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AN ILLUSTRATED KEY AND NOTES ON THE PHYLLOSOMA STAGES OF THE WESTERN ROCK LOBSTER *Panulirus cygnus* George

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Abstract

An improved, illustrated key for identification of the 9 phyllosoma stages of *Panulirus cygnus* George, based on examination of over 16 000 specimens, is presented, together with summarised length-frequency data for the stages described.

INTRODUCTION

The phyllosoma larval stages of palinurids and scyllarids are commonly separated into stages on the basis of morphological changes which occur during the larval development. Different numbers of phyllosoma stages have been described for different species, e.g. 13 stages for *Jasus lalandii* (Lazarus 1967); 11 stages for *Panulirus argus* (Lewis 1951), *P. interruptus* (Johnson 1956), *P. penicillatus* (Prasad and Tampi 1959) and *P. japonicus* (Inoue 1978); and 9 stages for *P. cygnus* (Chittleborough and Thomas 1969).

Each stage does not necessarily represent a single instar and there may be variation in the number of instars from year to year or between individuals, depending on the environment of the larvae, including food supply. Although these stages are somewhat arbitrary and the duration of each stage has not been determined, they do enable an approximate developmental sequence to be applied to the larvae.

Difficulties were encountered in assigning specimens of *P. cygnus* to a stage using the 9 stage key produced by Chittleborough and Thomas (1969). It was found particularly hard to separate stages IV through VIII. There were individual variations in the sequence in which certain morphological features appeared and differences in the rate of development of some appendages, as well as a considerable range in the body size within some stages. Specimens in which diagnostic features showed a noticeable range in size or degree of development were frequently observed and required an arbitrary decision to be made to assign a specimen to a particular stage.

Examination of the phyllosoma of *P. cygnus* collected during recent studies has permitted more definitive descriptions of their development to be made. This paper presents an improved key with illustrations of the characters used to distinguish the 9 phyllosoma stages of *P. cygnus* and summarised length frequency data for each stage.

MATERIAL AND METHODS

The material was collected from 1973 to 1977 at stations off the west coast of Australia between 25°30'S to 35°00'S and from 115°00'E to 99°00'E as part of an extensive study of the larval ecology of *P. cygnus* (Phillips *et al.* 1978; Rimmer and Phillips unpublished data; Phillips, Brown, Rimmer and Reid unpublished data). Sampling equipment and methods have been described by Phillips and Rimmer (1975) and Griffiths and Rimmer (1977).

All phyllosoma larvae were separated into types based on morphological characteristics and were identified as *Scyllarus* (5 species), *Scyllarides* (1 species), *Ibacus* (2 species) and *Panulirus* (1 species). In view of *Panulirus* material in collections, the distribution of the sampling, the known distribution of adult Palinurids and descriptions of their phyllosoma larvae in the literature, all *Panulirus* specimens discussed here were identified as the larvae of *P. cygnus*.

A total of 16 146 *P. cygnus* phyllosoma was examined under dissecting and compound microscopes to determine consistently appearing features suitable for defining the cut-off points between the stages. Measurements of total body length were made on all specimens and length-frequency histograms prepared for each stage.

RESULTS AND DISCUSSION

A key designed to clearly define the features used to distinguish between the stages is presented as Table 1. Diagrams of the diagnostic characters used in the key are presented in Figs 1 to 10. Fig. 1 illustrates a stage IX phyllosoma to show abbreviations used in the key figures. Supplemental notes are presented in Appendix I for use in conjunction with the key to clarify certain points which the authors have found liable to be confusing or to appear ambiguous to the inexperienced worker.

Summarised length-frequency data are presented in Table 2. Modal lengths shown in Table 2 were fitted by eye from peaks in the length-frequency hostograms for each stage. Length frequencies for stages I, II, III, V, VII and IX appeared to be normal distributions. Stages IV and VIII exhibited bimodal distributions and stage VI had a polymodal distribution.

Table 2. Size distribution of phyllosoma stages of western rock lobster (Total body length, mm)

Stage	Number measured	Mean length	Range Min.	Range Max.	Mode(s)
I	911	1.8	1.6	2.0	1.8
II	417	2.4	2.0	2.7	2.4
III	443	2.9	2.3	3.4	2.9
IV	308	4.0	3.2	5.3	3.8, 4.6
V	590	5.3	4.0	7.5	5.0
VI	6252	11.6	5.0	17.0	6.3, 8.0, 10.0 12.3, 14.5
VII	4436	17.6	12.0	22.0	17.0
VIII	2121	23.8	17.0	30.0	22.0, 26.0
IX	668	33.9	28.0	38.0	35.0

The unimodal size distributions of stages I, II, III, V, VII and IX imply that these stages each comprise a single instar. The bimodal size distributions of stages IV and VIII imply that these each comprise 2 instars. Stage VI, with its polymodal size distribution appears to include about 5 instars. However, overlap in size between the instars of stage VI makes it difficult to delimit clearly the modal peaks in the frequency distribution. This, combined with the absence of morphologically distinct features appearing in a consistent sequence makes the exact number of instars in stage VI uncertain.

Although the total number of instars in the phyllosoma development sequence may vary to a certain extent, the above data suggest that there are approximately 15 instars of the phyllosoma of *P. cygnus*. A plot of total body length for the observed modal peaks (Fig. 11) from the combined length-frequency data shows that the 15 modal peaks lie on a smooth curve, thus supporting the proposed 15 instars as a reasonable inference.

Representative material of the stages discussed in this paper has been lodged with the Western Australian Museum under catalogue numbers 94/78 to 102/78.

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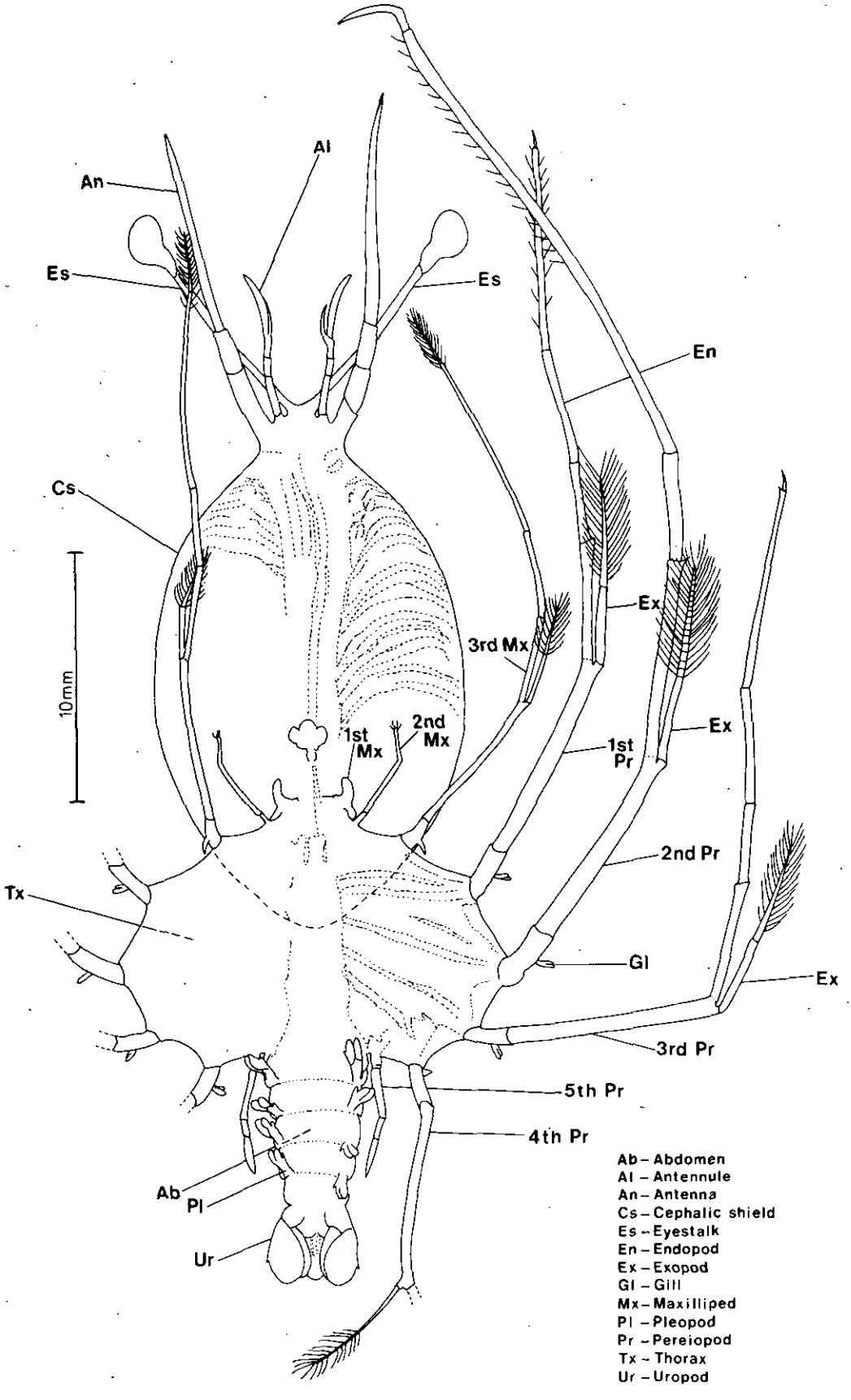


Fig. 1. Stage IX phyllosoma of *Panulirus cygnus* showing abbreviations used on Figs 2-10.

Table 1. Key to phyllosoma stages of western rock lobster

1.	Eyestalk simple, unsegmented (Fig. 2).	Stage I
	Eyestalk segmented (Fig. 3).	2
2.	Exopod of 3rd pereiopod not setose	Stage II
	Exopod of 3rd pereiopod setose (Fig. 4A)	3
3.	4th pereiopod shorter than abdomen and not segmented (Note a, Fig. 4B).	Stage III
	4th pereiopod segmented (Fig. 5A) and as long as or longer than abdomen.	4
4.	Antennule comprises 2 segments (Fig. 5B) exopod of 4th pereiopod not setose (Fig. 5A)	Stage IV
	Exopod of 4th pereiopod setose (Fig. 6A)	5
5.	Antennule comprises 3 segments (Fig. 6B,C)	Stage V
	Antennule comprises 4 segments (Note b, Fig. 7A,B)	6

Fig. 2. Stage I — Simple unsegmented eyestalk.

Fig. 3. Stage II — Segmented eyestalk.

Fig. 4. Stage III

A. Ventral aspect showing (a) setose exopod of 3rd pereiopod.

B. Enlargement of posterior region showing (b) unsegmented 4th pereiopod.

Fig. 5. Stage IV

A. Posterior region showing (a) segmented 4th pereiopod and (b) non-setose exopod of 4th pereiopod.

B. Anterior region showing (c) antennule comprising 2 segments.

Fig. 6. Stage V

A. Posterior region showing (a) setose exopod of 4th pereiopod.

B. and C. Anterior region showing antennules comprising 3 segments with (b) weakly developed spur and (c) strongly developed spur.

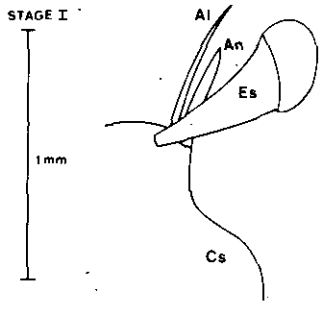
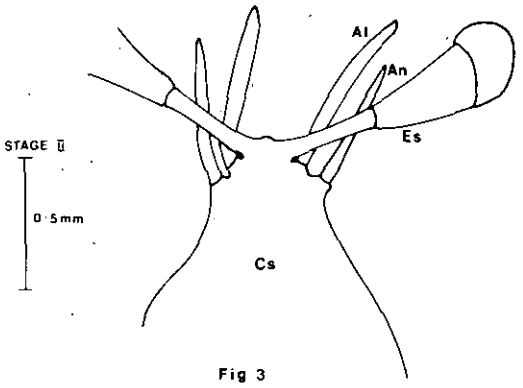


Fig 2



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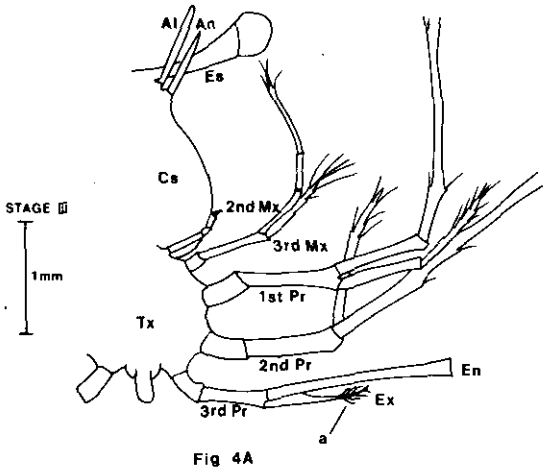


Fig 4A

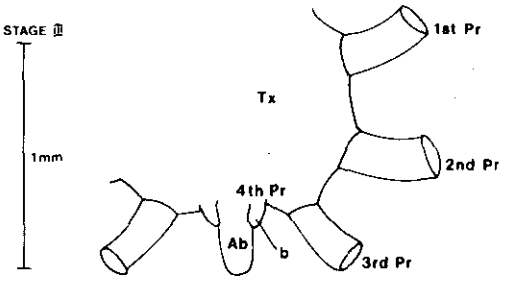


Fig 4B

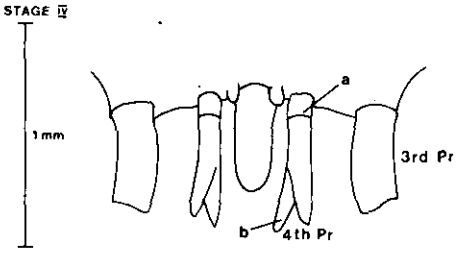


Fig 5A

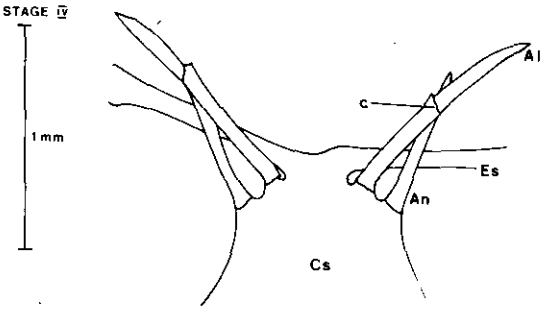


Fig 5B

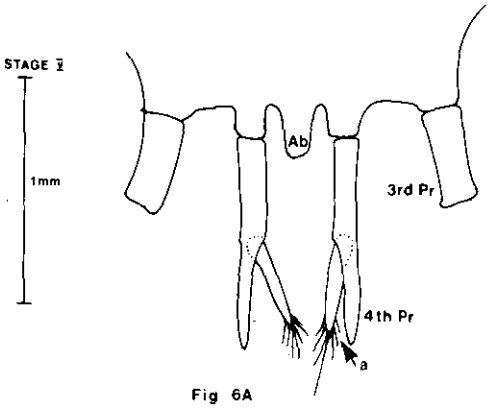


Fig 6A

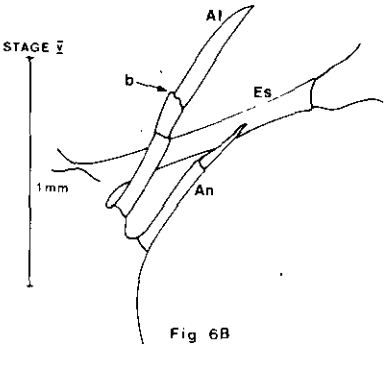


Fig 6B

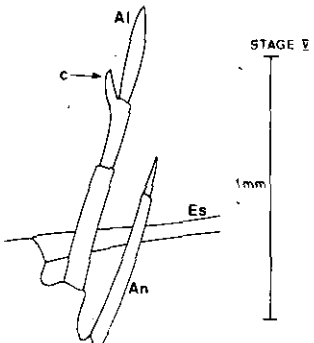


Fig 6C

Table 1 (Cont'd). Key to phyllosoma stages of western rock lobster

6.	Uropods not bifid (Note c, Fig. 7C)	Stage VI
	Uropods bifid (Fig. 8A)	7
7.	Distal pair of pleopods not bifid (Note c, Fig. 8B) abdomen not segmented or segmentation very weakly defined (Note d). .	Stage VII
	Distal pair of pleopods bifid (Fig. 9A,B) abdomen segmented (Note d, Fig. 9A,C)	8
8.	Gills not present at base of pereiopods or adjacent thorax, pleopods without appendix interna, uropods without lateral spine (Fig. 9C)	Stage VIII
	Gills present on dorsal surface at base of pereiopods and adjacent thorax (Fig. 10A). Pleopods with appendix interna, uropods with lateral spine (Fig. 10B)	Stage IX

Fig. 7. Stage VI

A. and B. Anterior region showing antennules comprising 4 segments with (a) well defined segmentation and (b) poorly defined segmentation.

C. Ventral view of abdomen with non-bifid uropods showing measurements for determining bifidness of uropod. x is the length of the cleft and y is the length of the uropod.

Fig. 8. Stage VII

A. Ventral view of non-segmented abdomen with bifid uropods. x is the length of the cleft and y the length of the uropod.

B. Enlargement of non-bifid pleopods showing degrees of cleft development which are considered non-bifid.

Fig. 9. Stage VIII

A. Ventral view of weakly segmented abdomen with bifid pleopods (pleopods omitted from one side).

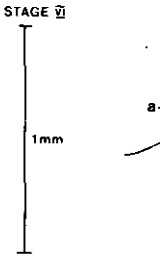
B. Enlargement of bifid pleopods showing extremes in degree of bifidness.

C. Ventral view of strongly segmented abdomen (with pleopods omitted from one side) to show (a) where segments overlap, (b) appendix interna absent from pleopods and (c) lateral spine absent from uropods.

Fig. 10. Stage IX

A. Enlargement of dorsal aspect of thorax and base of pereiopods showing gills.

B. Ventral view of abdomen showing (a) pleopods with appendix interna and (b) uropods with lateral spine (pleopods omitted from one side).



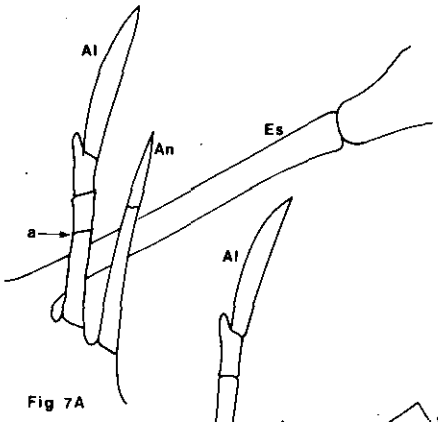


Fig 7A

Fig 7B

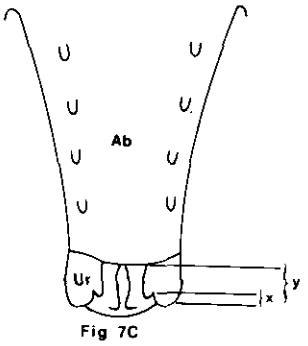


Fig 7C

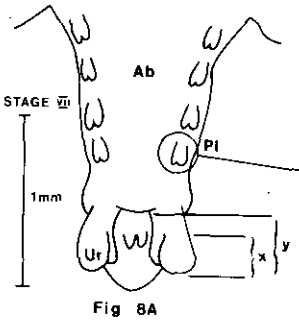


Fig 8A

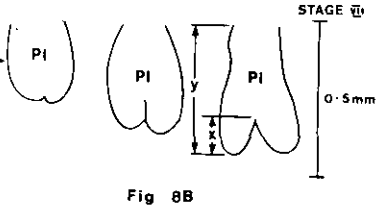


Fig 8B

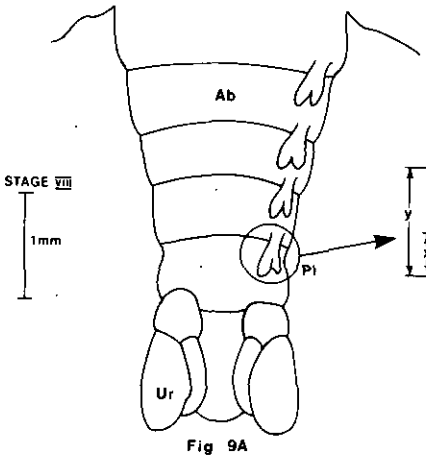
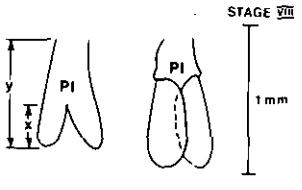


Fig 9A



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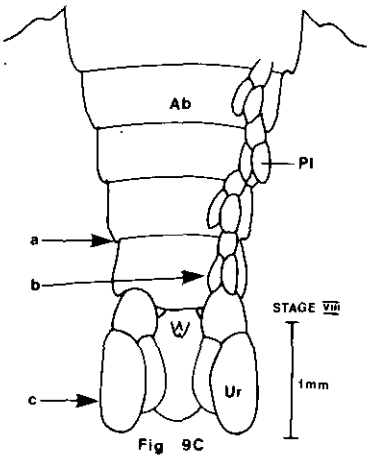

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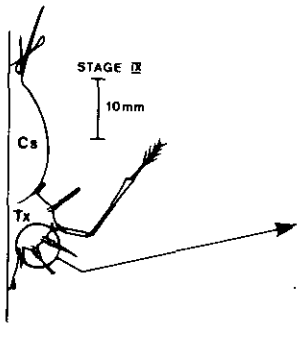
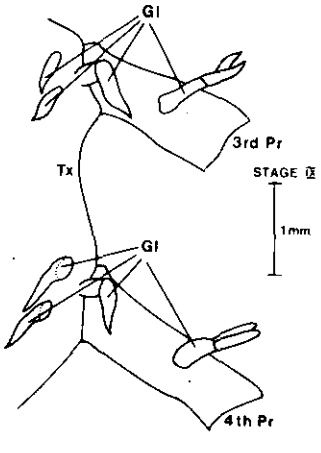


Fig 10A



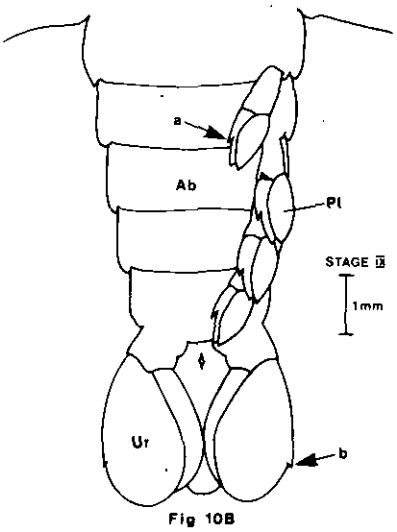


Fig 10B

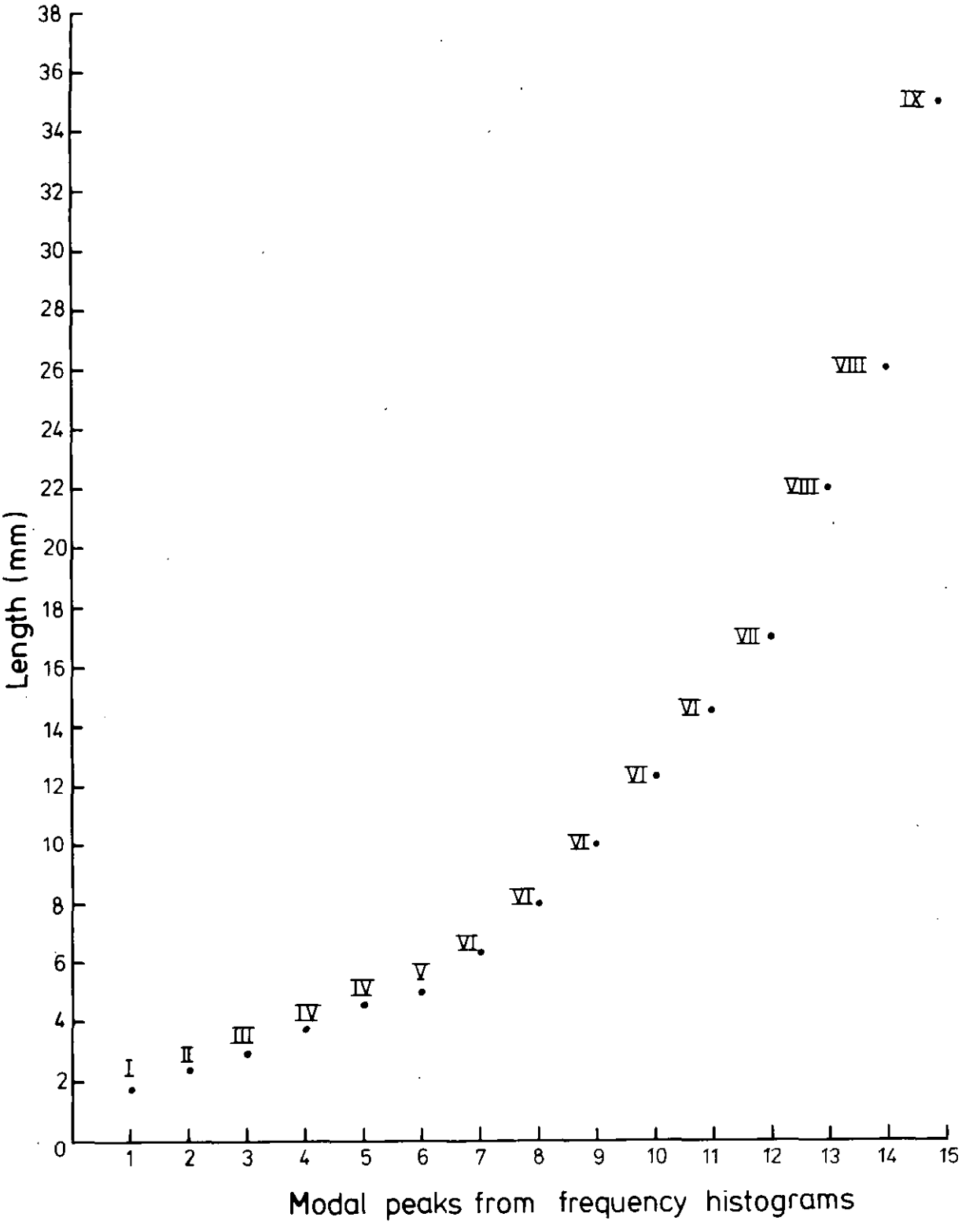


Fig. 11. Modal peaks in total body length of the phyllosoma larvae of *P. cygnus* for the combined length frequencies of 16 146 specimens.

APPENDIX I

SUPPLEMENTAL NOTES FOR KEY TO PHYLLOSOMA STAGES OF *P. cygnus*

a) In some stage III individuals the fourth pereiopod may be bifid but still not segmented.

b) Development of a 4th antennule segment should not be confused with development of the spur on the antennule which sometimes occurs in stage V (Fig. 6C). In some stage VI individuals the segmentation of the antennules can be indistinct, particularly if the specimen has been poorly preserved. When a faint ring is seen around the antennule or when small bumps can be seen in the cuticle where segmentation would be expected, then this is taken as sufficient evidence for segmentation even though internal division may not be evident (Fig. 7B). Magnification in the order of 150x is frequently required to confirm the presence of four antennule segments and the microscope used must have good optical resolution.

c) The uropods and pleopods exhibit a wide range in the degree of development of the cleft which produces bifidness. For the purpose of this key they are considered bifid when the length of the cleft (x) is more than $\frac{1}{3}$ the total length of the appendage (y) measured from the medial side of the base to the distal tip (Figs 7C, 8B, 9B). Only the distal pair of pleopods is considered when determining bifidness as this condition can develop at different times in different pairs of pleopods, but usually develops first in the distal pair.

d) Segmentation of the abdomen is normally only used to distinguish between stages VII and VIII when improper preservation or damage to the last pair of pleopods has occurred. What appears to be subcuticular segmentation of the abdomen can occur in stage VII, but for the purpose of this key a definite jointing of the cuticle at the lateral margin of the abdomen must be observed before the abdomen is considered segmented (Figs 9A, C).

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