CSIRO FISHERIES AND OCEANOGRAPHY
Fisheries Synopsis No. 8

DFO/S8

SYNOPSIS OF BIOLOGICAL DATA ON THE BANANA PRAWN

Penaeus merguiensis de Man, 1888

Prepared by
I. Kirkegaard and D. J. Tuma and R. H. Walker

DIVISION OF FISHERIES AND OCEANOGRAPHY
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION
Cronulla, Sydney, Australia, 1970

SYNOPSES OF FISHERIES BIOLOGICAL DATA

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Penaeus merguiensis de Man, 1888

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CONTENTS [1/]

1/ This synopsis has been prepared in accordance with Outline Version No. 2 in H. Rosa Jr, 1965, Preparation of synopses on the biology of species of living aquatic organisms, F.A.O. Fisheries Synopses 1 (Revision 1).

*As no information was available to the authors, these items have been omitted from the text

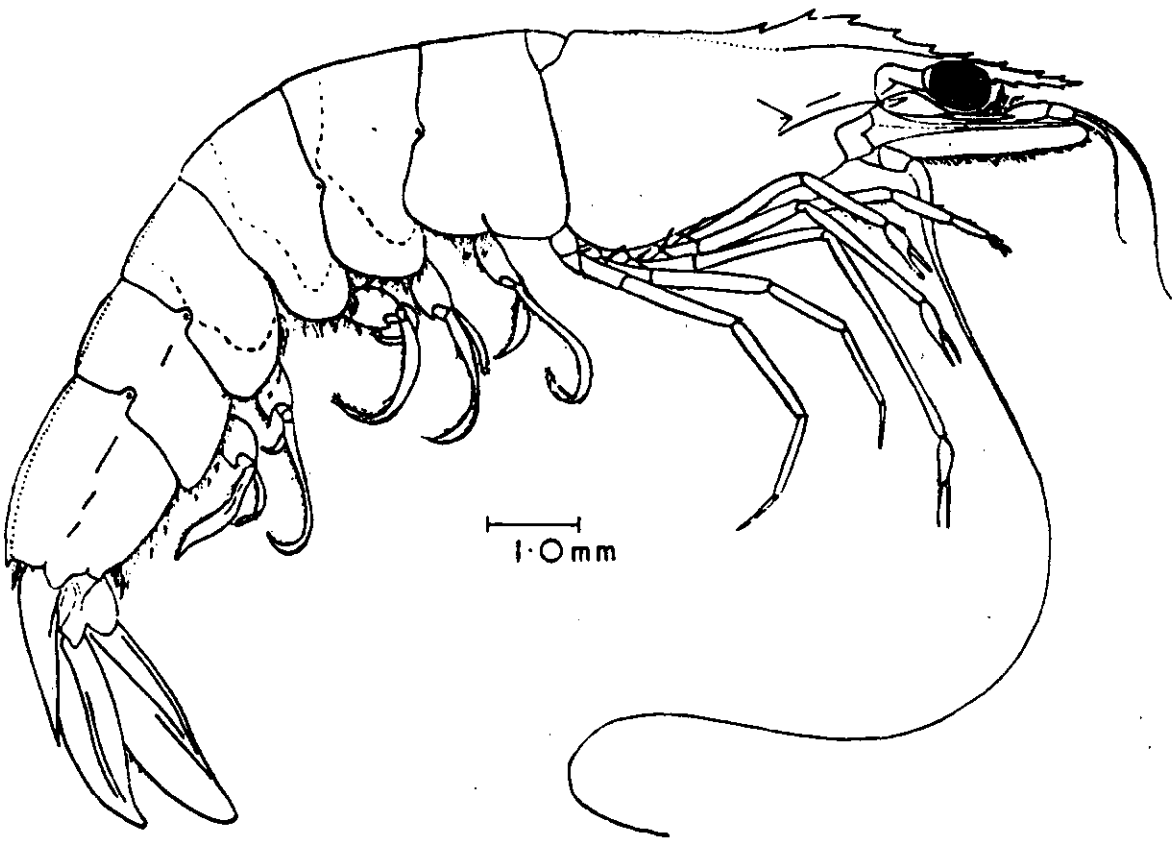


Fig. 1.- Penaeus merguiensis de Man, 1888: female, carapace length 33 mm (from Hall, 1962).

1 IDENTITY

1.1 Nomenclature

1.11 Valid name

Penaeus merguiensis de Man, 1888, J. Linn. Soc., 22(140): 1-312.

1.12 Objective synonymy

None.

1.2 Taxonomy

1.21 Affinities

- Suprageneric

Phylum Arthropoda
Class Crustacea
Subclass Malacostraca
Series Eumalacostraca
Superorder Eucarida
Order Decapoda
Suborder Natantia
Section Penaeidea
Family Penaeidae
Subfamily Penaeinae

- Generic

Genus: Penaeus Fabricius, 1798, "Supplementum Entomologiae Systematicae", p. 408.

Genotype: Penaeus monodon Fabricius, 1798 (neotype Holthuis, 1949).

Generic concept is that of Dall (1957, pp. 141-2):

"Rostrum toothed ventrally. Carapace without longitudinal or transverse sutures; cervical and orbito-antennal sulci and antennal carinae always present. Hepatic and antennal spines pronounced, pterygostomial angle rounded. Telson with deep sulcus, without fixed subapical spines, with or without lateral movable spines. First antennular segment without a spine on ventral distomedian border. Antennular flagella shorter than carapace. Maxillulary palp with 2 or 3 segments, usually 3. Maxilliped 3 sexually dimorphic. Basial spines on 1st and 2nd pereiopods, exopods on 1st 4 pereiopods, usually present on 5th. Petasma pod-like with thin

median lobes, usually with small thickened distal protuberances and forming a posterior tube-like projection; lateral lobes usually with thickened distal rounded margins. Appendix masculina with an ovoid distal segment, bearing numerous spinules. Thelycum usually with an anterior process, variable in shape, lying between the coxae of 4th pereiopods and seminal receptacle occupying ventral surface of last thoracic sternite, receptacle often closed by 2 flaps which meet or overlap on the mid line; seminal receptacle sometimes open. Zygocardiac ossicle consisting of a principal tooth followed by a longitudinal row of smaller teeth which often end in a cluster of minute teeth. Pleurobranchiae on 3rd to 8th thoracic somites; a rudimentary arthrobranch on 1st, and a posterior arthrobranch on 7th thoracic somites; mastigobranchiae on 1st to 6th thoracic somites. Body glabrous."

- Specific

Type specimen: Reg. No. Crust. D. 1183, Rijksmuseum van Natuurlijke Historie, Leiden, a single specimen of de Man's original type series, and is a female of carapace length 40 mm (including rostrum) (Holthuis, personal communication).

Type locality: Mergui Archipelago.

Diagnosis: P. merguiensis is illustrated in Figure 1. A colour illustration is given by Grant (1965, Plate 14). The following description is from Dall (1957, pp. 160-1).

"Rostrum.—Teeth, 5-8/2-5, usually 6-7/4-5. Long, slender, upcurving, $1\frac{1}{2}$ to twice carapace length in postlarvae; 1st 5 dorsal teeth close together, penultimate and distal tooth widely separated; position of latter variable, at $\frac{1}{2}$ length of rostrum when there are 6, and 1/3 from tip when there are 7, but sometimes varying regardless of number of teeth. Becoming shorter with increasing size, equalling length carapace in prawns of 80 mm, almost straight and with higher blade. Rostrum not exceeding 2nd segment of antennular peduncle in large prawns, blade high of broad triangular form. Adrostral carina usually ending between 1st and 2nd teeth, sometimes reaching 1st. Postrostral carina ending at posterior 1/5 carapace.

Carapace.—Glabrous, thin, sulci and carinae feebly defined. Gastro-orbital carina absent or feeble, occupying middle 1/3 distance between hepatic spine and postorbital margin; orbito-antennal sulcus wide and ill defined; antennal carina ending in front of hepatic spine, hepatic carina absent. Cervical sulcus 1/6-1/7 length carapace.

Antennules.—Outer flagellum $1\frac{1}{2}$ to twice inner, longer than peduncle. Prosartema exceeding tip, stylocerite barely reaching $\frac{1}{2}$ basal segment.

Thoracic appendages.—Endopod 3rd maxilliped reaching tip of antennular peduncle in adult male, usually not exceeding basal

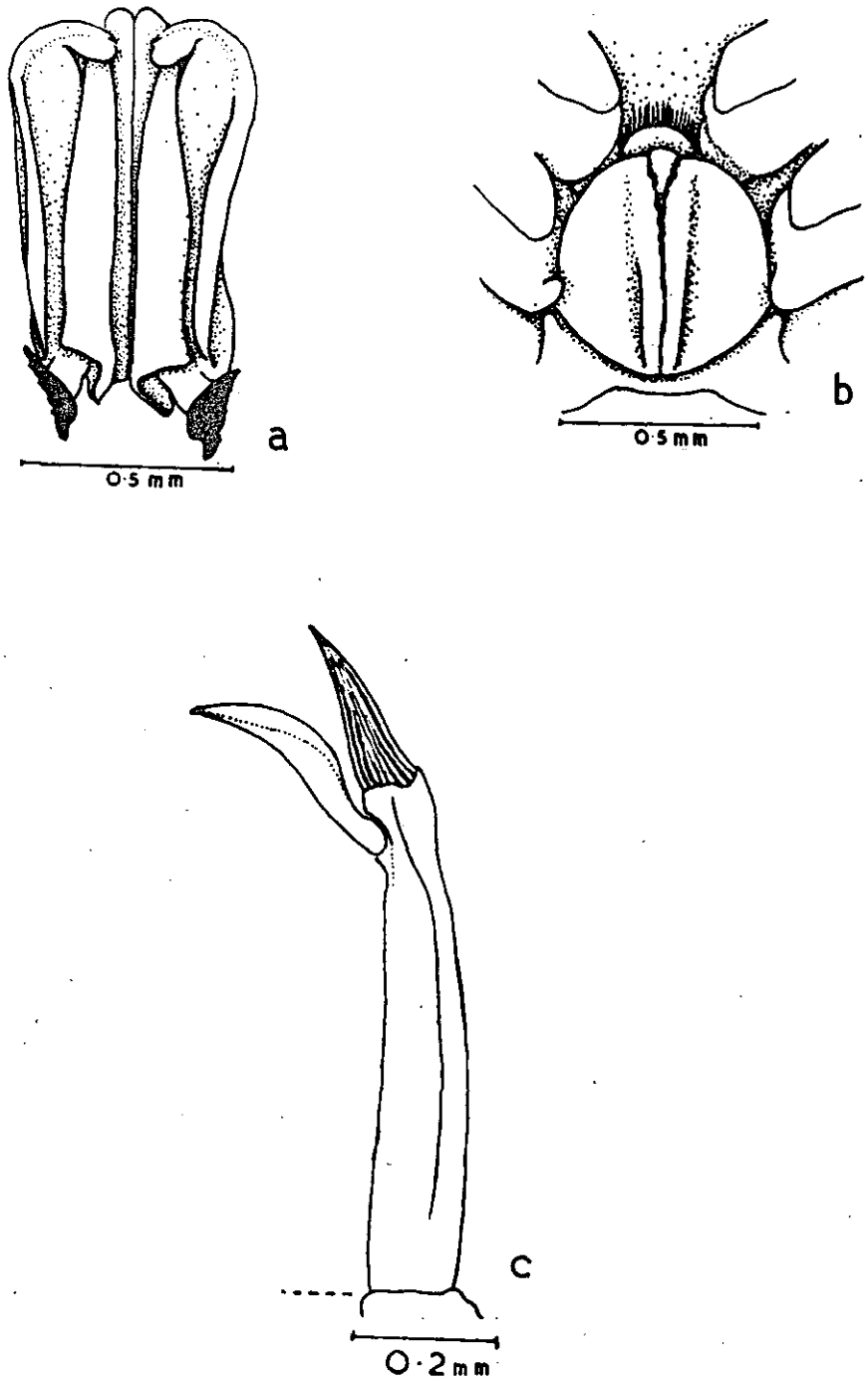


Fig. 2.- Penaeus merguiensis: a, petasma, of male, carapace length 34 mm; b, thelycum, of female, carapace length 34 mm; c, terminal segment of maxilliped 3, of male, 34 mm long (from Hall, 1962).

segment in female; dactyl $\frac{1}{2}$ propodus, inserted subapically in male with apical tuft of setae reaching $\frac{1}{2}$ dactyl (Fig. 2c). First pereiopod exceeding carpocerite by dactyl, 2nd reaching tip of 2nd segment antennular peduncle, 3rd exceeding 3rd antennular segment by at least dactyl, 4th and 5th exceeding carpocerite by dactyl. Ischial spine on 1st pereiopod.

Abdomen.—Dorsally carinated from middle of 4th somite in larger prawns, on 5th and 6th only in specimens below 80 mm. Fifth somite with 1, 6th with 3 small lateral cicatrices. Telson unarmed.

Gastric mill.—Cardiac plate with 22-28, usually 24 spinules. Zygocardiac ossicle with principal + 7-10 smaller teeth and longitudinal row of very small teeth. Prepyloric acute with 7-9 separated lateral teeth.

Petasma.—Median distal projections not overhanging lateral lobes when seen from side. Distal tip of lateral lobe minutely serrate, outer surface of lobe with large number of minute conical teeth. (Fig. 2a).

Appendix masculina.—Length distal piece 1-1$\frac{1}{4}$ times width, $\frac{3}{4}$ length basal piece.

Thelycum.—Anterior plate slightly concave, $\frac{1}{4}$ length seminal receptacle, with posterior convex projection, inserted between flaps of seminal receptacle for $\frac{1}{3}$ length. Seminal receptacle round with two flaps forming tumid lips on mid line (Fig. 2b).

Colour in life (mature prawns living in open waters).—Body cream to yellow, sometimes minutely speckled with blue; rostral blade often blue; antennules banded with brown; antennae red; legs and pleopods yellowish, sometimes with brown or pink tinge; abdominal carina brownish red, sometimes blue; uropods brown tipped with yellow, sometimes with blue. Body sometimes pink to red, especially when coming from deeper waters. Juveniles in muddy estuaries.—Body cream, speckled with blue, rostral tip dark brown, outer edges of antennal scales, abdominal carina, telson, and uropods often more or less brown. Post larvae.—Body white to cream, tip of rostrum dark brown."

Material examined by present authors: Specimens from the east coast of Queensland and the Gulf of Carpentaria were examined. A male and female from the Gulf of Carpentaria have been deposited in the Queensland Museum (Reg. No. W3169).

Subjective synonymy:

Penaeus indicus Bate (1888) place in synonymy in de Man (1911), with reasons.

Penaeus indicus var. merguiensis de Man (1892) placed in synonymy in de Man (1911), with reasons.

Penaeus indicus var. merguiensis Alcock (1906) placed in synonymy in de Man (1911), with reasons.

Penaeus merguiensis Schmitt (1926) placed in synonymy in Kubo (1949), with reasons.

Key to Indo-Pacific species of Penaeus (Dall, 1957):

1 Adrostral carina reaching almost to posterior border of carapace; gastrofrontal carina present 2
Adrostral carina not reaching behind middle of carapace; gastrofrontal carina absent 10

2(1) Telson armed, usually with 3 pairs of spinules 3
Telson unarmed 8

3(2) Postrostral carina sulcate; not more than 1 ventral rostral tooth 4
Postrostral carina nonsulcate; usually 2 ventral rostral teeth 7

4(3) Sulcus on postrostral carina less than $\frac{1}{2}$ length of carapace; ischial spine on 1st pereiopod ..... P. longistylus Kubo
Sulcus on postrostral carina more than $\frac{1}{2}$ length of carapace; no ischial spine on 1st pereiopod 5

5(4) Rostrum with accessory pair of carinae on blade of rostrum, gastrofrontal sulcus with trifurcate posterior end ..... P. plebejus Hess (=P. maccullochi Schmitt)
Rostrum without accessory pair of carinae; gastrofrontal sulcus with bifurcate posterior end 6

6(5) Thelycum with apex of anterior plate rounded; seminal receptacle cylindrical, not closed by 2 flaps; adrostral sulcus narrower than postrostral carina ..... P. japonicus Bate
Thelycum with apex of anterior plate bifid; seminal receptacle flat, closed by 2 flaps; adrostral sulcus as wide as postrostral carina ..... P. latisulcatus Kishinouye

7(3) Adrostral carinae continuing almost to posterior edge of carapace; anterior plate of thelycum with lanceolate apical process ..... P. teraoi Kubo
Adrostral carinae becoming indistinct posteriorly; anterior plate of thelycum without lanceolate apical process ..... P. marginatus Randall

8(2) Rostrum with 1 ventral tooth ..... P. canaliculatus Olivier
Rostrum with more than 1 ventral tooth 9

9(8) Thelycum with a median longitudinal carina on sternite of 7th thoracic somite; ventral surface of flaps of seminal receptacle not pubescent ..... P. californensis Holmes
Thelycum without a median carina on sternite of 7th thoracic somite; ventral surface of flaps of seminal receptacle pubescent ..... P. brevirostris Kingsley

10(1) Hepatic carina present 11
Hepatic carina absent 17

11(10) Third maxilliped in male with apical tuft of setae on propodus; lateral lobe of petasma thickened distally; thelycum with seminal receptacle closed by 2 flaps 12
Third maxilliped in male without apical tuft of setae on propodus; lateral lobe of petasma not thickened distally; thelycum with open seminal receptacle (spp. limited to Pacific America) 15

12(11) Fifth pereiopods with small but distinct exopods 13
Fifth pereiopods without exopods ..... P. monodon Fabricius (=P. carinatus Dana)

13(12) Postrostral carina sulcate ..... P. semisulcatus de Haan
Postrostral carina nonsulcate 14

14(13) Hepatic carina arcuate, extending behind posterior end of antennal carina; rostral teeth 9/2 ..... P. gracilirostris Thallwitz
Hepatic carina straight, not extending beyond posterior end of antennal carina, rostral teeth 5-7/3-4 ..... P. esculentus Haswell

15(11) Adrostral carina reaching as far as epigastric tooth; rostral teeth usually 9/2 ..... P. vannamei Boone
Adrostral carina extending posteriorly to epigastric tooth; ventral rostral teeth more than 2 16

16(15) Antennular flagella longer than peduncle; thelycum with prominent pyramidal upheaval on 8th thoracic somite; an expanded coxal projection on 5th pereiopod of female ..... P. stylirostris Stimpson
Antennular flagella as long as or shorter than peduncle; thelycum without pyramidal upheaval; no coxal projections on 5th pereiopods of female ..... P. occidentalis Streets

17(10) Third pereiopod exceeding scaphocerite by at least dactyl; maxillulary palp 2-segmented 18
Third pereiopod not quite reaching tip of scaphocerite; maxillulary palp 3-segmented ..... P. orientalis Kishinouye

18(17) Gastro-orbital carina occupying the posterior 2/3 distance between hepatic spine and orbital angle ..... P. indicus Milne Edwards
Gastro-orbital carina absent or not reaching hepatic spine and occupying the middle $\frac{1}{2}$ distance between hepatic spine and orbital angle 19

19(18) Dactyl of 3rd maxilliped of adult male $\frac{1}{2}$ propodus; adrostral carina not reaching as far as epigastric tooth ..... P. merguiensis de Man
Dactyl of 3rd maxilliped of adult male much longer than propodus; adrostral carina reaching just beyond epigastric tooth ..... P. penicillatus Alcock

1.22 Taxonomic status

P. merguiensis is a morphospecis. "Penaeus penicillatus Alcock, P. merguiensis de Man, and P. indicus H. Milne Edwards are three very similar species. Although adults demonstrating the features typical of the respective species may be identified fairly easily, there are many cases in which features of all three species may be exhibited by a single individual." (Hall, 1956). Thus it appears that these three species form a species complex and their satisfactory separation must await detailed morphometric studies. Table 1 gives characters which can be used to separate these species.

TABLE 1

FEATURES SEPARATING P. MERGUIENSIS, P. PENICILLATUS, AND P. INDICUS

P. penicillatus	P. merguiensis	P. indicus
Rostral crest elevated, assumes high triangular form in females	Rostral crest of high broad triangular form	Rostral crest low
Gastro-orbital carina poorly defined, occupying central half of distance between hepatic spine and margin of carapace	Gastro-orbital carina absent or feebly developed in Australian forms, bluntly defined in Asian forms; occupies middle $\frac{1}{3}$rd of distance between hepatic spine and margin of carapace	Gastro-orbital carina occupies posterior 2/3 distance between hepatic spine and margin of carapace
Ratio propodus: dactylus of 3rd maxilliped, males 0.6 : 1	Ratio propodus: dactylus of 3rd maxilliped, males 2 : 1	Ratio propodus: dactylus of 3rd maxilliped, males 1 : 1

1.23 Subspecies

It is not known if the difference in gastro-orbital carinae between Asian and Australian forms pointed out in Table 1 is indicative of the presence of subspecies (Racek and Dall, 1965).

1.24 Standard common names, vernacular names

Table 2 gives standard and vernacular names.

TABLE 2

STANDARD AND VERNACULAR NAMES OF P. MERGUIENSIS

Country	Standard Name	Vernacular Name	Authority
Australia	Banana prawn		
Hong Kong	White prawn		Cheung (1960)
Malaysia		Udang Kaki merah	Hall (1962)
Pakistan		Jiaro	Qureshi (1956)

1.3 Morphology

1.31 External morphology (For description of spawn, larvae, and juveniles, see 3.17; 3.22; 3.23.)

A carapace which covers the cephalothorax bears a prominent rostrum anteriorally. Two compound eyes arise on either side of the rostrum. Thereafter the following pairs of appendages are found attached to the sternites of the cephalothoracic segments; antennules, antennae, mandibles, maxillae I and II, maxillipeds I, II, and III, and pereiopods I to V, pereiopods I to III with small chelae. In females, the sternite of the segment bearing pereiopod V is modified into a thelycum. The abdomen consists of six individually distinct segments and a telson. The sternites of the first five abdominal segments bear paired pleopods, the sixth bears uropods on its posterior margin. The endopods of the first pair of pleopods of males are modified into a petasma, each of the second pair of pleopods bear an appendix masculina.

Prawns of this species from India, Pakistan, and south-east Asian waters have a gastro-orbital carina on the carapace, however, Australian and New Guinean specimens do not possess this feature (Section 1.23).

The rostrum of juvenile P. merguiensis is long in relation to the carapace, with a low upper blade; as the prawns mature the upper blade of the rostrum assumes a high triangular form and the rostrum becomes relatively shorter and straighter (Dall, 1957).

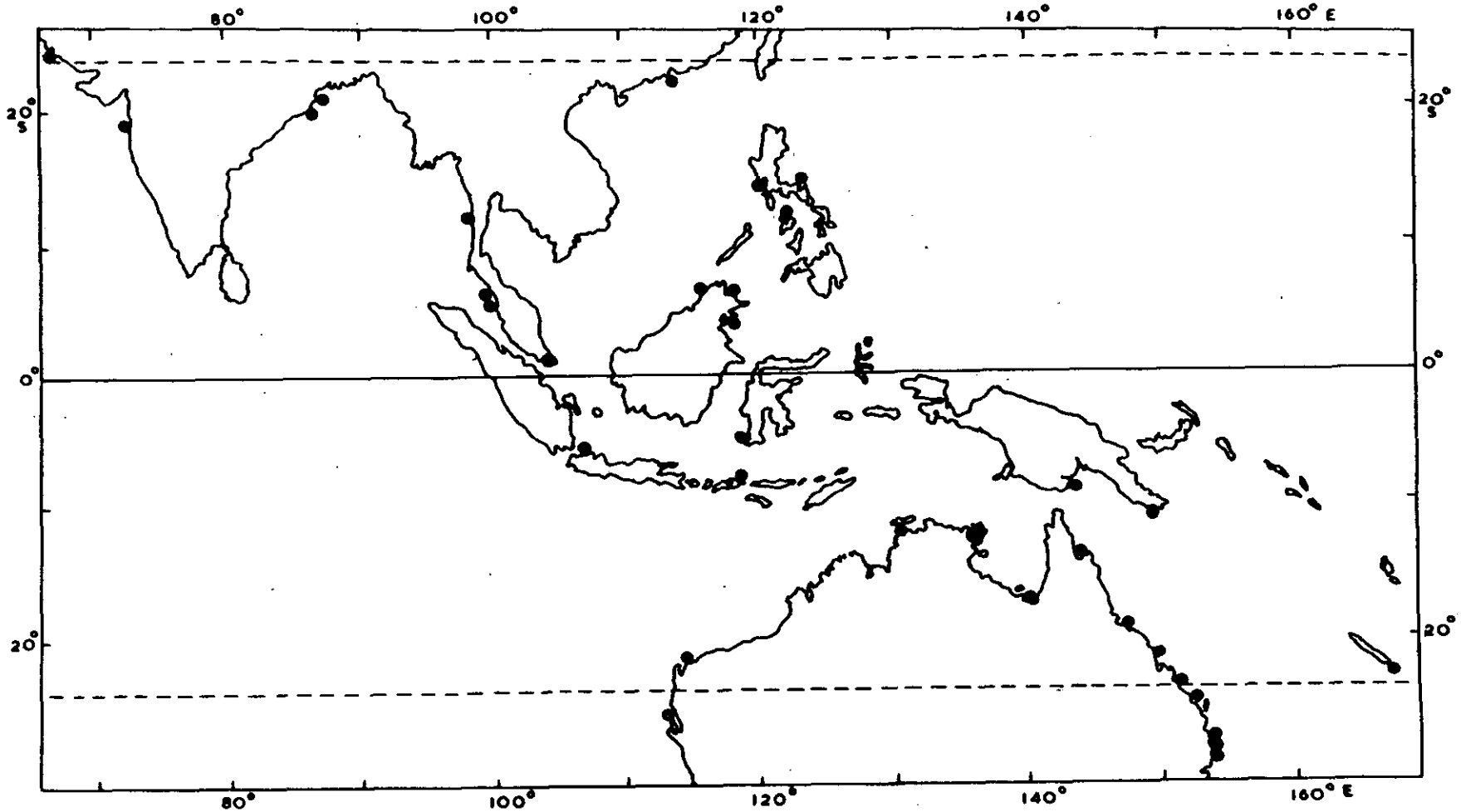


Fig. 3.- Distribution of Penaeus merguiensis. Recorded occurrences shown thus ● .

2 DISTRIBUTION

2.1 Total area

This species occurs throughout Asian and Australasian tropical and subtropical waters from longitude 67°E. to 166°E., and from latitude 25°N. to 29°S. (Fig. 3, Table 3). The species occupies estuarine to coastal waters, according to the different stages of its life cycle (see 2.2).

TABLE 3

AREAS WHERE P. MERGUIENSIS OCCUR

Land area	Code (Rosa 1965)
Pakistan	421
India	423
Ceylon	424
Malaysia	433
Singapore	433
Java	434
Sumatra	434
Celebes	434
North Borneo	436
Philippines	437
Hong Kong	442
Northern Territory	611
Western Australia	612
New South Wales	615
Queensland	616
New Guinea	620
New Caledonia	682

2.2 Differential distribution

2.21 Spawn, larvae, and juveniles

Larvae move from the spawning grounds at sea (see 3.16) to coastal inlets and estuaries. They enter the coastal environment as post-larvae.

Juveniles are found in estuarine environments (Dall, 1958; Hall, 1962).

2.22 Adults

Adult P. merguiensis generally occur in shallow coastal water. In the Gulf of Carpentaria prawns grow larger as they leave the

coast and travel toward the 20 m line. During March to September, fully adult prawns occurring in depths between 16 and 24 m school extensively (Munro, pers. comm.).

2.3 Determinants of distribution changes

In the Gulf of Carpentaria, Queensland, small prawns leave the rivers during the monsoon, probably because of increased flow in the rivers (Munro, pers. comm.). Thus their occurrence on the fishing grounds is closely linked to weather conditions.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.11 Sexuality

P. merguiensis is heterosexual. Sexes may be distinguished externally after the late post-larval stages have been completed. The male carries a petasma on the first pair of pleopods and an appendix masculina on each of the second pair of pleopods. The endopod of the 3rd maxilliped reaches the tip of the antennular peduncle. In males the dactyl of this appendage is inserted subapically with an apical tuft of setae reaching halfway along the dactyl. The female has a thelycum between the 4th and 5th pairs of pereiopods. The endopod of the 3rd maxilliped does not exceed the basal segment of the antennular peduncle.

Adults show a distinct difference in size for age: as growth proceeds females become noticeably larger than males of the same age (Tuma, 1967).

3.12 Maturity

Tuma (1967) found the smallest size of prawn with mature gonads to be, for males, 18.5 mm carapace length, and for females, 31.0 mm carapace length. The smallest size of prawn with structurally complete genitalia was, for males, approx. 20 mm carapace length, and for females, approx. 24 mm carapace length.

3.13 Mating

P. merguiensis is promiscuous (Tuma, 1967). In the southern Gulf of Carpentaria, Queensland, inseminated females occur throughout the year, but are most frequently found during March to September (Tuma, 1967).

3.14 Fertilization

Fertilization is external (Tuma, 1967). Females must be in a soft-shelled condition and males must be in a hard condition for impregnation of spermatophores.

3.15 Gonads

- Ovarian development

Tuma (1967) described the ovaries of P. merguiensis and divided ovarian development into 5 arbitrary stages: (1) quiescent, (2) developing, (3) early maturity, (4) ripe, and (5) spent. In stages 1 and 2 ovaries are translucent. The colour changes from pale

buff or yellow during stage 3 to olive-green during stage 4, and greyish-green during stage 5.

Females of carapace length 30 to 40 mm (the size when insemination occurred) possessed ovaries in various stages of development. For females with similarly developed ovaries there was no consistent relation between number of yolked ova and length of the individual.

There was evidence that some females may go through a sequence of ovarian stages more than once (Tuma, 1967 and unpublished).

- Fecundity

Approximately 100,000 ripe ova are released by a female at one spawning (Tuma, 1967). Histological examination of ovarian tissue suggests that females spawn more than once during their life (Tuma, unpublished data).

3.16 Spawning

- Number of spawnings

It is not known whether P. merguiensis spawn more than once during their life (see 3.15).

- Spawning seasons

In the southern Gulf of Carpentaria, Queensland, spawning occurs mainly during the period March to September, but post-larvae have been caught between September and May, thus some spawning must take place over that period. Hall (1962) found that the main spawning season in the Singapore Strait area was during the north-east monsoon, February to April. Observations on gonads indicate that P. merguiensis breeds during July and August in West Pakistan (Qureshi, 1956).

- Spawning grounds

In the southern Gulf of Carpentaria spawning is believed to occur in depths greater than 14 m but the actual location of the spawning grounds is unknown (Tuma, 1967). Hall (1962) believes that P. merguiensis caught at Singapore are spawned in depths of 20 to 40 m off the east coast of the Malay Peninsula 40 to 60 miles (64 to 96 km) east of Singapore Island.

- Distribution on the spawning grounds

Adult P. merguiensis school extensively (Racek, 1959; Munro, pers. comm.). The reasons for this are not fully understood but it is possible that this behaviour is associated with female ecdysis and insemination of females by hard-shelled males. The sex ratio of these schools is 1 : 1.

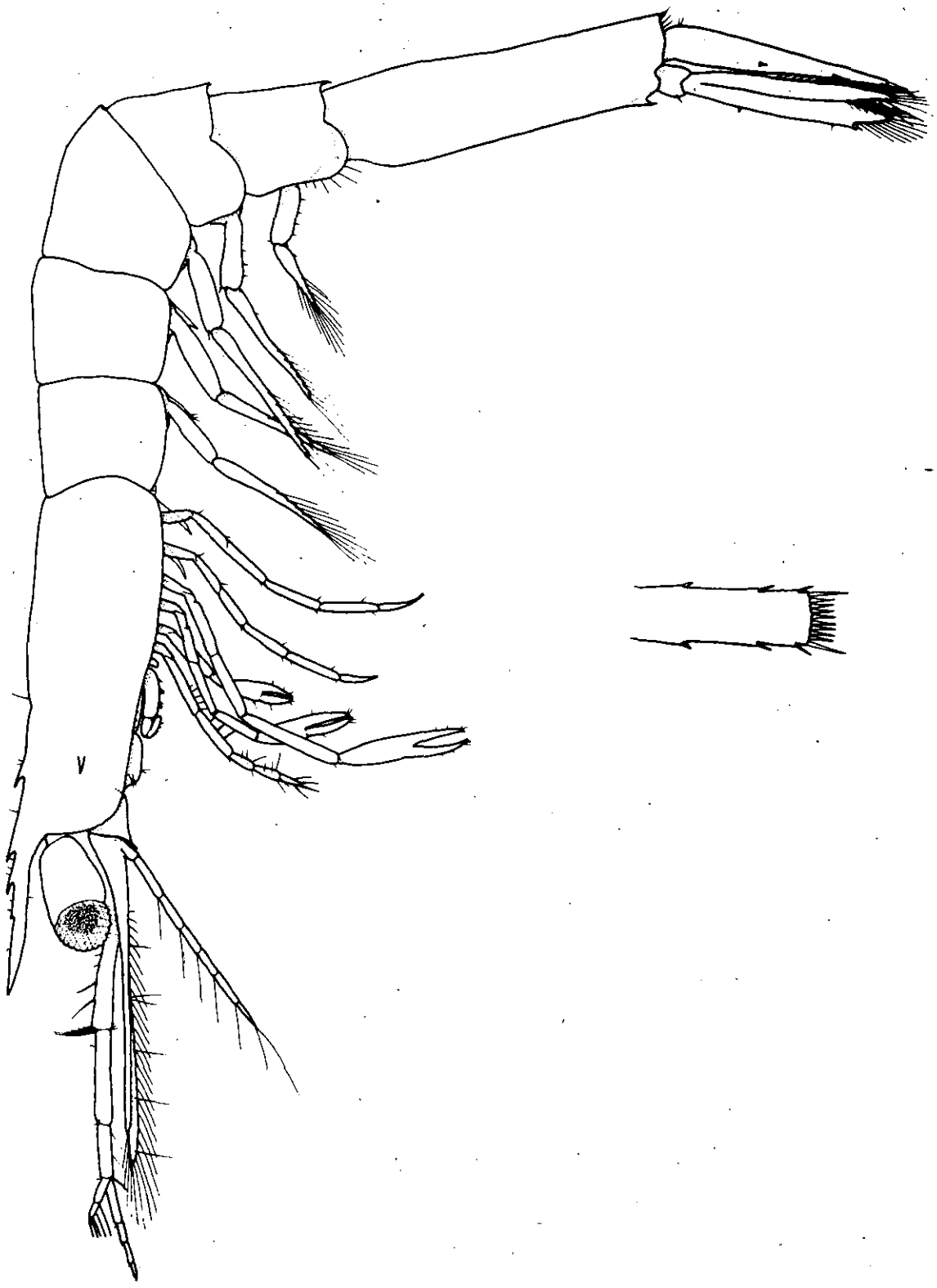


Fig. 4.- Early post-larva of Penaeus merguiensis taken from the Gulf of Carpentaria, Australia. Carapace length 1.8 mm (Kirkegaard).

- Spawning time

Prawns form schools which are possibly associated with mating and spawning during both day and night. Schools form close to the bottom during slack water or other periods of little tidal movement.

3.2 Pre-adult phase

3.22 Larval phase

Larvae move from the spawning grounds to coastal inlets and estuaries. The nauplius, protozoea, and mysis stages of P. merguiensis are unknown. They enter the coastal environment as post-larvae. Post-larvae (Fig. 4) have been taken in the Norman River in the southern Gulf of Carpentaria between September and May.

3.23 Adolescent phase

As the post-larvae metamorphose into juveniles the rostrum undergoes an elongation in relation to the carapace. The rostrum then becomes relatively shorter as juveniles progress toward adulthood. Male prawns are up to 26 mm and females up to 28 mm (carapace length) when they leave the Norman River, Queensland (Tuma, 1967). Juveniles of P. merguiensis have been found in freshwater 43 miles (69 km) from the mouth of the Norman River. Hall (1962) recorded juveniles (smaller than 25 mm carapace length) in a Singapore prawn pond, the annual variation of salinity of which was approx. 7-32‰.

Juveniles leave rivers to join adult populations in the southern Gulf of Carpentaria between November and May. In the Singapore fishery, juveniles occur in commercial captures during the change from the north-east to south-west monsoon and during the early south-west monsoon.

3.3 Adult phase

3.32 Hardiness

Young P. merguiensis have been found in estuaries which vary extensively in salinity from season to season.

3.33 Competitors

Penaeus esculentus, P. latisulcatus, and Metapenaeus endeavouri have all been caught with P. merguiensis in the Gulf of Carpentaria, although large schools of P. merguiensis are usually monospecific (Munro, pers. comm.). Penaeus esculentus may be caught on the periphery of these large schools. In Singapore, Hall (1962) found that P. monodon, P. indicus, and P. merguiensis occupied similar habitats and ate similar food.

3.34 Predators

In the southern Gulf of Carpentaria, Polydactylus spp. have been taken with their stomachs full of P. merguiensis (authors' observations).

3.35 Parasites, diseases, injuries, and abnormalities

- Parasites and diseases

Infection by a bopyrid crustacean parasite, Epipenaeon sp., causes male genitalia to remain structurally incomplete and gonads of males and females to fail to mature (Tuma, 1967).

3.4 Nutrition and growth

3.42 Food

Hall (1962) investigated the stomach contents of 35 specimens of P. merguiensis from Singapore and Kedah, Malaysia. He found that P. merguiensis feeds mainly on crustaceans and vegetable material (Table 4).

TABLE 4

STOMACH CONTENTS OF P. MERGUIENSIS FROM THE MALAY PENINSULA

The figures are numbers of individuals
(from Hall, 1962)

Item	Predominant	Residual	Total
Polychaeta	1	2	3
Echiurida	-	2	2
Small crustacea (ingested whole)	4	11	15
Large crustacea (too large to ingest whole)	6	6	12
Mollusca	-	2	2
Pisces	1	5	6
Vegetable	2	16	18

3.43 Growth rate

A population of male banana prawns kept in cages in the Norman River, Queensland, for 120 days increased in modal length from 11.0 to

26.97 mm carapace length and a population of female banana prawns increased in modal length from 9.6 to 29.38 mm carapace length (Tuma, unpublished data).

3.5 Behaviour

3.51 Migrations and local movements

After hatching the larvae move from the spawning grounds towards the coast. They are found in the estuarine environment as post-larvae. After the post-larvae metamorphose into juveniles they leave the estuarine environment and enter the coastal waters. As they grow they move towards the adult habitat on the spawning grounds.

In the Gulf of Carpentaria, Queensland (Munro, pers. comm.), small prawns leave the rivers during the monsoon, probably because of increased flow in the rivers. A movement of small juveniles from the coast to deeper waters occurs from November to May with the main movement occurring between December and March. This migration is accompanied by an increase in size. The migration is accomplished when the prawns are 20 to 50/lb (44 to 110/kg). Fully adult prawns are found in depths greater than 12 m. These adult prawns are found mainly between March and November.

3.52 Schooling

Adult P. merguiensis school extensively (Racek, 1959; Munro, pers. comm.). The reasons for this are not fully understood but it is possible that this behaviour is associated with mating and spawning. The sex ratio of these schools is 1 : 1. Schools form close to the bottom during slack water or other periods of little tidal movement. Prawns school during both day and night. In the Gulf of Carpentaria schooling of adults takes place in depths of 16 to 24 m, 20 miles (37 km) from the coast. The size and density of these schools are such that one trawler in the southern Gulf of Carpentaria took 1500 lb (680 kg) of prawns in 5 minutes' trawling. Prawns in these large schools are usually in the 12 to 17/lb (26 to 37/kg) size range (Munro, pers. comm.).

4 POPULATION

4.1 Structure

4.11 Sex ratio

Tuma (1967) found that the sex ratio of catches totalling 10 lb weight (4.5 kg) or more usually approaches a 1 : 1 ratio, but smaller catches consistently favour males in the ratio of about 9 : 7 in the southern Gulf of Carpentaria, Queensland.

4.13 Size composition

- Length composition

In the Gulf of Carpentaria, Queensland, small prawns (35 to 105/lb = 77 to 231/kg) are found from November to May as they move from the coast to deeper waters. At the end of this migration the prawns are 20 to 50/lb (44 to 110/kg), the main group being 20 to 35/lb (44 to 77/kg). Fully adult prawns are caught in depths greater than 12 m and range from 9 to 17/lb (20 to 37/kg). These adult prawns are found mainly between March and November (Munro, pers. comm.).

- Size at maturity

Tuma (1967) found that the size at first maturity of gonads was for males 18.5 mm carapace length, and for females, 31.0 mm carapace length.

- Length and weight relationship

Hall (1962) gives a graph of the relation between carapace length and body weight of P. merguiensis. This line is expressed by the equation

$$W = k\, C^{a}$$

where W = wet weight, C = carapace length (the distance from the postocular notch to the posterior dorsal midpoint of the carapace), and a is a constant calculated as follows,

$$a = \frac{\Sigma(\log C . \log W) - \frac{\Sigma(\log C)\ \Sigma(\log W)}{N}}{\Sigma[(\log C)^2] - \frac{(\Sigma \log C)^2}{N}}$$

and k is a constant calculated as follows,

$$k = \frac{\Sigma(\log C)\ \Sigma(\log C.\log W) - \Sigma(\log W)\ \Sigma[(\log C)^2]}{(\Sigma \log C)^2 - N\Sigma[(\log C)^2]}$$

For Hall's specimens a = 3.026 and k = 0.7586.

5 EXPLOITATION

5.1 Fishing equipment

5.11 Gears

P. merguiensis is fished with a variety of gears (Table 5).

TABLE 5

GEAR USED TO TAKE P. MERGUIENSIS

Type of Gear	Local Name	Country	Reference
Traps and set nets	Stripe net	Australia	
	Arr	West Pakistan	Qureshi (1956)
	Dora	West Pakistan	Qureshi (1956)
	Langgai beranipes	Malaya	Hall (1962)
	Kellong	Singapore	Hall (1962)
Cast nets	Cast net	Australia	Racek (1956)
	Jari	West Pakistan	Qureshi (1956)
Scoop nets	Scoop nets	Australia	Racek (1956)
Push nets	Scissor net	Australia	
	Sondong	Singapore	Tham Ah Kow (1955)
Seines	Bait net, seine	Australia	
	Bann	West Pakistan	Qureshi (1956)
	Pukat senyah	Malaya	Hall (1962)
	Pukat kisa	Malaya	Hall (1962)
Tangle nets	Gill net	Malaya	Hall (1962)
Otter trawls	Otter trawl	Australia	Racek (1956)
		West Pakistan	Qureshi (1956)

In Australia, echosounders are used continuously for locating schools and checking depth.

5.12 Boats

Scoop nets and push nets are usually operated by individual fishermen standing in the water. Seines, set nets, and traps are usually used in estuaries or sheltered seas and are operated by men

in small boats or on shore. These boats may or may not be powered depending on the state of development of the fisherman's country. Fairly large powered boats are used in all offshore otter trawl fisheries.

Three classes of boats are distinguishable in the Australian fishery.

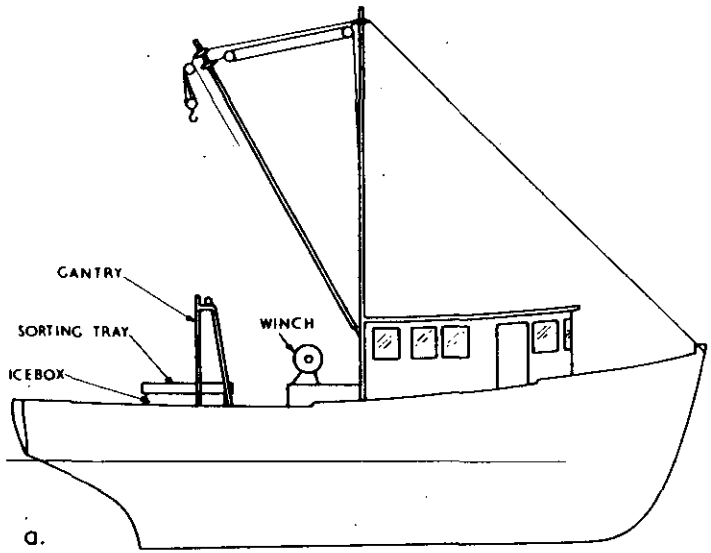
1. Boats generally under 30 ft (9 m) in length with a shallow draft and powered by a small inboard motor. These are used in estuaries for short trips and the prawns caught are cooked soon after capture, hence very few have any provision for storing prawns. These boats may be equipped with small beam or otter trawls or tend set nets of various kinds.

2. Boats from 30 to 70 ft (9 to 21 m) used for trips of 1 to 5 days duration. Prawns are stored on ice or in a freezing brine in insulated boxes on deck. Prawns caught by these boats are sold uncooked for processing or cooked for the local market. In some cases these boats have refrigerated fish holds. The boats are used in large enclosed bays like Exmouth Gulf and in the open seas.

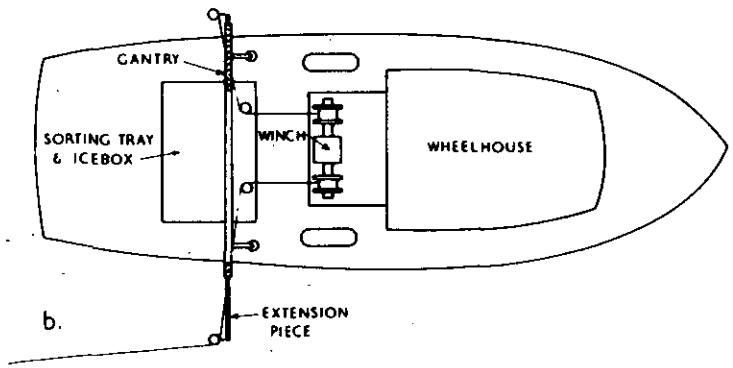
3. Larger boats, 50 to 70 ft (15 to 21 m) in length, fitted with refrigerated fish holds which are capable of processing and freezing prawns on board. These boats are capable of extended cruises and usually concentrate on large prawns suitable for export.

Boats of the first and second categories are equipped for otter trawling (Fig. 5, a & b). The method by which Australian trawlers are rigged is rather unusual and has been described by Wright (1966). In the standard type of trawler the winch, mounted athwartships, is usually a modified truck back axle and differential driven, via a clutch, by an auxiliary power take-off from the main engine. Each winch drum also has its own clutch and brake to allow for adjustments to the trawl wire. Wire from the winch drums is lead up to an overhead gallows with extensible arms which project outboard from the sides of the boat. The wire is lead out along the gallows to the otter boards on either side of the boat. When the trawl is brought up the otter boards are winched to the gallows head and the cod-end is brought aboard by means of a lazyline and derrick and emptied into the sorting tray. The rest of the trawl floats in the water. This enables the trawl to be reset in 3 to 5 minutes. Larger boats sometimes used modified tractors complete with motors as winches.

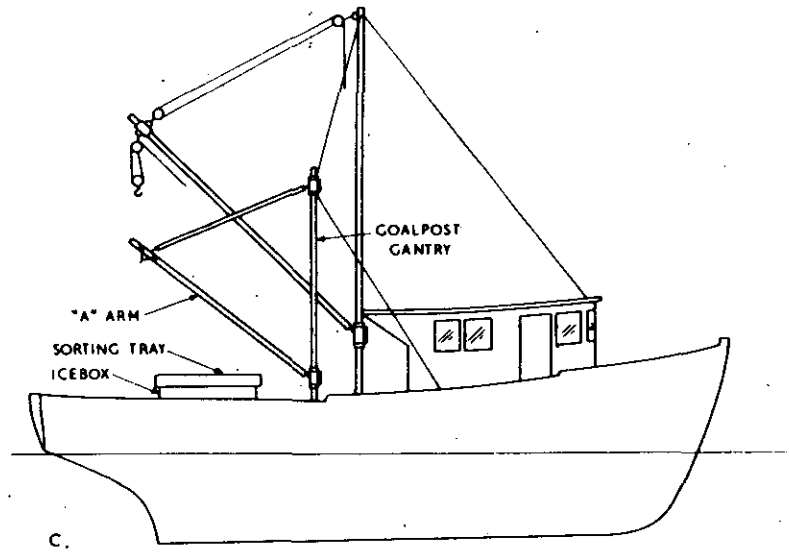
Some newer boats use double gear similar to that developed in the Gulf of Mexico (Fig. 5, c & d). The deck gear used for these trawls has evolved from the normal Australian overhead gallows. A large central goalpost gantry is used with hinged 'A' arms. These arms are swung back to the side of the boat when not in use. When the boat is trawling the 'A' arms are secured outboard. Wire is lead back along the gantry and down to the winch which is of a similar form to that described above with its drum axis athwartships. This is distinct from the American practice of having the winch drum axis



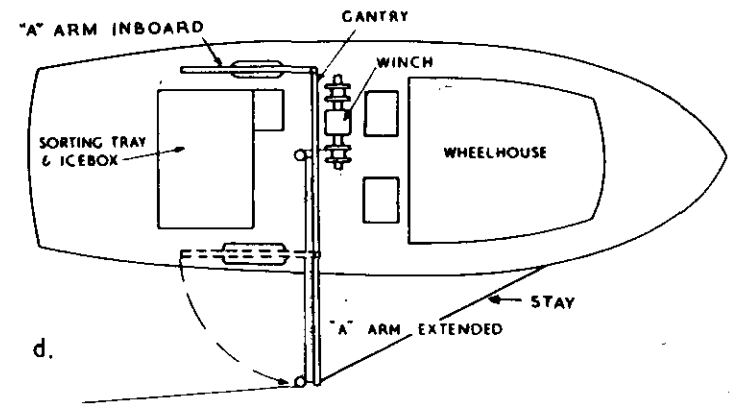
Small stern trawler rigged for single gear



Deck layout of above showing method of extending gantry.



Larger stern trawler rigged for double gear



Deck layout of above showing method of extending 'A' arm.

Fig. 5.- Deck layout of typical Australian prawn trawlers (after Wright, 1966).

fore and aft. Once again a lazyline is used to bring the cod-end aboard.

Some boats also use try nets. These usually operated with an auxiliary electric or hydraulic winch from a small derrick set aft.

Boats in the second and third categories are usually fitted with echo-sounders and radios. There are two to four crew depending on the size of the boat.

5.2 Fishing areas

5.21 General geographic distribution

P. merguiensis is fished throughout its range (see 2.1, Fig.3).

5.22 Geographic ranges

In Queensland, P. merguiensis is taken off the east coast of Australia in shallow water north of Hervey Bay and occasionally in rivers as far south as the Logan River in south Queensland (Grant, 1965). In the southern Gulf of Carpentaria, the main fishing grounds are in 16 to 24 m, 20 miles (6 km) off the Gilbert River estuary (Munro, pers. comm.). In Western Australia, most P. merguiensis are caught in Exmouth Gulf. In Pakistan, Malaysia, Singapore, and Sumatra, fisheries are estuarine and coastal.

P. merguiensis is caught in areas with muddy bottoms.

5.23 Depth ranges

In the Gulf of Carpentaria, Queensland, young prawns are caught as they leave the rivers during the wet season in 2 to 6 m, adults are caught during the dry season in 16 to 24 m. In the latter depth range the prawns are often caught as they school. In Exmouth Gulf, Western Australia, P. merguiensis is caught in depths of 12 to 16 m. Off the east coast of Queensland, P. merguiensis is caught in water shallower than 16 m.

In Malaysia, P. merguiensis is caught in traps and fixed nets inside the 6 m line, and with scoop nets and seines in waist-deep water (Hall, 1962).

5.3 Fishing seasons

5.31 General pattern of seasons

In Australia banana prawns are usually caught during the winter or dry season.

In Pakistan and on the Malayan peninsula most penaeid prawns are caught during the north-east monsoon.

5.32 Dates of beginning, peak, and end of season

Table 6 shows the pattern of fishing seasons in the different areas.

TABLE 6

PATTERN OF FISHING SEASONS

Country or State	Beginning of Season	Peak of Season	End of Season
Queensland	May		August
Western Australia	June		September
Singapore	January		December
West Pakistan			
Sind Coast	October	December/January	March
Mekran Coast	July		September
	November		January

5.4 Fishing operations and results

5.41 Effort and intensity

There are no effort data for the more advanced fisheries for this prawn available.

Tham Ah Kow (1955) published a table showing the catch per day of a Singapore sondong operator. This is reproduced as Table 7.

TABLE 7

AVERAGE CATCH OF PRAWNS PER DAY
BY A SINGAPORE SONDONG OPERATOR
BY MONTHS
(Tham Ah Kow 1955)

Month	Catch per Day (Katties*)
January	20
February	3
March	2
April	5
May	4
June	3
July	3
August	2
September	3
October	4
November	4
December	11

* 1 Katty = $1\frac{1}{3}$ lb = 0.6 kg

5.42 Selectivity

In Australia the mesh sizes and overall dimensions of gear used to take prawns are controlled (see 6.12).

5.43 Catches

Table 8 shows Australian catches of P. merguiensis.

In Australia the catches of fisheries at the southern limit of distribution of the banana prawn vary greatly from year to year. Elsewhere in Australia fisheries for this prawn are probably under-exploited.

TABLE 8

ANNUAL CATCH OF P. MERGUIENSIS IN AUSTRALIA
(Aust. Fish. Newsl. 1965, 1966, 1967)

State	Catch in financial year					
	1963-64		1964-65		1965-66	
	lb	kg	lb	kg	lb	kg
Queensland	142,000	64,545	293,177	133,262	289,521	131,600
Western Australia			44,854	20,388	114,952	52,520
Northern Territory	1,390	631				
TOTAL	143,390	65,176	338,031	153,650	404,473	184,120

6 PROTECTION AND MANAGEMENT

6.1 Regulatory (legislative) measures

In Australia different regulations exist in each State.

6.11 Limitation or reduction of total catch

- Limitation on the efficiency of fishing units

Maximum size of trawls: In Queensland, maximum headrope length of otter trawls is 8 fm (16 m) in estuarine waters and 20 fm (37 m) in ocean waters.

- Limitation on the number of fishing units, fishermen

None, except in certain areas of Western Australia (see 6.12).

- Limitation on total catches (quota)

None.

6.12 Protection of portions of the population

- Closed areas

In Queensland, trawling within one mile of the shore is prohibited. This regulation was established to protect juvenile king prawns. Portions of various estuaries and inlets are closed to prawn fishing.

In Western Australia nursery grounds in Shark Bay and at the head of Exmouth Gulf are closed to trawling. W.A. limits the number of boat licences available in Exmouth Gulf and Shark Bay. Seventeen licences are available for Exmouth Gulf and 30 for Shark Bay.

- Closed seasons

There are no closed seasons affecting major P. merguiensis fisheries in Australia.

- Limitations on size or efficiency of gear or craft.

Regulations provide for minimum mesh sizes and maximum net sizes in all States. Minimum mesh size supposedly allows escape of juveniles but its success is as yet unproven. Fishermen tend to use bigger mesh sizes to reduce the amount of drag on nets and to eliminate trash organisms.

In Queensland, minimum mesh size is 1 inch (2.5 cm) in estuaries and $1\frac{1}{2}$ inches (3.8 cm) in the open sea.

6.2 Control or alteration of physical features of the environment

A number of ports in Queensland are dredged and the dumping of waste sometimes affects trawling grounds.

7 POND FISH CULTURE

P. merguiensis form a small part of the prawn stocks in the Singapore prawn ponds, which have been described in detail by Hall (1962).

7.1 Procurement of stocks

Post-larvae and juveniles are carried into ponds by tidal action. No effort is made to collect post-larvae specifically for pond rearing. The prawns develop in the ponds until they are of a sufficient size to be commercially valuable.

7.5 Pond management

The ponds are built by clearing tidal swamp-land and erecting rough mud walls with suitably sited sluice gates. Ponds vary in size from less than five to 50 acres in extent.

Water level in the ponds rises and falls with the tides. However, the level of the water is regulated by sluice gates. Water in the ponds must not be allowed to become too shallow during the day or the temperature of the water could rise excessively. The difference in level between the water in the pond and the water outside must not be too great or undue pressure is put on the walls of the pond.

At suitable intervals (about six months) fish in the ponds are poisoned with tea seed cake and those of sufficient size are sold commercially. This prevents excessive predation on the prawns which are the most valuable products of the pond.

7.6 Foods, feeding

Prawns eat organisms which occur naturally in the ponds.

7.8 Harvest

Prawns are harvested by filling the pond on the high tide, and then as the tide turns nets are placed across the sluice gate openings and the prawns which are swept out are caught. After fishing has ceased the sluices are closed and the nets retrieved. The prawns are then sorted and stored on ice. This is usually carried out at night when the prawns are more active.

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