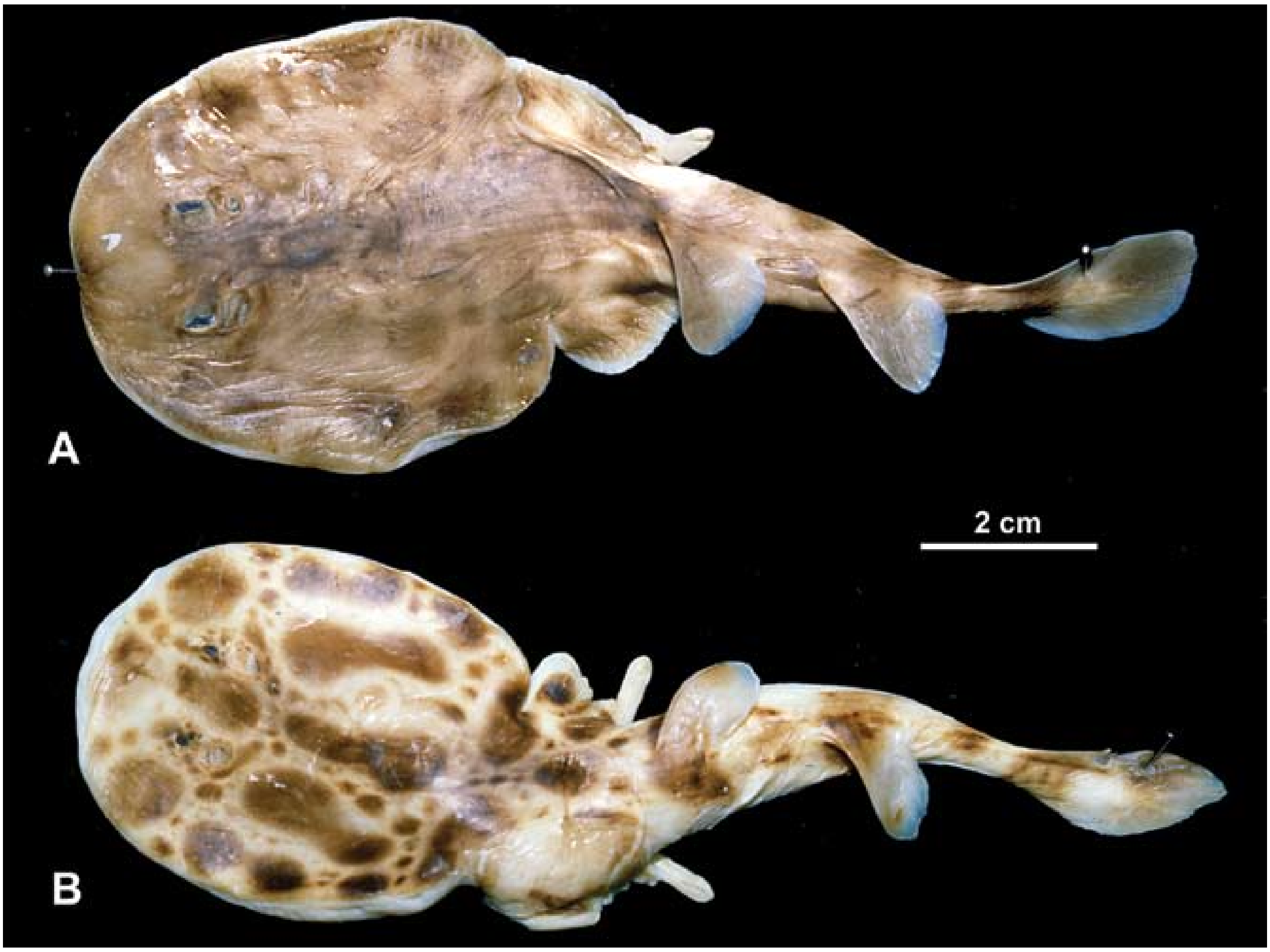

Figure 4. Variation in dorsal coloration in *Narcine ornata* sp. nov. (A) NTM S 13329–001 (173 mm TL adolescent male, Timor Sea); (B) CSIRO H 773–01 (166 mm TL adolescent or adult male, Arafura Sea).

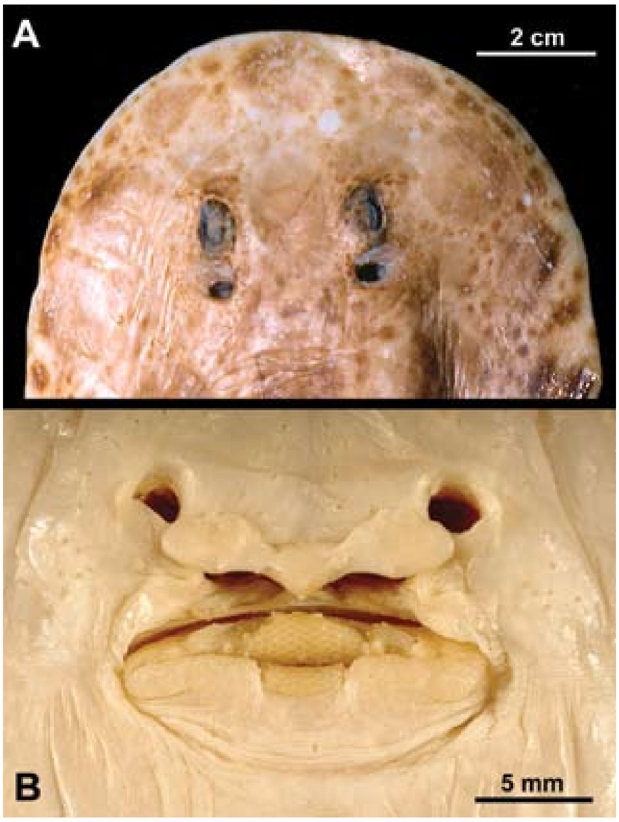

Figure 5. (A) Dorsal head region of paratype of *Narcine ornata* sp. nov. (QM I 27854, 237 mm TL adult female, Gulf of Carpentaria); (B) oronasal region of holotype of *Narcine ornata* sp. nov. (CSIRO H 3646–02, 186 mm TL adult male).

As in *N. westraliensis*, pores and canals of lateral-line system difficult to distinguish on dorsal surface. Pores on lateral aspect of tail few, not closely packed and continue posteriorly just dorsal to lateral tail fold. Ampullary pores numerous on ventral snout area, continuing on nasal curtain posteriorly to just beyond nostrils. One pair of ampullary pores present posterior to mouth, one on each side situated mesially in relation to first gill slits. Scattered pores outlining anterior one-third of electric organs on ventral surface.

COLORATION.— Coloration very distinctive (even in preserved specimens), composed on dorsal surface of large and small dark brown spots over a background colour that is usually creamy white, but may be light brown in specimens from the Timor Sea or from greater depths (see below; cf. Figs. 1–5). Spots vary in diameter, from roughly just larger than an ampullary pore to close to five to six times length of eye. Spots generally circular, but may also be irregular in shape, or even fused to other spots of same size appearing oval and elongated on disc longitudinally and across base of tail (CSIRO H 773–01). Smaller spots appear to outline larger spots on disc and base of tail region. Eyes and spiracles generally surrounded by numerous very small spots, which can also be present on disc margins outlining disc area. On dorsal disc region, there is generally one to three medium-sized spots (about equivalent to two or three eye-lengths) on snout region, a medium-sized spot in between eyes (only faintly visible on some specimens), two brown crescent-shaped markings posterior to spiracles, two large spots posterior to level of spiracles and crescent-shaped markings with a slightly smaller spot in between, one row of four medium- to large-sized spots across posterior quarter of disc, and medium-sized spots outlining disc. These spots are surrounded by numerous smaller spots which may be irregular in shape and may connect with each other, appearing to form a reticulated network over dorsal disc area. Large spots are present anteriorly on dorsal fins, covering portions of the fin bases and continuing underneath dorsal fins laterally on tail region (resembling elongated stripes). Large spot on lateral tail region in between dorsal fins. Large spot also on anterior caudal fin and sometimes present apically as well. Large spots on dorsal and caudal fins also with smaller peripheral spots. Dorsal surface of pelvic fins also with medium-sized spots. Continuous horizontal stripes are lacking in this species except occasionally at base of tail (these are clearly the result of fusion of two larger spots, as may occur over mid-disc region; cf. *N. westraliensis* which has continuous, strong horizontal stripes that are not due to fused spots; Fig. 7).

Ventrally specimens are creamy white, even those that have light brown dorsal background colour. Larger specimens, males and females, may present few small spots or blotches ventrally posterior to pelvic fins on tail region, continuing caudally to level of second dorsal fin. Some specimens from the Timor Sea and from greater depths of the Arafura Sea display a dorsal colour pattern composed of fewer and less defined medium to large spots, darker background colour, and lack of smaller spots surrounding larger spots forming reticulated patterns (if present, then not as defined). Some of these specimens have very few large spots that may be present only marginally on disc (other specimens from Timor and Arafura Seas may have similar patterns to those described above for "typical" *N. ornata*, just with a darker background colour; see discussion of variation in coloration below under "Remarks").

ETYMOLOGY.— From the Latin *ornatus*, meaning 'handsome' or 'beautiful', in allusion to its spectacular dorsal colour pattern; *N. ornata* has one of the most intricate patterns of dorsal coloration among species of *Narcine*. Gender feminine.

REMARKS.— This highly colorful species is similar to *N. westraliensis* in many proportional and external characters. Both species are readily separated by colour pattern, and are, as far as is known, disjunct geographically. *Narcine ornata* has a pattern of three medium-sized spots on dorsal snout region, whereas *N. westraliensis* has a uniformly colored dorsal snout region devoid of markings. Even though the spots covering *Narcine ornata* may be fused on occasion, these do not form the typical horizontal stripes characteristic

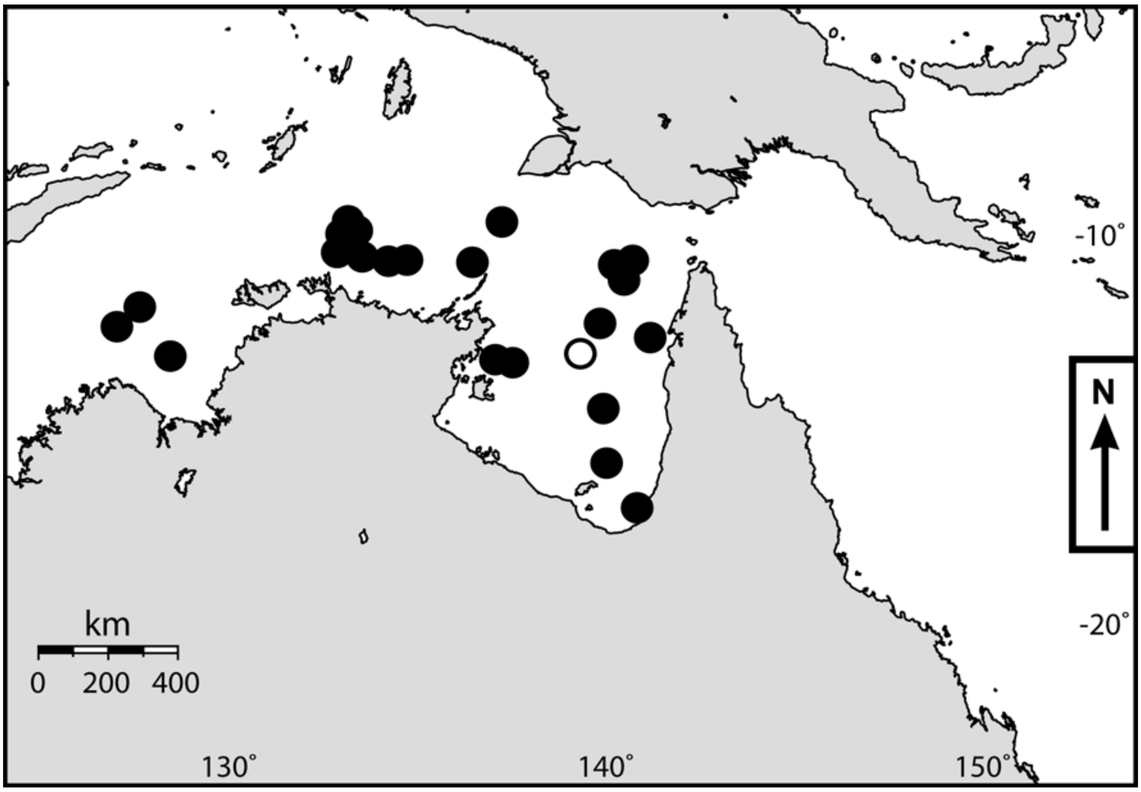

Figure 6. Map showing distribution of *Narcine ornata* sp. nov.; open circle denotes approximate locality of holotype.

Figure 7. Paratype of *Narcine westraliensis* McKay, 1966 from off Western Australia (WAM P 7033–001, 195 mm TL adult female), in dorsal view.

of *N. westraliensis* (Fig. 7). *Narcine westraliensis* may present blotches outlining horizontal stripes on the dorsal disc region (see also McKay, 1966), but these never appear to be the result of fused, well-defined large spots as seen in *N. ornata*. Also, *N. ornata* has a slightly more oval disc, with disc length being just greater than disc width in general (disc width ranges from 30.4–42.8% TL, mean 36.9; disc length ranges from 36.5–44.0% TL, mean 40.2), compared to *N. westraliensis*, which has a disc width slightly greater or equal to disc length (disc width ranges from 35.3–46.0% TL, mean 41.1; disc length ranges from 20.5–45.1% TL, mean 39.4). However, as disc width seems to be affected by poor-preservation in *N. ornata*, caution must be used in using this character to separate it from *N. westraliensis*. Additionally, the lateral tail fold is slightly more prominent in *N. westraliensis*.

The variation observed in the colour pattern of *N. ornata* is not necessarily depth-, locality- or size-related, although some correlation might occur. Specimens from the Gulf of Carpentaria, the eastern-most limit of this species, are more or less uniform in dorsal colour pattern, presenting the typical highly marked array of spots of various sizes over a creamy background color. Most specimens from this Gulf are from similar depths, spanning some seven degrees of latitude between extremes. However, specimens from more western localities show more variation in colour pattern. Specimen NTM S 12269–003, for example, from the Arafura Sea north of Goulburn Island (NT), and collected in waters 80 m deep, displays the typical colour pattern of *N. ornata* (i.e. in displaying great contrast between spots and background colour). Specimens NTM S 12924–001 and NTM S 13576–008 were collected from the same area (differing in less than one degree of latitude and longitude from NTM S 12269–003), but have a more drab dorsal coloration, with a darker background colour and fewer, less-defined spots. The former specimens (NTM S 12924–001) are from slightly deeper waters (105 m), and are relatively much larger. Another specimen from the same locality (NTM S 13347–002, 123 mm TL), however, is closer in size to NTM S 12269–003 (155 mm TL), but also has fewer less-defined spots over a darker background color. The specimens from the Timor Sea are also slightly heterogeneous in colour pattern, as NTM S 13329–001 (Fig. 4a) shows more spotting dorsally compared to NTM S 13400–001 which is more uniform. NTM S 13329–001 is more similar to Gulf of Carpentaria specimens, but with darker dorsal background coloration and spots that are slightly less-defined. All these specimens are presently considered to belong to one species that ranges from the Timor Sea to the Gulf of Carpentaria.

Narcine ornata may co-occur with specimens from the northeastern-most distribution of *N. lasti* (see below), north of Melville Island (NT) and south of Tanimbar Island (Indonesia). Specimens of *N. lasti* have been collected so far in slightly deeper waters (178 m is the shallowest record to date of *N. lasti*; Carvalho & Séret, 2002). Both species are easily distinguished by dorsal colour pattern (uniformly light tan in *N. lasti*), nasal curtain proportions (nasal curtain much wider than long in *N. lasti*, and relatively longer in *N. ornata*), nasal curtain sensory pore distribution (many more pores in *N. ornata*), disc shape (oval in *N. ornata* and shovel-shaped in *N. lasti*), and in general proportions (Carvalho, 1999).

Males appear to mature at about 180 mm in TL, but because many of the specimens are slightly shrunken, which confers to the claspers more firmness, sizes at maturity may be slightly greater. Females probably mature are similar sizes to males. Two dissected females of about 240 mm TL contained ova of about the same dimensions in both uteri, suggesting both to be functional and probably synchronous. Four to six ova were found in each uteri. Less than ten spiral valves are present in each of these dissected females.

GEOGRAPHIC DISTRIBUTION.— *Narcine ornata* is known from the continental shelf region of the Timor and Arafura Seas (off WA and the NT), but primarily from the Gulf of Carpentaria (off Western Australia, Northern Territory and northwestern Queensland), Australia (Fig. 6). It extends from 126°59′ E to 140°57′ E, varying little in latitude in the Timor and Arafura Seas, and reaching south in the Gulf of Carpentaria to just north of Wellesley Island. This species has been collected so far in waters ranging from 48–132 m in depth.

Narcine nelsoni sp. nov.

Figs. 8–12, Tables 3–4

Narcine sp. C: Last & Stevens, 1994: pp 374, 377, key fig. 5, fig. 39.3, pl. 66 (identification, description, distribution, illustrated in colour); Compagno *et al.*, 1999: p 1407 (listed); Carvalho *et al.*, 1999: pp 1435, 1437, 1442 (identification, brief description, distribution, illustrated).

Narcine sp. nov. C: Carvalho, 1999: pp 227–235, figs 82–84, tabs. 32–33 (identification, description, distribution, illustrated, colour photographs); Carvalho & Séret, 2002: pp 405, 406 (comparisons with *Narcine lasti*, originally described therein).

Holotype. CSIRO H 719–06, 260 mm TL adult male, south of Saumarez Reef, Capricorn Channel, 22°53–57′ S, 152°59′–153°01′ E, 325–338 m, FRV *Soela*, S06/85/12, P. Last, 18 Nov 1985 (Figs 8, 9, 11b).

Paratypes. (16 specimens, 213–348 mm TL): Queensland: CSIRO H 719–01, 295 mm TL adult male, CSIRO H 719–02, 313 mm TL adult male, CSIRO H 719–03, 307 mm TL adult female, CSIRO H 719–04, 295 mm TL adult male, CSIRO H 719–05, 254 mm TL adult male, CSIRO H 719–07, 348 mm TL adult female, CSIRO H 719–08, 280 mm TL adult female, CSIRO H 719–09, 297 mm TL adult female, CSIRO H 719–10, 283 mm TL adult male, CSIRO H 719–11, 271 mm TL adult male, collected with holotype; NMV A 4390 (3 specimens), 222–262 mm TL adolescent and adult

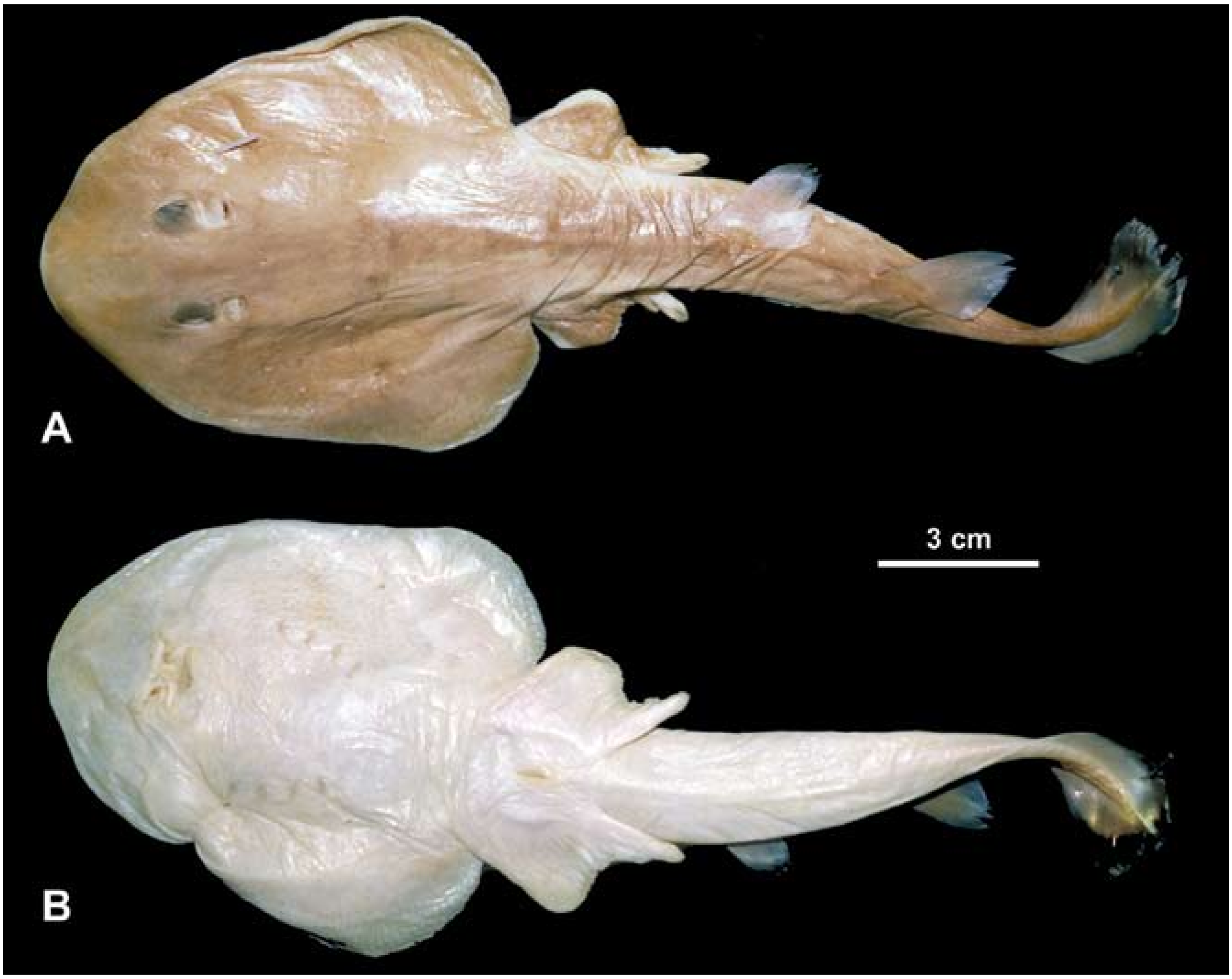

Figure 8. Holotype of *Narcine nelsoni* sp. nov. (CSIRO H 719–06, 260 mm TL adult male, Capricorn Channel, Queensland) in dorsal (A) and ventral (B) views. Caudal fin is downturned in (B).

females, east of Dunk Island, 17°57–59′ S, 147°01–03′ E, 260 m; QM I 18761, 304 mm TL adult female, 23°01–11′ S, 152°55′–153°00′ E (Fig. 10); QM I 20009, 213 mm TL adolescent male, south of Swain Reefs, 22°52′ S, 152°46′ E, 261 m, 03 Oct 1980; QM I 22095, 257 mm TL adolescent or adult male, off Swain Reefs, 22°02′ S, 153°10′ E, 210 m, FV *Southern Intruder*, 30 Aug 1983 (Fig. 11a).

Other material. (89 specimens, 75–347 mm TL) Queensland: AMS I 20968–009 (6 specimens), 85–242 mm TL juvenile to adolescent males, 100–195 mm TL juvenile to adolescent females, east of Hinchinbrook Island, 18°03′ S, 147°10′ E, 357 m, 27 Mar 1979; AMS I 25804–013 (6 specimens), 217 mm TL adolescent or adult male, 174–227 mm TL adolescent females, north of Townsville, 17°59′ S, 147°03′ E, 260 m, FRV *Soela*, 09 June 1986; AMS I 25808–012 (6 specimens), 199 mm TL adolescent female, 79–200 mm TL juvenile to adolescent males, north of Townsville, 17°59′ S, 147°06′ E, 306 m, FRV *Soela*, 11 Jan 1986; AMS I 25837–009 (2 specimens), 208 mm TL adolescent or adult male, 190 mm TL adult female, north of Townsville, 17°55′ S, 146°53′ E, 142 m, 20 Jan 1986; CSIRO H 718–24, 123 mm TL juvenile female, CSIRO H 1217 (5 specimens), 116–150 mm TL adolescent males, 131–157 mm TL adolescent females, south of Swain Reef, Capricorn Channel, 22°52′ S, 152°42′ E, 225–282 m, FRV *Soela*, SO 6/85/13, 19 Nov 1985; CSIRO H 630–32, 257 mm TL adolescent male, south of Saumarez Reef, 22°40–42′ S, 154°05–06′ E, 416–419 m, FRV *Soela*, SO 6/85/5, P. Last, 17 Nov 1985; CSIRO H 630–25, 305 mm TL adult female, south of Saumarez Reef, 22°35–36′ S, 153°46–50′ E, 340–350 m, FRV *Soela*, SO 6/85/4, P. Last, 17 Nov 1985; CSIRO H 720–35, 184 mm TL adolescent male, south of Saumarez Reef, 23°12′ S, 153°37–33′ E, 399–405 m, FRV *Soela*, SO 6/85/10, P. Last, 18 Nov 1985; CSIRO H 931–04 (2 specimens), 255–266 mm TL adolescent or adult males, south of Saumarez Reef, 22°59′ S, 152°57–59′ E, 343–350 m, FRV *Soela*, SO 6/85/11, P. Last, 18 Nov 1985; CSIRO H 682–07, 217 mm TL adolescent female, north of Townsville, 17°59–57′ S, 147°02–00′ E, 250–252 m, FRV *Soela*, S0 6/85/44, P. Last, 29 Nov 1985; NMV A 4389 (4 specimens), 191–200 mm TL adolescent females, 216–217 mm TL adolescent males, east of

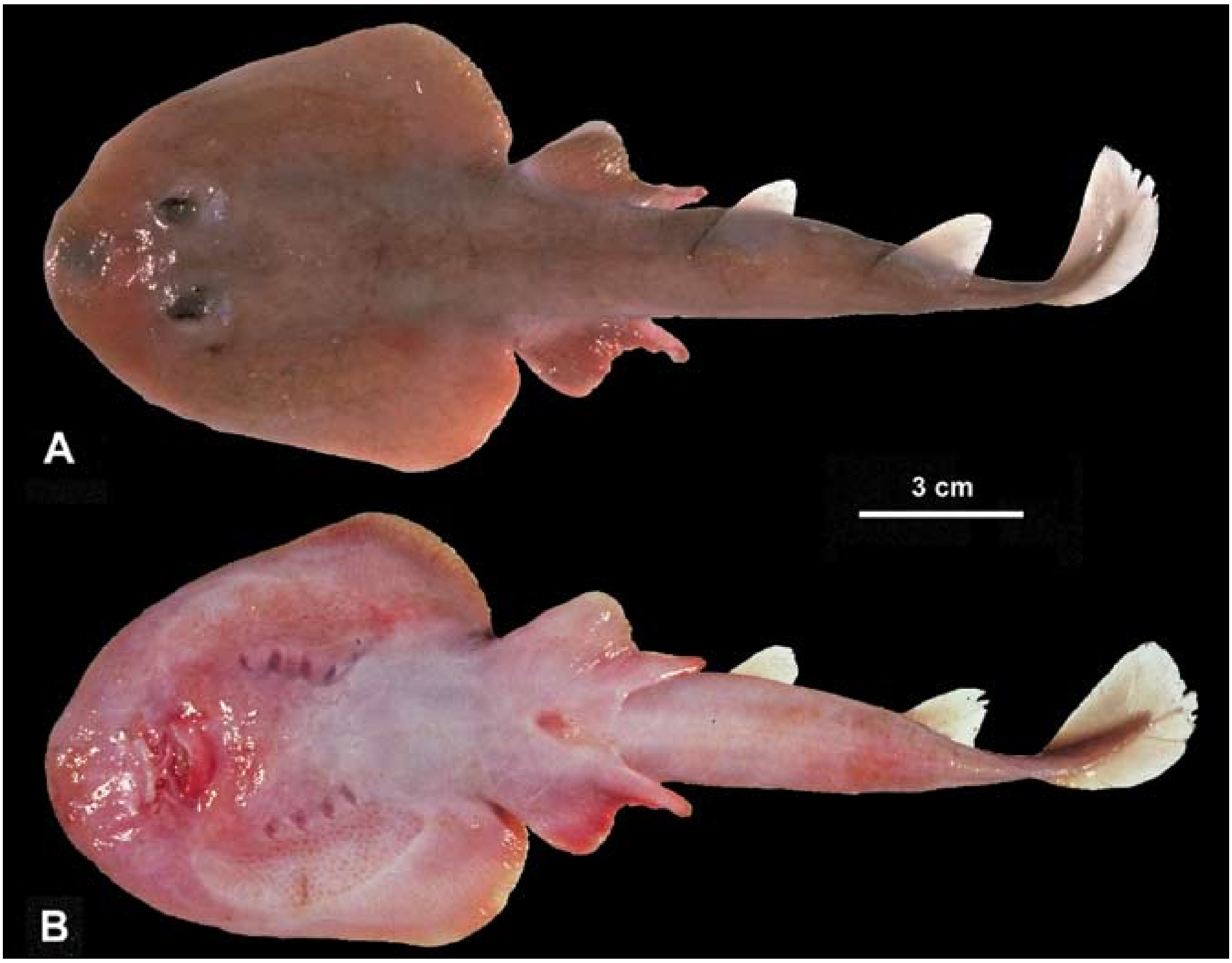

Figure 9. Coloration in freshly collected holotype of *Narcine nelsoni* sp. nov. (CSIRO H 719–06, 260 mm TL adult male, Capricorn Channel, Queensland): (A) dorsal view; (B) ventral view.

Dunk Island, 17°57′ S, 147°00′ E, 264 m; NMV A 4391 (15 specimens), 135–234 mm TL adolescent females, 154–220 mm TL adolescent males, east of Dunk Island, 17°58–59′ S, 147°03–06′ E, 302–308 m, FRV *Soela*, SO 1/86/15; NTM S 11750–003, east of Dunk Island, 17°57′ S, 147°01′ E; NTM S 11751–011 (4 specimens), 212–225 mm TL adolescent females, east of Dunk Island, 18°00′ S, 147°03′ E, 264 m, H. Larson, 10 Jan 1986; NTM S 11754–005 (3 specimens), 175 mm TL adolescent male, 120–172 mm TL adolescent females, east of Dunk Island, 17°58′ S, 147°04′ E; NTM S 11756–010 (3 specimens), 107–280 mm TL juvenile to adult (?) females, east of Dunk Island, 17°57′ S, 147°04′ E, 298–300 m, H. Larson, 11 Jan 1986; NTM S 12723–011, 232 mm TL adolescent female, east of Dunk Island, 17°53′ S, 146°51′ E, 140–142 m, H. Larson, 20 Jan 1986; QM I 15812 (6 of 12 specimens), 117–220 mm TL adolescent females, 155–161 mm TL adolescent males, east of Hinchinbrook Island, 18°03′ S, 147°10′ E, 320–360 m, 27 Feb 1979; QM I 18540, 305 mm TL adult female, 22°54–59′ S, 152°12′ E, 342–360 m, 03 Oct 1980; QM I 18972, 250 mm TL adolescent or adult male, 21°30–41′ S, 152°54–56′ E; QM I 19272, 295 mm TL adult female, 23°01–11′ S, 152°55′–153°00′ E, 20 Sep 1980; QM I 20002, 221 mm TL adolescent female, 23°18–30′ S, 153°00–04′ E, 540 m, 20 Sep 1980; QM I 20904, 154 mm TL adolescent female, east of Capricorn Group, 23°15′ S, 153°18′ E, 425 m, FV *Southern Intruder*, 06 Sep 1983; QM I 21622 (3 specimens), 80–310 mm TL embryonic and adult females, east of Capricorn Group, 23°07′ S, 153°24′ E, 400 m, FV *Southern Intruder*, 06 Sep 1983; QM I 21629, ca. 220 mm TL adolescent female, off Swain Reefs, 22°00′ S, 153°00′ E, 200–500 m, FV *Southern Intruder*, Aug 1983; QM I 23095, 230 mm TL adolescent or adult male, off Swain Reefs, 20°50′ S, 151°53′ E, 288 m, 20 Sep 1986; QM I 23426 (2 specimens), 186–217 mm TL adolescent males, off Capricorn Group, 23°22′ S, 152°45′ E, 310–350 m, FV *Southern Intruder*, 30 Nov 1983; QM I 24143, 159 mm TL adolescent female, 17°55′ S, 147°01′ E, 295–309 m, M. Pichon, A. Birtles, P. Arnold, 16 May 1986; QM I 25296 (3 specimens), 205–236 mm TL pre-adult to adult females, off Swain Reefs, 21°21′ S, 153°05′ E, 300 m, Raptis Fishing Co., Apri 1988. (6 specimens not measured): Queensland: QM I

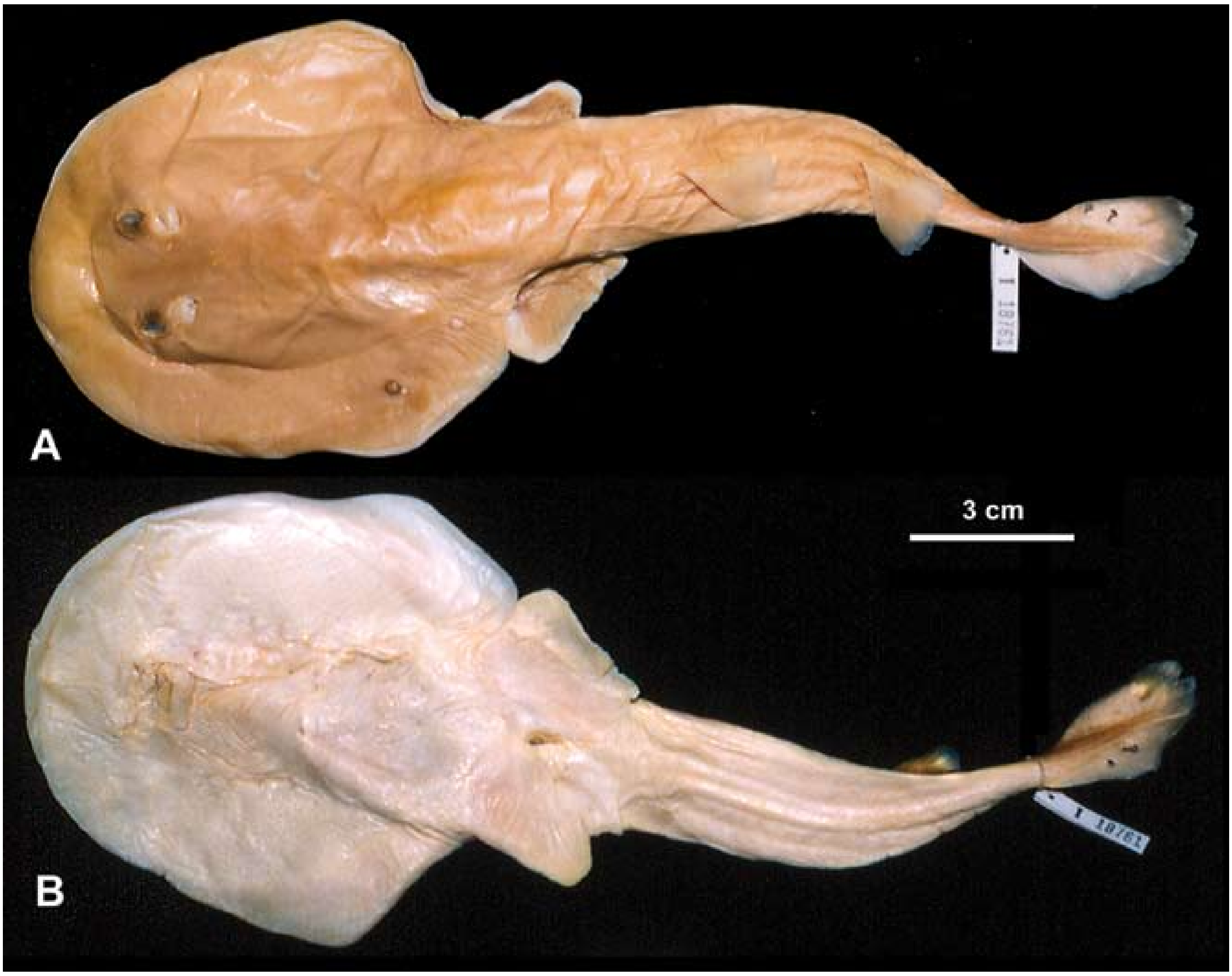

Figure 10. Dorsal (A) and ventral (B) views of paratype of *Narcine nelsoni* sp. nov. (QM I. 18761, 304 mm TL adult female, off Swain Reefs, Capricorn Channel, Queensland).

15812 (6 specimens), collection data specified above (all specimens previously dissected).

DIAGNOSIS.— A species of *Narcine* distinguished from most congeners by presenting tail length, as measured from cloaca, much longer than disc width or length (tail length averaging 54.1% TL, compared to 38.4% and 40.2% for disc width and length, respectively) (vs. tail length smaller than, or subequal to, disc width and length in all other species of *Narcine*, except *N. westraliensis*, *N. ornata*, *N. rierai*, *N. tasmaniensis*, and *N. lasti*). From *N. westraliensis* and *N. ornata*, *N. nelsoni* sp. nov. is distinguished by presenting a uniform light brown dorsal coloration, devoid of any spots or distinctive markings (vs. dorsal coloration composed of horizontal stripes in *N. westraliensis*, and a unique arrangement of spots and blotches in *N. ornata*; see description of this species above). From *N. rierai*, *N. nelsoni* sp. nov. is distinguished by its much wider than long nasal curtain (vs. nasal curtain slightly longer than wide in *N. rierai*). From *N. tasmaniensis*, *N. nelsoni* sp. nov. is clearly distinguished by having a ridge-like lateral tail fold (vs. lateral tail fold wider and flap-like in *N. tasmaniensis*), and by its light brown dorsal coloration (vs. usually chocolate brown in *N. tasmaniensis*). *Narcine lasti* and *N. nelsoni* sp. nov. are distinct in dorsal coloration (light brown in the latter species, vs. yellowish-brown in *N. lasti*), and numbers of exposed tooth rows (relatively fewer rows in *N. nelsoni*: 9–16/5–12 exposed rows, typically with 12/9 exposed rows in adults, vs. 11–20/8–15 rows in *N. lasti*, typically with 19/15 rows in adults). Certain proportional measurements further distinguish *N. nelsoni* sp. nov. from *N. tasmaniensis* and *N. lasti* (these are detailed in the “Remarks” section below).

DESCRIPTION.— Measurements and counts are presented in Tables 3 and 4, respectively. Disc faintly oval, generally longer than wide (disc length is 35.6–44.9% TL, disc width is 28.6–43.7% TL), and characteristically shovel-shaped. Disc widest at posterior one-third to one-fourth of its length in adults, and at around one-sixth in juveniles. Posterior aspect of disc overlaps origin of pelvic fins only slightly; disc does not leave pronounced free lobe posteriorly at apex. Snout slightly rounded to faintly

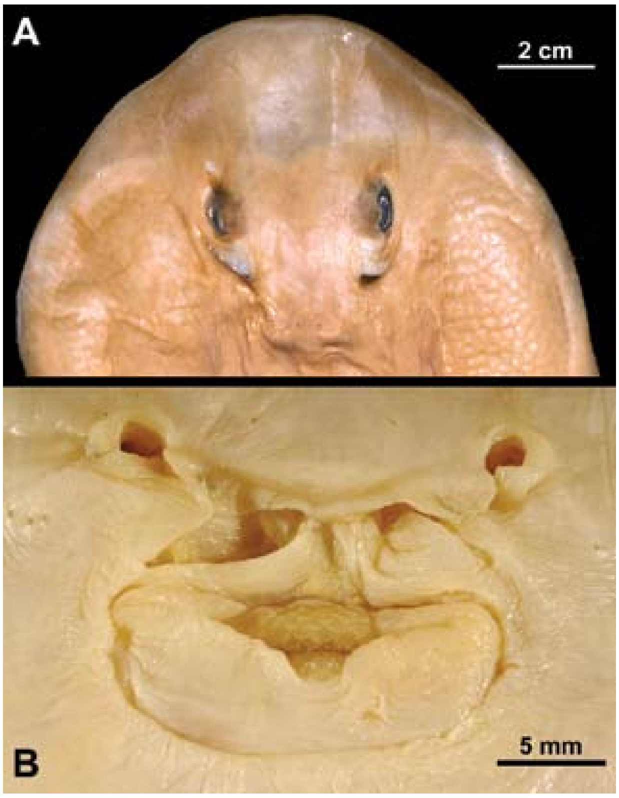

Figure 11. (A) Dorsal head region of paratype of *Narcine nelsoni* sp. nov. (QM I 22095, 257 mm TL adolescent or adult male, off Swain Reefs, Capricorn Channel, Queensland); (B) oronasal region of holotype of *Narcine nelsoni* sp. nov. (CSIRO H 719–06, 260 mm TL adult male).

acute; pectoral fin (disc) apex region rounded. Preorbital snout length averages about one-tenth of total length, and about one-fourth in disc length. Electric organs not very visible dorsally (more pronounced in juveniles). Electric organs extend from just anterior to level of eyes dorsally and reach posteriorly to about five-sixths of disc length. Ventrally, electric organs reach anteriorly to posterior level of nostrils. Electric organ length 14.3–23.5% TL; electric organ width 5.1–9.4% TL. Gill slits small, semi-circular, and positioned in more or less a straight line from first to last gill slit. Distance between last gill slits and branchial basket length about equal. Spiracles without strongly elevated rims and separated from eyes by small gap in juveniles (gap is less conspicuous in adults). Spiracle length and width almost equal; spiracles with rounded posterior margins. Eyes slightly pronounced (bulging) and darker than background disc color. Eye length greater than spiracle length.

Nasal curtain distinctly wider than long, sometimes with small central posterior lobe present in well-preserved specimens. Nasal curtain wider than distance between nostrils. Circular nostrils with slightly elevated rims. On average, prenasal snout length proportional to preorbital snout length in relation to total length (prenasal snout length has greater range, but both averaging 9.7% TL). Mouth generally wider than distance between nostrils. Upper tooth band wider than lower tooth band; upper tooth band fairly circular in outline, lower tooth band circular to sub-triangular in some specimens. Mouth projects anteriorly at corners in some specimens. Teeth in 9–16/5–12 exposed vertical rows in adolescents and adults (few specimens have 16 exposed upper tooth rows; an adult of some 280 mm TL typically has 12/9 rows). Teeth trapezoidal, some specimens without very pronounced cusps even in adults (longer cusps only on inner rows), other adults with well-developed and sharp cusps; more exposed teeth with worn-down, blunt cusps (exceptionally, some adult males with well-developed exposed cusps). Teeth set in quincunx, with wider-than-long, diamond-shaped bases.

Pelvic fins close to twice as wide as long, with longer posterior lobes compared to anterior lobes. Pelvic fins leave a small free lobe posteriorly. Posterior lobes of pelvic fins appear slightly concave in preserved specimens. Pelvic fins originate anteriorly from underneath disc, extending caudally to just anterior to level of first dorsal fin origin on tail. In males, claspers protrude posteriorly to underneath mid-length of base of first dorsal fin. Claspers in mature males project to about one-fifth of their total length beyond tips of pelvic fins. Tail relatively long, occupying from 50.5–56.6% TL as measured from cloaca. Tail relatively thin at base, but varying from juvenile to adult (12.7–20.0% TL; adults with proportionally wider tails), sub-circular in cross section. Tail more or less straight, not tapering greatly from base to second dorsal fin, or from second dorsal to caudal fin. Lateral tail folds not prominent, generally difficult to discern, appearing only as a slight ridge. Origin of lateral tail fold on lateral aspect of tail at level of posterior one-third of first dorsal fin base, in well-preserved specimens, inserting on lateral aspect of caudal peduncle close to its ventral margin. Dorsal fins semi-transparent in some specimens, slightly rounded to sub-acute at apex, with sloping anterior and curved to relatively straight posterior margins. Dorsal fins insert on tail so as to leave a small free lobe posteriorly. Both first and second dorsal fins very similar in proportions and outline, but second dorsal may be more inclined than first dorsal fin in some specimens. Distance between second dorsal and caudal fins is almost equivalent to distance between dorsal fins (both averaging 9.1% TL). Caudal fin low and moderately long (averaging roughly 12–13% TL), with relatively straight posterior margin. Combined height of both upper and lower lobes of caudal fin about equal to height of first and second dorsal fins. Upper and lower lobes of caudal fin begin at about same level on caudal peduncle.

Pores of ampullary and lateral-line systems very difficult to detect and identify on both dorsal and ventral surfaces. Few scattered pores on lateral tail region, situated dorsal to lateral tail fold, but precise pattern difficult to discern.

Table 3. Measurements for *Narcine nelsoni* sp. nov. N indicates number of specimens from which means and standard deviations (SD) were extracted. All measurements, except TL, are expressed as percentages of TL. See 'Appendix' for abbreviations. Holotype: CSIRO H 719–06.

	Holotype	Paratypes	All specimens	N	Mean	SD
TL (mm)	260	222 – 348	135 – 348	67	–	–
DW (%)	39.6	33.5 – 43.5	28.6 – 43.7	67	38.4	3.3
DL (%)	41.5	35.7 – 43.7	35.6 – 44.9	67	40.2	2.0
PBS (%)	10.3	8.7 – 10.5	8.6 – 11.1	67	9.7	0.7
POS (%)	13.6	12.1 – 14.3	11.8 – 15.9	67	13.5	0.9
PNS (%)	9.5	8.3 – 10.2	8.1 – 15.8	67	9.7	1.1
SDW (%)	32.7	29.2 – 33.8	26.3 – 35.9	64	31.7	2.1
IOD (%)	5.8	4.9 – 7.1	4.7 – 7.1	67	5.5	0.5
EL (%)	3.5	2.5 – 3.6	2.5 – 4.4	67	3.4	0.4
ISD (%)	6.0	4.8 – 6.4	4.8 – 6.4	67	5.7	0.4
SPL (%)	2.1	1.7 – 2.4	1.7 – 2.8	67	2.2	0.2
SPW (%)	2.1	1.9 – 2.9	1.6 – 2.9	67	2.3	0.3
MW (%)	6.1	5.4 – 6.7	4.4 – 7.1	67	6.0	0.5
UTB (%)	2.0	1.4 – 2.8	1.4 – 2.8	67	2.0	0.3
LTB (%)	1.3	1.0 – 1.7	1.0 – 1.8	67	1.4	0.2
NCW (%)	5.5	4.2 – 6.0	4.0 – 7.8	54	5.3	0.6
NCL (%)	2.3	1.9 – 3.0	1.6 – 3.3	51	2.4	0.4
DBN (%)	5.1	4.4 – 5.7	4.2 – 5.9	67	5.0	0.3
FGO (%)	13.5	9.4 – 14.4	9.4 – 14.4	67	12.6	1.1
LGO (%)	8.1	7.0 – 10.1	6.2 – 10.4	67	8.5	0.9
BBL (%)	9.2	7.2 – 9.8	7.1 – 10.7	67	8.5	0.8
PFL (%)	17.7	13.7 – 19.0	9.8 – 19.0	67	15.1	2.0
PFW (%)	24.6	22.1 – 27.1	21.3 – 30.0	67	25.2	1.8
AMP (%)	8.1	6.2 – 10.6	5.8 – 11.6	67	8.4	1.3
PMP (%)	13.1	11.8 – 16.9	6.2 – 17.6	67	12.8	2.4
TW (%)	16.2	13.1 – 18.9	12.7 – 20.0	67	16	1.5
HFD (%)	8.2	7.1 – 10.5	6.7 – 10.5	67	8.6	0.8
LFD (%)	5.3	4.7 – 6.3	4.7 – 6.6	67	5.7	0.4
HSD (%)	9.1	7.6 – 9.8	6.6 – 9.9	67	8.4	0.7
LSD (%)	6.8	5.1 – 7.0	4.7 – 7.5	67	6.2	0.5
LDC (%)	12.6	11.3 – 13.6	10.5 – 14.8	67	12.8	0.8
LVC (%)	13.7	12.0 – 14.7	11.3 – 15.4	67	13.2	0.8
HDC (%)	4.3	3.0 – 5.2	2.4 – 6.1	67	3.8	0.6
HVC (%)	4.1	3.0 – 5.1	2.1 – 5.1	67	3.4	0.5
HC (%)	9.4	7.8 – 12.2	5.8 – 12.2	67	8.5	1.1
DBD (%)	9.5	8.0 – 11.4	7.7 – 11.4	67	9.1	0.8
SDC (%)	9.7	7.4 – 10.0	7.4 – 10.5	67	9.1	0.7
SCL (%)	42.3	40.1 – 45.0	40.0 – 45.0	67	42.2	1.3
CLC (%)	56.2	50.5 – 56.3	50.5 – 56.6	67	54.1	1.5
SFD (%)	56.2	49.8 – 60.3	49.8 – 60.3	67	54.7	1.7
EOL (%)	23.5	18.0 – 22.5	14.3 – 23.5	67	19.5	1.5
EOW (%)	6.2	5.1 – 8.2	5.1 – 9.4	67	7.2	1.1
CL (%)	12.3	10.4 – 13.7	6.2 – 15.4	30	11.6	2.1

Table 4. Counts for *Narcine nelsoni* sp. nov. A) QM I 25296 (236 mm TL); B) QM I 25296 (205 mm TL); C) QM I 25296 (217 mm TL); D) NTM S 11750–003 (278 mm TL); E) NTM S 11750–003 (232 mm TL); F) QM I 21583. Dashes represent counts not available in radiographs. See 'Appendix' for abbreviations.

	A	B	C	D	E	F	RANGE
PRO	22	18	16	17	18	15	15–22
MES	7	5	7	8	7	7	5–8
MET	12	7	8	8	8	8	7–12
TPR	41	30	31	33	33	30	30–41
PVR	20	–	19	20	19	21	19–21
FDR	8	–	8	7	9	8	7–9
SDR	9	–	10	9	11	9	9–11
DCR	26	27	23	25	21	28	23–28
VCR	33	26	27	29	31	29	26–33
TCR	59	53	50	54	52	57	50–59
TC	18	17	16	17	16	17	16–18
PC	75	76	73	77	74	75	73–77
CC	32	26	31	26	29	27	26–32
TV	125	119	120	120	119	119	119–125
R	6	6	6	6	6	6	6

Very few scattered pores outlining electric organs both dorsally and ventrally. Ampullary pores on ventral snout area are situated in semi-parallel rows, from snout anterior margin to region of nostrils. Ampullary pores anterior to nasal curtain situated in two well-defined, more or less parallel and central anteroposterior rows. Posterior three or four pairs of ampullary pores from both rows radiate outward from mid-line at just above level of nostrils in many adults. Pores do not continue posteriorly from level of anterior margins of nostrils onto nasal curtain. Small group of pores present in either semi-straight or crescent-shaped pattern anterior to each nostril.

COLORATION.— Dorsal coloration generally a uniform light brown, sometimes with a streak of slightly darker brown on dorsal tail surface (see Figs. 8–11). Freshly collected specimens present a faint pinkish hue on edges of disc and ventrally on snout region and pelvic fins. Snout sometimes semi-transparent in freshly captured specimens, and generally more tan, lighter than rest of dorsal background color. Dorsal clasper surfaces light tan or off-white, with dorsal clasper glans area sometimes with shades of brown. Dorsal and caudal fins semi-transparent (more obvious in fresh material). Specimens ventrally are a uniform pale white to cream colour, without any distinct markings.

ETYMOLOGY.— This species is named after Gareth Jon Nelson, who was my PhD advisor at the American Museum of Natural History (New York), in honor of his very unique and meaningful contributions to both ichthyology and comparative biology in general.

REMARKS.— *Narcine nelsoni* more closely resembles two other numbfish species which occur predominantly in Australian waters, *N. tasmaniensis* Richardson, 1841 and the relatively recently described *N. lasti* Carvalho & Séret, 2002 (Fig. 13). *Narcine nelsoni* is separated from *N. tasmaniensis* by having a slender, ridge-like lateral tail-fold (vs. flap-like lateral tail fold in *N. tasmaniensis*), a uniform light brown or tan dorsal colour (vs. a usually dark, chocolate brown dorsal colour in *N. tasmaniensis*), and a more slender disc (disc width averages 38.4% TL in *N. nelsoni*, vs. an average of 43.4% in *N. tasmaniensis*).

Narcine nelsoni is indeed very similar to *N. lasti* from the continental slope of Western Australia, Northern Territory and southeastern Indonesia. Both species are comparable in morphometric proportions and external and internal morphology (see also Carvalho & Séret, 2002). *Narcine nelsoni* from Queensland generally has a light brown dorsal colour (compared to yellowish-brown in *N. lasti*), and also presents a faintly more acute and less rounded snout in most specimens. Characters that further differentiate these two species include the distance between the first and second dorsal fins (in *N. nelsoni*, the average distance is 9.1% TL compared to an average of 7.7% TL in *N. lasti*), disc width (in *N. nelsoni*, the average is 38.4% TL, whereas in *N. lasti* average disc width is 40.3% TL), and disc length (in *N. nelsoni* the average is 40.2% TL, compared to 42.1% TL in *N. lasti*). *Narcine nelsoni* also has relatively fewer rows of exposed teeth on upper and lower jaws compared to *N. lasti* (*N. nelsoni* has 9–16/5–12 exposed rows, and typically with 12/9 exposed rows in adults, compared to 11–20/8–15 exposed rows in *N. lasti*, which typically has 19/15 rows in adults). As both species are completely separated geographically, it is clearly justifiable to consider them as separate evolutionary entities given these morphological differences.

Males of *N. nelsoni* are unequivocally sexually mature at 245–260 mm TL, but some specimens of close to 210 mm TL have rigid claspers. Clasper rigidity, however, may be an artifact of preservation as dehydrated specimens will have claspers that are artificially more firm (and some males that may be sexually mature at just over 200 mm TL were somewhat dehydrated). But as one female specimen of 190 mm TL had a close-to-term embryo protruding from its cloaca, then it is possible that male sexual maturity occurs at close to 210 mm TL for at least some specimens. As other males were undoubtedly not sexually mature at 235 and 240 mm TL, then size at maturity may vary among specimens and/or in relation to some as yet unknown parameter. Claspers begin to project beyond pelvic fins at about 160 mm TL.

The embryo of the 190 mm TL female was a male specimen of 84 mm TL, and occupied the right uterus.

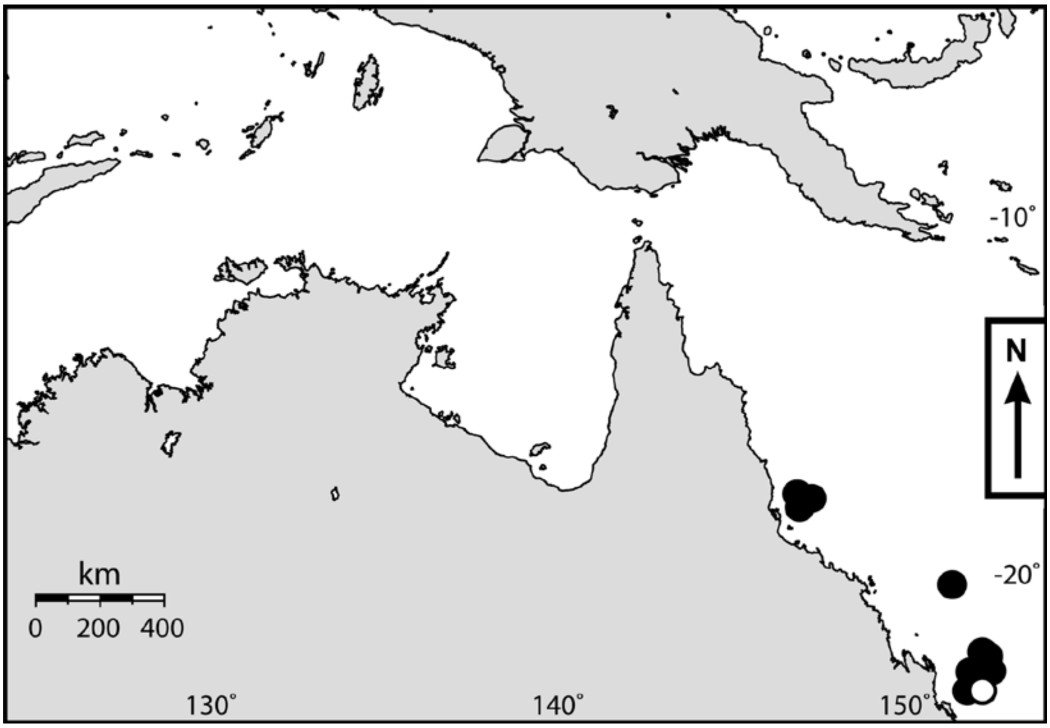

Figure 12. Map showing distribution of *Narcine nelsoni* sp. nov.; open circle is approximate locality of holotype.

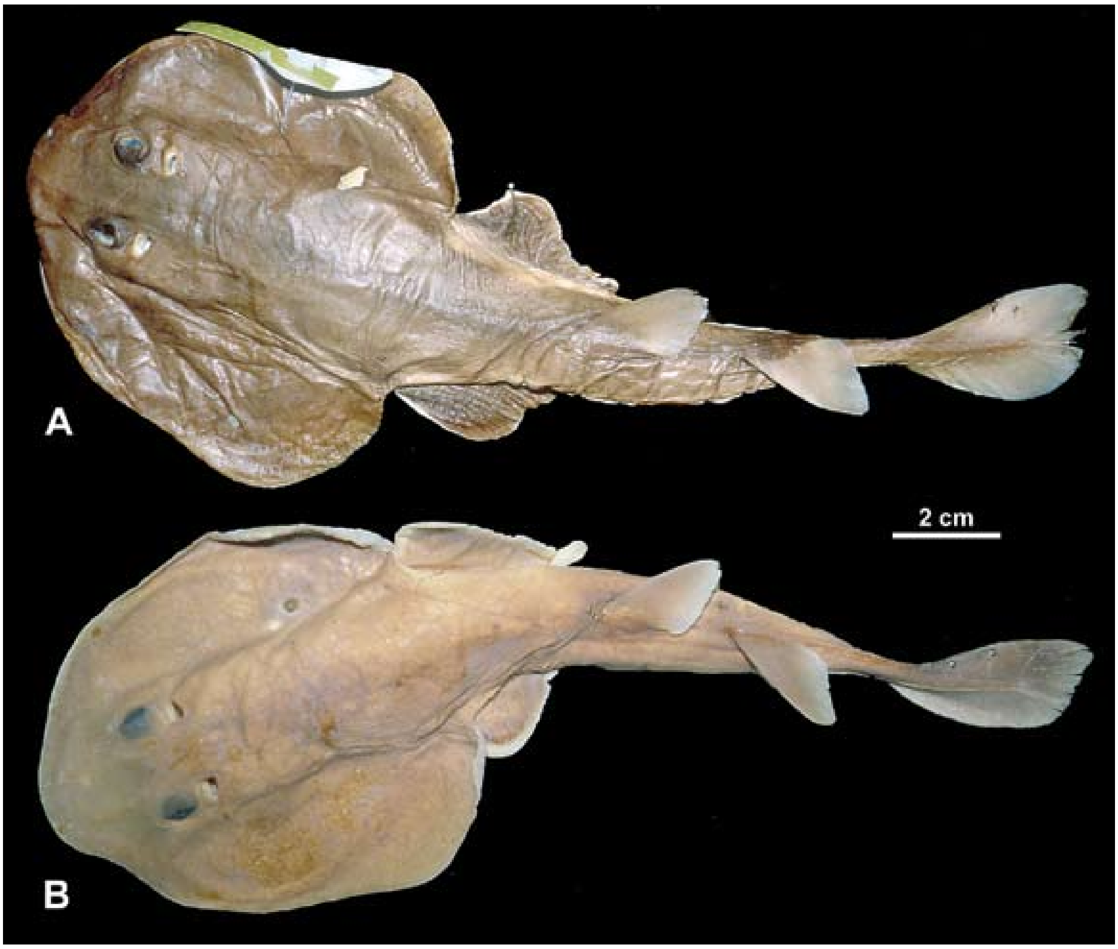

Figure 13. Dorsal views of (A) *Narcine tasmaniensis* Richardson, 1841 (CSIRO H 949–12, 360 mm TL adult male) and (B) *Narcine lasti* Carvalho and Séret, 2002 (CSIRO H 2597–09, 302 mm TL adult male), from off Sydney, off New South Wales and Western Australia, respectively.

Its disc was partially coiled, and was ventrally flexed. No associated yolk-reserve was evident, and the embryo was slightly protruded from the cloaca tail-first. In contrast, another female specimen (310 mm TL) contained a late-term embryo of about 80 mm TL in its right uterus, but with its head directed towards the cloaca. Its disc was wrapped around a ventral yolk-reserve (measuring 22 mm in diameter), with the tail curled and pelvic fins folded. The left uterus of this same specimen contained two large, partially connected, and somewhat indistinct ova.

More specimens of *N. nelsoni* have been captured compared to the other recently described species of *Narcine* from Australia (Carvalho & Séret, 2002; see above for *N. ornata*). Many specimens have been collected together, which may suggest more dense populations compared to, for example, *N. lasti*.

GEOGRAPHIC DISTRIBUTION.— Restricted to off the Queensland coast, this species has been collected in two principal areas: east of Dunk Island, and further south off Swain and Saumarez Reefs (Fig. 12). This species has not yet been captured, however, in between these two distributional extremes but is expected to occur in relative abundance there. *Narcine nelsoni* occurs in relatively deep waters ranging from 140–540 m.

Key to Australian species of *Narcine* Henle, 1834

1a. Dorsal colour pattern composed of spots, blotches, or stripes over disc and tail 2

b. Dorsal coloration uniform, without spots, stripes or other distinctive markings.................................... 3

2a. Dorsal coloration with irregular stripes across disc and tail, lacking large blotches surrounded by smaller spots ....*N. westraliensis* McKay, 1966 (off Western Australia)

b. Dorsal coloration composed of large blotches or spots (usually larger than interorbital distance; blotches sometimes fused into irregular streaks) surrounded by a pattern of smaller spots (smaller than eye-diameter) over disc and tail, and lacking horizontal stripes across disc ......*N. ornata* sp. nov. (Gulf of Carpentaria, Arafura and Timor seas)

3a. Lateral tail-fold prominent, resembling a true fold and not ridge-like; dorsal coloration usually a dark or chocolate brown.. ....*N. tasmaniensis* Richardson, 1841 (off southeastern Australia)

b. Lateral tail-fold low, inconspicuous and ridge-like, not resembling a true fold; dorsal coloration usually a light or yellowish-brown, never dark brown...... 4

4a. Dorsal coloration yellowish-brown over disc, tail and preorbital snout region; disc width and length with means of 40.3 and 42.1 % TL, respectively.... .... *N. lasti* (off western and northwestern Australia, off southeastern Indonesia in the Arafura Sea)

b. Dorsal coloration light brown over disc and tail, but with preorbital snout region usually more faded; disc width and length with means of 38.4 and 40.2 % TL, respectively.............*N. nelsoni* sp. nov. (off northeastern Australia)

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APPENDIX

MORPHOMETRICS.— TL: total length; **DW:** disc width (across widest aspect of disc, usually close to level of third gill openings); **DL:** disc length (from anterior snout region to greatest disc length, lateral to pectoral axil); **PBS:** preorbital snout length (from in between anterior level of eyes to anterior margin of snout); **POS:** preoral snout length (from top of lower tooth band to anterior margin of snout); **PNS:** prenasal snout length (from in between anterior level of nostrils to anterior snout margin); **SDW:** snout to greatest disc width (from anterior snout to level of greatest disc width, measured over mid-disc); **IOD:** interorbital distance (straight distance between inner margins of orbits); **EL:** eye length (between anterior and posterior margins of eye); **ISD:** interspiracular distance (between inner margins of spiracles); **SPL:** spiracle length (greatest antero-posterior distance through spiracle); **SPW:** spiracle width (greatest lateral extent of spiracle); **MW:** mouth width (distance between mouth corners, measured between junction of upper and lower labial cartilages on each side of jaws); **UTB:** upper tooth band width (width of exposed upper tooth band in between margins of lips [formed by the upper labial cartilages], close to mouth opening); **LTB:** lower tooth band width (width of exposed lower tooth band in between margins of lips [formed by the lower labial cartilages], close to mouth opening); **NCW:** nasal curtain width (width of nasal curtain at greatest width below nostrils); **NCL:** nasal curtain length (length of nasal curtain from level of anterior margin of nostrils to posterior-most point at mid-line of nasal curtain); **DBN:** distance between nostrils (between inner margins of nostrils); **FGO:** distance between first gill openings (between inner margins of first pair of gill openings); **LGO:** distance between last gill openings (between inner margins of last pair of gill openings); **BBL:** branchial basket length (between first and last gill openings); **PFL:** pelvic fin length (length of pelvic fin from insertion to posterior-most point, measured ventrally); **PFW:** pelvic fin width (distance between outer-most corners of pelvic fins, from tip to tip, measured ventrally); **AMP:** anterior margin of pelvic fin (greatest extent from insertion to outer-most corner of pelvic fin); **PMP:** posterior margin of pelvic fin (greatest extent from outer-most corner to posterior-most point of pelvic fin); **TW:** tail width (extent across base of tail at greatest width, measured dorsally); **HFD:** height of first dorsal fin (distance from greatest height at apex to mid-base of first dorsal fin); **LFD:** length of first dorsal fin (greatest length of base of first dorsal fin); **HSD:** height of second dorsal fin (distance from greatest height at apex to mid-base of second dorsal fin); **LSD:** length of second dorsal fin (greatest length of base of second dorsal fin); **LDC:** length of dorsal lobe of caudal fin (distance from origin on dorsal caudal peduncle to posterior-most tip of caudal fin); **LVC:** length of ventral lobe of caudal fin (distance from origin on ventral caudal peduncle to posterior-most tip of caudal fin); **HDC:** height of dorsal lobe of caudal fin (measured vertically from upper-most tip of caudal fin apex to base of dorsal lobe on tail); **HVC:** height of ventral lobe of caudal fin (measured vertically from lower-most tip of caudal fin to base of ventral lobe on tail); **HC:** height of caudal fin (greatest distance between dorsal and caudal fin margins, does not equal HDC+HVC); **DBD:** distance between dorsal fins (distance between posterior tip of first dorsal fin base and anterior tip of second dorsal fin base); **SDC:** distance between second dorsal and caudal fins (from posterior tip of second dorsal fin to dorsal origin of caudal peduncle); **SCL:** snout to cloaca length (distance between anterior snout margin to origin of cloaca); **CLC:** cloaca to caudal fin length (distance from posterior tip of cloaca to posterior margin of caudal fin, equals tail length); **SFD:** snout to first dorsal fin length (distance from anterior margin of snout to origin of first dorsal fin); **EOL:** electric organ length (from anterior margin to posterior margin of electric organ, measured ventrally); **EOW:** electric organ width (greatest width of electric organ at its mid-length, close to level of third gill slit, measured ventrally); **CL:** clasper length (from posterior tip of cloaca to distal-most tip of clasper).

MERISTICS.— PRO: propterygium radials; **MES:** mesopterygium radials; **MET:** metapterygium radials; **TPR:** total pectoral radials (TPR=PRO+MES+MET); **PVR:** pelvic radials; **FDR:** first dorsal fin radials; **SDR:** second dorsal fin radials; **DCR:** dorsal lobe of caudal fin radials; **VCR:** ventral lobe of caudal fin radials (includes radial situated in between dorsal and ventral aspects of caudal fin); **TCR:** total caudal radials (TCR=DCR+VCR); **UTR:** exposed vertical tooth rows on upper tooth band (corresponds to tooth rows visible externally on upper jaw when mouth is closed); **LTR:** exposed vertical tooth rows on lower tooth band (corresponds to tooth rows visible externally on lower jaw when mouth is closed); **TC:** trunk vertebral centra (from first whole distinguishable centrum in synarcual to anterior margin of pelvic girdle, further explained below); **PC:** precaudal vertebral centra (centra from anterior margin of pelvic girdle to origin of upper lobe of caudal fin); **CC:** caudal vertebral centra (from first centrum in caudal fin to last distinguishable centrum); **TV:** total vertebral centra (TV=TC+PC+CC); **R:** ribs (relatively elongated pleural ribs articulating with paired hemal spines, located posteriorly on disc slightly dorsal to pelvic girdle area).

Trygonoptera imitata sp. nov., a new stingaree (Myliobatoidei: Urolophidae) from southeastern Australia

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ABSTRACT.— A new stingaree, *Trygonoptera imitata* sp. nov., is described from material collected off southeastern Australia. It differs from *T. testacea*, with which it is sympatric off the southeastern Australian coast, in lacking a dorsal fin, having a shorter prespiracular length, deeper caudal fin, and a shorter prenasal length. It differs from a western congener, *T. mucosa*, which also lacks a dorsal fin, in having a shorter prespiracular length and is much larger. The new species is the largest *Trygonoptera* species and one of the largest urolophids. It occurs from Jervis Bay (New South Wales) south through northern Bass Strait (including Flinders Island) to Beachport (South Australia), in shallow embayments and coastal waters to depths of 120 m.

Key words. Urolophidae – *Urolophus* – *Trygonoptera* – new species – southwestern Pacific Ocean – Tasman Sea – Australia

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INTRODUCTION

The family Urolophidae comprises two genera, *Trygonoptera* Müller & Henle, 1841 and *Urolophus* Müller & Henle, 1837. Its distribution is restricted to the Indo–West Pacific, with most species occurring on Australia's continental shelves (Last & Stevens, 1994; Last & Compagno, 1999; Séret & Last, 2003; Yearsley & Last, 2006). The genera *Urobatis* Garman, 1913 and *Urotrygon* Gill, 1863, from the eastern Pacific and western Atlantic, are now widely regarded as members of the family Urotrygonidae (McEachran *et al*., 1996; Compagno, 2005).

The genus *Trygonoptera*, once considered a junior synonym of *Urolophus* (Paxton *et al*., 1989), can be distinguished from that genus by the presence of broad, flattened fleshy lobes on the mid-lateral margin of each nostril (lobes absent in *Urolophus*) (Last & Stevens, 1994). Phylogenetically significant skeletal differences between the two genera were observed by Last & Gomon (1987) and Yearsley (unpubl.), and are the subject of a forthcoming paper (Yearsley & Last, in prep).

Trygonoptera contains at least 6 species, all of which are restricted to southern Australian seas (Last & Stevens, 1994; Séret & Last, 2003). Two of these species (as *Trygonoptera* sp. A and *T.* sp. B *sensu* Last & Stevens, 1994) are undescribed and bear a strong resemblance to *T. mucosa* (Whitley 1939) and *T. testacea* Müller & Henle 1841. *Trygonoptera* sp. B is described below as a new species.

METHODS

Counts and measurements follow Séret & Last (2003). The holotype (CSIRO H 3548–01) and 5 paratypes (CSIRO H 1002–02, CSIRO H 2670–01, CSIRO H 2670–02, CSIRO H 3532–07 and NMV A 10830) were measured in full, and measurements were also made on specimens of related species to identify distinguishing characters. Meristics were taken from radiographs of the holotype and 7 paratypes. Type specimens and comparative material are deposited in the Australian National Fish Collection, Hobart (CSIRO), and ichthyological collections of the Australian Museum, Sydney (AMS), Museum Victoria (NMV) and the South Australian Museum (SAMA); their registration numbers are prefixed with these acronyms.

Trygonoptera imitata sp. nov.

Figs 1–4; Table 1

Trygonoptera sp. 2: Kuiter, 1993: p 22, col. fig.

Trygonoptera sp. B: Last & Stevens, 1994: pp 417, 423, key fig. 14, fig. 41.3, pl. 78.

Holotype. CSIRO H 3548–01, adult male 613 mm TL, east of Wilsons Promontory, Bass Strait, Victoria, 39°00′ S, 146°35′ E, 41–42 m, 29 Jul 1993.
Paratypes. 17 specimens. AMS I 44170–001, adult male 482 mm TL, west of Port Arlington, Port Phillip Bay, Victoria, 38°14′ S, 144°49′ E, 14–25 m, 15 Jun 1992; CSIRO H 35–01, female 531 mm TL, Jervis Bay, New South Wales, 35°05′ S, 150°44′ E, 20–30 m, 04 Apr 1984; CSIRO H 869–01, female 793 mm TL, east of Batemans Bay, New South Wales, 35°40′ S, 150°26′ E, 115–117 m, 10 Sep 1986; CSIRO H 999–07, adolescent male 474 mm TL, CSIRO H 1002–02, adult male 564 mm TL, Jervis Bay, New South Wales, 35°03′ S, 150°45′ E, 18–22 m, 14 Nov 1984; CSIRO H 2670–01, female 625 mm TL, CSIRO H 2670–02, female 643 mm TL, Tooradin Channel, Western Port Bay, Bass Strait, Victoria, 38°15′ S, 145°22′ E, 5 m, 28 Nov 1990; CSIRO H 3532–07, female 689 mm TL, Disaster Bay, New South Wales, 37°17′ S, 150°02′ E, 25–42 m, 11 Aug 1993; CSIRO H 3717–01, adolescent male 506 mm TL, south of Jervis Bay, New South Wales, 35°12′ S, 150°39′ E, 31–33 m, 03 Mar 1994; CSIRO H 3718–02, juvenile male 180 mm TL, CSIRO H 3718–03, juvenile male 181 mm TL, CSIRO H 3718–04, juvenile male 179 mm TL, east of Batemans Bay, New South Wales, 35°39′ S, 150°26′ E, 117–119 m, 22 Mar 1994; CSIRO H 4441–03, female 235 mm TL, CSIRO H 4441–05, juvenile male 217 mm TL, east of Bermagui, New South Wales, 36°23′ S, 150°06′ E, 27–29 m, 30 Nov 1996; NMV A 10825, female 485 mm TL, NMV A 10830, adult male 506 mm TL, NMV A 10832, juvenile male 342 mm TL, west of Port Arlington, Port Phillip Bay, Victoria, 38°14′ S, 144°49′ E, 14–25 m, 15 Jun 1992.
Other material. SAMA F 5063, adult male 668 mm TL, 20 miles off Beachport, South Australia, ca. 37°45′ S, 139°50′ E, 200–440 m, 3–4 Aug 1985.

DIAGNOSIS.— A large plain-coloured *Trygonoptera* with the following combination of characters: subcircular disc, width 62–67% TL; snout angle 122–129°; distance from snout tip to posterior edge of spiracle 17–19% of TL; eye length 19–24% of preorbital snout length, 9.3–10.9% of ventral head length; inter-eye distance 3.0–4.0 times eye diameter; short prenasal length 8.8–9.8% TL; length of main spiracular opening 1.7–2.3 times eye length; length of first gill slit 2.2–2.6 times in mouth width; tail without cutaneous folds; stinging spine(s) long, 9–13% TL when intact; dorsal fin absent; caudal fin deep (height 3.6–4.1% of TL); pectoral radials 98–107; total vertebral centra about 199–223; total diplospondylous centra about 166–185; uniform greyish brown to yellowish dorsally.

DESCRIPTION.— Disc weakly subcircular, broad, humped in largest specimens; wider than long; width 1.13 (1.05–1.12) times length, 4.65 (4.51–4.71) times distance between first gill slits; broadest at more than 2 eye diameters behind level of spiracles; anterior profile obtuse; anterior margins of disc weakly convex (straight to weakly convex); pectoral apices broadly rounded; posterior margins of disc convex. Snout fleshy, tip bluntly angular, barely extended; snout angle 129° (122–129°); preoral snout length 2.77 (2.85–3.46) times internarial distance, 0.88 (0.85–0.94) times distance between first gill slits; direct preorbital snout length 3.07 (2.53–2.98) times interorbital distance; snout to maximum disc width 2.69 (2.60–2.83) times in disc width; interorbital space broad, weakly concave (almost flat to moderately concave); orbital region barely distinguishable from head (sometimes elevated well above interorbit), orbit diameter 1.17 (0.96–1.37) in spiracle length; eye relatively small, lateral (appearing dorsolateral where head is flattened), length 21.12% (18.90–24.39%) of preorbital snout length, 9.53% (9.28–10.86%) of ventral head length, length 1.91 (1.68–2.32) in spiracle length; lower half of eye separated from spiracle by a fleshy curtain (when eyes raised, curtain wholly below eye); curtain originating forward of anterior third of eye, inserted near posterior margin of orbit; inter-eye distance 3.55 (3.04–4.04) times eye length. Spiracles broadly sigmoid and recurved medially, continuing posteriorly well behind orbit to form a deep pocket; pocket overlain with a low, cartilaginous protuberance; greatly enlarged, dorsolateral, forming a deep, cavernous opening, much larger than orbit, interspiracular distance 2.22 (1.88–2.10) times interorbit distance.

Mouth small, slightly concave (almost straight to slightly concave); width 2.64 (2.69–3.18) in snout tip to lower jaw. Oral papillae 6 in paratype CSIRO H 2670–01 (female 625 mm TL), 3 near middle of mouth, their bases not confluent; very short, subequal in size, with expanded or bilobed tips; 1–2 similar widely separated papillae closer to mouth corners; dense external patch of pored papillae below symphysis of lower jaw, most strongly developed on midline of chin; incomplete, deep post-oral grooves extend from angle of mouth posteromedially for a distance equivalent to nostril length. Jaws strongly asymmetric; mouth directed anteroventrally, upper jaw concealed, almost dorsal to lower jaw, without exposed tooth rows; lower jaw barely visible. Teeth in paratype CSIRO H 2670–01 quincuncial, similar in size in both jaws; those near symphysis of lower jaw with suboval to rhomboidal bases; labial and lateral teeth in lower jaw with cusps reduced or absent, inner teeth more strongly pointed lingually with serrated margins; about 6 prominent median teeth near middle of tooth band (about nine rows in from symphysis) with enlarged triangular lingual cusps; bases of teeth in upper jaw broadly oval, cusps rudimentary or absent; upper tooth band in vertical plane; lower tooth band in horizontal plane when mouth closed, larger than upper band. Internasal flap well developed, narrowly skirt-shaped, not distinctly broader distally than anteriorly, width 1.39 (1.32–1.66) times length, 1.22 (1.29–1.45) times internasal distance; posterior lateral apex with a weak lobe, depressible into a deep oronasal groove; distal fringe very well developed (less so in some paratypes), its margin irregular, somewhat pointed medially, fringe overlaying lower jaw, with a deep,

Figure 1. *Trygonoptera imitata* sp. nov., adult male holotype (CSIRO H 3548–01, 613 mm TL, preserved): A. dorsal view; B. ventral view.

Table 1. Morphometric data for the holotype of *Trygonoptera imitata* sp. nov. (CSIRO H 3548–01), with ranges and means provided for measured paratypes. Measurements expressed as a percentage of total length.

	Holotype	Paratypes		
		Min.	Max.	Mean
Total length (mm)	613	506	689	
Disc width	67.2	62.2	64.0	63.3
Disc length (direct)	59.4	56.0	60.5	58.0
Disc length (horizontal)	58.9	55.0	60.0	57.2
Snout to maximum width	25.0	22.3	24.4	23.7
Snout length - preorbital (direct)	13.3	12.0	12.9	12.3
Snout length - preorbital (horizontal)	11.3	9.6	11.5	10.5
Snout to spiracle - ant. (horizontal)	13.5	11.4	13.1	12.0
Snout to spiracle - post. (direct)	18.5	16.6	17.8	17.4
Orbit diameter	4.6	3.9	5.3	4.4
Eye diameter (cornea)	2.8	2.4	3.0	2.7
Orbit and spiracle length	7.2	6.4	7.6	6.9
Spiracle length	5.4	5.0	5.7	5.2
Distance between eyes	10.0	8.4	10.3	9.3
Distance between orbits	4.3	4.3	4.9	4.6
Distance between spiracles	9.6	8.7	9.5	9.1
Distance-snout to post. cloaca	56.0	53.4	57.1	55.4
Distance-cloaca to caudal fin tip	43.5	42.0	46.1	43.9
Spine origin to tail tip	26.0	22.8	28.6	25.1
Spine length - upper spine	dam.	8.5	12.9	10.5
Spine length - lower spine	11.8	10.7	12.8	11.9
Spine origin (upper) to lower tip	15.7	14.2	15.6	15.1
Epi-caudal lobe length	16.7	13.4	16.9	14.7
Hypo-caudal lobe length	22.2	20.5	25.9	23.0
Max. caudal height	4.0	3.6	4.1	3.9
Snout tip to lower jaw	12.8	11.8	12.7	12.1
Prenasal length (direct)	9.8	8.8	9.6	9.3
Head length to fifth gill (direct)	29.4	26.3	28.1	27.0
Mouth width (to corners)	4.8	4.0	4.4	4.2
Distance between nostrils	4.6	3.5	4.3	3.8
Nasal curtain-length	4.0	3.2	3.7	3.4
Nostril length	1.6	1.3	1.8	1.6
Nasal lobe length	3.1	2.6	3.2	2.9
Nasal lobe width	1.6	1.3	1.7	1.5
Nasal curtain (maximum width)	5.6	4.9	5.5	5.2
Width of first gill slit	1.9	1.7	1.8	1.7
Width of third gill slit	2.3	1.7	2.0	1.9
Width of fifth gill slit	1.6	1.3	1.5	1.3
Distance between first gill slits	14.4	13.5	14.0	13.8
Distance between fifth gill slits	6.9	7.2	11.9	8.5
Clasper-post cloacal length	14.0	11.6	13.0	12.3
Length of pelvic fin (max.)	16.1	13.8	16.6	15.2
Width across pelvic base	12.0	10.4	13.6	12.2
Width across pelvics (max.)	23.6	21.4	26.6	24.1
Tail width (pelvic axil)	4.9	4.7	6.3	5.6
Tail depth (pelvic axil)	3.4	3.4	4.0	3.7
Tail width (spine origin)	3.2	2.2	3.0	2.7
Tail depth (spine origin)	2.5	2.2	2.4	2.3

Figure 2. Orbito-spiracular region of *Trygonoptera imitata* sp. nov., adult male holotype (CSIRO H 3548–01, 613 mm TL, preserved) showing the relative sizes and positions of the spiracle and orbit.

longitudinal median furrow; with a dense arrangement of pored papillae. Nostril almost longitudinal (sometimes slightly oblique), much shorter than internasal flap; posterolateral margin with a greatly expanded, flattened, fleshy posterior lobe; lobe larger than nasal aperture.

Gill slits moderately S-shaped, fringed (less evident in smallest paratypes), margin membraneous; length of first gill slit 1.16 (1.17–1.39) times length of fifth gill slit, 2.60 (2.19–2.62) times in mouth width; distance between first gill slits 3.13 (3.22–3.99) times internasal distance, 0.49 (0.49–0.53) times ventral head length; distance between fifth gill slits 1.51 (1.73–3.24) times internasal distance, 0.24 (0.26–0.44) times ventral head length.

Body entirely smooth, sensory pores usually indistinct dorsally, most obvious above margin of abdomen; subcutaneous canal system evident ventrally.

Tail relatively short, postcloacal length 73.19% (69.41–82.28%) disc length; moderately depressed anteriorly, suboval in cross-section, tapering evenly, subcircular above anterior part of hypochordal lobe of caudal fin, compressed below epichordal lobe; flattened beneath stinging spine; lateral cutaneous tail folds absent. Dorsal fin absent. Pelvic fins subtriangular, moderate (small to moderate), length 1.47 (1.45–1.79) in greatest width across both fins, outer margin broadly rounded, anterior margin weakly convex (almost straight), posterior margins moderately convex, free rear tip weakly angular. Caudal fin broadly lanceolate, epichordal-lobe length 4.22 (3.28–4.64) times fin height; hypochordal lobe 5.59 (5.20–7.11) times fin height. Clasper robust, digitiform, not depressed; tapering, narrowly rounded distally. Two stinging spines (paratypes smaller than 350 mm TL with a single spine; largest paratypes usually with two spines, lower spine typically larger than upper spine), very elongate; upper spine damaged in holotype, length 0.57–0.90 times in epichordal lobe length in four undamaged paratypes, serrated for most of its length, point pungent when undamaged, with 16 recurved serrations on left side.

Tooth rows about 22 in upper jaw, about 24 in lower jaw. Pectoral-fin total radials 102–103 (98–107, n=7); 45–46 (40–48) propterygial, 13–14 (11–19) mesopterygial, and 43–44 (40–46) metapterygial. Total pelvic-fin radials 1 + 20–21 (1 + 18–19 in males, n=3; 1 + 23–26 in females, n=4). Total vertebral centra about 204 (199–223); monospondylous, including synarcual centra, 35 (33–39); pre-sting diplospondylous centra 53 (52–61); total diplospondylous centra about 169 (166–185).

COLOUR.— When fresh: Dorsal surface uniform greyish brown or yellowish (somewhat lighter or darker in paratypes); darkest on midline of head and central disc and tail, distinctly paler toward disc margin; a few, blackish spots scattered irregularly on pectoral disc (largest female CSIRO H 869–01 feebly mottled with denser arrangement of small, black and yellowish spots; smallest juveniles more uniform, without spots or blotches); centre of tail in smallest paratypes with blackish stripe from just forward of pelvic insertion to caudal fin. Ventral surface pale over centre of disc; anterior margin dark brownish black; lateral and posterior margins of disc similarly darker than central part of disc and tail (almost black in smallest paratypes, maximum width of this area equivalent to width between fourth gill slits); similar broad, dark margin on pelvic fins; irregular dark blotches on abdomen in some specimens; tail usually uniformly dark, similar to or darker than pectoral-fin margin in largest types. Mouth and cloaca uniformly pale. Caudal fin dark brown with whitish areas where skin abraded (paratypes usually darker brownish black). Claspers dark brown (paler in some paratypes). In preservative, similar, becoming more greyish dorsally.

SIZE.— The largest specimen examined was a female of 793 mm TL and 486 mm DW (CSIRO H 869–01); largest male a non-type specimen (SAMA F 5063) of 668 mm TL; smallest adult male 482 mm TL (AMS I 44170–001). The smallest specimen available, a 179 mm TL juvenile

Figure 3. Oronasal region of *Trygonoptera imitata* sp. nov., adult male holotype (CSIRO H 3548–01, 613 mm TL, preserved).

Figure 4. Lateral view of the posterior tail of *Trygonoptera imitata* sp. nov., adult male holotype (CSIRO H 3548–01, 613 mm TL, preserved).

male (CSIRO H 3718–04) had an umbilical scar and is likely to be an embryo.

DISTRIBUTION.— Occurs off southeastern Australia from Beachport (South Australia) to Jervis Bay (New South Wales); through Bass Strait off Victoria. Not yet recorded from mainland Tasmania but has been photographed at Flinders Island (Tasmania) by one of the authors (PL), and a specimen photographed in Gulf St Vincent, South Australia (photo supplied by Peter Kyne), is probably this species. Occurs in bays and coastal waters from close inshore near beaches to depths of at least 120 m (Last & Stevens, 1994).

ETYMOLOGY.— The new species resembles *Trygonoptera mucosa* and *T. testacea* in general appearance resulting in confusion over their identities. The epithet is based on the Latin *imitor* (copy or mimic) in allusion to this similarity. Vernacular: Eastern Shovelnose Stingaree.

REMARKS.— The morphological similarities between *T. imitata*, *T. testacea* and *T. mucosa* have resulted in confusion over their identity. *Trygonoptera imitata*, which attains about 80 cm TL, is the largest known member of the genus and one of the largest urolophids; *T. testacea* and *T. mucosa* attain 47 and 44 cm TL respectively. *Trygonoptera imitata* is sympatric with *T. testacea* off the south-east Australian coast but can be distinguished by the absence of a dorsal fin on the tail anterior to the stinging spine (present as a prominent fin or at least as a narrow ridge in *T. testacea*), a shorter snout to spiracle distance (direct measurement from snout tip to posterior edge of spiracle 16.6–18.5% of TL in *T. imitata* vs. 18.5–20.2% in *T. testacea*), a deeper caudal fin (3.6–4.1% vs. 3.2–3.6% of TL), and a shorter prenasal length (8.8–9.8% vs. 10.0–11.8% of TL). *Trygonoptera imitata* and its western congener, *T. mucosa*, both lack a dorsal fin but *T. imitata* has a shorter snout to spiracle distance (direct measurement from snout tip to posterior edge of spiracle 16.6–18.5% of TL in *T. imitata* vs. 18.8–20.5% in *T. mucosa*) and reach a much larger size (*T. imitata* males mature at about 48 cm TL vs. about 30 cm TL in *T. mucosa*).

As part of a concurrent study that aims to genetically barcode Australia's fish species (Ward *et al*., 2005, 2008), B. H. Holmes and R. D. Ward (pers. com.) found that cytochrome oxidase subunit 1 (CO1) sequences readily distinguished *T. imitata* (n=7) and *T. testacea* (n=15), with an interspecies divergence of 6.14±0.02%. This is well within the range of congeneric divergences in other fishes. In the same study, intraspecies CO1 sequence divergences were 0.04±0.02% for *T. imitata* and 0.20±0.02% for *T. testacea*. These values are characteristic of intraspecies sequence ranges for other fishes.

A recent investigation by the authors of *T. mucosa*-like specimens from Western Australia has identified additional species in the *T. mucosa* complex (Last & Yearsley, in press this series). Additional genetic material is required from *T. mucosa*-like specimens from southwestern Australia (particularly from the *T. mucosa* type locality off Albany) before reliable CO1 comparisons can be made between *T. imitata* and its western congeners.

The range of *Trygonoptera imitata* may extend onto the continental slope, but this needs to be confirmed. The largest male specimen available (SAMA F 5063, 668 mm TL) appears to be this species but was excluded from the type series because, based on its registration data, it was collected at a depth of 200–440 m. Other available specimens, including those of the type series, were collected mainly from close inshore (often less than 5 m depth) but always less than 120 m.

Comparative material.

Trygonoptera mucosa: <u>5 specimens</u>. CSIRO H 898–02, immature male 305 mm TL, CSIRO H 898–04, female 277 mm TL, CSIRO H 898–05, female 313 mm TL, CSIRO H 898–06, adolescent male 318 mm TL, CSIRO H 898–08, female 285 mm TL, off Albany, Western Australia, 35°02′ S, 117°53′ E, 20 m, 03 Mar 1986.

Trygonoptera testacea: <u>5 specimens</u>. CSIRO H 80–01 (1 of 3 specimens), female 426 mm TL, Port Hacking, New South Wales, 34°04′ S, 151°10′ E, 19 Nov 1984; CSIRO H 836–05, adult male 396 mm TL, north of Broughton Island, New South Wales, 32°33′ S, 152°23′ E, 22–36 m, 03 Oct 1985; CSIRO H 927–01, adult male 462 mm TL, east of Port Stephens, New South Wales, 32°44′ S, 152°15′ E, 45–63 m, 11 Apr 1985; CSIRO H 930–01, female 432 mm TL, north of North Solitary Island, New South Wales, 29°52′ S, 153°23′ E, 36–54 m, 24 Mar 1985; CSIRO H 999–08, adult male 436 mm TL, Jervis Bay, New South Wales, 35°03′ S, 150°45′ E, 18–22 m, 14 Nov 1984.

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Trygonoptera galba sp. nov., a new stingaree (Myliobatoidei: Urolophidae) from southwestern Australia

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ABSTRACT.— A new species of stingaree, *Trygonoptera galba* sp. nov., is described from material taken on the outer continental shelf off Western Australia, between the Abrolhos Islands and Shark Bay. *Trygonoptera galba* is similar to a closely related congener, *T. mucosa*, which occurs along the southwestern coast of Australia. These species differ subtly in morphology but can be easily distinguished by coloration and the relative lengths of the spiracle and eye. *Trygonoptera galba* is uniformly vivid yellow dorsally (rather than greyish or blackish), and the main aperture of the spiracle extends anteriorly to about mid-eye level (rather than forward to the anterior third of eye). Another similar morph, occurring on the outer continental shelf from Rottnest Island to the western sector of the Great Australian Bight, needs further investigation and may be conspecific with *T. galba*.

Key words. Urolophidae – *Trygonoptera galba* – new species – southeastern Indian Ocean – Australia

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INTRODUCTION

Four valid nominal species of the stingaree genus *Trygonoptera* Müller & Henle, 1841, *T. mucosa* (Whitley, 1939), *T. ovalis* Last & Gomon, 1987, *T. personata* Last & Gomon, 1987, and *T. testacea* Müller & Henle, 1841, are known from Australian seas, and another two undescribed species (as *Trygonoptera* sp. A and *T.* sp. B *sensu* Last & Stevens, 1994) have been identified. One of these, *T. imitata* (formerly *T.* sp. B), has been described from southeastern Australia in a previous paper in this publication (Yearsley *et al*., 2008). The other undescribed species (formerly *T.* sp. A) was discovered off the Western Australian coast during exploratory fishing surveys off the central and southern coasts of Western Australia by the Taiwanese vessel, FV *Hai Kung*, in the winter of 1981. The new species is formally named and described in this paper.

METHODS

Follows methodology adopted by Yearsley *et al*. (2008) and is based on Séret & Last (2003). The holotype (NMV A 1793) and 5 paratypes (CSIRO H 6665–01; NMV A 1712, 2 specimens; NMV A 1775, 2 specimens) were measured; measurements were also obtained from specimens of related species. Meristics were taken from radiographs of the holotype and all 7 paratypes. Tooth row and oral papillae counts were taken from a male paratype (NMV A 1775) and a female paratype (NMV A 1712, largest specimen) because these could not be extracted from the holotype without damaging it through dissection. Type specimens and comparative material are deposited in the Australian National Fish Collection, Hobart (CSIRO), and ichthyological collections of the Museum Victoria (NMV) and the Western Australian Museum (WAM); their registration numbers are prefixed with these acronyms.

Trygonoptera galba sp. nov.

Figs 1–4; Table 1

Trygonoptera sp. A: Last & Stevens, 1994: pp 417, 422, key fig. 9, fig. 41.2, pl. 78.

Holotype. NMV A 1793, adult male 328 mm TL, Houtman Abrolhos Islands, Western Australia, 27°55′ S, 113°13′ E, 100–183 m, 01 Mar 1981.

Paratypes. 7 specimens. CSIRO H 6665–01, juvenile male 281 mm TL, NMV A 1712 (2 specimens), female 268 mm TL, female 298 mm TL, Houtman Abrolhos Islands, Western Australia, 27°48′ S, 113°14′ E, 115–190 m, 01 Mar 1981; NMV A 1775 (2 specimens), adolescent male 315 mm TL, female 339 mm TL, south-west of Shark Bay, Western Australia, 26°37′ S, 112°41′

E, 105–180 m, 03 Mar 1981; WAM P 27217–001, juvenile male 299 mm TL, south-west of Shark Bay, Western Australia, 26°21′ S, 112°35′ E, 164–170 m, 03 Mar 1981; WAM P 27287–002, female 394 mm TL, north of Houtman Abrolhos Islands, Western Australia, 28°09′ S, 113°18′ E, 196–210, 29 Jul 1979.

DIAGNOSIS.— A small plain-coloured *Trygonoptera* with the following combination of characters: subcircular to suboval disc, width 58–65% TL; snout angle 114–120°; distance from snout tip to posterior edge of spiracle 19–21% of TL; eye length 27–29% of preorbital snout length, 11.5–12.5% of ventral head length; inter-eye distance 2.5–2.9 times eye diameter; relatively long prenasal length 10.8–11.8% TL; main spiracular opening extending forward to mid-eye, its length 1.2–1.4 times eye length; length of first gill slit 2.9–3.3 times in mouth width; tail lacking lateral cutaneous folds; stinging spine(s) long, 12–14% TL when intact; dorsal fin absent; caudal fin deep, height 3.9–4.9% of TL, 0.9–1.1 in internasal width; pectoral radials 97–106; total vertebral centra about 183–201; total diplospondylous centra about 147–162; dorsal surface of disc rich yellow.

DESCRIPTION.— Disc suboval to subcircular, not humped; slightly wider than long; width 1.05 (1.00–1.08) times length, 5.05 (4.38–5.06) times distance between first gill slits; broadest at about 2 eye diameters behind spiracles; anterior profile weakly convex (sometimes with a slight concavity just forward of orbits); pectoral apices broadly rounded; posterior disc margins convex; free rear tip narrowly rounded, inner margin almost straight. Snout relatively elongate, fleshy, tip angular, not extended, obtuse, snout angle 114° (116–120°); preoral snout length 3.33 (3.33–3.38) times internarial distance, 1.21 (1.01–1.12) times distance between first gill slits; preorbital snout length 2.89 (2.83–3.22) times interorbital distance; snout to maximum disc width 2.28 (2.33–2.44) in disc width; interorbital space broad, weakly concave, almost flat; orbital region barely distinguishable from head (orbit elevated slightly above interorbit in some specimens); eye of medium size, dorsolateral, length 26.5% (27.2–28.6%) of preorbital snout length, 12.1% (11.5–12.5%) of ventral head length, 1.21 (1.19–1.35) in spiracle length; orbit diameter 0.71 (0.70–0.77) in spiracle length, 1.70 (1.70–1.80) times eye length; lower orbital membrane fleshy, united with anterior edge of main spiracular aperture below mid-eye; inter-eye distance 2.54 (2.59–2.86) times eye diameter. Spiracles broadly sigmoid and recurved medially, continuing posteriorly well behind orbit to form a deep pocket; pocket overlain with a low, cartilaginous protuberance; greatly enlarged, dorsolateral, forming a deep, cavernous opening, much larger than orbit, extending forward to mid-eye (sometimes continuing slightly further forward as a low furrow when orbit depressed); interspiracular distance 1.68 (1.83–2.10) times interorbit distance.

Mouth almost straight, slightly concave medially, possibly weakly protrusible; width 3.06 (2.72–2.79) in preoral length; dense, evenly distributed, corrugated patch of pored papillae below symphysis of lower jaw; circum-oral grooves short, incomplete, deep, confined to angle of mouth and extending posteromedially for about a nostril length. Oral papillae 8 in paratype NMV A 1712 (female 298 mm TL, largest of 2); central pair thallate, truncate distally, with confluent bases, larger than those laterally; lateral pairs near jaw angles, papillose, their bases not confluent; single papilla located on each side of mouth midway between medial and lateral pairs, subequal or slightly shorter than lateral papillae; 9 papillae in paratype NMV A 1775 (adolescent male 315 mm TL), irregularly distributed, not paired, three near middle of jaw (one of these bilobed). Internasal flap well developed, narrowly skirt-shaped, not distinctly broader distally than anteriorly (Fig. 3), width 1.39 (1.37–1.45) times length, 1.11 (1.13–1.27) times internasal distance; posterior lateral apex without a weak lobe; flap depressible into deep oronasal groove; flap with a deep, longitudinal median furrow, papillae patch dense, corrugated; posterior fringe very well developed, filaments dense, long, length sometimes exceeding width of posterior nasal flap, its fleshy margin weakly V-shaped, fringe overlaying lower jaw. Nostril almost longitudinal (sometimes slightly oblique), much shorter than internasal flap; posterolateral margin with a greatly expanded, flattened, fleshy posterior lobe; lobe longer than nasal aperture, extending posteriorly to angle of jaws, posterior width greatly exceeding nostril width. Jaws strongly asymmetric; mouth directed anteroventrally, upper jaw concealed, almost dorsal to lower jaw, without exposed tooth rows (Fig. 3); lower jaw barely visible (outer row of teeth at symphysis exposed when internasal flap lifted); teeth of holotype obscured, in poorly defined series, those closest to symphysis of lower jaw with suboval bases and elongate subtriangular cusps, cusps reduced or absent laterally in jaw. Dissected paratypes (NMV A 1775, adolescent male; NMV A 1712, largest female) with teeth arranged in quincunx, bases rhomboidal with short lingual cusps near middle of jaws, lateral teeth mainly acuspid; labial margins of cusps less angular than lingual margins; lingual teeth not larger than labial teeth; cusps of teeth towards middle of jaw more pronounced than those laterally; teeth in upper jaw similar in size and shape to labial teeth of lower jaw.

Gill slits S-shaped, margin membranous, entire to weakly fringed; length of first gill slit 1.08 (1.02–1.46) times length of fifth gill slit, 3.28 (2.90–3.31) times in mouth width; distance between first gill slits 2.75 (2.97–3.35) times internasal distance, 0.40 (0.43–0.45) in ventral head length; distance between fifth gill slits 1.44 (1.56–1.68) times internasal distance, 0.21 (0.23) in ventral head length.

Body smooth, naked, sensory pores usually indistinct; subcutaneous canal system evident ventrally.

Tail relatively short, postcloacal length 79.5% (74.9–

A

B

Figure 1. *Trygonoptera galba* sp. nov., adult male holotype (NMV A 1793, 328 mm TL, preserved): A. dorsal view; B. ventral view.

Table 1. Morphometric data for the holotype of *Trygonoptera galba* sp. nov. (NMV A 1793), with ranges and means provided for measured paratypes. Measurements expressed as a percentage of total length.

	T. galba **sp. nov.**			
	Holotype	Paratypes		
		Min.	Max.	Mean
Total length (mm)	328	268	339	300
Disc width	61.3	58.1	64.8	62.1
Disc length (direct)	58.2	57.9	59.7	58.6
Disc length (horizontal)	57.7	56.0	58.9	57.3
Snout to maximum width	26.9	24.5	27.6	26.1
Snout length - preorbital (direct)	13.8	12.3	13.6	12.8
Snout length - preorbital (horizontal)	12.0	10.3	11.7	11.1
Snout to spiracle - ant. (horizontal)	14.1	12.7	14.6	13.9
Snout to spiracle - post. (direct)	20.6	19.0	20.3	19.7
Orbit diameter	6.3	5.9	6.3	6.1
Eye diameter (cornea)	3.7	3.3	3.7	3.5
Orbit and spiracle length	7.5	7.4	7.9	7.7
Spiracle length	4.5	4.2	4.6	4.4
Distance between eyes	9.3	9.1	9.6	9.4
Distance between orbits	4.8	3.9	4.5	4.2
Distance between spiracles	8.1	7.9	8.5	8.1
Distance-snout to post. cloaca	54.3	52.3	55.1	53.5
Distance-cloaca to caudal fin tip	46.3	44.0	47.1	45.6
Spine origin to tail tip	28.5	27.2	29.1	28.2
Spine length - upper spine	13.6	11.6	12.4	12.0
Spine length - lower spine	–	13.0	13.0	13.0
Epi-caudal lobe length	17.4	14.9	17.9	16.5
Hypo-caudal lobe length	26.9	24.8	27.7	26.0
Max. caudal height	4.2	3.9	4.9	4.5
Snout tip to lower jaw	14.7	13.4	14.8	14.0
Prenasal length (direct)	11.8	10.8	11.5	11.1
Head length to fifth gill (direct)	30.4	28.1	29.8	29.2
Mouth width (to corners)	4.8	3.7	5.1	4.5
Distance between nostrils	4.4	4.0	4.3	4.2
Nasal curtain-length	3.5	3.2	3.8	3.5
Nostril length	1.3	1.1	1.5	1.3
Nasal lobe length	1.5	1.5	2.0	1.9
Nasal lobe width	0.9	0.9	1.3	1.1
Nasal curtain (maximum width)	4.9	4.5	5.0	4.8
Width of first gill slit	1.5	1.5	1.8	1.7
Width of third gill slit	1.7	1.9	2.0	1.9
Width of fifth gill slit	1.4	1.0	1.5	1.2
Distance between first gill slits	12.1	12.0	13.3	12.8
Distance between fifth gill slits	6.3	6.4	6.9	6.6
Clasper-post cloacal length	10.6	0.0	8.7	5.2
Length of pelvic fin (max.)	11.8	11.5	12.7	12.1
Width across pelvic base	9.2	9.0	9.8	9.4
Width across pelvics (max.)	19.3	18.5	21.3	20.0
Tail width (pelvic axil)	4.2	4.0	4.8	4.5
Tail depth (pelvic axil)	3.3	2.8	3.1	2.9
Tail width (spine origin)	2.0	1.8	2.5	2.2
Tail depth (spine origin)	2.0	1.9	2.3	2.1

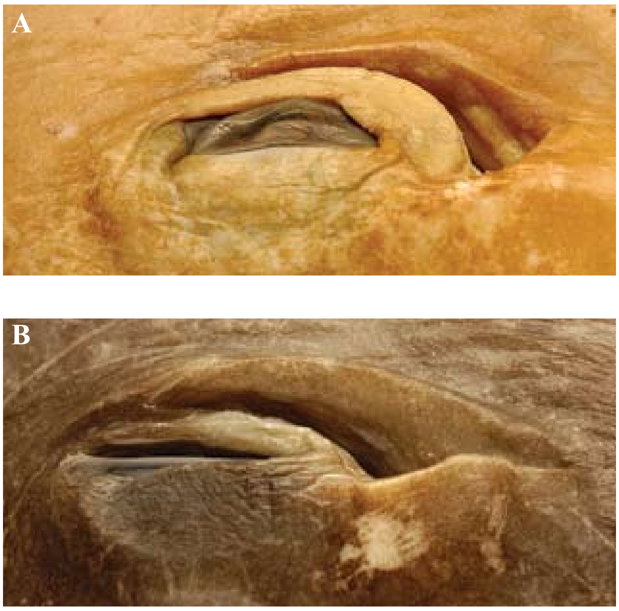

Figure 2. Orbito-spiracular region of: A. *Trygonoptera galba* sp. nov. adult male holotype (NMV A 1793, 328 mm TL, preserved); B. *Trygonoptera mucosa* adult male (CSIRO H 898–06, 318 mm TL, preserved), showing the relative sizes and positions of the spiracle and orbit (right side).

75.8%) disc length; moderately depressed anteriorly, suboval in cross-section, tapering evenly, subcircular at origin of hypochordal lobe of caudal fin, compressed below epichordal lobe; flattened with a basal furrow beneath stinging spine; lateral cutaneous tail folds absent. Dorsal fin absent. Pelvic fin subtriangular, small, length 1.63 (1.55–1.71) in greatest width across both fins, anterior margin weakly convex, apex broadly angular (more rounded in some paratypes), posterior margin straight to weakly convex, free rear tip angular, inner margin straight. Caudal fin broadly lanceolate, epichordal-lobe length 4.17 (3.34–3.80) times fin height, hypochordal lobe 6.47 (5.20–6.54) times fin height; subequal to internasal distance, height 1.06 (0.86–1.04) in internasal width. Clasper short, robust, digitiform, slightly depressed; tapering distally from mid-length, apex bluntly rounded distally. One stinging spine (two in paratype CSIRO H 6665–01), very elongate, length 1.28 (1.30–1.94) times in epichordal lobe length, serrated for distal two thirds or more of its length, point damaged in holotype, otherwise pungent.

Tooth rows about 19–20 in upper jaw, about 22–23 in lower jaw (n=2). Pectoral-fin radials 102 (97–106, n=7) in total; 46 (42–47) propterygial, 13–14 (11–16) mesopterygial, and 42–43 (40–46) metapterygial. Total pelvic-fin radials 1 + 18–19 (1 + 17–20 in males, n=2; 1 + 22–23 in females, n=4). Total vertebral centra about 190 (183–201); monospondylous, including synarcual centra, 43 (36–43); pre-sting diplospondylous centra 46 (45–54); total diplospondylous centra about 147 (147–162).

COLOUR.— Preserved specimens: Dorsal surface almost uniformly rich yellow (sometimes slightly darker yellowish brown in paratypes); not darker on midline of head and central disc and tail, not distinctly paler toward disc margin; no dark spots on body; orbital membranes yellowish, pupil blackish. Ventral surface of disc pale yellowish to whitish, with darker dusky to blackish apices and posterior margins (irregular dark blotches on abdomen in some paratypes); pelvic fins yellowish to white with broad dusky to blackish outer margins; mouth and cloaca uniformly pale. Tail similar to disc dorsally, greyish white ventrally; caudal fin yellowish grey, dusky in most paratypes. Claspers yellowish brown dorsally, pale ventrally with dusky tips.

SIZE.— Largest specimen examined was a female 394 mm TL; adult male holotype is mature at 328 mm TL, another smaller male adolescent at 315 mm TL; birth size unknown.

DISTRIBUTION.— Occurs on the outer continental shelf from the Abrolhos Islands northwards to Shark Bay (Western Australia) in 100–210 m depth. A similar form occurring southward on the outer continental shelf from Rottnest Island into the western sector of the Great Australian Bight may be conspecific.

ETYMOLOGY.— Derived from the Latin *galbus* (yellow) in reference to its distinctive dorsal coloration. Vernacular: Yellow Shovelnose Stingaree.

REMARKS.— Confusion has arisen about the identity of Western Australian individuals of *Trygonoptera* that are morphologically similar to *T. mucosa* (Whitley, 1939), originally described from material colleted off Albany in the western sector of the Great Australian

Figure 3. Oronasal region of *Trygonoptera galba* sp. nov., adult male holotype (NMV A 1793, 328 mm TL, preserved).

Figure 4. Lateral view of the posterior tail of *Trygonoptera galba* sp. nov., adult male holotype (NMV A 1793, 328 mm TL, preserved).

Bight. *Trygonoptera galba* (as *T*. sp. A) was identified by Last & Stevens (1994) based on specimens from off central Western Australia, but was not well defined or adequately distinguished from *T. mucosa*. We now know that these species differ significantly in the relative lengths of the spiracle and eye, as well as in coloration. *Trygonoptera galba* is uniformly yellow (rather than greyish or blackish as in *T. mucosa*), and the main aperture of the spiracle extends anteriorly to about the mid-eye (rather than about level with the anterior third of eye). These morphological differences are reflected in two orbito-spiracular ratios (spiracular length 1.19–1.35 vs. 1.68–2.06 times eye length in *T. mucosa*, n=5; 0.70–0.77 vs. 1.11–1.53 times orbit diameter). Of the other nominal species of *Trygonoptera*, *T. galba* resembles *T. imitata* in being almost uniformly coloured (without obvious dark blotches or stripes) and lacking a dorsal fin, but is smaller than *T. imitata* (reaching about 39 cm TL and males mature at about 33 cm TL vs. about 79 cm TL and 48 cm TL respectively in *T. imitata*). It also has longer prespiracular (snout tip to posterior edge of spiracle 19.0–20.6% vs. 16.6–18.5% TL in *T. imitata*) and prenasal lengths (10.8–11.8% vs. 8.8–9.6% of TL), generally a deeper caudal fin (mostly exceeding 4.1% vs. 3.6–4.1% TL), and fewer vertebrae (total centra about 183–201 vs. 199–223). Specimens collected recently from off Rottnest Island (Last *et al*., 2006) conform closely to *T. galba* but are larger and differ slightly in coloration. Their taxonomic status needs to be evaluated.

Other species of *Trygonoptera*, *T. ovalis* Last & Gomon, 1987, *T. personata* Last & Gomon, 1987, and *T. testacea* Müller & Henle, 1841, all have a small dorsal fin (absent in *T. galba*, *T. imitata* and *T. mucosa*). Unfortunately, unfixed tissue samples are currently unavailable for comparing *T. galba* with other species of *Trygonoptera* using the cytochrome oxidase, subunit 1 segment (CO1) of the genome (Barcode of Life for fishes - FISHBOL) and fresh specimens are needed.

Comparative material.
Trygonoptera mucosa: 7 specimens. CSIRO H 898–02, adolescent male 304 mm TL; CSIRO H 898–03, adult male 347 mm TL; CSIRO H 898–04, female 281 mm TL; CSIRO H 898–05, female 315 mm TL; CSIRO H 898–06, adult male 318 mm TL; CSIRO H 898–07, female 285 mm TL; CSIRO H 898–08, female 287 mm TL.

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Dasyatis parvonigra sp. nov., a new species of stingray (Myliobatoidei: Dasyatidae) from the tropical eastern Indian Ocean

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ABSTRACT.— A new stingray, *Dasyatis parvonigra* sp. nov., from the outer continental shelf of north-western Australia and possibly Indonesia, is described. It resembles a much larger, temperate Australian relative, *D. thetidis*, in body shape but these species differ markedly in external morphology, meristics and squamation. *Dasyatis parvonigra* appears to belong to a complex of poorly known species that are closely related to *D. akajei* (Müller & Henle, 1841). It may be more widespread in the central western Pacific.

Key words. Dasyatidae – *Dasyatis parvonigra* – stingray – new species – Australia – eastern Indian Ocean

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INTRODUCTION

Nishida & Nakaya (1990) published a review of species of *Dasyatis* of the North Pacific, in which they recognised 19 species level taxa of which two were thought to be un-named. Long-term, unpublished studies of dasyatids of the Indo–Pacific by the senior author and others have found that the taxonomy of this group is more complex than first thought. Rather than being widespread, some species have restricted distributions and species once considered ubiquitous are now known to consist of species complexes. These findings are being supported by data from the recently innovated Barcode of Life for fishes (FISHBOL) project, with some of these results published in preliminary papers (e.g. Ward *et al*., 2005, 2008).

Last & Stevens (1994) identified an un-named stingray (as *Dasyatis* sp. A) that superficially resembles the Black Stingray (*D. thetidis* Ogilby *in* Waite, 1899). The new species, which is known from only a few individuals, is described below.

METHODS

Characteristics of the disc (including squamation), and tooth row and meristic counts follow standards used in Manjaji (2004) and Last *et al*. (2006). Meristics were obtained from radiographs. Counts follow Compagno & Roberts (1982) with some minor modifications: the first enlarged anterior element of the pelvic fin (with 2–3 distal segments fused at their bases) is counted as one; first synarcual centra are included in vertebral counts as there are no strong mid-dorsal denticles to obscure centra; intermediate pectoral-fin radial elements were assigned to a pterygial unit based on the relative level of overlap with each of the adjacent units; and first distal propterygial and metapterygial elements were considered to form part of the main skeleton and were not incorporated into counts; the notochord of the tail was excluded from counts. A total of 63 measurements, expressed as proportions of disc width (DW, see Tables 1 & 2), were taken for the holotype and the 3 paratypes. Morphometric methods generally followed Compagno & Heemstra (1984) with additional characters derived to account for characteristic features of the tail. The shape of the tail and associated skin folds, also known as cutaneous folds, are important in distinguishing different species of dasyatids. Hence, tail widths and depth (height) were recorded at the origin and insertion of the ventral skin fold. Additional measurements of tail width, depth, and skin fold height were recorded at quartile intervals along the base of the skin fold: at points demarcated by 25%, 50% (its mid-base) and 75% of the base length from the fold's origin. The base length and maximum height of the dorsal fold were also measured. Specimens were deposited in the Australian National Fish Collection, at the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Marine and Atmospheric Research Laboratories in Hobart, Tasmania and at the Western Australian Museum, Perth (WAM). Institutional abbreviations follow Leviton *et al*. (1985).

Dasyatis parvonigra sp. nov.

Figs 1–4; Tables 1, 2

Dasyatis sp. A: Last & Stevens, 1994: pp 384, 385, key fig. 32, fig. 40.1, pl. 73.

Holotype. CSIRO H 1036–15, adult male 384 mm DW, north of Cape Lambert, Western Australia, 19°06′ S, 117°09′ E, 178–183 m, 12 Oct 1987.
Paratypes. 3 specimens. CSIRO CA 4125, adult male 368 mm DW, north-west of Port Hedland, Western Australia, 19°11′ S, 117°31′ E, 124 m, 14 Apr 1983; CSIRO H 1512–03, adult male 369 mm DW, north of Monte Bello Islands, Western Australia, 19°39′ S, 115°36′ E, 167–180 m, 11 Oct 1988; WAM P 29790–001, adult male, 347 mm DW, Western Australia, no other data.
Other material. 1 specimen. CSIRO H 5866–01, female 498 mm DW, Kedonganan (market collection), Jimbaran Bay, south coast of Bali, Indonesia, 08°45′ S, 115°10′ E, 24 Mar 2002.

DIAGNOSIS.— A relatively small species of *Dasyatis* (reaching at least 50 cm DW) with the following combination of characters: broad disc, width 1.2–1.3 times length; snout broadly triangular, angle 116–122°, length 1.7–1.8 times interorbital width; preoral length 2.0–2.2 times mouth width; internasal distance 1.3–1.4 in prenasal length; body and tail mostly naked, denticles confined to midline of disc, single continuous row of 6–10 small nucho-scapular thorns (usually with single scapular thornlet); tail long, very slender, whip-like beyond sting, and almost quadrangular in cross-section at midfold, width 0.8–1.0 times its depth, postcloacal tail length 2.1–2.3 times precloacal length; ventral cutaneous fold long, slender, its length 2.3–3.2 in DW, height 0.4–0.6 in tail depth at its midlength; dorsal skin fold elongate, low, barely taller than a ridge, much shorter than ventral fold; distance from cloaca to sting 1.9–2.2 in precloacal length; pectoral-fin radials 106–109; total vertebral centra 103–109.

DESCRIPTION.— Disc quadrangular, angular anteriorly and barely produced, length much shorter than width; width 1.20 times length in holotype (1.20–1.25 in paratypes); axis of greatest width of disc over scapular region, its distance from snout tip 1.69 (1.63–1.79) times in distance from tip of snout to pectoral-fin insertion; body moderately robust, thickness 9.1 (8.0–8.5) times in disc width, not raised markedly above cranium (marginally more so above scapular region); anterior margin of disc straight to weakly concave anteriorly, strongly convex just before pectoral-fin apex; apex broadly angular, pectoral angle 90° (85–90°); posterior margin initially straight, becoming weakly convex posteriorly; free rear tip broadly rounded. Pelvic fins weakly triangular, anterior and posterior margins almost straight, apices narrowly rounded, angular, free rear tip broadly rounded; relatively small, length 19.0% (17.7–19.5%) DW; 1.00 (1.14–1.28) times width across fin bases. Tail elongate, slender, with a long, low ventral skin fold and a shorter dorsal fold; postcloacal tail 2.27 (2.10–2.21) times precloacal length; base slightly depressed, broadly oval in cross-section, weakly convex above and below, width 1.44 (1.52–1.56) times its depth; tapering gradually and evenly to sting base; narrowly rounded in cross-section near origin of ventral skin fold, width 1.15 (1.10–1.11) times height at fold origin; tapering abruptly in dorsoventral view below sting; subcircular to weakly pentangular in cross-section at end of sting; very slender, whip-like beyond sting, becoming progressively more depressed toward tail tip; subquadrangular in cross-section above mid ventral fold, width 0.98 (0.84–1.04) times depth; at end of fold suboval, weakly depressed, width 1.18 (1.08–1.21) times height; filamentous, moderately depressed towards tail apex; dorsal surface of tail posterior to sting base with broad, strongly tapering, naked groove (partly housing sting and extending for about two-thirds to three-quarters of its length); no skin folds present along lateral margin of tail before sting. Dorsal skin fold reduced to low, elongate ridge, length about 69 (145–158) times its height, 1.22 (0.71–1.42) in snout length, 2.89 (1.29–3.29) in length of ventral fold; its height 2.94 (2.61–6.70) in height of mid ventral fold; origin near sting apex, terminating in a low ridge posteriorly, its exact origin and end unclear. Ventral skin fold long, narrow, length 2.34 (2.42–3.16) in disc width, 3.73 (3.50–4.43) in post cloacal tail; origin 1.4% (0.5–1.7%) before sting origin; depth at quarter length 0.34 (0.32–0.38), at mid length 0.60 (0.41–0.55), at three quarter 0.31 (0.25–0.42) in adjacent tail height; commencing almost below sting origin, terminating in an indiscernible ridge; distance from cloaca to sting origin 2.09 (1.88–2.20) in precloacal length; length of tail beyond ventral fold 0.52 (0.39–0.60) in fold length, 1.93 (1.75–2.09) in tail length. Sensory pores not demarcated. Lateral line on ventral surface indistinct.

Snout short, broadly triangular, acute at apex with indistinct, triangular apical lobe; angle 116° (117–122°); acute when viewed laterally, becoming more depressed towards apex; preoral snout length 2.12 (2.02–2.22) times mouth width, 1.71 (1.62–1.82) times internarial distance, 1.01 (0.92–1.03) times distance between first gill slits; direct preorbital snout length 1.81 (1.71–1.83) times interorbital length; snout to maximum disc width 2.29 (2.34–2.48) in DW; interorbital space broad, weakly concave; eyes of moderate size, dorsolateral, protruding slightly, ventral margin partly covered by thin skin fold; orbit usually elevated slightly above disc, diameter 0.79 (0.89–0.95) in spiracle length, eye diameter 1.09 (1.14–1.33) in spiracle length; inter-eye distance 3.21 (3.22–3.42) times eye diameter. Spiracles subrectangular to suboval, enlarged, opening dorsolaterally. Nostril narrowly oval, directed almost posteriorly; anterior margin fleshy; anterior nasal fold internal, broad, membranous; oronasal groove present; internasal distance 1.28 (1.29–1.37) in prenasal length, 3.28 (3.00–3.14) times nostril length. Nasal curtain skirt-like, relatively broad, long, width

A

B

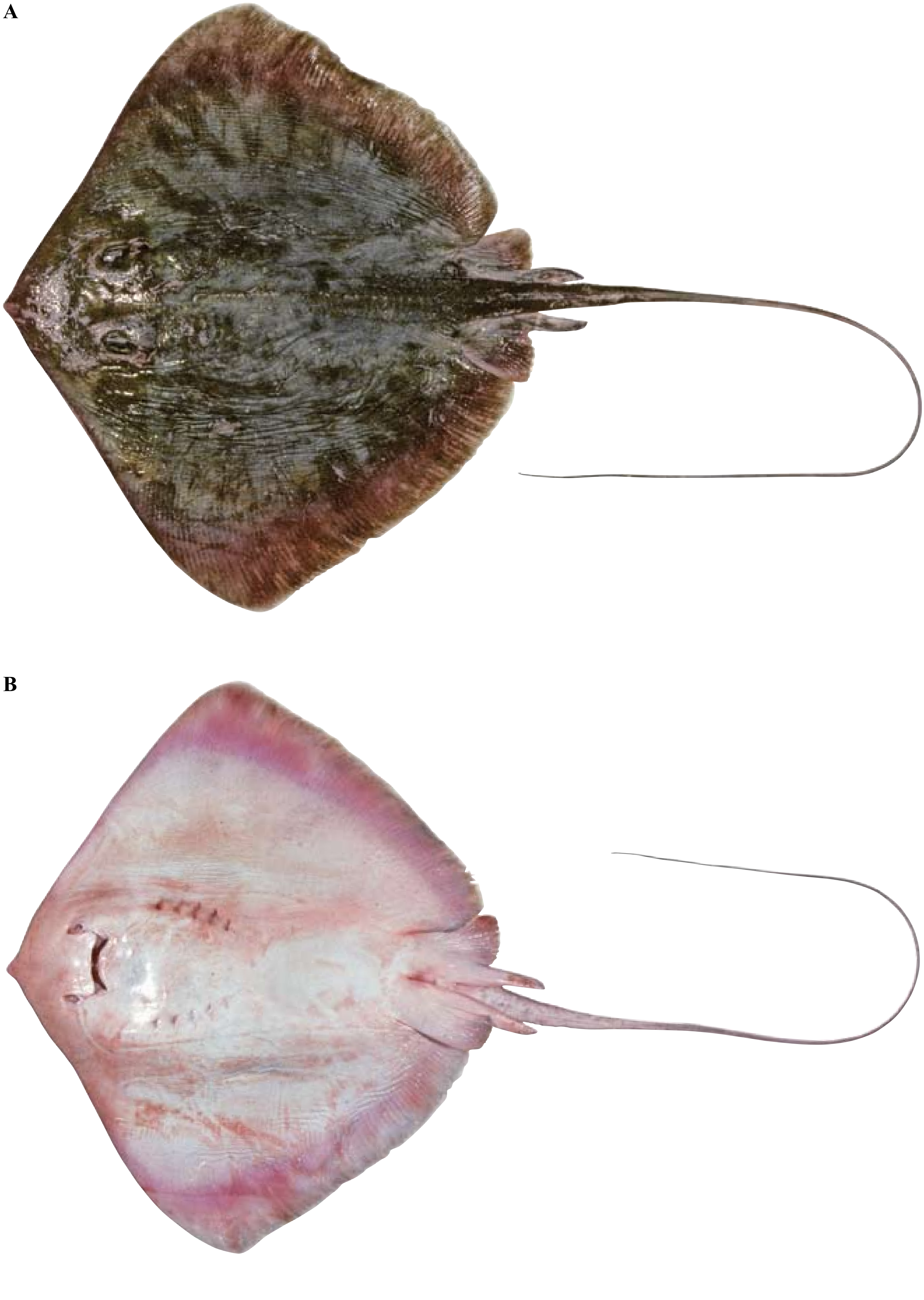

Figure 1. *Dasyatis parvonigra* sp. nov., adult male holotype (CSIRO H 1036–15, 384 mm DW, fresh): A. dorsal view; B. ventral view.

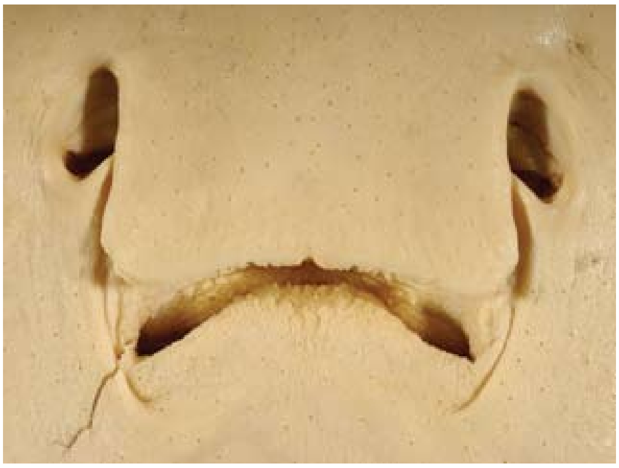

Figure 2. Oronasal region of *Dasyatis parvonigra* sp. nov. (CSIRO H 1036–15, adult male holotype 384 mm DW).

1.92 (1.71–1.94) times length; not strongly bilobed; surface flat, smooth, without longitudinal medial groove but covered with minute pores; apex recessible within lateral margin of oronasal groove; lateral margin almost straight, smooth edged; posterior margin very finely fringed, weakly concave, not following contour of lower jaw, abutting symphysis of lower jaw when mouth closed. Jaws slightly asymmetric. Upper jaw weakly arched (teeth concealed in some paratypes), symphysial part of jaw not projecting ventrally; lower jaw strongly convex, only outer symphysial teeth visible when mouth closed; lateral grooves deep, curved slightly, extending from nostril to well below lower jaw, length subequal to nasal curtain length. Lower jaw not projecting forward when mouth open, mouth not protrusible; skin on chin fleshy, corrugate and papillate beside teeth; floor in holotype with 4 large, closely spaced, medial oral papillae, and a slightly smaller papilla and about 2 rudimentary papillae near each corner. Teeth small, variable in shape; those at symphysis of upper jaw larger, more upright, with long slender cusps, much less oblique than those posterolaterally; symphysial teeth in lower jaw in a low knob, similar in size and shape to those of symphysis of upper jaw; those toward angle of lower jaw with very short cusps; teeth uniformly close-set in both jaws, in oblique rows, not arranged quincuncially; rows in upper jaw about 43; rows in lower jaw about 43.

Gill slits weakly S-shaped, forming a weakly fringed lobe laterally; length of first gill slit 1.40 (1.54–1.58) times length of fifth gill slit, 3.14 (2.99–3.31) times in mouth width; distance between first gill slits 1.70 (1.76–1.78) times internasal distance, 0.45 (0.44–0.48) times ventral head length; distance between fifth gill slits 1.06 (1.11–1.16) times internasal distance, 0.28 (0.29–0.30) times ventral head length.

SQUAMATION.— Disc and tail lacking denticles, except for a series of small, broadly lanceolate to seed-shaped thorns along mid-line of disc. Nucho-scapular region of disc with continuous row of 10 (6–10) closely spaced thorns; row length subequal to interorbital width; holotype with additional 5 small, irregularly spaced thorns on midline of posterior disc (not extending onto tail), evidence of similar extension on CSIRO H 1512–03 but lacking in other paratypes; all types with a single seed-shaped scapular thorn (except WAM P 29790–001) located close to each side of last nucho-scapular thorn.

Mature male holotype with single, intact sting (two stings present in paratype WAM P 29790–001, first significantly longer and overlapping second); sting longer than snout length; distance from sting base to pectoral-fin insertion 31.9% (28.7–32.6%) DW, 1.61 (1.63–1.99) times sting length; distance from cloaca to sting base 0.40 (0.38–0.44) in disc length. Clasper of adults moderately depressed, robust basally and tapering distally to a blunt point; length 4.0% (4.0–4.1%) DW.

MERISTICS.— Total pectoral radials 106 (106–109, n=3); propterygials 43–44 (41–44), mesopterygials 16 (14–18) and metapterygials 46–47 (47–51). Total pelvic radials 1 + 16 (16–19). Total vertebral segments (including first synarcual centra) 103 (106–109); monospondylous centra 35 (36–38); diplospondylous centra 68 (68–72).

COLOUR.— Disc of holotype almost uniformly dark greyish brown dorsally with paler areas beside its posterior margin; thorns, sting, hind margin of orbit, inner spiracle and anterior margins of pelvic fins white; claspers dark brown and white, palest along their inner margins; snout and dorsal surface of tail brown, with white patches where skin has been removed; tail beyond sting paler than anterior tail, whitish or light brown. Ventral surface of disc and tail almost uniformly white. Paratypes uniformly coloured but variable; WAM P 29790–001 very similar to the holotype; CSIRO H 1512–03 more greyish due to a coverage of mucous, typical dark greyish brown coloration evident where mucous has

Figure 3. Scapular denticles of *Dasyatis parvonigra* sp. nov. (CSIRO H 1036–15, adult male holotype 384 mm DW).

Table 1. Morphometric data for the holotype of *Dasyatis parvonigra* sp. nov. (CSIRO H 1036–15), with ranges and means provided for measured paratypes. Measurements expressed as a percentage of disc width.

	Holotype	Paratypes		
		Min.	Max.	Mean
Disc width (mm)	384	347	369	
Total length	229.7	213.8	221.7	217.8
Disc length	83.6	79.9	83.4	82.1
Snout to pectoral-fin insertion	73.8	69.8	72.1	71.3
Disc thickness	10.9	11.8	12.5	12.2
Snout (preorbital) length	18.0	17.0	17.8	17.4
Snout (preorbital) horizontal length	15.9	14.1	15.6	14.6
Pelvic-fin (embedded) length	19.0	17.7	19.5	18.4
Width across pelvic-fin base	15.6	14.9	15.7	15.3
Greatest width across pelvic fins	24.7	26.8	27.8	27.2
Cloaca origin to tail tip	159.4	144.8	152.6	148.7
Tail width at axil of pelvic fins	6.1	6.5	6.8	6.6
Tail height at axil of pelvic fins	4.2	4.1	4.4	4.3
Pectoral-fin insertion to sting origin	31.9	28.7	32.6	30.6
Cloaca origin to sting	33.6	31.5	35.2	33.1
Tail width at base of sting	2.6	2.3	2.9	2.6
Tail height at base of sting	2.3	2.3	2.6	2.4
Sting 1 length	19.9	16.3	18.7	17.5
Sting 2 length	–	5.2	5.2	5.2
Snout preoral (to lower jaw) length	18.4	16.7	17.8	17.2
Mouth width	8.7	7.6	8.5	8.0
Distance between nostrils	10.7	9.8	10.6	10.1
Interorbital width	9.9	9.7	9.9	9.8
Inter-eye width	14.9	13.3	14.7	14.0
Snout to maximum width	43.7	40.3	42.8	41.5
Eye length	4.6	4.1	4.5	4.2
Orbit diameter	6.4	5.7	5.9	5.8
Spiracle length	5.1	5.1	5.5	5.3
Interspiracular width	15.9	14.8	15.9	15.2
Orbit and spiracle length	9.8	9.5	9.9	9.7
Nostril length	3.3	3.2	3.4	3.3
Snout prenasal length	13.7	13.1	13.7	13.4
Nasal curtain length	5.8	5.4	6.1	5.7
Nasal curtain width	11.0	9.4	10.4	9.9
Orbit to pectoral-fin insertion	51.4	48.2	50.3	49.6
Snout to origin of cloaca	70.2	66.4	69.2	68.2
Width 1st gill slit	2.8	2.4	2.7	2.5
Width 3rd gill slit	3.1	2.7	3.0	2.9
Width 5th gill slit	2.0	1.6	1.7	1.6
Head length	40.8	37.9	39.2	38.7
Distance between 1st gill slits	18.2	17.2	18.6	17.9
Distance between 5th gill slits	11.4	11.1	11.8	11.4
Cloaca length	4.0	4.0	4.1	4.1
Clasper postcloacal length	19.1	19.4	21.0	20.4
Clasper length from pelvic axil	12.1	11.5	13.2	12.4

Table 2. Measurements associated with the dorsal and ventral skin folds for the holotype of *Dasyatis parvonigra* sp. nov. (CSIRO H 1036–15), with ranges and means provided for paratypes. Measurements expressed as a percentage of disc width; quartile points taken from orgin of ventral fold.

	Holotype	Paratypes		
		Min.	Max.	Mean
Dorsal fold base length	14.8	12.6	24.6	18.0
Dorsal fold maximum height	0.2	0.1	0.2	0.1
Ventral fold base length	42.8	31.7	41.4	35.8
Tail width at origin of ventral fold	2.5	2.4	2.7	2.5
Tail height at origin of ventral fold	2.2	2.2	2.4	2.3
Tail width at quarter length of ventral fold	1.5	1.3	1.6	1.5
Tail height at quarter length of ventral fold	1.4	1.3	1.5	1.4
Fold height at quarter length of ventral fold	0.5	0.5	0.5	0.5
Tail width at mid-length of ventral fold	1.0	1.0	1.1	1.0
Tail height at mid-length of ventral fold	1.0	1.1	1.2	1.1
Fold height at mid-length of ventral fold	0.6	0.4	0.6	0.5
Tail width at three quarter length of ventral fold	1.0	0.8	1.0	0.9
Tail height at three quarter length of ventral fold	0.9	0.9	1.0	1.0
Fold height at three quarter length of ventral fold	0.3	0.3	0.4	0.3
Tail width at end of ventral fold	0.9	0.8	0.9	0.9
Tail height at end of ventral fold	0.7	0.7	0.8	0.7
Tail length posterior to ventral fold	82.8	69.2	87.2	78.2
Ventral fold origin to sting origin interspace	1.4	0.5	1.7	1.0

been removed; CSIRO CA 4125 paler yellowish brown but this may be an artefact of preservation as the ventral surface is yellowish rather than white.

SIZE.— Males mature by 347 mm DW; largest adult male 384 mm DW. Females not collected from the type locality, possibly to 498 mm DW elsewhere.

DISTRIBUTION.— Type material collected from the outer continental shelf off northwestern Australia from north of Monte Bello Islands (19°39′ S, 115°36′ E) to north of Cape Lambert (19°06′ S, 117°09′ E), in 124–183 m depth. A single female non-type (CSIRO H 5866–01) collected off Bali in eastern Indonesia, as well as similar forms off West Papua and the Philippines, suggests a wider range in at least the western central Pacific.

ETYMOLOGY.— Derived from the Latin *parvus* (little) and *nigra* (black) in allusion to its resemblance to a larger Australian species, the Black Stingray, *Dasyatis thetidis*. Vernacular: Dwarf Black Stingray.

REMARKS.— Of the Australian stingrays, *Dasyatis parvonigra* most closely resembles its larger relative, *D. thetidis*, in body shape but differs markedly from this species in external morphology, meristics and squamation. *Dasyatis thetidis* is a large species with a maximum DW of about 180 cm (Last & Stevens, 1994), whereas males of *D. parvonigra* are sexually mature at 35 cm. The tail and dorsal disc of *D. thetidis* are densely covered with thorns and tubercles, even in late adolescent stages of growth. *Dasyatis thetidis* also has more vertebral segments (147–157, n=6 vs. 103–109, n=4), and pectoral-fin radials (126–131 vs. 106–109) than *D. parvonigra*. Another large Australian species *D. brevicaudata* (Hutton, 1875), which attains in excess of 210 cm DW, has a shorter tail with a much more prominent ventral fold than *D. parvonigra*. A tropical and warm temperate eastern Australian species *Dasyatis fluviorum* Ogilby, 1908, has prominent scutes on the midline of the tail (absent in *D. parvonigra*), a well-developed, broad patch of widely spaced denticles on the scapular region in adults (also absent in *D. parvonigra*), and usually has a higher number of vertebral centra (122–130, n=3 vs. 103–109) and slightly more pectoral-fin radials (110–117 vs. 106–109).

Dasyatis parvonigra differs from other species of *Dasyatis* by a combination of characters outlined in the diagnosis. Nishida & Nakaya (1990) published a review of North Pacific *Dasyatis*. Of the 19 species treated, *D. parvonigra* is closest to *D. longa* (Garman, 1880) from the Gulf of California to the Galapagos Islands. These species differ from other North Pacific *Dasyatis* in having a blunt snout, no spots on the dorsal surface, no groove on the belly, denticles present on the disc midline

Figure 4. Lateral view of tail near sting and dorsal and ventral skin folds of *Dasyatis parvonigra* sp. nov. (CSIRO H 1036–15, adult male holotype 384 mm DW).

in specimens smaller than 30 cm, and have a dorsal skin fold (or keel) and a long, low, dark ventral fold. However, based on Nishida & Nakaya (1990), *D. longa* has a longer disc (about 89 vs. 80–84% DW) a much longer pre-sting length (118% vs. 101–102% DW), and is a larger ray (reaching 260 cm TL, Froese & Pauly, 2008 vs. males mature at 74–88 cm TL in *D. parvonigra*). *Dasyatis ushiei* (Jordan & Hubbs, 1925) has a similar disc length (about 82% DW) and pre-sting length (about 108% DW) but it is a much larger ray, immature and with a smooth disc at 37 cm DW (holotype FMNH 59380), and attaining at least 202 cm DW and becoming very spiny on the disc and tail as an adult (White *et al*., 2006).

A female specimen, 498 mm DW (CSIRO H 5866–01), collected from the Kedonganan fish market (Bali, Indonesia), is similar to and may be conspecific with Australian *D. parvonigra*. However, it was excluded from the type series of *D. parvonigra* because it has slightly higher vertebral (total centra 116 vs. 103–109, n=4) and pectoral-fin radial counts (112–113 vs. 106–109, n=4). Work in progress has identified a complex of species in the Indo–West Pacific close to *D. akajei* (Müller & Henle, 1841) and *D. parvonigra* probably belongs to this subgroup. These results of this research will be summarised in a review of Indo–Pacific *Dasyatis*.

Comparative material.

Dasyastis brevicaudata: 4 specimens: CSIRO H 1003–01, female 368 mm DW; CSIRO H 6257–01, female 495 mm DW; CSIRO H 6312–19, juvenile male 670 mm DW; CSIRO H 6340–17, female 325 mm DW.

Dasyatis fluviorum: 3 specimens: CSIRO H 4591–01, female 460 mm DW; CSIRO H 4595–01, juvenile male 200 mm DW; CSIRO H 5769–01, juvenile male 220 mm DW.

Dasyatis thetidis: 6 specimens: CSIRO CA 3961, female 570 mm DW; CSIRO H 310–01, female 430 mm DW, CSIRO H 1404–01, female 793 mm DW, CSIRO H 1419–01, juvenile male 770 mm DW, CSIRO H 3228–02, juvenile male 410 mm DW, CSIRO H 5768–01, female 415 mm DW.

Dasyatis ushiei: 1 specimen: FMNH 59380 [ex CM 7778] (holotype), juvenile male 367 mm DW.

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Himantura dalyensis sp. nov., a new estuarine whipray (Myliobatoidei: Dasyatidae) from northern Australia

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ABSTRACT.— The Freshwater Whipray, *Himantura dalyensis* sp. nov., is described from material collected in rivers of northern Australia. It belongs to a group of Indo–West Pacific whiprays that mainly inhabit coastal and estuarine environments, but also penetrate well upstream into freshwater. It has been confused with the Estuary Stingray (*Dasyatis fluviorum*) and a close relative from Asia, *H. polylepis* (also widely known by its junior synonym *H. chaophraya*). *Himantura dalyensis* differs from *Dasyatis fluviorum* in disc shape, squamation and lacking a ventral skin fold on the tail, and from *H. polylepis* in having a smaller maximum size, a more truncate and shorter snout, a broader snout angle with a smaller apical lobe, a narrower dark marginal marking on the ventral disc, slightly more vertebral centra, and a much higher ratio of propterygial radials to mesopterygial radials. Considered to be endemic to Australia but a likely conspecific form has been recorded from New Guinea.

Key words. Dasyatidae – *Himantura dalyensis* – *Himantura polylepis* – *Himantura chaophraya* – whipray – new species – northern Australia

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INTRODUCTION

The Freshwater Whipray, referred to as *Himantura chaophraya* Monkolprasit & Roberts, 1991 by Last & Stevens (1994), is the only Australian stingray to live entirely in fresh and estuarine waters. It was discovered by Taniuchi *et al*. (1991) and has not been recorded since from euhaline marine waters anywhere in its known range (Pogonoski *et al*., 2002). This whipray is known from at least 10 rivers across northern Australia (Last & Stevens, 1994; Thorburn *et al*., 2003) and may occur in many others. Taniuchi *et al*. (1991) noted some differences in morphometrics and counts between Asian and Australian populations of *H. chaophraya*, and Last (2002) suggested that these regional forms may not be conspecific. Last & Stevens (1994) claimed that nomenclatural problems exist within the group, and a more detailed study of the genus *Himantura* by Manjaji (2004) has shown that coastal/estuarine rays referable to *H. chaophraya* probably represent more than a single species. In addition, Australian populations, thought to be widely and patchily distributed in the central Western Pacific, differ in molecular structure to those from South–East Asia (Manjaji, 2004). A morphological comparison of material from the two regions has led us to the conclusion that Australian and South–East Asia populations are not conspecific. The Australian form is described below as a new species and the validity of *H. chaophraya* is discussed.

METHODS

Morphological methodology follows standards developed for the junior author's doctoral dissertation (Manjaji, 2004). They are based on modifications from Compagno & Heemstra (1984) and Last & Stevens (1994), as outlined by Last *et al*. (2006), and include some new descriptive features (i.e. morphology of the disc and its attributes, and squamation). The only non-standard horizontal measurement is the distance from the snout tip along the midline of the disc to a perpendicular line joining the eyes. The thickness of the midscapular denticle was excluded in the measurement of disc thickness. Measurements were taken in millimetres (mm) as direct lengths (shortest point-to-point distance). The holotype (CSIRO H 2503–01) and 3 paratypes (CSIRO H 2524–01, CSIRO H 6657–01 and WAM P 32955–001) of the new species were measured in full. Morphometric data are presented in Table 1 and expressed as proportions of disc width (DW). Specimens from the University of Tokyo and Museum and Art Gallery of the Northern Territory, which were included to disperse the type series, were unavailable to the authors and did not contribute to the description of the new species.

Tooth rows for both upper and lower jaws were counted as diagonal rows across the tooth band beginning at one corner of the mouth (Fischer & Hureau, 1987), as well as vertical rows (Compagno, 1999). Corners of the mouth usually had to be slit so the tooth rows were fully visible for counting. Other meristic data for the holotype and 3 paratypes (CSIRO H 2524–01, CSIRO H 6657–01 and WAM P 32955–001) were obtained from radiographs. Counts follow Compagno & Roberts (1982) with some minor modifications: the first enlarged anterior element of the pelvic fin (with 2–4 distal segments fused at their bases) is counted as one; first synarcual centra are not included in vertebral counts (usually contains 1–2 centra and are often obscured by mid-dorsal denticles); intermediate pectoral-fin radial elements were assigned to a pterygial unit based on the relative level of overlap with each of the adjacent units; and first distal propterygial and metapterygial elements were considered to form part of the main skeleton and were not incorporated into counts; the notochord of the tail was excluded from counts. Comparative morphometric and meristics data are based on Manjaji (2004). Species of *Himantura* have developmental stages of the dorsal denticles that are extremely useful for distinguishing species (Manjaji, 2004; Last *et al*., 2006). The sequence of development usually varies between species, and not all species display all possible stages of development.

Type specimens are deposited in 4 repositories: Australian National Fish Collection, Hobart (CSIRO); Department of Fisheries, University Museum, University of Tokyo (FUMT); Museum and Art Gallery of the Northern Territory (NTM); and the Western Australian Museum, Perth (WAM). Comparative materials from several other repositories were also examined in this work. These include those from: National Natuurhistorisch Museum, Leiden (RMNH), Sabah State Museum, Kota Kinabalu (SMEC), Borneo Marine Research Institute Fish Collection, Kota Kinabalu (IPMB), and Museum of Fisheries Science, Tokyo University of Fisheries, Tokyo (MTUF). Institutional acronyms follow Leviton *et al*. (1985).

Himantura dalyensis sp. nov.

Figs 1, 2a, 3, 4; Table 1

?*Himantura* sp.: Compagno & Roberts, 1982: p 337, fig. 12 (identity uncertain).

Dasyatis fluviorum (not Ogilby): Merrick & Schmida, 1984: p 42 (misidentification); Herbert & Peeters, 1995: p 19, pl. 3 (misidentification).

Himantura chaophraya (not Monkolprasit & Roberts): Taniuchi *et al*., 1991: p 23, fig. 8 (misidentification); Last & Stevens, 1994: p 399, fig. 40.10, pl. 69 (misidentification).

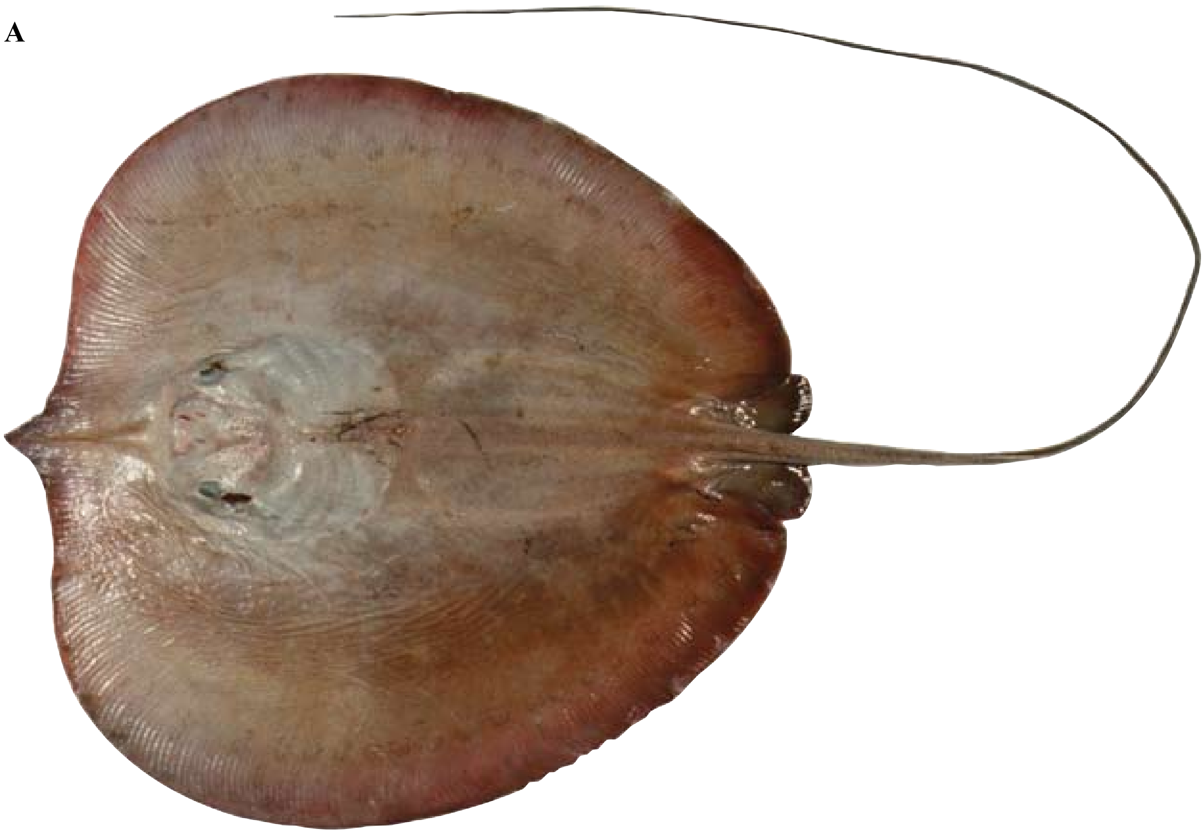
Holotype. CSIRO H 2503–01, juvenile male 620 mm DW, Pentecost River (Bindoola Creek junction), Western Australia, 15°42′ S, 127°51′ E, Sep 1990.

Paratypes. 8 specimens. CSIRO H 2524–01, female 450 mm DW, Gilbert River (crossing of the Burke Development Road), Queensland, 17°11′ S, 141°45′ E, 0.3 m, Aug 1989; CSIRO H 6657–01, juvenile male 517 mm DW, Fitzroy River (Telegraph Pool), Western Australia, 17°38′ S, 123°34′ E, 1.1 m, 13 Oct 2002; FUMT–P10863, female 474 mm DW, Mission, Daly River, Northern Territory, 18 Aug 1989; NTM S 14745–001, adolescent male 880 mm DW, Daly River (upstream from crossing), Northern Territory, 13°46′ S, 130°43′ E, 18 Nov 1998; NTM S 15183–001, juvenile male 380 mm DW, Daly River crossing, Northern Territory, 13°46′ S, 130°42′ E, Jul 1999; NTM S 15184–001, juvenile male 415 mm DW, Daly River crossing, Northern Territory, 13°46′ S, 130°42′ E, Aug 1999; NTM S 16248–001, juvenile male 415 mm DW, Daly River (below Oolloo crossing), Northern Territory, 14°00′ S, 131°14′ E, 9 Jul 2006; WAM P 32955–001, juvenile male 464 mm DW, Ord River, Western Australia, 15°34′ S, 128°37′ E, 3.5 m, 19 Nov 2002.

DIAGNOSIS.— A species of *Himantura* distinguished by a combination of the following features: disc subcircular, snout tip to axis of maximum width 41–44% DW; anterior disc margin truncated, almost transverse; preorbital snout obtuse, angle 120–121°, with a distinct apical lobe; preorbit long, length 27–28% DW, 2.1–2.2 times interorbital length; internasal distance 1.9–2.1 in prenasal length, 3.2–3.6 times nostril length; preoral snout length 3.3–3.4 times mouth width, 2.4–2.6 times internarial distance; lateral apices broadly rounded; orbits very small, protruded slightly; denticles along mid-trunk relatively sparse, band without well-defined margin, mid-scapular denticle small or inconspicuous; tertiary denticles present; disc uniformly pale brown or greyish brown dorsally; ventrally, disc whitish with broad, dark marginal bands, their inner margins irregular and bordered with dark blotches; marginal bands slightly broader posteriorly, their maximum width subequal to mouth width; pelvic-fin tips dark on ventral surface; tail dark brown to blackish dorsally, whitish ventrally forward of sting base, almost uniformly black beyond sting; propterygial radials 73–78, 2.7–2.9 times the number of mesopterygial radials; total vertebral segments 120–121.

DESCRIPTION.— Disc subcircular, width 98% of its length in holotype (95–99% in paratypes); moderately robust, raised above mid-scapulocoracoid, maximum thickness 0.09 (0.09–0.11) in disc width (DW); snout obtuse, with a pronounced apical lobe, angle 121° (120–121°); anterior margins strongly truncated, almost perpendicular to longitudinal axis of disc; lateral apices broadly rounded; posterior margin broadly convex, free

A



B

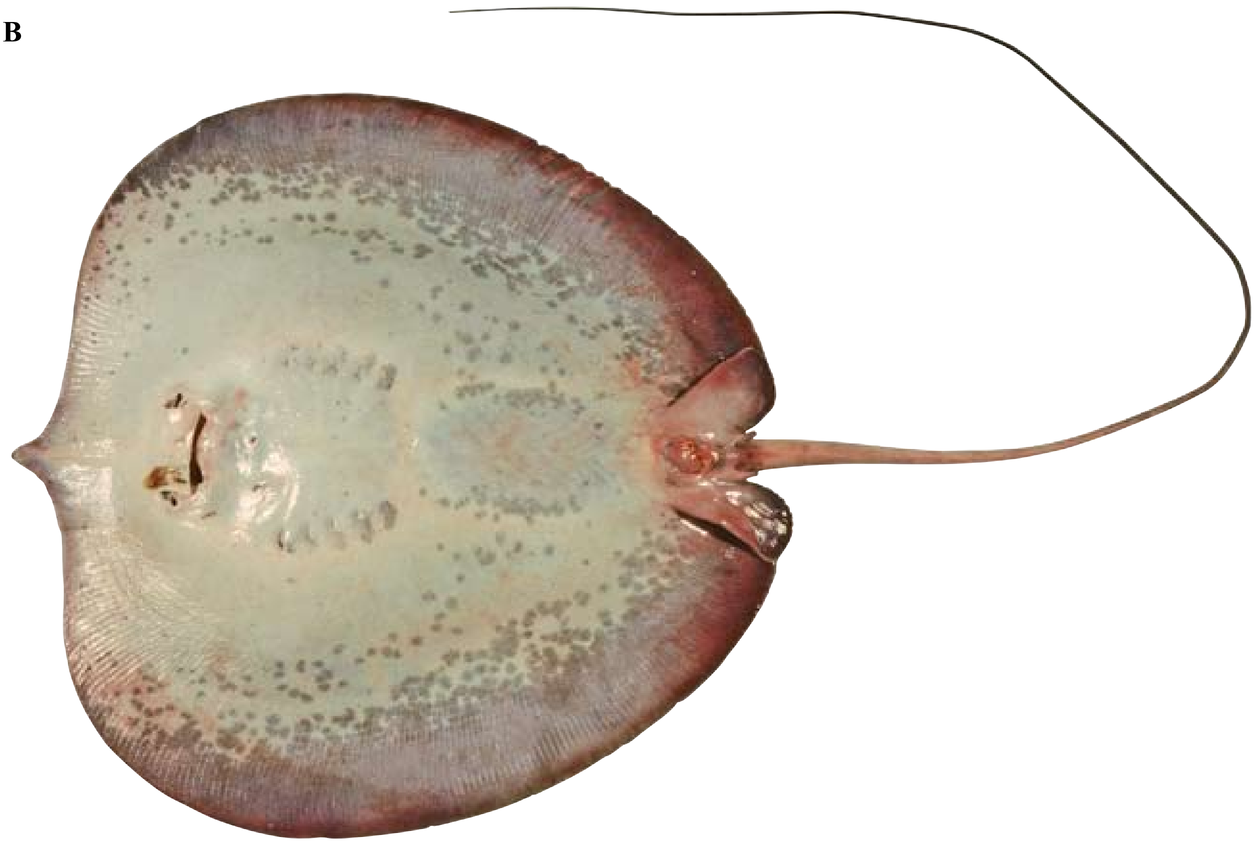


Figure 1. *Himantura dalyensis* sp. nov., juvenile male holotype (CSIRO H 2503–01, 620 mm DW, fresh): A. dorsal view; B. ventral view.

A

B

Figure 2. Dorsal view of: A. *Himantura dalyensis* sp. nov. female paratype (CSIRO H 2524–01, 450 mm DW, fresh); B. *H. polylepis* juvenile male holotype (RMNH T 7452, 301 mm DW, preserved).

Figure 3. Oronasal region of *Himantura dalyensis* sp. nov., juvenile male holotype (CSIRO H 2503–01, 620 mm DW, fresh).

rear tip narrowly rounded. Pelvic fins rather short, 19.0% (18.7–19.9%) DW; width across base 11.3% (10.9–11.6%) DW. Mature male unavailable for examination of adult clasper. Tail slender, whip-like, tapering gently toward sting, length 2.11 (1.94–2.22) times DW; base narrow, compressed to slightly subcircular in cross-section, width 1.38 (1.14–1.32) times height.

Snout relatively long, depressed; preoral snout length 3.28 (3.27–3.38) times mouth width, 2.36 (2.43–2.57) times internarial distance, 27.5% (27.5–28.2%) DW; direct preorbital snout length 2.18 (2.08–2.14) times interorbital length; snout to maximum disc width 41.6% (41.3–43.7%) DW; interorbital space elevated slightly; orbits very small, slightly protruded, diameter 1.60 (1.33–1.54) in spiracle length; eye length 2.64 (2.41–2.72) in spiracle length, intereye distance 7.48 (7.10–7.64) times eye length. Spiracles large, rectangular, situated dorsolaterally. Nostrils small, laterally expanded slightly, outer margin with a weak concavity, internasal distance 1.93 (1.94–2.07) in prenasal length, 3.61 (3.21–3.39) times nostril length. Nasal curtain subrectangular, broad, width 2.07 (2.08–2.28) times length; lateral margin weakly double concave, smooth edged; posterolateral apex nested within broad groove; posterior margin weakly fringed, weakly concave. Mouth arched slightly; oronasal groove shallow, extending posteriorly from posterolateral edge of mouth to chin, posterior extremity about half mouth width apart; skin on ventral surface of lower jaw moderately papillate, confined to narrow strip around lips. Mouth floor (based on paratype CSIRO H 6657–01) with 2 large, subrectangular, medial oral papillae, their height 5.5 mm, separated by about 7.5 mm; 2–3 much smaller lateral papillae, height about 2 mm; medial papillae simple, truncate distally with irregular margin, longitudinally flattened, subequal in size; outer pair located at each corner of mouth, widely separated from inner pair. Teeth small, broadly suboval to rhomboidal, in quincunx; subequal in size in upper and lower jaws; with prominent horizontal ridge and groove. Tooth rows in upper jaw of paratype CSIRO H 6657–01 about 37, in lower jaw about 45.

Gill slit margins smooth, straight; length of first gill slit 1.50 (1.33–1.61) times length of fifth, 2.43 (2.41–2.83) in mouth width; distance between first gill slits 1.81 (1.85–2.01) times internasal distance, 0.41 (0.41–0.43) times ventral head length; distance between fifth gill slits 1.28 (1.28–1.45) times internasal distance, 0.29 (0.28–0.31) in ventral head length.

SQUAMATION.— Development of dorsal denticle patches rapid and may not fit the profile of other *Himantura* species (Manjaji, 2004); all type specimens are juveniles but are at a late stage of ontogenetic development (i.e. partly conforming to stage 5); denticles distributed over entire dorsal surface of disc (including over orbital membranes and inner perimeter of spiracle posteriorly), absent from dorsal surface of most of pelvic fins; median denticle band indistinct, not strongly demarcated from lateral denticles of disc.

Suprascapular denticles small, variable in size, one of these much larger than rest (crowns 1.4–3.3 mm long in holotype); about 5 (2–3) in a single row, closely spaced, heart to seed-shaped. Secondary and tertiary denticle patches not easily distinguishable from each

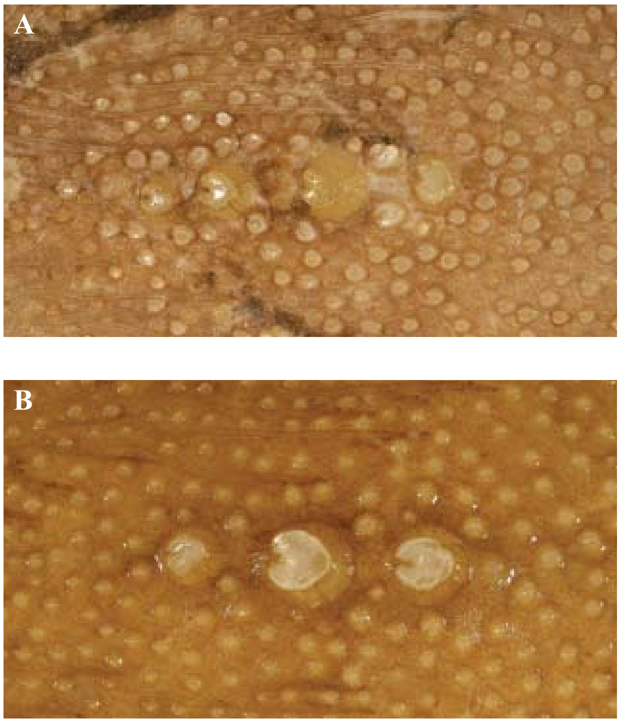


Figure 4. Scapular denticles of *Himantura dalyensis* sp. nov.: A. juvenile male holotype (CSIRO H 2503–01, 620 mm DW, preserved); B. female paratype (CSIRO H 2524–01, 450 mm DW, fresh)

Table 1. Morphometric data for the holotype of *Himantura dalyensis* sp. nov. (CSIRO H 2503–01), with ranges and means provided for measured paratypes (n=3). Measurements expressed as a percentage of disc width.

	Himantura dalyensis **sp. nov.**			
	Holotype	Paratypes		
		Min.	Max.	Mean
Disc width (mm)	620	450	517	
Total length	298.1	279.1	310.7	295.9
Disc length	101.6	100.9	105.8	103.2
Snout to pectoral-fin insertion	91.0	89.4	94.0	91.7
Disc thickness	9.4	9.1	10.7	9.7
Snout (preorbital) length	27.0	26.6	28.0	27.2
Snout (preorbital) horizontal length	25.9	24.8	25.3	25.0
Pelvic-fin (embedded) length	19.0	18.7	19.9	19.4
Width across pelvic-fin base	11.3	10.9	11.6	11.1
Greatest width across pelvic fins	22.3	19.2	24.4	21.6
Cloaca origin to tail tip	211.6	194.2	221.8	209.2
Tail width at axil of pelvic fins	5.3	5.2	5.9	5.5
Tail height at axil of pelvic fins	3.9	4.1	4.7	4.5
Pectoral-fin insertion to sting origin	29.8	33.0	35.8	34.2
Cloaca origin to sting	35.1	37.1	39.8	38.2
Tail width at base of sting	1.7	1.9	1.9	1.9
Tail height at base of sting	2.2	2.1	2.1	2.1
Sting 1 length	13.9	8.6	11.9	10.3
Sting 2 length	–	–	–	–
Snout preoral (to lower jaw) length	27.5	27.5	28.2	27.9
Mouth width	8.4	8.2	8.5	8.4
Distance between nostrils	11.7	10.7	11.4	11.1
Interorbital width	12.4	12.6	13.2	12.9
Inter-eye width	15.8	16.9	17.9	17.4
Snout to maximum width	41.6	41.3	43.7	42.5
Eye length	2.1	2.2	2.5	2.4
Orbit diameter	3.5	4.1	4.4	4.3
Spiracle length	5.6	5.9	6.5	6.2
Interspiracular width	15.8	17.0	17.7	17.4
Orbit and spiracle length	8.5	8.8	9.8	9.4
Nostril length	3.2	3.3	3.5	3.4
Snout prenasal length	22.6	22.2	22.7	22.4
Nasal curtain length	5.8	5.4	5.5	5.4
Nasal curtain width	12.1	11.5	12.3	12.0
Orbit to pectoral-fin insertion	61.4	59.2	64.2	61.8
Snout to origin of cloaca	84.8	84.9	88.8	86.7
Width 1st gill slit	3.5	3.0	3.5	3.3
Width 3rd gill slit	4.0	3.3	3.8	3.6
Width 5th gill slit	2.3	2.1	2.3	2.2
Head length	51.4	50.1	51.8	51.1
Distance between 1st gill slits	21.1	21.1	21.5	21.4
Distance between 5th gill slits	15.0	14.7	15.5	15.1
Cloaca length	5.0	4.4	5.0	4.8
Clasper postcloacal length	8.4	6.5	6.7	6.6
Clasper length from pelvic axil	4.1	2.2	2.4	2.3

other. Secondary denticles of holotype widely spaced, mainly weakly cuspid, heart-shaped to suboval; variable in size, largest across scapular region and along midline of disc and tail before sting; band along midline of disc poorly defined, narrow, mainly with cuspid denticles interspersed with slightly smaller upright, stellate-based denticles; stellate-based denticles becoming relatively more abundant laterally; both denticle types much larger than tertiary denticles; small paratype CSIRO H 2524–01 (female 450 mm DW) without cuspid denticles along midline, all denticles of central disc upright with stellate bases. Tertiary denticles minute, granular, their crowns upright, short, bluntly pointed, with broad stellate bases; much smaller and denser than secondary denticles, distributed to extremity of disc, including snout tip. On tail, cuspid denticles dense, largest along dorsal midline forward of stinging spine, extending posteriorly to below sting, interspersed with some slightly smaller, stellate-based denticles; lateral tail denticles almost exclusively short, upright, stellate-based; denticles absent from ventral tail before sting. Tail beyond sting with dense coverage of very short, upright denticles, their density similar dorsally and ventrally, slightly taller dorsally than ventrally. Ventral surface of disc naked.

MERISTICS.— Total pectoral-fin radials 169–170 (168–172, n=3); propterygium 75–76 (73–78), mesopterygium 27–28 (27–28), metapterygium 66–67 (66–68). Pelvic-fin radials, in males 1, 24 (1, 22–23, n=2), in females 1, 27 (n=1). Vertebral centra (total including 1st synarcual) 120 (120–121); monospondylous 55 (51–63); pre-sting diplospondylous 65 (56–68); post-spine diplospondylous 0 (0).

COLOUR.— Fresh specimens: dorsal surface of disc uniform pale brown to greyish brown. Ventral disc mainly white with broad, continuous, dark brown to blackish bands on the margins of each pectoral and pelvic fin; inner margins of bands irregular, flanked by small, dark blotches (most evident posteriorly); bands originating at level just forward of nostrils, narrow anteriorly, becoming slightly wider posteriorly, maximum width about equal to mouth width. Tail dark brown to blackish dorsally, white ventrally to sting; almost uniformly blackish beyond sting base.

SIZE.— Largest recorded specimen 124 cm DW taken from the Roper River (Thorburn *et al*., 2003), but usually less than 100 cm DW (n=30); size at maturity not known; one male paratype adolescent at 88 cm DW, male holotype juvenile at 62 cm DW.

DISTRIBUTION.— Mainly estuarine and freshwater, from several large rivers across northern Australia between the Fitzroy (Western Australia) and Normanby Rivers (Queensland): Ord, Fitzroy and Pentecost Rivers (WA), Daly, Roper and South Alligator Rivers (NT), and the Mitchell, Gilbert, Normanby and Wenlock Rivers (Qld) (Last & Stevens, 1994; Thorburn *et al*., 2003). Recorded from mesohaline water (less than 30 ppt) but usually less than 10 ppt (Thorburn *et al*., 2003). Two specimens figured by Compagno & Roberts (1982) from the Fly River Basin, New Guinea, may be conspecific with the Australian species.

ETYMOLOGY.— The first confirmed specimen of this ray was discovered on an expedition in 1989 to investigate the biodiversity of freshwater elasmobranchs across northern Australia (Taniuchi *et al*., 1991). One female paratype (FUMT–P10863, 474 mm DW) was collected by harpoon in the Daly River (Northern Territory) more than 80 km upstream from its mouth in a salinity of 0–2 ppt (Taniuchi & Shimizu, 1991). The epithet *dalyensis* is in recognition the major Northern Australian river where this species was first collected. Vernacular: Freshwater Whipray (Last & Stevens, 1994).

REMARKS.— *Himantura dalyensis* has been confused locally with an endemic Australian estuarine species, *Dasyatis fluviorum* (Merrick & Schmida, 1984; Herbert & Peeters, 1995), and a larger South–East Asian estuarine and coastal marine species, *H. chaophraya* (Last & Stevens, 1994; Thorburn *et al*., 2003). *Himantura chaophraya* reaches a huge size and one of the paratypes, collected in the Chao Phraya River (Thailand), measured 192 cm DW; other Thai specimens have been confirmed to at least 242 kg but reported to about 940 kg in weight (Monkolprasit & Roberts, 1990). *Himantura dalyensis* is a much smaller ray with the largest known specimen only 124 cm DW.

Older names are available for *H. chaophraya*. Bleeker (1852) described and figured *Trygon polylepis* based on a juvenile whipray (301 mm DW) from Java, Indonesia. This specimen, which presumably was not examined as it was ignored in Monkolprasit & Roberts' (1990) description of *H. chaophraya*, is conspecific with their species i.e. *Himantura polylepis* is a senior synonym of *H. chaophraya*.

Himantura polylepis differs from *H. dalyensis* in being a larger species, and in having a less truncate anterior disc margin, more acute snout (angle 112–117° vs. 120–121° in *H. dalyensis*) with a relatively larger apical lobe. Based on morphometric data for specimens of *H. polylepis* from India, Thailand and Borneo (Manjaji, 2004), the species also differ in the following proportions: preoral snout length 3.75–4.34 vs. 3.27–3.38 times mouth width in *H. dalyensis*, 2.78–3.22 vs. 2.36–2.57 times internarial distance; preorbital snout length 2.32–2.88 vs. 2.08–2.18 times interorbital length, orbit diameter 49–61% vs. 62–75% of spiracle length, internasal distance 0.36–0.42 vs. 48–52% of prenasal length, 2.69–3.34 vs. 3.21–3.61 times nostril length; distance between first gill slits 37–40% vs. 41–43% of ventral head length, a broader dark ventral margin (about 1.5 times mouth width or more vs. usually subequal to mouth width). There also appear to be differences in the squamation of the tail beyond the sting spine that need to be described. The vertebral counts are possibly slightly higher for *H. dalyensis* (total vertebral centra including 1st synarcual 120–121, n=4 vs. 117, n=1), and although the total pectoral-fin radial counts are similar for the two species 168–172, n=4 vs. 167–168, n=2), the ratio of propterygial radials to mesopterygial radials is much higher in *H. dalyensis* (number of propterygial radials 2.7–2.9 vs. 2.1–2.2 times the number of mesopterygial radials).

Molecular differences have been observed between the two species. Manjaji (2004) found minor differences in the Cytochrome B and 16 S genes.

Comparative material.
Himantura polylepis: 14 specimens: RMNH T 7452, juvenile male (holotype) 301 mm DW, Java, Indonesia; CSIRO H 5283–01 juvenile male 372 mm DW, SMEC KTG2–23397, juvenile male, 524 mm DW, SMEC KTG3–20497, female 545 mm DW, SMEC KTG7–21096, neonatal male 363 mm DW, IPMB MMKG1, juvenile male 515 mm DW, Kinabatangan River, Sabah, Malaysia; MTUF 30233, female 494 mm DW, Rajmehar, India; MTUF 30203, juvenile male 450 mm DW, Bhagalpur, India; MTUF 30204, juvenile male 460 mm DW, MTUF 30205 and MTUF 30206, female 466 mm DW and juvenile male 480 mm DW, Chao Phraya River, Thailand; RMNH 3365 (photo only), unspecified locality; SMEC BFT1–697, female 605 mm TL, Padas River, Sabah, Malaysia; SMEC SKN10–15697, adolescent male, 1210 mm DW, Sandakan, Sabah, Malaysia.

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Himantura leoparda sp. nov., a new whipray (Myliobatoidei: Dasyatidae) from the Indo–Pacific

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ABSTRACT.— A new whipray belonging to the 'uarnak' species complex is described based on material from the tropical Indo–West Pacific. *Himantura leoparda* sp. nov., which occurs on the continental shelf from southern Africa to Papua New Guinea, including northern Australia, has been confused in particular with two similar whiprays, *H. uarnak* and *H. undulata*, both of which are spotted as juveniles and variably spotted or reticulated as adults. *Himantura leoparda* can be distinguished from its relatives by the characteristic leopard-like rings on the dorsal surface of adults. It also differs subtly in squamation and body shape, as well as having a unique colour development within the complex.

Key words. Dasyatidae – *Himantura leoparda* – whipray – new species – Indo–Pacific

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INTRODUCTION

Manjaji (2004) divided the genus *Himantura* into a subgroup of mainly spotted, ocellated or reticulated whiprays called the 'uarnak' species complex. These species, which have been traditionally confused in the literature, are mainly large stingrays with the adults of most species exceeding 1 m in disc width. The disc is rhomboidal (rarely suboval) with an angular snout tip, rather angular apices, and a long, slender, whip-like tail which is subcircular in cross-section. Juveniles usually have a strongly banded tail, and the teeth are not sexually dimorphic with cusps of mature males not more acute and elongate than in females. The group is thought to contain six valid nominal species, *Himantura fai* Jordan & Seale, 1906, *H. gerrardi* (Gray, 1851), *H. jenkinsii* (Annandale, 1909), *H. toshi* Whitley, 1939, *H. uarnak* (Forsskål, 1775), and *H. undulata* (Bleeker, 1852), and four undescribed species. One of these un-named species, *Himantura* sp. A (*sensu* Manjaji, 2004), is formally described below.

METHODS

Methodology, which mostly follows standards developed for the senior author's doctoral dissertation (Manjaji, 2004), are based on modifications from Compagno & Heemstra (1984) and Last & Stevens (1994), as outlined by Last *et al*. (2006), and include some new descriptive features (i.e. morphology of the disc and its attributes, and stages of squamation). Comparative data for other *Himantura* species are based on information and material from Manjaji (2004). The only non-standard horizontal measurement is the distance from the snout tip along the midline of the disc to a perpendicular line joining the front of the eyes. The midscapular denticle was excluded from the measurement of disc thickness.

Measurements were taken in millimetres (mm) as direct lengths (shortest point-to-point distance). Tooth rows were counted as diagonal rows across the tooth band beginning at one corner of the mouth (Fischer & Hureau, 1987), as well as vertically (Compagno, 1999). Corners of the mouth usually had to be slit so that tooth rows were fully visible for counting. Meristic data for 5 paratypes (CSIRO H 635–02, CSIRO H 3863–01, CSIRO H 3863–02, CSIRO H 4131–01 and CSIRO H 5478–01) were obtained from radiographs (the holotype was too large for the radiographing equipment). Counts follow Compagno & Roberts (1982), with some minor modifications: the first enlarged anterior element of the pelvic fin (with 2–3 distal segments fused at their bases) is counted as one; first synarcual centra were included in vertebral counts (usually contains 3–5 centra) as vertebrae of juveniles radiographed were not obscured by mid-dorsal denticles; intermediate pectoral-fin radial elements were assigned to a pterygial unit based on the relative level of overlap with each of the adjacent units; and first distal propterygial and metapterygial elements were considered to form part of the main skeleton and were not incorporated into counts; the notochord of the tail was excluded from counts. Morphometric data, based on the holotype and 7 post-natal paratypes (1 specimen exceeding 500 mm DW, 6 specimens less than 500 mm DW), are presented in Table 1 and expressed as proportions of disc width (DW). Members of the genus *Himantura* have developmental stages of the dorsal denticles that are extremely useful for distinguishing species (Manjaji, 2004; Last *et al*., 2006) so these were applied to the new species. Type specimens are deposited in the following repositories (institutional abbreviations in parentheses) as follows: California Academy of Sciences, San Francisco (CAS), Australian National Fish Collection, Commonwealth Scientific and Industrial Research Organisation, Marine & Atmospheric Research, Hobart (CSIRO), the Museum and Art Gallery of the Northern Territory (NTM), and the Borneo Marine Research Institute Fish Collection, Kota Kinabalu (IPMB). Institutional acronyms follow Leviton *et al*. (1985).

Himantura leoparda sp. nov.

Figs 1–4, 5a; Table 1

Dasyatis uarnak (not Forsskål): Wallace, 1967: p 44 (description, morphometrics, illustration, misidentification).

Himantura fava (not Annandale): Compagno & Roberts, 1982: pp 323, 336 (listed, brief description, distribution, misidentification in part).

Himantura sp. 1: Gloerfelt-Tarp & Kailola 1984: p 38 (brief description, illustrated, misidentification).

Himantura uarnak (not Forsskål): Compagno, 1986: p 139, fig. 30.10 (brief description, illustrations, misidentification in part); Compagno *et al*., 1989: p 108 (misidentification in part).

Himantura undulata (not Bleeker): Last & Stevens, 1994: p 408 (description, illustrated, misidentification); Last & Compagno, 1999: p 1492 (description, illustration, after Last & Stevens, 1994, misidentification); White *et al*., 2006: pp 256, 257, fig. (misidentification).

Holotype. CSIRO H 2903–01, female 1105 mm DW, north-west of Weipa, Gulf of Carpentaria, Queensland, 12°08′ S, 139°58′ E, 46 m, 21 Nov 1991.

Paratypes. 11 specimens. CAS 213280, female 365 mm DW, south-east of Kau Sarmroiyord, Thailand, 12°03′ N, 100°30′ E, ca. 30 m, 11 Oct 1960; CSIRO H 635–02, female 200 mm DW, north of Arnhem Land, Arafura Sea, Northern Territory, ca. 10°S, 134°E, 15 Aug 1986; CSIRO H 3863–01, female 342 mm DW, CSIRO H 3863–02, juvenile male 338 mm DW, North Channel, east of Cape York Peninsula, Queensland, 11°39′ S, 143°26′ E, 37 m, 08 Apr 1994; CSIRO H 3903–02 (only claspers retained), adult male (DW unknown), west of Weipa, Gulf of Carpentaria, Queensland, 12°32′ S, 141°29′ E, 21 m, 02 Mar 1995; CSIRO H 4131–01, female 368 mm DW, Novotas market, Manila, Philippines, ca. 13°55′ N, 120°42′ E, 05 Oct 1995; CSIRO H 5284–05 (dissected; jaws, denticle band and pelvic girdle retained), female 805 mm DW, Kota Kinabalu fish market, Sabah, Malaysia, ca. 05°58′ N, 116°04′ E, Feb 1999; CSIRO H 5478–01, female 447 mm DW, Kota Kinabalu fish market, Sabah, Malaysia, ca. 05°58′ N, 116°04′ E, 04 May 1999; CSIRO H 5585–02 (only right clasper retained), adult male (DW unknown), off Beruwala, Sri Lanka, ca. 06°29′ S, 79°59′ E, 26 Nov 1995; NTM S 10765–002, female 260 mm DW, off south Java, Indonesia, 08°03′ S 110°05′ E, 50–70 m depth, Mar 1981; IPMB 38.01.04, female 660 mm DW, Kota Kinabalu fish market, Sabah, Malaysia, ca. 05°58′ N, 116°04′ E, 20 May 1999.

DIAGNOSIS.— A species of *Himantura* distinguished by a combination of the following features: disc rhomboidal; preorbital snout moderately long, with a distinct apical lobe; lateral apices moderately angular to narrowly rounded; orbits moderately large, protruded slightly; dorsal surface entirely covered with moderately large dark brown polygonal spots in young, large (>550 mm DW) specimens with thick, dark brown irregular rings (often incomplete, leopard-like ‘spots’); tail of young with dark spots on each dorsolateral surface between base and sting; tail banded behind sting, with alternating dark and pale rings dorsally, uniformly pale ventrally. Primary denticle band forming a single row of enlarged, widely spaced, narrow, heart-shaped denticles; two prominent broad heart-shaped suprascapular denticles, preceded and followed by up to 9 and 5 smaller primary denticles, respectively; pectoral-fin radials 148–158; vertebral centra (excluding synarcual) 117–123; including synarcual 120–126.

DESCRIPTION.— Disc rhomboidal, width 1.11 in holotype (1.00–1.16 in paratypes) times length, much broader in adults than in neonates; robust, raised prominently on mid-scapular region, maximum thickness 13.6 (9.0–12.7)% disc width (DW); snout with a distinct apical lobe, angle 110° (101–120°); anterior margins of disc double convex, lateral apices weakly angular to narrowly rounded; posterior margin broadly convex, free rear tip narrowly rounded. Pelvic fins moderately elongate, length 18.1 (17.1–19.0)% DW; width across base 10.8 (10.8–13.4)% DW. Clasper of adult male (CSIRO H 5585–02) long, stout, subcylindrical; dorsal and ventral surfaces broadly convex, concave ventrally in lateral view; lining of pseudopera smooth; hypopyle moderately long, about half of clasper length on its outer margin, prominent notch anteriorly. Tail missing in holotype; slender, whip-like, tapering gently toward sting in paratypes, length 2.5–3.8 times DW; narrow, subcircular in cross-section at base, width 1.15 (1.14–1.31) times height.

Snout relatively long, angular, depressed; preoral snout length 3.26 (2.79–3.30) times mouth width, 2.66 (2.33–2.69) times internarial distance, 23.3 (21.5–27.6)% DW; direct preorbital snout length 1.71 (1.25–1.73) times

A

B

Figure 1. *Himantura leoparda* sp. nov., female holotype (CSIRO H 2903–01, 1105 mm DW, preserved): A. dorsal view; B. ventral view.

Table 1. Morphometric data for the holotype of *Himantura leoparda* sp. nov. (CSIRO H 2903–01), a large (660 mm DW) paratype, and ranges and means provided for small (<500 mm DW) paratypes (n=6). Measurements expressed as a percentage of disc width.

	Holotype	Paratypes			
		large	small		
			Min.	Max.	Mean
Disc width (mm)	1105	660	200	447	
Total length	–	325.2	413.7	466.5	431.6
Disc length	90.1	86.1	89.9	100.8	94.2
Snout to pectoral-fin insertion	81.4	78.8	80.1	92.0	85.0
Disc thickness	13.6	10.6	9.0	12.7	11.4
Snout (preorbital) length	22.5	21.8	21.4	26.8	23.8
Snout (preorbital) horizontal length	21.5	20.3	20.4	24.1	21.9
Pelvic-fin (embedded) length	18.1	17.7	17.1	19.0	18.0
Width across pelvic-fin base	10.8	10.8	11.0	13.4	11.9
Greatest width across pelvic fins	22.6	32.3	19.5	33.6	24.8
Cloaca origin to tail tip	–	253.2	331.9	376.7	348.1
Tail width at axil of pelvic fins	5.3	5.3	6.2	7.9	6.8
Tail height at axil of pelvic fins	4.6	4.6	5.1	6.0	5.4
Pectoral-fin insertion to sting origin	–	34.1	39.1	41.5	40.4
Cloaca origin to sting	–	40.6	41.9	44.3	43.0
Tail width at base of sting	–	1.7	2.2	2.4	2.3
Tail height at base of sting	–	1.9	2.5	2.8	2.6
Sting 1 length	–	–	12.4	15.4	14.3
Sting 2 length	–	–	–	–	–
Snout preoral (to lower jaw) length	23.3	21.5	22.6	27.6	24.4
Mouth width	7.2	6.5	7.2	9.9	8.0
Distance between nostrils	8.8	8.6	9.2	11.8	9.7
Interorbital width	13.1	12.6	13.1	21.5	16.5
Inter-eye width	16.3	16.8	18.1	31.1	23.2
Snout to maximum width	38.0	38.0	37.9	52.1	43.7
Eye length	1.8	1.9	2.6	4.6	3.3
Orbit diameter	4.0	3.5	4.6	7.0	5.2
Spiracle length	5.6	5.6	6.6	12.1	9.1
Interspiracular width	15.8	15.2	17.5	25.8	21.0
Orbit and spiracle length	8.2	7.7	9.6	14.3	11.1
Nostril length	3.8	4.1	3.8	4.9	4.2
Snout prenasal length	18.3	16.4	16.6	21.1	18.5
Nasal curtain length	5.6	5.4	5.5	6.6	6.0
Nasal curtain width	10.8	10.2	10.2	14.0	11.3
Orbit to pectoral-fin insertion	56.6	54.5	54.6	62.5	59.2
Snout to origin of cloaca	75.6	72.0	76.3	89.8	81.2
Width 1st gill slit	3.1	2.8	2.8	3.3	3.0
Width 3rd gill slit	3.3	3.0	2.9	3.3	3.1
Width 5th gill slit	2.1	2.1	1.9	2.3	2.1
Head length	43.7	42.1	43.5	54.5	47.4
Distance between 1st gill slits	18.3	17.1	18.3	24.4	20.3
Distance between 5th gill slits	12.2	10.8	11.9	15.0	12.8
Cloaca length	6.3	4.3	3.7	5.4	4.7
Clasper postcloacal length	–	–	9.5	9.5	9.5
Clasper length from pelvic axil	–	–	4.6	4.6	4.6

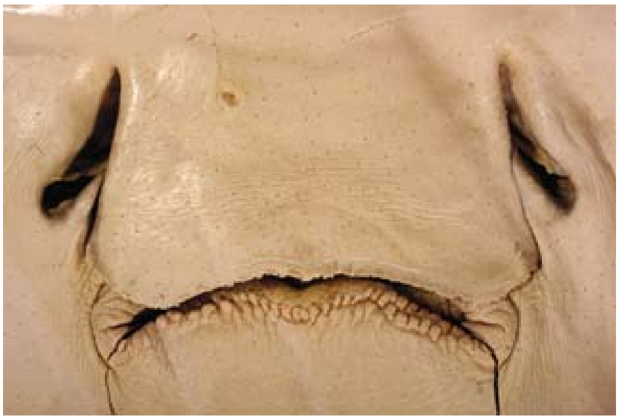

Figure 2. Oronasal region of *Himantura leoparda* sp. nov., female holotype (CSIRO H 2903–01, 1105 mm DW, preserved).

interorbital length; snout to maximum disc width 38.0 (37.9–52.1)% DW, ratio highest in small individuals; interorbital space slightly convex; eye moderately large, length 31.1 (28.0–53.4)% spiracle length; orbits protruded slightly, diameter 70.2 (49.1–79.8)% spiracle length, interorbital distance 3.31 (2.48–3.63) times orbit. Spiracles large, rectangular, situated dorsolaterally.

Nostrils moderately large, expanded laterally; outer margin with a weak double concavity, length 2.30 (2.11–2.49) in internasal distance; internasal distance 2.08 (1.79–2.11) of prenasal length. Nasal curtain subrectangular, relatively broad, width 1.92 (1.76–2.13) times length; lateral margin weakly double concave, smooth edged; posterolateral apex nested within broad groove; posterior margin weakly fringed, weakly concave.

Mouth moderately arched; prominent knob at symphysis of upper jaw, retractable into deep notch at symphysis of lower jaw; oronasal groove shallow, extending posteriorly from posterolateral edge of mouth to chin, posterior extremity about half mouth width apart; skin on ventral surface of lower jaw moderately papillose, not confined to narrow strip around lips. Mouth floor with 4 short papillae; medial pair simple, flattened, rounded distally, subequal in size (almost twice size of outer pair), located near to each other; single outer papilla located near each corner of mouth, widely separated from inner pair. Teeth small, subequal in upper and lower jaws; cone-shaped with blunt peak, with prominent horizontal groove; in about 59 vertical rows in upper jaw (CSIRO H 5478–01); given as about 56 diagonal rows by Manjaji (2004).

Gill slit margins smooth, strongly arched posteriorly; length of first gill slit 1.47 (1.32–1.51) times length of fifth, 2.29 (2.32–3.02) in mouth width; distance between first gill slits 2.08 (1.98–2.18) times internasal distance, 0.42 (0.41–0.45) of ventral head length; distance between fifth gill slits 1.38 (1.25–1.40) times internasal distance, 0.28 (0.25–0.28) in ventral head length.

SQUAMATION.— Ontogenetic stages 1 and 4 present; stages 2, 3, 5 and 6 not applicable. Denticle development relatively slow, specimens still sparsely covered with denticles at ca. 500 mm DW.

Stage 0: Disc entirely smooth at birth (ca. 200 mm DW); a few minute denticles above the first synarcual appearing soon after.

Stages 1 and 4: At ca. 330 mm DW, denticles above first synarcual and scapular becoming more exposed, forming primary, median denticle band and suprascapular denticles; development of primary band coinciding with initial development of continuous secondary denticle band along midline of trunk.

Primary band developing as a single row of enlarged, widely spaced, narrow, heart-shaped denticles; comprising up to 9 denticles anterior to, and 5 smaller ones posterior to, the two suprascapular denticles; space between each denticle in the row initially wider (2–3 times) than length of each denticle. Suprascapular denticle broad, heart-shaped with convex crowns (length 4.6–5.3 mm; n=5).

Secondary denticle band narrow, extending from interorbital to tail base; band with weakly defined margin. Denticles uniform, flat, narrow heart-shaped, widely spaced (separated by about 1–3 denticle lengths), gradually decreasing in size and number towards band margin.

At late stage 4, denticles fully exposed, still developing; band subrectangular along trunk; commencing anteriorly just forward of orbits, tapering gradually posteriorly; forming a narrow band at tail base before continuing onto tail; band margin well-defined; single elongate stinging

Figure 3. Scapular denticles of *Himantura leoparda* sp. nov., female holotype (CSIRO H 2903–01, 1105 mm DW, preserved).

Figure 4. Tail of *Himantura leoparda* sp. nov. female paratype (CSIRO H 4131–01, 368 mm DW): A. dorsal, B. lateral, and C. ventral views.

spine present in all specimens examined. Holotype with one main, broad heart-shaped mid-scapular thorn (width 4.7 mm), widely separated from two slightly smaller thorns (one before and one after main thorn); multiple row of much smaller thornlets preceding mid-scapular thorns; similar enlarged thornlets along disc midline posteriorly and onto tail; main band on disc strongly converging to tail base; small widely spaced denticles external to main band on outer disc.

MERISTICS.— Holotype not radiographed because specimen too large for radiography equipment, and tail removed. Total pectoral-fin radials (for paratypes) 148–158 (n=5); propterygium 61–65, mesopterygium 20–23, metapterygium 68–74. Pelvic-fin radials difficult to count, possibly 21–28 (n=4). Vertebral centra (excluding synarcual) 117–123, (including synarcual) 120–126 (n=4); monospondylous (including 2nd synarcual) 52–55 (n=5), prespine diplospondylous 65–68 (n=4); and postspine diplospondylous 0 (n=4).

COLOUR.— When fresh: Disc covered with moderately large, dark brown polygonal spots in small juveniles; spots on body and pre-sting tail becoming hollow with growth of specimen. Late juvenile, adolescent and adult specimens (>550 mm DW) with thick, dark brown, irregular rings (often incomplete) dorsally; central portion of each ring yellowish (rings 'leopard-like'); spots and rings largest over middle of trunk, gradually decreasing towards disc edge. Ventral disc surface uniformly pale. Tail of juveniles with a row of dark spots (similar in size to those of disc) on each dorsolateral surface from its base to its sting; uniformly pale ventrally before sting; entirely covered with narrow, white and black bands beyond sting; width of bands subequal near sting base, dark bands relatively wider (almost twice width of pale rings) towards tail tip. Tail of large juveniles and adults with fine, dark brown reticulations on a pale (whitish) background.

SIZE.— Birth size about 200 mm DW (CSIRO H 635–02 with an umbilical scar). Length at first maturity of males 700–800 mm DW (Manjaji, 2004). Females attain at least 1105 mm DW (i.e. holotype CSIRO H 2903–01).

DISTRIBUTION.— Widespread in the Indo–West Pacific. Reported by Manjaji (2004) from off India (Lower Bengal), Africa (Natal coast), New Guinea, Indonesia, Malaysia and tropical Australia (inner continental shelf); also Sri Lanka, Thailand and the Philippines (this study). Off northern Australia from Coral Bay (Western Australia) to Cape York (Queensland). Mainly inshore and coastal but on the continental shelf to at least 70 m depth.

ETYMOLOGY.— Derived from the Latin *leoparda* after the leopard-like markings on the dorsal surface of large specimens (>550 mm DW). Vernacular: Leopard Whipray (Last & Stevens, 1994).

COMPARISONS.— *Himantura leoparda* is closely related to *H. uarnak* and *H. undulata*. All three have a similar overall disc shape and a dorsal disc pattern consisting of large spots in juveniles that form a complex pattern of spots, reticulations and/or ocelli in adults. However, *H. leoparda* is unique in its squamation (evident in the arrangement of the midscapular denticles), and in having leopard-like markings on the dorsal surface of large specimens and adults. Its birth size (ca 200 mm DW) is also smallest of the three species (others ca 260 mm DW; Manjaji, 2004). Denticle development in *H. leoparda* is also slower than the other species. Newborns are either totally smooth dorsally, or have only a few scapular

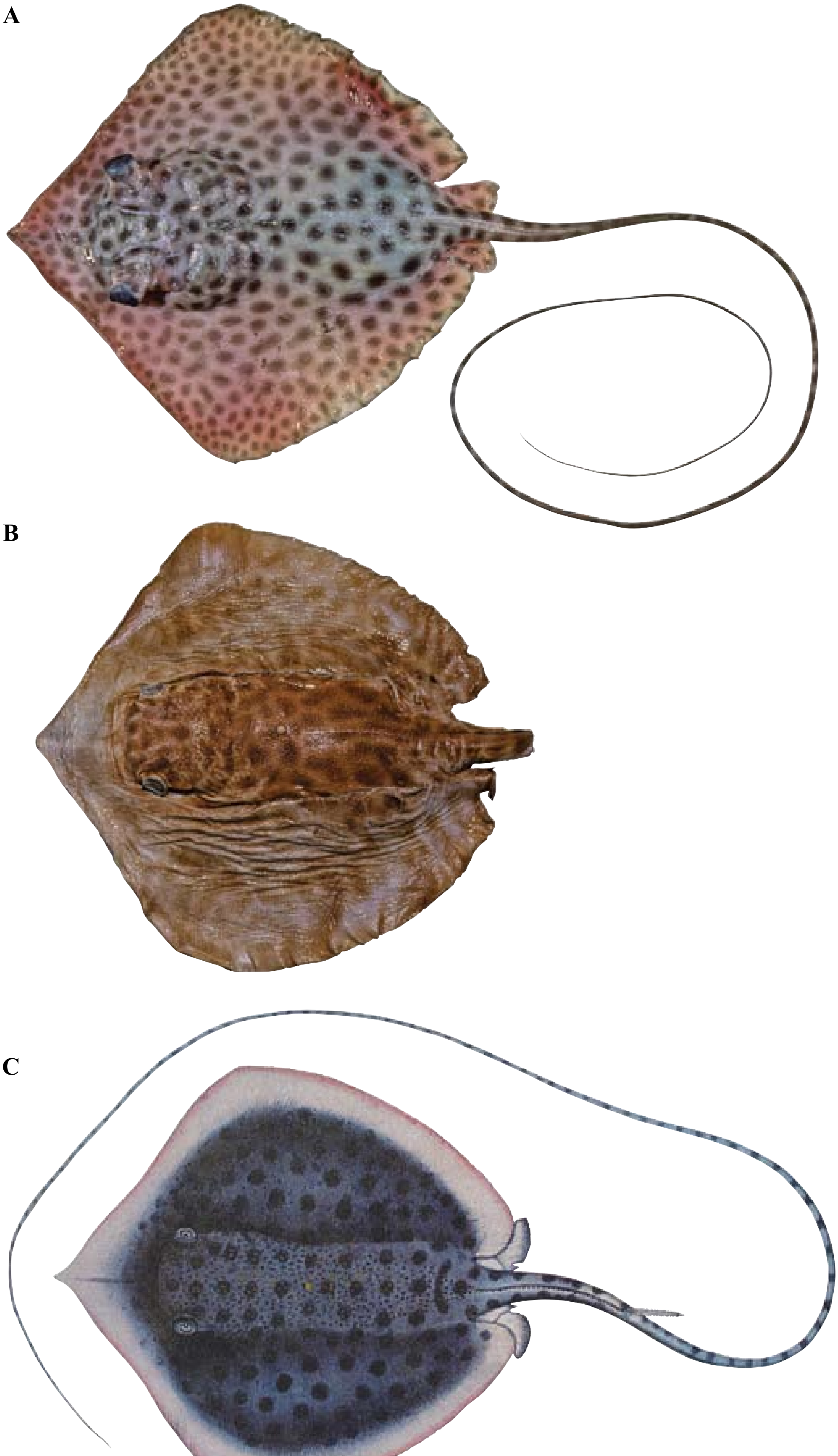

Figure 5. Dorsal view of: A. *Himantura leoparda* sp. nov., early juvenile paratype (CSIRO H 635–02, female 200 mm DW, preserved); B. *Trygon undulata* Bleeker, syntype (BMNH 1867.11.28.156, female 264 mm DW, preserved); C. *Trygon russellii* (original illustration by Gray).

denticles (mostly still embedded in skin), and specimens of 500 mm DW are still usually sparsely covered with denticles. At the same size in *H. uarnak* and *H. undulata*, the main denticle band is well developed and the primary denticles are inconspicuous. The midscapular denticles of *H. leoparda* consist of mainly two, small broad heart-shaped thorns that are preceded anteriorly by a row of smaller, widely spaced, narrow heart-shaped denticles of the primary denticle band, and followed by a row of smaller denticles posteriorly. *Himantura uarnak* has small black spots or fine reticulations in adults, whereas adults of *H. undulata* have striking pattern of course reticulations and rings.

REMARKS.— This group of similarly patterned (dark spotted and/or reticulated) whiprays have been often confused in the literature. Growth stages within species vary markedly in colour pattern and this has partly led to the confusion. Multiple scientific names for them exist. They have been inadequately described and the types are often damaged or lost, so the nomenclature is complicated. Hence, most authors have referred only to a single valid species *H. uarnak*, although recent molecular work supports their non-conspecificity (Manjaji, 2004).

Himantura leoparda has been described, either in part or entirely, as one of the following similarly patterned nominal taxa, i.e. *Himantura uarnak*, *H. undulata* and *H. fava* (Annandale). *Himantura leoparda* was described and illustrated in considerable detail and erroneously identified as *H. undulata* by Last & Stevens (1994), and later by Last & Compagno (1999). *Himantura undulata* is now considered by Manjaji (2004) to be a senior synonym of *H. fava*, demonstrating the confusion regarding the taxonomy of patterned whiprays. In the absence of an adequate developmental series of each species, the epithet *undulata* was wrongly applied to *H. leoparda*. Since the publication of Last & Stevens (1994) and Last & Compagno (1999), additional specimens representing the different developmental stages of these species have been obtained. This new material has enabled us to describe the ontogenetic character changes in each species, particularly regarding gradients in squamation and colour pattern. Apart from the typical 'leopard' form, two other regional morphs were identified by Manjaji (2004) and these will be treated in another study.

With the plethora of stingray names available it seems strange that no pre-existing name exists for *H. leoparda*. Manjaji (2004) suggested that *Trygon russellii* Gray, 1834 may be an available name for this species but was unsuccessful in procuring a copy of Gray's manuscript to confirm or refute this possibility. We have since obtained a high quality colour plate of Gray's specimens (Plate 100, see Fig. 5c) and can confirm that his species belongs to the 'uarnak' subgroup; based on available evidence it is closest to *H. undulata*. Unfortunately, the figure was not accompanied by descriptive text so there is no indication of specimen size (Fowler, 1941; Eschmeyer, 2008). However, the species figured resembles the juvenile of *H. undulata* (probably about the same size as a syntype, BMNH 1867.1.28.156, ca 264 mm DW, Fig. 5b) in possessing an acutely angular disc, similar spot size and distribution (although less regular in shape), a single scapular thorn, and a relatively well-formed secondary denticle band. In *H. leoparda* of similar size, the disc is equally angular with similar spots but more than one, enlarged scapular denticle is present (usually several in a median row) and the secondary band has not yet formed. Also, Gray's figure indicates a whitish outer dorsal disc margin (without spots) in *T. russellii* but *H. leoparda* is strongly spotted in this region. A syntype of *H. undulata* has paler markings along the disc margin but this could be related to preservation. Larger specimens of both species have a less angular snout, broader disc and better developed denticles.

Comparative material.
Trygon undulata: BMNH 1867.11.28.156 (syntype), female 264 mm DW, Java, Indonesia.

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Himantura astra sp. nov., a new whipray (Myliobatoidei: Dasyatidae) from northern Australia

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ABSTRACT.— A new whipray, *Himantura astra* sp. nov., is described based on material from the Arafura Sea and the Gulf of Carpentaria. It has been confused in the literature with *H. toshi*, a closely related, coastal whipray. *Himantura astra* has a strong colour pattern consisting of small, variably distributed black spots surrounded by pale, diffuse-edged white spots in adults, and with widely spaced black spots in juveniles. *Himantura toshi*, which occurs in shallow water and estuaries of northern and eastern Australia, is plain brownish in the young but often with small white spots near the edge of the disc in adults. These species, which are both medium-sized whiprays with a disc width less than 1 m, also differ in squamation and the coloration of the tail of adults.

Key words. Dasyatidae – *Himantura astra – Himantura toshi* – whipray – new species – Indo–Pacific

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INTRODUCTION

Manjaji (2004) has suggested that the genus *Himantura* consists of several subgroups. One of these, a subgroup of mainly spotted, ocellated or reticulated whiprays, was referred to as the 'uarnak' species complex. The group contains 7 valid nominal species, *Himantura fai* Jordan & Seale, 1906, *H. gerrardi* (Gray, 1851), *H. jenkinsii* (Annandale, 1909), *H. leoparda* Manjaji-Matsumoto & Last, 2008, *H. toshi* Whitley, 1939, *H. uarnak* (Forsskål, 1775) and *H. undulata* (Bleeker, 1852), and 3 undescribed species. These species have been frequently confused in the literature.

A whipray provisionally identified by Last & Stevens (1994) as *Himantura* sp. A was considered by Manjaji (2004) to be a synonym of *H. toshi*. However, recent information gained from additional material and a close inspection of the holotype of *H. toshi*, has revealed that two morphologically distinct species exist.

Australian whiprays recently identified as *Himantura toshi* have been confused with juvenile growth stages of *H. uarnak* (Forsskål) by Whitley (1940) and others (e.g. Marshall, 1966; Sainsbury *et al*., 1985; Grant, 1987, 1997). The holotype of *H. toshi* (AMS IA39) designated by Whitley (1939) was apparently initially obtained by Stead (1907) and identified as *Dasyatis uarnak*. Stead received the specimen from the Clarence River estuary, northern New South Wales, in November 1903. He noted that this species occurred commonly and widely along the Queensland coast and, suspecting that it might be distinct from *H. uarnak*, suggested a new common name 'banded tailed stingray'; the tail banding was considered to be more pronounced than in other forms of *H. uarnak*. However, contrary to claims by Manjaji (2004), he made no mention of any spotting on the dorsal surface of the disc.

In the following paper we describe a second Australian whipray with a close affinity to *H. toshi* and attempt to resolve nomenclatural issues arising.

METHODS

To avoid confusion of the new species with other potentially similar but presently unrecognised species of *Himantura*, the type series was selected from material collected in the Arafura Sea and the Gulf of Carpentaria. Morphological methods, which follow proposed standards developed by Manjaji (2004), are based on modifications of Compagno & Heemstra (1984) and Last & Stevens (1994). These have been outlined by Last *et al*. (2006) and include some new descriptive features (i.e. morphology of the disc and its attributes, and squamation). The only non-standard measurement is the horizontal snout length which is the distance along the longitudinal axis from the snout tip to a perpendicular line joining the eyes. Also, the thickness of the mid-scapular denticle was excluded in the measurement of disc thickness. Measurements were taken in millimetres (mm) as direct lengths (shortest point-to-point distance). Morphometric data, based on the holotype (CSIRO H 3377–01) and 14 paratypes (CSIRO CA 2406, CSIRO CA 4271, CSIRO H 312–01, CSIRO H 959–02, CSIRO H 959–04, CSIRO H 1222–01, CSIRO H 3329–01, CSIRO H 3352–01, CSIRO H 3369–01, CSIRO H 3380–02, CSIRO H 3387–03, CSIRO T 698, CSIRO T 699 and CSIRO T 700), are presented in Table 1 and data are expressed as proportions of disc width (DW).

Meristic data for the holotype and 5 paratypes (CSIRO H 38–01, CSIRO H 312–01, CSIRO H 959–01, CSIRO H 959–02 and CSIRO H 959–04) of the new species were obtained from radiographs. Counts follow Compagno & Roberts (1982) with some minor modifications: the first enlarged anterior element of the pelvic fin (with 2–4 distal segments fused at their bases) is counted as one; first synarcual centra are not included in vertebral counts (usually contains 1–2 centra and are often obscured by mid-dorsal denticles); intermediate pectoral-fin radial elements were assigned to a pterygial unit based on the relative level of overlap with each of the adjacent units; and first distal propterygial and metapterygial elements were considered to form part of the main skeleton and were not incorporated into counts; the notochord of the tail was also excluded from counts. Tooth rows for both upper and lower jaws (CSIRO H 959–02, CSIRO H 959–04, CSIRO T 699) were counted from angular rows across the tooth band beginning at one corner of the mouth (Fischer & Hureau, 1987), as well as vertical rows (Compagno, 1999). Corners of the mouth usually had to be slit so tooth rows were fully visible for counting.

Members of *Himantura* have developmental stages of the dorsal denticles that are extremely useful for distinguishing species (Manjaji, 2004; Last *et al*., 2006). The sequence of development usually varies between species and few species display all possible stages of development. Specimens referred to in this paper are deposited in the Australian National Fish Collection, Commonwealth Scientific and Industrial Research Organisation, Marine & Atmospheric Research, Hobart (CSIRO), and the fish collections of the Australian Museum, Sydney (AMS), Queensland Museum, Brisbane (QM) and the Western Australian Museum, Perth (WAM); their registration numbers are prefixed with these acronyms. Institutional acronyms follow Leviton *et al*. (1985).

Himantura astra sp. nov.

Figs 1–5; Table 1

Himantura uarnak (not Forsskål): Marshall, 1966: pl. 2(1) (listed, 300 mm DW); Sainsbury *et al*., 1985: p 51 (figured, 230 mm DW); Grant, 1987: p 45 (figured, 300 mm DW); Grant, 1997: p 75, pl. 27 (330 mm DW) (misidentifications).

Himantura toshi (not Whitley): Last & Stevens, 1994: p 405, fig. 40.14, pl. 68; Last & Compagno, 1999: p 1504 (figured); Daley *et al*. 2002: p 41 (figured); White *et al*. 2006: pp 250, 251, fig (misidentifications).

Holotype. CSIRO H 3377–01, adult male 589 mm DW, Gulf of Carpentaria, Queensland, 13°02′ S, 138°51′ E, 55 m, 07 Feb 1993.

Paratypes. 37 specimens. CSIRO CA 2406, female 263 mm DW, Gulf of Carpentaria, north of Groote Eylandt, Northern Territory, ca. 13° S, 136° E, 09 Jul 1981; CSIRO CA 4271, female 223 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, 09°50′ S, 136°15′ E, 60 m, 28 Nov 1982; CSIRO H 38–01, juvenile male 363 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, 09°47′ S, 136°20′ E, 50 m, 22 Feb 1982; CSIRO H 312–01, female 353 mm DW, CSIRO H 322–01, female 542 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, 09°47′ S, 136°23′ E, 50 m, 22 Feb 1982; CSIRO H 635–01, juvenile male 157 mm DW, CSIRO H 635–03, juvenile male 178 mm DW, CSIRO H 635–04, female 164 mm DW, Arafura Sea, north of Arnhem Land, Northern Territory, ca. 10° S, 134° E, 15 Aug 1986; CSIRO H 959–01, female 401 mm DW, CSIRO H 959–02, female 367 mm DW, CSIRO H 959–04, juvenile male 347 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, ca. 10° S, 137° E, Mar 1987; CSIRO H 964–01, female 348 mm DW, CSIRO H 964–02, female 422 mm DW, northern Australia; CSIRO H 1222–01, adult male 507 mm DW, CSIRO H 1222–02, female 600 mm DW, Gulf of Carpentaria, Albatross Bay, Queensland, 12°39′ S, 141°33′ E, 16 m, 26 Nov 1987; CSIRO H 3322–02, juvenile male 426 mm DW, Gulf of Carpentaria, west of Weipa, Queensland, 12°35′ S, 141°00′ E, 41 m, 22 Jan 1993; CSIRO H 3329–01, female 482 mm DW, Gulf of Carpentaria, west of Weipa, Queensland, 12°37′ S, 141°09′ E, 44 m, 28 Jan 1993; CSIRO H 3352–01, adult male 591 mm DW, north of Prince of Wales Island, Queensland, 10°27′ S, 141°50′ E, 10 m, 02 Feb 1993; CSIRO H 3369–01, female 458 mm DW, Gulf of Carpentaria, Queensland, 11°22′ S, 139°32′ E, 53 m, 05 Feb 1993; CSIRO H 3373–01, female ca. 811 mm DW (mis-shapen), CSIRO H 3373–02, juvenile male 177 mm DW, CSIRO H 3373–03, female 177 mm DW, CSIRO H 3373–08, juvenile male 177 mm DW, CSIRO H 3373–09, juvenile male 177 mm DW, Gulf of Carpentaria, Queensland, 12°04′ S, 140°42′ E, 59 m, 06 Feb 1993; CSIRO H 3380–01, female ca. 700 mm DW (mis-shapen), CSIRO H 3380–02, juvenile male 235 mm DW, Arafura Sea, east of Wessel Islands, Northern Territory, 11°35′ S, 137°20′ E, 47 m, 08 Feb 1993; CSIRO H 3381–01, female 723 mm DW, CSIRO H 3381–02, female 185 mm DW, CSIRO H 3381–03, female 182 mm DW, Arafura Sea, east of Wessel Islands, Northern Territory, 11°13′ S, 137°45′ E, 48 m, 09 Feb 1993; CSIRO H 3387–02, adult male ca. 507 mm DW (mis-shapen), CSIRO H 3387–03, female 473 mm DW, Gulf of Carpentaria, west of Weipa, Queensland, ca. 12° S, 141° E, 20 Jan 1993; CSIRO H 5204–01, juvenile male 302 mm DW, Arafura Sea, north of Melville Island, Northern Territory, 10°56′ S, 130°16′ E, 60 m, 10 Mar 1997; CSIRO H 5588–01, adult male 516 mm DW, Gulf of Carpentaria, Northern Territory, 15°28′ S, 137°41′ E, 35 m, 11 Dec 1990; CSIRO H 5589–01, adult male 592 mm DW, Arafura Sea, east of Wessel Islands, Northern Territory, 11°56′ S, 137°42′ E, 48 m, 12 Dec 1990; CSIRO T 698, female 215 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, 09°47′ S, 136°20′ E, 50 m, 22 Feb 1982; CSIRO T 699, juvenile male 334 mm DW, Arafura Sea, Northern Territory, 46 m, 11 Nov 1983; CSIRO T 700, female 235 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, 09°47′ S, 136°20′ E, 50 m, 22 Feb 1982.

Other material. 29 specimens. CSIRO CA 1245, juvenile male 312 mm DW, south-west of Lagrange Bay, Western Australia, 18°54′ S, 120°48′ E, 58 m, 13 Jun 1980; CSIRO CA 2405, juvenile male 200 mm DW, Gulf of Carpentaria, north of Groote Eylandt, Northern Territory, ca. 13° S, 136° E, 28 Jun 1981; CSIRO CA 3994, juvenile male 218 mm DW, north of Nickol Bay, Western Australia, 19°55′ S, 116°59′ E, 59 m, 16 Oct 1983; CSIRO H 963–01, male pup 146 mm DW, CSIRO H 963–02, female 148 mm DW, CSIRO H 963–03, male pup 143 mm DW, northern Australia, 24 Mar 1987; CSIRO H 1034–01, juvenile male 205 mm DW, CSIRO H 1034–02, juvenile male 204 mm DW, north of Port Hedland, Western Australia, 18°33′ S, 118°30′ E, 136–141 m, 30 Oct 1986; CSIRO H 1464–04, female 206 mm DW, north-west of Port Hedland, Western Australia, 19°29′ S, 117°50′ E, 63 m, 21 Sep 1988; CSIRO H 2376–01, juvenile male 383 mm DW, CSIRO H 2376–02, juvenile male 231 mm DW, CSIRO H 2376–03, juvenile male 253 mm DW, off Cairns, Queensland, 16°54′ S, 145°47′ E, 5 m, 14 Aug 1989; CSIRO H 3305–17, female 530 mm DW, east of Shelburne Bay, Queensland, 11°47′ S, 143°11′ E, 31 m, 14 Jan 1993; CSIRO H 3383–01, female ca. 527 mm DW (mis-shapen), Arafura Sea, north-east of Wessel Islands, Northern Territory, 10°26′ S, 137°33′ E, 47 m, 09 Feb 1993; CSIRO H 3387–01, adult male 546 mm DW, west of Weipa, Gulf of Carpentaria, Queensland, ca. 12° S, 141° E, 20 Jan 1993; CSIRO H 4077–01, female 223 mm DW, CSIRO H 4077–02, juvenile male 219 mm DW, CSIRO H 4077–03, juvenile male 209 mm DW, CSIRO H 4077–04, female 216 mm DW, west of Monte Bello Islands, Western Australia, 20°25′ S, 114°55′ E, 120–125 m, 21 Aug 1995; CSIRO H 4083–01, adolescent male 480 mm DW, north of Port Hedland, Western Australia, 18°31′ S, 118°32′ E, 123–130 m, 09 Sep 1995; CSIRO H 4913–02, female 260 mm DW, west Ajkwa River estuary, Irian Jaya, 04°52′ S, 136°47′ E, 9–11 m, 21 Aug 1998; CSIRO H 4914–01, juvenile male 245 mm DW, Minajerwi River estuary, Irian Jaya, 04°56′ S, 137°03′ E, 7 m, 04 Sep 1996; CSIRO H 5770–01, female 225 mm DW, Logan River mouth, Queensland, 27°42′ S, 153°19′ E, 2–3 m, Mar 2002; CSIRO H 5951–01, female 500 mm DW, north of Trinity Bay, Queensland, 16°17′ S, 145°32′ E, 27 m, 19 May 2002; CSIRO H 5980–04, female 210 mm DW, Merauke Beach, Indonesia, 08°31′ S, 140°22′ E, 09 Oct 2002; CSIRO H 6658–01, female 246 mm DW, Shark Bay, Western Australia, 25°35′ S, 113°42′ E, 14 m, 19 Jun 2006; CSIRO T 701, juvenile male 188 mm DW, probably northern Australia, 25 May 1983; QM I 12946, female 245 mm DW, Moreton Bay, Queensland, 27°15′ S, 153°19′ E, 26 m, 26 Mar 1975; WAM P 29180–001, female 361 mm DW, Dampier Creek, Broome, Western Australia, 17°57′ S, 122°15′ E, 1 m, 26 May 1982.

DIAGNOSIS.— A species of *Himantura* distinguished by a combination of the following features: disc rhomboidal, trunk not greatly thickened; preorbital snout moderately long, with a weak apical lobe, angle 102–112°; lateral apices moderately angular to narrowly rounded; orbits moderately large, protruded slightly; tail with deep longitudinal groove on mid-ventral surface and prominent ridge along its mid-lateral edge; primary denticle band present in postnatal juveniles (exceeding 200 mm DW) and larger; secondary denticle band subrectangular, with well-defined lateral margins, band extending along trunk from preorbital and onto tail, its maximum width subequal to interspiracular width; band fully developed by 480 mm disc width; dorsal surface with diffuse dark brown spots or specks, spots extending onto tail to stinging spine base; distance between spots more than diameter of largest spot apart; tail banded beyond sting in juveniles (less than 300 mm DW), saddled above and pale ventrally in largest adults; pectoral-fin radials 130–135; total vertebral count (excluding 1st synarcual centra) 94–102, monospondylous centra 43–47, pre-sting diplospondylous centra 50–56.

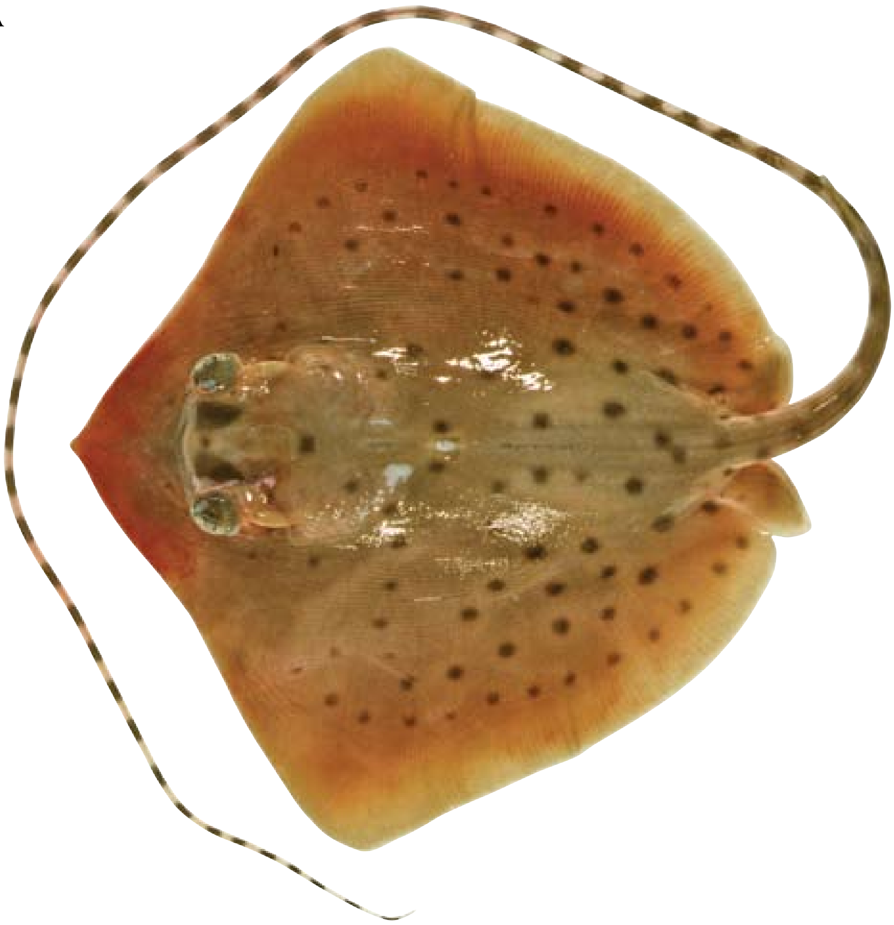
DESCRIPTION.— Disc rhomboidal, width 1.18 times length in holotype (1.12–1.22 in post-neonatal paratypes); moderately flat, raised slightly on mid-scapular region (more pronounced in larger specimens), maximum thickness 11% (8–12%) of disc width (DW); preorbital snout broadly triangular, with or without weak medial lobe at the snout tip, angle 102° (106–112°) (no obvious ontogenetic or sexual variability); anterior margins of disc weakly undulate to concave (rarely to almost straight in most juveniles), lateral apices moderately angular to narrowly rounded, posterior margins broadly convex, free rear tip narrowly rounded, subangular. Pelvic fins subtriangular, short, length 18.0% (16.1–19.5%) DW; width across base 8.9% (9.2–11.5%) DW. Claspers of adult male moderately elongate, stout, depressed slightly; dorsal surface weakly convex, ventral surface weakly convex, lateral edge arched; lining of pseudopera smooth; hypopyle short, about 1/3rd of length of clasper outer margin, without prominent anterior notch. Tail slender, whip-like; tapering very gently and evenly toward sting, with very weak taper beyond sting to tail tip; length 2.02–2.73 times disc width (holotype with tail damaged distally); base relatively narrow, subcircular in cross-section, its width 1.14 (1.04–1.51) times its

A

B

Figure 1. *Himantura astra* sp. nov., adult male holotype (CSIRO H 3377–01, 589 mm DW, preserved): A. dorsal view; B. ventral view.

A



B

Figure 2. Dorsal view of: A. *Himantura astra* sp. nov. juvenile male paratype (CSIRO H 3373–02, 177 mm DW, fresh); B. *H. toshi* juvenile male holotype (AMS IA 39, 294 mm DW, preserved).

Table 1. Morphometric data for the holotype of *Himantura astra* sp. nov. (CSIRO H 3377–01), with ranges and means provided for measured paratypes. Measurements expressed as a percentage of disc width.

	Holotype	Paratypes		
		Min.	Max.	Mean
Disc width (mm)	589	215	591	
Total length	190.0	212.5	346.6	302.0
Disc length	85.1	82.3	89.0	85.3
Snout to pectoral-fin insertion	76.1	73.7	79.8	76.3
Disc thickness	11.4	8.4	11.7	10.2
Snout (preorbital) length	20.3	18.0	20.8	19.4
Snout (preorbital) horizontal length	17.3	17.2	19.2	18.1
Pelvic-fin (embedded) length	18.0	16.1	19.5	17.8
Width across pelvic-fin base	8.9	9.2	11.5	10.2
Greatest width across pelvic fins	22.1	20.2	30.4	25.5
Cloaca origin to tail tip	–	202.6	273.3	240.2
Tail width at axil of pelvic fins	4.1	4.3	6.5	5.4
Tail height at axil of pelvic fins	3.6	3.4	4.7	4.2
Pectoral-fin insertion to sting origin	29.1	28.4	35.3	32.8
Cloaca origin to sting	29.5	32.2	40.4	37.7
Tail width at base of sting	1.4	1.4	2.1	1.7
Tail height at base of sting	1.6	1.6	2.3	2.0
Sting 1 length	–	10.4	16.2	13.7
Sting 2 length	–	7.9	16.2	12.0
Snout preoral (to lower jaw) length	20.7	18.7	22.2	20.3
Mouth width	6.9	6.1	7.3	6.7
Distance between nostrils	9.5	8.2	10.1	9.0
Interorbital width	11.7	9.7	12.4	10.9
Inter-eye width	15.3	15.0	19.2	16.5
Snout to maximum disc width	43.2	38.0	44.0	40.2
Eye length	2.5	2.5	4.3	3.4
Orbit diameter	5.3	4.1	6.5	5.6
Spiracle length	5.0	4.7	6.4	5.5
Interspiracular width	15.5	14.2	17.9	15.7
Orbit and spiracle length	8.3	7.2	10.1	8.8
Nostril length	3.9	3.9	5.2	4.4
Snout prenasal length	15.4	14.3	17.0	15.6
Nasal curtain length	6.0	5.4	7.0	6.1
Nasal curtain width	10.5	9.4	10.9	10.2
Orbit to pectoral-fin insertion	52.8	50.7	55.9	53.2
Snout to origin of cloaca	70.8	67.7	74.2	70.9
Width 1st gill slit	2.6	2.6	3.1	2.7
Width 3rd gill slit	2.8	2.7	3.3	3.0
Width 5th gill slit	2.0	1.6	2.1	1.8
Head length	40.2	37.8	42.8	39.8
Distance between 1st gill slits	16.0	14.6	17.2	15.9
Distance between 5th gill slits	9.0	9.0	10.2	9.6
Cloaca length	3.8	3.4	4.9	4.2
Clasper postcloacal length	15.2	8.5	15.7	11.8
Clasper length from pelvic axil	7.6	4.8	11.4	7.6

Figure 3. Oronasal region of *Himantura astra* sp. nov. (CSIRO H 3377–01, adult male holotype, 589 mm DW).

height at base (slightly less depressed in individuals exceeding 380 mm DW); depressed distally (slightly wider than deep near tail tip); deep longitudinal groove on mid-ventral surface (variable in length, originating beneath or slightly posterior to stinging spine), flanked by low ventral ridges; larger, more prominent ridge along mid-lateral edge of tail, originating near stinging spine, extending to tip of tail.

Snout moderately long, depressed; preoral snout length 2.98 (2.83–3.26) times mouth width, 2.18 (2.03–2.38) times internarial distance, 20.7% (18.7–22.2%) DW; direct preorbital snout length 1.73 (1.67–1.94) times interorbital length; snout to maximum disc width 43.2% (38.0–44.0%) DW; interorbital space flat; eye moderately large, diameter 50% (52–68%) spiracle length; orbits slightly protruded, diameter 1.04 (0.87–1.16) times spiracle length, interorbital distance 2.22 (1.62–2.58) times orbit. Spiracles large, subrectangular to oval, situated dorso-laterally. Nostrils narrow, slightly oblique, outer margin with a weak double concavity; internasal distance 1.63 (1.54–1.84) in prenasal length, 2.40 (1.74–2.36) times nostril length. Nasal curtain relatively narrow, width 1.75 (1.53–1.77) times length; lateral margin almost straight, smooth edged, posterolateral apex lying within broad groove; posterior margin weakly fringed, weakly concave to weakly double concave (often expanded slightly medially).

Mouth arched strongly (less so in female paratypes); deeply concave near symphysis of lower jaw in adult males, slotting into an expanded symphysial knob of upper jaw; oronasal groove prominent, deep; skin on ventral surface of lower jaw moderately well-corrugated, confined to narrow strip around lips, weakly papillate posteriorly. Mouth floor with 4 well-developed papillae; medial pair simple, rounded distally, often bifurcated to its base, longitudinally flattened, sub-equal in size and larger than outer pair, closer to each other than outer two; outer pair located at each corner of mouth, widely separated from inner pair. Teeth small, subequal in size in upper and lower jaws; broadly conical with blunt apices. Tooth rows of three paratypes about 41–49 in upper jaw, 40–50 in lower jaw; counts not obtainable from holotype without dissection.

Gill slit margins moderately S-shaped, smooth-edged; length of first gill slit 1.30 (1.35–1.62) times length of fifth, 2.66 (2.20–2.76) in mouth width; distance between first gill slits 1.68 (1.60–1.86) times internasal distance, 0.40 (0.39–0.42) times ventral head length; distance between fifth gill slits 0.95 (0.96–1.13) times internasal distance, 0.22 (0.23–0.25) in ventral head length.

SQUAMATION.— Ontogenetic stages (see definitions below after Manjaji, 2004) 0, 1, 2 and 4 present; stages 3, 5 and 6 are not applicable. Denticle development rapid, well developed primary denticles present at 235 mm DW; suprascapular denticles small, main denticle band well developed in adults; no enlarged thorn-like denticles on disc or tail.

Stage 0: Disc entirely smooth at birth (ca. 170–190 mm DW). Suprascapular denticles appearing soon after (ca. 215 mm DW), initially weakly evident and entirely covered with skin, soft when first exposed; increasing in size (largest denticles ranging between 1–4 mm length) and becoming more pronounced in shape (seed-shaped to narrow heart-shaped); numbering between 1–3 denticles; development coinciding with centre of disc being slightly raised and development of anterior row of primary denticles.

Stage 1: (ca. 235–260 mm DW) —Primary denticle band extending forward above first synarcual, adjacent suprascapular denticles. Band initially forming a single row, later flanked by an additional row on each side, before finally flaring slightly in scapular region at final part of the stage. Denticles flat ovate to narrow heart-shape, slightly upright, closely set, abutted; subequal in size (those of anterior median row slightly larger than those adjacent, but smaller than suprascapular denticles).

Stage 2: (ca. 260–300 mm DW) — Initial stage for development of discontinuous secondary denticle patches; onset on dorsal surface of tail behind sting, followed by simultaneous development of cranial (interorbital above fontanelle, and inner margin of spiracles behind orbits), and scapular patches; scapular patch in particular with well-defined margin. Denticles in cranial and scapular patches with flat crowns, varying from ovate to heart-shape; conical on inner margin of spiracles, base rounded to weakly stellate; on tail, bluntly pointed, varying in shape from subconical to conical; scattered and well-spaced; minute, smaller than suprascapular and primary denticles. A juvenile male (CSIRO H 5204–01) 302 mm DW is in late stage 2, with a weakly-developed denticle band.

Figure 4. Scapular denticles of *Himantura astra* sp. nov. (CSIRO H 3377–01, adult male holotype, 589 mm DW).

Stage 4: (ca. >300 mm DW) — Early stage (ca. 300–350 mm DW): cranial and nucho-scapular denticle patches weakly coalesce through a median patch of scattered, widely spaced denticles. Denticles similar in shape and size to those in adjacent secondary patches. Mid-stage (ca. 350–400 mm DW): cranial and scapular patches connected through a narrow band of connective denticles, forming a continuous, irregular, longitudinal secondary band, but discontinuous with those on tail; band widest in scapular region, constricted over gills; anteriorly, following outline of fontanelle, its anterior margins adjacent to orbits. Band varying in shape above scapular, from subrectangular to suboval; posteriorly, converging sharply to pectoral-fin insertion. Denticle patch on inner margin of spiracles barely developed, patch weakly triangular-shaped on antero-dorsolateral surface. On tail, denticles reaching just anterior to stinging spine base on dorsal and dorsolateral surfaces, becoming dense anteriorly; sparse distally on tail, with smaller similar-shaped denticles resembling those of disc. Late-stage (ca. >400 mm DW): secondary denticle band well-developed, continuous along trunk and tail; flask-shaped, becoming subrectangular in larger individuals, margin well-defined; extending anteriorly to slightly forward of orbits, naked snout ratio 65–110%; very weakly constricted above first synarcual; slightly expanded above abdominal region; converging laterally toward pectoral-fin insertion, apical margin weakly truncate or convex; extending on to tail, initially across almost entire dorsal half, enveloping tail just forward of stinging spine (largest adults with tail completely covered in denticles). Denticles on anterior tail small, flat, ovate to heart-shaped, interspersed with small conical denticles with scalloped bases; sparse towards tail tip, absent ventrally and at tail tip in initial stages, becoming fully scaled in large adults; large adult paratype (CSIRO H 3381–01) with additional short, subconical, upright denticles along midline of post-sting tail.

Holotype at Stage 4 (late stage), typical of stage; main denticle band almost rectangular, posterior apices angular, notched about an orbit diameter forward of pelvic-fin insertion; two main, slightly enlarged scapular denticles; primary patch in about five rows; subequal to interspiracular width. Claspers, pelvic fins and ventral surface of disc naked. Stinging spine absent from holotype; when present in paratypes of moderate length, narrow-based, very slender; ventral-most spine longer than dorsal-most spine when present.

MERISTICS.— Total pectoral-fin radials 130–131 (132–135, n=5); propterygium 50–51 (48–50), mesopterygium 20 (19–22), metapterygium 60 (61–64). Pelvic-fin radials: males 1 + 22 (1 + 20–22, n=2); females (1 + 23–27, n=3). Vertebral count (total excluding 1st synarcual centra) 95 (94–102); monospondylous (excluding 1st synarcual) 44 (43–47), pre-sting diplospondylous 51 (50–56), post-sting diplospondylous 0 (0).

COLOUR.— In preservative: Dorsal surface of disc of adult male holotype greyish brown (apex and posterior margin slightly paler) with dense pattern of diffuse-edged, dark brown spots surrounded by pale markings; pelvic fins and clasper similar to disc, margins often white; tail spotted and/or banded dorsally and laterally, white ventrally; disc almost uniformly white ventrally. Dark spots more than their diameter apart, widespread dorsally, most densely concentrated on snout, denticle band and over posterior disc; highly variable in large paratypes, from confined to posterior disc in CSIRO H 3322–02 to densely spotted all over in CSIRO H 1222–02. Size of spots varying slightly in holotype, 2–10 mm in diameter, smallest along outer margins of disc; 1–14 mm in paratypes, uniformly small in CSIRO H 1222–02, uniformly large in CSIRO H 959–01 and CSIRO H 3369–01. In holotype, dark spots variably surrounded by slightly smaller, diffuse-edged white spots (diameter 3–9 mm); in large paratypes, white spots varying from indistinct to prominent, or sometimes coalesced to form indistinct white rings (pseudo-ocelli). Dorsal margin of eye dark greyish brown, usually peppered with fine brownish black spots; margin strongly contrasted with white anterior, ventral and posterior margins (as well as margin of spiracular opening). Tail coarsely or finely spotted dorsally before sting (spots often confined to dorsolateral margin); beyond sting in holotype and largest paratypes, tail with alternating light and dark saddles, pale portions narrower than dark portions; juveniles (less than 500 mm DW) with alternating light and dark bands (often less pronounced ventrally in large juveniles). Primary and secondary denticle bands and stinging spines (when present) white. Small neonatal juvenile paratype (CSIRO H 3373–02) pale greyish brown dorsally, palest near margins; dark spots widely separated (diameter 3–6 mm), concentrated on posterior disc (spots similar in shape and distribution in other small juvenile paratypes less than 300 mm DW); pale marginal spots weak, indistinct; tail

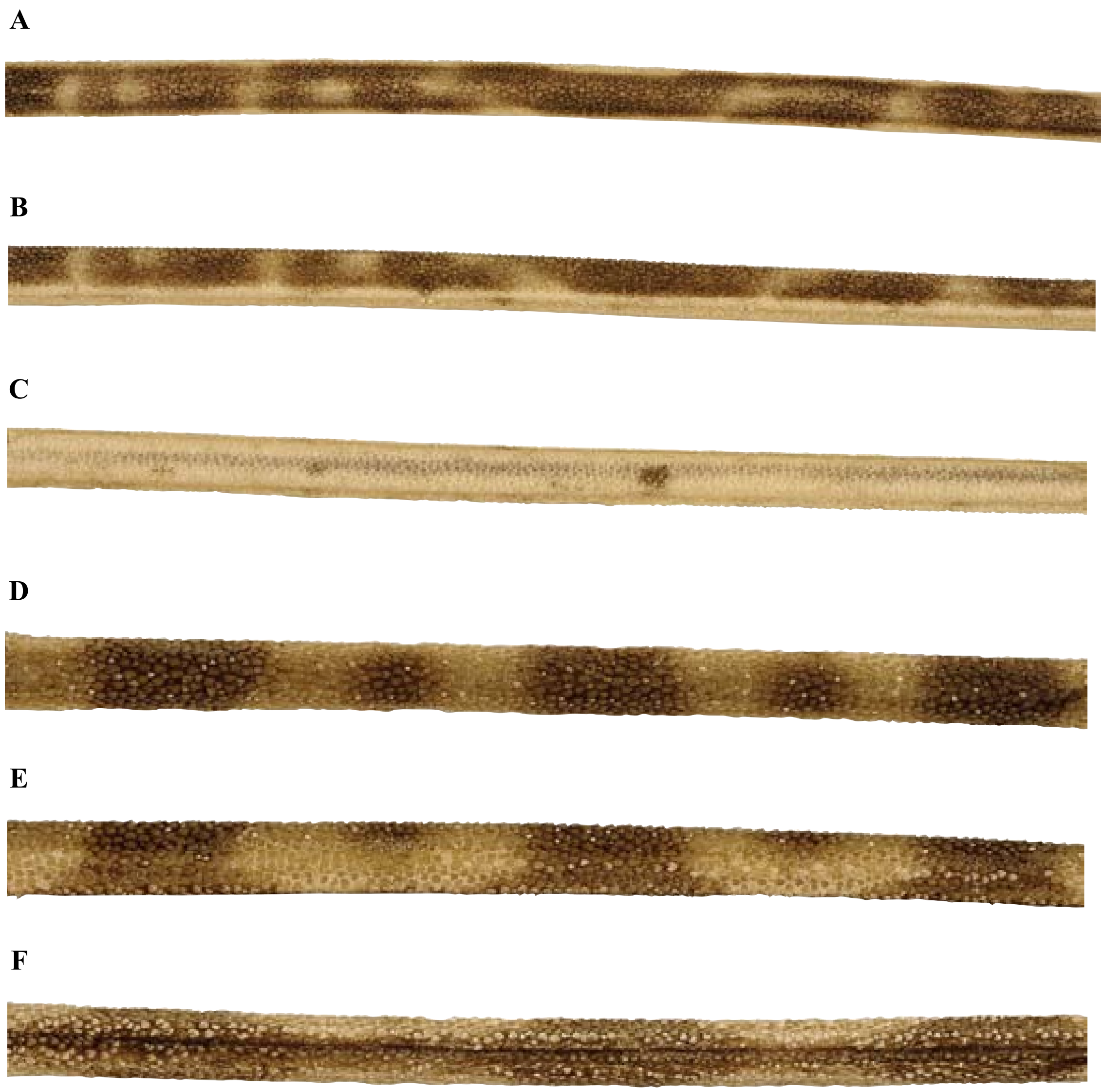


Figure 5. Tail of *Himantura astra* sp. nov. adult male holotype (CSIRO H 3377–01, 589 mm DW): A. dorsal, B. lateral, and C. ventral views; female paratype (CSIRO H 3329–01, 482 mm DW): D. dorsal, E. lateral, and F. ventral views.

bands pronounced, their widths subequal.

SIZE.— Attains at least 800 mm DW and 1800 mm TL. First maturity (males) about 500 mm DW; a 480 mm DW male specimen (CSIRO H 4083–01) was a late adolescent, two slightly larger male specimens (CSIRO H 1222–01 & H 3387–02), both 507 mm DW, had fully developed claspers. Birth size about 170–190 mm DW.

DISTRIBUTION.— Widely distributed throughout tropical Australia; material examined from Shark Bay in Western Australia (ca. 25°35′ S) to Moreton Bay in Queensland (27°42′ S) in 1–141 m, including near the Timor Sea (i.e. specimen with registration CSIRO CA1245 misidentified as *H. uarnak* by Gloerfelt-Tarp & Kailola, 1984) and southern West Papua in Indonesia.

ETYMOLOGY.— Derived from the Latin *astrum* (star, constellation) with reference to the dorsal coloration, which usually consists of dark spots orbited in various ways by whitish spots, vaguely resembling a cluster of stars (most evident in larger specimens). Vernacular: Black-spotted Whipray (Last & Stevens, 1994).

REMARKS.— Manjaji (2004) proposed that *Himantura* sp. A (*sensu* Last & Stevens, 1994) should be synonymised with *H. toshi* (*sensu* Last & Stevens, 1994) based on a combination of external and internal characters (i.e. colour, morphometric ratios, squamation, and skeletal structures, particularly the shape of the scapulocoracoid). Specimens of *H. toshi*, and those tentatively identified as *H.* sp. A, have a distinctive primary denticle band consisting of 2–3 acute, heart-shaped mid-scapular denticles. Last & Stevens (1994) had suggested that the two colour forms, earlier referred to by Whitley (1940) as morphs of *H. toshi*, were separate species based primarily on their colour and then known distribution and habitat (i.e. *H*. sp. A is common inshore over muddy bottoms on mangrove flats, whereas *H. toshi* is more common offshore in the Gulf of Carpentaria). A wide selection of specimens of *H. toshi* was available for examination representing newborns to adult stages, whereas specimens tentatively identified as *H*. sp. A were fewer and limited (less than 5 specimens were available). Unfortunately, efforts by Manjaji to obtain additional material and tissue samples for DNA sequence analysis from *H*. sp. A were unsuccessful.

Since Manjaji's initial investigation of these forms, we were able to gain access to more material from eastern Australia confirming the existence of two closely related species. The absence of black spots on juveniles of *H. toshi* and their presence in *H. astra* is useful in distinguishing juveniles. Adults of *H. toshi* are similar to juveniles in colour but often have fine whitish spots and flecks on the dorsal disc (rather than being covered in dark spots surrounded by a rosette of white spots in *H. astra*) and the dorsal and ventral surfaces of the post-sting tail are blackish (rather than black and white banded dorsally and pale ventrally). A large female of *H. toshi* (CSIRO H 6315–02) has fine denticles on the disc external to the main denticle band (skin always smooth in *H. astra*), and has enlarged denticles on the midline of the pre-sting tail that extend dorsally over the post-sting tail (no enlarged denticles in *H. astra*). Other more subtle differences between the species may exist in denticle band widths, eye size, clasper shape and ventral markings. These need further investigation.

A specimen from Moreton Bay (Queensland) figured and identified as *Dasyatis uarnak* by Tosh (1903) was later reproduced in Whitley (1940) as *Himantura toshi*. Tosh remarked that the species was 'not as common' as another species (i.e. *D. kuhlii*). He described this specimen as having only one spine on the dorsal disc, preceded by a small bony ridge, apparently referring to the midscapular denticle as the spine. The colour of the dorsal disc was described as being dark brown, and the tail length twice the body length with thirty-five bluish white bars; no mention was made of black spots on the dorsal disc. Whitley (1939) noted the holotype of *H. toshi* was an immature male with a 305 mm DW or '12 inches across the disc, and disc a little broader than long, tail three times the length of the body'. This specimen has obviously undergone shrinkage as Manjaji (2004) obtained a 294 mm disc width. The holotype is greatly darkened, presumably through preservation. However, a careful examination of the skin of this species failed to reveal the presence of any dark spots on the dorsal surface, although a dark marginal marking remains evident along the ventral disc margin and banding is weakly persistent on the tail. We conclude that Whitley's type lacks dark spots making it consistent with coloration of the coastal form. In addition, no recent material has been collected from estuaries in northern New South Wales.

Newborns and small juveniles of *H. astra* are similar in disc shape, meristics and sometimes coloration to other species of the uarnak complex, particularly to *H. gerrardi* and *H. uarnak*. The snout angle of *H. astra* is the narrowest of the three species, ranging between 102–112° (108–124° in *H. gerrardi*, 115–129° in *H. uarnak*). *Himantura gerrardi* is very similar in adult size and shape but has small white spots. *Himantura astra* also differs from *H. gerrardi* in squamation (primary denticle band present vs. absent in *H. gerrardi*) and in the structure of their scapulocoracoid (Manjaji, 2004). Moreover, the rate of denticle band development is slower in *H. astra* compared with *H. gerrardi*. The interspaces between the dark spots on the dorsal surface are relatively smaller in juvenile *H. uarnak* (separated by less than the diameter of the largest spot) than *H. astra*. Adults of *H. uarnak* have a reticulate colour pattern.

Comparative material.
Himantura toshi: AMS IA39 (holotype), juvenile male 294 mm DW, Clarence River estuary, New South Wales, Australia; CSIRO H 6315–02, female ca. 620 mm DW, off North Stradbroke Island, Queensland.

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Resurrection of the genus *Neotrygon* Castelnau (Myliobatoidei: Dasyatidae) with the description of *Neotrygon picta* sp. nov., a new species from northern Australia

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ABSTRACT.— The genus *Neotrygon* Castelnau is resurrected as a valid generic name for a group of dasyatids termed 'maskrays'. *Neotrygon leylandi*, *N. kuhlii* and *N. annotata* have previously been placed in the widespread genus *Dasyatis* by most authors, but recent morphological and molecular studies have shown that these species are not congeneric with *Dasyatis*. Members of this genus are characterised by a mask-shaped colour pattern around the eyes, a long and narrow internasal curtain, and a short tail that is variably banded apically, and has well-developed dorsal and ventral skin folds. A new maskray, *Neotrygon picta* sp. nov., is described from material collected off tropical northern and northeastern Australia. This species was initially thought to be a colour variant of another Australian maskray, *Neotrygon leylandi*, from off northwestern Australia, but recent molecular analysis and morphometric and meristic investigation has shown that the two are specifically distinct.

Key words. Dasyatidae – *Neotrygon picta* – maskray – new species – Australia

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INTRODUCTION

Blue-spotted stingrays referable to *Trygon kuhlii*, Müller & Henle 1841, have been widely assigned to the genus *Dasyatis* (see Eschmeyer, 2008). Other authors (e.g. Paxton *et al*., 1989; Rainboth, 1996) have placed this species in *Amphotistius* (a junior synonym of *Dasyatis*, Last, unpublished) which is based on *Dasyatis sabina* Lesueur, 1824, a distant relative from the Western Atlantic. Last (1987) described *Dasyatis annotata* and *D. leylandi*, two Australian stingrays that he felt belonged to a species complex that included *D. kuhlii*, now informally known as the 'kuhlii group'. He discussed a possible link with *Amphotistius* but, in the absence of conclusive data, tentatively assigned the group to *Dasyatis* to avoid further confusion. Whitley (1940) assigned *Trygon kuhlii* to *Neotrygon* and Mould (1997), without explanation, also included *Dasyatis leylandi* and *Amphotistius* sp. 3 (*sensu* Sainsbury *et al*., 1985) in this genus.

More recent morphological investigations of members of the 'kuhlii group' in the Indo–West Pacific, and molecular studies conducted in parallel, have conclusively shown that these fishes form a natural genus-level group, distinct from other dasyatids, including members of the genus *Dasyatis*. Manjaji (2004) has shown that 'kuhlii group' members are tightly clustered together apart from *Himantura* and *Pastinachus* in a larger unresolved clade that includes four other dasyatids i.e. *Dasyatis acutirostra* Nishida & Nakaya, 1988, *D. laosensis* Roberts & Karnasuta, 1987, *D. zugei* (Müller & Henle, 1841), and *Pteroplatytrygon violacea* (Bonaparte, 1832). However, important differences exist between *Dasyatis* and members of the 'kuhlii group' in tail and buccal morphology, and coloration (Last & Manjaji-Matsumoto, in prep.), supporting recognition of the group as a genus-level taxon. *Neotrygon* Castelnau, 1873 is available as a group name for this taxon.

Molecular studies, conducted for the Barcode of Life project for fish (FISHBOL), have shown that a Maskray, identified and figured by Last & Stevens (1994) as a likely regional colour morph of *D. leylandi*, is an undescribed species. Whitley (1940) also figured this species, and the blue-spotted form, as variations of *Neotrygon kuhlii* but highlighted that the larger blue-spotted specimen had less well-developed claspers than the much smaller black-spotted form (i.e. the new species). In the following paper the new maskray is described and the genus *Neotrygon* is redefined.

METHODS

Characteristics of the disc (including squamation, tooth row counts and meristic counts) follow standards used in Manjaji (2004) and Manjaji-Matsumoto & Last

(2006). Meristics were obtained from radiographs of the holotype (CSIRO H 5771–01) and 5 paratypes (CSIRO H 2376–06, CSIRO H 3332–02, CSIRO H 3374–05, CSIRO H 3374–06 and CSIRO H 3385–01) of the new species, and from the holotype (CSIRO CA 2806) and 4 other specimens (CSIRO H 1458–06, CSIRO H 1458–07, CSIRO H 1458–08 and CSIRO H 6659–04) of *N. leylandi*. Morphometric methods generally follow Compagno & Heemstra (1984) with additional characters derived to account for characteristic features of the tail. The shape of the tail and associated ventral skin folds are important in distinguishing different species of dasyatids. Hence, tail widths and depth (height) were recorded at the origin and insertion of the ventral skin fold. These points were often difficult to determine as extremities of the folds often extend along the tail as low ridges; hence, we assessed endpoints of a fold as a point where an obvious fold unites with a ridge. Additional measurements of tail width, depth, and fold depth (height) were recorded at quartile intervals along the skin-fold base: at points demarcated by 25%, 50% (its mid-base) and 75% of the base length from the fold's origin. While measurer-introduced variability can be non-trivial, the morphometry of these folds are important taxonomic characters for distinguishing species. A total of 63 measurements, expressed as proportional measurements of disc width (DW), were taken for the holotype (CSIRO H 5771–01) and 6 paratypes (CSIRO H 2376–07, CSIRO H 3374–05, CSIRO H 3374–06, CSIRO H 3385–01, CSIRO H 5590–02 and NTM S 16597–001) of the new species, and from the holotype (CSIRO CA 2806) and two paratypes (CSIRO T 676 and CSIRO T 681) of *N. leylandi*. Specimens were deposited in the Australian National Fish Collection (CSIRO), at the Commonwealth Scientific and Industrial Research Organisation's Marine Laboratories in Hobart (Tasmania), and at the Northern Territory Museum (NTM) in Darwin (Northern Territory). Institutional acronyms follow Leviton *et al*. (1985).

Neotrygon Castelnau, 1873

Neotrygon Castelnau, 1873:122. Type species: *Raya trigonoides* Castelnau, 1873 (by monotypy).

DEFINITION.— Small dasyatids (maximum 47 cm DW) with the following combination of characters: variably developed, mask-shaped pattern on head between and beside eyes; dorsal coloration variable (plain, strongly patterned or with blue spots); disc largely naked, thorn-like denticles confined to single series on mid-line of disc and tail; no greatly enlarged scapular thorns or tubercles; mouth small with 2 long centrally located papillae; a row of enlarged, long-cusped teeth mid-way along upper jaw on each side; nasal curtain long, narrow; tail very short with well-developed dorsal and ventral skin folds; dorsal skin fold short based but elevated centrally; ventral skin fold long-based, its height about equal to height of dorsal fold for most of its length; tail tip filamentous beyond skin folds, mainly banded black and white beyond stinging spine.

INCLUDED SPECIES.— *Neotrygon annotata* (Last, 1987), *Neotrygon kuhlii* (Müller & Henle, 1841), *Neotrygon leylandi* (Last, 1987) and *Neotrygon picta* Last & White, 2008.

REMARKS.— The status of *Neotrygon* has been not been widely discussed in the literature, and Eschmeyer (2008) makes no comment on the validity of the taxon. The type species, *Raya trigonoides* Castelnau, 1873, was described from a single specimen collected from New Caledonia (NMV A 5255). An examination of this specimen corroborates Eschmeyer (2008) as being a synonym of *Dasyatis kuhlii* (Müller & Henle, 1841). This is the only available nominal genus name that can be applied to this group, otherwise known as maskrays (Last & Stevens, 1994). They are highly conservative for the defining characters listed above and no other dasyatid genera possess this combination of characters. *Neotrygon* is genetically distinct from other dasyatid genera examined (Manjaji, 2004; Ward *et al*., 2008), and its members can be easily distinguished using the CO1 gene (Ward *et al*., 2008). Maskrays also exhibit differences from other stingrays in buccal structure and skeletal morphology (Last & Manjaji-Matsumoto, in prep.), and a more comprehensive treatment of the group will be provide in another publication along with a redefinition of other dasyatid genera.

Neotrygon picta sp. nov.

Figs 1–4, Tables 1 and 2

Dasyatis leylandi (in part): Last & Stevens, 1994: pp 393, 394, fig. 40.6b, pl. 71.

Holotype. CSIRO H 5771–01, female 236 mm DW, east of Rockhampton, Queensland, 23°15′ S, 151°15′ E, 27 m, 02 Oct 2000.

Paratypes. 12 specimens. CSIRO H 1218–01, adult male 181 mm DW, Gulf of Carpentaria, west of Albatross Bay, Queensland, 12°33′ S, 141°15′ E, 43 m, 24 Feb 1988; CSIRO H 2376–06, adult male ca. 240 mm DW, CSIRO H 2376–07, adult male 217 mm DW, off Cairns, Queensland, 16°54′ S, 145°47′ E, 5 m, 14 Aug 1989; CSIRO H 3332–02, female 270 mm DW, Gulf of Carpentaria, west of Weipa, Queensland, 12°38′ S, 141°13′ E, 41 m, 28 Jan 1993; CSIRO H 3333–03, female 140 mm DW, Gulf of Carpentaria, west of Weipa, Queensland, 12°38′ S, 141°13′ E, 41 m, 28 Jan 1993; CSIRO H 3361–07, adult male 170 mm DW, west of Cape York Peninsula, Queensland, 11°10′ S, 141°04′ E, 34 m, 04 Feb 1993; CSIRO H 3374–05, female 215 mm DW, CSIRO H 3374–06, adult male 183 mm DW, Gulf of Carpentaria, Queensland, 11°59′ S, 140°53′ E, 54 m, 06 Feb 1993; CSIRO H 3385–01, female 275 mm DW, west of Prince of Wales Island, Queensland, 10°52′ S, 141°09′ E, 28 m, 03 Feb 1993; CSIRO H 3895–01, juvenile male 172 mm DW, north-east of Cape Grenville, Queensland, 11°37′ S, 143°28′ E, 18 m, 21 Oct 1994; CSIRO H 5590–02, adult male 221 mm DW, Gulf of Carpentaria, north of Groote Eylandt, Northern Territory, 13°11′ S, 136°44′ E, 27 m, 24 Sep 1998; NTM S 16597–001, female 212 mm DW, Arafura Sea, north-east of Wessel Islands, Northern Territory, ca.10°13′ S, 137°38′ E, 46 m, 07 Oct 1986.

Other material. 33 specimens. CSIRO C 3384, adolescent male 115 mm DW, Gulf of Carpentaria, north of Karumba, Queensland, 16°26′ S, 140°39′ E, 22 m, 24 Aug 1963; CSIRO C 3583, juvenile male 100 mm DW, Gulf of Carpentaria, Queensland, 1965; CSIRO C 3587, female 170 mm DW, Gulf of Carpentaria, Queensland, May 1965; CSIRO C 3947, female 187 mm DW, Gulf of Carpentaria, north-east of Robinson River, Northern Territory, 15°55′ S, 137°30′ E, 31 Oct 1971; CSIRO C 4054, female 160 mm DW, Gulf of Carpentaria, east of Wellesley Islands, Queensland, 16°38′ S, 140°05′ E, 25 m, 28 Aug 1963; CSIRO C 4059, adolescent male 125 mm DW, Gulf of Carpentaria, east of Wellesley Islands, Queensland, 16°44′ S, 140°03′ E, 20 m, 28 Aug 1963; CSIRO C 4469, female 160 mm DW, Gulf of Carpentaria, north-east of Bentinck Island, Queensland, 16°55′ S, 139°37′ E, 12 m, 01 Nov 1972; CSIRO CA 729, female 115 mm DW, CSIRO CA 730, juvenile male 115 mm DW, Torres Strait, near Yorke Island, Queensland, 09°45′ S, 143°56′ E, 24 Apr 1979; CSIRO CA 2278, female ca. 230 mm DW, Arafura Sea, Northern Territory, 08°57′ S, 135°00′ E, 92–96 m, 27 Jun 1981; CSIRO CA 2496, adult male 237 mm DW, no collection data; CSIRO CA 2566, juvenile male 125 mm DW, CSIRO CA 2567, adolescent male 172 mm DW, Gulf of Carpentaria, off Tasman Point, Northern Territory, 14°20′ S, 136°10′ E, 18 m, 27 May 1981; CSIRO CA 3894, adult male 193 mm DW, probably northern Australia, 03 Dec 1982; CSIRO CA 4272, adolescent male 150 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, 9°50′ S, 136°15′ E, 60 m, 28 Nov 1982; CSIRO CA 4552, female 265 mm DW, no collection data; CSIRO H 39–01, juvenile male 125 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, 09°47′ S, 136°20′ E, 50 m, 22 Feb 1982; CSIRO H 961–01, female 245 mm DW, CSIRO H 961–02, juvenile male 122 mm DW, CSIRO H 961–03, juvenile female 90 mm DW, CSIRO H 961–04, juvenile female 100 mm DW, probably northern Australia, 21 Mar 1987; CSIRO H 1117–01, juvenile male 122 mm DW, Arafura Sea, Queensland, 10°58′ S, 139°26′ E, 51 m, 01 Nov 1987; CSIRO H 1219–01, juvenile male 105 mm DW, possibly Albatross Bay, Queensland, 12 m, 26 Feb 1988; CSIRO H 3307–22, juvenile male 140 mm DW, south-east of Hannibal Island, Queensland, 11°43′ S, 143°01′ E, 17 m, 14 Jan 1993; CSIRO H 3374–07, embryo 50 mm DW, Gulf of Carpentaria, Queensland, 11°59′ S, 140°53′ E, 54 m, 06 Feb 1993; CSIRO H 3375–03, female 115 mm DW, Gulf of Carpentaria, west of Cape York Peninsula, Queensland, 11°51′ S, 141°12′ E, 38 m, 06 Feb 1993; CSIRO H 3386–01, adult male 190 mm DW, north of Hannibal Island, Queensland, 11°31′ S, 142°56′ E, 18 m, 15 Jan 1993; CSIRO T 673, female 247 mm DW, CSIRO T 686, adult male 226 mm DW, CSIRO T 687, female 146 mm DW, Arafura Sea, Northern Territory, Mar 1983; CSIRO T 688, adult male 206 mm DW, Arafura Sea, north of Wessel Islands, Northern Territory, 09°47′ S, 136°20′ E, 50 m, 22 Feb 1982; CSIRO T 689, adolescent male 140 mm DW, Arafura Sea, Northern Territory, 50 m, 11 Nov 1983; CSIRO T 690, adult male 232 mm DW, Arafura Sea, Northern Territory, 50 m, 11 Nov 1983.

DIAGNOSIS.— A small dasyatid (reaching 27 cm DW) with the following combination of characters: disc quadrangular, broader than long, width about 1.2 times length; variably peppered dorsally with an irregular scattering of asymmetric black spots but lacking blue spots; snout broadly triangular, angle 113–124°, snout length 1.7–2.1 times interorbital width; preoral length 2.1–2.6 times mouth width; internasal distance 1.3–1.4 in prenasal length; interspiracular distance 13.2–14.6% DW; nostril length 3.2–3.6% DW; nasal curtain width 8.8–9.9% DW; mouth width 7.1–8.1% DW; body and tail mostly naked; 0–22 thornlets in single continuous row along midline of disc; pectoral-fin radials 101–105; total vertebral centra (including synarcual) 113–122, trunk centra (including synarcual) 37–40.

DESCRIPTION.— Disc quadrangular, angular anteriorly and barely produced, broader than long; width 1.19 times length in holotype (1.15–1.20 in paratypes); axis of greatest width of disc just forward of scapular region, its distance from snout tip 1.83 (1.76–2.01) times in distance from tip of snout to pectoral-fin insertion; body relatively flattened, thickness 8.7 (8.0–10.2) times in disc width, not raised markedly above cranium (barely raised above scapular region); anterior margin of disc straight to slightly undulated, very weakly concave at level of orbits, then convex just before pectoral-fin apex; apex broadly angular, pectoral angle 90° (90–93°); posterior margin weakly convex; free rear tip broadly angular. Pelvic fins narrowly triangular, anterior margin straight, apex narrowly angular, posterior margin straight to weakly convex, united with inner margin (free rear tip indiscernible); relatively small, length 22.3% (20.2–22.4%) DW; 1.34 (1.19–1.45) times width across fin bases. Claspers of adult males strongly depressed, tapering, acutely pointed apically; outer length 13.7–15.3% DW.

Tail relatively short, moderately broad-based, tapering rapidly to stinging spine(s), with two moderate skin folds; postcloacal tail 1.49 (1.29–1.79) times precloacal length; base moderately depressed, broadly oval in cross section, weakly convex above and below, width 1.46 (1.33–1.56) times depth; subcircular to rhomboidal in cross section near origin of ventral skin fold, width 1.74 (1.29–1.82) times height at fold origin; tapering evenly in dorsoventral view posterior to stinging spine(s); moderately compressed at end of stinging spine(s); short, somewhat filamentous

A

B

Figure 1. *Neotrygon picta* sp. nov., female holotype (CSIRO H 5771–01, 236 mm DW, fresh): A, dorsal view; B, ventral view.

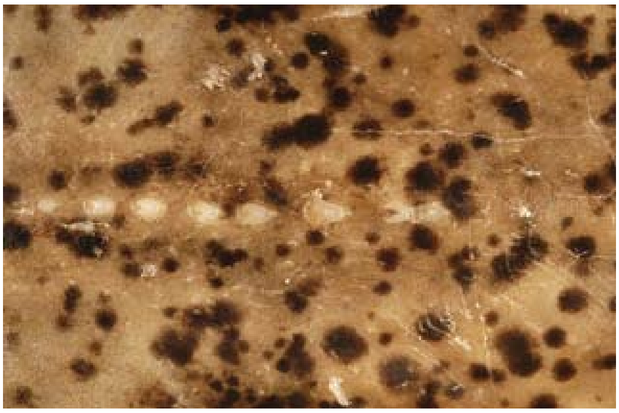

Figure 2. Denticle band on midline of dorsal disc of the female holotype of *Neotrygon picta* sp. nov. (CSIRO H 5771–01, 236 mm DW).

distally, with prominent dorsal and ventral skin folds, not slender or whip-like beyond stinging spine(s); compressed suboval in cross section above mid ventral fold, width 0.68 (0.72–0.82) times depth; at end of fold compressed suboval, width 0.61 (0.93–1.13) times height; dorsal surface of tail posterior to stinging spine(s) base with a weak naked groove (partly housing sting and extending for about two-thirds to three-quarters of its length); no skin folds present along lateral margin of tail. Dorsal skin fold well developed, short based, pronounced, length 22 (16–26) times its height, 0.68 (0.64–1.03) in snout length, 2.40 (2.27–3.59) in length of ventral fold; its height 1.02 (1.11–1.21) in height of mid ventral fold; origin usually forward of stinging spine apex, continuing posteriorly as a low ridge before an elevated portion, tallest just posterior to tip of intact stinging spine; elevated portion about subequal to snout length; posterior portion low, often persisting to almost to tail tip as a low ridge (its point of termination often unclear). Ventral skin fold long, narrow, almost uniform in height for most of its length (often tapering rapidly posteriorly near tail tip); much longer but only slightly taller than dorsal skin fold; length 1.74 (1.29–1.82) in disc width, 1.80 (1.53–2.07) in post cloacal tail; origin 1.4% (0.5–1.7%) within sting origin; depth at quarter length 0.60 (0.70–0.90), at mid length 0.93 (0.75–1.22), at three quarter 0.59 (0.18–0.97) in adjacent tail height; originating almost below sting origin; distance from cloaca to sting origin 1.75 (1.72–1.95) in precloacal length; length of tail beyond ventral fold extremely variable, 11.7 (2.8–233.6) in fold length, more than 5.7 in tail length. Sensory pores evident, not strongly demarcated. Lateral line indistinct on ventral surface; sensory pores evident but not strongly demarcated.

Snout short, broadly triangular, acute at apex with no obvious apical lobe; angle 119° (113–124°); bluntly acute when viewed laterally, becoming more depressed towards apex; preoral snout length 2.24 (2.14–2.55) times mouth width, 2.06 (2.12–2.40) times internarial distance, 0.99 (0.98–1.20) times distance between first gill slits; direct preorbital snout length 1.74 (1.81–2.14) times interorbital length; snout to maximum disc width 2.50 (2.41–2.64) in DW; interorbital space narrow, weakly concave (flatter in juvenile paratypes); eyes of moderate size (relatively larger in mature males than juveniles), dorsolateral, protruding, ventral margin partly covered by thin skin fold; orbit usually well elevated above disc, diameter 0.85 (0.81–0.94) in spiracle length, eye length 1.22 (0.97–1.17) in spiracle length; inter-eye distance 3.02 (2.52–3.03) times eye length. Spiracles small, usually crescentic to suboval in shape with dorsolateral opening. Nostril narrowly oval to slit-like, directed longitudinally; anterior margin abrupt, not fleshy; anterior nasal fold internal, narrow, membranous; strong oronasal groove present; internarial space 1.59 (1.66–1.80) in prenasal length, 2.20 (2.05–2.65) times nostril length. Nasal curtain narrowly skirt-like, long, width 1.96 (1.32–1.50) times length; strongly bilobed, posterior margin of each lobe moderately convex; surface crenulated, papillate, usually with well-defined medial groove and covered with minute pores; apex recessible within lateral margin of oronasal groove; lateral margin almost straight to weakly concave, smooth edged, usually partly enveloped by narrow posterior fold of nostril; posterior margin strongly fringed, strongly concave, not following contour of lower jaw, abutting most of lower jaw when mouth closed.

Mouth small, jaws slightly asymmetric; lateral grooves shallow, curved slightly, extending from nostril to slightly below lower jaw, length much shorter than nasal curtain length; not projecting forward when mouth open, mouth not protrusible; skin on chin and margin of lower jaw very fleshy, strongly papillate; teeth uniformly close-set in both jaws, in oblique rows, not arranged in quincunx, rows in upper jaw about 33–38, rows in lower jaw about 31–40. Upper jaw strongly arched, strongly double convex, more so in adult female (CSIRO H 3385–01) than adult male (CSIRO H 2376–06); teeth concealed when mouth closed; symphysial part of jaw not projecting ventrally. Lower jaw very strongly convex with a prominent symphysial

Figure 3. Oronasal region of *Neotrygon picta* sp. nov., female holotype (CSIRO H 5771–01, 236 mm DW).

Table 1. Morphometric data for the holotype of *Neotrygon picta* sp. nov. (CSIRO H 5777–01), with ranges and means provided for measured paratypes, and for the holotype (CSIRO CA 2806) and two paratypes (CSIRO T 676 and CSIRO T 681) of *Neotrygon leylandi*. Measurements expressed as a percentage of disc width.

	Neotrygon picta **sp. nov.**				***Neotrygon leylandi***		
	Holotype	Paratypes			Holotype	Paratypes	
		Min.	Max.	Mean		Min.	Max.
Disc width (mm)	236	183	275		192	190	254
Total length	172.9	163.6	205.1	184.4	180.7	190.9	198.4
Disc length	84.0	83.2	87.3	85.0	80.2	79.2	86.3
Snout to pectoral-fin insertion	73.3	73.0	77.2	74.6	70.6	70.7	75.9
Disc thickness	11.4	9.8	12.4	11.8	10.4	10.5	11.8
Snout (preorbital) length	16.4	17.4	18.1	17.7	16.7	17.3	18.5
Snout (preorbital) horizontal length	13.5	14.1	15.9	15.2	15.2	15.2	15.9
Pelvic-fin (embedded) length	22.3	20.2	22.4	21.5	21.7	20.5	21.9
Width across pelvic-fin base	16.7	14.0	18.0	16.1	13.7	15.8	17.4
Greatest width across pelvic fins	25.9	20.9	34.9	29.6	27.7	24.5	31.0
Cloaca origin to tail tip	30.7	26.6	30.2	28.9	112.6	117.7	130.0
Tail width at axil of pelvic fins	8.0	6.6	8.2	7.5	8.2	7.5	7.9
Tail height at axil of pelvic fins	5.5	4.9	6.2	5.3	5.0	4.4	4.9
Pectoral-fin insertion to sting origin	35.8	35.6	39.6	37.3	36.3	36.1	38.8
Cloaca origin to sting	39.7	36.0	41.4	39.0	37.3	37.7	39.5
Tail width at base of sting	3.1	3.0	3.3	3.2	3.1	3.1	3.3
Tail height at base of sting	3.2	2.5	3.4	3.0	3.0	2.6	3.1
Sting 1 length	19.2	13.4	20.2	17.2	–	15.6	15.6
Sting 2 length	0.0	16.0	23.5	19.8	–	18.5	18.5
Snout preoral (to lower jaw) length	15.9	15.9	18.8	17.5	16.9	16.7	18.3
Mouth width	7.1	7.1	8.1	7.5	6.7	6.4	7.1
Distance between nostrils	7.7	7.0	8.5	7.8	7.4	7.0	7.2
Interorbital width	9.4	8.3	9.7	8.9	8.1	9.1	9.2
Inter-eye width	15.5	14.1	15.9	15.1	14.0	14.0	14.7
Snout to maximum width	40.0	37.8	41.5	39.1	38.2	36.8	38.8
Eye length	5.1	5.3	6.2	5.6	5.6	5.1	5.2
Orbit diameter	7.3	6.3	7.7	7.0	8.4	6.9	7.0
Spiracle length	6.2	5.2	6.3	5.9	5.7	5.4	6.1
Interspiracular width	14.0	13.2	14.6	13.7	12.7	13.1	13.3
Orbit and spiracle length	9.6	8.9	10.7	9.8	10.3	8.9	9.7
Nostril length	3.5	3.2	3.6	3.4	2.7	2.6	3.0
Snout prenasal length	12.3	12.2	14.4	13.5	12.5	13.1	13.6
Nasal curtain length	4.8	5.9	7.2	6.5	5.9	4.4	5.8
Nasal curtain width	9.4	8.8	9.9	9.3	8.5	7.8	8.3
Orbit to pectoral-fin insertion	50.5	49.9	54.3	51.6	47.8	48.9	54.7
Snout to origin of cloaca	69.3	69.8	73.4	71.1	68.2	68.4	73.2
Width 1st gill slit	3.3	2.9	3.7	3.2	2.9	2.8	3.1
Width 3rd gill slit	3.4	2.8	3.5	3.2	3.0	3.1	3.2
Width 5th gill slit	2.3	1.9	2.3	2.1	2.1	2.1	2.1
Head length	38.2	38.9	42.3	40.3	38.8	38.3	38.4
Distance between 1st gill slits	16.1	15.2	17.1	16.2	15.3	15.7	16.2
Distance between 5th gill slits	10.2	8.7	9.8	9.3	8.8	8.5	9.1
Cloaca length	6.4	4.6	6.7	5.7	4.5	5.2	6.3
Clasper postcloacal length	–	20.8	23.3	21.9	20.0	–	–
Clasper length from pelvic axil	–	13.7	15.3	14.7	12.9	–	–

Table 2. Morphometry of the dorsal and ventral skin folds of the holotype of *Neotrygon picta* sp. nov. (CSIRO H 5777–01), with ranges and means provided for measured paratypes and for the holotype (CSIRO CA 2806) and two paratypes (CSIRO T 676 and CSIRO T 681) of *Neotrygon leylandi*. Measurements expressed as a percentage of disc width; quartile points taken from orgin of ventral fold.

	***Neotrygon picta* sp. nov.**				***Neotrygon leylandi***		
	Holotype	Paratypes			Holotype	Paratypes	
		Min.	Max.	Mean		Min.	Max.
Dorsal fold base length	23.9	17.3	28.5	21.8	23.2	21.7	25.2
Dorsal fold maximum height	1.1	0.9	1.4	1.1	1.3	1.4	2.0
Ventral fold base length	57.4	54.8	77.6	65.1	66.5	56.8	68.9
Tail width at origin of ventral fold	2.8	2.9	3.5	3.1	3.6	3.5	3.5
Tail height at origin of ventral fold	3.1	2.5	3.3	2.8	3.0	2.7	3.0
Tail width at quarter length of ventral fold	1.3	1.4	1.7	1.6	1.6	1.7	2.1
Tail height at quarter length of ventral fold	1.8	1.4	2.2	1.8	2.0	1.9	2.0
Fold height at quarter length of ventral fold	1.1	1.0	1.8	1.4	1.3	1.2	1.5
Tail width at mid-length of ventral fold	0.8	0.9	1.2	1.0	1.2	1.2	1.2
Tail height at mid-length of ventral fold	1.2	1.2	1.6	1.4	1.6	1.7	1.8
Fold height at mid-length of ventral fold	1.1	1.0	1.6	1.3	1.0	1.2	1.2
Tail width at three quarter length of ventral fold	0.6	0.6	0.9	0.7	0.7	0.9	1.1
Tail height at three quarter length of ventral fold	1.0	0.8	1.2	0.9	1.0	1.2	1.2
Fold height at three quarter length of ventral fold	0.6	0.1	1.1	0.7	0.4	0.7	0.8
Tail width at end of ventral fold	0.5	0.4	0.7	0.5	0.5	0.7	1.1
Tail height at end of ventral fold	0.8	0.5	0.6	0.5	0.7	0.8	0.8
Tail length posterior to ventral fold	4.9	0.3	19.8	11.7	8.8	21.0	22.2
Ventral fold origin to sting origin interspace	0.7	0.7	2.9	1.5	1.3	1.9	2.3

knob, interlocking into upper jaw when mouth closed; teeth not visible when mouth closed. Teeth in upper jaw of adult male paratype small, variable in shape; those at symphysis barely larger than those laterally, directed lingually, with long bluntly pointed cusps, slightly less oblique than those posterolaterally; in female paratype, teeth with very short cusps, in quincunx, those at 8th row from corner of mouth enlarged with a prominent distal cusp. Teeth in lower jaw of adult male similar in size and shape to those of symphysis of upper jaw, those toward angle of lower jaw with slightly shorter cusps; in female paratype uniformly short cusped to acuspid, in quincunx. Floor of mouth in adult male and large female paratypes with 2 long, very closely spaced, medial oral papillae; no smaller papilla near angle of each jaw.

Gill slits elongated S-shaped, forming a weakly fringed lobe laterally; length of first gill slit 1.46 (1.25–1.73) times length of fifth gill slit, 2.15 (2.06–2.78) times in mouth width; distance between first gill slits 2.08 (1.96–2.30) times internarial space, 0.42 (0.39–0.42) times ventral head length; distance between fifth gill slits 1.31 (1.11–1.33) times internasal distance, 0.27 (0.22–0.25) times ventral head length.

Total pectoral-fin radials 101–102 (101–105); propterygium 40–41 (42–44), mesopterygium 17 (15–16), metapterygium 44 (43–46). Pelvic-fin radials: females (n=4) 1 (1) + 20 (21–23); males (n=2) (1 + 18–19). Vertebral centra total (including synarcual) 117 (113–122); total (excluding synarcual) 114 (109–118); monospondylous (including synarcual) 37 (37–40); monospondylous (excluding synarcual) 34 (32–35); pre-sting diplospondylous 60 (57–67); post-sting diplospondylous 20 (14–23).

SQUAMATION.— Disc and tail lacking denticles, except for a single series of small, spear-shaped to narrow lanceolate thornlets along mid-line of disc in nucho-scapular region; row continuous, with 8 (5–22) closely spaced thornlets; in holotype, row length slightly shorter than interspiracular width (similar for most paratypes except CSIRO H 3332–02 where evidence of denticle row extending onto posterior disc); largest thornlet barely larger than those adjacent, angle at about 45° to horizontal (appearing saw-shaped in lateral view); development of denticles probably rapid, absent in paratypes <175 mm DW (CSIRO H 3333–03 and CSIRO H 3895–01), but present in smallest mature males 170–183 mm DW (CSIRO H 1218–01, CSIRO H 3361–07 and CSIRO H 3374–06); lateral scapular thorns absent, but some minute, widely-spaced denticles present in this

Figure 4. Lateral view of the post-stinging spine tail of *Neotrygon picta* sp. nov., female holotype (CSIRO H 5771–01, 236 mm DW).

area in largest individuals.

Stinging spine(s) of holotype two (usually with one in smallest paratypes, usually with two in largest paratypes), uppermost stinging spine intact, slightly shorter than lower spine (damaged); stinging spines elongate, slender, narrow based, longer or subequal to snout length when intact; distance from sting base to pectoral-fin insertion 35.8% (35.6–39.6%) DW, 1.86 (1.80–2.88) times sting length; distance from cloaca to sting base 0.47 (0.43–0.49) in disc length.

COLOUR.— Dorsal surface with a variable underlying pattern of either faint or well-defined, coarse, dark greyish brown reticulations on a paler yellowish brown body; variably peppered with irregular scattering of asymmetric black spots (up to 3.5 mm in diameter); peppering often densest in large adults (particularly so in holotype), but variable; in holotype, peppering densest in position of mask (across interorbit and beside orbit) and on scapular region; mask-like pattern around eyes variably developed in paratypes, from particularly obvious to indistinct; orbital membrane usually with at least some dark spots, dense in holotype; posterior margin of disc and pelvic fins slightly paler than central area, often lacking reticulations and spots; thornlets on midline and stinging spine(s) whitish to translucent; inner spiracles usually whitish. Ventral surface of disc and pre-stinging spine tail uniformly white; outer margin of pectoral and pelvic fins sometimes slightly dusky. Tail before stinging spine similar to dorsal disc (reticulations and spots usually evident in preserved material); post-sting tail with weak, dark saddles to weakly banded, usually white tipped when undamaged (lacking strong alternating black and white bands); dorsal skin fold variegated, markings on lateral tail usually extending onto fold; ventral skin fold with a whitish base, distal half dark, almost black (less pronounced in some larger paratypes).

SIZE.— Specimens examined ranged from 90–275 and 100–240 mm DW for females and males, respectively. Adolescent males 115–172 mm DW, adult males 170–237 mm DW. New-born specimens 90–105 mm DW.

DISTRIBUTION.— Known from the inner continental shelf waters of northern and northeastern Australia from the Arafura Sea off the Northern Territory (08°57′ S, 135°00′ E) to east of Rockhampton, Queensland (23°15′ S, 151°15′ E), at depths of 5–96 m.

ETYMOLOGY.— Derived from the Latin *pictus* (painted, coloured) with reference to the colour pattern of peppery spots on a well-defined or weak reticulate background. Vernacular: Peppered Maskray.

REMARKS.— *Neotrygon picta* differs from *N. kuhlii* in its smaller maximum size (275 mm DW vs. to at least 470 mm DW) and lacking prominent blue spots on the dorsal disc. Like *N. leylandi* (Fig. 5a), it usually has a strong colour pattern of brownish reticulations (dorsal disc plain in *N. annotata*) but it differs from *N. leylandi* in other aspects of its colour pattern (reticulated pattern strongly peppered with small black spots vs. lacking these spots), and in the following morphometric and meristic characters: interspiracular distance 13.2–14.6 vs. 12.7–13.3% DW; nostril length 3.2–3.6 vs. 2.6–3.0% DW; nasal curtain width 8.8–9.9 vs. 7.8–8.5% DW; mouth width 7.1–8.1 vs. 6.4–7.1% DW; total pectoral-fin radials 101–105 vs. 107–108. It also differs in the structure of the CO1 gene (Ward *et al*., 2008).

Regional Indo–Pacific variants currently identified in the literature as *Dasyatis kuhlii* have a unique CO1 and are probably distinct species. A revision of the group is needed to identify these taxa and provide additional characters other than colour to separate them. A close examination of the holotype of *Raya trigonoides* Castelnau, 1873 from New Caledonia (Fig. 5b) confirmed that it is conspecific with eastern Australian forms of *N. kuhlii*. Forms from this region seem to lose their blue spots in preservative but retain some dark speckling similar to *N. picta*. The two species differ markedly in vertebral (total centra including synarcual 131–132 in eastern Australian/Papua New Guinea *N. kuhlii*, n=2 vs. 113–122 in *N. picta*, n=6) and pectoral-fin radial counts (113–115 vs. 101–105).

Comparative material.
Neotrygon leylandi. CSIRO CA 2806 (holotype), adult male 192 mm DW. CSIRO T 676 (paratype), female 190 mm DW; CSIRO T 681 (paratype), female 254 mm DW; CSIRO H 1458–06, female 223 mm DW; CSIRO H 1458–07, female 215 mm TL; CSIRO H 1458–08, adolescent male 160 mm DW; CSIRO H 6659–04.
Raya trigonoides. NMV 51864 [=A5255] (holotype), immature male 182 mm DW, New Caledonia.
Neotrygon kuhlii. 2 specimens: CSIRO H C 850, juvenile male 150 mm TL; CSIRO H 5965–01, juvenile male 250 mm TL.

A

B

Figure 5. Dorsal view of: A. *Neotrygon leylandi*, adult male holotype (CSIRO CA 2806, 192 mm DW, preserved); B. *Raya trigonoides*, juvenile male holotype (NMV 51684, 182 mm DW, preserved).

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Three new species of the genus *Chimaera* Linnaeus (Chimaeriformes: Chimaeridae) from Australia

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ABSTRACT.— Three new chimaerid species, *Chimaera fulva* sp. nov., *C. macrospina* sp. nov. and *C. obscura* sp. nov., are described based on material collected from the mid and lower continental slope of southern Australia. The three new species differ from each other and from other *Chimaera* species by a combination of coloration, morphology and structure of the CO1 gene. The new species are characterised by having a large interspace between pectoral and pelvic fins, and a relatively tall second dorsal fin, but are separable based on coloration, length of dorsal spine, structure of the CO1 gene and some additional morphological characteristics.

Key words. Chimaeridae – *Chimaera fulva* – *Chimaera macrospina* – *Chimaera obscura* – new species – southern Australia

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INTRODUCTION

Members of the Order Chimaeriformes (chimaeras, ghostsharks or ratfishes) are an ancient group of deep-sea cartilaginous fishes which are found throughout the world and belong to one of three families, i.e. Callorhinchidae, Chimaeridae and Rhinochimaeridae (Didier, 2004). The majority of species belong to the Family Chimaeridae (ca. 34 species) which consists of two genera that are distinguished by the presence (*Chimaera*) or absence (*Hydrolagus*) of an anal fin (Last & Stevens, 1994; Eschmeyer, 2008). However, it has been shown recently that the anal fin can be present or absent in at least one species which questions the robustness of this character alone to separate the genera. The genus *Chimaera* was proposed by Linnaeus (1758) for *C. monstrosa* from the Atlantic. A total of 7 species of *Chimaera* are currently recognised as nominal species (Eschmeyer, 2008): *C. cubana* Howell Rivero, 1936; *C. jordani* Tanaka, 1905; *C. lignaria* Didier, 2002; *C. monstrosa*; *C. owstoni* Tanaka, 1905; *C. panthera* Didier, 1998; and *C. phantasma* Jordan & Snyder, 1900. Last & Stevens (1994) treated 5 species of *Chimaera* from Australian waters, *C*. sp. A–E, with one of these, *C*. sp. D, since being described by Didier (2002) as *C. lignaria*. Thus, with inclusion of the 4 remaining undescribed species, a total of 11 species of *Chimaera* are currently recognised. This paper formally names and describes three new species of *Chimaera*, previously referred to as *C*. sp. A–C (Last & Stevens, 1994).

METHODS

Measurements follow Compagno *et al*. (1990) and Didier (2002), and were taken directly (point to point), rather than horizontally, using calipers. A total of 34 measurements were taken: total length (TL); precaudal length (PCL); body length (BDL); snout-vent length (SVL); trunk length (TRL); pre-second dorsal length (PD2); pre-first dorsal length (PD1); second dorsal fin base (D2B); anterior second dorsal fin, maximum height (D2AH); posterior second dorsal fin, maximum height (D2PH); caudal dorsal margin (CDM); dorsal caudal fin, maximum height (CDH); total caudal fin length including filament (CTL); caudal ventral margin (CVM); ventral caudal fin, maximum height (CVH); head length (HDL); preorbital length (POB); first dorsal fin base (D1B); dorsal spine length (DSA); first dorsal fin, maximum height (D1H); pectoral fin anterior margin (P1A); pelvic fin anterior margin (P2A); interdorsal space (IDS); dorsal–caudal space (DCS); posterior base of pectoral fin to anterior base of pelvic fin (PPS); anterior edge of first dorsal fin base to anterior edge of pectoral fin base (D1P1); anterior edge of base of first dorsal fin to anterior edge of pelvic base (D1P2); anterior edge of second dorsal fin base to anterior edge of pectoral fin base (D2P1); anterior edge of second dorsal fin base to anterior edge of pelvic fin base (D2P2); horizontal eye length (EYL); vertical eye height (EYH); total length of claspers from pelvic fin base to tip (CLT); length of medial branch of clasper from fork to tip (CLM); length of lateral branch of clasper from fork to tip (CLL).

All measurements were taken on preserved specimens. For *Chimaera* sp. A, the holotype (CSIRO H 5301–08) and 5 paratypes (CSIRO H 2294–02, CSIRO H 2584–22, CSIRO H 2616–03, CSIRO H 2621–03 and CSIRO H 4873–05) were measured in full. For *Chimaera* sp. B, the holotype (CSIRO H 1383–02) and paratype (CSIRO H 1383–01) were measured in full. For *Chimaera* sp. C, the holotype (CSIRO H 1517–02) and 5 paratypes (CSIRO H 1382–01, CSIRO H 2284–01, CSIRO H 2302–01, CSIRO H 2549–06 and CSIRO H 6417–02) were measured in full. Type specimens are deposited in the Australian National Fish Collection, Hobart (CSIRO); their registration numbers are prefixed with this acronym.

Chimaera fulva sp. nov.

Fig. 1; Table 1

Chimaera sp. A: Last & Stevens, 1994: pp 468–470, key fig. 8, fig. 48.1, pl. 83.

Chimaera sp. 1: May & Maxwell, 1986: p 158, fig.

Hydrolagus sp.: Last *et al*., 1983: p 169, fig. 12.3.

Holotype. CSIRO H 5301–08, female 972 mm TL, 474 mm BDL, south-east of Cape Everard, Victoria, 38°20′ S, 149°41′ E, 991–1009 m, 17 Apr 2000.

Paratypes. 6 specimens: CSIRO H 1190–03, female 717 mm TL (damaged), 348 mm BDL, east of Sydney, New South Wales, 33°44′ S, 152°01′ E, 990–1005 m, 18 Feb 1988; CSIRO H 2294–02, adult male 1000 mm TL, 524 mm BDL, south of King Island, Tasmania, 40°53′ S, 143°41′ E, 815–820 m, 09 Mar 1989; CSIRO H 2584–22, female 846 mm TL, 440 mm BDL, west of Shoal Point, Western Australia, 28°00′ S, 112°41′ E, 854–853 m, 01 Feb 1991; CSIRO H 2616–03, juvenile male 684 mm TL, 340 mm BDL, west of Mandurah, Western Australia, 32°38′ S, 114°26′ E, 880–960 m, 14 Feb 1991; CSIRO H 2621–03, adolescent male 811 mm TL, 465 mm BDL, west of Bunbury, Western Australia, 33°24′ S, 114°22′ E, 780–817 m, 16 Feb 1991; CSIRO H 4873–05, female 964 mm TL, 543 mm BDL, Cascade Plateau, Tasman Sea, 44°01′ S, 150°28′ E, 950 m, 12 Oct 1998.

Other material. 13 specimens: CSIRO H 1380–01, adolescent male 960 mm TL, 488 mm BDL, east of Jervis Bay, New South Wales, 35°20′ S, 151°01′ E, 1075–1095 m, 29 Mar 1988; CSIRO H 2294–01, adult male 795 mm TL (damaged), 484 mm BDL, south of King Island, Tasmania, 40°53′ S, 143°41′ E, 815–820 m, 09 Mar 1989; CSIRO H 2295–01, female 960 mm TL (damaged), 553 mm BDL, south-west of King Island, Tasmania, 40°36′ S, 143°26′ E, 845–850 m, 08 Mar 1989; CSIRO H 2296–01, female 1187 mm TL, 661 mm BDL, west of Cape Sorell, Tasmania, 42°14′ S, 144°42′ E, 845–845 m, 18 Mar 1989; CSIRO H 2297–01, adult male 795 mm TL (damaged), 465 mm BDL, locality unknown, New South Wales?, 1988; CSIRO H 2301–01, female 854 mm TL (damaged), 500 mm BDL, Great Australian Bight, Western Australia, 33°45′ S, 127°15′ E, 993–1020 m, 02 Nov 1989; CSIRO H 2349–01, female 667 mm TL (damaged), 473 mm BDL, south of Cape Leeuwin, Western Australia, 35°07′ S, 115°01′ E, 945 m, 23 Dec 1989; CSIRO H 2500–03, female 697 mm TL (damaged), 390 mm BDL, east of Broken Bay, New South Wales, 33°33′ S, 152°09′ E, 1037–1049 m, 12 Feb 1986; CSIRO H 2592–01, female 797 mm TL, 397 mm BDL, west of Leander Point, Western Australia, 29°20′ S, 113°45′ E, 942–970 m, 06 Feb 1991; CSIRO H 2616–12, juvenile male 723 mm TL (damaged), 355 mm BDL, west of Mandurah, Western Australia, 32°38′ S, 114°26′ E, 880–960 m, 14 Feb 1991; CSIRO H 2621–02, female 928 mm TL, 489 mm BDL, west of Bunbury, Western Australia, 33°24′ S, 114°22′ E, 780–817 m, 16 Feb 1991; CSIRO H 2878–01, female 816 mm TL, 412 mm BDL, Great Australian Bight, South Australia, 33°47′ S, 131°00′ E, 910–920 m, 06 Mar 1992; CSIRO H 2961–02, female 697 mm TL (damaged), 426 mm BDL, Great Australian Bight, South Australia, 33°36′ S, 129°52′ E, 852–952 m, 01 Jun 1992.

DIAGNOSIS.— *Chimaera fulva* is distinguished from its congeners by the following combination of characters: thin, deciduous skin; silvery pink to pale brownish in colour; preopercular and oral lateral line canals sharing a common branch; dorsal spine short, subequal or slightly shorter than first dorsal fin; claspers of adult males long (17–19% BDL), trifurcate, divided for slightly less than half of their length; structure of the CO1 gene.

DESCRIPTION.— Snout short, preorbital snout 6.7 (7.1–8.0) in body length; tip broadly pointed in lateral view, narrowly pointed in dorsoventral view. Postorbital head compressed. Eyes large, horizontally oval, directed slightly anterodorsally; horizontal length 4.14 (3.15–3.66) in head length, vertical height 0.93 (0.71–0.76) times horizontal length; almost lateral on head, with weak subocular ledges. Gill openings large, broadly separated, with prominent posterior flap which stands outwards from base of head and forms a short tube with rear end of gill cover. Gular flap between gill openings low. Nostrils, lips and mouth expanded below ventral contour of snout. Nostrils with incurrent apertures close together on underside of snout located close to mouth, separated by a narrow septum; a deep blind dermal pocket between incurrent apertures; anterior nasal flaps extending posteriorly from incurrent apertures lateral to tooth plates of upper jaw and delimiting ventromedial surfaces of nasal cavities; nasal cavities delimited ventrolaterally by high, narrow, longitudinal vertical flap with a lobular distal end; excurrent apertures posterior to incurrent apertures and vertical flap, lateral to tooth plates of upper jaw, and inside pockets formed by large upper labial folds.

Mouth narrow, short; upper labial folds and furrows prominent; upper and lower furrows deep; lower lip

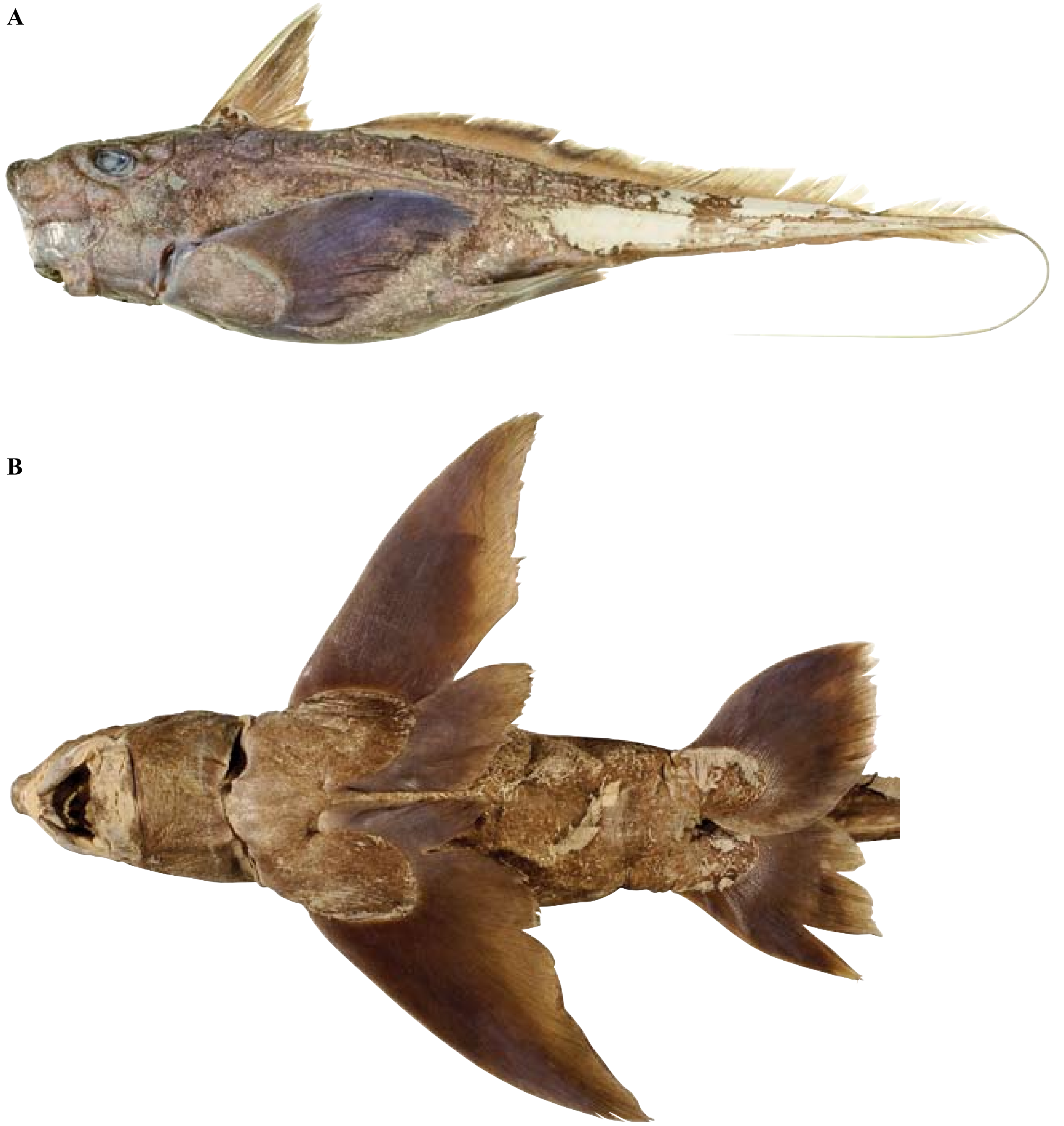

Figure 1. *Chimaera fulva* sp. nov., female holotype CSIRO H 5301–08 (972 mm TL, 474 mm BDL): A. lateral view (right side, image reversed); B. ventral view (excluding tail).

with a deep pocket between mandibular tooth plates and its outer edge. Upper anterior tooth plates (vomerine tooth plates) small, incisor-like with 5–6 tritors visible; posterior upper tooth plates (palatine) with very small, knobby tritors on wear surface, only several small tritors evident on anterior margins; lower tooth plates (mandibular) incisor like with tritors along edge of wear, forming a concave ridge posteriorly; tooth plates pale.

Trunk short and slightly compressed; deep groove on interdorsal space which partly receives depressed first dorsal fin; a low membrane connects soft elements of first and second dorsal fins; precaudal tail tapering evenly from pelvic fins to caudal base; anal insertion connected to ventral origin of caudal fin by a low membrane. Skin smooth, leathery, with fine corrugations on parts of head. Dermal denticles absent.

Lateral line canal originating at fork between occipital and otic head canals at level of upper eye; deeply notched anteriorly, then strongly elevated below first dorsal spine, extending posteriorly in a nearly straight, non-waved line; line directed posteroventrally beyond insertion of second dorsal fin, reaching ventral margin of tail slightly forward of midpoint of fin; line running along ventral margin of tail to caudal filament. Occipital canals short, only slightly longer than half eye length, directed almost vertically, arched slightly posteriorly, united to supratemporal and supraorbital canals about two-thirds distance between eye and dorsal-fin spine origin, near dorsal margin of head when viewed laterally. Supratemporal canals short, curved anteriorly, united at dorsal midline slightly forward of dorsal-fin spine. Supraorbital canal extending anteriorly from supratemporal junction, curving weakly to strongly anteroventrally then becoming straight parallel to dorsal margin of eye, strongly notched slightly forward of eye, following profile of snout tip apically to join infraorbital canal. Otic canal longer than occipital canal, distinctly longer than eye length, united to infraorbital and origin of oral and preopercular canals below hind margin of eye. Preopercular and oral canals sharing a common branch from infraorbital-otic junction. Preopercular canal extending posteroventrally; termination obscure, between upper and mid gill. Oral canal short, extending anteroventrally, divided into mandibular and angular canals below mid eye. Mandibular canal extending slightly ventrolaterally, upper portion curved posteriorly, joined to post-oral pores near mouth. Angular canal sub-horizontal, directed slightly anteroventrally, with prominent sensory pores, divided into nasal and subrostral canals near ventral margin of snout when viewed laterally; nasal canals strongly arched ventrally, then directed anterodorsally to unite on midline of snout slightly more than a nostril length from nostril; subrostral canal parallel to anterior portion of nasal canal, left and right branches united slightly forward of prenarial snout. Infraorbital canal long, from otic junction directed anterodorsally, following ventral contour of eye; forming a prominent S-shaped, double loop forward of eye; united to supraorbital canal slightly less than half eye length from snout tip near ventral midline of snout. Ampulla pores present anterior to occipital and mandibular canals, at angle of infraorbital and oral canals, below upper margin of infraorbital canal, and concentrated on snout tip.

Dorsal-fin spine long, subequal in length to soft first dorsal fin, slightly convex anteriorly, spine length 1.10 (0.95–1.39) in head length, 1.19 (1.05–1.15) times first dorsal-fin height; origin over pectoral-fin origin; anterior margin of spine forming a narrow keel, not serrated; posterior distal margin of spine finely serrated. Soft portion of first dorsal fin with a relatively short base, slightly longer than snout length; posterior margin of fin moderately concave.

Second dorsal long-based, margin not to weakly incised (possibly due to preservation), mostly uniform in height, length of longest elements subequal to eye length; origin slightly anterior to midpoint of depressed dorsal-fin spine; insertion slightly forward of anal-fin insertion; united to upper lobe of caudal fin by a low membrane.

Pectoral fins long, broad, subfalcate; anterior margin weakly convex anteriorly, strongly convex distally; apex narrowly pointed; posterior margin almost straight, more concave distally; inner margin, free rear tip and ventral portion of posterior margin broadly rounded; anterior margin 42.9 (36.9–41.0)% BDL; apex when laid adpressed to body extending slightly posterior to origin of pelvic fin. Pelvic fin large, broad, paddle-shaped; anterior margin strongly convex; apex angular; posterior margin, free rear tip and inner margin broadly convex.

Frontal tenaculum of adult male paratype (CSIRO H 2294–02) with a narrow neck (about half eye length) and a prominent distal knob; distal knob with eight longitudinal rows of 3–8 pointed, slender, posteriorly directed, unicuspid spines on its sides and ventral surface. Pelvic claspers of adult male paratype (CSIRO H 2294–02) relatively long (clasper total length 19% BDL), trifurcate, not extending beyond distal edge of the pelvic fins; divided for slightly less than half their length; bulbous distally with large patches of bristles. Prepelvic tenaculae of adult male paratype (CSIRO H 2294–02) blade-like, concealed in pouches anterior to the pelvic fins, with 6–7 stout denticles along the medial edge. Females with fleshy anal pad posterior to the cloaca, lacking in males.

Caudal fin short, much lower than second dorsal fin, margins of dorsal and ventral lobes strongly convex; dorsal and ventral lobes subequal in height; dorsal lobe insertion well anterior to ventral lobe insertion; height of dorsal lobe 0.98 (0.69–1.35) times height of ventral lobe; caudal filament very long (when undamaged), slender.

COLOUR.— When fresh: Pale brownish to silvery pinkish dorsally and laterally, slightly paler ventrally; sides of tail below lateral line canal usually with several faint longitudinal stripes; caudal filament white; first dorsal fin pale brownish, posterior margin paler; second dorsal fin pale brownish basally, dusky on upper half of fin. **Preserved specimens:** Pale brownish dorsally and laterally; faint longitudinal stripes on sides of tail still evident; first dorsal, caudal, pectoral and pelvic fins brown, with pale posterior margins; second dorsal fin pale brownish basally, darkish brown to dusky distally; claspers pale.

SIZE.— Material examined ranged from ca. 667–1187 mm TL, 348–661 mm BDL for females, and ca. 684–1000 mm TL, 340–524 mm BDL for males. A single adolescent male of 811 mm TL, 465 mm BDL; adult males 795 (damaged)–1000 mm TL, 465–524 mm BDL.

DISTRIBUTION.— Material examined collected on the mid continental slope of southern Australia from east of Broken Bay in New South Wales (33°33′ S, 152°09′ E) to west of Shoal Point in Western Australia (28°00′ S, 112°41′ E), including Tasmania, at depths of 780–1095 m.

ETYMOLOGY.— The species name is derived from the Latin *fulva* (brown) in allusion to the pale brownish body coloration. Vernacular: Southern Chimaera.

REMARKS.— *Chimaera fulva* differs from other Indo–Pacific species of *Chimaera* by a combination of morphology, coloration, size and structure of the CO1 gene.

Chimaera fulva differs from *C. owstoni* and *C. panthera* in being uniformly coloured rather than having a colour pattern dominated by distinct dark reticulations or mottling. It also differs from *C. lignaria* in colour pattern (pale brownish to silvery pink vs. grey-blue to lavender) and size (attaining 1187 mm TL, 661 mm BDL vs. 1420 mm TL, 890 mm BDL; Didier, 2002). *Chimaera fulva* differs from *C. jordani* in body colour (pale brownish to silvery pink dorsally and laterally, paler ventrally vs. uniformly dark brown or black) and height of second dorsal fin (height of posterior part of second dorsal fin almost twice height of dorsal caudal-fin lobe vs. subequal to) (Nakabo, 2002; Didier, 2004). *Chimaera fulva* is clearly separable from *C. phantasma* in having a lateral line canal without undulations along its entire length (vs. with tight sinuous undulations along its entire length) and a longer interspace between pectoral and pelvic fins (vs. pectoral fin free rear tip much further forward of pelvic-fin origin vs. just anterior to pelvic-fin origin).

As part of a concurrent study that aims to genetically barcode Australia's fish species, Ward *et al.* (2008), found that cytochrome oxidase subunit 1 (CO1) sequences readily distinguished *C. fulva* (n=6; as *C.* sp. A), *C. panthera* (n=1) and *C. lignaria* (n=4).

Chimaera macrospina sp. nov.

Fig. 2; Table 1

Chimaera sp. C: Last & Stevens, 1994: pp 468, 471–472, key fig. 7, fig. 48.3, pl. 83; Compagno, 1999: pp 1534, 1536, fig.

Holotype. CSIRO H 1517–02, female 820 mm TL, 466 mm BDL, east of Brush Island, New South Wales, 35°32′ S, 150°52′ E, 1060–1100 m, 12 May 1988.
Paratypes. 7 specimens: CSIRO H 1382–01, adolescent male 939 mm TL, 563 mm BDL, CSIRO H 1382–02, adult male ca. 925 mm TL, 605 mm BDL, east of Brush Island, New South Wales, 35°31′ S, 150°52′ E, 1135–1190 m, 29 Mar 1988; CSIRO H 2284–01, female 792 mm TL, 352 mm BDL, west of Lihou Reef and Cays, Queensland Plateau, Queensland, 16°54′ S, 151°30′ E, 880 m, 06 Dec 1985; CSIRO H 2302–01, adult male 926 mm TL, 608 mm BDL, east of Nowra, New South Wales, 34°53′ S, 151°14′ E, 1080–1115 m, 06 Sep 1988; CSIRO H 2348–01, female ca. 940 mm TL, 511 mm BDL, north-west of Cape Naturaliste, Western Australia, 33°20′ S, 114°30′ E, 435 m, 25 Dec 1989; CSIRO H 2549–06, adolescent male 746 mm TL, 444 mm BDL, west of North West Cape, Western Australia, 21°49′ S, 113°47′ E, 650–685 m, 24 Jan 1991; CSIRO H 6417–02, female 1034 mm TL, 527 mm BDL, north-west of North West Cape, Western Australia, 19°39′ S, 113°12′ E, 886–907 m, 16 May 2006.

DIAGNOSIS.— *Chimaera macrospina* is distinguished from its congeners by the following combination of characters: thin, deciduous skin; uniformly chocolate brown in colour; preopercular and oral lateral line canals usually sharing a common branch; dorsal spine long, longer than first dorsal fin; claspers of adult male short (11–13% BDL), trifurcate, divided at about distal third of clasper; structure of the CO1 gene.

DESCRIPTION.— Snout short, preorbital snout 9.7 (7.4–9.7) in body length; tip broadly pointed in lateral view, narrowly pointed in dorsoventral view. Postorbital head compressed. Eyes large, horizontally oval, directed slightly anterodorsally; horizontal length 3.89 (3.28–4.37) in head length, vertical height 0.66 (0.69–0.73) times horizontal length; almost lateral on head, with very weak subocular ledges. Gill openings moderately large, broadly separated, with prominent posterior flap which stands outwards from base of head and forms a short tube with rear end of gill cover. Gular flap between gill openings low. Nostrils, lips and mouth expanded below ventral contour of snout. Nostrils with incurrent apertures close together on underside of snout located close to mouth, separated by a narrow septum; a deep blind dermal pocket between incurrent apertures; anterior nasal flaps extending posteriorly from incurrent apertures lateral to tooth plates of upper jaw and delimiting ventromedial surfaces of nasal cavities; nasal cavities delimited ventrolaterally by high, narrow, longitudinal vertical flap with a lobular distal end; excurrent apertures posterior to incurrent apertures and vertical flap, lateral to tooth plates of upper jaw, and inside pockets formed by large upper labial folds.

Mouth narrow, short; upper labial folds and furrows prominent; upper and lower furrows deep; lower lip with a deep pocket between mandibular tooth plates and its outer edge. Upper anterior tooth plates (vomerine tooth plates) small, incisor-like with 5 tritors visible; posterior upper tooth plates (palatine) with small, knobby tritors on wear surface, around 6 very small tritors evident on anterior margins; lower tooth plates (mandibular) incisor like with several tritors along edge of wear, forming a concave ridge posteriorly; upper anterior and lower tooth plates mostly pale yellowish (sometimes dusky basally), upper posterior tooth plates dark greyish.

Figure 2. *Chimaera macrospina* sp. nov., female holotype CSIRO H 1517–02 (820 mm TL, 466 mm BDL): A. lateral view; B. ventral view (excluding tail).

Trunk short and slightly compressed; deep groove on interdorsal space which partly receives depressed first dorsal fin; a low membrane connects soft elements of first and second dorsal fins; precaudal tail tapering evenly from pelvic fins to caudal base; anal insertion connected to ventral origin of caudal fin by a low membrane. Skin smooth, leathery, with fine corrugations on parts of head. Dermal denticles absent.

Lateral line canal originating at fork between occipital and otic head canals at level of upper eye; weakly to deeply notched anteriorly, then elevated below first dorsal spine, extending posteriorly in a nearly straight, non-waved line; line directed posteroventrally beyond insertion of second dorsal fin, reaching ventral margin of tail at about a third length of dorsal lobe of caudal fin; line running along ventral margin of tail to caudal filament. Occipital canals short, only slightly longer than half eye length, directed almost vertically, sometimes arched slightly posteriorly, united to supratemporal and supraorbital canals about mid-way between eye and dorsal-fin spine origin, near dorsal margin of head when viewed laterally. Supratemporal canals short, curved anteriorly, united at dorsal midline slightly forward of dorsal-fin spine. Supraorbital canal extending anteriorly from supratemporal junction, curving anteroventrally then becoming straight parallel to dorsal margin of eye, strongly notched slightly forward of eye, following profile of snout tip apically to join infraorbital canal. Otic canal longer than occipital canal, distinctly longer than eye length, united to infraorbital and origin of oral and preopercular canals at level of hind margin of eye. Preopercular and oral canals sharing a common branch from infraorbital-otic junction (in paratype CSIRO H 2284-01, not sharing a common branch on left side of head; sharing a very short common branch on right side of head). Preopercular canal extending posteroventrally; termination obscure, between upper and mid gill. Oral canal short, extending anteroventrally, divided into mandibular and angular canals below mid eye. Mandibular canal extending slightly ventrolaterally, upper portion curved posteriorly, joined to post-oral pores near mouth. Angular canal sub-horizontal, directed slightly anteroventrally, with prominent sensory pores, divided into nasal and subrostral canals near ventral margin of snout when viewed laterally; nasal canals strongly arched ventrally, then directed anterodorsally to unite on midline of snout slightly more than a nostril length from nostril; subrostral canal parallel to anterior portion of nasal canal, left and right branches united slightly forward of prenarial snout. Infraorbital canal long, from otic junction directed anterodorsally, following ventral contour of eye; forming a prominent S-shaped, double loop forward of eye; united to supraorbital canal slightly less than half eye length from snout tip near ventral midline of snout. Ampulla pores present anterior to occipital and mandibular canals, at angle of infraorbital and oral canals, below upper margin of infraorbital canal, and concentrated on snout tip.

Dorsal-fin spine very long, taller than soft first dorsal fin, slightly convex anteriorly, spine length 1.13 (0.88–0.97) in head length, 1.17 (1.14–1.35) times first dorsal-fin height; origin over pectoral-fin origin; anterior margin of spine forming a narrow keel, not serrated; posterior distal margin of spine finely serrated. Soft portion of first dorsal fin with a relatively short base, slightly longer than snout length; posterior margin of fin moderately concave.

Second dorsal long-based, margin not to weakly incised (possibly due to preservation), mostly uniform in height, length of longest elements slightly less than eye length; origin slightly anterior of midpoint of depressed dorsal-fin spine; insertion slightly forward of anal-fin insertion; united to upper lobe of caudal fin by a low membrane.

Pectoral fins long, broad, subfalcate; anterior margin weakly convex anteriorly, strongly convex distally; apex narrowly pointed to narrowly rounded; posterior margin almost straight, more concave distally; inner margin, free rear tip and ventral portion of posterior margin broadly rounded; anterior margin 39.5 (37.5–41.4)% BDL; apex when laid adpressed to body extending slightly posterior to origin of pelvic fin (well posterior in some paratypes). Pelvic fin large, broad, paddle-shaped; anterior margin moderately convex; apex angular; posterior margin, free rear tip and inner margin broadly convex.

Frontal tenaculum of adult male paratype (CSIRO H 2302–01) with a narrow neck (about two-thirds eye length) and a prominent distal knob; distal knob with 9 longitudinal rows of 3–7 pointed, slender, posteriorly directed, unicuspidate spines on its sides and ventral surface. Pelvic claspers of adult male paratype (CSIRO H 2302–01) relatively short (clasper total length 11–13% TL), trifurcate, not extending beyond distal edge of the pelvic fins; divided at about distal third of clasper length; slightly enlarged distally with patches of bristles. Prepelvic tenaculae of adult male paratype (CSIRO H 2302–01) blade-like, concealed in pouches anterior to the pelvic fins, with 4–5 very stout denticles along the medial edge. Large females with fleshy anal pad posterior to the cloaca, lacking in males.

Caudal fin short, much lower than second dorsal fin, margins of dorsal and ventral lobes convex; dorsal lobe usually shorter than ventral lobe; dorsal lobe insertion well anterior to ventral lobe insertion; height of dorsal lobe 0.89 (0.56–1.31) times height of ventral lobe; caudal filament very long (when undamaged), slender.

COLOUR.— When fresh: Body uniformly chocolate brown (whitish where skin deciduous). **Preserved specimens:** Head and trunk chocolate brown, darker ventrally; tail dark brownish with several indistinct, pale longitudinal stripes; fins dark brownish to blackish; second dorsal fin with a narrow pale basal portion; dorsal spine mostly dusky to yellowish, slightly darker anteriorly; caudal filament mostly dark brownish, sometimes pale; claspers uniformly dark brownish.

SIZE.— Material examined ranged from 792–1034 mm TL, 352–527 mm BDL for females, and 746–939 mm TL, 444–608 mm BDL for males. Adolescent males 746–939 mm TL, 444–563 mm BDL; two adult males ca. 925–926 mm TL, 605–608 mm BDL.

DISTRIBUTION.— Material examined from the upper to mid continental slope of Western Australia, from Cape Naturaliste (33°20′ S, 114°30′ E) north to North West Cape (19°39′ S, 113°12′ E), and eastern Australia, from Queensland Plateau (16°54′ S, 151°30′ E) south to off Brush Island in New South Wales (35°32′ S, 150°52′ E), at depths of 435–1190 m.

ETYMOLOGY.— The species name is derived from a combination of the Greek *makros* (long) and the Latin *spina* (spine, thorn) in allusion to the very long dorsal spine which is taller than the first dorsal fin. Vernacular: Longspine Chimaera.

REMARKS.— *Chimaera macrospina* differs from other Indo–Pacific species of *Chimaera* by a combination of morphology, coloration, size and structure of the CO1 gene.

Chimaera macrospina differs from *C. owstoni* and *C. panthera* in being uniformly coloured rather than having a colour pattern dominated by distinct dark reticulations or mottling, and differs from *C. lignaria* in colour (chocolate brown vs. grey-blue to lavender) and size (attaining 1034 mm TL, 608 mm BDL vs. 1420 mm TL, 890 mm BDL) (Didier, 2002). *Chimaera macrospina* is similar to *C. jordani* in colour but differs in height of second dorsal fin (height of posterior part of second dorsal fin almost twice height of dorsal caudal-fin lobe vs. subequal to) (Nakabo, 2002; Didier, 2004). *Chimaera macrospina* is clearly separable from *C. phantasma* in having a lateral line canal without undulations along its entire length (vs. with tight sinuous undulations along its entire length) and a longer interspace between pectoral and pelvic fins (vs. pectoral fin free rear tip much further forward to pelvic-fin origin vs. just anterior to pelvic-fin origin).

Chimaera macrospina is clearly separable from *C. fulva* in the following characters: snout-vent length (55.1–61.3 vs. 63.8–67.0% BDL), pre-second dorsal length (40.4–48.5 vs. 49.5–52.7% BDL), pelvic-fin anterior margin length (15.6–18.4 vs. 18.6–22.1% BDL), second dorsal-fin origin to pectoral-fin origin distance (24.2–28.7 vs. 29.7–32.4% BDL) and has smaller claspers (clasper total length 10.8–13.1 vs. 16.7–19.2% BDL, clasper lateral branch length 3.7–5.2 vs. 6.8–9.5% BDL).

Cytochrome oxidase subunit 1 (CO1) sequences readily distinguish *C. macrospina* (n=2), from *C. fulva* (n=6), *C. panthera* (n=1) and *C. lignaria* (n=4) (Ward *et al*., 2008; B.D. Ward, unpubl. data).

Chimaera obscura sp. nov.

Figs 3, 4; Table 1

Chimaera sp. B: Last & Stevens, 1994: pp 468, 470, 471, key fig. 9, fig. 48.2, pl. 83; Compagno, 1999: pp 1534, 1536, fig.

Holotype. CSIRO H 1383–02, female 744 mm TL, 397 mm BDL, east of Tuncurry, New South Wales, 32°06′ S, 153°09′ E, 1025–1080 m, 04 May 1988.
Paratype. CSIRO H 1383–01, female 951 mm TL, 531 mm BDL, collected with holotype.

DIAGNOSIS.— *Chimaera obscura* is distinguished from its congeners by the following combination of characters: thin, deciduous skin; uniformly dark brownish to black in colour; preopercular and oral lateral line canals either sharing a common branch or not sharing; dorsal spine long, longer than first dorsal fin; structure of the CO1 gene.

DESCRIPTION.— Snout short, preorbital snout 8.0 (7.7) in body length; tip broadly pointed in lateral view, narrowly pointed in dorsoventral view. Postorbital head compressed. Eyes large, horizontally oval, directed slightly anterodorsally; horizontal length 3.37 (4.07) in head length, vertical height 0.68 (0.81) times horizontal length; almost lateral on head, with weak subocular ledges. Gill openings large, broadly separated, with prominent posterior flap which stands outwards from base of head and forms a short tube with rear end of gill cover. Gular flap between gill openings low. Nostrils, lips and mouth expanded below ventral contour of snout. Nostrils with incurrent apertures close together on underside of snout located close to mouth, separated by a narrow septum; a deep blind dermal pocket between incurrent apertures; anterior nasal flaps extending posteriorly from incurrent apertures lateral to tooth plates of upper jaw and delimiting ventromedial surfaces of nasal cavities; nasal cavities delimited ventrolaterally by high, narrow, longitudinal vertical flap with a lobular distal end; excurrent apertures posterior to incurrent apertures and vertical flap, lateral to tooth plates of upper jaw, and inside pockets formed by large upper labial folds.

Mouth narrow, short; upper labial folds and furrows prominent; upper and lower furrows deep; lower lip with a deep pocket between mandibular tooth plates and its outer edge. Upper anterior tooth plates (vomerine tooth plates) small, incisor-like with 6 tritors visible; posterior upper tooth plates (palatine) with prominent knobby tritors on wear surface, 6 prominent tritors on anterior margins; lower tooth plates (mandibular) incisor like with tritors along edge of wear, forming a concave ridge posteriorly; tooth plates dark grey to black.

Trunk short and slightly compressed; deep groove on interdorsal space which partly receives depressed first dorsal fin; a low membrane connects soft elements of

Figure 3. Lateral view of *Chimaera obscura* sp. nov., female holotype CSIRO H 1383–02 (744 mm TL, 397 mm BDL).

first and second dorsal fins; precaudal tail tapering evenly from pelvic fins to caudal base; anal insertion connected to ventral origin of caudal fin by a low membrane. Skin smooth, leathery, with fine corrugations on parts of head and body (some of these possibly due to preservation). Dermal denticles absent.

Lateral line canal originating at fork between occipital and otic head canals at level of upper eye; deeply notched anteriorly, then strongly elevated below first dorsal spine, extending posteriorly in a nearly straight, non-waved line (paratype with a minor broad concavity below anterior of second dorsal fin); line directed posteroventrally beyond insertion of second dorsal fin, reaching near ventral margin of tail, slightly behind origin of ventral lobe of caudal fin (more posterior in paratype, declining slightly behind origin of ventral lobe of caudal fin and reaching ventral margin of tail slightly forward of midpoint of fin; line running along ventral margin of tail to caudal filament). Occipital canals short, only slightly longer than half eye length, directed almost vertically, arched slightly posteriorly, united to supratemporal and supraorbital canals about halfway between eye and dorsal-fin spine origin, near dorsal margin of head when viewed laterally. Supratemporal canals short, strongly curved anteriorly, united at dorsal midline slightly forward of dorsal-fin spine. Supraorbital canal extending anteriorly from supratemporal junction, strongly laterally convex above eye, strongly notched slightly forward of eye, following profile of snout tip apically to join infraorbital canal. Otic canal longer than occipital canal, distinctly longer than eye length, united to infraorbital and preopercular canals (sharing a common union with and oral canal in paratype) below hind margin of eye. Preopercular canal extending posteroventrally; termination obscure, between upper and mid gill (persistent ventrally in paratype as a scar). Oral canal very short, extending anteroventrally, divided into mandibular and angular canals below posterior third of eye. Mandibular canal extending slightly ventrolaterally, upper portion curved posteriorly, joined to post-oral pores near mouth. Angular canal sub-horizontal, directed slightly anteroventrally, with prominent sensory pores, divided into nasal and subrostral canals near ventral margin of snout when viewed laterally; nasal canals strongly arched ventrally, then directed anterodorsally to unite on midline of snout slightly more than a nostril length from nostril; subrostral canal parallel to anterior portion of nasal canal, left and right branches united slightly forward of prenarial snout. Infraorbital canal long, from otic junction directed anterodorsally, following ventral contour of eye; forming a prominent s-shaped, double loop forward of eye; united to supraorbital canal slightly less than half eye length from snout tip near ventral midline of snout. Ampulla pores present anterior to occipital and mandibular canals, at angle of infraorbital and oral canals, below upper margin of infraorbital canal, and concentrated on snout tip.

Dorsal-fin spine damaged in holotype; in paratype long, subequal in length to soft first dorsal fin, slightly convex anteriorly, spine length (0.92) in head length, (1.14) times first dorsal-fin height; origin over pectoral-fin origin; anterior margin of spine forming a narrow keel, not serrated; posterior distal margin of spine finely serrated. Soft portion of first dorsal fin with a relatively short base, slightly longer than snout length; posterior margin of fin deeply concave.

Second dorsal long-based, margin strongly incised (possibly through damage), mostly uniform in height, length of longest elements subequal to eye length; origin slightly posterior to midpoint of depressed dorsal-fin spine; insertion slightly forward of anal fin insertion; almost united to upper lobe of caudal fin by a low membrane.

Pectoral fins long, broad, subfalcate; anterior margin almost straight anteriorly, strongly convex distally; apex

A

B

Figure 4. *Chimaera obscura* sp. nov., female paratype CSIRO H 1383–01 (female 951 mm TL, 531 mm BDL): A. lateral view; B. ventral view (excluding tail).

Table 1. Morphometric data for the holotypes of *Chimaera fulva* sp. nov. (CSIRO H 5301–08), *Chimaera macrospina* sp. nov. (CSIRO H 1517–02), and *Chimaera obscura* sp. nov. (CSIRO H 1383–02), with ranges provided for the measured paratype(s). Measurements expressed as a percentage of body length.

	C. fulva **sp. nov.**			***C. macrospina*** **sp. nov.**			***C. obscura*** **sp. nov.**	
	Holotype	Paratypes		Holotype	Paratypes		Holotype	Paratype
		Min.	Max.		Min.	Max.		
TL	205.0	174.3	201.4	175.8	152.3	224.8	187.4	179.1
PCL	124.8	124.2	127.2	124.4	120.4	126.6	124.2	124.3
BDL (mm)	474.2	339.6	543.1	466.4	352.3	608.0	397.0	531.0
SVL	66.8	63.8	67.0	58.7	55.1	61.3	62.2	67.2
TRL	42.8	39.4	43.5	39.8	37.3	40.5	39.1	45.2
PD2	51.0	49.5	52.7	43.6	40.4	48.5	49.3	49.5
PD1	30.2	29.1	31.5	25.6	23.8	28.5	29.6	29.2
POB	14.9	12.6	14.2	10.3	10.3	13.5	12.5	13.1
D2B	74.7	72.9	76.7	79.3	77.2	80.3	77.3	78.5
D2AH	6.0	4.5	5.8	5.2	4.5	6.2	5.0	4.9
D2PH	5.4	3.9	5.1	5.6	4.1	5.8	6.2	6.1
D1B	18.1	14.5	16.4	14.7	13.3	17.6	16.8	17.9
DSA	26.2	22.0	27.8	23.0	25.3	31.2	dam.	27.2
D1H	22.1	19.4	24.1	19.7	19.4	24.4	23.0	23.8
CDM	20.1	16.0	19.7	28.5	15.3	29.6	18.2	20.7
CDH	3.1	2.1	3.1	3.0	1.7	3.2	3.5	3.4
CTL	80.3	48.1	73.7	50.6	31.3	97.4	64.2	55.0
CVM	27.9	24.3	30.4	34.1	27.5	36.0	23.9	27.3
CVH	3.2	2.1	3.0	3.4	2.4	4.4	2.5	3.1
HDL	28.8	26.6	30.6	25.9	24.1	27.3	24.5	25.0
P1A	42.9	36.9	41.0	39.5	37.5	41.4	38.9	39.6
P2A	22.1	18.6	21.7	17.9	15.6	18.4	20.8	20.9
IDS	4.5	5.4	8.5	3.2	2.4	5.1	11.9	9.3
DCS	0	0	0	0	0	1.8	0	0
PPS	33.0	29.0	34.7	32.7	28.8	32.0	31.8	35.8
D1P1	22.8	19.6	21.7	20.0	18.3	20.2	18.4	20.7
D1P2	44.6	39.8	43.7	40.1	36.1	42.1	40.4	44.8
D2P1	32.4	29.7	31.6	27.2	24.2	28.7	31.2	32.9
D2P2	29.2	25.4	27.6	26.2	21.8	26.9	22.8	28.0
EYL	7.0	7.4	9.7	6.6	5.7	8.3	7.3	6.1
EYH	6.5	5.5	7.4	4.4	4.0	6.0	5.0	5.0
CLT	–	16.7	19.2	–	10.8	13.1	–	–
CLM	–	7.2	9.3	–	3.8	4.6	–	–
CLL	–	6.8	9.5	–	3.7	5.2	–	–

narrowly pointed; posterior margin almost straight, more concave distally; inner margin, free rear tip and ventral portion of posterior margin broadly rounded; anterior margin 38.9 (39.6)% BDL; apex when laid adpressed to body extending slightly posterior to origin of pelvic fin. Pelvic fin large, broad, paddle-shaped; anterior margin strongly convex; apex broadly angular; posterior margin, free rear tip and inner margin broadly convex. Females with fleshy anal pad posterior to cloaca (more pronounced in paratype).

Caudal fin short, much lower than second dorsal fin, margins of dorsal and ventral lobes strongly convex; dorsal and ventral lobes subequal in height; dorsal lobe insertion well anterior to ventral lobe insertion; height of dorsal lobe 1.40 (1.09) times height of ventral lobe;

caudal filament very long (when undamaged), slender.

COLOUR.— Preserved specimens: Head and trunk uniformly chocolate brown; pale where skin deciduous; tail chocolate brown with narrow, pale stripes (most prominent below lateral line); fins dark brownish to blackish; second dorsal fin with a narrow pale basal portion; dorsal spine mostly dark anteriorly, paler yellowish posteriorly; caudal filament mostly pale.

SIZE.— The two female type specimens were 744 and 951 mm TL, 397 and 531 mm BDL.

DISTRIBUTION.— The two type specimens were collected on the mid continental slope east of Tuncurry in New South Wales (32°06′ S, 153°09′ E) at a depth of 1025–1080 m. Last & Stevens (1994) records this species from Townsville (Queensland) to Ulladulla (new South Wales) at 450–1000, but these records require validation.

ETYMOLOGY.— The species name is derived from the Latin *obscurus* (dark) in allusion to the dark brownish to black body coloration. Vernacular: Shortspine Chimaera.

REMARKS.— *Chimaera obscura* differs from other Indo–Pacific species of *Chimaera* by a combination of morphology, coloration, size and structure of the CO1 gene.

Chimaera obscura differs from *C. owstoni* and *C. panthera* in coloration (uniformly coloured vs. a pattern of distinct dark reticulations or mottling). It differs from *C. lignaria* in colour pattern (uniformly dark brownish to black vs. grey-blue to lavender) and size (attaining 951 mm TL, 531 mm BDL vs. 1420 mm TL, 890 mm BDL; Didier, 2002). *Chimaera obscura* differs from *C. jordani* in height of second dorsal fin (height of posterior part of second dorsal fin almost twice height of dorsal caudal-fin lobe vs. subequal to) (Nakabo, 2002). *Chimaera obscura* is clearly separable from *C. phantasma* in having a lateral line canal without undulations along its entire length (vs. with tight sinuous undulations along its entire length) and a longer interspace between pectoral and pelvic fins (vs. pectoral fin free rear tip much further forward to pelvic-fin origin vs. just anterior to pelvic-fin origin).

Chimaera obscura is clearly separable from *C. macrospina* in the structure of the CO1 gene and in the following characters: snout-vent length (62.2–67.2 vs. 55.1–61.3% BDL), pre-second dorsal length (49.3–49.5 vs. 40.4–48.5% BDL), pelvic-fin anterior margin length (20.8–20.9 vs. 15.6–18.4% BDL), interdorsal space (9.3–11.9 vs. 2.4–5.1% BDL) and second dorsal-fin origin to pectoral-fin origin distance (31.2–32.9 vs. 24.2–28.7% BDL).

Chimaera obscura is morphologically similar to the sympatric *C. fulva* but these species are clearly separable based on colour, structure of the CO1 gene and some morphological aspects. *Chimaera obscura* differs from *C. fulva* in colour (adults uniformly dark brownish to black vs. pale silvery brownish dorsally and paler ventrally) and in the following morphological characters: second dorsal-fin posterior height (6.1–6.2 vs. 3.9–5.4% BDL), dorsal caudal-fin lobe height (3.4–3.5 vs. 2.1–3.1% BDL) and head length (24.5–25.0 vs. 26.6–30.6% BDL). Cytochrome oxidase subunit 1 (CO1) sequences readily distinguish *C. obscura* (n=1, holotype), *C. fulva* (n=6), *C. macrospina* (n=2), *C. panthera* (n=1) and *C. lignaria* (n=4) (Ward *et al*., 2008; B.D. Ward, unpubl. data).

Cytochrome oxidase subunit 1 (CO1) sequences:

Chimaera fulva (holotype CSIRO H 5301–08):
CCTTTACCTCCTTTTTGGTGCTTGAGCAGGCATA
GTGGGGACTGCCCTTAGCCTGTTAATCCGAGCC
GAGCTAAACCAACCCGGCGCCCTAATGGGAGA
TGACCAAATTTATAATGTTGTTGTTACCGCCCA
CGCTTTTGTAATAATTTTCTTCATGGTAATACC
AATTATGATTGGGGGCTTTGGAAACTGACTAGTA
CCTTTAATAATTGGAGCACCAGATATAGCTTTC
CCCCGAATAAACAACATAAGTTTTTGACTTCTTC
CCCCCTCTTTCCTTTTACTACTAGCATCAGCAGG
AGTAGAAGCAGGCGCCGGCACTGGATGAACCG
TTTATCCCCCTCTAGCAGGTAATCTAGCACATGC
CGGAGCATCTGTAGACCTAACCATCTTCTCCCTT
CATTTAGCCGGAATCTCTTCAATCCTAGCCTCC
ATTAACTTCATTACTACAATTATTAACATAAAAC
CCCCATCAATTACCCAATATCAAACCCCCTTAT
TCGTATGATCTATTTTAATTACTACAGTCCTTC
TCTTACTATCTTTACCTGTTCTAGCAGCTGGTA
TTACCATATTACTCACAGACCGTAATCTAAACAC
TACATTCTTTGACCCAGCAGGAGGAGGAGACC
CTATTTTATACCAACATTTA (652 bp).

Chimaera macrospina (paratype CSIRO H 1382–02):
CCTCTACCTCCTTTTTGGTGCTTGAGCAGGGAT
AGTAGGGACTGCCCTTAGCCTGTTGATCCGAGC
TGAGCTTAACCAACCCGGCGCCCTAATGGGAG
ATGATCAAATCTATAATGTTGTTGTTACTGCCCA
CGCCTTTGTAATAATTTTCTTCATAGTAATACC
AATTATGATTGGAGGATTTGGAAACTGACTTGT
ACCTTTAATAATTGGAGCCCCTGACATAGCCTT
CCCCCGAATAAACAACATAAGTTTTTGACTTCTT
CCCCCTTCTTTCCTTTTACTTCTAGCATCAGCA
GGGGTAGAAGCAGGTGCGGGTACTGGATGGAC
TGTCTACCCCCCTCTAGCAGGGAATCTAGCAC
ATGCCGGAGCATCCGTAGACCTGACCATCTTC
TCCCTTCACTTAGCAGGGATCTCTTCAATTCTA
GCCTCCATTAACTTCATTACTACAATTATCAAT
ATAAAACCCCCGTCAATCACCCAATATCAAAC
CCCCTTATTTGTATGATCTATTCTAATTACTAC
GGTCCTCCTCTTACTTTCTTTACCTGTTCTAGC
AGCCGGTATCACAATATTACTCACAGACCGC
AATCTAAACACTAC (603 bp).

Chimaera obscura (holotype CSIRO H 1383–02):
CCTTTATCTCCTTTTTGGTGCTTGAGCAGGTAT
AGTAGGTACTGCCCTTAGCCTATTAATCCGAGC
TGAGCTAAATCAACCCGGCGCCCTAATAGGAG
ATGATCAAATTTATAATGTTGTTGTTACTGCCC
ATGCTTTTGTAATAATTTTCTTCATAGTGATAC
CAATTATAATCGGAGGCTTTGGAAACTGACT
TGTACCCCTAATAATTGGAGCACCAGACATAG
CCTTCCCCCGAATAAACAACATAAGTTTTTG
ACTTCTTCCCCCCTCTTTCCTTCTACTCCTAG
CATCAGCAGGGGTAGAAGCAGGCGCCGGCA
CTGGATGAACTGTTTACCCCCCTCTAGCAGGA
AATCTAGCACATGCCGGAGCATCCGTAGACCT
AACCATTTCTCCCTTCACTTAGCCGGAATCT
CTTCAATTCTAGCCTCCATCAACTTCATTACT
ACAATTATTAACATAAAACCCCCATCAATTA
CCCAATATCAAACCCCCTTATTCGTATGATC
TATTTTAATTACTACAGTCCTTCTCTTACTAT
CTTTACCTGTTCTAGCAGCCGGAATTACAAT
ATTACTCACAGACCGTAATCTAAACACTAC
(603 bp).

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Chimaera argiloba sp. nov., a new species of chimaerid (Chimaeriformes: Chimaeridae) from northwestern Australia

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ABSTRACT.— A new species of chimaerid, *Chimaera argiloba* sp. nov, is described based on material collected from the upper continental slope of northwestern Australia. *Chimaera argiloba* is clearly separable from other Australian congeners by a combination of coloration and morphology, and is most similar to *C. phantasma* from the north-west Pacific. *Chimaera argiloba* differs from *C. phantasma* in coloration and some morphometric characteristics.

Key words. Chimaeridae – *Chimaera argiloba* – new species – Australia

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INTRODUCTION

The family Chimaeridae is comprised of two genera, *Chimaera* and *Hydrolagus*, which are separated based on the presence of absence of an anal fin. The genus *Chimaera*, proposed by Linnaeus (1758) for *C. monstrosa* from the Atlantic, comprises 10 nominal species: *C. cubana* Howell Rivero, 1936; *C. fulva* Didier, Last & White, 2008; *C. jordani* Tanaka, 1905; *C. lignaria* Didier, 2002; *C. macrospina* Didier, Last & White, 2008; *C. monstrosa*; *C. obscura* Didier, Last & White, 2008; *C. owstoni* Tanaka, 1905; *C. panthera* Didier, 1998; and *C. phantasma* Jordan & Snyder, 1900. In addition, one species remains undescribed *C.* sp. E (*sensu* Last & Stevens, 1994). This paper formally names and describes a new species of *Chimaera*, previously referred to as *Chimaera* sp. E (*sensu* Last & Stevens, 1994), based on material collected off northwestern Australia.

METHODS

Measurements follow Compagno *et al*. (1990) and Didier (2002), and were taken directly (point to point), rather than horizontally, using calipers. A total of 34 measurements were taken: total length (TL); precaudal length (PCL); body length (BDL); snout-vent length (SVL); trunk length (TRL); pre-second dorsal length (PD2); pre-first dorsal length (PD1); second dorsal fin base (D2B); anterior second dorsal fin, maximum height (D2AH); posterior second dorsal fin, maximum height (D2PH); caudal dorsal margin (CDM); dorsal caudal fin, maximum height (CDH); total caudal fin length including filament (CTL); caudal ventral margin (CVM); ventral caudal fin, maximum height (CVH); head length (HDL); preorbital length (POB); first dorsal fin base (D1B); dorsal spine length (DSA); first dorsal fin, maximum height (D1H); pectoral fin anterior margin (P1A); pelvic fin anterior margin (P2A); interdorsal space (IDS); dorsal–caudal space (DCS); posterior base of pectoral fin to anterior base of pelvic fin (PPS); anterior edge of first dorsal fin base to anterior edge of pectoral fin base (D1P1); anterior edge of base of first dorsal fin to anterior edge of pelvic base (D1P2); anterior edge of second dorsal fin base to anterior edge of pectoral fin base (D2P1); anterior edge of second dorsal fin base to anterior edge of pelvic fin base (D2P2); horizontal eye length (EYL); vertical eye height (EYH); total length of claspers from pelvic fin base to tip (CLT); length of medial branch of clasper from fork to tip (CLM); length of lateral branch of clasper from fork to tip (CLL).

The holotype (CSIRO H 2585–02) and all paratypes of the new species were measured in full. Specimens examined, including types, are deposited in the Australian National Fish Collection, Hobart (CSIRO) and Moss Landing Marine Laboratories, California (MLML); their registration numbers are prefixed with these acronyms.

Chimaera argiloba sp. nov.

Figs 1, 2; Table 1

Chimaera sp. E: Last & Stevens, 1994: pp 467, 474, key fig. 6, fig. 48.5, pl. 84.

Holotype. CSIRO H 2585–02, late adolescent male 897 mm TL, 424 mm BDL, north-west of Geraldton, Western Australia, 28°16′ S, 113°17′ E, 520 m, 02 Feb 1991.
Paratypes. 5 specimens: CSIRO H 1207–09, juvenile male 654 mm TL, 320 mm BDL, north-west of Port Hedland, Western Australia, 18°20′ S, 117°50′ E, 430 m, Oct 1987; CSIRO H 2585–01, female 835 mm TL, 414 mm BDL, collected with holotype; CSIRO H 2587–16, female 822 mm TL, 413 mm BDL, south-west of Shark Bay, Western Australia, 27°06′ S, 112°44′ E, 370–438 m, 02 Feb 1991; CSIRO H 4071–17, adult male 912 mm TL, 440 mm BDL, CSIRO H 4071–18, female 877 mm TL, 448 mm BDL, south-west of Rowley Shoals, Western Australia, 18°02′ S, 118°14′ E, 388–392 m, 09 Sep 1995.
Other material. 3 specimens: CSIRO H 2586–08, female 782 mm TL, 379 mm BDL, CSIRO H 2586–10, female ~830 mm TL, 421 mm BDL, CSIRO H 2586–11, juvenile male 793 mm TL, 376 mm BDL, south-west of Shark Bay, Western Australia, 27°15′ S, 112°44′ E, 510–520 m, 02 Feb 1991.

DIAGNOSIS.— *Chimaera argiloba* is distinguished from its congeners by the following combination of characters: moderately long snout; relatively thick, non-deciduous skin; uniformly silvery greyish dorsally and laterally, paler ventrally; preopercular and oral lateral line canals usually not sharing a common branch; dorsal spine long, longer than first dorsal fin; structure of the CO1 gene.

DESCRIPTION.— Snout moderately long, preorbital snout 5.9 (5.4–6.8) in body length; tip broadly pointed in lateral view, narrowly pointed in dorsoventral view. Postorbital head compressed. Eyes moderately large, horizontally oval, parallel to body axis (not directed anterodorsally); horizontal length 4.20 (4.10–4.30) in head length, vertical height 0.68 (0.60–0.70) times horizontal length; almost lateral on head, without subocular ledges. Gill openings large, broadly separated, with prominent posterior flap which stands outwards from base of head and forms a short tube with rear end of gill cover. Gular flap between gill openings low. Nostrils, lips and mouth slightly expanded below ventral contour of snout. Nostrils with incurrent apertures close together on underside of snout located close to mouth, separated by a narrow septum; a deep blind dermal pocket between incurrent apertures; anterior nasal flaps extending posteriorly from incurrent apertures lateral to tooth plates of upper jaw and delimiting ventromedial surfaces of nasal cavities; nasal cavities delimited ventrolaterally by high, narrow, longitudinal vertical flap with a lobular distal end; excurrent apertures posterior to incurrent apertures and vertical flap, lateral to tooth plates of upper jaw, and inside pockets formed by large upper labial folds.

Mouth narrow, short; upper labial folds and furrows prominent; upper and lower furrows deep; lower lip with a deep pocket between mandibular tooth plates and its outer edge. Upper anterior tooth plates (vomerine tooth plates) small, incisor-like with 8–10 tritors visible (sometimes very weakly defined); posterior upper tooth plates (palatine) with very small knobby tritors on wear surface, up to 6 prominent weak tritors on anterior margins; lower tooth plates (mandibular) incisor like with tritors along edge of wear, forming a straight ridge posteriorly; upper anterior and lower tooth plates pale yellowish, upper posterior tooth plates pale greyish to yellowish.

Trunk very short and slightly compressed; deep groove on interdorsal space which partly receives depressed first dorsal fin; a low membrane connects soft elements of first and second dorsal fins; precaudal tail tapering evenly from pelvic fins to caudal base; anal insertion usually connected to ventral origin of caudal fin by a very low membrane. Skin smooth, leathery. Dermal denticles absent.

Lateral line canal originating at fork between occipital and otic head canals at level of upper eye; notched anteriorly, then strongly elevated below first dorsal spine, extending posteriorly with tight sinuous undulations, becoming slightly wavy below anterior half of second dorsal-fin base, nearly straight posterior to second dorsal-fin mid base; line directed strongly posteroventrally to ventral margin of tail just posterior to origin of dorsal caudal lobe; line running along ventral margin of tail to caudal filament. Occipital canals short, only slightly longer than half eye length, directed anterodorsally, arched posteriorly, united to supratemporal and supraorbital canals about half distance between eye and dorsal-fin spine origin, near dorsal margin of head when viewed laterally. Supratemporal canals short, curved anteriorly, united at dorsal midline about half an eye length forward of dorsal-fin spine. Supraorbital canal extending anteriorly from supratemporal junction, curving slightly anteroventrally then becoming straight parallel to dorsal margin of eye, strongly notched slightly forward of eye, following profile of snout tip apically to join infraorbital canal. Otic canal longer than occipital canal, slightly longer than eye, united to infraorbital and origin of oral and preopercular canals below hind margin of eye. Preopercular and oral canals connected separately from infraorbital-otic junction, not sharing a common branch (in paratype CSIRO H 2587–16, preopercular and oral canals connected together but falling just short of and not connected to infraorbital or otic canals). Preopercular canal extending posteroventrally; terminating at about mid gill. Oral canal short, extending very slightly anteroventrally, divided into mandibular and angular canals below posterior 2/3 of eye. Mandibular canal extending slightly ventrolaterally, almost straight, joined to post-oral pores near mouth. Angular canal directed slightly anteroventrally, with prominent sensory pores, divided into nasal and subrostral canals near ventral margin of snout when viewed laterally; nasal canals

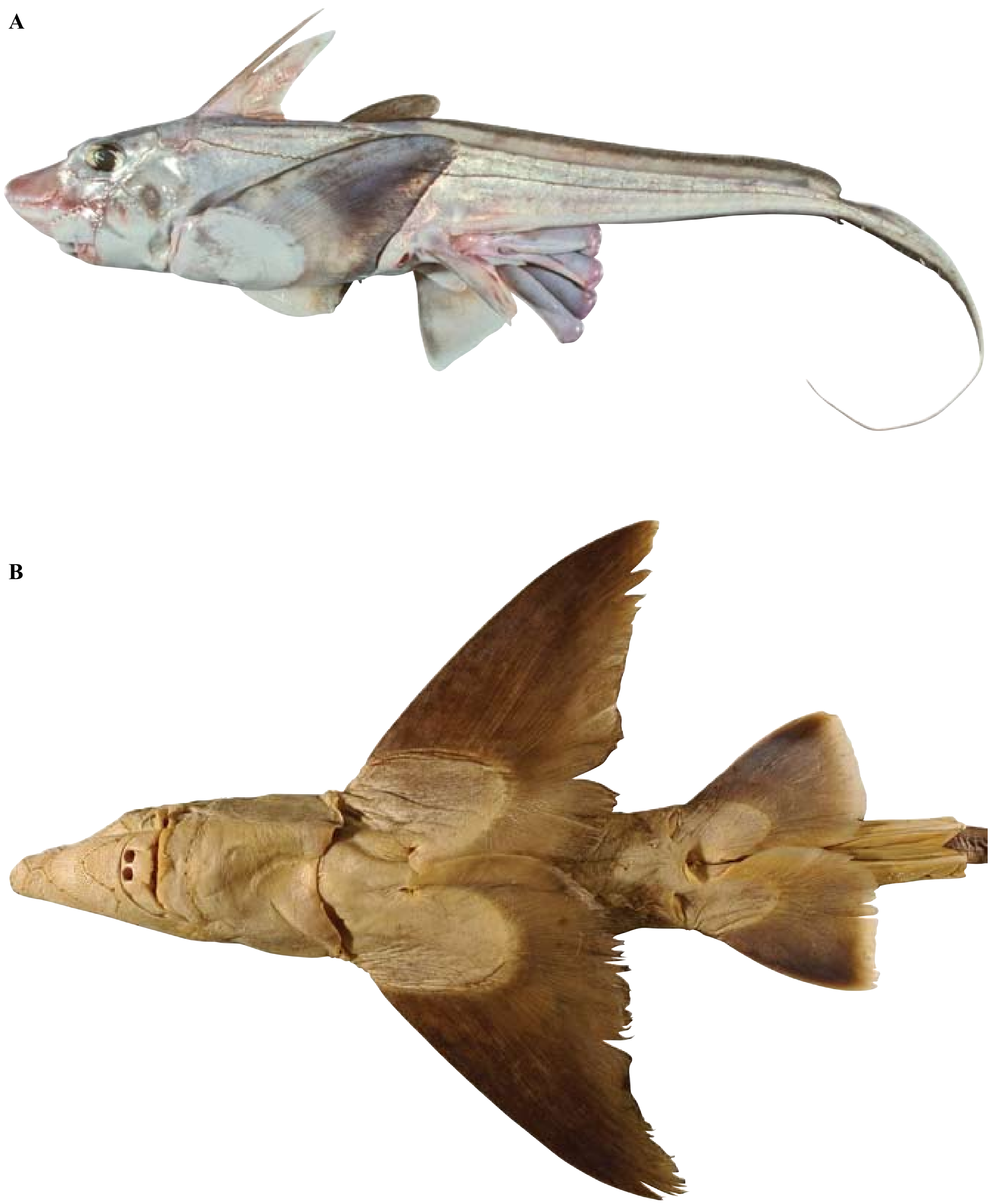

Figure 1. *Chimaera argiloba* sp. nov.: A. lateral view of adult male holotype (CSIRO H 2585–02, 897 mm TL, 424 mm BDL); B. ventral view (excluding tail) of adult male paratype (CSIRO H 4071–17, 912mm TL, 580 mm BDL).

Table 1. Morphometric data for the holotype of *Chimaera argiloba* sp. nov. (CSIRO H 2585–02), with ranges provided for the measured paratypes. Measurements expressed as a percentage of body length.

	C. argiloba sp. nov.		
	Holotype	Paratypes	
		Min.	Max.
TL	211.4	195.6	207.3
PCL	133.2	129.7	138.0
BDL (mm)	424.3	320.0	448.4
SVL	65.8	64.5	67.6
TRL	36.6	36.2	37.3
PD2	57.2	55.5	64.2
PD1	32.9	29.8	36.2
POB	17.1	14.7	18.7
D2B	74.7	71.3	77.8
D2AH	4.4	4.0	5.2
D2PH	4.1	3.7	4.9
D1B	19.0	17.5	21.9
DSA	30.8	28.5	35.0
D1H	26.3	23.8	30.3
CDM	24.1	20.4	25.0
CDH	1.8	1.6	2.4
CTL	76.8	61.5	73.9
CVM	44.4	37.7	61.3
CVH	2.1	1.7	2.7
HDL	31.7	31.3	36.1
P1A	46.9	43.1	50.2
P2A	21.2	19.1	21.3
IDS	10.9	7.5	12.0
DCS	1.8	0.8	1.9
PPS	26.0	24.7	28.4
D1P1	23.1	21.4	24.3
D1P2	40.6	41.0	43.4
D2P1	34.3	32.7	36.6
D2P2	22.5	21.8	25.0
EYL	7.6	7.3	8.8
EYH	5.2	5.0	6.1
CLT	26.5	25.1	25.1
CLM	–	–	–
CLL	15.5	15.2	15.2

strongly arched ventrally, then directed anterodorsally to unite on midline of snout slightly more than a nostril length from nostril; subrostral canal parallel to anterior portion of nasal canal, left and right branches united slightly forward of prenarial snout. Infraorbital canal long, from otic junction following ventral contour of eye; forming a prominent S-shaped, double loop forward of eye; united to supraorbital canal close to snout tip near ventral midline of snout. Ampulla pores, not particularly numerous, present anterior to occipital and mandibular canals, at angle of infraorbital and oral canals, below upper margin of infraorbital canal, and concentrated on snout tip.

Dorsal-fin spine long, slightly taller than soft first dorsal fin (much longer in some paratypes), mostly straight (sometimes slightly convex), spine length 1.03 (0.96–1.15) in head length, 1.17 (1.06–1.41) times first dorsal-fin height; origin over pectoral-fin origin; anterior margin of spine forming a very narrow keel, not serrated; upper half of posterior margin of spine finely serrated. Soft portion of first dorsal fin with a relatively short base, slightly longer than snout length; posterior margin of fin moderately concave.

Second dorsal long-based, margin usually not incised, mostly uniform in height, length of longest elements about three quarters eye length; origin posterior of midpoint of depressed dorsal-fin spine; insertion above anal-fin insertion (well posterior to in paratype CSIRO H 1207–09); united to upper lobe of caudal fin by a low membrane.

Pectoral fins very long, broad, not falcate; anterior margin weakly convex anteriorly, strongly convex distally; apex narrowly pointed to narrowly rounded; posterior margin almost straight to weakly concave; inner margin, free rear tip and ventral portion of posterior margin broadly rounded; anterior margin 46.9 (43.1–50.2)% BDL; apex when laid adpressed to body usually extending well posterior to insertion of pelvic fin. Pelvic fin large, broadly triangular; anterior margin convex; apex angular; posterior margin, free rear tip and inner margin broadly convex.

Frontal tenaculum of adult male paratype (CSIRO H 4071–17) with a broad, short neck (about a third eye length), and a prominent distal knob; distal knob with eight longitudinal rows of 3–7 large, pointed, relatively slender, posteriorly directed, unicuspidate spines on its sides and ventral surface. Pelvic claspers of adult male paratype (CSIRO H 4071–17) very large, broad, extending well posterior to distal edge of the pelvic fins; bifurcate; forked for the distal 1/2 to 2/3 of their length, with very large, pale yellowish, bulbous tips covered in a shagreen of fine denticles. Prepelvic tenaculae of adult male paratype (CSIRO H 4071–17) blade-like, concealed in pouches anterior to the pelvic fins, with 9–10 very stout denticles along the medial edge. Large females with fleshy anal pad posterior to the cloaca, lacking in males.

Caudal fin short, much lower than second dorsal fin, margins of dorsal and ventral lobes moderately convex; dorsal and ventral lobes subequal in height; dorsal lobe insertion well anterior to ventral lobe insertion; height of dorsal lobe 0.88 (0.77–1.04) times height of ventral lobe; caudal filament very long (when undamaged), slender.

COLOUR.— Preserved specimens: Silvery to pale greyish dorsally and laterally, slightly paler ventrally; dorsal surface of body above lateral line with very faint, pale longitudinal stripes and poorly differentiated, whitish blotches; pale stripes and faint blotches sometimes also evident on tail; first dorsal fin greyish with distinctly white posterior margin; dorsal spine mostly yellowish; pectoral fins greyish to brownish usually with broad, dusky posterior margins; pelvic fins greyish with narrow, white anterior margins and broad, white posterior margins; second dorsal fin pale basally, upper quarter to third of fin dark greyish to blackish; dorsal caudal lobe greyish basally, distinctly whitish distally; lower caudal lobe mostly dark greyish with a narrow, pale basal marking; caudal filament white; claspers uniformly pale yellowish. **When fresh:** Silvery dorsally and laterally, white ventrally; markings on fins more prominent.

SIZE.— Material examined ranged from 782–877 mm TL, 379–448 mm BDL for females, and 654–912 mm TL, 320–440 mm BDL for males. Holotype a late adolescent male of 897 mm TL, 424 mm BDL; one adult male paratype of 912 mm TL, 440 mm BDL.

DISTRIBUTION.— Material examined from the upper continental slope of northwestern Australia, from north-west of Geraldton (28°16′ S, 113°17′ E) north to the Rowley Shoals (18°02′ S, 118°14′ E), at depths of 370–520 m. Specimens collected off New Caledonia and eastern Indonesia (Bali and Lombok) are possibly conspecific, but further investigation is required for this to be confirmed (Sam Iglésias, pers. comm.; White *et al.*, 2006).

ETYMOLOGY.— The species name is derived from the combination of the Greek *argos* (white) and the Latin *lobus* (a rounded projection) in allusion to the disitnct white posterior margin of the first dorsal fin. Vernacular: Whitefin Chimaera.

REMARKS.— *Chimaera argiloba* differs from other Indo–Pacific species of *Chimaera* by a combination of morphology, coloration, size and structure of the CO1 gene.

Chimaera argiloba differs from *C. owstoni* and *C. panthera* in being uniformly coloured rather than having a colour pattern dominated by distinct dark reticulations or mottling, and differs from *C. lignaria* in colour (silvery white vs. grey-blue to lavender) and size (attaining 912 mm TL, 448 mm BDL vs. 1420 mm TL, 890 mm BDL) (Didier, 2002). *Chimaera argiloba* differs from *C. jordani* in colour (silvery white vs. dark brown) and height of second dorsal fin (height of posterior part of second dorsal fin almost twice height of dorsal caudal-fin lobe vs. subequal to) (Nakabo, 2002; Didier, 2004). It differs from *C. fulva*, *C. macrospina* and *C. obscura* in colour (silvery white vs. pale brownish, chocolate brown or dark brownish to black) and in morphology of the lateral line (with tight sinuous undulations along entire length vs. nearly straight to only slightly wavy). *Chimaera argiloba* can also be clearly distinguished from *C. fulva* and *C. obscura* based on the following morphometric features: shorter trunk (trunk length 36.2–37.3 vs. 39.1–45.2% BDL, pectoral–pelvic space 24.7–28.4 vs. 29.0–35.8% BDL), longer head and snout (head length 31.3–36.1 vs. 24.5–30.6% BDL, preorbital length 14.7–18.7 vs. 12.5–14.9% BDL) and a longer pre-second

Figure 2. Lateral view of *Chimaera phantasma*, female (MLML TAI–182, 663 mm TL).

dorsal length (55.5–64.2 vs. 49.3–52.7% BDL). It also differs from both *C. fulva* and *C. macrospina* in structure of the clasper: clasper total length 25.1–26.5 vs. 10.8–19.2% BDL, clasper lateral branch length 15.2–15.5 vs. 3.7–9.5% BDL and bifurcate vs. trifurcate.

Cytochrome oxidase subunit 1 (CO1) sequences readily distinguish *C. argiloba* (n=1), from *C. macrospina* (n=2), *C. fulva* (n=6), *C. panthera* (n=1) and *C. lignaria* (n=4) (Ward *et al*., 2008; B.D. Ward, unpubl. data; Table 2). Last & Stevens (1994) suggested that *C. argiloba* (as *C.* sp. E) more closely resembles a *Hydrolagus* than a *Chimaera* species. Results of recent barcode analyses (B.D. Ward, unpubl. data) lends support to this suggestion in that the structure of the CO1 gene for this species falls in the same clade as *Chimaera phantasma*, *Hydrolagus lemures*, *H.* cf *lemures* (*sensu* White *et al*., 2006) and *H. ogilbyi*, with the other *Chimaera* species sequenced and the deepwater *Hydrolagus* species sequenced, i.e. *H. trolli*, *H.* sp. A (*sensu* Last & Stevens, 1994) and *H. novaezealandiae*, in a separate clade. Although *C. argiloba* has been considered by some to be conspecific with *C. phantasma*, their CO1 sequences are clearly distinct. *Chimaera* cf sp. E (*sensu* White *et al*., 2006) from Indonesia may also be conspecific with *C. argiloba*, but further examination is required as they differ in some features (i.e. clasper morphology and fin coloration) and slightly in CO1 gene structure. A similar species recorded off New Caledonia (S. Iglésias, pers. comm.), which was tentatively identified as *C. phantasma*, also has a similar, although slightly different, CO1 gene structure to *C. argiloba*. Further investigation of material from New Caledonia is required to elucidate whether it is conspecific with *C. argiloba* or whether it represents a new, undescribed taxon.

Chimaera argiloba is morphologically similar to *C. phantasma* (Fig. 2), but the two species can be clearly separated based on coloration and some morphological differences. The new species differs from *C. phantasma* in the following characters: first dorsal fin pale greyish with distinct white posterior margin (vs. uniformly dark greyish to blackish except for a small white marking on fin apex), second dorsal fin with distal 1/4 to 1/3 blackish (vs. distal 2/3 to 3/4 blackish), head mostly pale (vs. mostly dusky), ventral surface of head and body whitish (vs. paler but with dusky areas), pectoral fins greyish to brownish (vs. blackish), body often with evidence of darker longitudinal stripes (vs. blackish longitudinal stripes usually obvious), dark bar absent on lateral midline between pectoral- and pelvic-fin bases (vs. distinctive blackish bar present on lateral midline between pectoral- and pelvic-fin bases; see Masuda *et al*., 1984) and snout moderately long (vs. short).

Table 2. Mean Kimura 2 parameter (K2P) distances (%) and standard error within species and for each species vs. *C. argiloba* sp. nov.

	N	within	between
C. argiloba	1	–	–
C. cf *argiloba* (Indonesia)	3	0	1.51 ± 0.50
C. cf *argiloba* (New Caled.)	1	–	1.68 ± 0.54
C. fulva	6	0.14 ± 0.09	1.61 ± 1.62
C. lignaria	4	0.08 ± 0.07	16.1 ± 1.6
C. macrospina	2	0	16.4 ± 1.17
C. obscura	1	–	13.8 ± 1.14
C. panthera	1	–	18.5 ± 1.18
C. phantasma	1	–	9.41 ± 1.21
H. lemures	10	0.48 ± 0.13	10.0 ± 1.27
H. cf *lemures*	3	0	11.3 ± 1.38
H. ogilbyi	7	0.11 ± 0.06	9.86 ± 1.25

Cytochrome oxidase subunit 1 (CO1) sequences:

Chimaera argiloba (paratype CSIRO H 2587–16):
CCTTTATCTCCTCTTTGGTGCTTGAGCGGGGATA
GTAGGTACCGCTCTCAGTCTACTAATCCGAGCG
GAATTAAACCAGCCCGGTGCCCTAATAGGAGAT
GACCAAATCTATAATGTTGTTGTTACTGCACACG
CTTTTGTAATAATTTTCTTCATAGTGATACCTAT
CATGATTGGAGGCTTTGGAAACTGACTAGTACC
CCTAATAATCGGAGCTCCCGACATAGCCTTCCC
CCGTATAAATAATATAAGTTTCTGACTCCTTCC
CCCATCTTTTCTATTACTACTAGCCTCAGCAGG
TGTAGAAGCAGGAGCTGGTACCGGATGGACTG
TTTACCCGCCCCTAGCAGGAAATATAGCCCAC
GCCGGGGCATCTGTAGACCTAACCATCTTCTCC
TTACACCTAGCTGGTATCTCTTCTATTCTTGCC
TCCATCAACTTTATTACTACAATTATTAACATA
AAACCCCCATCAATTACACAATACCAAACACC
CTTATTCGTATGATCTATCTTAATTACTACCAT
CCTTCTATTACTGTCTTTACCTGTTTTAGCCGC
CGGCATTACAATACTACTCACAGATCGCAACC
TAAACACCAC (603 bp).

Comparative material.
Chimaera phantasma: 3 specimens: CSIRO H 6292–06, female 493 mm TL, 184 mm BDL; CSIRO H 6295–23, juvenile male 556 mm TL, 203 mm BDL; MLML TAI–182, female 663 mm TL; collected from Tashi fish market, Taiwan.

ACKNOWLEDGEMENTS

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Two new species of the genus *Hydrolagus* Gill (Holocephali: Chimaeridae) from Australia

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ABSTRACT.— Two new species of *Hydrolagus* are described from Australia, one of which is also common in deep waters around New Zealand. The first, *Hydrolagus homonycteris* sp. nov., is known from the continental slope and seamounts off southeastern Australia as well as deepwater fishing grounds off New Zealand in depths ranging from 866–1447 m. *Hydrolagus homonycteris* sp. nov. is distinguished from all other members of the genus by distinctly rounded pelvic fins, dark brown to black coloration, large dorsal spine, and oral and preopercular canals that share a branch from the infraorbital canal. A second new species, *Hydrolagus marmoratus* sp. nov., is known from the eastern coast of Australia from New South Wales to Queensland in depths ranging from 603–995 m. This new species of *Hydrolagus* is distinguished from all other members of the genus by a distinct network of reticulations on the dorsal surface of the head and body, and by its small size.

Key words. Holocephali – Chimaeridae – *Hydrolagus homonycteris* – *Hydrolagus marmoratus* – Australia – New Zealand – taxonomy

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INTRODUCTION

In recent years, a surprising diversity of chimaeroid fishes has been recognised from Australia and New Zealand as a direct result of years of research cruises and donations from commercial fishermen (Paulin *et al*., 1989; Hardy, 1990; Last & Stevens, 1994). All of the new species collected belong to the Family Chimaeridae, the most speciose of the three families of chimaeroids. At present there are 22 described species in the Family Chimaeridae: 7 species of *Chimaera* and 15 species of *Hydrolagus* (Didier, 2004). Last & Stevens (1994) recognised 5 species of *Chimaera* and 4 species of *Hydrolagus* from Australia and there are 3 species of *Chimaera* and at least 4 species of *Hydrolagus* recognised from New Zealand (Paulin *et al*., 1989). Of these 14 species only two, *Chimaera lignaria* Didier, 2002 and *Hydrolagus homonycteris* sp. nov., overlap in their distribution and are found off both Australia and New Zealand.

The description of these two new species currently doubles the number of known nominal species of *Hydrolagus* from Australia from two (*H. ogilbyi* and *H. lemures*) to four. A fifth species of *Hydrolagus* (sp. C) appears to be conspecific with *H. trolli* from New Zealand and New Caledonia, however, more specimens, and possibly genetic data, are needed before the status of this species can be confirmed.

METHODS

All measurements were taken on preserved specimens, measured point to point to the nearest one-tenth millimetre using a dial caliper and ruler or measuring tape. Measurements are based on a scheme suggested by Compagno *et al*. (1990), and discussed and illustrated in Didier (2002) and Didier & Séret (2002). A total of 34 measurements were taken: total length (TL); precaudal length (PCL); body length (BDL); snout-vent length (SVL); trunk length (TRL); pre-second dorsal length (PD2); pre-first dorsal length (PD1); second dorsal fin base (D2B); anterior second dorsal fin, maximum height (D2AH); posterior second dorsal fin, maximum height (D2PH); caudal dorsal margin (CDM); dorsal caudal fin, maximum height (CDH); total caudal fin length including filament (CTL); caudal ventral margin (CVM); ventral caudal fin, maximum height (CVH); head length (HDL); preorbital length (POB); first dorsal fin base (D1B); dorsal spine length (DSA); first dorsal fin, maximum height (D1H); pectoral fin anterior margin (P1A); pelvic fin anterior margin (P2A); interdorsal space (IDS); dorsal–caudal space (DCS); posterior base of pectoral fin to anterior base of pelvic fin (PPS); anterior edge of first dorsal fin base to anterior edge of pectoral fin base (D1P1); anterior edge of base of first dorsal fin to anterior edge of pelvic base (D1P2); anterior edge of second dorsal fin base to anterior edge of pectoral fin base (D2P1);

anterior edge of second dorsal fin base to anterior edge of pelvic fin base (D2P2); eye length (EYL); eye height (EYH); total length of claspers from pelvic fin base to tip (CLT); length of medial branch of clasper from fork to tip (CLM); length of lateral branch of clasper from fork to tip (CLL).

Preserved specimens were obtained and studied from collections at the Australian Museum, Sydney (AMS), National Museum of New Zealand (NMNZ), National Science Museum, Tokyo (NSMT), and the Australian National Fish Collection, CSIRO Marine and Atmospheric Research, Hobart, Tasmania (CSIRO). Museum acronyms follow Leviton *et al*. (1985).

Hydrolagus homonycteris sp. nov.

Fig. 1; Table 1

Hydrolagus sp. A: Paulin *et al*., 1989: p 31; Last & Stevens, 1994: p 468, 475, key fig. 12, fig. 48.6, pl. 84.

Hydrolagus sp. B: Hardy, 1990: p 93.

Holotype. CSIRO H 2291–01, adult male 1085 mm TL, 667 mm BDL, west of Point Hibbs, Tasmania, Australia, 42˚38′ S, 144˚49′ E, 1085–1140 m, FRV *Soela*, SO 0289/89, 19 Mar 1989.

Paratypes. 11 specimens (474–1085 mm TL, 235–638 mm BDL): CSIRO H 485, male, South Tasman Rise, Tasmania, Australia, 47˚11′ S, 148˚30′ E, 1016–1020 m, FRV *Soela*, SO 0286/4, 18 Mar 1986; CSIRO H 2287–01, male, south-east of Portland, Victoria, Australia, 38˚55′ S, 142˚02′ E, 1115–1200 m, FRV *Soela*, SO 0289/12, 02 Mar 1989; CSIRO H 2288–01, female, south of King Island, Tasmania, Australia, 40˚51′ S, 143˚35′ E, 1200–1220 m, FRV *Soela*, SO 0289/44, 09 Mar 1989; CSIRO H 2290–01, female, south-east of Portland, Bass Strait, Victoria, Australia, 38˚53′ S, 141˚56′ E, 1090–1240, FRV *Soela*, SO 0289/9, 02 March 1989; CSIRO H 2814–01, male, South Tasman Rise, Australia, 47˚28′ S, 148˚51′ E, 1114–1120 m, Karagach stn. 3, 23 Jan 1992; NMNZ P 18079, female, off White Island, New Zealand, 37˚23.4–24.2′ S, 177˚41.1–37.9′ E), 1090–1120 m, RV *Wanaka*, WK3/18/85, 08 Dec 1985; NMNZ P 25964, male, north-east of Chatham Rise, New Zealand, 42˚38.4–38.7′ S, 176˚52.2–48.3′ E, 1436–1447 m, RV *Cordella* C2/135/90, 07 Jul 1990; NMNZ P 28796, male, Chatham Rise, New Zealand, 44˚44.3–44.9′ S, 176˚24.7–22.3′ E, 1103–1181 m, RV *Tangaroa*, TAN9104/108, 02 Nov 1991; NMNZ P 31202, male, Chatham Rise, New Zealand, 44˚32.86–32.83′ S, 175˚41.49–41.03′ E, 690–866 m, RV *Tangaroa*, TAN9406/027, 07 May 1994; NSMT P 32227, female, New Zealand, 35˚42′ S, 165˚10′ E, 950 m, FV *Eikyu-maru No. 8*, 01 Jun 1989; NSMT P 43481, male, New Zealand, 46˚14′ S, 170˚32′ E, 1143 m, RV *Shinkai-maru*, 31 Dec 1983.

Other material. 9 specimens: CSIRO H 501, male, south of King Island, Tasmania, Australia, 40˚59′ S, 143˚42′ E, 1000–1253 m, FRV *Soela*, SO 0585/16, 15 Sep 1985; CSIRO H 587, male, South Tasman Rise, Tasmania, Australia, 47˚33′ S, 148˚10′ E, 1100–1124 m, FRV *Soela*, SO 0286/3, 17 Mar 1986; CSIRO H 790–16, male, west of West Point, Tasmania, Australia, 40˚58′ S, 143˚42′ E, 1264–1280 m, FRV *Soela*, SO 0386/30, 15 May 1986; CSIRO H 805–05, female, west of Trial Harbour, Tasmania, Australia, 41˚48′ S, 144˚21′ E, 1384–1416, FRV *Soela*, SO 0386/41, 18 May 1986; CSIRO H 2292–01, male, south of Portland, Victoria, Australia, 38˚52′ S, 141˚55′ E, 975–990 m, FRV *Soela*, SO 0289/8, 02 Mar 1989; NMNZ P 25794, female, east of Chatham Rise, New Zealand, 42˚32′ S, 176˚31′ E, 1481–1483 m, RV *Cordella*, C2/011/90, 16 Jun 1990; NMNZ P 28640, male, Chatham Rise, New Zealand 42˚37′ E, 179˚16′ S, 1287–1304 m, RV *Tangaroa*, Tan 9206/065, 19 Jun 1992; NMNZ P 31204, male, east of Chatham Rise, New Zealand, 42˚37′ S, 178˚30′ E, 1194–1200 m, RV *Tangaroa*, Tan 9406/088, 22 May 1994; NMNZ P 31353, female, east of Chatham Rise, New Zealand, 43˚31′ S, 173˚51′ E, 1389–1418 m, RV *Tangaroa*, Tan 9406/271, 7 Jul 1994.

DIAGNOSIS.— A species of chimaeroid fish assigned to the genus *Hydrolagus* on the basis of a ventral caudal fin that that is not indented at its origin to form a separate anal fin. *Hydrolagus homonycteris* is distinguished from its congeners by the following combination of characters: body colour an even dark black or blackish-brown, dorsal-fin spine longer than height of first dorsal fin, pelvic fins distinctly round in shape, and males with pelvic claspers that are dark at the base with pale tips, divided for the distal 1/3 of their length.

DESCRIPTION.— A medium bodied species with gently pointed snout, large eyes (EYL 18–33% HDL), and deciduous, flaky skin. Body colour an even black or blackish-brown, slightly paler along ventral side of tail, with some faint longitudinal stripes visible on the base of the tail. Adults usually less than 1 m in length (BDL <650 mm). Tail ending in a long, stout filament. Total tail length (CTL) ranges from 34 to 106% BDL, but generally is about 30–60% BDL, and rarely exceeds 65% BDL. Tooth plates dark grey in colour. Upper anterior tooth plates (vomerine tooth plates) small, incisor-like with 5–6 tritors visible, posterior upper tooth plates (palatine) with knobby tritors on wear surface and lower tooth plates (mandibular) incisor like with tritors along edge of wear, forming a concave ridge posteriorly.

Lateral line canals of the head and trunk appear as open grooves with canals on the snout characterised by wide dilations. The oral and preopercular lateral line canals branch together from the infraorbital, and usually share a small common branch. Trunk lateral line canal straight, rising slightly just past pelvic-fin base in some individuals.

A

B

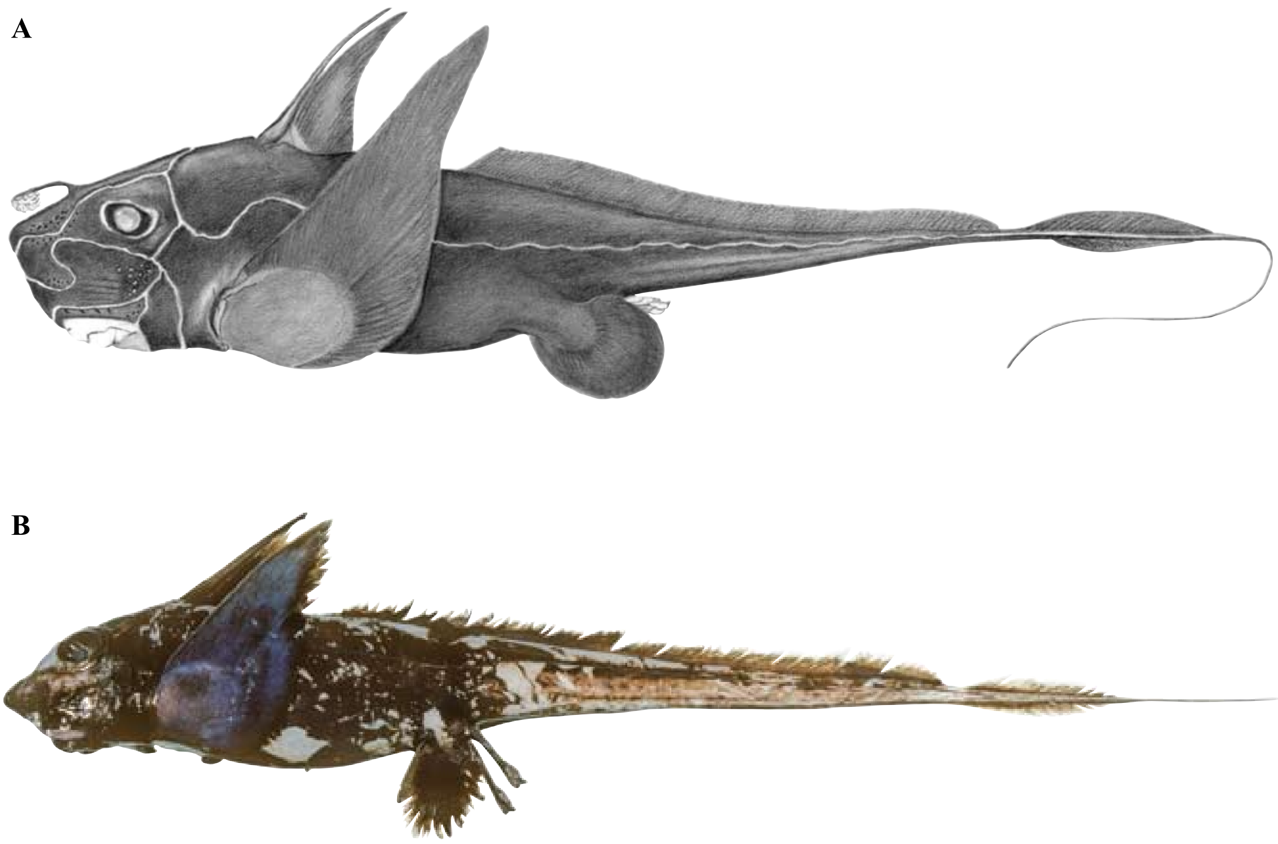

Figure 1. Lateral view of *Hydrolagus homonycteris* sp. nov.: A. adult male holotype (CSIRO H 2291–01, 1085 mm TL, 667 mm BDL), drawing by Dana Stott Cohen; B. adult male paratype (CSIRO H 485, 942 mm TL, 567 mm BDL).

Fins black, easily frayed, and almost always in poor condition. Pectoral fins with elongate anterior (lateral) edge, pointed and slightly curved at the distal tip. There appears to be wide variation in the shape of the pectoral fins with some specimens exhibiting pectoral fins that are more elongate and pointed while other specimens have more broad and stout pectoral fins. There is some evidence to suggest that variation in pectoral fin shape may be related to sex with males often having longer, more pointed fins while females tend to have broader fins; however, only a small number of adult female specimens were available for study. Pectoral fin may just reach pelvic-fin origin when depressed, but does not reach beyond pelvic-fin base. Pelvic fin is characteristic in this species in that it is distinctly rounded in shape, almost circular. First dorsal fin narrow and tall, preceded by a long, stout spine with two rows of small serrations present on the posterior side near the tip of the spine. Fin spine length exceeds height of first dorsal fin, and reaches to or beyond the origin of the second dorsal fin when depressed. Second dorsal is long and evenly tall along its length. Caudal fin rounded with dorsal and caudal lobes almost equal in size.

Frontal tenaculum in males large, robust and long with deep bulbous tip bearing about 50 large denticles in 7–9 overlapping rows. Males with slender, black pelvic claspers, forked for the distal 1/3 of their length with small, pale greyish, bulbous tips covered in a shagreen of fine denticles. Pelvic claspers relatively small, not extending beyond distal edge of the pelvic fins. Prepelvic tenaculae blade-like, concealed in pouches anterior to the pelvic fins, with 3–4 stout denticles along the medial edge. Females with fleshy anal pad posterior to the cloaca, lacking in males.

SIZE.— Attains at least 1085 mm TL, 667 mm BDL. Sexual maturity in males and females probably reached at >850 mm TL and BDL >550 mm BDL in males and >600 mm BDL in females. No small juveniles have been observed.

DISTRIBUTION.— Continental slope and seamounts off southeastern Australia from southern New South Wales to Victoria, including Tasmania. Known from deepwater commercial fishing grounds off New Zealand (e.g. Chatham Rise and Lord Howe Rise), probably widespread in deep waters around New Zealand. Reported from depths of 866–1447 m and likely inhabits depths greater than 1500 m.

Table 1. Morphometric data for the holotype of *Hydrolagus homonycteris* sp. nov. (CSIRO H 2291–01), with ranges provided for the measured female and male paratypes. Measurements expressed as a percentage of body length.

	Holotype		Paratypes			
			Females (n=4)		Males (n=6)	
	mm	% BDL	mm	% BDL	mm	% BDL
TL	1085	163	896–1085	140–174	474–1022	151–202
PCL	795	119	690–766	120–123	320–730	120–136
BDL	667	100	565–638	100	235–594	100
SVL	380	57	361–392	59–65	167–360	53–71
TRL	243	36	217–255	36–42	87–234	33–41
PD2	300	45	264–308	44–49	140–293	42–60
PD1	175	26	153–173	27–28	95–174	24–40
POB	68	10	69–77	11–13	46–69	11–20
D2B	504	75	415–495	74–78	181–484	77–82
D2AH	28	4	29–31	5	19–29	4–8
D2PH	23	3	25–28	4	165–260	42–70
D1B	74	11	58–86	10–13	41–81	9–18
DSA	132	20	142–155	25	104–132	19–22
D1H	–	–	86	14	37–95	16–17
CDM	141	21	102–144	16–23	50–145	18–24
CDH	18	3	16–20	3–4	9–19	3–4
CTL	308	46	293–334	52–54	185–327	34–79
CVM	190	29	164–190	27–31	80–194	26–34
CVH	15	2	17–20	3	8.6–15	3–4
HDL	140	21	138–154	23–26	80–143	21–34
P1A	227	34	182–222	32–37	93–210	34–40
P2A	92	14	76–96	13–15	43–95	14–18
IDS	68	10	35–71	6–12	8–80	3–14
DCS	17	3	10–18	2–3	3.8–12	2
PPS	192	29	193–209	33–34	68–191	28–33
D1P1	110	17	103–113	16–20	45–103	15–19
D1P2	245	37	237–268	40–43	94–250	37–43
D2P1	190	29	160–182	25–31	68–145	25–29
D2P2	130	20	143–160	23–26	54–141	21–25
EYL	41	6	28–41	5–7	21–42	6–9
EYH	30	5	24–33	4–5	13–36	4–6
CLT	75	11	–	–	5.6–69	2–12
CLM	20	3	–	–	–	–
CLL	20	3	–	–	–	–

ETYMOLOGY.— Derived from the Latin *homo* (n.) = man and *nycteris* (f.) = bat. Named for Thomas A. Griffiths, Professor of Biology at Illinois Wesleyan University. An expert on bat systematics and known affectionately as the "bat man" to his students, it was he who introduced me to the chimaeroid fishes. Vernacular: Black Ghostshark.

Hydrolagus marmoratus sp. nov.

Fig. 2; Table 2

Hydrolagus sp. B: Last & Stevens, 1994: pp 468, 476, key fig. 13, fig. 48.7, pl. 84; Compagno, 1999: pp 1534, 1537, fig.

Holotype. AMS I 29762–003, adult male 710 mm TL, 357 mm BDL, east of Hawks Nest, New South Wales, Australia, 32°45–41′ S, 152°49–50′ E, 796 m, FRV *Kapala*, 14 Jun 1989.
Paratypes. 8 specimens (490–801 mm TL, 199–403 mm BDL): AMS I 24615–004, female, New South Wales, Australia, 33°33′ S, 152°03′ E, FRV *Kapala*, 603 m, 16 Jun 1977; AMS I 29739–001, male, east of Sydney, New South Wales, Australia, 33°53–50′ S, 151°49–52′ E, 760–970 m, FRV *Kapala*, K87–20–01, 14 Oct 1987; CSIRO H 2276–01, female, south of Saumarez Reef, Saumarez Plateau, Queensland, Australia, 22°56′ S, 154°21′ E, 590–606 m, FRV *Soela*, SO 0685/8, 17 Nov 1985; CSIRO H 2303–01, female, CSIRO H 2303–02, female, CSIRO H 2303–05, male, east of Sydney, New South Wales, Australia, 33°43′ S, 151°55′ E, 630–660 m, FRV *Kapala*, K88–17–01, 30 Aug 1988; CSIRO H 2304–01, male, CSIRO H 2304–02, female, east of Newcastle, New South Wales, Australia, 32°55′ S, 152°44′ E, 830–995 m, FRV *Kapala*, K87–24–02, 08 Dec 1987.
Other material. 9 specimens: AMS I 15975–015, female, 35 miles south-east of Newcastle, New South Wales, Australia, 33°11′ S, 152°23′ E, 567 m, 1971; AMS I 20459–022, female, east of Danger Point, Queensland, Australia, 28°01′ S, 154°00′ E, 548 m, 1978; AMS I 24626–002, female, off Broken Bay, New South Wales, Australia, 33°34′ S, 152°04′ E, 732 m, 1984; AMS I 24645–003, female, off Sydney, New South Wales, Australia, 33°27′ S, 152°10′ E, 823 m, 1984; AMS I 24979–016, male, east of Broken Bay, New South Wales, Australia, 33°32–36′ S, 152°01–05′ E, 759 m, 1984; AMS I 26998–001, female, off Bulli, New South Wales, Australia, 34°15′ S, 151°31′ E, 781 m, 1987; AMS I 29739–001, female, east of Sydney, New South Wales, Australia, 33°50′ S, 151°52′ E, 970 m, 1987; CSIRO H 2277–01, female, north-east of Whitsunday Group, Queensland, Australia, 18°58′ S, 150°29′ E, 879–886 m, FRV *Soela*, SO 0685/36, 24 Nov 1985; CSIRO H 2303–04, female, east of Sydney, New South Wales, Australia, 33°43′ S, 151°55′ E, 630–660 m, FRV *Kapala*, K 88–17–01, 30 Aug 1988.

DIAGNOSIS.— A species of chimaeroid fish assigned to the genus *Hydrolagus* on the basis of a ventral caudal fin that that is not indented at its origin to form a separate anal fin. *Hydrolagus marmoratus* is distinguished from its congeners by the following combination of characters: body colour pale brown with prominent reticulations on sides, dorsal fin and spine whitish basally, dorsal-fin spine slightly shorter than or subequal in height of first dorsal fin, pelvic fins somewhat rectangular in shape (not broadly rounded), and males with pelvic claspers that are mostly pale, divided for the distal 2/3 of their length.

DESCRIPTION.— Small to medium-bodied fish with blunt snout, large eyes (EYL 23–37% HDL), and deciduous skin which easily flakes off in large patches. Adults less than 1 m in total length, maximum size appears to be just over 800 mm TL, probably not greater than 900 mm TL. Maximum BDL probably not greater than 450 mm. Body colour an even pale brown, lighter ventrally with dark area around the mouth, faint reticulations present on dorsal body surface, not extending onto ventral body surface or fins. Tail ending in a long, stout filament. Total tail length (CTL) is 43–134% BDL, generally greater than 70% BDL. Tooth plates dark grey in colour. Upper anterior tooth plates (vomerine tooth plates) small, incisor-like with 5–6 tritors visible, posterior upper tooth plates (palatine) with knobby tritors on wear surface and lower tooth plates (mandibular) incisor like with tritors along edge of wear, forming a concave ridge posteriorly

Lateral line canals of the head appear as open grooves, canals on the snout characterised by wide dilations. The oral and preopercular lateral line canals branch together from the infraorbital canal, rarely sharing a common branch.

Fins brown, easily frayed, and almost always in poor condition. Pectoral fins relatively short and broad, not elongate and distinctly pointed at distal end, reaching just to, or in rare cases, just past origin of pelvic-fin base. Pelvic fins relatively long and somewhat rectangular shaped, not broadly rounded, especially along medial edge. First dorsal fin triangular, preceded by a slender spine that is slightly less than or equal to height of fin; whitish at anterior of base of soft portion and posterior basal region of spine. Second dorsal fin elongate, nearly evenly tall along its length, pale at base of fin, darker distally. Caudal fin rounded with dorsal and caudal lobes almost equal in size, base of dorsal caudal fin pale, darker distally.

Frontal tenaculum in males small, slender, with a bulbous tip bearing ca. 50 long, fine, denticles in 8–9 overlapping rows. Males with very slender, pale pelvic claspers, forked for the distal 2/3 of their length with relatively large, pale, bulbous tips covered in numerous enlarged denticles giving a rough, bristly texture. Pelvic claspers relatively large, extending well beyond distal edge of the pelvic fins. Prepelvic tenaculae blade-like, concealed in pouches anterior to the pelvic fins, with 5–6 stout denticles along the medial edge. Large females with fleshy anal pad posterior to the cloaca, lacking in males.

SIZE.— Attains at least 801 mm TL, 403 mm BDL. Sexual maturity in males and females reached at >600 mm TL and >400 mm BDL.

DISTRIBUTION.— Found on the continental slope off eastern Australia from the Whitsunday Group in Queensland (18°58′ S, 150°29′ E) south to off Bulli in New South Wales (34°15′ S, 151°31′ E), in depths ranging from 548–995 m.

ETYMOLOGY.— Derived from the Latin *marmor* (marbled) in allusion to the marbled pattern of greyish brown reticulations on the sides of the body. Vernacular: Marbled Ghostshark.

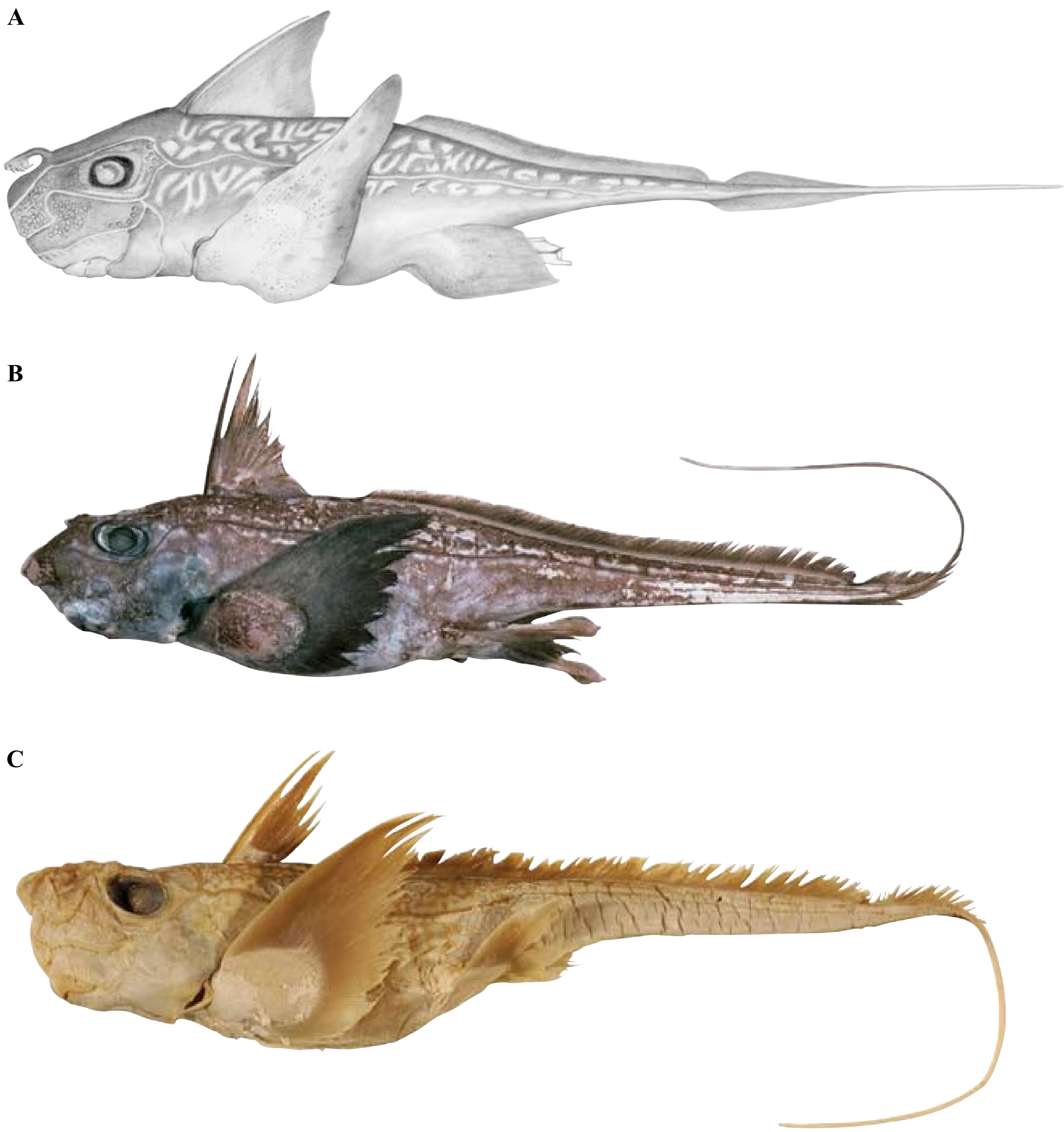

Figure 2. Lateral view of *Hydrolagus marmoratus* sp. nov.: A. drawing by Dana Stott Cohen, and B. fresh image of adult male holotype (AMS I 29762–003, 710 mm TL, 357 mm BDL); C. female paratype (CSIRO H 2276–01, 515 TL, 251 mm BDL, preserved, right side, image reversed).

DISCUSSION

The two new species of *Hydrolagus* are clearly separable from each other and their congeners in a combination of morphology, sensory line canal distribution and coloration. *Hydrolagus homonycteris* is the only species of black *Hydrolagus* with round pelvic fins and although fins are usually frayed, the overall round shape is distinctive enough to be apparent even in specimens with damaged fins. The round pelvic fins appear to be a key feature for identifying the species. It differs from the other Australian and New Zealand species of *Hydrolagus*, i.e. *H. bemisi*, *H. lemures*, *H. ogilbyi*, *H. novaezealandiae*, *H. marmoratus* and *H. trolli*, in having a uniform black body colour (vs. pale brown, silvery white, blue-grey or dark brown to grey with white spots and blotches). *Hydrolagus homonycteris* is also clearly distinguishable from *H. ogilbyi* and *H. lemures* in having a nearly straight to slightly waved

Table 2. Morphometric data for the holotype of *Hydrolagus marmoratus* sp. nov. (AMS I 29762–003), with ranges provided for the measured female and male paratypes. Measurements expressed as a percentage of body length.

	Holotype		Paratypes			
			Females (n=5)		Males (n=3)	
	mm	% BDL	mm	% BDL	mm	% BDL
TL	710	199	490–801	199–246	615–790	162–225
PCL	447	125	255–488	121–129	422–455	120–129
BDL	357	100	199–403	100	336–379	100
SVL	205	57	145–241	60–73	209–238	62–68
TRL	136	38	80–162	37–43	132–161	39–43
PD2	200	56	120–205	51–60	177–194	47–55
PD1	112	31	75–125	30–38	93–112	25–32
POB	47	13	34–55	13–17	31–47	8–13
D2B	270	76	144–318	72–79	255–283	75–78
D2AH	14.4	4	12–18	5–6	14–18	4–5
D2PH	131	37	98–140	35–49	128–160	37–42
D1B	48	13	34–47	16–17	50–54	14–15
DSA	86.8	24	46–62	23–24	76–85.3	23–24
D1H	63.5	18	53	20	50–58	15
CDM	66	19	42–55	14–21	55–70	16–19
CDH	9.6	3	6.1–10	3	8–10	2–3
CTL	277	78	246–323	80–134	161–351	43–100
CVM	95	27	75–107	24–43	87–105	26–30
CVH	8.1	2	4–8	2–3	6–8	2
HDL	82.9	23	67–88	22–34	81–98	22–28
P1A	134.7	38	85–140	35–43	120–139	36–38
P2A	67.8	19	42–70	17–21	62–75	19–21
IDS	42.2	12	8–29	4–10	32–35	8–10
DCS	1.5	0.4	1–2	0.5–0.6	2	0.5
PPS	98.6	28	56.5–123	25–31	95–116	28–32
D1P1	64	18	36–71	18–20	62–70	18–19
D1P2	146.4	41	76–185	38–46	143–156	41–45
D2P1	112	31	52–112	26–32	97–119	29–31
D2P2	83.6	23	45–120	23–30	85–90	22–27
EYL	29.2	8	21–32	8–11	27.5–31	8–9
EYH	16	5	14–22	6–7	17.5–24	5–6
CLT	83.2	23	–	–	77–85.5	20–24
CLM	49.6	14	–	–	47–51	12–15
CLL	45.2	13	–	–	48–49	13–15

lateral line (vs. a lateral line with regular sinuous undulations along its length) and claspers divided for about a third of their length (vs. divided for at least half of their length, also the case in *H. marmoratus*). It also occurs in deeper waters to these species (866–1447 vs. usually <500 m depth), similar to the depths that *H. trolli* occurs.

Hydrolagus marmoratus differs from other Australian and New Zealand *Hydrolagus* species in having a pale brown body colour with prominent, but often faint, darker reticulations on sides. *Hydrolagus bemisi* from New Zealand can occasionally have some faint mottling on the dorsal surface but only very rarely, whereas *H. marmoratus* has a distinctive colour pattern of reticulations in all specimens. It is also smaller in size (maximum size 403 vs. 572 mm BDL) than *H. bemisi*.

Hydrolagus marmoratus differs from *H. homonycteris* in colour (see above) and in the following features: pelvic-fin shape (rectangular shaped vs. broadly rounded), slightly larger pelvic fins (pelvic-fin anterior margin 13–18 vs. 17–21% BDL), second dorsal and dorsal caudal lobe almost touching (dorsal–caudal space 0.4–0.6 vs. 2–3% BDL) and larger eyes (eye length averaging ca. 25% HDL vs. ca. 30% HDL).

Cytochrome oxidase subunit 1 (CO1) sequences readily distinguish *H. homonycteris* (n=3), from *H. lemures* (n=8), *H. novaezealandiae* (n=2), *H. ogilbyi* (n=7) and *H. trolli* (n=5) (B.D. Ward, unpubl. data; and see Ward *et al*., 2008). No tissue samples for *H. marmoratus* have been obtained for sequencing to date.

Because many chimaeroids are known to be widespread in distribution (e.g. *Harriotta raleighana*, *Hydrolagus affinis* and *Chimaera phantasma*) one might expect to see more overlap in the Australian and New Zealand faunas. However, most species of *Chimaera* and *Hydrolagus* known from Australia occur in shallower depths of the shelf and upper slope (starting at around 150 m and not exceeding 1,000 m) and the only species that do overlap are known to occur in depths greater than 1000 m. It may well be that species occurring in shallow depths of the shelf and upper slope tend to be more restricted than species typically occurring in deeper waters with distributions starting at 800 m but more commonly found below 1000 m. Thus, it is not surprising that there is very little overlap in species distribution.

ACKNOWLEDGEMENTS

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Appendix I – Errata to Publications 1 and 2

Publication #1:

Last, P.R., White, W.T. & Pogonoski, J.J. (eds) (2007) *Descriptions of New Dogfishes of the Genus* Squalus *(Squaloidea: Squalidae).* CSIRO Marine & Atmospheric Research 014, 130 pp.

1. Page 11 (right column, in synonomies)
Error:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 48, 95, figs 18, 8.34, pl. 6"
Correction:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 48, 95, key fig. 18, fig. 8.34, pl. 6"

2. Page 39 (right column, in synonomies)
Error:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 93, figs 20, 8.32, pl. 6"
Correction:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 93, key fig. 20, fig. 8.32, pl. 6"

3. Page 43 (right column, in synonomies)
Error:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 94, figs 21, 8.21, 8.33, pl. 6"
Correction:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 94, key fig. 21, fig. 8.33, pl. 6"

4. Page 48 (left column, in synonomies)
Error:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 48, 95, figs 19, 8.31, pl. 6"
Correction:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 48, 91–92, key fig. 19, fig. 8.31, pl. 6"

5. Page 62 (right column, in synonomies)
Error:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 101, figs 8.24, 8.39, pl. 5"
Correction:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 101, key fig. 24, fig. 8.39, pl. 5"

6. Page 75 (right column, in synonomies)
Error:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 97, figs 8.26, 8.36, pl. 5"

Correction:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 97, key fig. 26, fig. 8.36, pl. 5"

7. Page 79 (right column, 1st paragraph, 2nd last sentence):
Error:
"Vertebral centra 113 (108–116), monospondylous 40 (38–42)..............."
Correction:
"Vertebral centra 113 (105–116), monospondylous 40 (37–42)..............."

8. Page 83 (right column, in synonomies)
Error:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 96, figs 8.25, 8.36, pl. 5"
Correction:
"Last and Stevens, 1994, *Sharks and rays of Australia*, pp 49, 96, key fig. 25, fig. 8.35, pl. 5"

9. Page 92 (right column, in synonomies, *Squalus mitsukurii*):
Error:
"Last and Stevens, 1994: 101–102, 8.39, Plate 5"
Correction:
"Last and Stevens, 1994: 101–102"
Reason:
Both the figure and plate used in Last and Stevens (1994) refer to *Squalus chloroculus* and not *Squalus griffini*.

10. Page 115 (key couplet 13a and b):
Error:
13a. First dorsal-fin low (first dorsal-fin height 2.4–4.0% TL), usually angled rearwards 14
b. First dorsal-fin tall (first dorsal-fin height 4.4–5.9% TL), usually upright (sometimes angled rearwards in *S. crassispinus* ………….. 15
Correction:
13a. First dorsal-fin spine short (first dorsal-fin spine length 2.4–3.4% TL), usually angled rearwards 14
b. First dorsal-fin spine long (first dorsal-fin spine length 4.4–5.9% TL), usually upright (sometimes angled rearwards in *S. crassispinus*………….15

11. Pages 22, 29, 38, 53, 69, 81, 90, 100, 108 and 115 (references, author order and initials)
Error:
Last, P.R., White, W.T., Pogonoski, J.J., Gledhill, D.C., Ward, B. and Yearsley, G.K. (2007) Part 1 — Application of a rapid taxonomic approach to the genus *Squalus*, pp. 1–10. ....
Correction:
Last, P.R., White, W.T., Pogonoski, J.J., Gledhill, D.C., Yearsley, G.K. and Ward, R.D. (2007) Part 1 — Application of a rapid taxonomic approach to the genus *Squalus*, pp. 1–10. ....

Publication #2:

Last, P.R., White, W.T., Pogonoski, J.J. & Gledhill, D.C. (eds) (2008) *Descriptions of New Australian Skates (Batoidea: Rajoidei).* CSIRO Marine & Atmospheric Research 021, 181 pp.

1. Page 77 (left column, 2nd paragraph, 1st sentence):

Error:
"Material from the *Endeavour* survey held by the Queensland Museum (QM I 19257 and QM I 19970) may be from Ogilby's original type series, or at least from the type locality."

Correction:
"Material from the *Endeavour* survey held by the Queensland Museum (QM I 1540) may be from Ogilby's original type series, or at least from the type locality."

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