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**LITTORAL PENAEINAE (CRUSTACEA  
DECAPODA) FROM  
NORTHERN AUSTRALIA, NEW GUINEA,  
AND ADJACENT WATERS**

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N.V. NOORD-HOLLANDSCHE UITGEVERS MAATSCHAPPIJ-AMSTERDAM

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DECAPODA) FROM  
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AND ADJACENT WATERS

*For Finner A. Chace  
in appreciation  
A. A. Racek  
Washington, August 1968*

A. A. RACEK and W. DALL

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## SUMMARY

Recent extensive collections of littoral Penaeinae from northern Australian waters, as well as from the regions of New Guinea, Indonesia, North Borneo, and the Philippines are subjected to a detailed taxonomic study. The number of species recorded from that general area is raised to 57, and 13 new species are fully described and figured. The status of the hitherto-known species from this part of the Indo-West Pacific is revised, and some taxonomic criteria redescribed and illustrated.

The stridulating species of the genus *Metapenaeopsis* are completely reviewed, and the names of some doubtful or forgotten species of early workers restored. Taxonomic problems involving the genus *Metapenaeus* are discussed with reference to recent nomenclatural controversies threatening the validity of this generic name.

Fully revised keys are given for all Indo-West Pacific species of *Metapenaeopsis*, as well as for all species of *Metapenaeus*.

## I. INTRODUCTION

In spite of the efforts of the present authors, to clarify and revise the taxonomy of penaeid prawns in Australian waters and adjacent seas (RACEK, 1955, 1957, 1959; DALL, 1957), to date practically no information has been available from Australia's north. The vast stretches of the Timor and Arafura Seas, due to their remoteness and the complete absence of prawn fisheries, remained unexplored so far as penaeids were concerned. The "Chevert" and "Challenger" expeditions, during the latter half of the nineteenth century, were the last to collect in parts of this region, and they obtained only a few scattered specimens from the Northern Territory, Torres Strait, and New Guinea. The descriptions of new species from these collections (HASWELL, 1879, 1882; BATE, 1888) were often based on solitary or immature specimens, which contributed to the confusion of subsequent workers who relegated most of them to doubtful positions. Further to the north, the "Siboga" Expedition began to amass valuable material of Indonesian penaeids, and added many species to those already known from India and Malaysia. However, the comparison of these species with the few recorded penaeids from Australian waters remained a difficult task, and consequently a number of distinct species became relegated to the position of synonyms.

In an attempt to close this gap in the knowledge of northern Australian prawns, the present authors increased their efforts to obtain as many penaeids as possible from this region. Commencing in 1953, these collecting efforts were at first independent and separate. W.D. acquired extensive

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collections from Papua and New Guinea, and checked some few specimens from the vicinity of New Britain already present in the Australian Museum in Sydney. A.A.R. examined material from Indonesia, North Borneo, and the Philippines, and succeeded in securing numerous specimens from the Northern Territory, the Gulf of Carpentaria, Torres Strait, India and Tanganyika, through the kindness of reliable private collectors.

After comparing their separate collections, consisting of a considerable number of new species, the authors – realising the taxonomic importance – decided to combine their studies in order to describe all genera and species of the subfamily Penaeinae present in the region examined. This stretches from northern Western Australia to North Borneo (Sabah), embraces the whole of Indonesia, the Philippines, and New Guinea, and reaches south to central New South Wales. The reference to Northern Australia and New Guinea in the title is merely to aid the reader in centralising the region studied, which now connects with those waters of the Indo-West Pacific in which the taxonomy of penaeids has become fairly well known.

In the absence of a proper zoogeographic term for this part of the Indo-West Pacific, the area mentioned above will be called “the general region studied” wherever reference is made in the text to its whole extent.

The material examined comprises 60 species, of which 57 were found in the region mentioned above. Thirteen new species are fully described; of these five each belong to the genera *Metapenaeopsis* and *Metapenaeus*, and one each to the genera *Atypopenaeus*, *Parapenaeopsis* and *Trachypenaeus*. Several new records for this region are discussed or endorsed. All holotypes, allotypes, and most paratypes have been deposited in the collection of the Australian Museum, Sydney.

This paper also represents a supplementary revision of material described in earlier publications on Indo-West Pacific penaeids, including those of the present authors. In particular, all stridulating species of the genus *Metapenaeopsis* have been compared and critically reviewed, and HASWELL's (1879, 1882) species *M. palmensis* restored. Furthermore, new light is thrown on the recent controversy as to the true identity of *Penaeus affinis* H. Milne Edwards, 1837, and the priority of the generic name *Mangalura* Miers, 1878 over *Metapenaeus* Wood-Mason & Alcock, 1891.

Specific status has been given in this paper to such specimens, or groups of specimens, which differ from others at least in the morphology of their genitalia in both sexes. The authors are fully aware of the possibility that future research may relegate some of their new species to subspecific rank. However, they feel that the extent of the present material does not as yet provide the data necessary for such a decision, and consider it better to record all different forms as species, than to repeat the mistakes of a number of previous workers in obscuring valuable taxonomic evidence.

In view of the possible importance of the present study to taxonomists and fisheries biologists in adjoining regions, the taxonomic criteria of most of the species present in this part of the Indo-West Pacific have been photographed to avoid possible misrepresentation through incorrect drawings. In addition, line drawings have been prepared for the illustration of some new species.

## II. TAXONOMIC CRITERIA AND METHODS

The importance of the various morphological features of penaeids in taxonomic differentiation has already been commented on in a number of previous papers. KUBO's (1949) comprehensive monograph in particular fully deals with these aspects, and the present authors follow his general scheme and, for the most part, use the same terminology. However, some of KUBO's criteria, particularly features concerning the stomodaeal apparatus, are only used sparsely in this paper, since they appear to lack the constant intraspecific values originally accredited to them.

Features of systematic importance are the rostrum, the carapace with all its characters, the carination and length of the abdominal somites, the telson, antennules, antennae, all mouthparts, ambulatory legs and their armature, gills, and the secondary sexual characters (petasma, appendix masculina, thelycum). In regard to the position, structure, and nomenclature of these major criteria the reader is referred to KUBO (1949), and DALL (1957).

To maintain uniformity in the spelling of penaeid generic names, as recently suggested by HOLTHUIS (1962), the diphthong "ae" is now used in the root word *Penaeus* for all genera here described. This is a deviation from previously adopted procedure of following the spelling of the various original authors of existing generic names (see RACEK, 1955, 1959). According to the rules of grammar, the genera *Metapenaeopsis* and *Parapenaeopsis* must be considered as feminine gender, and the spelling of some specific names, originally described as members of the genera *Penaeus*, *Metapenaeus*, or *Parapenaeus*, has been changed to serve this purpose.

WOLFF (1962) has discussed uniformity in the spelling of the Greek term for crustacean walking legs, formerly given as either "peraeopods" or "pereiopods", and suggested reducing the classical diphthong "ae" of Latin, and "ai" of Greek to "e". This spelling, already used by several carcinologists, has been adopted by the present authors in contrast to their earlier papers.

The length and other measurements, referred to in this paper, are made to the nearest millimetre. The length of specimens described here-under refers to the total length, i.e. the distance between tip of rostrum and tip of telson with the abdomen extended. Carapace length, whenever this is indicated, is measured from the postorbital margin to the median posterior border. Length of other parts are always maximum distances between extreme points unless otherwise stated.

Coloration notes, which are given whenever possible, always refer to live or freshly dead specimens. The importance of coloration, and especially colour patterns, in diagnosis during field studies (RACEK, 1955; DALL, 1957) is again emphasised.



### III. TAXONOMY

#### Subfamily PENAEINAE

Penaeinae Burkenroad, 1934a, p. 72. Anderson & Lindner, 1943, pp. 285, 302. Kubo, 1949, pp. 260-62. Racek, 1955, p. 214. Dall, 1957, pp. 139-41. Hall, 1962, pp. 177-181 (part).

For the definition of this subfamily, as well as for keys to its genera and groups of genera, the reader is referred to the papers listed above.

Nine genera of this subfamily are now recorded from the general region studied. They are *Penaeus* Fabricius, *Metapenaeopsis* Bouvier, *Penaeopsis* Bate, *Parapenaeus* Smith, *Trachypenaeopsis* Burkenroad, *Metapenaeus* Wood-Mason & Alcock, *Atypopenaeus* Alcock, *Trachypenaeus* Alcock, and *Parapenaeopsis* Alcock. Of these, the genera *Penaeopsis* and *Trachypenaeopsis* are not represented in the material discussed hereunder, even though deep-water collections were available to the authors from some parts of the New Guinea region.

#### Genus *Penaeus* Fabricius

*Penaeus* Fabricius, 1798, p. 408. Bate, 1888 (part), p. 229. De Man, 1911, p. 95. Balss, 1914, p. 13. Burkenroad, 1934a, p. 74. Kubo, 1949, pp. 268-70. Barnard, 1950, pp. 582-3. Racek, 1955, p. 214. Liu, 1955, p. 9. Dall, 1957, pp. 141-43.

*Peneus* Alcock, 1901, p. 14; 1906, p. 7.

Type-species *Penaeus monodon* Fabricius, 1798 (neotype Holthuis, 1949).

The above references provide adequate information on the generic definition of *Penaeus*. For the differentiation of the species of this genus the reader is particularly referred to the key to all Indo-Pacific species (DALL, 1957, pp. 142-43), as well as to the recent work of HALL (1962, pp. 178-79).

During the present investigations only the following 8 species of *Penaeus* were found to occupy the general region studied: *P. monodon* Fabricius, *P. semisulcatus* de Haan, *P. esculentus* Haswell, *P. japonicus* Bate, *P. latisulcatus* Kishinouye, *P. longistylus* Kubo, *P. indicus* Milne Edwards and *P. merguiensis* de Man. *Penaeus orientalis* Kishinouye, and *P. penicillatus* Alcock, although expected in this region, are not represented in the material available. The identity of *P. gracilirostris* Thallwitz (1890) has still to be resolved; in spite of the examination of numerous specimens of this genus from the vicinity of the type locality (North Celebes), THALLWITZ's species could not be recognised. This supports the suggestion of ALCOCK (1906, p. 49) that *P. gracilirostris* most probably is a malformed specimen of *P. semisulcatus*, comparable with the traumatic form of *P. plebejus* Hess, which SCHMITT (1926) raised to specific rank as *P. maccullochi* (see DALL, 1957, p. 149; RACEK, 1959, p. 11).

**Penaeus monodon** Fabricius, 1798

*Penaeus monodon* Fabricius, 1798, p. 408. Haswell, 1882, p. 199. Kishinouye, 1900, pp. 7, 15. Stebbing, 1910, p. 380. Holthuis, 1949, pp. 1051-57. Kubo, 1949, p. 291 (part synonymy only). Barnard, 1950, p. 584. Dall, 1957, pp. 152-54.

*Penaeus carinatus* Dana, 1852, p. 602. De Man, 1911, p. 101. Kemp, 1915, p. 317. Burkenroad, 1934a, p. 74. Anderson & Lindner, 1943, p. 305. Racek, 1955, pp. 215-17; 1959, pp. 10-11.

*Penaeus semisulcatus* Alcock, 1906, pp. 10-11.

*Penaeus caeruleus* Stebbing, 1905, p. 77. Burkenroad, 1934a, p. 74. Racek, 1955, p. 217-18; 1959, p. 10-11.

*Penaeus carinatus* Schmitt, 1926, pp. 359, 363.

*Penaeus bubulus* Kubo, 1949, pp. 296-301.

**Material.** 153 specimens, ranging from 85-273 mm; WESTERN AUSTRALIA: Exmouth Gulf; NORTHERN TERRITORY: Chambers Bay, Arnhem Bay; QUEENSLAND: Gulf of Carpentaria, Cape York, Princess Charlotte Bay, Repulse Bay; NEW GUINEA: Orangerie Bay, Kinikini Bay, Hercules Bay, Yule I.; INDONESIA: Java, East Borneo; MALAYSIA: North Borneo; PHILIPPINES: Manila Bay, Miguel Bay.

**Distribution.** Widely distributed throughout the greater part of the Indo-West Pacific region, ranging from South Africa to southern Japan, and from Karachi to northern New South Wales; apparently preferring warm-water habitats.

**Discussion.** This common and very large species has been extensively discussed in previous literature, and the designation of a neotype in place of the lost real type of FABRICIUS by HOLTHUIS (1949) has finally rectified the century-long confusion of this species with *P. semisulcatus* de Haan and helped to abolish some junior synonymy.

Females of *P. monodon* grow to a very large size. The largest specimen ever found in Australia (337 mm) was captured by experimental trap in deeper waters (65-70 fm) off northern New South Wales.

Nothing of importance can be added to the description of this species, apart from the colour pattern mentioned by DALL (1957, p. 153) in connection with a single female from Brisbane R. This had a "dull-red dorsal strip, width of body, running from rostrum to 6th abdominal somite, rest of animal an inky blue". Although this colour pattern was then considered an abnormal one, it has since been found by the writers in a small, but widely distributed, number of specimens of both sexes (North Borneo, Java, Northern Territory, New South Wales). Specimens thus coloured are never very large, and usually belong to the range of 105-135 mm; but their peculiar and most conspicuous colour pattern is absolutely constant irrespective of habitat, size, sex, or stage of maturity. The red strip in live specimens ranges from bright vermillion to dark orange, and the rest of the body from dark blue to black. The pleopods are fringed with bright-red setae. Pleopods and uropods are tipped with light blue.

In spite of this conspicuous coloration, all other criteria, including

thelycum and petasma, are fully comparable with those of a typical *P. monodon* and a separation of these colour-aberrant forms cannot be attempted.

### ***Penaeus semisulcatus* de Haan, 1850**

*Penaeus semisulcatus* de Haan, 1850, p. 191. De Man, 1911, pp. 97–100. Barnard, 1950, p. 588. Racek, 1955, pp. 218–19; 1959, p. 10. Dall, 1957, pp. 154–57.

*Penaeus monodon* Bate, 1888, p. 250. Kubo, 1949 (part synonymy only), pp. 291–96.

*Penaeus ashiaka* Kishinouye, 1900, pp. 7–14. Rathbun, 1902, p. 38. Nobili, 1903, p. 2; 1906, p. 16.

*Peneus monodon* Alcock, 1906, p. 8.

*Peneus semisulcatus* Schmitt, 1926, pp. 360, 364.

Material. 58 specimens, ranging from 61–154 mm; NORTHERN TERRITORY: Chambers Bay, Joseph Bonaparte Gulf; QUEENSLAND: Gulf of Carpentaria, Princess Charlotte Bay, Townsville, Repulse Bay; NEW GUINEA: Kinikini Bay, Hercules Bay, Oyster Bay, Daru I., Yule I.; INDONESIA: Java, East Borneo, Halmahera I.; MALAYSIA: North Borneo; PHILIPPINES: Manila Bay.

Distribution. Widely distributed in the tropical Indo-West Pacific, ranging from the Red Sea through Indus Delta, Malaysia, Indonesia to northern and north-eastern Australia, and through New Guinea, Philippine Is. to southern Japan; apparently preferring tropical habitats, not yet recorded from Western Australia.

Discussion. This species has also been extensively described and the present material examined has not offered any additional criteria for further discussion. Since members of this species could easily be confused with the closely related *P. esculentus*, the reader is referred to the comprehensive keys of DALL (1957). The present study has confirmed the earlier assumption of the writers that *P. semisulcatus* is to be considered rare even in tropical Australia.

### ***Penaeus esculentus* Haswell, 1879**

*Penaeus esculentus* Haswell, 1879, p. 38; 1882, p. 200. De Man, 1911, p. 96. Burkenroad, 1934a, p. 74. Kubo, 1949, pp. 315–17. Racek, 1955, pp. 219–20. Dall, 1957, pp. 157–59.

*Peneus esculentus* Schmitt, 1926, pp. 360, 362.

*Penaeus monodon* Whitelegge, 1890, p. 224.

Material. 49 specimens, ranging from 67–138 mm; WESTERN AUSTRALIA: Shark Bay, Roebuck Bay; NORTHERN TERRITORY: Darwin, Chambers Bay, Arnhem Bay; QUEENSLAND: Gulf of Carpentaria, Cape York, Princess Charlotte Bay, Townsville, Keppel Bay, Moreton Bay.

Distribution. From Shark Bay, W.A. to central New South Wales.

Discussion. KUBO (1949, pp. 315–317) records this species for the first time from outside Australia, and describes 1 male and 1 female from South Borneo. However, *P. esculentus* is not represented in the present

material from Indonesian waters and, in spite of intense collecting efforts, has not yet been recorded from the New Guinea region. It can, therefore, be considered a warm water species probably endemic to Australia.

***Penaeus japonicus* Bate, 1888**

(Plate 1 fig. 1)

*Penaeus canaliculatus* var. *japonicus* Bate, 1888, pp. 245-48.

*Penaeus canaliculatus* Ortmann, 1890, p. 488. Kishinouye, 1900, pp. 11-12. Rathbun, 1902, p. 37.

*Penaeus canaliculatus* Alcock, 1906, pp. 14-16 (part synonymy only).

*Penaeus japonicus* Nobili, 1906, p. 10. De Man, 1911, p. 107. Balss, 1914, p. 13. Kubo, 1949, pp. 273-78. Barnard, 1950, pp. 590-92. Hall, 1956, p. 71; 1962, p. 14. Dall, 1957, p. 142 (key). Racek, 1959, p. 11 (footnote).

**Material.** QUEENSLAND: Princess Charlotte Bay, Quoin I. ("Challenge"), 7 ♀, 2 ♂, 81-182 mm; NORTHERN TERRITORY: Chambers Bay ("Paxie"), 1 ♀, 116 mm; NEW GUINEA: Port Romilly, Panaroa R., Jokea, 13 specimens, 52-103 mm; NORTH BORNEO: Sandakan, 17 specimens 65-141 mm; INDONESIA: East Java, 8 specimens, 64-96 mm.

**Distribution.** Apparently widely distributed throughout the greater part of the tropical Indo-West Pacific, from Africa to Fiji. In Australia restricted to northern and north-eastern shores.

**Discussion.** HALL (1956, p. 71, Pl. 9 fig. 4) mentions and depicts some differences in the shape of the fused lateral plates of the thelycum. The present material obtained from North Borneo has the thelyca exactly as illustrated by HALL, a condition which differs from the descriptions and figures of BATE, ALCOCK, and KUBO. The lateral plates have a pronounced w-shaped anterior opening in the Sandakan specimens, and are extremely flat. Although this condition seemed at first a constant one, material obtained later from New Guinea and northern Australia has established that this aberrant form of the thelycum is only found in immature specimens, and that the seminal receptacle changes its anterior opening during further growth to the condition depicted by many previous authors as typical. All specimens from the region studied are identical in all other criteria, and the colour pattern remains constant, so that a separation of the condition recorded from Singapore and Sandakan appears unwarranted. HALL (1962) apparently came to the same conclusion, since he lists *P. japonicus* without a further discussion, and his illustration of the thelycum is that of the typical form.

To date this species is rare in Australian waters. The material collected by the L.F.B. "Challenge" in 1958 in northern Queensland waters represented the first record of *P. japonicus* in Australia.

***Penaeus latisulcatus* Kishinouye, 1900**

*Penaeus latisulcatus* Kishinouye, 1900, p. 12. De Man, 1911, pp. 108-11. Kubo, 1949, pp. 278-82. Racek, 1955, pp. 222-23; 1959, pp. 10-11. Hall, 1956, p. 72; 1962, pp. 14-15. Dall, 1957, p. 149-51.

*Peneus latisulcatus* Schmitt, 1926, pp. 365-7 (except ♂ E3157).

"*Penaeus canaliculatus* Oliv. var.?" Lanchester, 1901, p. 571.

*Penaeus canaliculatus* var. *australiensis* de Man, 1902, p. 905.

**Material.** 137 specimens, 65-201 mm; WESTERN AUSTRALIA: Shark Bay, Exmouth Gulf; NORTHERN TERRITORY: Arnhem Bay, Joseph Bonaparte Gulf; QUEENSLAND: Gulf of Carpentaria, Princess Charlotte Bay, Townsville, Mackay, Prudhoe I.; NEW GUINEA: Orangerie Bay, Tatana.

**Distribution.** Apparently scattered distribution from Red Sea through Malaysia and the Molluccas to Korea and Japan. In the Australian region it occurs from Kangaroo I., S.A., round Western Australia, Northern Territory, northern Queensland, Thursday I. to New Guinea; scattered down the eastern Australian coast to New South Wales.

**Discussion.** Apart from some slight differences in the length of the pereopods of specimens from widely separated localities, the material studied agrees well with the description of this species in previous literature. The occurrence of *P. latisulcatus*, previously known from South Australia and Western Australia, along the eastern coast of tropical Queensland, was established for the first time by the "Challenge" Survey in 1958 (see RACEK, 1959, p. 11, footnote). In regard to the typical coloration of live specimens the reader is referred to DALL (1957, p. 151). *P. latisulcatus* is not represented in material collected for the present study from Indonesia, North Borneo, or the Philippines.

### ***Penaeus longistylus* Kubo, 1943**

(Plate 1 fig. 2)

*Penaeus longistylus* Kubo, 1943, pp. 200-01; 1949, pp. 282-86. Hall, 1956, p. 72; 1962, p. 15. Dall, 1957, pp. 142, 146. Racek, 1959, p. 11 (footnote).

*Penaeus jejunos* Hall, 1956, pp. 75-77; 1962, pp. 16-17.

*Penaeus caesi* Dall, 1957, pp. 143-47.

*Peneus latisulcatus* Schmitt, 1926, p. 365 (♂ E3157 only).

**Material.** 14 ♀♀, 27 ♂♂, 49-186 mm; QUEENSLAND: Princess Charlotte Bay, Northwest I., Keppel Bay ("Challenge"), Heron I.; NORTHERN TERRITORY: Chambers Bay ("Paxie").

**Distribution.** Apparently restricted to and scattered over reef regions, ranging from N.W. Australia round the Northern Territory to central Queensland; also recorded from Lord Howe I. (DALL); Hainan I. (KUBO); South China Sea, Malaysia (HALL).

**Discussion.** Following the original descriptions of *Penaeus longistylus* by KUBO (1943, 1949), which were based on very limited material, a number of slight discrepancies between KUBO's specimens and those obtained from other parts of the Indo-West Pacific were recorded by HALL (1956), and DALL (1957). Both these authors, unaware of the other's revisions, considered these differences important enough for the erection of two new species, *P. jejunos* and *P. caesi* respectively.

The availability of numerous specimens from the Australian region, chiefly collected during the "Challenge" Survey (Commonwealth of Australia, 1959), made it possible for the present authors to study a wide range of ecomorphic variations in the structure of important criteria of the *P. longistylus* "complex". In the course of these studies, most of the criteria separating both *P. jejunus* and *P. caesius* from the true *P. longistylus* were found in many intermediate stages represented in the Australian material examined, and the present writers are therefore of the opinion that the three species should be united.

*P. jejunus* was erected by HALL (1956) on a single specimen of unknown origin, a juvenile female with an incompletely formed thelycum. Apart from differences of minor importance, e.g. width of adrostral grooves and length of stylocerite, which could be expected in an immature specimen, HALL (1962) drew particular attention to the taxonomic importance of the small spine on the anterior plate of the thelycum as a constant criterion. He found this directed anteriorly in both *P. jejunus* and *P. caesius*, in contrast to the condition in *P. longistylus* in which it points ventrally at a right angle in the few specimens at his disposal. The authors have not seen the type specimens of KUBO, who does not mention or depict this spine in his descriptions. However, in the numerous Australian specimens the position of the spine varies in almost every female examined from strictly dorsoventral to obliquely forward; in the thelyca of three fully grown females it is even reduced to a hardly discernible rounded boss.

DALL (1957) has erected his *P. caesius* following the examination of 9 specimens, available to him then from the Australian region. In view of KUBO's somewhat short description and partly sketchy illustrations of *P. longistylus*, DALL recorded 9 differences in the various criteria of the Australian material, including structures of thelyca and petasmata. Furthermore, the strikingly different coloration of his allotype, showing all the typical colour patterns in blue, instead of red, seemed to be an additional justification for a separation of his specimens from KUBO's material. However, field observations on live material from the Australian region have since shown that the allotype of *P. caesius* must have been a colour-aberrant form, since none of the specimens collected by or for the present authors had the typical markings in another colour than red, including juvenile stages. Omitting the colour values of DALL's allotype from further consideration, the number of differences between *P. caesius* and *P. longistylus* can now be lowered to seven. Of these, the length of the second and third pereopods cannot be applied as a reliable feature for the distinction of the two species, since all intermediate lengths were found to occur in the Australian material recently examined. The same applies to the armature of the stomodaeal apparatus, which in this species appears to be extremely variable. The length of the stylocerite, although constantly somewhat shorter than described by KUBO, is also

subject to variation in specimens from different localities, and of different age groups.

This leaves the thelyca and petasmata as the only 2 major criteria by which the Australian specimens appear to differ, at least in some respects, from KUBO's description and figures. This author presents the seminal receptacle as of "inverted dome shape", whereas the thelycum in all Australian specimens has a rectangular and relatively flat shape, and the median borders of its lateral plates are raised in the form of longitudinal lips. In this regard, however, the thelyca of our material are fully comparable with HALL's (1962) illustration of the seminal receptacle of a specimen from the South China Sea, and it is possible that KUBO could have based his description on an atypical specimen.

The petasma of Australian specimens is also at slight variance with KUBO's descriptions in that the apical projections of its median lobes, in mature males, are prominent and exceed the lateral lobes. Again, this condition is identical with that depicted by HALL (1962), who notes its resemblance to *P. caesioides* without seeing it necessary to remove his specimens from the "forma typica" of *P. longistylus*. As can be seen from the wide range of males in the Australian material, these apical projections are only found to increase in size in specimens from 38.5 mm carapace length onward, whereas in smaller males the petasma has the same appearance as that figured by KUBO.

The writers have little hesitation, therefore, in relegating *P. caesioides* to a synonym of *P. longistylus*, a decision which appears fully supported by the results of HALL's studies; his material of *P. longistylus* shows no significant differences from *P. caesioides*, although it is at slight variance with KUBO's descriptions in the same points as our material. If *P. jejunus* is to be considered identical with *P. caesioides*, as HALL claims, then it too must become a synonym of *P. longistylus*.

The fact that *P. longistylus* has not yet been captured in quantities by conventional trawling methods led to the opinion that it is a rare species. However, during recent studies at Heron I. at the southernmost end of the Great Barrier Reef, juveniles of this species were found abundantly on coral reefs. Since all the trawls of the "Challenge" Survey, in which mature specimens of this species were recorded, were from stations in the close vicinity of such reefs it can be assumed that this species is restricted to reef areas unsuitable for bottom trawling gear.

### ***Penaeus indicus* H. Milne Edwards, 1837**

*Penaeus indicus* H. Milne Edwards, 1837, p. 45. Dana, 1852, p. 604. Heller, 1865, p. 122. Miers, 1878, p. 301. Bate, 1888, p. 248. Lanchester, 1900, p. 474. Kubo, 1949, pp. 311-15. Barnard, 1950, pp. 588-90. Racek, 1955, pp. 220-21; 1959, p. 10. Hall, 1956, p. 75; 1962, p. 16. Dall, 1957, p. 162. Cheung, 1960, pp. 67-68.

*Penaeus indicus* var. *longirostris* de Man, 1892, p. 511.

*Peneus indicus* Alcock, 1906, p. 12. Schmitt, 1926, p. 361.

*Penaeus semisulcatus* Stebbing, 1915, p. 69 (non de Haan, 1850).

Material. 19 ♂♂, 23 ♀♀, 52–168 mm; QUEENSLAND: Gulf of Carpentaria, (1 ♂ 145 mm); NEW GUINEA: Port Moresby (Macleay Museum, Sydney); NORTH BORNEO: Labuan, Sandakan; INDONESIA: Palembang, East Kalimantan, Java; PHILIPPINES: Manila Bay, St. Miguel Bay.

Distribution. Ranging from the coasts of India and Ceylon west through the Gulf of Aden to east coast of Africa, east to Malaysia and Indonesia. Apparently scattered distribution in the Philippines, New Guinea, and northern Australia.

Discussion. *Penaeus indicus*, *P. penicillatus*, and *P. merguiensis* are three very closely related species which, as preserved specimens, are fully distinguishable only in adult stages. Difficulties preventing a uniformly applicable and absolutely reliable interspecific separation of these three well-known species were discussed by HALL (1956, 1962), DALL (1957), and CHEUNG (1960). HALL has furthermore demonstrated the inadequacy of the stomodaeal structures for the separation of these species, and DALL discussed the striking similarity of juveniles of *P. merguiensis* to those of *P. indicus*. At present, the few conspicuous criteria used for their separation are the following: Height and shape of rostral crest, length of adrostral sulci, presence and form of gastro-orbital carina, shape of anterior plate of thelycum, and the ratio propodus: dactylus of the third maxillipeds in mature males. It is obvious that these few usable features will remain highly inadequate until detailed morphometric studies, involving sufficient material of all three species, will be carried out.

The material of *P. indicus*, present in the collections from the general area studied, shows all the typical features already described in the literature. The rostral crest of all mature specimens is quite low; the adrostral sulci slightly exceed the epigastric tooth; the gastro-orbital carina is well defined and occupies posterior  $\frac{2}{3}$  distance between hepatic spine and margin of carapace; and the ratio propodus: dactylus of the third maxillipeds in mature males is almost constantly 1:1. The third maxillipeds of males collected from Manila Bay have slightly longer dactyli, but all their other criteria exclude the possibility that they could belong to *P. penicillatus*.

*P. indicus* has already been recorded from Australian waters (RACEK, 1955). Judging from the paucity of specimens collected for the present study, however, this species must be considered rare in waters east and south-east of Borneo (Kalimantan).

### ***Penaeus merguiensis* de Man, 1888**

*Penaeus merguiensis* de Man, 1888, pp. 287–90; 1911, pp. 104–05. Kubo, 1949, pp. 308–11. Racek, 1955, pp. 221–22; 1959, pp. 10, 12. Hall, 1956, pp. 74–75; 1962, p. 15. Dall, 1957, pp. 160–62. Cheung, 1960, p. 67.

*Penaeus indicus* Bate, 1888, p. 248.



*Penaeus indicus* var. *merguiensis* de Man, 1892, p. 511.

*Peneus merguiensis* Schmitt, 1926, pp. 360-61. Boone, 1935, pp. 96-101.

*Peneus indicus* var. *merguiensis* Alcock, 1906, p. 13.

**Material.** Extremely numerous specimens of both sexes 38-198 mm; WESTERN AUSTRALIA: Shark Bay, Exmouth Gulf; NORTHERN TERRITORY: Arnhem Bay, Chambers Bay; QUEENSLAND: Gulf of Carpentaria, Princess Charlotte Bay, Townsville, Mackay, Keppel Bay, Sandy Cape, Moreton Bay; NEW SOUTH WALES: Ballina, Yamba; NEW GUINEA: Kinikini Bay, Daru I., Yule I., Orangerie Bay, Hercules Bay; NORTH BORNEO: Sandakan Harbour, Tawan, Labuan; PHILIPPINES: Manila Bay, St. Miguel Bay; INDONESIA: East Kalimantan, Java.

**Distribution.** Apparently widely distributed in tropical waters from India eastward to New Caledonia, penetrating the Australian region southward to about 29°.

**Discussion.** Apart from the details already discussed in dealing with the previous species, little of importance can be added to the description of this species in the literature. DALL (1957) has drawn attention to the apparent intraspecific variation of the gastro-orbital carina between specimens from Karachi and Australia. This carina, although feebly developed in comparison with that of *P. indicus*, is present in all adult specimens from Indian seas, as well as in those from Malaysia, Indonesia, and the Philippines. This feature, however, is absent in all, even fully developed, specimens from Australia and New Guinea. It is possible that future detailed morphometric studies will be able to decide whether or not two distinct races of *P. merguiensis* occur in the general area studied.

Some few specimens from Indonesia, labelled by our Indonesian collectors *P. orientalis*, were found to be *P. merguiensis* and *P. indicus* respectively. *P. orientalis*, another close relative of the *P. indicus* group, is clearly distinguishable from all the other species by the presence of a three-segmented endopodite of the maxillula. It is not present in the material collected for this study.

### Genus *Metapenaeopsis* Bouvier

*Metapenaeopsis* Bouvier, 1905, p. 981. Kubo, 1949, pp. 408-11. Liu, 1955, p. 17. Dall, 1957, pp. 166-67. Hall, 1962, p. 32.

*Penaeopsis* de Man, 1911 (part), pp. 53-55, 61. Balss, 1914 (part), pp. 6-7. Kemp, 1915 (part), p. 321. Schmitt, 1926 (part), pp. 319-23. Burkenroad, 1934b, pp. 4-12. Barnard, 1950, p. 592. Racek, 1955, p. 225.

*Leptopenaeus* Kishinouye, 1929, p. 282.

*Ceratopenaeus* Kishinouye, 1929, p. 282.

*Erythropenaeus* Kishinouye, 1929, p. 283.

*Metapeneus* Alcock, 1906 (part), p. 16.

Type-species by original designation: *Metapenaeopsis pubescens* Bouvier, 1905 (rejected as a junior secondary homonym of *Penaeus pubescens* Stimpson, 1871, by HOLTHUIS, 1952, and replaced by the name *Penaeopsis miersi* Holthuis, 1952).

The status of BOUVIER's genus was redefined for the first time by

BURKENROAD (1934b), who relegated *Metapenaeopsis* to a subgenus of *Penaeopsis* Bate and separated it from the other subgenus *Penaeopsis* sensu stricto mainly on account of the shape of the petasma. KUBO (1949) has elevated the subgenus *Metapenaeopsis*, as defined by BURKENROAD, to generic rank, an arrangement which is followed by the present writers. *Metapenaeopsis* is adequately defined in recent literature, and the reader is particularly referred to the papers by BURKENROAD (1934b), KUBO (1949), and DALL (1957).

This genus comprises a considerable number of species from the Atlantic, American Pacific, and Indo-West Pacific, of which a few must still be considered obscure and doubtful. DALL (1957) presented a comprehensive key to 19 Indo-West Pacific species, considering material and data then available to him from that region. This key has become inadequate by the present study, as well as by the recent work of HALL (1962), which have raised the number of Indo-West Pacific species to 28. Thirteen of these, including 5 new species, were found to occur in the general region studied; *M. barbata* (de Haan) and *M. borradaili* (de Man), although previously recorded from this region, are not represented in the material available.

#### KEY TO THE INDO-WEST PACIFIC SPECIES OF *Metapenaeopsis*

1. Anteromedian spine of basal antennular segment vestigial or small;  
thelycal plate without posterior extension . . . . . 2
- Anteromedian spine of basal antennular segment well developed;  
thelycal plate with posterior extension . . . . . 22

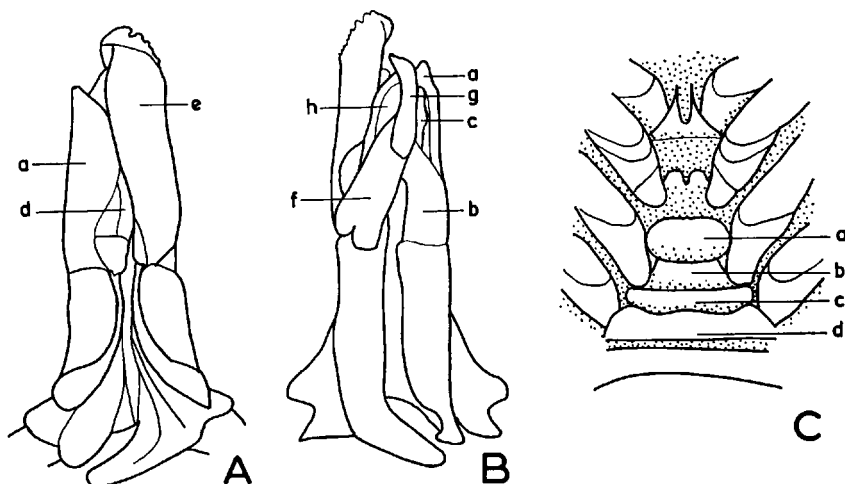


Fig. 1. Diagrammatic representation of distinguishing criteria of petasma and thelycum in *Metapenaeopsis* spp.

A, ventral view of petasma: *a*, right distoventral projection; *d*, distoventral flap. B, dorsal view of petasma: *b*, right distodorsal lobule; *c*, distomedian lobule; *f*, left distodorsal lobule; *g*, inner intermediate strip; *h*, outer intermediate strip. C, thelycum: *a*, thelycal plate; *b*, intermediate plate, *c*, anterior sternal plate; *d*, posterior sternal plate.

- 2 (1). Stridulating organ present on posterior branchiostegite . . . . . 3  
 Stridulating organ absent from posterior branchiostegite . . . . . 12
- 3 (2). Rostrum distinctly sinuous; length 6th pleonic somite more than twice depth near posterior end; right petasmas lobe slightly exceeding left . . . . . *M. sinuosa* Dall  
 Rostrum slightly sinuous, straight, or upcurved; length 6th somite less than twice depth near posterior end; left petasmas lobe much longer than right . . . . . 4
- 4 (3). Dorsal carina of 3rd pleonic somite sulcate . . . . . 5  
 Dorsal carina of 3rd pleonic somite convex or flat . . . . . 10
- 5 (4). Sulcus narrow and deep; stridulating organ low and strongly curved, its ridges anteriorly small and inconspicuous; intermediate plate of thelycum with deep posterior transverse sulcus . . . . . 6  
 Sulcus wide and shallow; stridulating organ high and moderately curved or almost straight, its ridges anteriorly rather wide; intermediate plate of thelycum with wide and shallow depression . . . . . 9
- 6 (5). Pterygostomian spine very large . . . . . *M. crassissima* sp. nov.  
 Pterygostomian spine small or moderately large . . . . . 7
- 7 (6). Left petasmas lobe with processes radiating from a horseshoe-like distal base . . . . . *M. rosea* sp. nov.  
 Left petasmas lobe with processes radiating from a conical or bulbous distal base . . . . . 8
- 8 (7). Apical processes strewn irregularly across tip of bulbous base; rostrum moderately upcurved; stridulating ridges 15-20; Malaysian species . . . . . *M. toloensis* Hall  
 Apical processes radiating laterally from a conical base; rostrum strongly upcurved; stridulating ridges 28-35; Japanese species . . . . . *M. dura* Kubo
- 9 (5). Stridulating organ moderately curved; anterior edge of thelycal plate minutely mucronate; left petasmas lobe distally swollen, toe-like; rostrum slightly elevated and straight, teeth close together . . . . .  
*M. palmensis* (Haswell) (= *M. velutina* (Bate); = *M. barbeensis* (Hall))  
 Stridulating organ almost straight; anterior edge of thelycal plate entire; left petasmas lobe sharply pointed, triangular; rostrum low and horizontal, teeth wide apart . . . . . *M. stridulans* (Alcock)
- 10 (4). Coxal plates of ♀ 5th pereopods separated from each other by a narrow space, conspicuously larger than thelycal plate . . . . .  
 . . . . . *M. acclivis* (Rathbun)  
 Coxal plates of ♀ 5th pereopods separated from each other by a wider space, smaller than thelycal plate . . . . . 11
- 11 (10). Thelycal plate much wider than long; left petasmas lobe with processes arranged in a circular manner; inner intermediate strip as long as outer . . . . . *M. novaeguineae* (Haswell)  
 Thelycal plate about as wide as long; left petasmas lobe with processes arranged in a semi-circular manner; inner intermediate strip much longer than outer. *M. barbata* (de Haan) (= *M. akayebi* (Rathbun))
- 12 (2). Epigastric tooth slightly posterior to  $\frac{1}{2}$  carapace; antennal scale twice as long as wide . . . . . *M. lamellata* (de Haan)  
 Epigastric tooth at  $\frac{1}{4}$  carapace; antennal scale more than twice as long as wide . . . . . 13
- 13 (12). With 2 median spines, one behind the other, on sternum between ♀ 4th and 5th pereopods . . . . . *M. evermanni* (Rathbun)  
 With transverse plates on sternum of ♀ 4th and 5th pereopods . . . . . 14



- of thelycal plate non-sulcate . . . . . *M. coniger* (Wood-Mason)  
 27 (22). Abdomen dorsally carinated posterior to 1st somite. *M. lata* Kubo  
 Abdomen dorsally carinated posterior to 2nd somite . . . . .  
 . . . . . *M. kyushuensis* (Yokoya)

***Metapenaeopsis novaeguineae* (Haswell, 1879) rdf.**

(Figure 2 A; Plate 1 fig. 3; Plate 4 figs. 1, 2; Plate 9 fig. 1)

*Penaeus Novae-Guineae* Haswell, 1879, p. 43; 1882, p. 203. Alcock, 1906, p. 55.  
 Schmitt, 1926, p. 341 (part).

*Penaeopsis novae-guineae* Schmitt, 1926, pp. 338-48 (part).

*Metapenaeopsis novae-guineae* Dall, 1957, pp. 170-72 (part synonymy only).

*Metapenaeopsis barbata* Racek, 1959, p. 10.

**Material.** Numerous specimens of both sexes, 28-101 mm; WESTERN AUSTRALIA: Exmouth Gulf; NORTHERN TERRITORY: Chambers Bay, Shell I., Darwin; QUEENSLAND: Port Curtis, Thursday I., Masthead I., Gloucester Passage, Albany Passage, Cape York, Gulf of Carpentaria, Cape Moreton, Moreton Bay, Great Sandy Strait; NEW GUINEA: Sandbank Bay.

**Description.** Rostrum slightly sigmoidal, narrow in profile, slowly tapering off to sharp tip, base and distal  $\frac{1}{3}$  somewhat elevated; reaching

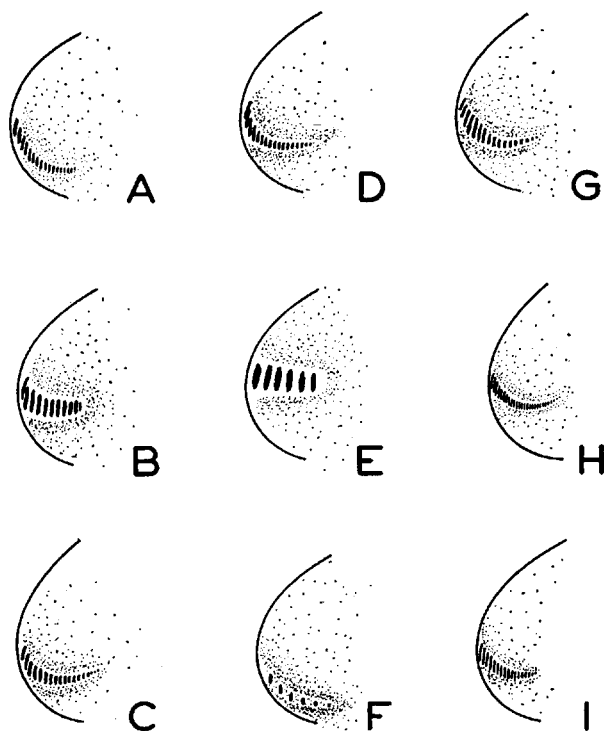


Fig. 2. Position and shape of the stridulating organ in some *Metapenaeopsis* spp.  
 A, *M. novaeguineae*; B, *M. palmensis*; C, *M. crassissima*; D, *M. rosea*;  
 E, *M. stridulans*; F, *M. sinuosa*; G, *M. barbata*; H, *M. dura*; I, *M. acclivis*.

to terminal segment of antennular peduncle, armed dorsally with 5-6 teeth + epigastric. Postrostral carina absent or only faintly indicated in anterior half of carapace. Position of the small epigastric tooth almost constantly at  $\frac{1}{4}$  carapace, penultimate tooth slightly anterior to frontal margin of carapace. Carapace entirely covered with strong, velvet-like tomentum. Orbital spine minute and dentiform; orbito-antennal sulcus barely defined to absent; hepatic spine pronounced but small, with a feeble indication of a cervical groove immediately above it. Antennal spine very prominent, without carina. Hepatic sulcus shallow and tomentose, horizontal, slightly behind and below hepatic spine. Stridulating organ consists of 11 to 17 ridges on a narrow, non-pubescent, crescent-shaped band; ridges extremely inconspicuous and situated very low, about  $\frac{1}{6}$  depth of carapace (fig. 2 A).

Antennules with upper flagellum slightly shorter than lower, which is  $\frac{2}{5}$  peduncle and  $\frac{1}{3}$  length carapace in ♂,  $\frac{1}{4}$  peduncle and  $\frac{1}{5}$  carapace in ♀. Prosartema reaching as far as eye, stylocerite usually reaching to tip of basal segment.

Second abdominal somite with a short and faint carina, the 3rd to 6th strongly carinated; that of the 3rd completely flat or slightly convex, without the slightest indication of a sulcus.

The typical petasma is shown in Plate 4 figs. 1, 2. Right distoventral projection (a) bearing few small distal processes, often bare; left distoventral projection (e) with 10-15 larger thorn-like processes arranged in a circular manner, radiating from a comparatively narrow base. Inner intermediate strip (g) finger-like and cylindrical; outer intermediate strip (h) with numerous distal setae, just about as long as inner strip, and slightly larger than distomedian lobule (c).

The typical thelycum is shown in Plate 9 fig. 1. Thelycal plate (a) oval, with anterior edge entire, almost twice as wide as long. Coxal plates of 4th pereopods densely setose, moderately small, laterally bounding the intermediate plate (b) which is of broadly trapezoidal shape. Anterior sternal plate between the 5th pereopods (c) with blunt and short lateral projections turned forward at less than 45°. Posterior sternal plate (d) divided into 3 blunt lobes.

Colour in life. Tan, irregularly mottled with very dark brown; transverse dark bands across posterior carapace, rostrum, uropods and distal half of telson.

Distribution. Apparently restricted to tropical waters of northern Australia, ranging north into New Guinea, and south to about Moreton Bay, Q. in the east, and Exmouth Gulf, W.A. in the west.

Discussion. Owing to the insufficient and partly incorrect original description by HASWELL (1879, 1882), the true *M. novaeguineae* has been grossly confused with a number of other species by all previous writers, including the present authors. SCHMITT (1926) considered HASWELL's two separate species *M. novaeguineae* and *M. palmensis*

identical, and even relegated ALCOCK's (1906) well-described species *M. stridulans* to a synonym of *P. novaeguineae*. Following the publication of the initial papers on Australian penaeids by the present writers (RACEK, 1955; DALL, 1957), it soon became evident that the material originally identified by them as *M. novaeguineae* certainly consisted of more than one species. Detailed morphometric studies substantiated this assumption, and led to a re-examination of HASWELL's holotypes, as well as to the restoration of HASWELL's *M. palmensis*. The stigma of "great variability" could thus be lifted from the Australian stridulating species of *Metapenaeopsis*, all of which can now be easily separated from each other by a number of intraspecifically constant morphological features.

In the light of these investigations it became necessary to redefine both *M. novaeguineae* and *M. palmensis* in order to correct earlier misconceptions. SCHMITT's (1926) figures 1 and 2a on Plate 61, as well as figure 2a on Plate 68, refer to *M. palmensis*, figures 2b on both these plates to *M. novaeguineae*. DALL (1957) described "*M. novaeguineae*" from material chiefly collected in warmer Queensland waters, RACEK (1955) from material mostly off northern and central New South Wales. Although both these descriptions allow for obvious "variations", and include more than one species, DALL's figures on p. 171 refer to *M. novaeguineae* s.s., whereas the thelycum and petasma depicted by RACEK on Plate 7 figs. 1 and 2 are those of a typical *M. palmensis*, which will be redescribed below.

Apart from 2 additional and new species of stridulata from Australian waters, which will be described later in this paper, some few specimens of *M. stridulans* (Alcock) have also been found in adjacent tropical waters.

***Metapenaeopsis palmensis* (Haswell, 1879) rdf.**

(Figure 2 B; Plate 4 figs. 3, 4; Plate 9 fig. 2)

*Penaeus palmensis* Haswell, 1879, p. 43; 1882, p. 204. Schmitt, 1926, p. 344.

*Metapeneus palmensis* Alcock, 1906, p. 51.

*Penaeopsis palmensis* de Man, 1911, pp. 8, 55, 73.

*Penaeus velutinus* Bate, 1888, p. 253 (non Dana, 1852).

*Penaeopsis stridulans* de Man, 1911, pp. 65-69 (part).

*Penaeopsis* (*Metapenaeopsis*) *novae-guineae* Racek, 1955, pp. 226-27, (part synonymy only, N.S.W. material only); 1959, p. 10.

? *Metapenaeopsis barbeensis* Hall, 1962, pp. 32-33.

**Material.** Numerous specimens of both sexes, 46-105 mm; WESTERN AUSTRALIA: Shark Bay, Exmouth Gulf; NORTHERN TERRITORY: Arnhem Bay, South Shell I., Darwin; QUEENSLAND: Albany Passage, Gloucester Passage, Thursday I., Lindeman I., Cumberland group, Hayman I., Proserpine, Bowen Harbour, Sandy Cape, Keppel Bay; NEW SOUTH WALES: Lennox Head, Sydney Harbour; NEW GUINEA: Orangerie Bay, Sandbank Bay; South of New Guinea ("Challenger" Exped., BATE,

Aust. Mus. reg. P 3160); INDONESIA: Halmahera I., Depth of occurrence 5-30 fm.

Description. Rostrum straight, strongly reflexed from base, wide near base, slowly tapering to sharp tip which points in the direction of rostrum; slightly exceeding second segment of antennular peduncle, or at least reaching it; armed dorsally with 7-8 teeth + epigastric. Postrostral carina feebly indicated just behind epigastric tooth; position of epigastric tooth almost constantly at  $\frac{1}{5}$  carapace, penultimate tooth in level with frontal margin of carapace. Carapace entirely covered with strong and dense tomentum. Orbital spine minute, not much more than a sharp angle; orbito-antennal sulcus shallow; hepatic spine small, with a well-defined but usually obscured cervical groove. Antennal spine very prominent, with a feeble and short carina. Hepatic sulcus appears shallow because of tomentum, but is much deeper than in *M. novaeguineae*. Cervical groove clearly defined, somewhat shorter than  $\frac{1}{2}$  carapace. Stridulating organ consists of 6-11 ridges on a rather wide, non-pubescent, only slightly curved band; ridges very conspicuous and situated rather high, slightly more than  $\frac{1}{3}$  depth of carapace (fig. 2 B).

Antennules slightly unequal with upper flagellum somewhat shorter than lower which is  $\frac{1}{3}$  length carapace in ♂, slightly more than  $\frac{1}{4}$  length carapace in ♀. Prosartema slightly surpassing eye, stylocerite usually reaching to tip of basal segment.

Second abdominal somite dorsally carinated in its posterior half, without sulcus, the 3rd to 6th strongly carinated; that of the 3rd flat and narrow in anterior  $\frac{1}{3}$ , widening and with distinct broad sulcus in the rest. A small median spine present on posterior margin of carina on 5th and 6th somite. Inner uropod usually exceeding tip of telson by length of 1st pair of spines, outer uropod slightly surpassing inner.

The typical petasma is shown in Plate 4 figs. 3, 4. Right distoventral projection (a) appears bare at tip in ventral view, but possesses a number of dorsally bent spinules. Left distoventral projection (e) broadly swollen, toe-like, with a semicircular arrangement of 9-12 blunt to sharp spinules. Inner intermediate strip (g) extremely short and cylindrical; outer intermediate strip (h) with numerous distal crenulations or setae, broad and curved, conspicuously longer than inner strip. Distomedian lobule (c) triangular and long.

The typical thelycum is shown in Plate 9 fig. 2. Sternum of 2nd pereopods with 2 spinous processes, that of the 3rd with 2 short closely set blunt projections; genital openings on coxae curved and rounded. Coxae of 4th pereopods forming densely setose round plates, bounding posterolaterally the thelycal plate (a) which is subrectangular, about as long as wide, and usually carries a minute anteromedian projection. The posterior of the 2 sternal ridges between the 5th pereopods (d) is 3-lobed and carries a pointed projection on the anteromedian margin of the central lobe. The anterior of these ridges (c) is  $\Sigma$ -shaped, with its lateral projections



turned forward at right angle to the transverse line. The sternum between this ridge and the anterior thelycal plate forms a sunken trapezoidal plate with strongly elevated and densely setose lateral sides (*b*).

Colour in life. Tan to reddish-brown with irregular dark brown, occasionally dark red, mottlings and narrow transverse bands.

Distribution. Tropical and warm temperate waters of Australia, ranging south to at least Shark Bay, W.A. in the west, and Sydney, N.S.W. in the east, more common in north-eastern Australia; eastern Borneo (HALL), Halmahera I., New Guinea.

Discussion. The relegation of *M. palmensis* to a synonym of *M. novaeguineae* by SCHMITT (1926) appears to have been aided by the fact that HASWELL's holotypes of both these species in the Macleay Museum are of different sex. The immature female holotype of *M. palmensis* was indeed difficult to identify with certainty until extensive material of all Australian stridulata became available and morphometric studies were made possible. The difference in the shape and structure of the rostrum, the varying number of stridulating ridges, and many other striking features were interpreted by SCHMITT as intraspecific variation and thus *M. palmensis* remained in obscurity for almost a century.

HALL (1962), using the technique of plotting the number of stridulating ridges against the carapace length, found a Malaysian stridulating species which seemed different from DALL's (1957) description and figures of *M. novaeguineae*, yet was well within the range of "variation" formerly accredited to this species complex. Unaware of the present authors' revision, HALL created a new species *M. barbeensis* for a form which he justifiably considered not yet described. From his description and figures it seems very likely that HALL's species is in fact *M. palmensis*, and the writers have little hesitation in considering *M. barbeensis* synonymous. HALL's drawings of the petasma (118 *a*, *b*), thelycum (118 *c-e*), and stridulating organ (118 *f*) are certainly most typical for these structures in *M. palmensis*. However, since HALL has omitted to depict the decisive dorsal view of the petasma in all species of *Metapenaeopsis*, no information is available as to the shape, structure, and proportions of the various petasmas hidden dorsally.

A morphometric study of the "Challenger" specimen in the Australian Museum, Sydney, determined by BATE as *Penaeus velutinus* (Reg. No. P 3160) has also revealed its identity with *M. palmensis* in all structural details, and the status of this species can thus finally be clarified.

*M. palmensis* has a much more wide-spread distribution than *M. novaeguineae*, and ranges even into warm temperate waters in the Australian region. Ironically, even in New Guinea waters *M. novaeguineae* does not appear to be so widely distributed as *M. palmensis*, though its specific name would imply otherwise.

**Metapenaeopsis crassissima** sp. nov.

(Figure 2 C; Plate 2 fig. 1; Plate 4 figs. 5, 6; Plate 9 fig. 3)

*Metapenaeopsis durus* Dall, 1957, pp. 168-70 (non Kubo, 1949).*Penaeopsis novae-guineae* Hale, 1927, p. 39 (non Haswell, 1879, 1882).

Material. WESTERN AUSTRALIA: Shark Bay, 13.X.1958: holotype ♂, 111mm; allotype ♀ 118 mm; paratypes numerous specimens of both sexes, 34-121 mm; Roebuck Bay, Broome, Cape Bossut, Shark Bay ("Lancelin"); NORTHERN TERRITORY: Arnhem Bay ("Paxie"), Darwin (C.S.I.R.O.); SOUTH AUSTRALIA: Coffin Bay, Depth of occurrence 4-10 fm, usual habitat mud.

Description. Rostrum slightly upcurved, slightly reflexed from base, narrow in profile, slowly tapering to sharp tip which points horizontally forward; almost reaching tip of antennular peduncle; armed dorsally with 8-9 teeth+epigastric. Postrostral carina absent in both sexes; position of epigastric tooth almost constantly at  $\frac{1}{4}$  carapace, penultimate tooth in level with frontal margin of carapace. Carapace entirely covered with dense and harsh tomentum. Orbital spine minute but sharp; orbito-antennal sulcus moderately shallow; hepatic spine small, with an indistinct cervical and hepatic sulcus owing to presence of tomentum; when this is removed sulci are distinct and deep. Antennal spine prominent, reaching cornea; carina short reaching barely  $\frac{1}{3}$  distance between tip of spine and hepatic spine. Cervical sulcus straight reaching  $\frac{1}{2}$  carapace; hepatic sulcus reaching  $\frac{2}{3}$  distance between hepatic and pterygostomial spines. Pterygostomial spine unusually large reaching almost as far as spine of basicerite. Stridulating organ consists of 14-17 ridges on a narrow, non-pubescent, strongly curved band; ridges are rather inconspicuous and situated at about  $\frac{1}{4}$  depth of carapace (fig. 2 C).

Antennules with almost equal flagella which are slightly longer than  $\frac{1}{3}$  carapace in mature ♂, about  $\frac{1}{3}$  carapace in mature ♀. Prosartema reaches eye, often slightly surpassing it, stylocerite usually reaching to tip of basal segment.

Second abdominal somite dorsally carinated in its posterior half, with a clear indication of a shallow sulcus in most ♂♂, without such sulcus in most ♀♀, the 3rd to 6th abdominal somites strongly carinated. Carina of 3rd bearing well defined, narrow but deep sulcus which is about of the same width throughout its length. An indistinctly sharp angle on posteromedian margin of 5th somite, the corresponding margin of the 6th broadly rounded. Telson about as long as both uropods, bearing 3 long lateral movable spines in addition to the apical fixed pair as in all other species of this genus.

The typical petasma is shown in Plate 4 figs. 5, 6. Right distoventral projection (a) bearing 1-3 sharp small spinules, never completely bare; left distoventral projection (e) greatly thickened distally, with 12-15 deeply cleft and long finger-like irregular processes, radiating more or

less laterally from a broadly triangular base which points away from the axis of the right projection. Inner intermediate (*g*) strip broadly leaf-like, not quite reaching tip of right projection, and much shorter than outer intermediate strip (*h*).

The typical thelycum is shown in Plate 9 fig. 3. Sternum of 2nd pereopods with 2 long spinous processes, that of the 3rd with 2 short and very closely set blunt projections, which appear as two parallel ridges on a single median boss. Thelycal plate (*a*) slightly suboval with mucronate anterior edge, with angular anterolateral corners, and only slightly broader as long in mature ♀♀. Coxal plates of 4th pereopods smaller than thelycal plate, only moderately pubescent, bounding and slightly overlying the intermediate plate (*b*), which has the shape of a broad reversed T. The anteromedian and anterolateral margins of this plate are strongly elevated and pubescent, forming a narrow but deep median sulcus and posteriorly an anchor-shaped somewhat broader transverse depression. This depression is bounded posteriorly by the anterior sternal plate (*c*) between the 5th pereopods, which has its lateral projections turned forward at right angles. The posterior sternal plate (*d*) with a median, broadly triangular, and 2 rounded lateral projections.

Colour in life. Rosy pink, with only inconspicuous slightly darker mottlings.

Distribution. Apparently restricted to tropical and warm temperate waters of western and southern Australia, possibly ranging along the northwestern coast towards Darwin, N.T.

Discussion. The present species is closely allied to *M. dura* Kubo but can be distinguished from the latter by a great number of features which remain intraspecifically constant in mature specimens.

DALL (1957) had only 2 not yet fully mature females at his disposal, and was therefore hesitant to separate his material from Western Australia from *M. dura*, although calling attention to several structural differences. His description agrees in all important details with the present definition, except in some minor details concerning the structure of the thelycum of his 2 specimens, but his figure 10 B on p. 168 fails to show the typical and deep anteromedian sulcus of the intermediate plate, as well as the comparatively deep and broad posterior, anchor-shaped sulcus which are both present in his material now re-examined by us.

The present authors had access to extensive material, chiefly from Western Australia, collected during the cruises of the research vessel "Lancelin". The direct comparison of specimens of this species with a male and female of *M. dura* Kubo from Japanese waters revealed the following structural differences:

Criterion	<i>M. crassissima</i>	<i>M. dura</i>
Rostrum	Very slightly upturned; almost reaching tip of antennular peduncle.	Strongly upturned; hardly reaching $\frac{1}{2}$ 2nd antennular segment.
Pterygostomial spine	Large and conspicuous.	Small and angular.
Stridulating ridges	14-17 at $\frac{1}{4}$ depth carapace.	28-35 at almost $\frac{1}{6}$ depth carapace.
Antennular flagella	About $\frac{1}{3}$ carapace.	Half length carapace.
Petasma	Left distoventral projection pointing away from right; inner intermediate strip broadly leaflike.	Left distoventral projection parallel to right; inner intermediate strip subrectangular.
Thelycum	Coxal plates 4th pereopods moderately pubescent; antero-lateral swollen margins of intermediate plate separated by deep longitudinal sulcus.	Coxal plates 4th pereopods glabrous; antero-lateral swollen margins of intermediate plate confluent, forming a shallow longitudinal depression.

Especially in the features of the thelycum, *M. crassissima* is also very closely related to *M. toloensis* Hall, 1962, according to the published description and figures. However, it differs from *M. toloensis* in the following details:

Criterion	<i>M. crassissima</i>	<i>M. toloensis</i>
Fully grown rostrum	Narrow in profile, very slightly upturned; almost reaching tip of antennular peduncle.	Wider in profile, considerably upturned; reaching tip of 2nd antennular segment.
Pterygostomial spine	Large and conspicuous.	Small.
Stridulating ridges	14-17	15-20
Antennular flagella	About $\frac{1}{3}$ carapace length.	About $\frac{1}{4}$ carapace length.
Petasma	Processes on left distoventral projection radiating from triangular base laterally which points away from right projection.	Processes on left distoventral projection lying across tip of bulbous base, which is parallel to right projection.

Criterion	<i>M. crassissima</i>	<i>M. toloensis</i>
Thelycum	Coxal plates 4th pereopods smaller than thelycal plate; intermediate plate with distinct longitudinal median sulcus.	Coxal plates 4th pereopods somewhat larger than thelycal plate; intermediate plate with indistinct longitudinal median sulcus.

*M. toloensis* must therefore be considered a distinct species, particularly in regard to its petasmas structures, though, unfortunately, the ventral view only is available. The assumption by HALL that *M. durus* Dall, 1957, should be considered synonymous with *M. toloensis* can be fully contradicted by the results of the present comparative studies.

It is possible that, following the better understanding of the speciation problems of the stridulata, additional species will be located in the Indo-West Pacific. *M. toloensis* could well be an endemic Malaysian species of the *M. dura* group, just as *M. crassissima* appears to be endemic to Australia. The differentiation of species of the *M. dura* group by using the thelycal structures only still remains a difficult though not impossible task, and a whole range of specimens of both sexes has to be scrutinized before a satisfactory separation can be attempted. In eastern Australian waters, particularly in the region of the Great Barrier Reef, a number of specimens were collected for the present investigation, the ♀♀ of which were at first considered by the writers identical with *M. crassissima*. Detailed morphological studies, however, revealed that the Queensland material differed in many respects from *M. crassissima*, just as this species is at pronounced variance with *M. toloensis*, and all these three species clearly distinct from the true *M. dura*. The material from north-eastern Australia will therefore be described below as a new species.

*M. crassissima* can be considered one of the largest species of this genus. It is essentially a shallow-water form, and has been located by the Western Australian Research Vessel "Lancelin" in promising quantities. Its conspicuous and typical coloration in life makes it easy to separate in the field from associated species of this genus, with overlapping distribution, particularly *M. novaeguineae* and *M. palmensis*.

#### ***Metapenaeopsis rosea* sp. nov.**

(Figures 2 D, 3; Plate 1 fig. 4; Plate 4 figs. 7, 8; Plate 9 fig. 4)

Material. QUEENSLAND: Mackay, coll. R. JONDAHL, 24.X.1955, 4 fm, mud: holotype ♂, 98 mm; allotype ♀ 104 mm; paratypes ♂, 96 mm, Wreck Rock, Q., August 1960; 2 ♀♀, 106, 107 mm, off Mackay, mud-sand, 16 fm, July 1958, coll. "Challenge": Australian Museum collection, Reg. No. P 12730-part, 9 specimens of both sexes, 36-79 mm. Albany

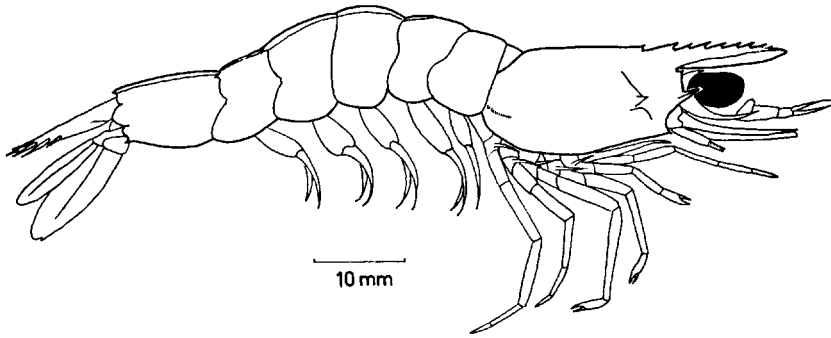


Fig. 3. *Metapenaeopsis rosea*, sp. nov., ♂, 96 mm, paratype.

Passage, P 12492, Cape York, P 10592, Hayman I. NORTHERN TERRITORY: off Darwin, October 1962, coll. V. WELLS, 7 fm, mud; depth of occurrence 4–16 fm.

Description. Rostrum straight and horizontal in ♂, very slightly ascending but not upturned in ♀, wide in profile, tapering to sharp tip which points horizontally forward; slightly surpassing 2nd antennular segment, but much shorter than tip of peduncle; armed dorsally with 9 teeth+epigastric. Postrostral carina inconspicuous but present for about  $\frac{1}{3}$  distance between epigastric and posterior margin of carapace; position of epigastric not quite at  $\frac{1}{3}$  carapace, penultimate tooth about in level with frontal margin of carapace. Carapace entirely covered with dense but fine tomentum. Orbital spine minute, not much more than a sharp angle; orbito-antennal sulcus barely defined at all; hepatic spine small, with an indistinct cervical and hepatic sulcus owing to presence of tomentum; even when this is removed sulci are shallow and short. Antennal spine prominent, reaching cornea; carina short, reaching about  $\frac{1}{3}$  distance between tip of spine and hepatic spine. Cervical sulcus straight, reaching  $\frac{1}{2}$  carapace, hepatic sulcus slightly descending below spine, turning towards pterygostomial spine in front of hepatic spine. Pterygostomial spine very small and inconspicuous. Stridulating organ consists of 15–18 ridges on a posteriorly wider and anteriorly narrowing, non-pubescent, strongly curved band; ridges are rather inconspicuous and situated at about  $\frac{1}{4}$  of carapace (fig. 2 D).

Antennules with almost equal flagella which are about  $\frac{1}{4}$  carapace in mature ♂, slightly shorter in mature ♀. Prosartema surpasses eye by about  $\frac{1}{3}$  its length, stylocerite reaches to tip of basal segment.

Second abdominal somite dorsally carinated in its posterior half, without any perceptible sulcus in both sexes; the 3rd to 6th abdominal somites strongly carinated. Carina of 3rd bearing a well-defined narrow, but posteriorly widening, deep sulcus in posterior  $\frac{2}{3}$ ; the anterior  $\frac{1}{3}$  bearing an extremely narrow and shallow sulcus in ♀, a narrow but deep groove in ♂. A distinct sharp angle on postero-median margin of 5th and

6th somite. Telson as long as inner uropods, slightly exceeded by outer uropods; 1st telsonic spine inserted almost  $\frac{2}{3}$  length of telson.

The typical petasma is shown in Plate 4 figs. 7, 8. Right distoventral projection (*a*) bearing few very small distal processes, never bare; left distoventral projection (*e*) with 12–18 triangular processes radiating from a horseshoe-like plate which is directed toward the right projection. Inner intermediate strip (*g*) flat leaf-like, greatly surpassing tip of outer intermediate strip (*h*).

The typical thelycum is shown in Plate 9 fig. 4. Sternum of 2nd pereopods with 2 long spinous processes, that of the 3rd with 2 diverging blunt projections. Thelycal plate (*a*) suboval with anterior edge entire, and with rounded corners, about as wide as long in mature ♀. Coxal plates of 4th pereopods much smaller than thelycal plate, densely pubescent, bounding and slightly overlying the intermediate plate (*b*) which is broadly anchor-shaped. The anteromedian and anterolateral margins of this plate are strongly elevated and densely pubescent, forming 2 semicircular ridges, which are separated from each other by a wide, long and deep longitudinal sulcus. Bounding the semicircular ridges posteriorly is a deep transverse depression of the shape of a double C. This depression is bounded posteriorly by the anterior sternal plate (*c*) between the 5th pereopods which has its lateral projections turned forward at about right angles. The posterior sternal plate (*d*) with a median, broadly triangular, and 2 rounded projections.

Colour in life. Rosy pink, without mottlings, but with a number of transverse darker narrow bands on abdomen.

Distribution. Apparently restricted to tropical waters of north-eastern Australia in the vicinity of the Great Barrier Reef.

Discussion. In regard to the shape and general structure of its thelycum, this species is more closely related to *M. crassissima* than to any other species of the *M. dura* group. However, it can readily be distinguished from *M. crassissima* by position, length, and shape of its rostrum, by the absence of unusually large pterygostomial spines, by the shorter length of its antennulae, by the differently sulcate 3rd abdominal carina, by the somewhat more posterior insertion of the first telsonic spine, and particularly by the structure of its petasmal components. Even the thelycum of *M. rosea*, although superficially resembling that of *M. crassissima* in general facies, is distinctly at variance with the latter species. From *M. dura* the species discussed can readily be distinguished by length of antennules, rostrum, and the structure of thelycum and petasma; it also differs from *M. toloensis* in rostral characteristics, in having smaller coxal plates on the 4th pereopods, in some details of its thelycum, and in not sharing the quite unique petasmal structures present in *M. toloensis*. The petasmal components, however, cannot be fully compared with HALL's species until the taxonomically important median and dorsal components of the latter are illustrated.

*M. rosea* has not yet been found abundantly enough to make reliable conclusions as to its optimal habitat and distribution. Its conspicuous coloration in life enables its ready separation from other associated species of this genus in the field.

***Metapenaeopsis stridulans* (Alcock, 1905)**

(Figures 2 E, 4 A-C; Plate 9 fig. 5)

*Metapeneus stridulans* Alcock, 1905, p. 526; 1906, pp. 27-29 (not synonymy, nor figure 14b, Plate 5).

*Metapenaeopsis stridulans* Hall, 1962, p. 32.

Material. NEW GUINEA: Milne Bay, coll. A. RAPSON, 10.V.1955, 5-6 fm, 1 ♂, 48 mm; NORTH BORNEO: Tawau Fish Market, coll. CHIN PHUI KONG, 18.XII.1959, 2 ♀♀, 71, 79 mm; NEW BRITAIN: Henry Reid Bay, Wide Bay, coll. C.S.I.R.O., 27.X.1949, 1 ♂, 40 mm, 1 ♀, 42 mm.

Description. Rostrum low and straight, narrow in profile, tapering to a sharp styliform tip which points horizontally forward; reaching to terminal segment of antennular peduncle, armed dorsally with 6-7 wide-set teeth+epigastric. Postrostral carina absent in both sexes; position of epigastric tooth at  $\frac{1}{4}$  carapace, penultimate tooth anterior to frontal margin of carapace. Carapace entirely covered with dense but short tomentum. Orbital spine minute but sharp; orbito-antennal sulcus moderately shallow; hepatic spine small, with a distinct, but often obscured, cervical and hepatic sulcus. Antennal spine prominent, reaching cornea; carina barely defined at all. Pterygostomial spine moderately small, but sharp and conspicuous. Stridulating organ consists of 5-8 ridges on a very wide, non-pubescent, straight band; ridges are extremely prominent and situated almost at  $\frac{1}{3}$  depth of carapace (fig. 2 E).

Antennules with almost equal flagella which are only slightly longer

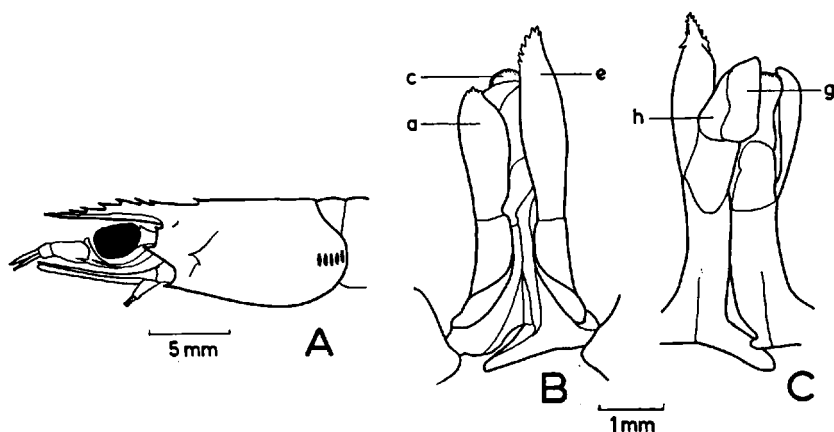


Fig. 4. *Metapenaeopsis stridulans* (Alcock).

A, ♂, 48 mm, Milne Bay, cephalothorax; B, ventral view of petasma; C, dorsal view of petasma (legends as in fig. 1).



than  $\frac{1}{5}$  carapace in material examined. Prosartema slightly surpassing eye, stylocerite reaching to tip of basal segment.

Second abdominal somite dorsally carinated in its posterior half, bearing a clearly defined but shallow sulcus in both sexes; the 3rd to 6th abdominal somites strongly carinated. Carina of 3rd bearing well defined, often rather broad, sulcus. In the males from New Guinea this carina is broad and appears therefore shallow, and widens posteriorly only slightly; the females from North Borneo possess a more narrow, but apparently deeper sulcus which begins to widen in its posterior half. A distinct tooth on posteromedian margin of 5th and 6th somite. Telson almost reaching tips of outer uropods; 1st telsonic spine inserted about  $\frac{1}{2}$  length of telson.

The typical petasma is shown in figures 4 B, C. Right distoventral projection (a) bearing a few small apical processes, rarely bare; left distoventral projection (e) with 9–12 larger processes which give the tip of the projection a sharply pointed triangular shape. Inner intermediate strip (g) broadly quadrangular, surpassing tip of right projection and that of the outer intermediate strip (h). Distomedian lobule (c) strongly crenulated at tip, much broader but somewhat shorter than inner intermediate strip.

The thelycum is shown in Plate 9 fig. 5. Sternum of 2nd pereopods with 2 long spinous processes, that of the 3rd with 2 rather closely set, blunt projections. Thelycal plate (a) suboval with anterior edge entire, and with rounded corners, slightly wider than long. Coxal plates of 4th pereopods small and pubescent, laterally bounding the intermediate plate (b) which is broadly trapezoidal, and posteriorly overlying the lateral extensions of the anterior sternal plate (c). In immature females the intermediate plate is just a broad depression; in the 79 mm long female from North Borneo, this plate possesses a pair of strongly raised and pubescent wing-like ridges, with a shallow sulcus separating them from each other, and a deep transverse sulcus separating them from the anterior sternal plate (c). This latter plate between the 5th pereopods has its lateral projections turned forward at a blunt angle. The posterior sternal plate (d) is divided into 3 blunt lobes.

Colour in life. Not yet recorded.

Distribution. Indian Seas (Alcock), through Malaysian waters (HALL) to eastern New Guinea. Recorded depth of occurrence 5–30 fm.

Discussion. The writers are as yet unable to carry out direct comparison of their material with that of ALCOCK and HALL from India and Malaysia respectively. HALL (1962), although presenting well-drawn figures from his material, merely refers in that paper to an unfortunately never published M.S. without giving a redescription of this species. This would have been the more necessary in view of the fact that ALCOCK (1906) obviously described his *M. stridulans* from more than one species. His figure 14b on Plate 5 certainly does not refer to this species, judging

from the shape of the carapace and the arrangement of the stridulating ridges.

Owing to the absence of comparative material, the writers were at first unable to identify the material from New Guinea and North Borneo with certainty, since the typical petasma of *M. stridulans* has never before been depicted in dorsal view. However, the most striking arrangement of the wide and straight stridulating organ, as well as the form of the rostrum, the ventral view of the petasma, and the thelycum appear to agree well with the description by ALCOCK, and the figures by both ALCOCK and HALL. The present writers have, therefore, preferred to identify their material with *M. stridulans* instead of creating a new species, as originally intended.

***Metapenaeopsis sinuosa* Dall, 1957**

(Figure 2 F; Plate 10 fig. 1)

*Metapenaeopsis sinuosus* Dall, 1957, pp. 176-78.

Material. QUEENSLAND: Lindeman I., September 1935, dredged by Professor W. DAKIN, 6 fm, coral bottom, 1 ♂, 19 mm, 2 ♀♀, 38, 40 mm.

Distribution. Hitherto found only in the vicinity of the type locality in the Great Barrier Reef.

Discussion. The specimens examined agree in all major details with the comprehensive description and figures by DALL (1957). That author, in discussing the possible relationship of this species, compared it with those *Metapenaeopsis* spp. which are immediately distinguishable from the remainder of the genus by their well-developed abdomen and the length of their 6th abdominal somite. In doing so, however, DALL found his *M. sinuosa* strikingly different from this typically deep-water group of species not only in regard to its shallow-water habitat but also in the structure of its thelycum and rostrum, as well as by the presence of only a small anteromedian spine on the 1st antennular (not antennal, as mistakenly quoted on p. 178) segment.

The examination of these additional specimens revealed the close relationship of *M. sinuosa*, in spite of its atypically longer 6th abdominal somite, to the group of stridulating species. The branchiostegites of both females examined bear inconspicuous but well-developed stridulating organs which consist of 5-8 very small ridges on a narrow, slightly curved, and partly pubescent band which is situated at about  $\frac{1}{7}$  depth of carapace (figure 2 F). The male specimen has this raised band clearly developed on both branchiostegites but ridges on it are not perceptible. A re-examination of the types has also established the presence of a complete stridulating organ on one branchiostegite of the allotype, the other being damaged. This organ was probably overlooked by DALL due to the partly damaged branchiostegites of the type material, and by the similarity of this species to the deep-water group of the genus.

Since the figure of the thelycum given by DALL (1957) fails to emphasize the relationship to the stridulata, the thelycum of *M. sinuosa* has been photographed (Plate 10 fig. 1) in order to be readily comparable with the other stridulating species of this genus.

***Metapenaeopsis barbata* (de Haan, 1850)**

(Figure 2 G; Plate 4 figs. 9, 10; Plate 9 fig. 6)

*Penaeus affinis barbatus* de Haan, 1850, p. 192.

*Parapenaeus akayebi* Rathbun, 1902, p. 39.

*Penaeus (Metapenaeus) akayebi* de Man, 1907, pp. 433-34.

*Penaeopsis barbatus* de Man, 1911, p. 88.

*Metapenaeopsis barbatus* Kubo, 1949, pp. 413-19.

*Metapenaeopsis barbatus* Dall, 1957, p. 167 (key).

*Metapenaeopsis barbata* Hall, 1962, p. 32.

(non *Metapenaeopsis barbata* Racek, 1959, p. 10).

**Material.** 3 ♂♂, 3 ♀♀, 81-108 mm, from Japanese waters, leg. I. KUBO, May 1956.

**Distribution.** Japanese Seas to Indonesia (KUBO), Malaysia (HALL).

**Discussion.** *Metapenaeopsis barbata* has been clearly defined and described by previous workers, and the reader is particularly referred to the comprehensive work by KUBO (1949), who has identified material from the southern waters off Borneo (Kalimantan) as belonging to this species. HALL (1962), again merely referring to an apparently not yet published M.S. (1956), even extends the known distribution of *M. barbata* to Malaysia. Although the occurrence of this species in the general region studied in this paper can thus be expected, it is not present in collections for the present study.

In the view of the separation of the Australasian stridulata into clearly distinct species, it is possible that a future scrutiny of all specimens formerly considered to be *M. barbata* could also result in the differentiation of a number of species. The species called *P. akayebi* by RATHBUN (1902) most probably is synonymous with *M. barbata* as most recent writers assume. But KISHINOUE's (1900) *P. velutinus*, considered synonymous with *M. barbata* with the exception of its petasma by KUBO (1949), seems something different, most probably a member of the *M. dura* group. Even *Metapenaeus barbatus* of MAKI and TSUCHIYA (1923) from Formosa is quoted by KUBO as differing in some details from DE HAAN's species. In view of these differences, and in order to facilitate future comparative studies of the stridulata in the Indo-West Pacific, the outer genitalia of the Japanese material are hereunder redescribed and figured.

The petasma is shown in Plate 4 figs. 9, 10. Right distoventral projection (a) bearing 2-5 sharply outward bent small spinules, never bare; left distoventral projection (e) with narrowing tip, bearing 10-12 larger processes. Inner intermediate strip (g) broad and leaf-like, much surpassing tip of outer intermediate strip (h) which is finely setose. Inner

lobule (c) broadly quadrangular, of same length as inner intermediate strip.

The thelycum is shown in Plate 9 fig. 6. Sternum of 2nd pereopods with 2 long spinous processes, that of the 3rd with 2 widely set blunt projections. Thelycal plate (a) suboval with anterior edge entire, and with rounded and slightly elevated corner, about as wide as long. Coxal plates of 4th pereopods rather small and pubescent, laterally bounding the intermediate plate (b) which is subrectangular, and posteriorly overlying the lateral extensions of the anterior sternal plate (c). The antero-lateral margins of this plate are slightly raised and moderately pubescent, forming a broad and shallow depression between them, and posteriorly a deeper sinuous transverse sulcus. This sulcus is bounded by the anterior sternal plate between the 5th pereopods (c) which has its lateral projections turned forward at about 80 to 90°. The posterior sternal plate (d) with a median, less prominent and slightly pointed projection, and 2 rounded lateral projections.

In regard to shape of body, armature as well as shape of rostrum, and general structure of the 3rd abdominal median carina, *M. barbata* is extremely similar to *M. novaeguineae*, as redefined in this paper. However, the thelyca and petasmata of these species are strikingly different and enable their fast and reliable differentiation. From the only other species with a low rostrum bearing comparatively few and wide-set teeth, *M. stridulans*, *M. barbata* can be easily separated by the presence of a non-sulcate 3rd abdominal carina, and the much different shape of its strongly curved and inconspicuous stridulating organ (fig. 2 G).

### **Metapenaeopsis acclivis** (Rathbun, 1902)

(Figure 2 I; Plate 4 figs. 11, 12; Plate 9 fig. 8)

*Parapenaeus acclivis* Rathbun, 1902, p. 41.

*Penaeus* (*Metapenaeus*) *acclivis* de Man, 1907, pp. 434-44.

*Penaeopsis barbatus* Parisi, 1919, pp. 61-62.

*Metapenaeopsis acclivis* Kubo, 1949, pp. 419-21.

*Metapenaeopsis acclivis* Dall, 1957, p. 167 (key).

Material. 3 ♂♂, 2 ♀♀, 66-90 mm, from Japanese waters, leg. I. KUBO, May 1956.

Distribution. Apparently restricted to Japanese waters.

Discussion. Although this species is unlikely to occur in the general region studied, its outer genitalia are herewith redescribed and figured for comparative purposes. For a general account of this species the reader is referred to the papers by RATHBUN (1902) and KUBO (1949).

The petasma is shown in Plate 4 figs. 11, 12. Right distoventral projection (a) thin with several spinous apical processes, never bare; left distoventral projection (e) fringed on apex with many pointed and long processes. Inner intermediate strip (g) quadrangular, somewhat surpassing apex of outer intermediate strip (h) and inner lobule (c).

The thelycum is shown in Plate 9 fig. 8. Sternum of 2nd pereopods with 2 long spinous processes, that of the 3rd with 2 diverging and blunt projections. Thelycal plate suboval with anterior edge entire, and with sharply rounded lateral corners, much wider than long. Coxal plates of 4th pereopods unusually large and moderately pubescent, separated from each other by an extremely narrow space, corresponding to the deep and narrow longitudinal sulcus of the intermediate plate which is thus hardly visible. The slightly sinuous transverse sulcus of this plate (*b*) is very narrow and moderately deep. It borders posteriorly the anterior sternal plate (*c*) which is broad and almost straight, and the lateral projections of which turn forward abruptly at right angles. Posterior sternal plate between 5th pereopods (*d*) with a less prominent and somewhat angular median, and two rounded lateral, projections.

The thelycum can hardly be confused with that of any other species hitherto described, and the size and insertion of the coxal plates of the 4th pereopods are quite unique among the species of *Metapenaeopsis*. The petasma too is at variance with any other known species of the genus. In most of its general features this species could almost be considered a member of the *M. dura* group, but it is readily separated from that group by its flattish, or feebly sulcate, carina on the 3rd abdominal tergum.

### *Metapenaeopsis dura* Kubo, 1949

(Figure 2 H; Plate 5 fig. 1; Plate 9 fig. 7)

*Metapenaeopsis durus* Kubo, 1949, pp. 421-24. Dall, 1957, p. 167 (key). (Non Dall, 1957, pp. 168-70).

Material. 1 ♂, 76 mm, 1 ♀, 92 mm (paratypes), from Japanese waters, leg. I. KUBO, May 1956.

Distribution. Apparently restricted to Japanese waters.

Discussion. This is another stridulating species of *Metapenaeopsis* which has not yet been found outside the Japanese region. The Australian species, considered as *M. dura* by DALL (1957), has already been shown to be a new species, *M. crassissima*. The Malaysian species described by HALL (1962) as *M. toloensis* appears to be a distinct species even though it was not available to the writers for comparison. In order to facilitate future comparative studies the structure of the outer genitalia of both sexes of *M. dura* is here redescribed, and the ventral view of the petasma, as well as that of the thelycum figured. Since the male specimen of KUBO's paratypes had to be returned, the dorsal view of the petasma could not be depicted, and the reader is referred to KUBO (1949, p. 62, fig. 18).

The petasma is shown in Plate 5 fig. 1. Right distoventral projection (*a*) leaf-shaped, thickened, with 3 spiniform apical processes; left distoventral projection distally much thickened, with about 15 pointed outgrowths

on apical margin, radiating laterally from a broadly conical base which is directed straight forward. Inner intermediate strip (*g*) laterally compressed, subrectangular, with rounded apex. Outer intermediate strip (*h*) surpassing inner strip, distally with a greater number of short setae.

The thelycum is shown in Plate 9 fig. 7. Sternum of 2nd pereopods with 2 long spinous processes, that of the 3rd with a rounded rectangular plate on which 2 broad lateral bosses are barely perceptible. Thelycal plate (*a*) oval with a minute median projection, with rounded anterolateral corners, and about as long as wide. Coxal plates of 4th pereopods slightly smaller than thelycal plate, almost completely glabrous, bounding the intermediate plate (*b*) which has the form of a reversed V. The lateral margins of this plate are only slightly elevated and almost glabrous, forming a broad and inconspicuous depression between them, and posteriorly a sinuous groove. This groove is bounded posteriorly by the anterior sternal plate (*c*) between the 5th pereopods, which has its lateral projections sharply turned forward at right angles. The posterior sternal plate (*d*) with a median sharply triangular, and 2 rounded lateral, projections.

### ***Metapenaeopsis lamellata* (de Haan, 1850)**

(Plate 2 fig. 2; Plate 10 fig. 4)

*Penaeus lamellatus* de Haan, 1850, p. 193. Miers, 1878, p. 308. Kishinouye, 1900, pp. 25–26. Doflein, 1902, p. 631.

*Penaeus (Metapenaeus) lamellatus* de Man, 1907, p. 432.

*Parapenaeus lamellatus* Rathbun, 1902, p. 38.

*Penaeopsis lamellatus* Balss, 1914, p. 9. Parisi, 1919, pp. 62–63. Yoshida, 1941, p. 14.

*Metapenaeopsis lamellatus* Kubo, 1949, pp. 429–32. Dall, 1957, p. 167 (key).

*Penaeopsis (Metapenaeopsis) lamellata* Racek, 1959, p. 11 (footnote).

*Metapenaeopsis lamellata* Hall, 1962, p. 36.

**Material.** QUEENSLAND: 5 ♀♀, 69–97 mm, 6 miles S.E. off Northwest I., 23.VII.1957, coll. "Challenge", trawl No. 36, bottom coral, 20 fm (first record for Australia); NORTHERN TERRITORY: 1 ♀, 78 mm, Joseph Bonaparte Gulf, 5.X.1961, coll. V. WELLS ("Paxie"), bottom coral and polyzoa, 17 fm.

**Distribution.** Formerly known only from Japanese waters; apparently ranging through tropical Australian waters (RACEK, 1959) to Malaysia (HALL, 1962).

**Discussion.** This species has been adequately described by a number of previous authors, and the reader is particularly referred to KUBO (1949) and KISHINOUE (1900). The peculiar shape of its rostrum, the salient carina on its 3rd abdominal tergum, the robust body and thoracic appendages, as well as the form of its outer genitalia will immediately separate this species from any other of the genus *Metapenaeopsis* hitherto recorded. The most typical thelycum is shown in Plate 10 fig. 4. Unfortunately, males of this species have not yet been recorded from Australia.

The Australian material of *M. lamellata* agrees in all details with the descriptions of this species by all previous authors. However, as HALL (1962) notes, the length of the antennular flagella in his Malaysian male specimen is shorter than the length recorded by KUBO (1949) for Japanese males, but agrees with the length depicted by KISHINOUE (1900). The female specimens from Australian waters correspond in this regard fully to the range given by KUBO, and their lower antennular flagella range in length from slightly under  $\frac{1}{3}$  to a full  $\frac{1}{3}$  of carapace length.

Colour in life. Ranging from dark pink to bright red, with colour patterns in vermillion on all thoracic and abdominal carinae, particularly on that of the 3rd abdominal tergum; all appendages bright red to orange, tip of uropods purplish-blue.

*M. lamellata* has previously been, and still is, considered a rare species. However, in view of its recently established range of occurrence from Japan to Malaysia it can reasonably be assumed that it will eventually be found in much greater quantities in its optimal habitat, which at present defies conventional bottom trawling methods. Information on its optimal habitat is not available for Japanese populations, but the few specimens trawled in Australian waters were all obtained on, or in the close vicinity of, coral reefs, and the cod-end was invariably filled with large amounts of broken coral, rubble and weed whenever this species was taken. *M. lamellata* is associated in Australian waters with *Penaeus longistylus* and occasionally with *Parapenaeopsis cornuta*.

### **Metapenaeopsis quinquedentata** (de Man, 1907)

(Figure 5 A, B)

*Metapeneus quinquedentatus* de Man, 1907, p. 133.

*Penaeopsis quinquedentatus* de Man, 1911, pp. 71-73.

*Penaeopsis quinquedentata* Barnard, 1950, pp. 593-95.

*Metapenaeopsis quinquedentatus* Dall, 1957, p. 167 (key).

*Penaeus* sp. de Man, 1902, p. 906.

Material. NEW GUINEA: 1 ♂, 38 mm, Piara Point, Papua, from stomach of pipe-fish, coll. C.S.I.R.O., 10.X.1948; TANGANYIKA: Mafia Archipelago, 3.IX.1960, coll. Dr. A. J. BRUCE, coral debris, 22 fm, 1 ♀, 35 mm, 1 ♂, 38 mm; N.E. of Ras Mkumbe, Mafia Is., 22.X.1960, Dr. A. J. BRUCE, 50 fm, 1 ♀, 51 mm.

Description. Rostrum short and directed obliquely upward, wide in profile, with almost straight lower, conspicuously convex upper, margin; somewhat shorter than eye, armed dorsally with 6 teeth+epigastric. Postrostral carina absent; position of epigastric tooth at  $\frac{2}{5}$  carapace, 2 posterior rostral teeth on carapace, the 3rd slightly anterior to frontal margin of carapace. Carapace entirely covered with short but dense tomentum. Orbital spine minute; orbito-antennal sulcus moderately shallow; hepatic spine small, with a distinct cervical and hepatic sulcus.

Antennal spine small without any trace of a carina. Pterygostomial spine slightly subequal in length to antennal spine. Stridulating ridges absent.

Antennules subequal, the lower flagellum slightly longer than  $\frac{1}{4}$  length carapace. Prosartema slightly surpassing eye, stylocerite reaching about to tip of eye.

Second abdominal somite dorsally carinated in its posterior half, the 3rd to 6th terga strongly carinated. Carina of 3rd somewhat elevated in profile and non-sulcate. A distinct tooth on posteromedian margin of 6th somite only. Telson not quite reaching tips of uropods, the outer of which is slightly longer than the inner.

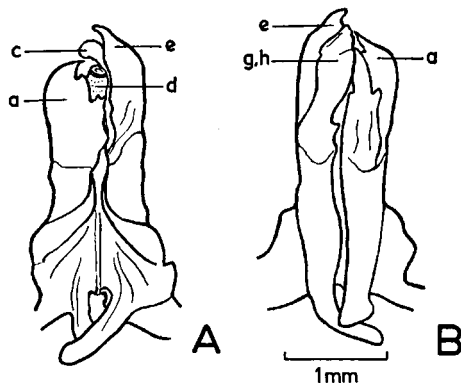


Fig. 5. *Metapenaeopsis quinquedentata* (de Man), ♂, 38 mm, Papua. A, ventral view of petasma; B, dorsal view of petasma (legends as in fig. 1).

The petasma is shown in figure 5 A, B. Right distoventral projection (*a*) distally swollen, its anterior tip armed with an inward directed spine; left distoventral projection longer than right, with a blunt and inward curved apical process. Inner (*g*) and outer intermediate strip (*h*) fused in form of a subrectangular plate. Distomedian lobule (*c*) with a broadly blunt, and slightly inward curved distal process. Sternum of 2nd pereopods with 2 well developed and long spinous processes, similar to those found in this sternum in females.

Distribution. Apparently a warm-water species, ranging from S.E. Africa through Indonesian waters to New Guinea.

Discussion. The male from New Guinea agrees in all major details with the description and figures by DE MAN (1902, 1911), except in the length of the left petasmal lobe which appears in the specimen discussed slightly longer than in DE MAN's (1911) drawing. However, it is fully comparable with the male from the Mafia Archipelago examined during this study. The apical fixed spines of the telson are minute and can easily be overlooked. In spite of the fact that this condition is shown in the figures of DE MAN (1902), and BARNARD (1950), it is not discussed in either of these papers.



***Metapenaeopsis insona* sp. nov.**

(Figure 6 A, B; Plate 2 fig. 3; Plate 10 fig. 2)

**Material.** NEW SOUTH WALES: 7 miles off Long Reef, 3.VI.1955, coll. A. A. RACEK, mud bottom, 40 fm, holotype ♀, 59 mm; off Broken Bay, 1.VII.1959, coll. "Challenge", trawl No. 316, mud bottom, 30–35 fm, allotype ♂, 38 mm (rostrum broken); paratype, ♀, 50 mm.

**Description.** Rostrum very slightly upcurved and somewhat ascending, moderately wide in profile, slowly tapering to a blunt tip; reaching tip of second antennular segment; armed dorsally with 7–8 teeth + epigastric. Postrostral carina absent in both sexes; position of epigastric tooth at  $\frac{1}{4}$  carapace, penultimate tooth just anterior to frontal margin of carapace. Carapace entirely covered with dense but soft tomentum. Orbital spine minute but sharp; orbito-antennal sulcus shallow and obscured by tomentum; hepatic spine moderately small, with a distinctly visible cervical and hepatic sulcus in spite of tomentum. Antennal spine prominent, almost reaching cornea, without carina. Cervical sulcus straight, reaching  $\frac{3}{4}$  carapace; hepatic sulcus reaching  $\frac{3}{4}$  distance between hepatic and pterygostomial spines. Pterygostomial spine minute but sharp. Stridulating ridges absent.

Antennules with subequal flagella, lower somewhat longer than  $\frac{1}{4}$  carapace in both sexes. Prosartema reaches eye, stylocerite reaches tip of basal antennular segment.

Second abdominal somite dorsally carinated in its posterior half, the 3rd to 6th strongly carinated. Carina of 3rd with a faint indication of a very narrow sulcus in its anterior  $\frac{1}{3}$  in both ♀♀, with a very narrow sulcus almost throughout its length in the allotype. A distinct tooth on posteromedian margin of 6th somite only. Telson, not quite reaching tips of uropods, the outer of which is slightly longer than the inner, armed with 3 pairs of movable spines and a pair of fixed conspicuous spines.

The petasma is shown in figure 6 A, B. Right distoventral projection broadly leaf-like, widest in its centre, carrying a blunt lateral, and 2–3 smaller blunt processes, all of which are directed forward; left distoventral projection flattish and dorso-ventrally curved, and distally cut into two lobes the inner of which is more prominent; the tip of this projection has no perceptible spinules and points inwardly to follow the curvature of the right projection. Inner intermediate strip (*g*) triangular, only partly fused to outer (*h*), which bears a unique apical structure. This consists of 2 strongly bent, long and 1 shorter blunt, spines with a chitinous membrane between them. Sternum of 2nd pereopods without the long spinous processes found in the ♂ of *M. quinquedentata*, but with a small bilobed plate with 2 rounded processes.

The thelycum is shown in Plate 10 fig. 2. Sternum of 2nd pereopods with 2 long spinous processes, broad at their base; that of the 3rd with a blunt triangular plate not divided into lateral processes. Thelycal

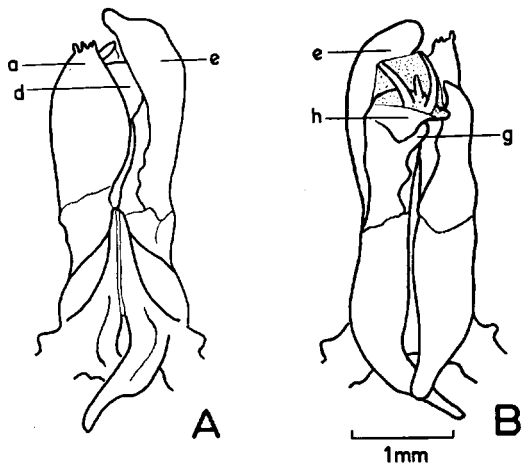


Fig. 6. *Metapenaeopsis insona*, sp. nov., allotype.

A, ventral view of petasma; B, dorsal view of petasma (legends as in fig. 1).

plate (a) subrectangular with a large acicular spine at centre of anterior margin and with rather angular anterolateral corners. Coxal plates of 4th pereopods rather small and pubescent, bounding the intermediate plate (b) which forms a deep, bowl-like depression behind the thelycal plate. The anterior sternal plate between the 5th pereopods (c), with a rounded median protrusion, and with a pair of swollen and laminar protuberances with rounded apices directed anterolaterally. The posterior sternal plate between the 5th pereopods (d) cut into a median pointed, and 2 lateral rounded, lobes.

Colour in life. Light tan, with yellow appendages, and uropods tipped with purple.

Distribution. As yet found only at the type locality in central New South Wales, between 35 and 40 fm, on mud.

Discussion. *Metapenaeopsis insona* is closely allied to *M. quinquedentata* but can readily be distinguished from it by shape and armature of the rostrum, the greater length of the antennal spine, the presence of a very narrow but discernible sulcus on the 3rd abdominal ♂ tergum, the absence of long spinous processes on the ♂ sternum between the 2nd pereopods, longer telsonic fixed spines, and by the structure of thelycum and petasma. The thelycum as a whole has a superficial resemblance to that of *M. dalei*, but its thelycal plate is similar to that of *M. lamellata*. The ventral view of the petasma reveals some general affinities to the petasma of *M. quinquedentata*, but its dorsal components are not comparable with any other known species of the genus.

#### ***Metapenaeopsis mogiensis* (Rathbun, 1902)**

(Figure 7 A, B; Plate 5 figs. 2, 3; Plate 10 fig. 3)

*Parapenaeus mogiensis* Rathbun, 1902, p. 39.

*Metapeneus mogiensis* Alcock, 1906, pp. 29–30.

*Penaeopsis mogiensis* Schmitt, 1926, pp. 346-48.

*Penaeopsis* (*Metapenaeopsis*) *mogiensis* Racek, 1959, p. 11 (footnote).

*Metapenaeopsis mogiensis* Dall, 1957, pp. 172-74. Hall, 1962, p. 35.

*Penaeopsis hilarulus* de Man, 1911, pp. 70-71. Barnard, 1950, pp. 595-96.

**Material.** QUEENSLAND: 3 miles W. off Prudhoe I., 10.VIII.1957, coll. "Challenge", trawl No. 85, sand bottom, 16 fm, 6 ♀♀, 80-96 mm; 6 miles N.E. off Northwest I., 23.VII.1957, coll. "Challenge", trawl No. 36, sand and broken coral, 20 fm, 1 ♀, 81 mm; TANGANYIKA: Mafia Archipelago, 3.IX.1960, coll. Dr. A. J. BRUCE, coral debris, 22 fm, 1 ♂, 59 mm.

**Distribution.** From Durban Bay, South Africa (BARNARD), through Indian waters (ALCOCK), Malaysia (HALL), Indonesian waters (DE MAN) to Japan (RATHBUN) in the north-east, and tropical Queensland (SCHMITT, DALL, RACEK) in the south-east. Usually occurring in the vicinity of coral reefs in waters of moderate depths.

**Colour in life.** Not yet recorded.

**Discussion.** Owing to the paucity of specimens collected for the present study nothing of importance can be added to the description of *M. mogiensis* by previous authors, and the reader is particularly referred to ALCOCK (1906) and DALL (1957), as well as to the figures 120a, b, by HALL (1962). DALL (1957), in discussing some structural differences between the thelyca of mature and immature females, came to the conclusion that the shape and size of the 2 spines or platelets behind the thelycal plate, and the structure of the anterior sternal plate between the 5th pereopods, could be assumed to change during growth. Differences of this kind were chiefly responsible for the reluctance of DE MAN (1911) in identifying his Indonesian material with those of RATHBUN (1902) and ALCOCK (1906) from Japan and India respectively.

However, one would expect that these 2 platelets should also increase in size during the process of growth of the whole thelycal structure, and to be most inconspicuous in the smallest specimens available. This apparently is not the case in DE MAN's small and mostly juvenile specimens; the platelets are figured by that author as laminose and prominent structures, whereas those of mature Australian and Japanese females are comparatively small in comparison with the thelycal plate, and of a distinctly spinous nature.

SCHMITT (1926) has noted differences between Australian and Indian specimens of this species, but found the Queensland specimens comparable in most features with RATHBUN's types. DALL (1957) found similar discrepancies between Australian and Indian specimens, particularly in regard to rostrum and thelycum, and explained these by "some variation between adults from various localities". It could well be possible, considering the confusion of some well-known stridulating species in the past, that even *M. mogiensis* Auctorum consists of more than one species, and that DE MAN's tentative name *P. hilarulus* will eventually be used for a distinct species. Although BARNARD (1950) has already used

DE MAN's name for his material from South Africa, the material examined by the present writers is not numerous enough to attempt a revision, and males were not yet available from Australian waters.

A single female, 41 mm in total length, from Massava Bay, New Britain (Aust. Museum, Reg. No. P 14244) shows a number of structural differences from mature specimens of *M. mogiensis*, particularly in regard to its thelycum (figure 7 B). The thelycal plate has a semicircular shape and is only at slight variance with DE MAN's (1911) figure 22c on Plate 7, but fully comparable with figure 108h of BARNARD (1950). The two median prominences posterior to this plate, however, are much larger than those depicted by BARNARD and form a pair of laminose plates which occupy the whole space between the anterior sternal plate between the 5th pereopods and the anterior  $\frac{1}{4}$  of the thelycal plate. Their inner margins are raised to form a pair of almost adjoining parallel ridges. The sternum between the 2nd pereopods bears a pair of broad but short spinous processes, that between the 3rd 2 bluntly triangular projections.

In view of the fact that this specimen has been retrieved from the stomach of a fish, and additional comparative material is not available, it is thought advisable to include it with *M. mogiensis* till further studies can be carried out.

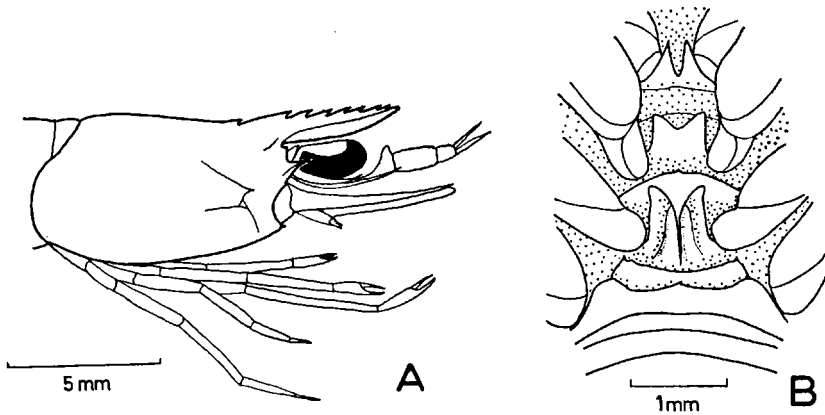


Fig. 7. ?*Metapenaeopsis mogiensis* (Rathbun), ♀, 41 mm, New Britain.  
A, cephalothorax; B, thelycum.

***Metapenaeopsis distincta* (de Man, 1907)**  
(Figure 8 A-C)

*Metapeneus distinctus* de Man, 1907, p. 132.

*Penaeopsis distinctus* de Man, 1911, pp. 69-70.

*Metapenaeopsis distinctus* Dall, 1957, p. 167 (key).

? *Metapenaeopsis* sp. Chace, 1955.

**Material.** NEW BRITAIN: Henry Reid Bay, Wide Bay, coll. C.S.I.R.O., 27.X.1949, 2 ♂♂, 5 ♀♀, 24-31 mm.

**Description.** Rostrum straight and slightly ascending, moderately

wide at base, widest at 2nd tooth, tapering to a sharp apex; reaching tip of 1st antennular segment, armed dorsally with 6-7 teeth + epigastric. Postrostral carina absent; position of epigastric tooth at  $\frac{1}{4}$  carapace, penultimate slightly anterior to frontal margin of carapace. Carapace entirely covered with short but dense tomentum. Orbital spine not more than a sharp angle; orbito-antennal sulcus shallow and rather wide; hepatic spine small, with a feeble cervical and an hepatic sulcus. Antennal spine small without any trace of a carina. Pterygostomial spine small, well above the antero-inferior corner of carapace. Stridulating ridges absent.

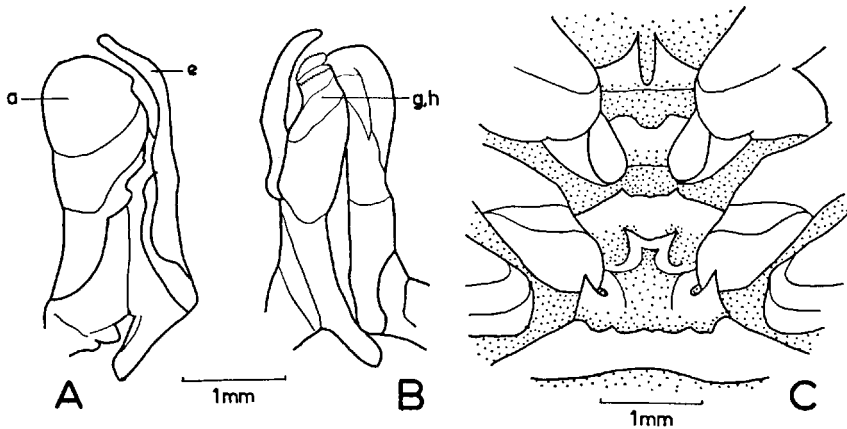


Fig. 8. *Metapenaeopsis distincta* (de Man).

A, ventral view of petasma; B, dorsal view of petasma; C, thelycum (legends as in fig. 1).

Antennules with subequal flagella, lower about  $\frac{1}{2}$  length peduncle. Prosartema slightly shorter than eye, stylocerite reaching tip of 1st antennular segment. Distomedian spine on 1st segment hardly discernible; distolateral spine long, pointing obliquely upwards.

Second abdominal somite with an indication dorsally of a low and flat carina in its posterior  $\frac{1}{2}$ , the 3rd to 6th terga strongly carinated. Carina of 3rd with a distinct but shallow sulcus throughout its length. A distinct tooth on posteromedian margin of 6th somite; depth 6th somite  $\frac{5}{8}$  length. Telson slightly shorter than outer, as long as inner, uropods.

The petasma is shown in figure 8 A, B. Right distoventral projection (a) considerably swollen, club-like, with a small number of apical crenulations; left distoventral projection (e) longer than right, very slender, its tip curved inward. Inner (g) and outer intermediate strip (h) fused; the tip of this structure bears 2 partly fused crenulated flaps.

The thelycum is shown in figure 8 C. Sternum between 2nd pereopods with 2 spinous processes, broad at their base; that of the 3rd with 2 blunt

projections. Thelycal plate (a) semicircular, slightly mucronate in the middle of its anterior margin, with 2 angular projections anterolaterally. Arising from the longitudinally deeply grooved intermediate plate (b), and reaching to the centre of the thelycal plate, are 2 sharp teeth on a longitudinally grooved plate the posterolateral corners of which turn at a sharp angle toward the coxae of the 4th pereopods. The anterior sternal plate (c) between the 5th pereopods bears a conspicuous spine on each of its anterolateral corners, the lateral margins are slightly arcuate.

Distribution. Indonesian waters (DE MAN) to New Britain.

Discussion. The identification of these apparently immature specimens with DE MAN's species must be considered as only a tentative solution. The specimens from New Britain show a close resemblance in general features to *M. mogiensis*, but they also agree, except in some details of the thelycum, with the brief description by DE MAN. The petasma, which is very like that of *M. mogiensis* cannot be compared with DE MAN's species since, so far as the writers know, the male of *M. distincta* has never been described. It also shows a close resemblance to that of *M. sp.* of CHACE (1955). The thelycum is quite different from that of *M. mogiensis*, particularly in the structure and shape of the anterior sternal plate between the 5th pereopods, as well as those of the 2 teeth behind the thelycal plate. From *M. distinctus* de Man, the thelycum merely differs in the absence of the pair of dentiform tubercles posterior to those teeth. However, it is very likely that the pronounced posterolateral angles of the plate, which anteriorly produce the anterior pair of sharp teeth, could become more defined during further growth to produce the dentiform tubercles. The specimens examined are all considerably smaller than those depicted by DE MAN, and their thelyca are not yet fully developed.

Although the identity of the specimens at hand could not yet be fully established the writers consider it advisable to include them with *M. distincta* until additional material becomes available for their revision.

### ***Metapenaeopsis tarawensis* sp. nov.**

(Figure 9 A-D)

Material. GILBERT IS.: Tarawa Group, Nov. 1951, coll. Dr. R. CATALA, holotype ♀, 38 mm, allotype ♂, 30 mm; paratype ♀, 39 mm.

Description. Rostrum straight and distinctly ascending, moderately wide in profile; reaching to tip of basal antennular segment; armed dorsally with 7 teeth + epigastric. Postrostral carina absent in both sexes; position of epigastric tooth at  $\frac{1}{4}$  carapace, penultimate tooth just anterior to frontal margin of carapace. Carapace entirely covered with minute tomentum. Orbital spine not much more than a sharp angle; orbito-antennal sulcus shallow and obscured by tomentum; hepatic spine moderately small with a distinct cervical and hepatic sulcus. Cervical sulcus almost straight, hepatic sulcus horizontal below spine, anteriorly

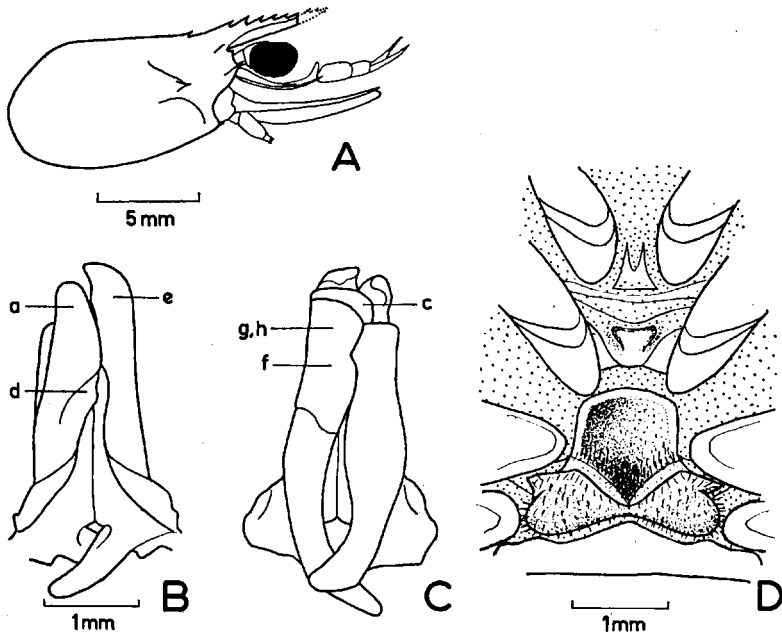


Fig. 9. *Metapenaeopsis tarawensis*, sp. nov.

A, cephalothorax of holotype; B, ventral view of petasma of allotype; C, dorsal view of same; D, thelycum of paratype (legends as in fig. 1).

turning sharply ventrally, about parallel to frontal margin of pterygostomian angle. Antennal spine prominent but not quite reaching cornea, with a pronounced but flat carina. Pterygostomian spine minute but sharp. Stridulating ridges absent.

Antennules with subequal flagella, length of lower  $\frac{1}{4}$  carapace in both sexes. Anteromedian spine of 1st antennular segment vestigial. Prosartema slightly shorter than eye, stylocerite almost reaching tip of basal antennular segment.

First and 2nd abdominal terga not carinated medially, the 3rd bearing a blunt carina in its posterior  $\frac{5}{8}$ , the 4th to 6th sharply carinated; a distinct tooth on posteromedian margin of 6th somite. Length 6th somite 1.9 times depth measured at the posterior edge. Telson slightly shorter than inner uropods, armed with 3 pairs of movable, and 1 minute pair of fixed, spines.

The petasma is shown in figure 9 B, C. Left lobe slightly exceeding right and reaching bases of 2nd pereopods. Right distoventral projection (a) thickened distally and smoothly rounded; left distoventral projection (e) with a bilobed, inward projecting, distal process. Distoventral flap (d) large, its apex spirally truncate; distomedian lobule (c) partly fused with inner and outer intermediate strip, slender, widening toward apex. Inner (g) and outer intermediate strip (h) fused, the combined structure distally bearing a semicircular, crenulated, and dorsally bent plate. Sternum between ♂ 2nd pereopods without spinous processes.

The thelycum is shown in figure 9 D. Sternum of 2nd pereopods with 2 spinous processes arising from a broad base; that of the 3rd with a sunken trapezoidal plate, narrowest posteriorly. Thelycal plate (a) tongue-like, with frontal margin entire, and with smoothly rounded anterolateral corners; anterior and lateral margins slightly raised, a V-shaped depression on posterior margin. The intermediate plate (b), deep in its centre, is partly obscured by the large and laminose anterior sternal plate between the 5th pereopods (c), which produces a pair of high and strongly pubescent lateral protuberances (lateral plates) of sub-rhomboidal shape. The posterior sternal plate between the 5th pereopods cut into a median triangular, and 2 rounded lateral lobes.

Discussion. This species has a superficial resemblance to *M. insona*, but differs from it in details of petasma and thelycum, as well as by a longer 6th abdominal somite. It apparently is closely allied to *M. incompta* Kubo, but can be readily distinguished from that species by the different shape of the thelycal plate and the anterior sternal plate between the 5th pereopods, by the rostrum, and by the abdominal carination. The peculiar shape of the trapezoidal plate between the bases of the 3rd pereopods is incomparable with any other known species of this genus. The absence of a distinct anteromedian spine on the basal antennular segment excludes *M. tarawensis*, the exact habitat of which is not known to the writers, from the deep-water group of *Metapenaeopsis* spp.

***Metapenaeopsis provocatoria* sp. nov.**

(Figure 10 A-D)

Material. QUEENSLAND: NNE off Cape Moreton, 18.XI.1959, coll. "Challenge", trawl No. 31, 80-90 fm, holotype ♀, 56 mm, allotype ♂, 54 mm; paratypes 2 ♂♂, 54, 56 mm, 1 ♀, 48 mm.

Description. Rostrum short, distinctly ascending, moderately wide at base, tapering to a sharp tip; reaching to posterior  $\frac{1}{3}$  of 2nd antennular segment; armed dorsally with 6 teeth+epigastric. Postrostral carina feebly developed, perceptible in anterior  $\frac{1}{2}$  carapace; penultimate tooth well anterior to frontal margin of carapace. Carapace entirely covered with short and sparse tomentum, setae in sulci longer and dense. Orbital spine minute, not much more than a sharp angle; orbito-antennal sulcus ill-defined; hepatic spine small with obscured and short cervical and hepatic sulci. Antennal spine moderately large, with a broad and flattened carina reaching about half the distance to hepatic spine. Pterygostomial spine minute but sharp, slightly inclined anteroventrally. Branchiocardiac carina clearly visible as a faint, moderately broad, sinuous ridge, reaching from posterior end of hepatic sulcus to almost posterior margin of carapace. Branchiocardiac sulcus faintly indicated.

Antennular flagella different in length, and sexually dimorphic; upper flagellum  $\frac{2}{3}$  length of lower which is  $\frac{2}{5}$  carapace in ♀ and just under



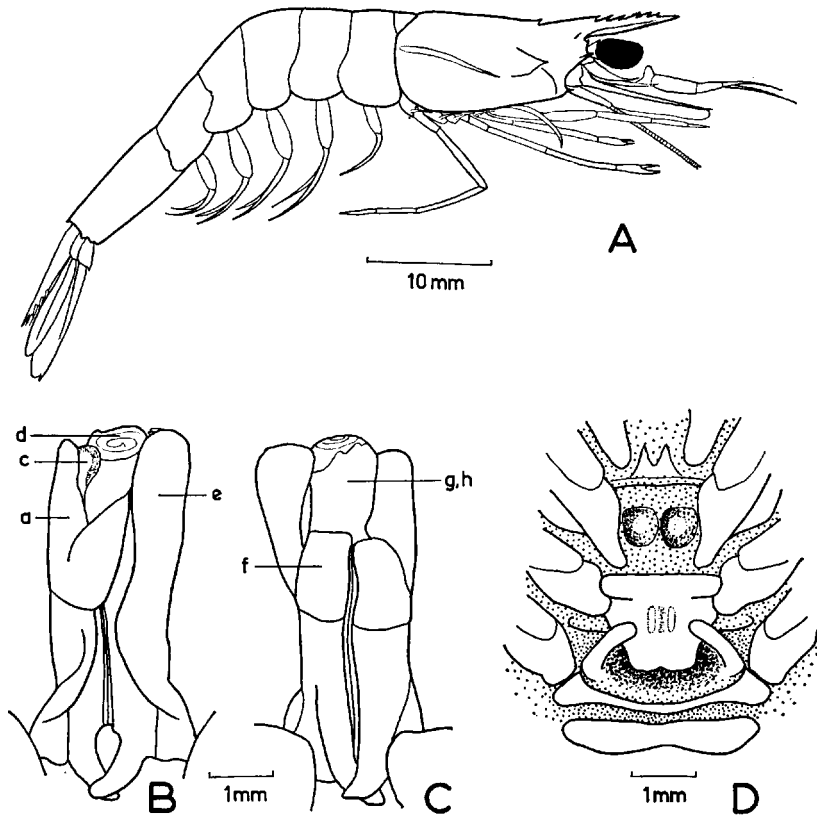


Fig. 10. *Metapenaeopsis provocatoria*, sp. nov.  
A, ♀, 56 mm, holotype; B, ventral view of petasma of allotype; C, dorsal view of same; D, thelycum of holotype (legends as in fig. 1).

$1/2$  carapace in ♂. Inner margin of lower flagellum of ♂ concave, curvature ending anteriorly in blunt conical lateral process. Antennular peduncle is  $8/10$  carapace; anteromedian spine on basal segment long and slender. Prosartema slightly shorter than eye, stylocerite reaching tip of basal antennular segment.

Abdomen well developed and slender; abdominal terga dorsally carinated beginning from 2nd somite; faint carina on 2nd in its anterior  $1/3$ , that on the 3rd well-developed but flattish, the 4th to 6th somites sharply carinated; distinct subcarinae on 4th to 6th only. Length 6th somite almost 3 times depth measured at the posterior edge. Telson shorter than inner uropods; armed with 3 pairs of movable, and a distal pair of fixed, long spines.

The petasma (figure 10 B, C) has subequal lobes, the left slightly surpassing the right. Right distoventral projection (a) distally with irregular minute spinules, extending as far as distoventral flap (d); left distoventral projection distally somewhat wider than right, its apex with a number of irregularly-shaped, inward pointing, minute processes.

Distoventral flap (*d*) ribbon-like and coiled. Left distodorsal lobule (*f*), inner (*g*), and outer intermediate strip (*h*) almost completely fused. Distomedian lobule (*c*) with semicircular, distinctly crenulated apical plate.

The thelycum (figure 10 D) consists of the following structures: sternum between 2nd pereopods with 2 short spinous processes, arising from a broad base; that of the 3rd with 2 circular low bosses. Thelycal plate (*a*) broadly T-shaped, with a cylindrically raised anterior transverse ridge; posterior to this ridge, about midway between it and the base of the T, 2 parallel longitudinal ridges defining a short and flat median sulcus; posterior margin of thelycal plate with a short incision, producing two rounded posterolateral lobes. Sternum posterior to thelycal plate with a deep and wide C-shaped depression, its anterolateral margins conspicuously raised to form 2 arcuate salient ridges, which reach from the bases of the 5th pereopods to the outer margins of the short parallel ridges in the centre of the thelycal plate. Sternal plate between 5th pereopods single, without appreciable projections.

Discussion. *Metapenaeopsis provocatoria* is a member of the closely related *M. coniger* group of species, all of which are in urgent need of a comprehensive revision. HALL (1962) has criticized DALL (1957, p. 168) for relegating the "variety" *M. coniger andamanensis* (Wood-Mason and Alcock, 1901), as well as BATE's (1888) species *M. philippinensis* to a synonym of *M. philippii* (Bate). However, HALL apparently was not aware of the fact that it was CALMAN (1923) who introduced this arrangement of synonyms, a view which was accepted by ANDERSON and LINDNER (1943) and ultimately by DALL (1957).

DE MAN (1911) drew attention to taxonomic difficulties in dealing with species of this group, caused in particular by the absence of a figure of the thelycum of *M. coniger*. The thelycum depicted by KUBO (1949) as that of *M. coniger* differs from the description by ALCOCK (1906) in the presence of a longitudinal groove throughout the posterior projection of the thelycal plate, and seems to belong to a different species. This difference was noted by HALL (1962) who considered KUBO's (1949) *M. coniger* synonymous with *M. andamanensis*.

The present writers have no comparative material at hand, and are therefore not in a position to contribute to the revision of this group as a whole. The petasmata of all species of this group are indeed intimately related, and superficially seem even alike. However, petasmas were rarely discussed by previous authors, and detailed comparative studies might yet reveal conspicuous differences. The peculiar shape of the left distoventral projection in BATE's (1888) figure 3", plate 35, for *M. philippinensis* is obviously a misrepresentation by the artist, and most probably refers to the coiled structure of the distoventral flap (*d*).

At present the various "species" are merely differentiated by the structure of the thelycum, as well as the length and shape of rostrum and antennular flagella. Using these criteria, HALL (1962) has raised *M. anda-*

*manensis* to specific rank, at the same time separating it from *M. philippinensis* Bate. However, if speciation trends are perceptible, as HALL has demonstrated, between the Indian species *M. coniger*, and that from the Andaman Sea known as *M. andamanensis*, it can be reasonably assumed that speciation could also have taken place in such distant regions as the Philippines, Japan, and Australia. The question remains whether to consider obvious differences as of specific or subspecific nature, a problem which can only be solved by a future comprehensive revision of all "forms" of this group.

Pending such a revision, *M. provocatoria* is here described as a full species in order to record a number of obvious differences from all hitherto known members of this group. Its short and distinctly ascending rostrum cannot be compared with that of any other species recorded. Its comparatively short antennulae are similar in length only to *M. philippinensis* (Bate), from which however the thelycum differs in the absence of a distinct and complete median sulcus, as well as in the shape of the posterolateral salient ridges. The thelycal plates of the specimens available to us are similar to that figured by HALL (1962) for *M. andamanensis*, except in the presence of the median pair of short ridges, but the thelycum can be readily distinguished from that of HALL's specimen by the different shape and position of the posterolateral salient ridges. Rostrum and antennules are furthermore much longer in *M. andamanensis*, and the sinuous branchiocardiac carina appears absent in HALL's figure of this species.

### Genus *Parapenaeus* Smith

*Parapenaeus* Smith, 1885, p. 170. De Man, 1911, pp. 77-79. Kubo, 1949, pp. 308-09. Barnard, 1950, pp. 600-01. Dall, 1957, p. 178. Hall, 1962, p. 30.

Type-species by original designation: *Penaeus longirostris* Lucas, 1846.

The above references provide adequate information on the generic definition of *Parapenaeus*. For the differentiation of the species of this genus, the reader is particularly referred to the key to all species by DALL (1957), as well as to the description of an additional species by HALL (1962).

During the present investigations only the following 3 species were found to occupy the general region studied: *P. australiensis* Dall, *P. longipes* Alcock, and *P. fissurus* (Bate).

### *Parapenaeus australiensis* Dall, 1957

(Plate 5 fig. 4; Plate 10 fig. 5)

*Parapenaeus australiensis* Dall, 1957, pp. 179-81. Racek, 1959, p. 10.

Material. 58 ♂♂, 69 ♀♀, 57-146 mm; NEW SOUTH WALES: Stockton Bight, N.E. off Sydney, S.E. off Nowra, E. off Twofold Bay; QUEENSLAND: off Cape Moreton, off Heron I., 55-90 fm, soft mud.

Colour in life. Rosy pink to light orange, thoracic and abdominal carinae dark red, body with orange-red irregular stripes and blotches; antennae, antennulae, and antennal scale bright red; posterior half of uropods and telson vermilion; peduncles of pleopods bluish white, uropods with longitudinal lines of the same colour.

Distribution. Abundantly present in deeper waters off central New South Wales, ranging from the Victorian border to southern Queensland, northern range not yet fully established.

Discussion. Although erected on merely 4 specimens in the collection of the Australian Museum, Sydney, *P. australiensis* has been adequately described and figured by DALL (1957). Shortly after its description large populations of this species were located on various deep-water grounds off central New South Wales, and since 1960 captured in commercial quantities in the vicinity of Newcastle.

Apart from the numerous specimens collected for this study, several hundreds of freshly trawled specimens were used for detailed morphometric studies in the field. Coloration and colour patterns in life, sex ratio, as well as diurnal and seasonal behaviour of populations of this abundant species could thus be recorded.

Unlike most of its congeners, *P. australiensis* does not occur beyond the 90 fm line but its populations are largest at an average depth of about 65 fm. The preference for moderate depths, which this species appears to share with *P. longipes*, can possibly be linked with the light coloration of both these species, which is in contrast to the deep red colour of other species of this genus.

The northern zoogeographic boundary cannot be fully established as yet, but single specimens have been taken during the "Challenge" survey off Cape Moreton and Heron I. respectively. It is possible that *P. australiensis* ranges further north along the outer fringe of the Great Barrier Reef from where data and material are still lacking.

The thelycum and petasma of mature specimens have been photographed to facilitate comparison with other species.

### **Parapenaeus longipes (Alcock, 1905)**

(Plate 5 fig. 5; Plate 10 fig. 6)

*Parapenaeus longipes* Alcock, 1905, p. 525; 1906, p. 33.

*Parapenaeus longipes* de Man, 1911, pp. 81-82. Kubo, 1949, p. 400 (key); 1951, pp. 259-63. Dall, 1957, p. 179 (key).

Material. NEW GUINEA: Yule I., October 1962, coll. L. W. FILEWOOD, 1 ♂, 6 ♀♀, 46-58 mm; TANGANYIKA: Mafia Archipelago, outflow of Rufiji R., 6.XI.1960, coll. Dr. A. J. BRUCE, 20 fm, 1 ♂, 50 mm, 1 ♀, 61 mm.

Distribution. East Africa through Indian and Indonesian waters to New Guinea and Japan.

Discussion. The specimens from New Guinea are fully comparable with the ♂ and ♀ from the Mafia Archipelago, and both lots agree in all

major details with the original description and illustrations by ALCOCK (1906). However, in view of ALCOCK's somewhat brief description a number of additional criteria are listed hereunder. The rostrum reaches almost to the tip of the basal antennular segment and is slightly curved downward; armed with 5-6, usually 6 teeth+epigastric, the foremost tooth being very small. Postrostral carina distinct, reaching almost to posterior margin of carapace. Antennular flagella unequal, and of different proportions in both sexes; upper flagellum about  $\frac{8}{10}$  lower which is 1.1 length peduncle in ♀ and 1.5 length peduncle in ♂. Third abdominal somite with an inconspicuous and flat carina, 4th sharply carinated in its posterior  $\frac{8}{10}$ , 5th and 6th throughout their length; a distinct tooth on the posteromedian margin of 4th to 6th somites. Sixth abdominal somite about twice as long as wide at its posterior end. Telson, with a pair of long spines, and as much shorter than the inner uropods as these are shorter than the outer. The petasma and the thelycum of specimens available are shown on Plate 5 fig. 5, and Plate 10 fig. 6 respectively.

The specimens from New Guinea represent the first record of this species from Australian or New Guinea waters. In the absence of detailed trawling records no conclusions can be made as to their optimal habitat in the New Guinea region. Most of the previously recorded specimens, however, were taken in depths similar to those inhabited by *P. australiensis*, and *P. longipes* can thus also be considered a deep-water species of the outer littoral area.

The close similarity of all distinguishing criteria of the specimens from New Guinea to those of the African material examined indicates that *P. longipes* possesses constant structural features throughout its presently recognised geographic range.

***Parapenaeus fissurus* (Bate, 1888)**  
(Plate 10 fig. 7)

*Penaeus fissurus* Bate, 1888, p. 263-66.

*Parapenaeus fissurus* Alcock, 1905, p. 520; 1906, pp. 31-32.

*Parapenaeus fissurus* de Man, 1911, pp. 79-80; 1922, p. 9. Balss, 1914, pp. 10-11; 1925, p. 44. Stebbing, 1914, pp. 19-20. Kubo, 1949, pp. 400-03. Barnard, 1950, pp. 601-02. Dall, 1957, p. 179 (key). Hall, 1962, p. 30.

Material. South China Sea, 4° 44' N., 113° 23' E., 60 miles off Sarawak, coll. I. BENNETT, "Te Vega", beam trawl, 6.X.1963, 100 m; 4 ♀♀, 41-44 mm.

Colour in life. Salmon red (BARNARD).

Distribution. East Africa (BARNARD), Indian Seas (ALCOCK), Malaysia (HALL), Indonesian waters (DE MAN), Philippines (BATE), to Japan (KUBO).

Discussion. The "Te Vega" specimens are immature but agree in all major details with the descriptions by BATE (1888), ALCOCK (1906), and DE MAN (1911, 1922). HALL (1962) found the petasmata of his Malaysian specimens fully comparable with those described and figured by KUBO (1949), but considered the thelyca of his material to differ

slightly from previous descriptions. The posterolateral tubercles of the thelyca of the specimens available do not show the "angularly emarginate" condition of those of HALL's material, but have the same rounded shape as recorded by BATE and ALCOCK. Additional collections of mature specimens of this and allied species are highly desirable in order to elucidate possible speciation trends in distant populations, and locate females of the closely related species *P. lanceolatus* Kubo.

### Genus *Metapenaeus* Wood-Mason & Alcock

*Metapenaeus* Wood-Mason and Alcock, 1891, p. 271. Burkenroad, 1934b, p. 4, 29. Kubo, 1949, pp. 327-28. Barnard, 1950, pp. 596-97. Liu, 1955, p. 12. Dall, 1957, pp. 182-83.

*Metapeneus* Alcock, 1906 (part), p. 16.

*Penaeopsis* de Man, 1911 (part), pp. 53-55, 61. Schmitt, 1926 (part), pp. 319-23.

Type-species by original designation: *Penaeus affinis* H. Milne Edwards, 1837.

The status of this genus has recently become the subject of controversial views due to two independent developments. HALL (1958, 1962), commenting on his re-examinations of type material deposited by H. MILNE EDWARDS in the Muséum National d'Histoire Naturelle in Paris, came to the conclusion that the type specimen of *Penaeus affinis* did not belong to the species *Metapenaeus affinis* Auctorum, but was actually a specimen of the species now known as *Parapenaeopsis sculptilis* (Heller). HALL, prior to 1962, was apparently not aware of the taxonomic consequences of his opinion, which, had his view been correct, would have necessitated the use of the generic name *Metapenaeus* for those species at present known as *Parapenaeopsis*, and left all the species known as *Metapenaeus* without a generic name. HOLTHUIS (1962), in his desire to safeguard the continuity of well-established generic names, submitted a recommendation to the International Commission on Zoological Nomenclature asking for the retention of the name *Metapenaeus* for all the species hitherto known under this generic name, as well as for the designation of a new type species, *Penaeus monoceros* Fabricius, 1798. BURKENROAD (1963a, and personal communication) opposed HOLTHUIS' recommendation on the grounds of the invalidity of HALL's (1958) neotype of *P. monoceros*, and pointed to the fact that the Fabrician species is not even generically determinable from the original description. BURKENROAD furthermore made it clear that the specimen considered by HALL (1962) to be the type of MILNE EDWARDS' *P. affinis* could not possibly belong to the type lot, and that HALL had apparently overlooked the actual type specimens of this species. In his reply to BURKENROAD's objections HOLTHUIS (1963) agreed that in view of the evidence submitted there was no need for the designation of a new type species for the genus *Metapenaeus*, since its true type, *Penaeus affinis*, at present is treated as belonging to that genus.

One of the controversies concerning the genus *Metapenaeus* was thus eliminated, but the other is not yet settled. BURKENROAD (1963b, and personal communication) pointed out that, regardless of the agreement on the validity of MILNE EDWARDS' type specimen of *P. affinis*, the generic name *Mangalura* Miers, 1878, has priority over *Metapenaeus* Wood-Mason and Alcock, 1891, and should therefore be used instead of the latter. HOLTHUIS (1962) demonstrated that the introduction of the unfamiliar generic name *Mangalura* would cause inavoidable and unnecessary confusion, and recommended its suppression under the plenary powers of the Commission. From BURKENROAD's (1963b, p. 170) remarks it appears likely that that author now intends to use the taxon *Mangalura* in a subgeneric sense for a group of species closely related to *Metapenaeus dobsoni*.

Apart from the fact that the generic name *Mangalura*, as proposed by MIERS (1878), would certainly have priority over *Metapenaeus* if the International Code were strictly applied, its use instead of *Metapenaeus* is open to some criticism. MIERS intended to separate the species *Penaeus dobsoni* mainly in view of the "rudimentary and indurated condition" of the 5th pereopods in females of this species. On p. 303 he wrote "Should further researches, however, prove that the rudimentary condition of the 5th legs exists in both sexes, the name *Mangalura* may be adopted to designate the genus which will be characterised not only by the above-mentioned character, but also by the triangular shape of the terminal joint of the mandibular palpus . . . . . and the slender outer maxillipeds. The species will then stand as *Mangalura dobsoni*". From examination of the literature, as well as from our own observations, it appears that the rudimentary condition of the 5th, and often also 4th, pereopods is restricted to females, and most probably is the result of an injury caused by the strong basal spine on the 3rd pereopods of the male during copulation. Moreover, this stumpy condition of the last one or two pairs of pereopods has not yet been observed in any other closely related species of this group. These species apparently will be grouped into a subgenus *Mangalura* in a forthcoming paper by BURKENROAD (personal communication). Pending BURKENROAD's revision of the genus *Metapenaeus*, as well as the final decision by the International Commission on Zoological Nomenclature, the present writers are treating the specimens of their collection as belonging to the genus *Metapenaeus* as redefined by BURKENROAD (1934b) and used by a number of subsequent authors.

DALL (1957) presented a comprehensive key to 16 species of *Metapenaeus*, considering material and data then available to him. This key has become inadequate by subsequent investigations, including the present study, which have raised the number of determinable species to 22. Of these, 12 previously recorded and 5 new species were found to occur in the general region studied. The following revised key refers to adult criteria

only, and differs from previous keys in the disregard of body pubescence, and the presence or absence of an ischial spine on the 1st pereopod, as *general* distinguishing criteria. Although this arrangement offers a clearer picture of the relationship of some species, the key does not represent an intentional grouping of all *Metapenaeus* spp. Intraspecific categories are not keyed out.

### KEY TO THE SPECIES OF *Metapenaeus*

1. Telson armed with 3 or 4 pairs of conspicuous mobile spines . . . . . 2  
Telson armed with a single row of very minute mobile spinules, with or without 1-2 pairs of somewhat larger distal spines . . . . . 4
- 2 (1). Three pairs of subequal telsonic spines; rostrum straight, teeth extending to its apex . . . . . 3  
Four pairs of telsonic spines, progressively increasing in size posteriorad; rostrum sigmoidal, anterior  $\frac{1}{2}$  edentate, styliform . . . . .  
. . . . . *M. macleayi* (Haswell)
- 3 (2). Branchial region with small pubescent areas; coxal projection of ♀ 4th pereopod long and curved, dagger-like; thelycum with rounded median boss posterior to lateral plates; distomedian petasmas projections without an anterolateral spinous process . . . . .  
. . . . . *M. intermedius* (Kishinouye)  
Branchial region with 2 large pubescent areas; coxal projection of ♀ 4th pereopod a straight conical spine; thelycum without a rounded boss posterior to lateral plates; distomedian petasmas projections with a distinct anterolateral spinous process. *M. endeavouri* (Schmitt)
- 4 (1). Distomedian petasma projection with fully developed or vestigial apical filament; thelycum of impregnated females usually with white conjoined pads . . . . . 5  
Distomedian petasma projection without apical filament; thelycum of impregnated females without white conjoined pads . . . . . 9
- 5 (4). Rostrum wide and short, not reaching to distal end of basal antennular segment; thelycum with ovoid anterior and lateral plates of subequal size; conjoined pads usually set askew; apical filaments of petasma vestigial, represented by a pair of rounded bosses . . . . .  
. . . . . *M. lysianassa* (de Man)  
Rostrum projecting beyond basal antennular segment, with a marked edentate distal portion . . . . . 6
- 6 (5). Posterior part of rostrum with distinctly elevated crest; basal spine on ♂ 3rd pereopod simple . . . . . 7  
Posterior part of rostrum without distinctly elevated crest; basal spine on ♂ 3rd pereopod long and barbed . . . . . 8
- 7 (6). Ischial spine on 1st pereopod subequal to basal spine; telson usually with 1 distal pair of slightly larger spinules; distolateral petasma projections directed outwards; apical filaments of distomedian projections slender, slightly converging; thelycum with a large anterior, and small lateral plates . . . . . *M. brevicornis* (Milne Edwards)  
Ischial spine on 1st pereopod much smaller than basal spine; telson usually with 2 distal pairs of slightly larger spinules; distolateral petasma projections pointing anteriorad; apical filaments of distomedian projections lobe-like; thelycum with a small anterior, and very large lateral plates . . . . . *M. tenuipes* Kubo (= *M. spinulatus* Kubo)



- 8 (6). Apical petasmas filaments not readily visible; anterior thelycal plate tongue-like . . . . . *M. dobsoni* (Miers)  
Apical petasmas filaments large and lobe-like, curved dorsally; anterior thelycal plate styliform . . . . . *M. joyneri* (Miers)
- 9 (4). Branchiocardiac sulcus distinct in at least posterior  $\frac{1}{3}$  carapace; distomedian petasmas projections flap-like . . . . . 10  
Branchiocardiac sulcus almost completely absent; distomedian petasmas projections anteriorly filiform, each with a serrate ventral margin . . . . . *M. stebbingi* (Nobili)
- 10 (9). Ischial spine on 1st pereopod distinct . . . . . 11  
Ischial spine on 1st pereopod small or absent . . . . . 13
- 11 (10). Ischial spine subequal to basial spine; petasmas apices turned at 30° towards midline, semicircular; anterior thelycal plate spoon-like; lateral plates with raised ventral ridges, each with anterolateral and posteromedian spinous process . . . . . *M. suluensis* sp. nov.  
Ischial spine much smaller than basial spine; anterior thelycal plate tongue-like . . . . . 12
- 12 (11). Distomedian petasmas projections directed anteriorad; lateral thelycal plates with raised lateral ridges, each with a posterior inwardly-curved triangular plate; occurrence east of Malacca Strait . . . . .  
*M. ensis* (de Haan) (= *M. mastersii* (Haswell); = *M. incisipes* (Bate))  
Distomedian petasmas projections directed anterolaterally; lateral thelycal plates with salient and parallel lateral ridges only; occurrence west of Malacca Strait . . . . . *M. monoceros* (Fabricius)
- 13 (10). Ischial spine minute and blunt . . . . . 14  
Ischial spine absent . . . . . 17
- 14 (13). Rostral teeth more or less evenly spaced; thelycal structure posteriorly open . . . . . 15  
Rostral teeth unevenly spaced, anterior 2 teeth separated from each other and from the rostral apex by a much wider space; thelycal structure posteriorly closed . . . . . *M. demani* (Roux)
- 15 (14). Distomedian petasmas projections not superficially separated into 2 lobes, almost completely overlying distolateral projections; lateral thelycal plates kidney-shaped, with strongly raised ventrolateral ridges . . . . . *M. conjunctus* sp. nov.  
Distomedian petasmas projections more or less superficially separated into 2 lobes, not overlying distolateral projections; lateral thelycal plates ear-shaped, with salient lateral ridges . . . . . 16
- 16 (15). Distomedian petasmas projections directed anteriorad, parallel, longitudinal sulcus ill-defined; posterior end of salient ridges on lateral thelycal plates curved outwards; spine on merus of ♂ 5th pereopod slightly bent inwards . . . . . *M. papuensis* sp. nov.  
Distomedian petasmas projections directed anterolaterally, diverging, longitudinal sulcus distinct; posterior end of salient ridges on lateral thelycal plates curved inwards; spine on merus of ♂ 5th pereopod slightly bent outwards. . . . .  
. . . . . *M. elegans* (de Man) (= *M. singaporensis* Hall)
- 17 (13). Rostrum with a marked edentate distal portion; anterior thelycal plate bluntly pointed, lateral plates large, separated by a narrow fissure . . . . . *M. eboracensis* Dall  
Rostrum without edentate distal portion . . . . . 18
- 18 (17). Branchiocardiac carina distinct, extending from posterior margin of carapace almost to hepatic spine; anterior thelycal plate longitudinally grooved, wider posteriorly than anteriorly; distomedian petasmas

- projections crescent-shaped . . . . . *M. affinis* (Milne Edwards)  
 . . . . . (= *M. mutatus* (Lanchester); = *M. necopinans* Hall)  
 Branchiocardiac carina feeble or ill-defined, anterior end not exceeding  
 posterior  $\frac{1}{3}$  of carapace . . . . . 19
- 19 (18). Anterior thelycal plate tongue-like, with a pair of anterolateral  
 rounded tubercles; lateral plates with a characteristic patch of dense  
 setae; distomedian petasmas projections strongly diverging, each  
 forming a broad outwardly-curved tooth . . . *M. insolitus* sp. nov.  
 Anterior thelycal plate flask-shaped, with a longitudinal median ridge;  
 distomedian petasmas projections finger-shaped . . . . . 20
- 20 (19). Anterior margin of anterior thelycal plate with 3 tubercles . . . . 21  
 Anterior margin of anterior thelycal plate with 2 fang-like teeth and  
 a median indistinct tubercle; petasma with slightly diverging tubular  
 distomedian projections . . . . . *M. dalli* Racek
- 21 (20). Median tubercle more prominent than lateral ones; distal margin of  
 anterior thelycal plate distinctly triangular; petasma with almost  
 parallel tubular distomedian projections, their distal  $\frac{1}{2}$  twisted  
 dorsoventrally . . . . . *M. bennettiae* sp. nov.  
 All tubercles of equal size; distal margin of anterior thelycal plate  
 convex to indistinctly triangular; petasma with laminae and strongly  
 diverging distomedian projections . . . . . *M. burkenroadi* Kubo

### **Metapenaeus ensis** (de Haan, 1850)

(Plate 2 fig. 4; Plate 3 figs. 1, 2)

*Penaeus monoceros ensis* de Haan, 1850, p. 192.

*Penaeus monoceros* Haswell, 1882, p. 200.

*Penaeus mastersii* Haswell, 1879, p. 42; 1882, p. 203.

*Penaeus incisipes* Bate, 1888, pp. 257–58 (not including female). Kishinouye, 1900, pp. 18–19. Blanco and Arriola, 1937, p. 223.

*Penaeopsis monoceros* de Man, 1911, pp. 55–57. Schmitt, 1926, pp. 325–29 (including part of "*Penaeus Mastersii*").

*Metapenaeus incisipes* Alcock, 1906, p. 51.

*Metapenaeus monoceros* Kubo, 1949, pp. 329–33 (part synonymy only). Hall, 1956, pp. 77–78 (not including fig. 11). Dall, 1957, pp. 184–87 (part synonymy only, not structure of spine on ischium of ♂ 5th pereopod).

*Metapenaeus incisipes* Racek, 1955, pp. 230–32; 1959, p. 10.

*Metapenaeus ensis* Hall, 1958, pp. 537–44; 1962, pp. 22–23. Cheung, 1960, pp. 66, 68.

(Non *Metapenaeus mastersii* Racek, 1955, 1957, 1959; Dall, 1956, 1957, 1958; Hall, 1962).

**Material.** Numerous specimens of both sexes 29–159 mm; WESTERN AUSTRALIA: Shark Bay, Exmouth Gulf; NORTHERN TERRITORY: Arnhem Bay, Chambers Bay, 50 miles W.N.W. off Darwin; QUEENSLAND: Gulf of Carpentaria, Princess Charlotte Bay, Townsville, Mackay, Keppel Bay, Moreton Bay; NEW SOUTH WALES: Tweed Heads, Ballina, Yamba, Forster, Stockton Bight, Wollongong, Nowra; NEW GUINEA: Kinikini Bay, Yule I., Orangerie Bay, Daru I.; NORTH BORNEO: Sandakan Harbour, Labuan; PHILIPPINES: St. Miguel Bay; INDONESIA: Java, East Borneo (Kalimantan), Halmahera I.; comparative material from Japanese waters, donated by Dr. I. KUBO. Depth of occurrence 10–35 fm.

**Distribution.** From Malacca Strait through Indonesian waters to New Guinea, ranging north along S.E. China to Japan, and south to Western Australia, the Northern Territory, Queensland, and most of New South Wales.

**Discussion.** This species has been adequately described by KUBO (1949) and DALL (1957) under the name *M. monoceros* Fabricius, as well as by KISHINOUE (1900) and RACEK (1955) as *M. incisipes* Bate. HALL (1958), in discussing structural and zoogeographic differences between this species and *M. monoceros* Auctorum from the Indo-African region, suggested the restoration of DE HAAN's (1850) specific name "*ensis*" from *Penaeus monoceros ensis* for the species later described by BATE (1888) as *Penaeus incisipes*. The curious fact that DE HAAN's type specimen in the Leiden Museum is a composite specimen, having the cephalothorax of *Metapenaeus incisipes* (Bate) and an erroneously attached abdomen of *Metapenaeopsis barbata* (de Haan) (fide HALL, 1958), was first noticed by BURKENROAD during his examination of the type specimen in 1938. Although the latter author apparently still considers DE HAAN's type of *M. ensis* indeterminable (personal communication), the present studies were able to demonstrate beyond doubt that the thelycum of DE HAAN's type is that of *M. incisipes* (Bate), and not that of any other closely related species from the vicinity of its type locality. The argument remains, whether DE HAAN's description of 3 minute lateral telsonic spines referred to the present abdomen of a *Metapenaeopsis* sp., or to the original abdomen of the type specimen, as HALL tried to demonstrate. Taxonomically, this must be considered irrelevant since the cephalothorax of the type specimen is clearly determinable. The authors are therefore now in a position to endorse HALL's (1958) views of the identity of the cephalothorax of DE HAAN's type specimen, and relegate the well-described species *M. incisipes* (Bate) to the synonymy of *M. ensis* (de Haan). The cephalothorax of the composite type specimen of *Penaeus monoceros ensis* de Haan, deposited in the Leiden Museum, is herewith selected as the lectotype of *Metapenaeus ensis* (de Haan). Two photographs of this cephalothorax, obtained through the kindness of Dr. L. B. HOLTHUIS in 1955, are shown on Plate 3 figs. 1, 2.

The extensive collections of juvenile specimens of *M. ensis* available for the present study have solved the hitherto problematic identity of *Penaeus mastersii* Haswell (1879, 1882). In view of the previous almost complete absence of collections from Australia's north and northwest, RACEK (1955), after an examination of the only syntype in the Macleay Museum, used HASWELL's apparently available name for an eastern Australian species, closely related to *M. burkenroadi* Kubo. DALL (1957), although following RACEK in the use of HASWELL's name for the same species from eastern Australia, already had sufficient material and data available to realise the paucity of specimens of his and RACEK's *M. mastersii* in northern Queensland waters. The present investigations

have convincingly shown that the species recently called *M. mastersii* suddenly becomes less common north of Bowen, and is completely absent in waters north and west of Cape York. Since HASWELL's syntype came from Port Darwin, Northern Territory, it thus became obvious that, unless the type locality was incorrect, this apparently endemic eastern Australian species could not possibly be identified as *Penaeus mastersii*. A re-examination of HASWELL's syntype of *P. mastersii* (the only original type ever deposited) is now impossible, since an extensive search by the authors in the Macleay Museum, at the University of Sydney, failed to reveal its present whereabouts, and it must now be considered as lost. It was last seen in 1953 when it was examined by RACEK in connection with his 1955 revision, but could not be relocated in 1954 for examination by DALL (1957, p. 192).

A large collection of juveniles of the 6 species of *Metapenaeus* from the Darwin area was therefore morphometrically examined, and compared with HASWELL's descriptions and SCHMITT's (1926) illustration of the Macleay Museum "cotype". These detailed studies revealed beyond doubt that all the juvenile specimens of *M. ensis*, which are extremely common along Australia's northern coast-line, agree in all details with the descriptions and illustration of the now lost syntype. One of these specimens, a male of almost exact body length (72 mm) as the lost syntype (71 mm to broken tip of rostrum, fide SCHMITT, 1926) has been selected as the neotype of *Penaeus mastersii* Haswell (Australian Museum Reg. No. P 14394; 50 miles W.N.W. of Darwin, coll. V. WELLS ("Paxie"), sand, 18 fm, 5.X.1961). The pubescence in this neotype, as well as in all other juveniles of *M. ensis* examined, is scarce and restricted to the dorsum and last abdominal pleura; the petasmas are undeveloped, separate, and simple; there is a faint notch and tubercle on the merus of the 5th pereopod; the branchiocardiac carina is identical with that shown by SCHMITT (1926), not yet fully developed but reaching almost to the extension of the hepatic spine; the branchiocardiac sulcus is deep as shown by SCHMITT, and as stated by HASWELL; abdominal carination begins from the anterior margin of the 4th somite; the rostrum is slightly upturned and armed with 9 teeth + an epigastric.

The material from which the neotype was selected has also been compared with a wide range of juveniles of *M. ensis* from the north-eastern coast of Queensland, as well as from the Philippines. None of the males examined had joined petasmas below an average body length of 80 mm, and they are fully comparable with HASWELL's original syntype. HASWELL's reference to the length of the type ( $3\frac{3}{4}$  inches) is obviously a printing error; a length of  $2\frac{3}{4}$  inches would correspond almost exactly with the length of the syntype, given by SCHMITT as 71 mm.

Of the other 5 species of *Metapenaeus*, present in the Darwin area, *M. endeavouri* (Schmitt) and *M. eboracensis* Dall cannot possibly be mistaken for *P. mastersii*, the former having conspicuous telsonic spines,

and the latter an anteriorly edentate rostrum. *M. dalli* Racek is a small species, and males of this species have fully joined petasmas with a total length of 46–48 mm, the branchiocardiac carina is ill-defined, and the branchiocardiac sulcus short, shallow, and inconspicuous. *M. burkenroadi* Kubo, which is rare in the Darwin area, can also be eliminated on similar evidence; a number of males of the length range 49–62 mm not only have fully joined, but specifically recognizable, petasmas. *M. insolitus* sp. nov., which will be described below, can easily be distinguished from HASWELL's syntype of *P. mastersii* by many features; moreover, males of this new species have joined petasmas with a total length of 45 mm, and specifically determinable petasmas with a total length of 58 mm,

The identity of *P. mastersii* has thus been satisfactorily established, and HASWELL's name must now be relegated to a synonym of *M. ensis*, as SCHMITT (1926) suggested. This arrangement, however, leaves the eastern Australian species, referred to by RACEK (1955, 1957, 1959) and DALL (1957, 1958) as *Metapenaeus mastersii*, without a name, and it will therefore be redescribed below as *Metapenaeus bennettiae* sp. nov.

The eastern zoogeographic boundary of the Indo-African species *M. monoceros* Auctorum was first suggested by BURKENROAD (MORRIS and BENNETT, 1952) as India, and HOLTHUIS and GOTTLIEB (1958) endorsed this view. HALL (1958) has specified BURKENROAD's opinion by stating that the Malacca Strait could well be the exact dividing line separating the true *M. monoceros* from its eastern congener *M. ensis*. However, although the eastern boundary of *M. monoceros* appears thus established, future zoogeographic and ecological investigations are highly desirable to determine the correct distribution of *M. ensis*, which in the past could have been confused with 2 additional species recently found, i.e. *M. suluensis* sp. nov., and *M. conjunctus* sp. nov., as well as with HALL's (1962) "variety" *M. ensis baramensis*, based on a solitary female specimen.

***Metapenaeus suluensis* sp. nov.**

(Figure 11 A, B; Plate 5 figs. 6, 7; Plate 10 fig. 8)

Material. Sulu Sea, Philippines, July 1959, coll. K. HILL, 20 fm, mud bottom, holotype ♂, 99 mm, allotype ♀, 120 mm, paratypes ♂ 72 mm, ♀ 109 mm.

Description. Body almost completely glabrous in ♂, pubescence in adult ♀ restricted to dorsum of anterior  $1\frac{1}{2}$  carapace, on abdomen present on pleura of the 4th, 5th, and 6th somites as small oblique setose patches. Rostrum slightly ascending in mature ♀, its tip somewhat upturned, moderately wide in profile, almost reaching to tip of antennular peduncle, armed with 7 teeth + epigastric; in ♂ low and straight, narrow in profile, slightly surpassing tip of 2nd antennular segment, armed with 6–7 teeth + epigastric. Adrostral carina ending between epigastric and penultimate

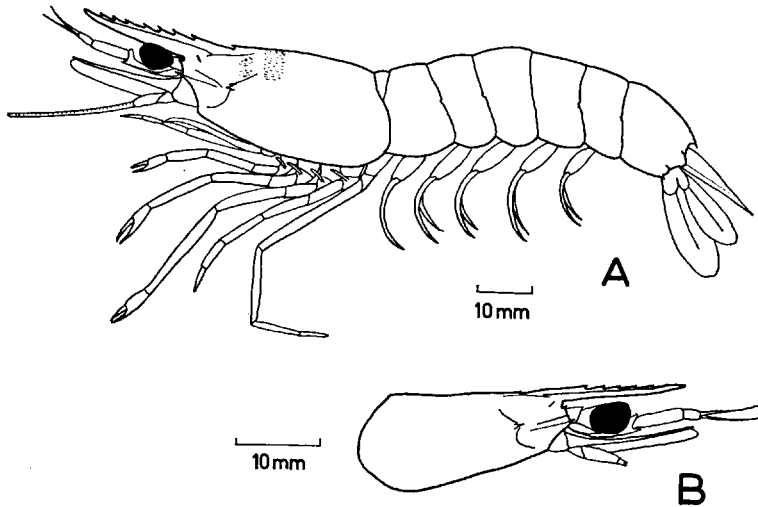


Fig. 11. *Metapenaeus suluensis*, sp. nov.  
A, ♀, 120 mm, allotype; B, cephalothorax of ♂, 99 mm, holotype.

tooth, adrostral sulcus extending well behind epigastric tooth. Postrostral carina broad and low, posterior  $\frac{1}{4}$  indistinct, ending  $\frac{1}{10}$  length of carapace from its posterior margin. Epigastric and penultimate tooth on carapace, former at a little over  $\frac{1}{3}$  carapace. Gastrofrontal sulcus indistinct and wide, postocular sulcus at an angle of about  $40^\circ$  to rostrum, and deep. Orbits-antennal sulcus wide but distinct, ending in front of hepatic spine. Antennal carina ending  $\frac{1}{5}$  distance between antennal and hepatic spines. Cervical sulcus straight, ending at not quite  $\frac{1}{2}$  carapace. Hepatic sulcus descending vertically in its posterior part, turning towards pterygostomial angle anteriorly. Branchiocardiac carina distinct, almost meeting posterior extension of hepatic spine, not quite extending to posterior margin of carapace; branchiocardiac sulcus wide and distinct, barely setose in ♀, fully glabrous in ♂.

Antennules with subequal flagella which are  $\frac{2}{3}$  length of peduncle in ♂,  $\frac{1}{3}$  length of peduncle in ♀. Prosartema almost reaching tip of basal segment, stylocerite attaining  $\frac{1}{2}$  basal segment.

Third maxilliped and 1st pereopod reaching  $\frac{1}{2}$  carapocerite; 2nd pereopod surpassing tip of 1st antennular segment by dactyl, 3rd attaining tip of antennular peduncle; 4th surpassing tip of carapocerite by dactyl; 5th slightly surpassing base of 2nd antennular segment. A sharp ischial spine on 1st pereopod, only slightly smaller than basal spine. Distoventral keel on ischium of ♂ 5th pereopod triangular, notch on merus proximally bounded by a triangular prominent spine pointing ventrally at angle  $50^\circ$  to axis of merus, and inward at angle  $45^\circ$ ; further distally a ventral row of 8-9 conical tubercles which end in a small keel at distal  $\frac{1}{4}$  merus.

Abdominal somites 1 to 3 without a dorsal carina; 4th with a carina in its posterior  $\frac{2}{3}$ , 5th and 6th strongly carinated, carina of 6th posteriorly

ending in a sharp tooth. Telson somewhat shorter than inner uropods, its lateral margins armed with a single row of minute spinules.

The petasma of the holotype is shown in Plate 5 figs. 6, 7. Distomedian projections  $\frac{1}{5}$  total length of petasma, overlying distolateral projections, with openings facing dorsally; apices turned at about  $30^\circ$  towards the midline, semicircular, their anterior margins strongly crenulated. Distolateral projections similar to those of *M. ensis*, spout-like, with large distal openings.

The thelycum of the allotype is shown on Plate 10 fig. 8. Anterior plate spoon-like, with a deep median depression in its anterior  $\frac{1}{2}$ , bounded laterally and anteriorly by a high, parabolic ridge. Lateral plates with a crescent-shaped ventral ridge, ending anterolaterally and posteromedially in a large and blunt spinous process; the posterior of these processes very close together, slightly diverging, and pointing anterolaterally.

Distribution. As yet known only from the type locality.

Discussion. *Metapenaeus suluensis* is a close relative of *M. ensis* (de Haan) but may readily be distinguished from it by the following features:

Criterion	<i>M. suluensis</i>	<i>M. ensis</i>
Rostrum	6-7 teeth + epigastric; strongly sexually dimorphic.	8-10 teeth + epigastric; less sexually dimorphic.
Branchiocardiac sulcus	Distinct, barely setose in ♀ glabrous in ♂.	Indistinct, being strongly setose in both sexes.
Ischial spine 1st pereopod	Sharp and large.	Blunt and small.
Abdomen	Anterior 3 somites non-carinated; carina beginning on posterior $\frac{2}{3}$ of 4th.	Traces of carina beginning on 1st somite; 2nd to 6th with distinct carina.
Pubescence	Completely lacking in ♂; in ♀ restricted to dorsum of anterior $\frac{1}{2}$ carapace, and a lateral pair of setose patches on abdominal pleura 4 to 6.	Carapace strongly pubescent in both sexes even below branchiocardiac carina, large patches on all abdominal pleura.
Petasma	Distomedian projections pointing inward, moderately large.	Distomedian projections parallel, very large.
Thelycum	Anterior plate spoon-like; lateral plates with raised ventral ridges, each with an anterolateral and a posteromedian spinous process; thelycum posteriorly closed.	Anterior plate tongue-like; lateral plates with raised lateral ridges, each with a posterior inwardly-curved triangular plate; cup-like structure of thelycum posteriorly open.

The large and sharp ischial spine on the 1st pereopod is a feature which *M. suluensis* shares with HALL's (1962) "variety" *baramensis* of *M. ensis*. However, even though the male of *M. e. baramensis* has not as yet been found, the thelycum of HALL's "variety" is completely different from that of the species discussed here.

***Metapenaeus conjunctus* sp. nov.**

(Figure 12; Plate 5 figs. 8, 9; Plate 11 fig. 1)

**Material.** NORTH BORNEO (Sabah): shallow brackish water at mouth of Tuaran R., coll. CHIN PHUI KONG, 18.XII.1959, 4-5 fm, holotype ♂, 88 mm, allotype ♀, 100 mm, paratypes ♂, 81 mm, ♀, 84 mm; Sandakan Fish Market, coll. CHIN PHUI KONG, 5.XI.1959, 2 ♂♂, 75, 77 mm, 4 ♀♀, 76-88 mm. MALAYA: Johore Bahru, coll. E. CHEAH, December 1961, numerous adolescent ♂♂ and ♀♀.

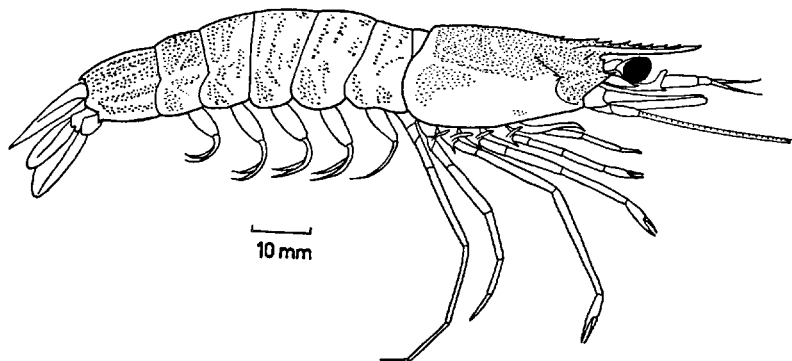


Fig. 12. *Metapenaeus conjunctus*, sp. nov. ♀, 100 mm, allotype.

**Description.** In both sexes body strongly pubescent in dorsal half of carapace; branchiostegites glabrous except for a small setose patch below the posterior boundary of branchiocardiac carina; abdomen with a number of moderately large setose patches on all somites. Rostrum distinctly ascending in mature ♀, only slightly lower in ♂, straight, reaching at least tip of basal antennular segment in ♂, but usually reaching mid point of 2nd segment in ♀; armed with 6-8 teeth + epigastric, the latter and the penultimate tooth on carapace. Adrostral carina ending between epigastric and penultimate tooth, adrostral sulcus well behind epigastric tooth. Postrostral carina well developed, distinct in its entire length, ending  $\frac{1}{10}$  length of carapace from its posterior margin. Gastro-



frontal sulcus indistinct, postocular sulcus at an angle of about  $40^\circ$  to rostrum. Orbito-antennal sulcus deep and distinct, ending in front of hepatic spine. Antennal carina ending  $\frac{1}{3}$  distance between antennal and hepatic spine. Cervical sulcus straight, ending at  $\frac{2}{5}$  carapace. Hepatic sulcus descending at about  $95^\circ$  to longitudinal axis in its posterior part, turning towards pterygostomial angle anteriorly. Branchiocardiac carina distinct, meeting posterior extension of hepatic spine, almost extending to posterior margin of carapace; branchiocardiac sulcus wide but distinct, strongly setose in both sexes.

Antennules with subequal flagella which are  $\frac{8}{10}$  of peduncle in ♂,  $\frac{1}{2}$  to  $\frac{2}{3}$  of peduncle in ♀. Prosartema exceeding eye, stylocerite attaining tip of basal segment.

Third maxilliped and 1st pereopod reaching  $\frac{1}{2}$  carapocerite; 2nd pereopod surpassing tip of basal antennular segment by dactyl, 3rd surpassing tip of scaphocerite by dactyl, 4th reaching tip of carapocerite, 5th not quite reaching tip of 2nd antennular segment. A blunt and small ischial spine on 1st pereopod. Distoventral keel on ischium of ♂ 5th pereopod triangular, notch on merus bounded by a bluntly triangular spine pointing ventrally at angle  $40^\circ$  to axis of merus, and inward at angle of  $45^\circ$ ; further distally a ventral row of 6–7 rounded tubercles terminate in a small keel at distal  $\frac{1}{2}$  merus.

Traces of dorsal carina occasionally present on 1st and 2nd abdominal somite, carina on 3rd indistinct, becoming progressively more prominent from 4th to 6th, carina of 6th ending in a sharp tooth. Telson somewhat shorter than inner uropods, its lateral margins armed with a single row of minute spinules.

The petasma of the holotype is shown on Plate 5 figs. 8, 9. Distomedian projections directed anterolaterally, almost completely overlying distolateral projections, with openings facing anteriorly. Distolateral projections similar to those of *M. ensis*, spout-like, with large distal openings.

The thelycum of the allotype is shown on Plate 11 fig. 1. Anterior plate tongue-like, medially deeply grooved, about of the same width in its raised anterior  $\frac{2}{3}$ . Lateral plates basically very like those of *M. dalli* Racek, retort-shaped in ventral view, but with strongly raised ventro-lateral ridges which are separated from each other posteriorly by a wide space.

Distribution. Apparently ranging, as an estuarine species, from Singapore to North Borneo.

Discussion. *Metapenaeus conjunctus* is closely related to both *M. burkenroadi* Kubo and *M. ensis* (de Haan), and its thelycum can be considered a link between these two species. In regard to its petasma, however, the species under discussion differs markedly from *M. ensis* and *M. burkenroadi*, and displays certain similarities to *M. affinis* (Milne Edwards). HALL (1956, fig. 11) depicted the distal part of a petasma which he then considered to belong to *M. monoceros*, and which is certainly

identical with that of *M. conjunctus*. In his latest publication, HALL (1962) correctly withdrew figure 11 from the synonyms of *M. ensis*, but did not explain the identity of the petasma depicted. From this fact, as well as from the material of adolescent specimens examined from the Singapore region, it can be assumed that *M. conjunctus* could be the estuarine species, referred to by HALL (1956, 1962) as the "glabrous condition" of *M. ensis*. Since this form from the Jurong prawn ponds has not been described in detail by HALL, this assumption will have to be clarified by future work. Should it be found correct, however, the writers cannot accept HALL's (1956, p. 78) remarks that there are no differences between the genitalia of the "glabrous condition" and those of the true *M. ensis*. As already demonstrated, the petasma of *M. conjunctus*, when fully developed, is strikingly different from that of *M. ensis*, and the mature thelycum is also easily separable in both species. It must be admitted, however, that the discrimination of juvenile specimens of both sexes is a difficult task in most *Metapenaeus* spp. with minute telsonic spinules. Had it not been possible to compare the adolescent specimens from Johore Bahru morphometrically with the adult specimens from North Borneo, the identification of the majority of the former would certainly have presented some difficulties.

***Metapenaeus papuensis* sp. nov.**

(Plate 3 fig. 3; Plate 6 figs. 1, 2; Plate 11 fig. 2)

Material. NEW GUINEA: Mouth of Panaroa R., Gulf of Papua, coll. Dr. A. RAPSON, 5.IV.1955, holotype ♂, 78 mm, allotype ♀, 98 mm, paratypes 2 ♀♀, 65, 92 mm; Gulf of Papua, 8° 16' S., 144° 12' E., coll. Dr. A. RAPSON, 6.IV.1955, ♂, 70 mm, ♀, 86 mm; Hercules Bay, coll. L. W. FILEWOOD, 15.VI.1963, 3 ♀♀, 86, 95, 96 mm.

Description. Pubescence restricted in both sexes to dorsum of carapace and pleura of 6th abdominal somite; setae scattered and very short. Rostrum straight and horizontal in its proximal  $\frac{2}{3}$ , then distinctly uptilted in adult ♀, but less so in adult ♂; reaching to, or slightly surpassing, tip of antennular peduncle in ♀, only slightly shorter in ♂; armed with 9-10 teeth + epigastric, the latter and the penultimate tooth on carapace. Adrostral carina ending between epigastric and penultimate tooth, adrostral sulcus well behind epigastric tooth. Postrostral carina broad and low, but distinct in its whole length, ending  $\frac{1}{10}$  length of carapace from its posterior margin. Gastrofrontal sulcus ill-defined, postocular sulcus at an angle of about 40° to rostrum. Orbito-antennal sulcus wide but distinct, ending in front of hepatic spine. Antennal carina ending  $\frac{1}{6}$  distance between antennal and hepatic spine. Cervical sulcus straight, ending at  $\frac{2}{5}$  carapace. Hepatic sulcus descending at about 95° to longitudinal axis in its posterior part, turning towards pterygostomial

angle anteriorly. Branchiocardiac carina distinct, meeting posterior extension of hepatic spine, almost reaching to posterior margin of carapace; branchiocardiac sulcus short and glabrous.

Antennules with subequal flagella; lower flagellum  $\frac{8}{10}$  of peduncle in ♂,  $\frac{2}{3}$  of peduncle in ♀. Prosartema exceeding eye, stylocerite attaining tip of basal segment.

Third maxilliped reaching  $\frac{3}{4}$  carapocerite, 1st pereopod as far as carapocerite; 2nd pereopod surpassing tip of basal antennular segment by  $\frac{1}{2}$  dactyl, 3rd surpassing antennular peduncle by  $\frac{1}{2}$  dactyl; 4th reaching  $\frac{3}{4}$  carapocerite, 5th reaching middle of 2nd antennular segment. A small and blunt ischial spine on 1st pereopod. Distoventral keel on ischium of ♂ 5th pereopod smoothly rounded, notch on merus bounded by a bluntly-triangular small spine pointing ventrally at angle of  $45^\circ$  to axis of merus, its tip only very slightly bent inward; further distally 2-4 inconspicuous tubercles.

Abdominal somites 1-3 without dorsal carina; carination beginning from posterior  $\frac{2}{3}$  of 4th somite, becoming progressively sharper on 5th and 6th; carina of 6th ending in acute tooth. Telson shorter than inner uropods, its lateral margins armed with a single row of minute spinules.

The petasma of the holotype is shown on Plate 6 figs. 1, 2. Distomedian projections large, anteriorly bilobed, not overlying distolateral projections, pointing anteriorly, and with large openings facing anterodorsally. Longitudinal sulcus shallow, not dividing distomedian projection into two distinct lobes. Distolateral projections spout-like, with small distal openings.

The thelycum of the allotype is shown on Plate 11 fig. 2. Anterior plate tongue-like, with a slightly rounded anterior margin and smoothly rounded anterolateral corners, medially grooved; anteriorly widest, posteriorly tapering to a narrow plate which is bounded laterally by a pair of rounded bosses. Lateral plates posteriorly fused, their lateral margins strongly raised in form of a salient ridge, the posterior end of which is slightly turned outwards. The thelycal structure posteriorly open by a broad space between the hind ends of the salient ridges.

Distribution. To date known only from New Guinea waters.

Discussion. Although the thelycum of *M. papuensis* displays some affinities with that of *M. elegans* (de Man), as depicted by HALL (1962), the specimens at hand can be distinguished from DE MAN's species by the features on next page.

Even though the structural differences of the thelycum of both species listed below are small, and perhaps not decisive, *M. papuensis* has a markedly different petasma, and this alone would justify its separation from *M. elegans*. Whether the differences listed are to be considered of specific or merely subspecific importance, could be decided only after an examination of many more specimens of both forms.

Criterion	<i>M. papuensis</i>	<i>M. elegans</i>
Pubescence	Restricted to dorsum of carapace and pleura 6th abdominal somite.	Almost completely absent (DE MAN).
♀ Rostrum	Tip distinctly upcurved.	Tip indistinctly uptilted (HALL).
Postrostral carina	Distinct in whole length.	Indistinct in posterior part (DE MAN).
Spine on merus of ♂ 5th pereopod	Slightly bent inward.	Bent outward (DE MAN).
Distomedian projections of petasma	Hood-like, parallel, directed anteriorly; longitudinal sulcus indistinct and shallow.	Leaf-like, strongly diverging, directed anterolaterally; longitudinal sulcus distinct and deep.
Lateral thelycal plates	Posterior end of salient ridges curved outward.	Posterior end of salient ridges curved inward (HALL)

**Metapenaeus affinis** (H. Milne Edwards, 1837)

(Plate 5 fig. 10; Plate 11 fig. 3)

*Penaeus affinis* H. Milne Edwards, 1837, p. 416.

*Metapeneus affinis* Alcock, 1906, pp. 20–21 (part synonymy only).

*Penaeopsis affinis* Kemp, 1915, p. 321. De Man, 1924, pp. 4–5 (non 1911).

*Metapenaeus affinis* Burkenroad, 1934b, pp. 29–32. Kubo, 1954, pp. 82–92 (non 1949). Dall, 1957, p. 183 (key). Cheung, 1960, p. 66 (key).

*Penaeus mutatus* Lanchester, 1901, pp. 572–73.

*Metapenaeus necopinans* Hall, 1956, pp. 83–84.

*Metapenaeus mutatus* Hall, 1962, p. 25.

**Material.** Numerous specimens of both sexes, 59–136 mm; MALAYSIA: Penang, North Borneo; INDONESIA: Java, East Borneo.

**Distribution.** Indian Seas (most authors), through Malaysia and part of Indonesia to Hong Kong (Cheung).

**Colour in life.** Translucent green, uropods tipped with conspicuous green.

**Discussion.** *Metapenaeus affinis* has been adequately described, and the reader is referred particularly to the papers by ALCOCK (1906) and KUBO (1954) as well as to the descriptions and figures by HALL (1956, 1962) under the name of *M. necopinans* and *M. mutatus* respectively. The material examined has not offered any additional criteria for further discussion. However, the genitalia of *M. affinis* have been photographed so that they may be compared with those of a new species from India

which will be described in a forthcoming paper by Mr. M. J. GEORGE of the Central Marine Fisheries Research Station in Ernakulam, India (personal communication).

Since *M. affinis* is not present in the material collected east of the general line between Hong Kong in the north and the eastern tip of Java in the south, it can be assumed that the Makassar Strait and the western Sulu Sea represent some barrier to its eastern distribution.

***Metapenaeus insolitus* sp. nov.**

(Figure 13 A-C; Plate 6 figs. 3, 4; Plate 11 fig. 4)

**Material.** NORTHERN TERRITORY: Chambers Bay, coll. V. WELLS ("Paxie"), 24.VI.1961, mud and coral, 17 fm, holotype ♀, 85 mm, allotype ♂, 67 mm; paratypes 2 ♂♂, 58, 61 mm, 7 ♀♀, 45-86 mm; 50 miles W.N.W.

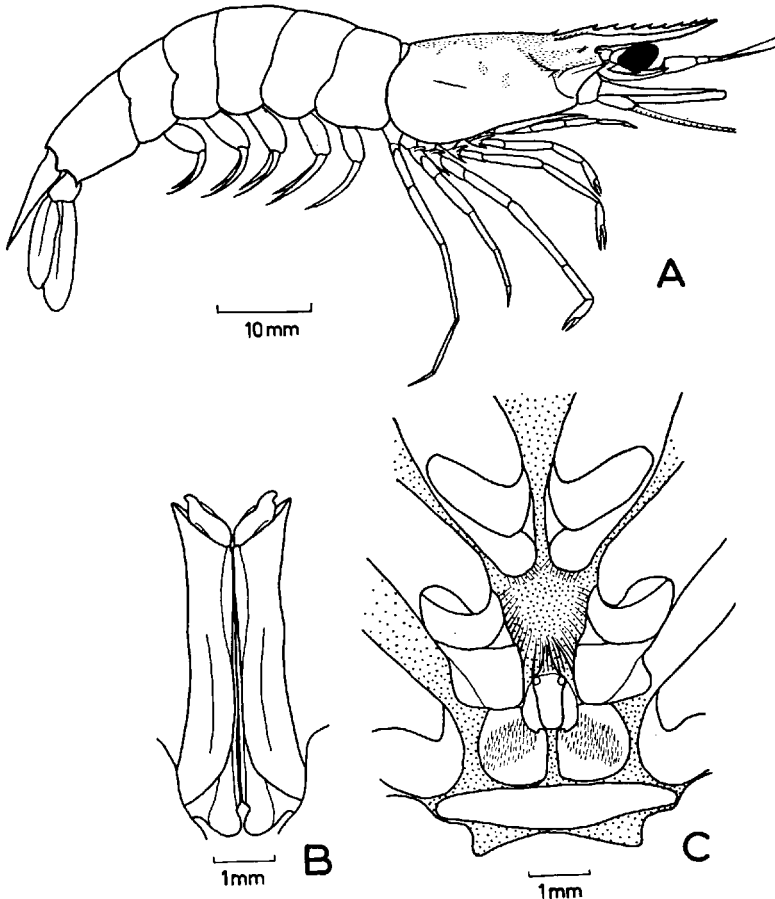


Fig. 13. *Metapenaeus insolitus*, sp. nov.  
A, ♀, 85 mm, holotype; B, ventral view of petasma of allotype;  
C, thelycum of holotype.

of Darwin, coll. V. WELLS ("Paxie"), 5.X.1951, sand bottom, 18 fm, ♂ 56 mm; QUEENSLAND: Mouth of Norman R., Gulf of Carpentaria, coll. "Rama" Prawn Survey, October 1963, mud, 7 fm, 2 ♂♂, 67, 68 mm, 2 ♀♀, 96, 111 mm; off Karumba, Gulf of Carpentaria, coll. "Rama" Prawn Survey, November 1963, mud, 8 fm, 8 ♂♂, 50-71 mm, 15 ♀♀, 58-94 mm.

Description. Pubescence restricted in both sexes to larger part of dorsum on carapace down to branchiocardiac carina, with one to two larger setose patches on branchiostegites; terga and pleura of all pleonic somites with a number of setose areas; tomentum scarce and short, conspicuous only in dry specimens. Base of rostrum between epigastric and penultimate tooth distinctly ascending, rest of rostrum slightly uptilted but straight in ♂, rostral tip in ♀ inconspicuously upcurved; reaching to, or slightly surpassing tip of antennular peduncle in ♀, attaining posterior  $\frac{1}{3}$  of 3rd antennular segment in ♂; armed with 8 teeth + epigastric in both sexes, epigastric and penultimate tooth on carapace. Epigastric tooth in ♂ often extremely small or rudimentary, its position marked by the anterior median sulcus. Adrostral carina ending between epigastric and penultimate tooth, adrostral sulcus fading away immediately behind epigastric tooth. Postrostral carina ill defined, broad and flat, and recognizable only as a glabrous strip, ending  $\frac{1}{10}$  length of carapace from its posterior margin. Gastrofrontal sulcus wide and shallow, continuous posteriorly with comparatively long postocular sulcus which runs at angle of  $45^\circ$  to rostrum. Orbito-antennal sulcus narrow posteriorly and ending in level with posterior end of antennal carina which reaches to  $\frac{1}{5}$  distance between antennal and hepatic spine. Cervical sulcus straight and ending at about  $\frac{2}{5}$  carapace. Hepatic sulcus descending vertically for more than  $\frac{1}{3}$  length, the rest inclined at an angle towards pterygostomial angle. Branchiocardiac carina flat but distinct, branchiocardiac sulcus shallow and tomentose, the anterior end of both only slightly exceeding the posterior  $\frac{1}{3}$  carapace.

Antennular flagella  $\frac{7}{10}$  of peduncle in ♂, slightly more than  $\frac{1}{2}$  in ♀. Prosartema slightly overreaching eye, stylocerite attaining tip of basal segment.

Third maxilliped reaching tip of carpocerite, 1st pereopod only slightly shorter; 2nd pereopod reaching anterior margin of cornea, 3rd attaining  $\frac{3}{4}$  of 2nd antennular segment; 4th almost reaching to tip of carpocerite, 5th reaching tip of scaphocerite. Distoventral keel on ischium of ♂ 5th pereopod smoothly rounded, notch on merus bounded by a blunt spinous process with a posterolateral suboval facet, the distolateral corner of which bears a rounded tubercle; a small ventral meral keel without tubercles.

Abdominal somites 1 to 3 without a dorsal carina, although a glabrous median strip on terga often present; dorsal carination beginning from posterior  $\frac{8}{10}$  of 4th somite in ♂, from posterior  $\frac{2}{3}$  of 4th somite in ♀,

becoming progressively sharper on 5th and 6th; carina on 6th ending in acute tooth. Telson shorter than inner uropods, its lateral margins armed with a single row of minute spinules.

The petasma of the immature allotype is shown in figure 13 B, that of a fully grown male is depicted on Plate 6 figs. 3, 4. Distomedian projections fully overlying distolateral projections, and strongly diverging; they are posteromedially simple, their anterolateral margins forming a broad outwardly curved tooth, their posterolateral margins ear-like and rounded; anterodorsal edge strongly crenulated and slightly convoluted. Distolateral projections with spatulate tips, similar to those of other species of the genus.

The thelycum of the holotype is shown in figure 13 C, that of a fully mature female is depicted on Plate 11 fig. 4. Anterior plate tongue-like with a broad longitudinal depression, its almost straight anterior margin with a lateral pair of conspicuous rounded tubercles, its lateral margins bounded by a pair of bulbous elongated plates. Lateral plates medially separated from each other by a narrow sulcus, broadly kidney-shaped; superficially divided by a curved sulcus into a crescent-shaped posterior, and an inwardly curved and pointed anterior part; this sulcus is present only in fully mature females and overgrown by a characteristic wide patch of strong and long setae; position of the yet invisible sulcus in less mature females already marked by this typical tomentum.

Colour in life. Translucent green with brownish chromatophores, antennal scale and tips of uropods vivid green.

Discussion. The interspecific relationship of *M. insolitus* is somewhat obscure. In regard to its thelycum, this species comes closest to the *M. burkenroadi* complex and the two anterolateral tubercles on the anterior thelycal plate are, to some extent, comparable with those in *M. dalli*. However, the strongly setose and curved dividing sulcus present on the lateral plates, shows some affinities to the thelycal structure of *M. affinis*. On the other hand, the petasma of *M. insolitus* displays characters not shared by the *M. burkenroadi* group, and can be considered intermediate between the *M. ensis* complex and *M. affinis*.

The species discussed was first discovered in the vicinity of Darwin, Northern Territory, but has since been found quite abundantly by the Joint Commonwealth-Queensland Prawn Survey in the Gulf of Carpentaria. It occupies the niche separating the western species *M. dalli* Racek, from its endemic eastern congener, formerly called *M. mastersii* by the present writers, in which an intermediate form between these two species was anticipated (DALL, 1957, p. 193). However, *M. insolitus* cannot possibly represent such a link since it does not possess transitional characters between *M. "mastersii"* (= *M. bennettiae* sp. nov.) and *M. dalli*.

The original discovery of this new species in the Darwin area made the re-examination of characters displayed by *Penaeus mastersii* Haswell a necessity. In the course of detailed morphometric studies, a number of

the criteria of *M. insolitus* were found at pronounced variance with those of HASWELL's syntype from Darwin; these are as follows:

Criterion	<i>M. insolitus</i>	<i>P. mastersii</i>
Pubescence on carapace	Larger part of dorsum; branchiostegites with 1-2 setose patches.	Smaller part of dorsum; branchiostegites glabrous.
Pubescence on pleon	All terga and pleura with setose patches.	Setose patches only on 5th and 6th somites.
Rostrum	Base distinctly ascending; 8 teeth + epigastric.	Base slightly ascending; 9 teeth + epigastric.
Adrostral sulcus	Ending just behind epigastric tooth.	Extending well behind epigastric tooth.
Branchiocardiac carina	Anterior end slightly exceeding posterior $\frac{1}{3}$ carapace.	Anterior end almost reaching posterior extension of hepatic spine.
Petasma at body length 72 mm	Fully mature.	Petasmal halves simple and separate.
5th pereopod ♂ at body length 72 mm	Notch on merus deep, spinous process fully formed.	Notch on merus hardly perceptible, spinous process small tubercle.

### *Metapenaeus burkenroadi* Kubo, 1954

- Metapenaeus burkenroadi* Kubo, 1954, pp. 92-93. Dall, 1957, p. 183 (key). Racek, 1957, pp. 6-7. Cheung, 1960, pp. 66, 68.  
*Penaeus affinis* Kishinouye, 1900, pp. 16-18.  
*Penaeopsis affinis* Balss, 1914, p. 7; 1924, p. 44 (non de Man, 1911).  
*Parapenaeus affinis* Rathbun, 1902, p. 38.  
*Metapenaeus affinis* Kubo, 1949, pp. 340-44 (part synonymy only).  
*Metapenaeus mastersii* Hall, 1962, pp. 23-24 (non Racek, 1955, 1957, 1959; Dall, 1957, 1958).

**Material.** 38 specimens of both sexes, 42-97 mm; QUEENSLAND: S.E. off Thursday I., coll. V. WELLS ("Paxie"), December 1960, 25 fm, mud; NORTH BORNEO: shallow brackish water at mouth of Tuaran R., coll. CHIN PHUI KONG, December 1959; Tawau Fish Market, caught with tidal net "togoh", 3-5 fm, 18.XII.1959; Sandakan Fish Market, 27.II.1953; MALAYA: Johore Bahru, coll. E. CHEAH, December 1961; comparative specimens from Japanese waters donated by Dr. I. KUBO, May 1956.

**Distribution.** Chiefly restricted to waters north of the equator, ranging from Japan (KISHINOUE, RATHBUN, KUBO) through Hong Kong Seas



(CHEUNG) and Malaysia (HALL) to southern India (GEORGE, unpublished data).

Discussion. *Metapenaeus burkenroadi* has been adequately described by KUBO (1954) and RACEK (1957), and the material examined during the present study has not offered any additional criteria for discussion. HALL (1962), although not having comparative material from Australia to examine, considered this species, together with *M. dalli* Racek, synonymous with the eastern Australian species formerly named *M. mastersii* by the present authors. The distinguishing criteria in mature specimens of these 3 species have already been demonstrated by RACEK (1957) to be constant features, although the differentiation of juveniles will remain a difficult task. The authors were able to examine a wide range of specimens from Johore Bahru, which are identical with those collected in North Borneo, both having the characteristic petasma and thelycum of a typical *M. burkenroadi*. There can be no doubt as to the true identity of the specimens examined by HALL, and that author's figures 92 *a-b*, perhaps with the exception of the anterior margin of the anterior thelycal plate, certainly refer to KUBO's species.

Even though the differences between the 3 species discussed by RACEK (1957) may yet be considered as of merely subspecific importance, as HALL claims, it is inevitable that these 3 clearly distinct forms should be taxonomically separated, a fact which is obscured by merging them under the one name. Moreover, since the name *M. mastersii* can no longer be applied to the endemic eastern Australian species formerly so called, *M. burkenroadi* now has priority for the specimens examined by HALL, regardless of whether the 2 Australian forms of this group are considered conspecific or not.

*M. burkenroadi* has now also been found near Thursday I., although its occurrence in tropical Australian waters is apparently rare. It has recently also been recorded from South India (Mr. M. J. GEORGE, personal communication) though specimens from that area have not yet been examined by the present authors. Its apparently wide distribution in waters north of the equator is in contrast to the more restricted occurrence of *M. dalli*, which ranges from Western Australia into Indonesia, and to that of *M. bennettiae* sp. nov. (previously known as *M. mastersii*), which is restricted to the eastern coast of Australia.

### **Metapenaeus dalli Racek, 1957**

*Metapenaeus dalli* Racek, 1957, pp. 4-5.

*Penaeopsis affinis* de Man, 1911, pp. 57-58.

*Metapenaeus mastersii* Racek, 1955, p. 233 (Western Australian distribution).  
Dall, 1956, pp. 13, 15; 1957, p. 193 (Western Australian specimens).

Material. Numerous specimens of both sexes, 45-81 mm; WESTERN

AUSTRALIA: Shark Bay, Exmouth Gulf, Mandurah, Gascoyne R.;  
NORTHERN TERRITORY: 50 miles W.N.W. off Darwin, 18 fm, sand;  
INDONESIA: Eastern Java, 5 fm, mud.

Distribution. Greatest abundance along the coast of Western Australia from about Mandurah to Broome, ranging north into southern Indonesian waters, and north-east towards Darwin.

Discussion. *Metapenaeus dalli* has been adequately described by RACEK (1957) and its structural differences from the eastern Australian endemic species were also discussed by DALL (1957). Its distribution has been further substantiated by the present studies as reaching Java and its adjacent waters though apparently it does not transgress the distributional path of *M. burkenroadi*, which latter species is not uncommon in northern parts of Borneo. *M. dalli*, although ranging east to about Darwin, is absent in material collected between Darwin and Cape York from where the morphologically different species *M. insolitus* sp. nov. has now been recorded.

### ***Metapenaeus bennettiae* sp. nov.**

*Penaeus* sp. Whitelegge, 1890, p. 225; in Ogilby, 1893, p. 203.

*Penaeopsis monoceros* Schmitt, 1926, pp. 325-29 (♂ 74 mm of "Endeavour" material only, Reg. No. P4287).

"Dana" *Metapenaeus* sp. n.' Morris and Bennett, 1952, pp. 164-82 (life history and larval development).

*Metapenaeus mastersii* Racek, 1955, pp. 232-35; 1957, pp. 5-6; 1959, pp. 10, 12. Dall, 1957, pp. 190-93; 1958, pp. 111-32 (ecology and behaviour) (non Hall, 1962, pp. 23-24).

Material. NEW SOUTH WALES: Lake Budgewoi, Tuggerah Lakes, coll. I. BENNETT, 1945-1947, holotype ♂, 70 mm, allotype ♀, 79 mm, paratypes 23 ♂♂, 76 ♀♀, 26-95 mm, Aust. Mus. Reg. No. P 12525; additional paratypes numerous specimens of both sexes from Port Jackson (Sydney Harbour), collected and identified by HASWELL and WHITELEGGE, Aust. Mus. Reg. Nos. P 440-444; extremely numerous specimens of both sexes, larval stages to 109 mm; NEW SOUTH WALES: Coila L., Conjola L., St. George's Basin, Sussex Inlet, Greenwell Pt., Illawarra L., Sydney Harbour, Hawkesbury R., Tuggerah Lakes, L. Macquarie, Hunter R., Wallis L., L. Innes, Cathie Cr., Clarence R., Richmond R., Tweed R.; QUEENSLAND: Moreton Bay, Brisbane R., Noosa L., Mary R., Pioneer R., Cooktown (Reg. No. P 4287 - part, male 74 mm, "Endeavour" material).

Diagnosis. Rostrum slender, with slight upward curve, reaching tip of 2nd antennular segment in ♂, usually at least attaining tip of antennular peduncle in ♀, armed with 7-8 teeth + epigastric. Postrostral carina low, but distinctly visible as glabrous strip extending to about posterior  $\frac{1}{10}$  of carapace. Adrostral sulcus ending immediately behind

epigastric tooth, which latter is situated at  $\frac{1}{4}$  carapace. Branchiocardiac carina low and short, branchiocardiac sulcus feeble, anterior end of both not exceeding posterior  $\frac{1}{3}$  carapace. Mature petasma with more or less parallel distomedian projections which are distally twisted dorso-ventrally. Mature thelycum with flask-shaped anterior plate which has a bluntly triangular anterior margin bearing a larger median conical tubercle, and a pair of less prominent anterolateral rounded tubercles; lateral plates kidney-shaped, their posterolateral margins slightly raised.

Distribution. Restricted to the greater part of the warm temperate and tropical coasts of eastern Australia, ranging from southern New South Wales to at least Bowen, Queensland, occasionally occurring further north to Cooktown.

Discussion. The reasons for the erection of this new species have already been given in the discussion of *M. ensis* (de Haan). Since *M. bennettiae* has never before been described under a valid name, and its type specimens have not been designated, its separation from other species of this group by using a *nomen novum* would have been taxonomically impossible. However, a renewed detailed description of this new species is unnecessary since it has been adequately described and figured by RACEK (1955, 1957) and DALL (1957) as *M. mastersii* (Haswell). It has been named after Miss ISOBEL BENNETT, School of Biological Sciences, University of Sydney, in recognition of her extensive studies of the life history of this species.

### **Metapenaeus demani** (Roux, 1922)

(Plate 6 fig. 5; Plate 11 fig. 5)

*Penaeopsis demani* Roux, 1922, pp. 599-601.

*Metapenaeus demani* Burkenroad, 1934b, p. 30. Rapson, 1955, p. 15. Dall, 1957, p. 183 (key).

Material. NEW GUINEA: Gulf of Papua, off Purari R., coll. C.S.I.R.O., 4.IV.1955, 2 ♂♂, 75, 79 mm; 8° 16' S., 144° 12' E., coll. Dr. A. RAPSON, 6.IV.1955, ♀, 87 mm; off Fly R. mouth, coll. Dr. A. RAPSON, 7.IV.1955, impregnated ♀, 84 mm; 8° 32' S., 143° 55' E., near entrance to Fly R., coll. C.S.I.R.O., 7.IV.1955, 2 ♀♀, 90, 91 mm; Orangerie Bay, Papua, coll. Dr. A. RAPSON, 14.II.1961, 17 fm, 11 ♀♀, 79-121 mm, 4 ♂♂, 73-79 mm; Orangerie Bay, Papua, coll. L. W. FILEWOOD, July 1963, 2 ♂♂, 89, 96 mm, ♀, 118 mm; QUEENSLAND: Near Cairns, coll. F. BARDSLEY, date unknown, 3 ♀♀, 78-81 mm.

Description. Body almost completely glabrous, sulci on carapace and abdomen occasionally with scarce and short tomentum. Base of rostrum abruptly ascending towards 2nd posterior rostral tooth, rostrum becoming anteriorly rather horizontal, its styliform tip somewhat upcurved; reaching tip of antennular peduncle in ♂, slightly surpassing it in ♀. Rostral

teeth 7-8+epigastric; posterior 5-6 rostral teeth placed equidistantly, the anterior 2 separated from each other by a wider space which is equal the distance between foremost tooth and rostral apex. Adrostral carina ending between penultimate tooth and epigastric, adrostral sulcus indistinct and ending just below epigastric tooth. Postrostral carina broad and low, becoming posteriorly indistinct, ending  $\frac{1}{10}$  length of carapace from its posterior margin. Epigastric and penultimate tooth on carapace, former at  $\frac{1}{4}$  carapace. Gastrofrontal sulcus barely perceptible, postocular sulcus at angle of  $45^\circ$  to rostrum and deep. Orbito-antennal sulcus wide but distinct, ending in front of hepatic spine. Antennal carina ending  $\frac{1}{5}$  distance between antennal and hepatic spines. Cervical sulcus straight, tomentose, ending at  $\frac{1}{2}$  carapace. Hepatic sulcus descending vertically in its posterior part, turning towards pterygostomial angle anteriorly. Branchiocardiac carina indistinct in its anterior part, reaching to posterior extension of hepatic spine; branchiocardiac sulcus ill-defined, glabrous and short, ending at posterior  $\frac{1}{3}$  of carapace.

Antennular flagella  $\frac{9}{10}$  length of peduncle in ♂,  $\frac{3}{5}$  length of peduncle in ♀. Prosartema reaching as far as eye, stylocerite attaining tip of basal antennular segment.

Third maxilliped surpassing tip of carpocerite by dactyl; 1st pereopod attaining  $\frac{1}{2}$  carpocerite, 2nd surpassing tip of carpocerite by  $\frac{1}{2}$  dactyl, 3rd reaching to tip of 2nd antennular segment; 4th attaining middle of cornea, 5th exceeding scaphocerite by distal  $\frac{1}{8}$  of propodus and dactylus. Distoventral keel on ischium of ♂ 5th pereopod a rounded lobe, the deep notch on merus proximally bounded by a wide and long lanceolate spinous process, which reaches distal margin of ischium and is bent outward at about  $25^\circ$ ; meral keel without tubercles. A small but distinct ischial spine on 1st pereopod.

Abdominal somites 1 to 3 without a dorsal carina; 4th with a carina in its posterior  $\frac{7}{8}$ , carination becoming progressively more acute towards 6th somite, the latter with a median tooth. Telson only slightly shorter than inner uropods, its lateral margins with a single row of minute spinules.

The mature petasma is shown on Plate 6 fig. 5. Distomedian projections low, wrapping around anterior margin of distolateral projections, with a 2-lobed ventral, and an elongated dorso-lateral convolution. Distolateral projections with slightly inward curved apices.

The mature thelycum is shown on Plate 11 fig. 5. Anterior plate in its distal  $\frac{1}{2}$  very broad, smoothly rounded and slightly concave, proximally very narrow, stem-like; this latter part laterally bounded by a pair of large semicircular bosses, and posteriorly by a setose triangular anterior projection of the fully fused lateral plates; lateral plates of rounded W-shape defining, together with the semicircular bosses, a bowl-like depression.

Discussion. The specimens examined agree in most details with the description by ROUX (1922) but differ from it in the following:

Criterion	Present specimens	Roux' description
Rostrum	Distinctly ascending at base; slightly surpassing antennular peduncle in ♀.	Horizontal at base; surpassing antennular peduncle by as much as $\frac{1}{4}$ of rostrum in ♀.
Thoracic pubescence	Almost completely absent, restricted to some sulci.	Anterior part of carapace finely pubescent.
Ischial spine 1st pereopod	Small but distinct.	Not mentioned.
Thelycum	Lateral plates fused, with a median triangular anterior projection.	Lateral plates separated medially, anteriomedian projection indistinct.
Petasma	Distance between distolateral projections only slightly greater than width of petasma.	Distance between distolateral projections much greater than median width of petasma.

The differences listed, however, are of no great importance; some of them, particularly those relating to the shape of the outer genitalia, are certainly the result of incorrect drawings in ROUX' paper, and the greater length of the rostra in the type material must be considered of doubtful significance. The opinion of BURKENROAD (1934b, p. 30) that *M. demani* "seems very like" *M. macleayi* from eastern Australia, has already been contradicted by DALL (1957).

The badly preserved specimens from the Cairns area represent the first record of this species from outside New Guinea. It is therefore possible that *M. demani*, which has been considered a morphologically and geographically isolated species, may yet be found in other areas of northern Australia.

### **Metapenaeus endeavouri** (Schmitt, 1926)

*Penaeopsis endeavouri* Schmitt, 1926, pp. 329-33.

*Metapenaeus endeavouri* Kubo, 1949, pp. 339-40. Racek, 1955, pp. 229-30; 1959, pp. 10, 12, 13. Dall, 1957, pp. 187-89.

**Material.** Numerous specimens of both sexes, 53-156 mm; WESTERN AUSTRALIA: Shark Bay, Exmouth Gulf; NORTHERN TERRITORY: Off Darwin, Joseph Bonaparte Gulf; QUEENSLAND: Gulf of Carpentaria, Mackay, Keppel Bay, Moreton Bay; NEW SOUTH WALES: Lennox Head, Ballina.

**Distribution.** Apparently endemic to Australia, ranging from Shark Bay in the west through northern coastal waters to southern Queensland, occasionally penetrating into northern New South Wales.

**Discussion.** This species has been adequately described and illustrated, and the specimens examined during the present study do not offer any additional criteria for discussion.

**Metapenaeus intermedius** (Kishinouye, 1900)

(Plate 6 fig. 7; Plate 11 fig. 6)

*Penaeus intermedius* Kishinouye, 1900, pp. 21-22.*Metapeneus ensis* Alcock, 1906, pp. 24-25.*Penaeopsis ensis* Balss, 1914, p. 8. Yokoya, 1933, p. 9.*Penaeopsis intermedia* var. *anchista* de Man, 1922, pp. 5-8.*Metapenaeus intermedius* Burkenroad, 1934b, pp. 36-40. Kubo, 1949, pp. 333-40. Hall, 1956, pp. 78-79; 1962, p. 23. Dall, 1957, pp. 183 (key), 189. Cheung, 1960, p. 66.

**Material.** NORTH BORNEO: Off Sandakan, trawled by CHIN PHUI KONG, 5.XI.1959, 7 fm, mud, ♂ 79 mm; JAPAN: ♀, 142 mm, donated by Dr. I. KUBO and used by him for his (1949) figure 122.

**Distribution.** Japan, Hong Kong, Malaysia.

**Discussion.** The single male from North Borneo agrees in all details with the description of a male from the Kei Is. by DE MAN (1922), who demonstrated the presence of a number of criteria which are at variance with the description of *M. intermedius* by KISHINOUE (1900). The male at hand also possesses all the criteria tabulated by KUBO (1949, pp. 338-39) for the differentiation of DE MAN's "variety" *anchista* from Japanese specimens of *M. intermedius*: the setose patch below the glabrous branchiocardiac strip is absent; the transverse setose groove on the 1st pleonic tergum is simple; the cervical sulcus is unusually long and extends to the vicinity of the adrostral sulcus; the distomedian projections of the petasma are much shorter than the distolateral projections, which latter are directed almost completely anteriorly.

BURKENROAD (1934b) discussed certain discrepancies between the descriptions of *M. intermedius* by KISHINOUE (1900) and SCHMITT (1926), and indicated the identity of BALSS' (1914) specimens with DE MAN's variety *anchista*. KUBO (1949) has since extensively redescribed KISHINOUE'S species from Japan so that it is readily distinguishable from the now equally well-known *M. endeavouri* (Schmitt) from northern Australia.

The examination of the single male specimen at hand does not allow the authors to revise the status of DE MAN'S *P. intermedia anchista*, and females of this "variety" from the Indonesian-Malaysian region were not available for direct comparison. However, should the thelycal structures of specimens from that region be found as distinct from *M. intermedius* as DE MAN'S (1922) and HALL'S (1962) figures seem to indicate, *P. intermedia anchista* will have to be raised to specific rank since it would then differ from KISHINOUE'S species by criteria similar in number and importance to those separating *M. endeavouri* (Schmitt) from *M. intermedius* (Kishinouye).

The typical thelycum of *M. intermedius* from Japanese waters is shown on Plate 11 fig. 6 in order to facilitate its future comparison with that structure in DE MAN'S "variety".

**Metapenaeus lysianassa** (de Man, 1888)

(Plate 6 fig. 10; Plate 11 fig. 7)

*Penaeus lysianassa* de Man, 1888, pp. 290-95.*Metapenaeus lysianassa* Alcock, 1906, pp. 23-24.*Metapenaeus lysianassa* Burkenroad, 1934b, p. 36. Kubo, 1949, pp. 359-361; Hall, 1956, pp. 82-83; 1962, p. 24. Dall, 1957, p. 183 (key).

Material. NORTH BORNEO: Sandakan Fish Market, coll. CHIN PHUI KONG, 27.II.1953, ♂ 55 mm, 2 ♀♀, 62, 67 mm; off Tawau, coll. CHIN PHUI KONG, 18.XII.1959, tidal net "togoh", 3-5 fm, 5 ♀♀, 64-88 mm.

Distribution. Eastern Indian waters to North Borneo.

Discussion. HALL (1962) drew attention to consistent differences in petasmal structures between specimens of this species from the general region between India and Malacca, and those collected between Penang and Sumatra, and suggested the erection of a "variety" *M. lysianassa malaccaensis* for the latter group. Although the females of HALL's material, as well as those examined by the present authors, do not show any appreciable differences from those depicted by DE MAN (1888) and ALCOCK (1906), the petasma of the male from North Borneo is distinctly at variance with the figures of both these authors, but fully comparable with HALL's (1962) figure 93e referring to his *M. lysianassa malaccaensis*. The distolateral projections of the petasma examined lack the deep cleft present in the petasma of the "western" form, and the lateral spine on these projections is extremely small. The identity of the male at hand with the "variety" of HALL is thus established beyond doubt, and the range of this aberrant form can now be extended to North Borneo. Future research may justify the necessity of splitting *M. lysianassa* into two subspecies, i.e. *M. lysianassa lysianassa* and *M. lysianassa malaccensis*, as already suggested by HALL.

The conjoined white pads attached to the thelycum of 4 females from Tawau are of the same shape as those depicted by KUBO (1949, p. 355). However, these pads are fixed at an angle to the longitudinal axis of the thelycum, and one is inserted at full 90°. This unusual position in impregnated females of this species was first recorded by BURKENROAD (1934b, p. 36).

As already pointed out by BURKENROAD (1934b), *M. lysianassa* belongs to a group of *Metapenaeus* spp. which are clearly separable from other species of this genus by a number of morphological features as well as by the presence, in fertilized females, of the conjoined pads already mentioned. In this group the distomedian projection of the petasma usually produces a readily visible free filament or auxiliary lobe, a paired petasmal structure which is very conspicuous in 3 species, i.e. *M. joyneri* (Miers), *M. brevicornis* (Milne Edwards), and *M. tenuipes* Kubo. The presence of petasmal filaments in *M. dobsoni* (Miers) has since been demonstrated by BURKENROAD (personal communication), and these structures will be mentioned in the discussion of *M. dobsoni* below.

*M. lysianassa* was hitherto considered to lack distomedian petasmal filaments, although it shares all other distinguishing criteria with the remainder of the group. Even though complete petasmal filaments could not be found in the male from North Borneo, a close examination of its petasma revealed a stumpy prominence on each ventral posteromedian corner of the distomedian projections which most probably represents the rudiment of such an apical outgrowth (Plate 6 fig. 10). The authors were unable to examine the petasma of the "western" form, as figured by DE MAN and ALCOCK, but the presence of a similar distoventral pair of petasmal prominences in the "true" *M. lysianassa* is most likely.

***Metapenaeus dobsoni* (Miers, 1878)**

(Plate 6 figs. 6, 8, 9; Plate 11 fig. 8)

*Penaeus dobsoni* Miers, 1878, p. 302.

*Metapenaeus dobsoni* Nobili, 1903, p. 3. Menon, 1952, pp. 80-93. Dall 1957, p. 183 (key). Hall, 1962, p. 25.

*Metapeneus dobsoni* Alcock, 1906, pp. 21-22.

*Penaeopsis* sp. de Man, 1911, pp. 60-61.

*Penaeopsis dobsoni* Kemp, 1915, p. 322.

Material. 36 ♀♀, 13 ♂♂, 56-104 mm; INDONESIA: Djangkaran, Djokjakarta, Tjilatjap; PHILIPPINES: Manila Bay; CEYLON: Balapitiya Lagoon; INDIA: Narakkal.

Distribution. Indian waters (most authors) through Malaysia (HALL) and Indonesia (DE MAN) to Philippine Is.

Discussion. The specimens examined agree well with the previous descriptions of *M. dobsoni*. BURKENROAD (personal communication) has drawn attention to the fact that the free filament of the distomedian projection of the petasma, which is readily visible in other related species of this genus, is also present in this species. It follows the anterior curvature of the distomedian projection and is thus hidden in dorsal view. The position of the pair of filaments can be seen in the photograph on Plate 6 fig. 8, as well as in figure 98a of HALL's (1962) paper. The thelycum, which is shown on Plate 11 fig. 8, is obscured in impregnated females by a pair of white conjoined pads; these have a broadly triangular outline, tapering from a broad posterior base to a bluntly rounded anterior tip, and can thus be readily distinguished from those of other species.

The strong basial spine on the ♂ 3rd pereopod is shown on Plate 6 fig. 6. In 2 immature males from Indonesia this spine is short and lacks the terminal hook-like tooth, but its base is considerably wider than that of the basial spines on the 1st 2 chelipeds. This feature enables a ready distinction of juvenile males of *M. dobsoni* from those of other species, perhaps with the exception of *M. joyneri* where a similar basial spine can be found on the ♂ 3rd pereopod.



Unlike *M. lysianassa*, which often possesses a small but perceptible spine on the ischium of the 1st pereopod, *M. dobsoni* seems to lack this structure completely.

***Metapenaeus brevicornis* (H. Milne Edwards, 1837)**

(Plate 6 fig. 11; Plate 12 fig. 1)

*Penaeus brevicornis* H. Milne Edwards, 1837, p. 417. Bate, 1881, p. 180. Lanchester, 1901, p. 571.

*Metapenaeus brevicornis* Alcock, 1906, pp. 22-23.

*Penaeopsis brevicornis* Kemp, 1918, pp. 294-95.

*Metapenaeus brevicornis* Burkenroad, 1934b, pp. 33-36. Kubo, 1949, pp. 351-55. Hall, 1956, p. 81; 1962, pp. 24-25. Dall, 1957, p. 184 (key).

? *Penaeus avirostris* Dana, 1852, p. 603.

*Penaeopsis avirostris* Balss, 1914, p. 10.

*Penaeus* sp. Lanchester, 1901, pp. 571-72.

Material. 29 ♂♂, 41 ♀♀, 53-129 mm; MALAYA: Fishmarket Penang; NORTH BORNEO: Sandakan Harbour, Labuan, Sandakan Fishmarket; INDONESIA: Tjilatjap (Java). Depth of occurrence 2-23 fm.

Distribution. West Pakistan through Indian, Malaysian, Thai, and Indonesian waters to about East Borneo.

Discussion. *M. brevicornis* has been adequately described, and a detailed account of the various criteria found in the specimens examined is therefore not necessary. KUBO (1949) described the telson of this species as "devoid of lateral spines", a condition which is present in only 5 adult specimens of our material. All other adult specimens examined possess a pair of clearly perceptible distal spines, and in addition a series of minute spinules extending proximad to about  $\frac{2}{3}$  of the length of the telson. In this regard our specimens are fully comparable with those described by DE MAN (1924b) and BURKENROAD (1934b).

The typical petasma (Plate 6 fig. 11) and thelycum (Plate 12 fig. 1) of this species will always readily separate adult specimens of *M. brevicornis* from those of the closely related *M. lysianassa* and *M. tenuipes*. The different outline of the white conjoined pads on the thelycum of impregnated females of these three species are, as already shown by KUBO (1949), a useful additional distinguishing criterion. The distinction of juveniles of *M. brevicornis* from those of *M. lysianassa* has already been discussed by BURKENROAD (1934b); however, the distinction of juveniles of the former from those of *M. tenuipes* Kubo will remain a difficult task, particularly when examining males with separate petasmas halves.

The ischial spine of the 1st pereopod of *M. brevicornis* is well developed in both sexes, and only slightly smaller than the basal spine. This feature is already clearly perceptible in the smallest specimen examined (53 mm) and is therefore useful in the separation of juveniles of this species from those of *M. tenuipes*.

The identity of *Penaeus avirostris* Dana, 1852, has still to be resolved. HALL (1962) drew attention to the fact that the specimens in the British Museum, attributed to DANA's species, were so named by BURKENROAD in 1939, although they are typical representatives of *M. brevicornis*. HALL concluded from this that *P. avirostris* should therefore be relegated to a synonym of MILNE EDWARDS' *P. brevicornis*, since this specific name takes priority. However, DANA's (1852) description could equally apply to the species at present known as *M. tenuipes* Kubo (= *M. spinulatus* Kubo), a view which is now held by BURKENROAD (personal communication.) The present authors were unable to examine and compare the type specimens involved, and are therefore not in a position to clarify the status of *P. avirostris*.

### **Metapenaeus tenuipes** Kubo, 1949

(Plate 7 fig. 1; Plate 12 fig. 2)

*Metapenaeus tenuipes* Kubo, 1949, pp. 348-51. Dall, 1957, p. 184 (key).

*Metapenaeus spinulatus* Kubo, 1949, pp. 355-59. Hall, 1956, pp. 81-82; 1962, p. 25. Dall, 1957, p. 184 (key).

? *Penaeus avirostris* Dana, 1852, p. 603.

**Material.** 9 ♂♂, 36 ♀♀, 53-97 mm; INDONESIA: Kuala Sungsang (Sumatra); NORTH BORNEO: Brunei Bay, brackish water; Labuan, 2-15 fm.

**Distribution.** Thailand to Java.

**Discussion.** *M. tenuipes* has been adequately described by KUBO (1949) under this specific name (males), as well as under the name of *M. spinulatus* (females), and its detailed redescription is therefore unnecessary. The erection of the separate species *M. spinulatus* by KUBO was obviously aided by the fact that *M. tenuipes* displays a number of morphological features which are sexually dimorphic to a greater degree than in other related species of this group. KUBO's failure in recognizing that *M. tenuipes* and *M. spinulatus* belong to the same species, can furthermore be explained by his lack of females of the former, and males of the latter species. The material examined during the present study revealed clearly that KUBO's 2 species represent the males and females of one species, and should therefore be united. Since *M. tenuipes* has page priority in KUBO's (1949) paper, *M. spinulatus* must be relegated to a synonym.

Features of sexual dimorphism in this species are the pubescence on carapace and abdomen, the shape and dentition of rostrum, the length of pereopods, the length of the ischial spine on 1st pereopod, and the armature of the telson. The tomentose areas on carapace and pleon of males examined during the present study are not as large or numerous as those shown by KUBO; nor is the body of females devoid of similar patches justifying KUBO's description "shell glabrous". However, in most

of our males the pubescence appears slightly more pronounced than in the females examined. The rostrum in males lacks the posterior triangular crest present in females, and the dentition in males is 5-6+epigastric, while in the females of our series there are 6-7 teeth+epigastric. The pereopods are all longer in females than in males. The ischial spine on the 1st pereopod is small in both sexes, but in males it is obscured by long tomentum and can be easily overlooked. The telsonic spinules in males progressively increase in size towards the apex of the telson, and the distal pair of "spines" are therefore less distinct than in females, in which there is an abrupt increase in the length of these spinules in the posterior  $\frac{1}{3}$  of the telson.

The petasma, which is shown on Plate 7 fig. 1, is similar to that of *M. joyneri*. The thelycum (Plate 12 fig. 2) is readily distinguishable from that of other species, although it shows close affinities to *M. brevicornis*.

As already mentioned in the discussion of the foregoing species, BURKENROAD (personal communication) considers both *M. tenuipes* and *M. spinulatus* synonymous with DANA's (1852) *P. avirostris*. The relative paucity of specimens of *M. tenuipes* available, and the somewhat obscure description of DANA's species, make it impossible for the present writers to attempt such a revision, and it is thought advisable to retain KUBO's specific name until additional information is available.

***Metapenaeus eboracensis* Dall, 1957**

(Plate 7 fig. 2; Plate 12 fig. 3)

*Metapenaeus eboracensis* Dall, 1957, pp. 193-96. Racek, 1959, p. 10.

Material. 13 ♂♂, 29 ♀♀, 61-111 mm; NORTHERN TERRITORY: Van Diemen's Gulf, Chambers Bay; QUEENSLAND: S.E. off Thursday I., Gulf of Carpentaria, Princess Charlotte Bay, Townsville; NEW GUINEA: Daru, Orangerie Bay, Kinikini Bay. Depth of occurrence 2-15 fm.

Distribution. Northern Territory to Gulf of Carpentaria, through Torres Strait north to Papua, south to about Townsville, Queensland.

Discussion. *M. eboracensis* has been adequately described by DALL (1957) and the examination of the present specimens has not offered any criteria for further discussion. However, the petasma and the thelycum of mature specimens have been photographed in order to augment the drawings accompanying DALL's original description.

This species is probably also closely related to *M. dobsoni* and its allies, although it is distinct from that group in the complete absence of petasmas or their rudiments, and conjoined white pads on the thelycum of impregnated females have not yet been observed.

The range of this species, originally thought to represent an Australian endemic form, can now be extended to New Guinea in the north and to the Darwin area in the west.

Genus *Atypopenaeus* Alcock

*Atypopenaeus* Alcock, 1905, p. 524; 1906, p. 45.

*Atypopenaeus* de Man, 1911, p. 83. Kubo, 1949, p. 365.

*Atypopenaeus* Dall, 1957, pp. 198-99.

Type-species by original designation: *Penaeus compressipes* Henderson, 1893.

Prior to the revision of DALL (1957), who amended the generic definition of ALCOCK (1905, 1906), this genus comprised only two determinable species, i.e. *A. compressipes* (Henderson), the type species, and *A. dearmatus* de Man. DALL (1957) described an additional species, *A. formosus*, from north-eastern Australia, and the present investigations revealed the presence of still another species, *A. bicornis* sp. nov., in waters of New Guinea. HALL (1962) has relegated *A. compressipes* to a synonym of *A. stenodactylus* (Stimpson), an approach which as yet cannot be followed by the present authors, since in their material *A. compressipes* is represented by only a solitary female from New Guinea. *A. dearmatus* is not present in the collections for the present study.

*Atypopenaeus compressipes* (Henderson, 1893)

(Plate 12 fig. 4)

*Penaeus compressipes* Henderson, 1893, pp. 450-51.

*Atypopenaeus compressipes* Alcock, 1906, pp. 45-46.

*Atypopenaeus compressipes* de Man, 1911, pp. 83-84. Kubo, 1949, pp. 366-68.

*Atypopenaeus compressipes* Dall, 1957, p. 199 (key).

*Parapenaeopsis brevirostris* Kubo, 1936, pp. 55-58.

? *Penaeus stenodactylus* Stimpson, 1860, p. 431.

? *Atypopenaeus stenodactylus* Hall, 1962, pp. 25-26.

Material. NEW GUINEA: Yule I., Papua, mud, coll. L. W. FILEWOOD, October 1962, ♀, 46 mm.

Distribution. Indian seas through Malaysian and Hong Kong waters to Japan.

Discussion. The single female examined, which represents the first record of this species from New Guinea, agrees in all major details with the previous descriptions of *A. compressipes*, except in some minor points as discussed by KUBO (1949). It is possible that distant populations will be found to show certain speciation trends, and detailed studies of this species and its allies appear desirable. The status of *P. stenodactylus* Stimpson from Hong Kong has still to be resolved. HALL (1962) relegated the readily determinable *A. compressipes* to a synonym of STIMPSON's (1860) species without giving any reasons for his decision, other than a reference to an apparently still unpublished manuscript. Even though *P. stenodactylus* certainly must be considered congeneric, its identity with *A. compressipes* has yet to be demonstrated. *P. stenodactylus*, judging from STIMPSON's description, still differs from *A. compressipes* by

the shorter postrostral carina, the finely granulated dorsum of the carapace, and the greater length of the outer maxillipeds, which extend beyond the antennal scales (fide DE MAN, 1911). In these details, the female from New Guinea is distinctly different from STIMPSON's description of *P. stenodactylus*, while it is readily comparable with all previous descriptions of *A. compressipes*.

***Atypopenaeus formosus* Dall, 1957**

(Plate 7 figs. 3, 4; Plate 12 fig. 5)

*Atypopenaeus formosus* Dall, 1957, pp. 199–202.

*Atypopenaeus formosus* Racek, 1959, pp. 10, 12.

**Material.** 7 ♂♂, 15 ♀♀, 43–81 mm; **NORTHERN TERRITORY:** Joseph Bonaparte Gulf, coll. V. WELLS ("Paxie"), 5.X.1961, 17 fm, coral and polyzoa; Chambers Bay, coll. V. WELLS ("Paxie"), 7.XI. 1959; **QUEENSLAND:** Keppel Bay, coll. "Challenge", July 1957; **NEW GUINEA:** 8 miles E. off Parama I., in the Fly R. mouth, coll. L. W. FILEWOOD, July 1963.

**Distribution.** Moreton Bay (type locality) to Gulf of Carpentaria, Queensland, ranging west to the Darwin area, Northern Territory, and north into Papua, New Guinea.

**Discussion.** *A. formosus* has been adequately described by DALL (1957), and the present material has not offered any additional criteria for discussion. However, the petasma and thelycum of this species have been photographed in order to augment DALL's original illustrations. The range of this species can now be extended west to the vicinity of Darwin, Northern Territory, and north to Papua, New Guinea.

***Atypopenaeus bicornis* sp. nov.**

(Figure 14; Plate 7 figs. 5, 6; Plate 12 fig. 6)

**Material.** **NEW GUINEA:** Off Fly R. mouth, coll. Dr. A. M. RAPSON, 6.IV.1955, holotype ♂, 61 mm, allotype ♀, 76 mm, paratypes 2 ♀♀, 65, 73 mm; paratypes: off South Fly R., 7.IV.1955, ♀, 74 mm; Yule I., Papua, coll. L. W. FILEWOOD, October 1962, ♂, 58 mm; 8 miles E. off Parama I., in the Fly R. mouth, coll. L. W. FILEWOOD, July 1963, ♀, 70 mm.

**Description.** Rostrum strongly sexually dimorphic; in ♂ distinctly sigmoid, its anterior  $\frac{1}{2}$  edentate and styliiform, reaching to middle of 2nd antennular segment, dorsally armed with 2 wide-set teeth + epigastric; in ♀ long, slender, and upcurved, teeth uniformly spaced along its entire length, exceeding tip of antennular peduncle, dorsally armed with 5–6 wide-set teeth + epigastric; in both sexes epigastric and penultimate tooth on carapace. Adrostral carina and sulcus absent. Postrostral carina distinct but flat, ending at  $\frac{1}{5}$  length of carapace from its posterior margin. Postocular sulcus very deep, indenting base of rostrum, running at an angle of 40° to rostrum, sigmoidal in lateral view. Orbital spine completely

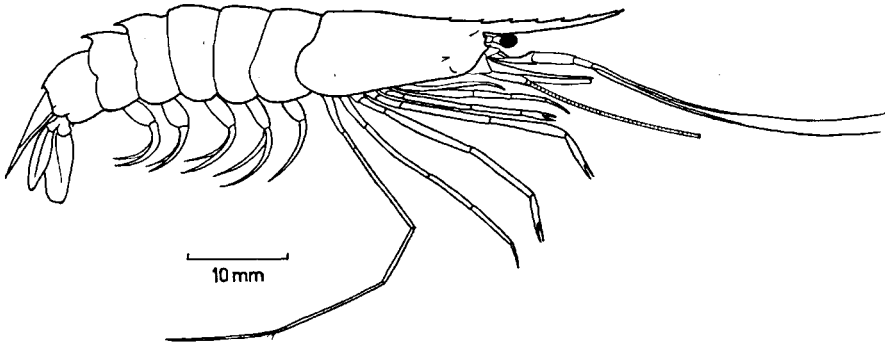


Fig. 14. *Atypopenaeus bicornis*, sp. nov., ♀, 65 mm, paratype, Fly R. mouth.

absent in ♂, in ♀ represented by a blunt tubercle. Antennal and hepatic spines small and conical; cervical sulcus extremely short and barely perceptible. A wide shallow indentation only in front of and below hepatic spine, sulcus absent. Branchiocardiac sulcus feebly indicated.

Eyes with slender peduncle, cornea (measured anteroposteriorly) from  $\frac{1}{10}$  to  $\frac{1}{12}$  length carapace.

Antennules with equal flagella, which are  $2\frac{1}{2}$  length of antennular peduncle and  $1\frac{3}{4}$  length carapace in ♂, slightly more than twice length antennular peduncle and about  $1\frac{1}{2}$  length carapace in ♀. Prosartema reaching tip of junction of optic peduncle with cornea; stylocerite attaining  $\frac{2}{3}$  basal segment. Second segment cylindrical, equal length of 1st; 3rd segment somewhat less than  $\frac{1}{3}$  length 2nd, often inclined at blunt angles to it.

Third maxilliped reaching to tip of 2nd antennular segment; 1st pereopod exceeding carapace by entire chela; 2nd and 3rd surpassing tip of scaphocerite by  $\frac{1}{4}$  carpus and entire chela, 4th by  $\frac{1}{4}$  dactylus; 5th almost attaining tip of antennular flagella. Excepting 5th legs, thoracic appendages with long and dense setae, particularly on ventral edges of 2nd to 4th pereopods. Fifth pereopods very slender, particularly the distal 3 joints; dactylus usually long and filiform, a small tuft of apical setae on propodus. Telson without lateral spines or spinules.

A broad and low dorsal carina on 1st and 2nd abdominal somites, as well as in anterior  $\frac{1}{2}$  of 3rd, a sharp carina beginning in posterior  $\frac{1}{2}$  of 3rd pleonic tergum and extending to posterior margin of 6th; a conspicuous spine, arising from a flat and wide base, on posterior end of carina on 4th and 5th somite; small spine on tergum of 6th, often broken off, resulting in a bluntly or sharply rounded shape of the posteromedian angle.

The petasma is shown on Plate 7 figs. 5, 6. The prominent distolateral projections have the shape of curved incisor teeth, projecting forwards and bent inwards; their apices are bluntly serrated; 2 small and ovoid distomedian projections at the base of the "incisors".

The thelycum is shown on Plate 12 fig. 6. Anterior plate lanciform with oval median depression and spinous apex, coxal projections from 4th pereopod lying above it; posterior margin slightly convex. Lateral plates parallel to each other, flattish and leaf-shaped, enclosing posterior part of anterior plate; posteriorly the lateral plates meet a U-shaped extension of the posterior sternal plate, making an almost circular seminal receptacle.

Colour in life. Given by our collectors as a bright pink.

Distribution. So far known only from the type locality.

Discussion. *A. bicornis* shows close affinities to *A. compressipes* in regard to its petasma, but differs from the latter species, as well as from *A. dearmatus* in a great number of characters. It is very closely related to *A. formosus*, sharing with it the peculiar and long rostrum, the prominent abdominal median spines, and a similar arrangement of the thelycal structures. However, it differs from *A. formosus* in the features on next page.

All the specimens of *A. bicornis* examined were found to emit a strong and unpleasant odour, even though they were kept in alcohol for a relatively long time. The writers are as yet unable to ascertain whether this apparently characteristic odour is perceptible in live or freshly dead specimens, and field observations are desirable.

### Genus *Trachypenaeus* Alcock

*Trachypeneus* Alcock, 1901, p. 15; 1906, p. 43. Burkenroad, 1934a, pp. 94-96.

*Trachypenaeus* de Man, 1911, pp. 87-88. Balss, 1914, p. 11. Kubo, 1949, pp. 391-92. Liu, 1955, p. 14. Dall, 1957, p. 202.

Type-species by original designation: *Penaeus anchoralis* Bate, 1881.

BURKENROAD (1934a), in his desire to demonstrate specified taxonomic characters within the genus *Trachypenaeus*, established two subgenera, *Trachypenaeus* and *Trachysalambria*, largely on the presence or absence of mastigobranchiae on the 1st and 2nd pereopods. However, since prior to 1962 only one species of the subgenus *Trachysalambria*, i.e. *T. curvirostris*, was known from the Indo-West Pacific, most of the workers on material from that region considered a subdivision of *Trachypenaeus* (Alcock) unnecessary. The description of an additional species, *T. sedili*, by HALL (1962), and the discovery of the similarly aberrant *T. gonospinifer* sp. nov. by the present writers, made it clear that these 2 species do not readily fit into any of BURKENROAD's subgeneric divisions. Both have mastigobranchiae on their 1st and 2nd pereopods, and would thus fall into BURKENROAD's subgenus *Trachysalambria*. However, their thelycum is quite an unusual structure, and cannot be interpreted as consisting of "a pair of invaginated sperm sacs, whose apertures are continuous medially with the opening of an unpaired pocket into which sperm-free male secretion is received" (BURKENROAD, 1934a, p. 94).

Criterion	<i>A. bicornis</i>	<i>A. formosus</i>
Rostrum	Strongly sexually dimorphic.	Similar in both sexes.
Postrostral carina	Flat but distinct.	Indistinct to absent.
Orbital spine	Rounded tubercle in ♀, absent in ♂.	Small but distinct in both sexes.
Cornea	$1/10$ – $1/12$ length carapace.	$1/7$ length carapace.
Antennular flagella	$2\frac{1}{2}$ length of peduncle in ♂; twice length of peduncle in ♀.	Length of peduncle in ♂; at least twice length of peduncle in ♀.
Third maxilliped	Reaching to tip of 2nd antennular segment.	Reaching $1/2$ 2nd antennular segment.
First pereopod	Exceeding carpocerite by chela.	Exceeding carpocerite by dactyl.
2nd and 3rd pereopods	Surpassing tip of scaphocerite by $1/4$ carpus and chela.	Reaching about $1/2$ 2nd antennular segment.
Fourth pereopod	Surpassing tip of scaphocerite by $1/4$ dactylus.	Slightly exceeding base of 2nd segment.
Fifth pereopod	Almost attaining tip of antennular flagella; dactylus as long as propodus.	Slightly exceeding tip of antennular peduncle; dactylus much shorter than propodus.
Pleonic carination	Begins on 1st somite; acute spines on terga of 4th–5th somites strongly raised.	Begins on 4th somite; acute spines on terga of 4th–5th somites moderately raised.
Distolateral petasmal projections	Incisor-like, curved.	Ovoid, smoothly rounded.
Thelycum	Lateral plates flattish leaf-like; anterior extension of posterior sternal plate U-shaped, receptacle nearly circular.	Lateral plates a rounded bar shape; anterior extension of posterior sternal plate V-shaped, receptacle pentagonal.



The present writers consider it therefore advisable to treat their material as belonging to the genus *Trachypenaeus* (Alcock), as amended by DALL (1957). At the present, no effort is made to accentuate the possible interspecific relationship of the Indo-West Pacific species of this genus studied.

For the differentiation of the hitherto-known species of *Trachypenaeus* the reader is referred to DALL's (1957, p. 203) key, as well as to the recent work of HALL (1962, pp. 180–81). In view of the pronounced speciation trends perceptible in the majority of species of this genus, a revised key cannot as yet be contemplated and additional observations are desirable.

### ***Trachypenaeus curvirostris* (Stimpson, 1860)**

*Penaeus curvirostris* Stimpson, 1860, p. 44. Kishinouye, 1900, p. 23.

*Penaeus granulosus* Miers, 1884, p. 295 (non Haswell, 1879, 1882).

*Parapenaeus curvirostris* Rathbun, 1902, p. 38.

*Trachypeneus asper* Alcock, 1905, p. 531; 1906, p. 43.

*Trachypeneus curvirostris* Alcock, 1905, p. 523. Schmitt, 1926, pp. 353–58. Hall, 1962, p. 29.

*Trachypeneus (Trachysalambria) curvirostris* Racek, 1955, pp. 235–56 (except fig. 4, Plate 7); 1959, p. 10.

*Trachypenaeus curvirostris* Balss, 1914, p. 11; 1924, p. 44. Kubo, 1949, pp. 393–95. Liu, 1955, pp. 14–16. Dall, 1957, pp. 203–06. Cheung, 1960, p. 65 (key).

**Material.** Numerous specimens of both sexes, 22–91 mm; WESTERN AUSTRALIA: Shark Bay, Exmouth Gulf; NORTHERN TERRITORY: Off Darwin; QUEENSLAND: Bowen, Repulse Bay, Mackay, Keppel Bay, Heron I., Sandy Cape, Moreton Bay, Southport; NEW SOUTH WALES: Ballina, Evans Head, Yamba, Sydney Harbour; NEW GUINEA: Kinikini Bay, Yule I.; NEW BRITAIN: Wide Bay; comparative specimens from Japanese waters, and Mafia Archipelago, Tanganyika.

**Distribution.** From eastern Africa through Indian and Malaysian waters to Japan and Australia. Depth of occurrence 10–30 fm.

**Discussion.** *T. curvirostris* has been adequately described and figured, and the material examined has not offered any additional criteria for discussion. In spite of its apparently wide distribution, this species is not present in material collected for the present study from Indonesia, North Borneo, or the Philippines. Its occurrence in coastal waters of Northern Australia is also somewhat rare, a phenomenon which can possibly be explained by the preference of *T. curvirostris* for greater depths (DALL, 1957).

### ***Trachypenaeus gonospinifer* sp. nov.**

(Figure 15; Plate 7 figs. 7, 8; Plate 12 fig. 7)

**Material.** NEW GUINEA: S. of Port Romilly, 7° 55' S., 144° 48' E., coll. Dr. A. M. RAPSON, 6.IV.1955, 7 fm, holotype ♀, 74 mm; Fly R.

estuary, off Kiwai I., 26.IV.1955, paratypes, 2 ♀♀, 62, 65 mm; Fly R. mouth, 6.IV.1955, paratype ♀ 68 mm; NORTHERN TERRITORY: Chambers Bay, 12° 12' 8" S., 131° 31' 2" E., coll. V. WELLS ("Paxie"), 7.XI.1959, 9 fm, grey mud, allotype ♂, 45 mm, paratypes 4 ♀♀, 34-39 mm, 2 ♀♀, 40, 58 mm.

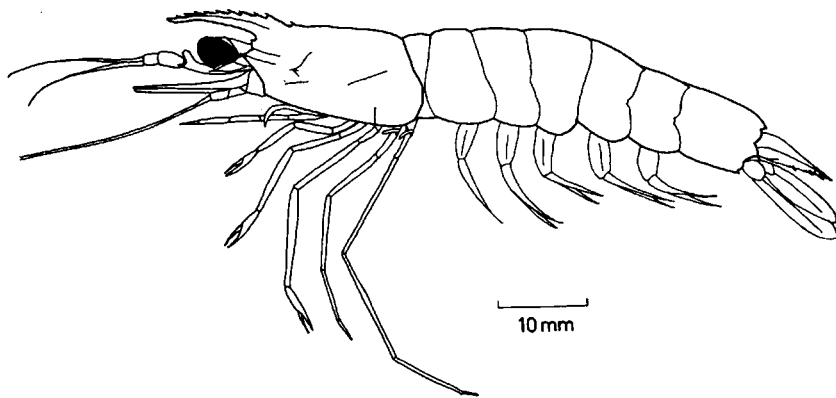


Fig. 15. *Trachypenaeus gonospinifer*, sp. nov., ♀, 74 mm, holotype.

Description. Base of rostrum ascending well above level of carapace, distal  $\frac{1}{2}$  recurved to horizontal position in both sexes and very slender; upper rostral margin distinctly convex; rostrum only slightly exceeding tip of basal antennular segment in ♂, reaching  $\frac{1}{3}$ – $\frac{2}{3}$  2nd antennular segment in ♀; armed with 7–9 (usually 8) teeth+epigastric, the latter and the penultimate tooth on carapace. Adrostral carina slightly sigmoidal, ending below penultimate rostral tooth. Postrostral carina distinct but low, reaching to posterior margin of carapace. Longitudinal suture reaching almost to level of epigastric tooth at  $\frac{1}{5}$  carapace. An indistinct and short transverse suture at the bases of 3rd pereopods. A shallow postocular sulcus present below end of adrostral carina; orbital angle sharp; gastro-orbital carina and orbito-antennal sulcus absent. Cervical sulcus feeble and shallow. Antennal carina reaching  $\frac{1}{2}$  distance between tip of antennal and hepatic spines. A shallow sulcus below hepatic spine; branchiocardiac carina distinct,  $\frac{1}{3}$  length carapace. Pterygostomial angle sharp.

Antennular flagella subequal, upper flagellum longer than lower,  $1\frac{1}{3}$  as long as peduncle, and about as long as carapace. Prosartema reaching as far as eye, stylocerite almost attaining  $\frac{1}{2}$  basal segment.

Scaphocerite exceeding antennular peduncle by  $\frac{1}{5}$  its length; carpocerite reaching  $\frac{2}{3}$  cornea.

Mandibular palp reaching base of carpocerite, distal segment  $\frac{3}{5}$  as wide as long, triangular, with distolateral margin straight. Incisor process

with 2 well separated teeth, molar process with 2 flat posterior teeth, and 2 rounded anterior tubercles. Maxillular palp unsegmented with 2 inner projections; the proximal rounded and setose, the distal acute and bearing 2-3 sharp spines; posterodistal surface with a row of 6 sharp spinules.

Third maxilliped reaching as far as, or slightly exceeding, tip of basal antennular segment; 1st pereopod exceeding tip of carpocerite by dactyl; 2nd reaching to tip of antennular peduncle, 3rd exceeding it by dactyl; 4th about as long as 2nd; 5th very long and slender, and exceeding tip of scaphocerite by at least  $\frac{1}{2}$  propodus and dactylus. Basial spines on 1st and 2nd pereopod, and a small ischial spine on 1st. Mastigobranchiae on 1st-3rd pereopods.

A small and elongated median tubercle on 2nd abdominal somite, dorsal carina beginning from anterior margin of 3rd somite; 4th and 5th somites with posteromedian notch and 2 acute processes on either side; 6th somite with a small median tooth, and a pair of small lateral teeth below the rounded postero-inferior angle. Telson shorter than inner uropods, armed with 3 pairs of mobile spinules, the subapical set larger than the 2 preceding pairs.

Cardiac plate of gastric mill with 10-12 small indistinct spinules. Zygocardiac ossicle consisting of an upper portion, the 1st tooth large and triangular, followed by 3-4 flat-topped teeth, then a row of 6-8 small sharp teeth; below the 1st tooth a smaller conical tooth, and below this a cluster of 5-6 small spines; lower portion a large tooth, followed by a row of about 10 smaller teeth. Prepyloric ossicle with 12-14 teeth on either side.

The petasma is shown on Plate 7 figs. 7, 8. Distolateral projections very broad, lateral tips curving forward, anteromedian processes broadly triangular; distomedian projections curved ventrally, fully closing distal opening of petasma. Greatest width of petasma across distolateral projections in about anterior  $\frac{1}{3}$  of its length, almost equal to length.

The thelycum is shown on Plate 12 fig. 7. Anterior plate broadly oval, representing the wide base of a large forwardly directed spine with slightly broadened and flattened apex; lateral plates heavily chitinized, with posterior semicircular rim extending anteriorly to enclose a shallow and smooth lunar depression. In fertilised females a pair of brownish spermatophores are implanted on either side of the lunar depression.

Colour in life. Not yet observed.

Distribution. To date known only from southern New Guinea, and the vicinity of Darwin, Northern Territory.

Discussion. At the time of the discovery of *T. gonospiniifer* in material from New Guinea, which contained only female specimens, the assessment of the generic position of this species presented certain difficulties. The thelycum was then incomparable with that of any other species of the subfamily Penaeinae, and the apparent absence of mastigobranchiae on

the 3rd pereopods pointed to a relationship to the genus *Parapenaeopsis*, even though the carapace, the short longitudinal suture, and the telsonic armature were more reminiscent of *Trachypenaeus* spp. However, the subsequent collection of specimens of both sexes of our new species from waters off the Northern Territory revealed clearly that epipodites are present on the 3rd pereopods, and that the petasma, although slightly aberrant, is that of a typical *Trachypenaeus* sp.

Meanwhile, HALL (1962) recorded and illustrated a new *Trachypenaeus* sp., *T. sedili*, from Malaysian waters, of which the male is still unknown. Judging from that author's depiction of this species, the thelycum shows close affinities to that of *T. gonospinifer*, and so do the filiform 5th pereopods, and the sharply pointed and slender rostrum. Since *T. sedili* has not yet been described (HALL merely referred to an apparently still unpublished manuscript), its detailed comparison with our new species cannot be contemplated. However, *T. gonospinifer* appears distinctly different from *T. sedili* in the following criteria, assessed from HALL's drawings of the latter species:

Criterion	<i>T. gonospinifer</i>	<i>T. sedili</i>
Rostrum	Base distinctly elevated; distal $\frac{1}{2}$ deflected to horizontal position; upper margin convex; reaching $\frac{2}{3}$ 2nd antennular segment.	Base not elevated; distal $\frac{1}{3}$ slightly upcurved; upper margin slightly concave; reaching $\frac{1}{2}$ 3rd antennular segment.
Branchiocardiac carina	Distinct, $\frac{1}{3}$ length carapace.	Not indicated in figure.
Antennulae	$1\frac{1}{3}$ length peduncle, as long as carapace.	$\frac{9}{10}$ length peduncle, $\frac{6}{10}$ length carapace.
5th pereopod	Exceeding scaphocerite by at least $\frac{1}{2}$ propodus.	Attaining $\frac{7}{10}$ of scaphocerite.
Anterior thelycal plate	Anterior spine prominent; plate not in contact with lateral plates.	Anterior spine small; plate partially obscured by lateral plates.
Lateral thelycal plates	Narrow, rim-like; seminal receptacle a smooth, almost circular depression.	Wider, leaf-shaped; seminal receptacle appears subdivided into lateral pockets.

In view of these differences, *T. gonospinifer* must be considered a distinct species, even though it has not yet been compared with the type material of *T. sedili*. It is very likely that the male of the Malaysian species will have a petasma similar to that of our new species.

**Trachypenaeus fulvus** Dall, 1957

*Trachypenaeus fulvus* Dall, 1957, pp. 106-09.

*Trachypenaeus asper* Kubo, 1949, pp. 395-98. Cheung, 1960, p. 65 (key). (Non *T. asper* Alcock, 1906).

*Trachypeneus fulvus* Hall, 1962, pp. 29-30.

*Trachypeneus (Trachysalambria) curvirostris* Racek, 1955, (Plate 7, figure 4 only).

**Material.** Numerous specimens of both sexes, 32-79 mm; WESTERN AUSTRALIA: Exmouth Gulf, Shark Bay; QUEENSLAND: Gulf of Carpentaria, Keppel Bay, Moreton Bay; NEW GUINEA: Orangerie Bay, Kinikini Bay, Yule I., W. of Mogubu; PHILIPPINES: Manila Bay; NORTH BORNEO: Marudu Bay, off Kudat.

**Distribution.** Malaysia (HALL) through Indonesian waters (KUBO) to the Philippines, and south to Australia (DALL, RACEK).

**Discussion.** All specimens from Australia fully agree with the description and illustrations of *T. fulvus* by DALL (1957), and differ from *T. "asper"* Kubo (1949) in all those points already discussed in DALL's paper. On the other hand, some specimens from New Guinea, and all from North Borneo and the Philippines examined have much longer pereopods and are thus fully comparable with those of KUBO's material of *T. "asper"*.

Detailed morphometrical studies, involving both these apparently constantly differing forms, have failed to establish specific differences. The thelycum and petasma, the appendix masculina, the rostrum, the abdomen, the length of the antennular flagella, and the structure of the carapace are indistinguishable. It is very likely that *T. fulvus*, a distinctly shallow-water species, will be found to display speciation trends in distant populations. This assumption appears supported by the fact that the "short-legged" form is restricted to Northern Australia, whereas the "long-legged" condition has an equatorial spread from Malaysia to the Philippines, and New Guinea.

In view of the conspicuous difference in pereopodal length, a subdivision of *T. fulvus* into two subspecies would already appear justified. However, the comparatively limited number of specimens of *T. "asper"* in the material examined does not as yet permit such a decision by the present authors, and further collections and morphometric studies are therefore desirable.

**Trachypenaeus anchoralis** (Bate, 1888)

(Plate 7 fig. 10; Plate 12 fig. 8)

*Penaeus anchoralis* Bate, 1888, pp. 258-61 (female only).

*Trachypeneus anchoralis* Alcock, 1906, p. 54. Schmitt, 1926, pp. 348-51.

*Trachypeneus (Trachypeneus) anchoralis* Racek, 1955, pp. 236-37; 1959, p. 10.

*Trachypenaeus anchoralis* Dall, 1957, pp. 209-11 (non de Man, 1911, pp. 88-90).

**Material.** Numerous specimens of both sexes, 38-104 mm; WESTERN AUSTRALIA: Shark Bay, Exmouth Gulf; NORTHERN TERRITORY: Chambers

Bay; QUEENSLAND: Gulf of Carpentaria, Princess Charlotte Bay, Townsville, Repulse Bay, Keppel Bay, Heron I. Depth of occurrence 7–29 fm.

Distribution. Apparently endemic to Australia, ranging from northern Western Australia to about Keppel Bay, Queensland.

Discussion. *T. anchoralis* has been adequately described and figured by SCHMITT (1926) and DALL (1957), and the examination of the present material has not offered additional criteria for discussion. However, the petasma and the thelycum of this species have been photographed, in order to augment the drawings of the two authors mentioned above.

DALL (1957, p. 224) drew attention to the apparently restricted distribution of this species to Australian waters, but considered it possible that it may yet be found in Indonesian seas. However, *T. anchoralis* is not present in the voluminous material collected for the present study from Indonesia and New Guinea, and therefore must still be considered as a species endemic to northern Australia.

***Trachypenaeus granulosus* (Haswell, 1879)**

(Plate 3 fig. 4; Plate 7 fig. 9; Plate 13 fig. 1)

*Penaeus granulosus* Haswell, 1879, p. 41; 1882, p. 202 (female only).

*Trachypeneus granulosus* Schmitt, 1926, pp. 351–53.

*Trachypeneus (Trachypeneus) granulosus* Racek, 1959, pp. 10, 11.

*Trachypenaeus granulosus* Dall, 1957, pp. 211–13.

*Trachypenaeus salaco* de Man, 1907, p. 135; 1911, pp. 90–92.

? *Trachypeneus pescadoreensis* Schmitt, 1931, pp. 265–68. Hall, 1962, p. 29.

Material. QUEENSLAND: Princess Charlotte Bay, coll. "Challenge", 22.III.1958, mud and weed, 11 fm, ♂, 51 mm, ♀, 53 mm (first discovery in commercial trawl); Gulf of Carpentaria, coll. "Rama", October–December 1963, 5–7 fm, mud, 12 ♀♀, 78–90 mm, 3 ♂♂, 40–49 mm; Albany Passage, coll. M. WARD, September 1928, 9–12 fm, 1 ♂, 36 mm.

Distribution. Eastern Malaya through Indonesia to northern Australia.

Discussion. In spite of the paucity of specimens examined, *T. granulosus* has been adequately defined by SCHMITT (1926) and DALL (1957), so that its detailed redescription is unnecessary. Although DALL demonstrated the identity of the males of this species with those described by DE MAN (1907, 1911) as *T. salaco*, HALL (1962) associated DE MAN's species, together with females from Malaysian waters, with the rather insufficiently known Formosan species *T. pescadoreensis* Schmitt, of which the male has not as yet been found. Judging from HALL's illustrations, the thelycum and petasma of his Malaysian specimens would appear slightly different from these structures in *T. granulosus*, but the Malaysian as well as the Australian specimens lack the conspicuous longitudinal ridge on the anterior thelycal plate which SCHMITT (1931) showed to be a typical feature of *T. pescadoreensis*. The present authors consider it unlikely that SCHMITT, who only a few years earlier reviewed the Australian material of *T. granulosus*, could have erred in considering the Formosan

specimen distinct from HASWELL's species. However, without a re-examination of the type specimen of *T. pescadoreensis* it is impossible to decide whether its distinguishing criteria are of specific or subspecific nature.

In view of the rather scattered occurrence of *T. granulosus* in Australian waters, it seems reasonable to assume that this species will ultimately be found to display pronounced speciation trends in distant populations. The slightly differing shape of the petasmata of *T. granulosus*, *T. salaco*, and HALL's *T. pescadoreensis* from Malaysia, as well as the transition of thelycal characters in the Australian, Formosan, and Malaysian specimens of this group, appears to substantiate this assumption. These slight differences in secondary sexual characters are the following:

Criterion	<i>T. granulosus</i> (Haswell)	<i>T. salaco</i> de Man	<i>T. pescadoreensis</i> Schmitt	<i>T. pescadoreensis</i> Hall
Distolateral petasmal projections	Anterolaterally usually without wing-like flaps on outer curvature; anteromedian margins strongly reflected, forming sharp triangular prominence.	Anterolaterally with small wing-like flaps on outer curvature; anteromedian margins strongly reflected, forming sharp triangular prominence.	(Male unknown)	Anterolaterally with larger wing-like flaps on outer curvature; anteromedian margins slightly reflected, or merely angular.
Anterior thelycal plate	Slightly concave, without or with indistinct longitudinal ridge; posterior extension slightly projecting ventrally.	(Female unknown)	Flattish, with prominent longitudinal ridge; posterior extension slightly projecting ventrally.	Slightly concave, with indistinct longitudinal ridge; posterior extension forming a large ventral projection.

Should these slight differences be considered of specific nature, the males of *T. salaco* could not be associated with either *T. granulosus*, or *T. pescadoreensis* Hall, and the latter would then have to be redescribed as a distinct species, while the female of *T. salaco* would remain unknown. On the other hand, the much less pronounced differences in thelycal structures of the three species, of which females have been recorded, seem to emphasise their subspecific nature, as well as the closer relationship of HALL's Malaysian specimens to *T. granulosus* than to the true *T. pescadoreensis* from Formosan waters. The present authors are as yet unable to attempt a revision of this group of species, and the collection of many more specimens of *T. granulosus* and its allied species appears highly desirable.

The petasma and thelycum of *T. granulosus* from Australian waters

have been photographed in order to augment the drawings of these structures by SCHMITT (1926) and DALL (1957).

### Genus *Parapenaeopsis* Alcock

*Parapeneopsis* Alcock, 1901, p. 14; 1906, pp. 34–35. Burkenroad, 1934b, pp. 58–59.

*Parapenaeopsis* de Man, 1911, pp. 92–93. Balss, 1914, p. 14; 1925, p. 229. Kubo, 1949, pp. 368–70. Barnard, 1950, p. 604. Liu, 1955, p. 16. Dall, 1957, pp. 213–14.

Type-species by original designation: *Penaeus styliferus* H. Milne Edwards, 1837.

The above references provide adequate information on the generic definition of *Parapenaeopsis*. For the differentiation of the hitherto-known species of this genus the reader is particularly referred to the key to all Indo-Pacific species (DALL, 1957, pp. 214–15), as well as to the recent work of HALL (1962, pp. 26–29).

During the present investigations only the following 7 previously known species of *Parapenaeopsis* were found to occupy the general region studied: *P. stylifera* (H. Milne Edwards), *P. cornuta* (Kishinouye), *P. sculptilis* (Heller), *P. hardwickii* (Miers), *P. gracillima* Nobili, *P. hungerfordi* (Alcock), and *P. tenella* (Bate). Of these *P. stylifera* is present as the subspecies *P. stylifera coromandelica* (Alcock), while *P. cornuta* is represented by both its subspecies *P. cornuta cornuta* (Kishinouye), and *P. cornuta maxillipedo* (Alcock). An additional species, *P. arafurica* sp. nov. from waters of northern Australia and New Guinea, will be described below. *P. venusta* de Man, the male of which has recently been recorded by HALL (1962), is not present in the material examined, although it has been recorded by DALL (1957) from the Australian region.

The interspecific relationships within this genus can hardly be accentuated by using secondary sexual characters only. Both subspecies of *P. stylifera*, although having typical petasmata and thelyca, possess a telsonic armature of fixed spines, and can thus readily be distinguished from the remainder of the genus. *P. hungerfordi* possesses rather atypical outer genitalia, yet is fully comparable in all other criteria with its congeners. *P. gracillima* displays some unusual and aberrant morphological criteria, but its thelycum, and particularly its petasma, are characteristic for the genus. The grouping of *Parapenaeopsis* spp., as given hereunder, is therefore not to be interpreted as an intentional or significant arrangement.

### *Parapenaeopsis stylifera coromandelica* Alcock, 1906

(Plate 8 fig. 1; Plate 13 fig. 2)

*Parapeneopsis stylifera* var. *coromandelica* Alcock, 1906, p. 37.

*Parapeneopsis coromandelica* Hall, 1962, p. 27.

Material. Numerous specimens of both sexes, 76–117 mm: INDONESIA: Tjilatjap (Java), Padang (Sumatra), eastern Borneo (Kalimantan), leg. G. KHOE SIAUW HWIE, August 1962.



**Description.** Rostrum sigmoidal, distal  $\frac{1}{2}$  styliform and edentate, strongly upcurved, in both sexes much overreaching tip of antennular peduncle; dorsally armed with 4–6 teeth + epigastric. Adrostral carina ending about half way between epigastric and penultimate tooth, sulcus shallow. Postrostral carina distinct, almost reaching to posterior margin of carapace, with a pitted area about half way between epigastric tooth and posterior margin of carapace.

Orbital spine small, postocular sulcus moderately deep, at angle  $45^\circ$  to rostrum. Longitudinal suture becoming indistinct posteriorly, reaching  $\frac{2}{3}$  carapace. Cervical sulcus shallow and short, not quite reaching longitudinal suture. Antennal spine prominent, antennal carina ending below hepatic spine. Hepatic sulcus pronounced, slightly more than  $\frac{1}{3}$  length carapace, sinuous, attaining horizontal position in its anterior  $\frac{1}{4}$ ; hepatic carina distinct only for lower  $\frac{1}{2}$  sulcus, commencing from below hepatic spine and reaching to the sharp pterygostomial angle. Branchiocardiac sulcus barely perceptible, or absent.

Antennular flagella subequal, 1.8 length peduncle, and slightly longer than carapace in both sexes.

Third maxilliped surpassing carapocerite by dactyl; 1st pereopod reaching to base of carapocerite, 2nd to tip of carapocerite; 3rd exceeding carapocerite by chela, 4th slightly exceeding carapocerite; 5th attaining  $\frac{2}{3}$  2nd antennular segment. Mastigobranchiae and basial spines on 1st 2 pereopods.

Abdominal carination beginning from posterior  $\frac{1}{3}$  of 3rd somite, carina on 6th ending in a sharp spine; dorsal sulcus absent. A pair of lateral cicatrices on 6th abdominal somite only. Telson with 1–2 pairs of conspicuous subapical fixed spines; when 2 pairs are present, the distal set about twice the length of the preceding; proximal  $\frac{7}{10}$  of telson unarmed.

The petasma (Plate 8 fig. 1) reaches bases of 3rd pereopods; distolateral projections slender, horn-like, and straight, directed anterolaterally at  $45^\circ$  to petasmas axis, with ventral openings; distomedian projections small and curved ventrally. Proximal lateral enlargements of petasma of moderate size and evenly rounded.

The thelycum is shown on Plate 13 fig. 2. Anterior thelycal plate slightly concave and square, with rounded anterolateral corners; in fully mature females its anterior margin occasionally trilobed; posterior extension a slender, stem-like process. Lateral plates subrectangular, fused posteriorly, each with an anteromedian indentation, corresponding to a knob-like posterior process of the anterior plate.

Colour in life. Not yet observed.

**Distribution.** East coast of India (ALCOCK) through Malaysian waters (HALL) to Indonesia.

**Discussion.** *P. styliifera coromandelica* apparently has never been completely described, though ALCOCK (1906) provided useful drawings of his "variety", and pointed to the fact that it differs from *P. styliifera* (Milne Edwards) in telsonic armature. HALL (1962) considered this

difference as sufficient for specific discrimination, and raised ALCOCK's "variety" to specific rank. Our specimens examined are fully comparable with ALCOCK's illustrations of *P. s. coromandelica*, and differ from the true *P. stylifera* not only in the reduced, though more conspicuous, telsonic armature, but also in the smaller number of rostral teeth. Since all other morphological criteria are in complete agreement in both these forms, and the petasmata and thelyca are indistinguishable, the specific separation of ALCOCK's "variety" from MILNE EDWARDS' species cannot be attempted. However, the present authors are fully aware that these two forms represent distinct, and geographically separated, races, and consider it necessary to retain their taxonomic distinction at an infra-specific level. Consequently, the two subspecies *P. stylifera stylifera* (Milne Edwards), and *P. stylifera coromandelica* (Alcock) are herewith proposed.

***Parapenaeopsis cornuta cornuta* (Kishinouye, 1900)**

(Plate 8 fig. 2; Plate 13 fig. 3)

*Penaeus cornutus* Kishinouye, 1900, p. 23.

*Parapenaeopsis cornuta* de Man, 1911, p. 93.

*Parapenaeopsis cornutus* Maki and Tsuchiya, 1923, pp. 43-44. Kubo, 1949, pp. 374-78. Dall, 1957, pp. 215-17. ?Cheung, 1960, p. 67 (key).

*Parapeneopsis cornuta* Racek, 1959, p. 10.

Material. 31 ♀♀, 8 ♂♂, 58-112 mm; WESTERN AUSTRALIA: Exmouth Gulf; QUEENSLAND: Gulf of Carpentaria, Townsville, Keppel Bay, Sandy Cape; NEW SOUTH WALES: off Ballina (1 ♀); INDONESIA: Tjilatjap (Java).

Distribution. Hong Kong (CHEUNG) to Japan (KISHINOUE, MAKI and TSUCHIYA, KUBO); southern Java (DE MAN) to tropical Australia (DALL, RACEK).

Discussion. *P. cornuta* (Kishinouye) and *P. maxillipedo* Alcock are listed in previous literature as two distinct species, differing from each other primarily by the absence or presence of a basal spine on the ♀ 3rd pereopod. ALCOCK (1906), in describing *P. maxillipedo*, already expressed some doubts as to the possibility of its specific separation from *P. cornuta*, but to-date the status of ALCOCK's species remained unchallenged.

The examination of specimens of both these "species" during the present study demonstrated beyond doubt that their specific separation is unjustified. Morphometric studies revealed that the secondary sexual characters of *P. maxillipedo* are identical with those of *P. cornuta*, and that the few additional criteria, listed by DALL (1957) as distinguishing features, are subject to variation in distant or isolated populations. The gastric mill formulae fail to aid in the distinction of the two "species", a fact which is evident from the discrepancies, also listed by DALL, between Australian and Japanese specimens of *P. cornuta*. Although the

basial spine on the ♀ 3rd pereopod is quite distinct in specimens of this complex from Malaysia, the Philippines, and New Guinea, as well as absent in most specimens from northern Australia, some Australian specimens display a minute basial spine, and in Indonesian material this spine is vestigial.

Furthermore, even the racial discrimination of these two forms appears unsupported by a distinct distributional pattern, such as available for the *P. stylifera* complex. Clear-cut distributional barriers, separating the two "species" from each other are lacking, although the female condition of *P. maxillipedo* appears to have an equatorial spread, whereas the condition of *P. cornuta* seems to be confined to the Japanese and Australian regions. Even though these two species are undoubtedly conspecific, the present authors prefer not to obscure the existing slight discrepancies by relegating *P. maxillipedo* to a mere synonym of *P. cornuta*, and treat their material as belonging to 2 subspecies, *P. cornuta cornuta* (Kishinouye), and *P. cornuta maxillipedo* (Alcock). This arrangement, however, is unable to improve the difficult distinction of males, and further studies of this species complex are highly desirable.

*P. cornuta* (Kishinouye) has been adequately described by previous authors, and the reader is particularly referred to the papers by KISHINOUE (1900), KUBO (1949), and DALL (1957).

#### ***Parapeneopsis cornuta maxillipedo* Alcock, 1906**

*Parapeneopsis maxillipedo* Alcock, 1906, pp. 40-41. Hall, 1962, p. 26.

*Parapeneopsis maxillipedo* Kubo, 1949, pp. 380-81. Dall, 1957, p. 217.

?*Parapeneopsis cornutus* Cheung, 1960, p. 65 (key).

**Material.** 14 ♀♀, 6 ♂♂, 62-121 mm; QUEENSLAND: Princess Charlotte Bay (1 ♀); NEW SOUTH WALES: off Tweed Heads (1 ♀); NEW GUINEA: W. of Mogubu, Jokea, off Fly R. mouth; NORTH BORNEO: Sandakan area; PHILIPPINES: Manila Bay.

**Distribution.** Equatorial spread from the west coast of India (ALCOCK) through Malaysia (HALL) to the Philippines and New Guinea.

**Discussion.** As already mentioned in the discussion of the foregoing subspecies, the condition of the basial spine on the ♀ 3rd pereopod in *P. c. maxillipedo* does not appear to be a constant feature. This spine is conspicuous only in specimens from Malaysia and the Philippines, as well as in the majority of those from New Guinea. In some New Guinea females, as in the 2 specimens hitherto recorded from eastern Australia, this spine is much reduced, though clearly perceptible.

For the detailed description of *P. maxillipedo* (Alcock), treated here as a subspecies of *P. cornuta*, the reader is referred to ALCOCK (1906). KUBO (1949) and DALL (1957) listed some structural differences between *P. maxillipedo* and *P. cornuta*, which may be helpful in future revisions.

**Parapeneopsis sculptilis** (Heller, 1862)

(Plate 3 fig. 5; Plate 8 fig. 3)

*Penaeus sculptilis* Heller, 1862, p. 528; 1865, p. 122. Miers, 1880, p. 457.*Parapeneopsis sculptilis* Nobili, 1903, p. 5. Balss, 1914, p. 11. Boone, 1935, pp. 80-84. Kubo, 1949, pp. 389-91. Dall, 1957, pp. 217-20.*Parapeneopsis sculptilis* Burkenroad, 1934b, pp. 59-60. Racek, 1959, pp. 10, 12, 14.*Peneopsis* (printing error) *sculptilis* Alcock, 1906, pp. 37-38.*?Parapeneopsis sculptilis* var. *cultrirostris* Alcock, 1906, p. 39.*?Parapeneopsis cultrirostris* Kubo, 1949, pp. 378-80 (not figure 137).*Parapeneopsis affinis* Hall, 1962, p. 27.

**Material.** Numerous specimens of both sexes, 68-162 mm; **NORTHERN TERRITORY:** Chambers Bay, Darwin ("Paxie"); **QUEENSLAND:** Gulf of Carpentaria ("Rama"), Truant I. ("Paxie"), Princess Charlotte Bay, Keppel Bay ("Challenge"), Mackay; **MALAYSIA:** Penang, North Borneo; **INDONESIA:** Kroja, Tjilatjap (Java); **NEW GUINEA:** Orangerie Bay, off Parama I., off Fly R. mouth.

**Distribution.** West coast of India to Hong Kong (ALCOCK), through Malaysian waters (BURKENROAD, BOONE, KUBO, HALL) and Indonesia (HELLER, MIERS) to tropical Australia (DALL, RACEK) and New Guinea.

**Discussion.** This common and widely distributed tropical species has been extensively discussed in previous literature, and the reader is particularly referred to KUBO (1949) and DALL (1957). The status of ALCOCK's (1906) *P. sculptilis* var. *cultrirostris*, however, still remains somewhat obscure. KUBO (1949) raised this "variety" to specific rank, but DALL (1957) synonymized both ALCOCK's "variety" and KUBO's species *P. cultrirostris* with *P. sculptilis*, pointing to the fact that the cultrate condition of the rostrum is invariably found in males of the latter species after copulation. HALL (1962) questioned the correctness of DALL's identification, and suggested that the exact shape of the cultrate rostrum, as depicted by ALCOCK, is only comparable with that displayed by some mature males of *P. hardwickii*. It is unlikely that this difference of opinion could ever be eliminated without a direct comparison of ALCOCK's type specimens of *P. s. cultrirostris* with the males of both *P. sculptilis* and *P. hardwickii*. As can be expected from the structural similarities of the rostrum in these two species, the cultrate condition in males of both display close affinities. In 27 "cultrate" males of *P. sculptilis* in our material, the rostrum (Plate 3 fig. 5) fully agrees with the illustrations of ALCOCK (1906) and DALL (1957), and is distinctly different from the structure depicted by HALL (l.c., fig. 105c). On the other hand, 2 "cultrate" males of *P. hardwickii* examined would appear indistinguishable from those of *P. sculptilis* if this criterion only were used for their separation from the latter species. In view of these similarities it is possible that ALCOCK's material of *P. s. cultrirostris* in the Indian Museum also consists of males of both species mentioned, even though they could now readily be distinguished from each other by their secondary sexual characters.

**Parapeneopsis hardwickii** (Miers, 1878)

(Plate 8 fig. 4; Plate 13 fig. 4)

*Penaeus hardwickii* Miers, 1878, p. 300.*Parapeneopsis sculptilis* var. *hardwickii* Alcock, 1906, p. 39.*Parapeneopsis hardwickii* Burkenroad, 1934b, pp. 60–64. Hall, 1962, pp. 26–27.*Parapeneopsis hardwickii* Kubo, 1949, pp. 385–89 (not figure 140). Dall, 1957, p. 214 (key). Cheung, 1960, p. 65 (key).? *Parapeneopsis sculptilis* var. *cultrirostris* Alcock, 1906, p. 39.? *Parapeneopsis cultrirostris* Kubo, 1949, pp. 378–80 (not figure 137).

**Material.** NORTH BORNEO: Tawau area, caught with tidal net "togoh", 3–5 fm, coll. CHIN PHUI KONG, 18.XII.1959, 9 ♂♂, 21 ♀♀, 59–73 mm.

**Description.** Rostrum sigmoidal, distal  $\frac{1}{2}$  or more styliform and edentate, strongly upcurved; in ♀ at least  $\frac{1}{4}$  of rostrum extending beyond tip of antennular peduncle; rostrum in mature ♂ often cultrate, and not extending beyond 2nd antennular segment; dorsally armed with 7–8 teeth + epigastric. Adrostral carina ending about half way between epigastric and penultimate tooth, sulcus shallow. Postrostral carina distinct, almost reaching posterior margin of carapace, with a broadly open sulcus.

Orbital spine not much more than a sharp angle, postocular sulcus moderately deep, at angle  $40^\circ$  to rostrum. Longitudinal suture reaching about  $\frac{8}{10}$  carapace, distinct in its entire length. Cervical sulcus shallow and short, not quite reaching longitudinal suture. Antennal spine prominent, antennal carina reaching to  $\frac{2}{3}$  distance between hepatic and antennal spines. Hepatic sulcus pronounced, somewhat more than  $\frac{1}{3}$  length carapace, slightly sinuous; hepatic carina distinct only for lower  $\frac{1}{2}$  sulcus, commencing from base of hepatic spine, and reaching to the vicinity of the sharp pterygostomial angle. Branchiocardiac sulcus barely perceptible.

Antennular flagella not sexually dimorphic, slightly longer than their peduncle, which is  $0.6$  length of carapace.

Third maxilliped surpassing carpocerite by dactyl; 1st pereopod not quite reaching to base of carpocerite, 2nd surpassing it by dactyl; 3rd as long as outer maxillipeds, 4th reaching to base of carpocerite, 5th attaining anterior margin of cornea. Mastigobranchiae and slender basal spines on 1st 2 pereopods.

Abdominal carination beginning from anterior  $\frac{8}{10}$  of 3rd somite, carina on 6th ending in a sharp spine; dorsal sulcus absent. Two lateral cicatrices on 4th and 5th somites, 3 on 6th somite. Telson armed with 3–5, usually 4, pairs of mobile spines, of which the apical set is the largest.

The petasma is shown on Plate 8 fig. 4; distomedian projections not extending beyond tips of distolateral projections, about as long as wide, their anterolateral margins distinctly crenulated; distolateral projections pointing laterally; proximal lateral enlargements of petasma very large

and rounded. The sterna between the ♂ 4th and 5th pereopods often developed into a structure similar to the thelycum of mature ♀♀.

The thelycum is shown on Plate 13 fig. 4. Anterior plate slightly concave, wider than long, anteriorly and posterolaterally rounded; sternal plate between 5th pereopods flat, with a pair of anterolateral tooth-like processes directed anteriorly, and a convex anteromedian margin bearing a transverse row of long setae.

Colour in life. Not yet observed; the coloration of freshly preserved specimens has been commented on by BURKENROAD (1934b).

Distribution. East coast of India (ALCOCK) through Malaysia (BURKENROAD, HALL) to southern China (KUBO, CHEUNG).

Discussion. The specimens examined during the present study fully agree with the detailed descriptions of *P. hardwickii* by BURKENROAD (1934b) and KUBO (1949), as well as with the illustrations of this species by HALL (1962). KUBO's texts to his figures 137 and 140 are obviously misplaced and should be exchanged with each other, since the female of *P. hardwickii* is shown in place of the male of *P. cultrirostris*, and *vice versa*.

*P. hardwickii* is very closely related to *P. sculptilis*, but can be distinguished from the latter by a number of criteria, as already discussed by BURKENROAD (1934b). Helpful distinguishing criteria, apart from the quite distinct secondary sexual characters, are the lengths of the rostrum and the antennular flagella, the structure of the postrostral sulcus, and the telsonic armature. The malformation of the ♂ rostrum into a dagger-like stump is a feature which is shared by both *P. hardwickii* and *P. sculptilis*, and further studies are necessary before it can be decided with which of these species ALCOCK's (1906) *P. sculptilis* var. *cultrirostris* is synonymous.

### ***Parapenaeopsis arafurica* sp. nov.**

(Figure 16; Plate 8 figs. 6, 7; Plate 13 fig. 5)

Material. NEW GUINEA: off Fly R. mouth, Papua, coll. Dr. A. M. RAPSON, 25.IV.1955, mud, holotype ♂, 52 mm (carapace 12.5 mm), allotype ♀, 71 mm (carapace 17 mm), paratypes 4 ♂♂, 48–58 mm, 1 ♀, 69 mm; Gulf of Papua, 8° 16' S., 144° 12' E., 6.IV.1955, 2 ♂♂, 52, 54 mm; Fly R. estuary, near Kiwai I., 26.IV.1955, 2 ♂♂, 53 mm, 1 ♀, 74 mm (parasitised by Bopyrid); near N. entrance to Fly R., 7.IV.1955, 10 ♂♂, 43–54 mm, 1 ♀, 51 mm. NORTHERN TERRITORY: Chambers Bay, 12° 02' S., 131° 31' E., coll. V. WELLS ("Paxie"), 7.XI.1959, grey mud, 9 fm, 2 ♂♂, 41, 49 mm, 3 ♀♀, 58–78 mm.

Description. Rostrum slender and sigmoidal, distal  $\frac{2}{3}$  styliform and edentate; in immature specimens of both sexes up to about 45 mm in length, the rostrum is 1.1 to 1.2 length carapace, exceeding tip of antennular peduncle by 0.2–0.3 its length; in mature ♀ the rostrum is

0.9 length carapace, and exceeding the antennular peduncle by 0.2 its length; in all mature ♂♂ the rostrum is more slender than in ♀♀, about equal to, or short of, the antennular peduncle, the tip invariably showing slight malformation. Rostrum dorsally armed with 4–5 teeth, epigastric absent. Adrostral carina ending at  $\frac{1}{2}$  distance between hepatic spine and margin of carapace. Postrostral carina a broad, barely perceptible dorsal ridge, ending at about 0.8 length carapace, and with a distinct hump at almost  $\frac{1}{2}$  carapace, probably marking the position of the absent epigastric spine.

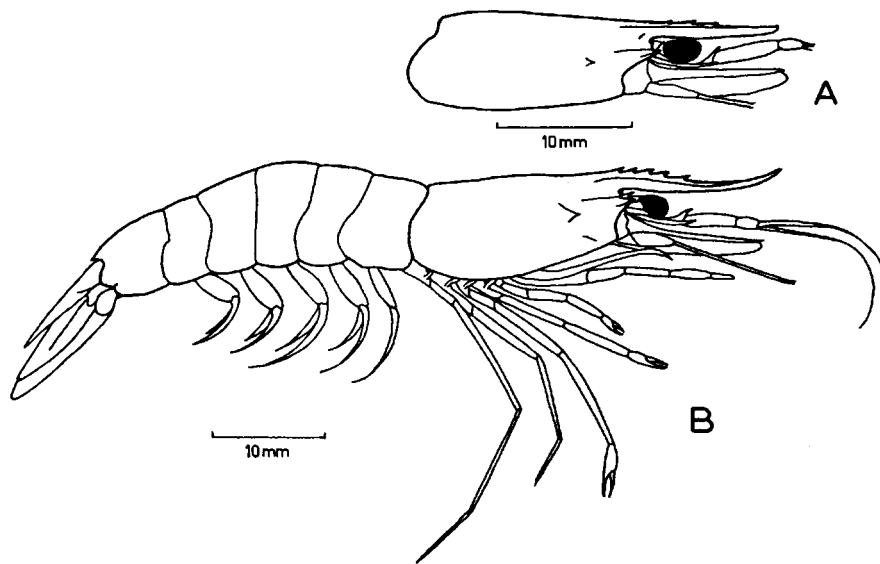


Fig. 16. *Parapenaeopsis arafurica*, sp. nov.  
A, cephalothorax of holotype; B, ♀, 71 mm, allotype.

Longitudinal suture reaching level of hepatic spine, transverse suture apparently absent. Postocular sulcus present, orbital and pterygostomian angles sharp. Antennal carina ending barely  $\frac{1}{4}$  distance between antennal and hepatic spines; cervical and orbito-antennal sulci barely defined; a shallow branchiocardiac sulcus present. Hepatic sulcus shallow, running downwards at  $45^\circ$  angle, and beginning below tip of hepatic spine; hepatic carina feebly developed, about 0.05 length carapace.

Antennular flagella subequal, upper 1.2 length lower, and 1.5 length peduncle. Prosartema reaching about  $\frac{2}{3}$  eye, stylocerite barely exceeding  $\frac{1}{3}$  1st antennular segment. Scaphocerite reaching from  $\frac{1}{2}$  to tip of antennular peduncle, carapocerite reaching as far as eye.

Mandibular palp reaching base of carapocerite, distal segment subrectangular, without a distolateral depression. Incisor process with a cleft, forming 2 angular teeth; molar process rectangular, with sharp posterior ridge. Maxillular palp unsegmented, broadened distally, with

tuft of about 5 spines on the inner corner, and a row of 6 spines on the posterolateral margin.

Third maxilliped reaching to tip of 2nd antennular segment, the ♂ dactyl distinctly curved; first pereopod exceeding base of carpocerite by  $\frac{1}{2}$  dactyl, 2nd reaching as far as, or slightly exceeding, carpocerite; 3rd reaching from  $\frac{1}{2}$  to tip of 2nd antennular segment, 4th exceeding 1st antennular segment by dactyl, 5th exceeding 3rd pereopod by dactyl. Mastigobranchiae absent from pereopods, a weak spine on basis and ischium of 1st pereopod only.

Cardiac plate of gastric mill with 10–12 small, indistinct spinules. Zygocardiac ossicle consisting of an upper portion, the 1st tooth large and triangular, followed by 3–4 flat-topped teeth, then a row of 6–8 small sharp teeth; below the first tooth a smaller conical tooth, and below this a cluster of 5–6 small spines; lower portion a large tooth, followed by a row of about 10 smaller teeth. Prepyloric ossicle with 12–14 teeth on either side.

Abdominal carination beginning on anterior margin of 4th somite, carina on 6th ending in a sharp spine. A pair of lateral cicatrices on 6th somite. Length of telson  $\frac{8}{10}$  length of inner uropod; telson without perceptible mobile spines, but often with 3 lateral pairs of vestigial sockets for the insertion of such spines.

The petasma (Plate 8 figs. 6, 7) proximally narrow, widening towards the distolateral projections, with rounded proximal enlargements of moderate size. Distomedian projections very prominent, arising from a tubular ventral base, and with a flattened anterior margin; each projection laterally divided into a ventral inwardly curved hook, and a dorsal finger-like process. Distolateral projections slightly curved, flattened, and bluntly triangular. Greatest width of petasma 0.85 length, width of distomedian projection 0.5 length petasma. Endopod of ♂ 2nd pleopod arising from middle of proximal segment, turning abruptly posteriorad, bearing an elongate distal process, which runs back to a forwardly directed dorsal lobe.

The thelycum is shown on Plate 13 fig. 5. Anterior plate concave, slightly wider than long, with an evenly rounded anterior margin, and sharply rounded posterolateral corners; a tongue-like posterior extension, bearing an irregular clump of long setae, and fitting into the U-shaped indentation of the posterior sternal plate between the 5th pereopods; the latter with convex anteromedian margin, and a forwardly directed spine on each anterolateral corner.

Colour in life. Not yet observed.

Distribution. Hitherto known only from the type locality in Papua, and the vicinity of Darwin, Northern Territory.

Discussion. While the general structure of the thelycum of *P. arafurica* is quite typical for the genus, the petasma cannot be compared with that of any other hitherto-known species of *Parapenaeopsis*. The absence



of mastigobranchiae on the 1st 2 pereopods is a feature shared by 4 other species, i.e. *P. hungerfordi*, *P. venusta*, *P. tenella*, and *P. acclivirostris*, of which the last two also lack an epigastric spine. In view of the absence of mastigobranchiae on the 3rd pereopods *P. arafurica* must be considered a *Parapenaeopsis* sp., although the atypical petasma, as well as the relatively short longitudinal suture, are features with a closer resemblance to those usually found in *Trachypenaeus*. This emphasises the insufficiency of the only clearly visible distinguishing criterion for generic determination, i.e. the presence or absence of epipodites on the 3rd pereopods, and further detailed studies of all species of *Trachypenaeus* and *Parapenaeopsis* are highly desirable.

***Parapenaeopsis gracillima* Nobili, 1903**

(Plate 8 figs. 8, 9; Plate 13 fig. 6)

*Parapenaeopsis gracillima* Nobili, 1903, p. 4. Balss, 1914, p. 12. De Man, 1924, p. 40. Boone, 1935, pp. 84–91. Kubo, 1949, pp. 384–85. Dall, 1957, p. 214 (key).

*Parapeneopsis gracillima* Hall, 1962, p. 26.

*Parapenaeopsis dosfeini* Balss, 1913, p. 234.

**Material.** INDONESIA: Kuala Putran, Palembang, coll. 28.I.1955, 1 ♀, 57 mm; Sumatra, coll. 1957, 2 ♀♀, 78, 80 mm; MALAYSIA: "East coast of Malaya", coll. D. STEAD, 1922, 1 ♂, 49 mm.

**Description.** Rostrum of ♀ with strongly elevated base, and a posterior convex crest, anterior  $\frac{1}{3}$ – $\frac{1}{2}$  styliform and edentate, and distinctly recurved; reaching to tip of 2nd antennular segment, dorsally armed with 5 teeth; epigastric spine absent. Rostrum of the only ♂ examined wide and short, distinctly ascending, and almost straight; barely attaining  $\frac{1}{2}$  of cornea, armed with 5 teeth; epigastric spine absent. Adrostral carina in both sexes ending at  $\frac{1}{2}$  distance between hepatic spine and anterior margin of carapace. Postrostral carina broad but distinctly elevated, almost reaching to posterior margin of carapace.

Longitudinal suture reaching half way between hepatic spine and posterior margin of carapace; a distinct transverse suture at bases of 3rd pereopods. Postocular sulcus short but distinct, orbital and pterygostomial angles sharp. Antennal carina indistinct and broad, ending barely  $\frac{1}{4}$  distance between antennal and hepatic spines; cervical and orbito-antennal sulci barely perceptible; a shallow branchiocardiac sulcus present. Hepatic sulcus tomentose and obscured, running downward at 45° angle and beginning below tip of hepatic spine; hepatic carina feeble and short.

Antennular flagella subequal, upper 1.1 length lower, and 2.2 length of carapace. Scaphocerite 2.5 times as long as wide, narrowing distally; carpocerite overreaching eye by  $\frac{1}{4}$  its length.

Third maxilliped exceeding tip of carpocerite by dactylus; 1st pereopod exceeding tip of basipodite by dactylus, 2nd attaining tip of carpocerite; 3rd reaching to tip of antennular peduncle, 4th exceeding it by  $\frac{1}{2}$

dactylus; 5th reaching beyond tip of scaphocerite at least by dactylus. First 2 pereopods with mastigobranchiae, basal and ischial spines absent on all pereopods.

Abdominal carination beginning on anterior margin of 4th somite, carina on 6th ending in a sharp spine; 2-3 pairs of lateral cicatrices on 6th somite only. Length of telson 0.55 length of inner uropod; telsonic spines absent.

The petasma is shown on Plate 8 figs. 8, 9. Distolateral projections long and slender, directed anterolaterally, deviating from longitudinal axis of petasma at 30°. Distomedian projections small, recurved ventrally. Petasma proximally with small rounded enlargements, and a pair of prominent and sharply triangular lateral processes.

The characteristic and large thelycum is shown on Plate 13 fig. 6. Anterior plate up to 3 times as wide as long, with a slightly 3-lobed anterior margin, and a stem-like posterior extension; the latter embraced by a U-shaped anteromedian incision of the posterior sternal plate between the 5th pereopods.

Colour in life. Not yet observed.

Distribution. Malaysia to Indonesia.

Discussion. The few females examined during the present study agree in all major details with the descriptions of *P. gracillima* by NOBILI (1903) and KUBO (1949). Some minor discrepancies in BALSS' (1914) definition of this species were already discussed by KUBO (l.c., p. 385). HALL (1962), who was the first to record the apparently elusive male of *P. gracillima*, depicted a petasma which differs from that of our only male by its slightly wider shape, and strongly diverging distolateral projections. Since HALL's description of the male condition apparently has not yet been published, a comparison of other male criteria cannot be contemplated.

The paucity of specimens ever collected tends to create the impression that *P. gracillima* is a rare species. However, it seems more likely that it is not a true bottom dweller, and thus unobtainable in quantities by conventional trawling methods. This assumption is supported by various morphological features, in particular the well-developed pleopods, and the filiform last two pairs of pereopods.

### ***Parapenaeopsis hungerfordi* Alcock, 1905**

(Plate 8 fig. 5; Plate 13 fig. 7)

*Parapeneopsis hungerfordi* Alcock, 1905, p. 530. Burkenroad, 1934b, pp. 67-70. Hall, 1962, p. 26.

*Parapenaeopsis hungerfordi* Balss, 1924, pp. 44-45. Yu, 1935, p. 166. Kubo, 1949, pp. 381-85. Dall, 1957, p. 215 (key). Cheung, 1960, p. 65 (key).

Material. 39 ♀♀, 9 ♂♂, 62-104 mm; NORTH BORNEO: Sandakan Harbour, Tawau area, Labuan; INDONESIA: Eastern Borneo; depth of occurrence 3-7 fm.

Description. Rostrum slightly sigmoidal, distal  $\frac{1}{4}$  to  $\frac{1}{3}$  styliform and edentate, posterior armed portion not conspicuously elevated; in ♀ exceeding the antennular peduncle by about  $\frac{1}{8}$  rostral length, in ♂ slightly shorter; dorsally armed with 6–7 teeth+epigastric. Adrostral carina ending half way between epigastric and penultimate tooth, sulcus indistinct. Postrostral carina distinct, almost reaching posterior margin of carapace, with a wide and moderately shallow sulcus, which is slightly constricted in its midsection as well as in its posterior  $\frac{1}{8}$ .

Orbital spine small but distinct, postocular sulcus shallow, at an angle  $40^\circ$  to rostrum. Longitudinal suture reaching past the transverse suture, which is in level with the bases of the 3rd pereopods. Cervical sulcus ill-defined and short. Antennal spine prominent, antennal carina reaching to  $\frac{1}{2}$  distance between hepatic and antennal spines. Hepatic sulcus distinct, somewhat more than  $\frac{1}{3}$  length carapace, slightly sinuous; hepatic carina distinct only for lower  $\frac{1}{2}$  sulcus; pterygostomian angle sharply rounded. Branchiocardiac sulcus fairly well defined, branchiocardiac carina broad and inconspicuous.

Antennular flagella about  $\frac{1}{2}$  length of peduncle in ♀, only slightly longer in ♂. Prosartema not quite reaching anterior margin of cornea, stylocerite slightly exceeding  $\frac{1}{2}$  of basal segment.

Third maxilliped exceeding carpocerite by dactyl, 1st pereopod not quite attaining anterolateral margin of carapace; 2nd reaching to tip of basicerite, 3rd exceeding carpocerite by chela; 4th attaining  $\frac{1}{2}$  carpocerite, 5th extending as far as 3rd pereopod. First 2 pereopods with long and slender basal spines, and without mastigobranchiae.

First abdominal tergum with a faint longitudinal median depression; a blunt and faint carina on 3rd; 4th–6th abdominal somites with a sharp dorsal carina, that on the 6th ending in a sharp spine. A pair of lateral cicatrices on 4th and 5th somite, 3 pairs on 6th. Telson  $\frac{7}{10}$  length of inner uropods and unarmed.

The petasma (Plate 8 fig. 5) is quite an unusual structure. Distolateral projections semirectangular in outline, their median margins more or less parallel and closely adjoining; each projection with a ventral spinous process, arising from anterolateral corner and pointing at  $45^\circ$  towards the midline of the petasma; and with a dorsal, outwardly directed, fleshy lobe. Distomedian projections extremely small, as in most species of this genus.

The thelycum (Plate 13 fig. 7) consists of an elongated median plate, which is longitudinally grooved, and posteriorly of 2 convoluted lateral plates, which actually represent a posterolateral extension of the anterior plate.

Colour in life. Not yet observed.

Distribution. Hong Kong (ALCOCK, BALSS, CHEUNG) and Amoy (YU) through Malaysian waters (BURKENROAD, HALL) to northern Indonesia.

Discussion. In regard to their secondary sexual characters, our

specimens fully agree with the descriptions of *P. hungerfordi* by all previous authors, even though some other criteria seem to be subject to variation in this species. The antennules of our specimens, for example, are much shorter than those described by KUBO (1949); however, their length is fully comparable with that given by BURKENROAD (1934*b*) and illustrated by HALL (1962) for Malaysian specimens. Other apparently variable characters are the length of the pereopods, the shape of the 1st and 2nd pleonic terga, and the distinctness of the branchiocardiac sulcus. In view of the relatively compact distribution of *P. hungerfordi*, these slight discrepancies in its previous descriptions are most unlikely to be explained by speciation trends in distant populations, and further detailed morphometric studies are desirable.

***Parapenaeopsis tenella* (Bate, 1888)**

(Plate 8 fig. 10; Plate 13 fig. 8)

*Penaeus tenellus* Bate, 1888, pp. 270–71. Kishinouye, 1900, p. 22.

*Penaeus (Parapenaeopsis) tenellus* de Man, 1907, pp. 435–36, 454.

*Parapenaeopsis tenella* de Man, 1911, pp. 9, 92. Balss, 1914, p. 11. Yoshida, 1941, pp. 15–16.

*Parapenaeopsis tenellus* Kubo, 1949, pp. 371–74. Liu, 1955, pp. 16–17. Dall, 1957, pp. 221–23.

*Parapeneopsis tenella* Hall, 1962, p. 26.

*Penaeus crucifer* Ortmann, 1890, p. 451.

**Material.** 12 ♂♂, 27 ♀♀, 36–44 mm; NORTHERN TERRITORY: Chambers Bay (“Paxie”); QUEENSLAND: Gulf of Carpentaria (“Rama”), Princess Charlotte Bay (“Challenge”); NEW GUINEA: off Kea Kea Creek, off Fly R. mouth, Hercules Bay. Depth of occurrence 3–9 fm.

**Distribution.** Southern Japan to northern Australia, northern China to Malaysia.

**Discussion.** *P. tenella* is a well-described species, and the reader is particularly referred to KUBO (1949), LIU (1955), and DALL (1957). This species is very closely related to *P. acclivirostris* (Alcock), two African specimens of which were also examined during the present study. These two species can readily be distinguished from each other by their secondary sexual characters. *P. acclivirostris* displays a rather slender and narrow petasma, which lacks the large wing-like lateral outgrowths present in *P. tenella*, and the distolateral projections in the former are considerably shorter, as well as strongly reflected. The thelycum of the female of *P. acclivirostris* examined fully agrees with the drawing of ALCOCK (1906), and lacks the posterior extension, present in *P. tenella*, as demonstrated by DALL (1957).

HALL (1962) extended the distribution of *P. tenella* to Malaysia, and during the present investigation this species was found to occur off the Northern Territory, as well as in waters of New Guinea. Owing to its

small size, this species is likely to escape the mesh of conventional otter trawls, and future more careful and efficient collecting methods may yet disprove the theory of present authors, that its distribution is discontinuous. DE BRUIN (personal communication) recently recorded *P. tenella* from Ceylonese waters. From his studies, which will be published soon, it can be assumed that the vicinity of Palk Strait could well be the zoogeographic boundary, separating the eastern species *P. tenella* from its western congener *P. acclivirostris*. Future comparative studies, involving both these species, are therefore desirable.

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## EXPLANATION OF THE PLATES

### PLATE 1

- Fig. 1. *Penaeus japonicus* Bate, ♂, 139 mm.
- Fig. 2. *Penaeus longistylus* Kubo, ♂, 148 mm.
- Fig. 3. *Metapenaeopsis novaeguineae* (Haswell), ♀, 96 mm.
- Fig. 4. *Metapenaeopsis rosea*, sp. nov., ♀, 106 mm, paratype.

### PLATE 2

- Fig. 1. *Metapenaeopsis crassissima*, sp. nov., ♀, 89 mm.
- Fig. 2. *Metapenaeopsis lamellata* (de Haan), ♀, 97 mm.
- Fig. 3. *Metapenaeopsis insona*, sp. nov., holotype.
- Fig. 4. *Penaeus mastersii* Haswell, neotype.

### PLATE 3

- Fig. 1. *Metapenaeus ensis* (de Haan), cephalothorax of lectotype.
- Fig. 2. *Metapenaeus ensis* (de Haan), thelycum of lectotype.
- Fig. 3. *Metapenaeus papuensis*, sp. nov., cephalothorax of ♀, 95 mm.
- Fig. 4. *Trachypenaeus granulatus* (Haswell), ♀, 90 mm.
- Fig. 5. *Parapenaeopsis sculptilis* (Heller), carapace of ♂, 86 mm, with cultrate rostrum.

### PLATE 4

- Fig. 1. Petasma of *Metapenaeopsis novaeguineae*, ventral view.
- Fig. 2. Petasma of *Metapenaeopsis novaeguineae*, dorsal view.
- Fig. 3. Petasma of *Metapenaeopsis palmensis*, ventral view.
- Fig. 4. Petasma of *Metapenaeopsis palmensis*, dorsal view.
- Fig. 5. Petasma of *Metapenaeopsis crassissima*, ventral view.
- Fig. 6. Petasma of *Metapenaeopsis crassissima*, dorsal view.
- Fig. 7. Petasma of *Metapenaeopsis rosea*, ventral view.
- Fig. 8. Petasma of *Metapenaeopsis rosea*, dorsal view.
- Fig. 9. Petasma of *Metapenaeopsis barbata*, ventral view.
- Fig. 10. Petasma of *Metapenaeopsis barbata*, dorsal view.
- Fig. 11. Petasma of *Metapenaeopsis acclivis*, ventral view.
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- Fig. 1. Petasma of *Metapenaeopsis dura*, ventral view.
- Fig. 2. Petasma of *Metapenaeopsis mogiensis* from Tanganyika, ventral view.
- Fig. 3. Petasma of *Metapenaeopsis mogiensis* from Tanganyika, dorsal view.
- Fig. 4. Petasma of *Parapenaeus australiensis*, ventral view.
- Fig. 5. Petasma of *Parapenaeus longipes*, ventral view.
- Fig. 6. Petasma of *Metapenaeus suluensis*, ventral view.
- Fig. 7. Petasma of *Metapenaeus suluensis*, dorsal view.
- Fig. 8. Petasma of *Metapenaeus conjunctus*, ventral view.
- Fig. 9. Petasma of *Metapenaeus conjunctus*, dorsal view.
- Fig. 10. Petasma of *Metapenaeus affinis*, ventral view.

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- Fig. 1. Petasma of *Metapenaeus papuensis*, ventral view.
- Fig. 2. Petasma of *Metapenaeus papuensis*, dorsal view.
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- Fig. 5. Petasma of *Metapenaeus demani*, ventral view.
- Fig. 6. Basial spine on ♂ 3rd pereopod of *Metapenaeus dobsoni*.
- Fig. 7. Petasma of *Metapenaeus intermedius* from North Borneo, ventral view.
- Fig. 8. Petasma of *Metapenaeus dobsoni*, ventral view.
- Fig. 9. Petasma of *Metapenaeus dobsoni*, dorsal view.
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### PLATE 7

- Fig. 1. Petasma of *Metapenaeus tenuipes*, ventral view.
- Fig. 2. Petasma of *Metapenaeus eboracensis*, ventral view.
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- Fig. 5. Petasma of *Atypopenaeus bicornis*, ventral view.
- Fig. 6. Petasma of *Atypopenaeus bicornis*, dorsal view.
- Fig. 7. Petasma of *Trachypenaeus gonospinifer*, ventral view.
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#### PLATE 8.

- Fig. 1. Petasma of *Parapenaeopsis stylifera coromandelica*, ventral view.
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- Fig. 3. Petasma of *Parapenaeopsis sculptilis*, ventral view.
- Fig. 4. Petasma of *Parapenaeopsis hardwickii*, ventral view.
- Fig. 5. Petasma of *Parapenaeopsis hungerfordi*, ventral view.
- Fig. 6. Petasma of *Parapenaeopsis arafurica*, ventral view.
- Fig. 7. Petasma of *Parapenaeopsis arafurica*, dorsal view.
- Fig. 8. Petasma of *Parapenaeopsis gracillima*, dorsal view.
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- Fig. 6. Thelycum of *Metapenaeus intermedius* from Japan.
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- Fig. 1. Thelycum of *Metapenaeus brevicornis*.
- Fig. 2. Thelycum of *Metapenaeus tenuipes*.
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- Fig. 5. Thelycum of *Atypopenaeus formosus*.
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#### PLATE 13.

- Fig. 1. Thelycum of *Trachypenaeus granulatus*.
- Fig. 2. Thelycum of *Parapenaeopsis stylifera coromandelica*.
- Fig. 3. Thelycum of *Parapenaeopsis cornuta cornuta*.
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#### Wood-Mason & Alcock

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### Genus *Parapenaeus* Smith

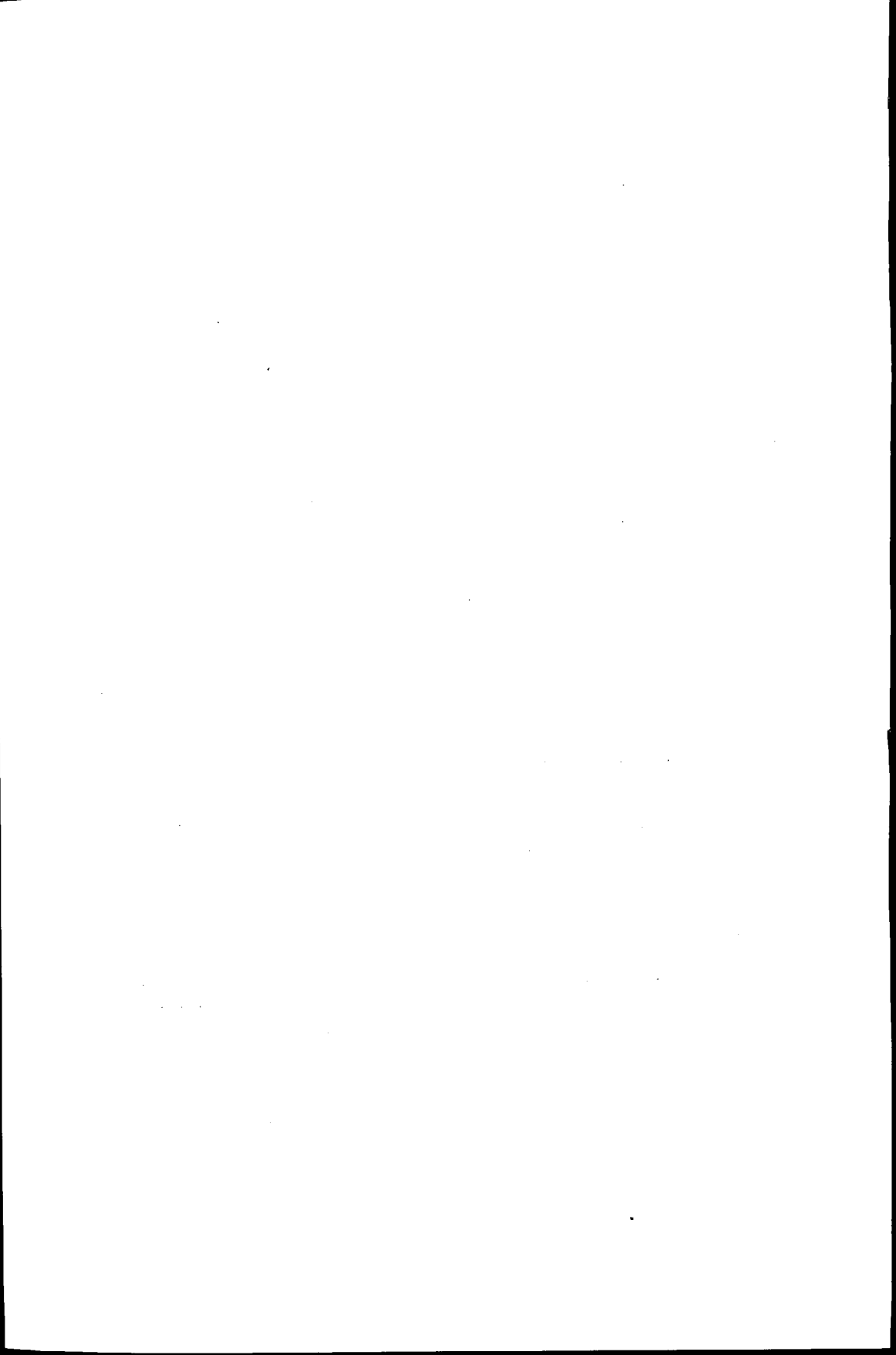
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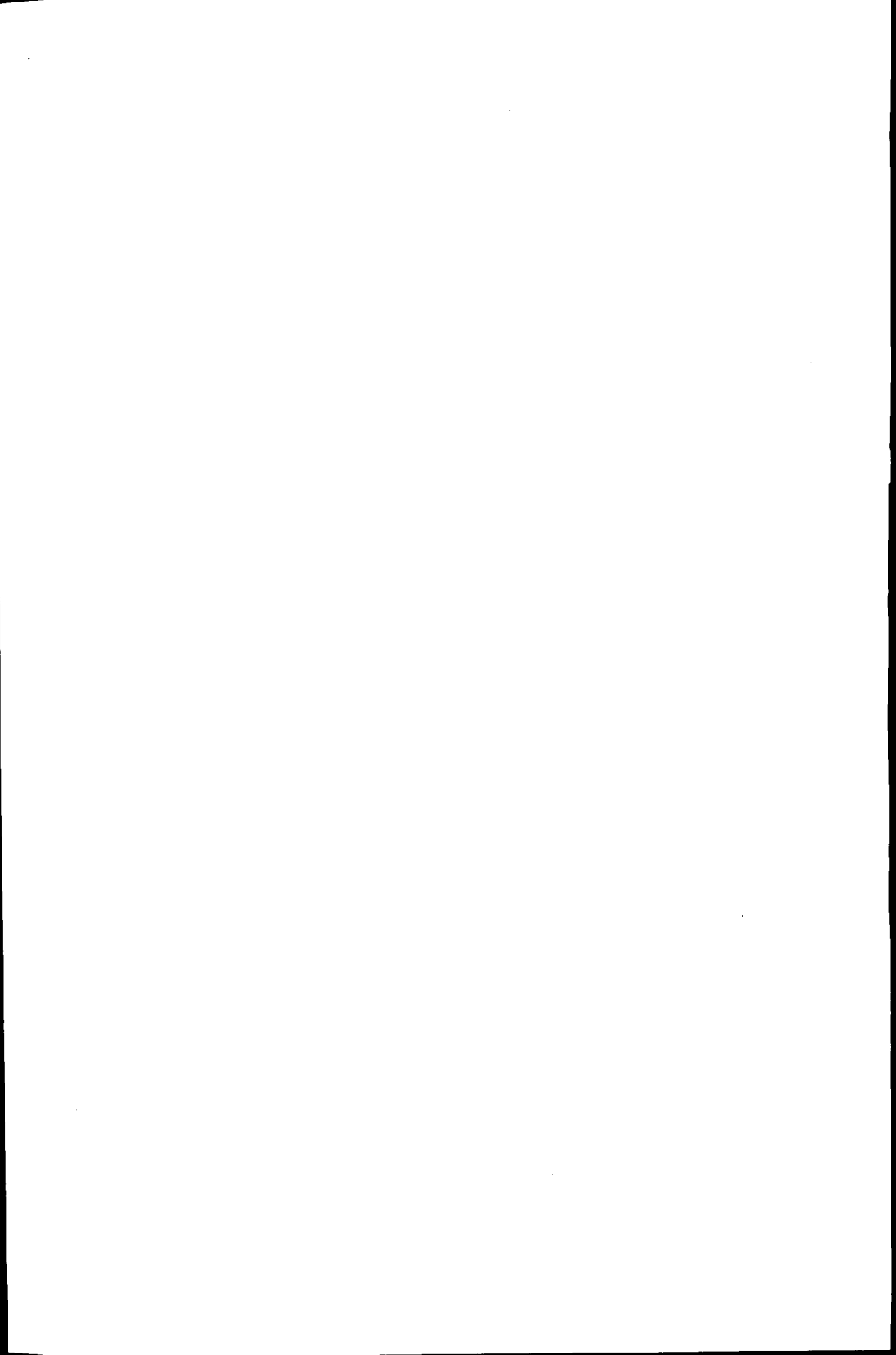
### Genus *Trachypenaeus* Alcock

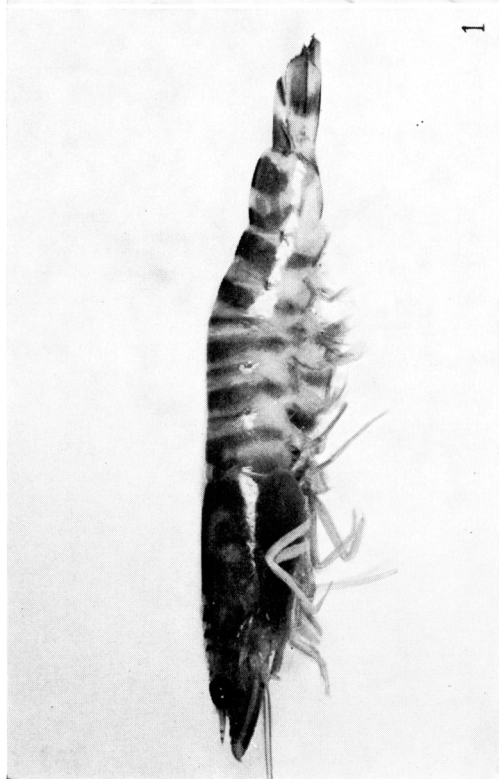
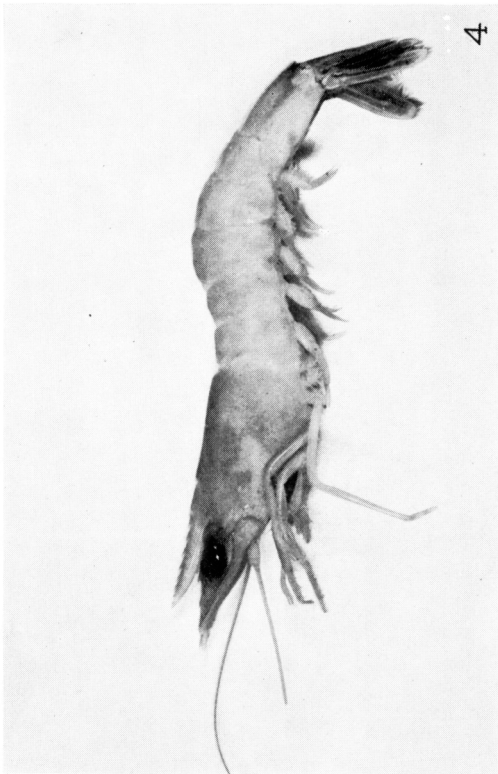
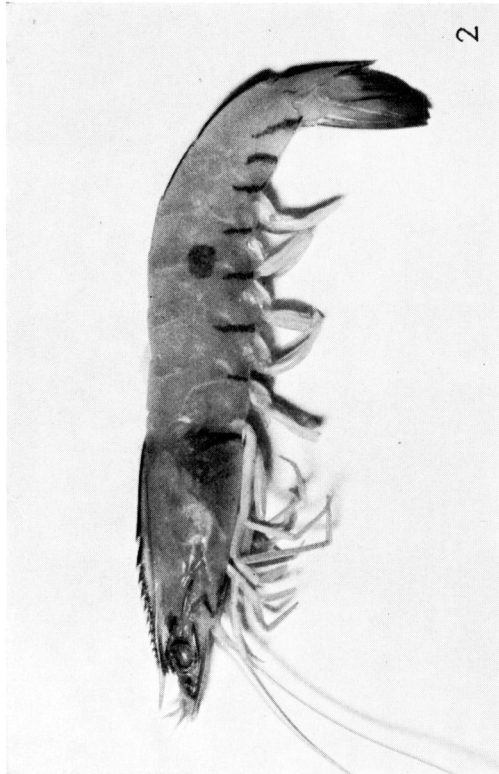
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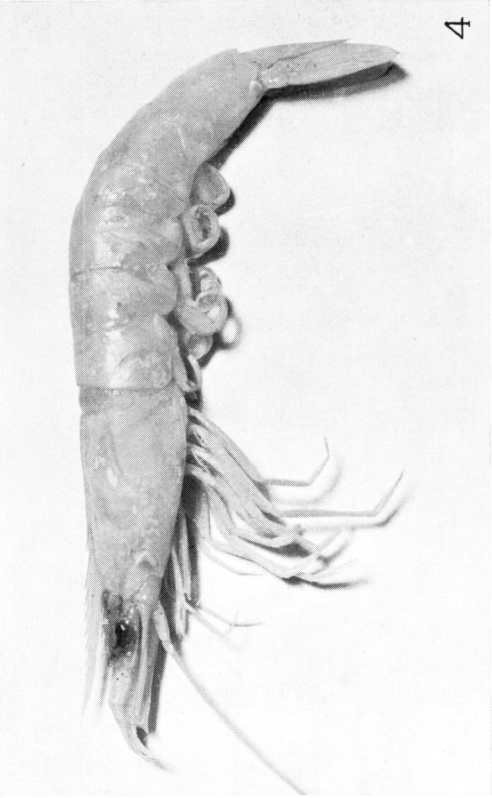
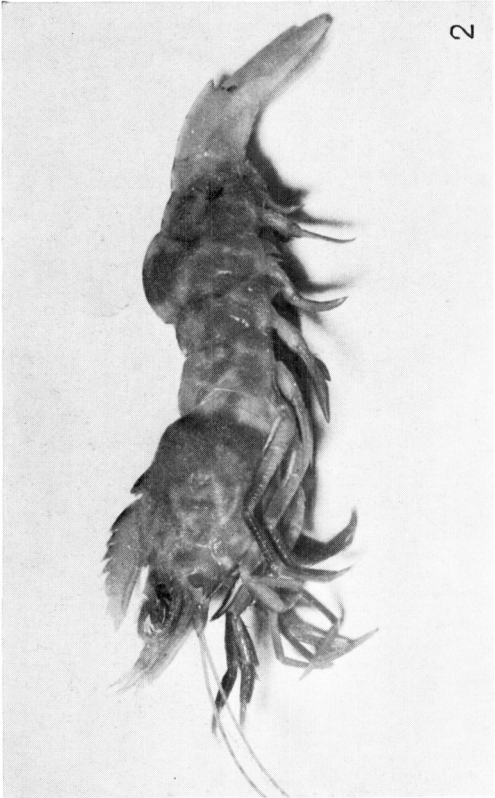
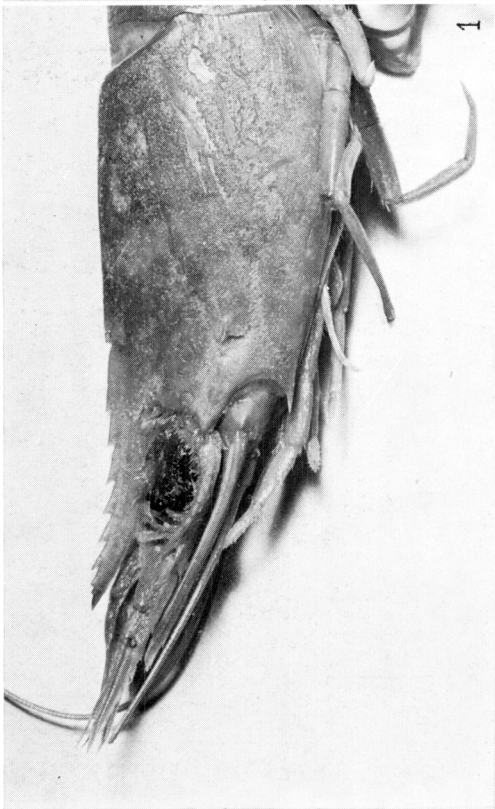


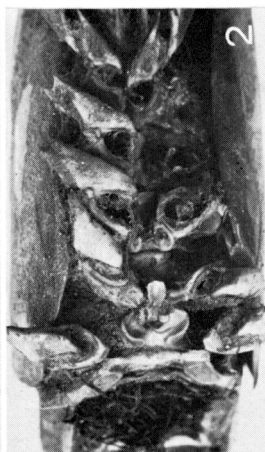
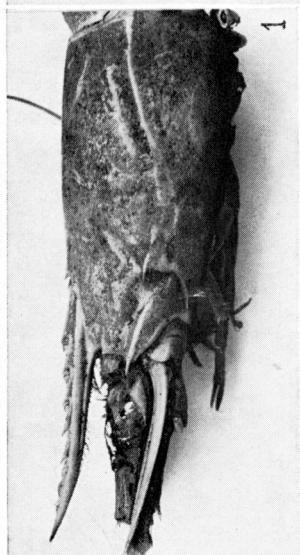
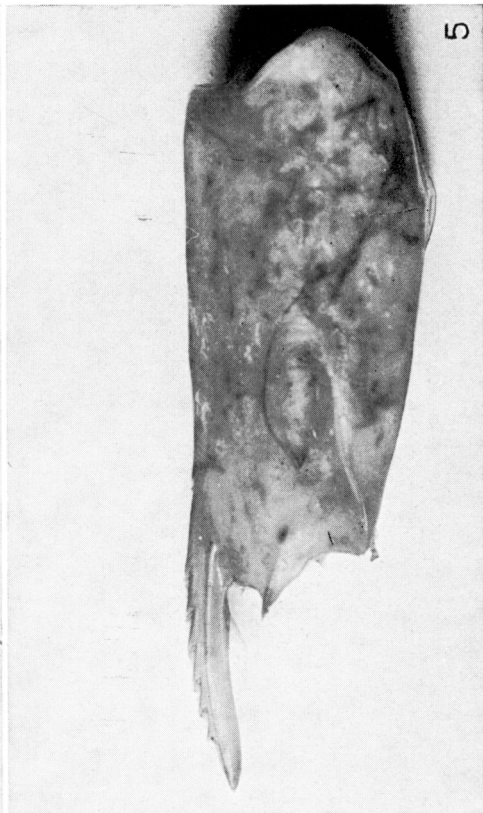
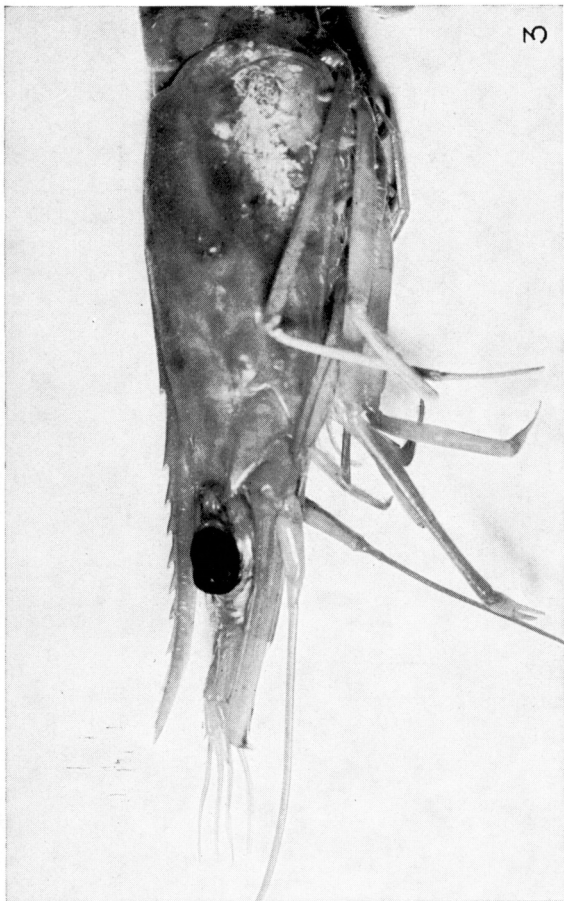


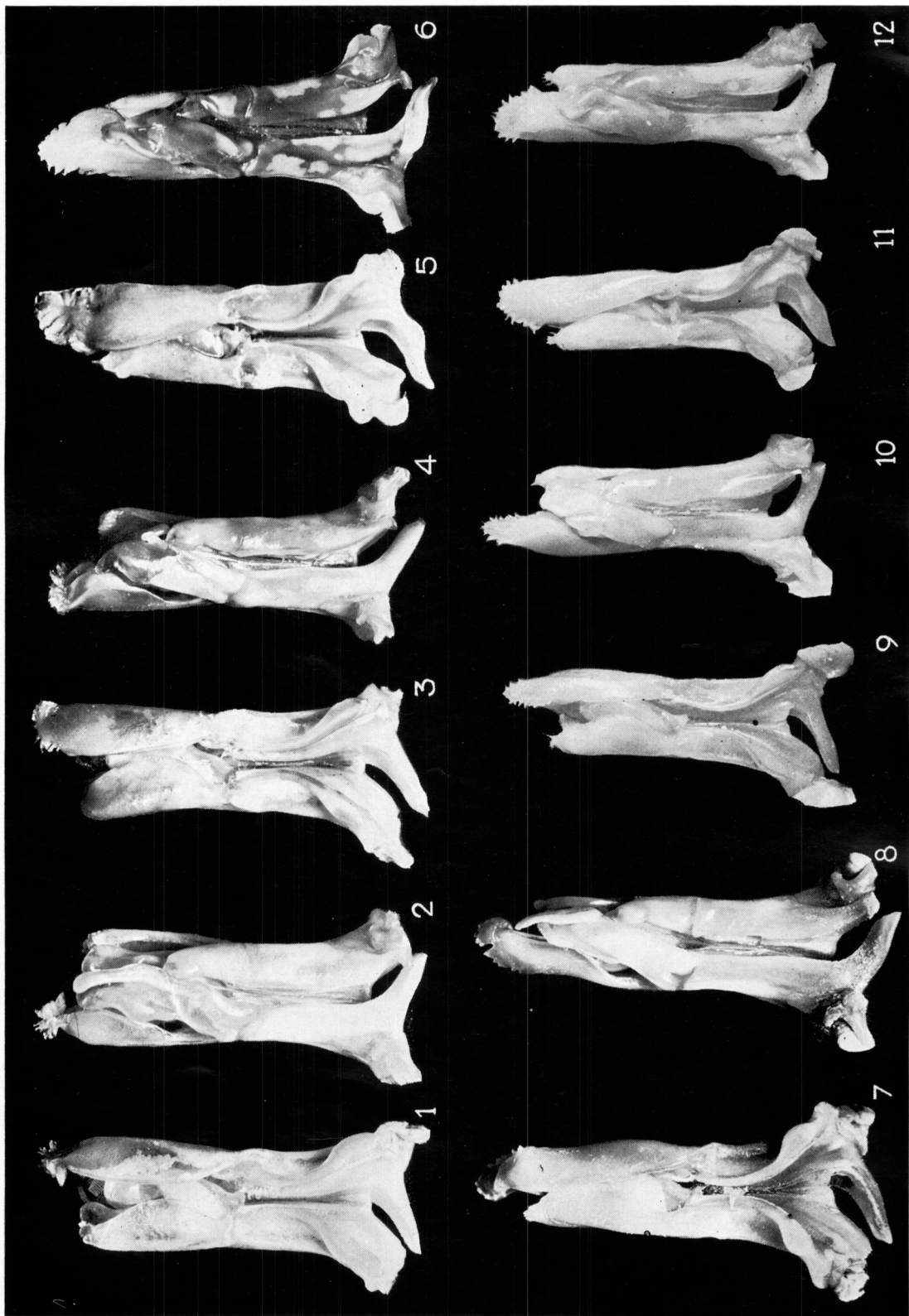
## PLATES 1–13





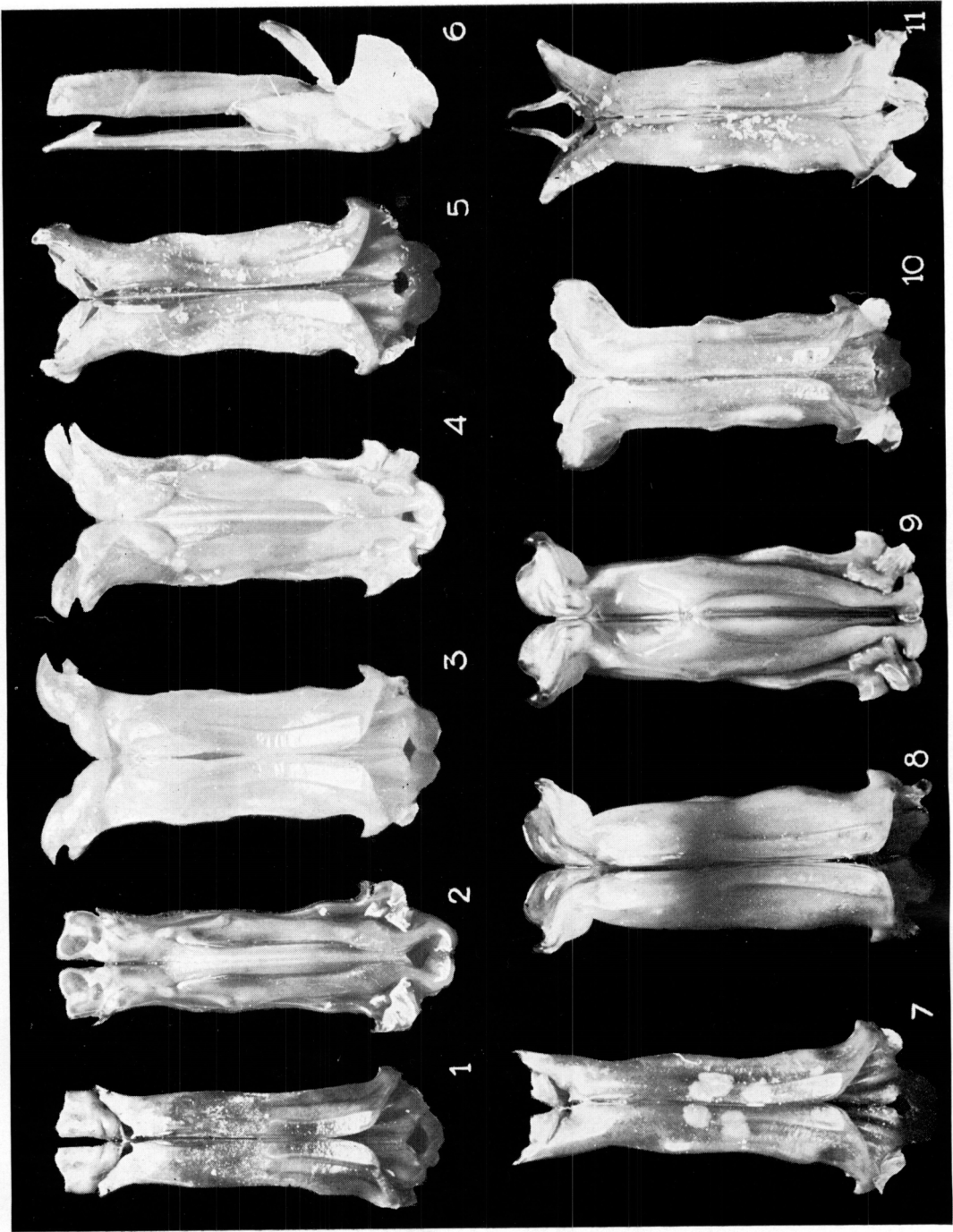




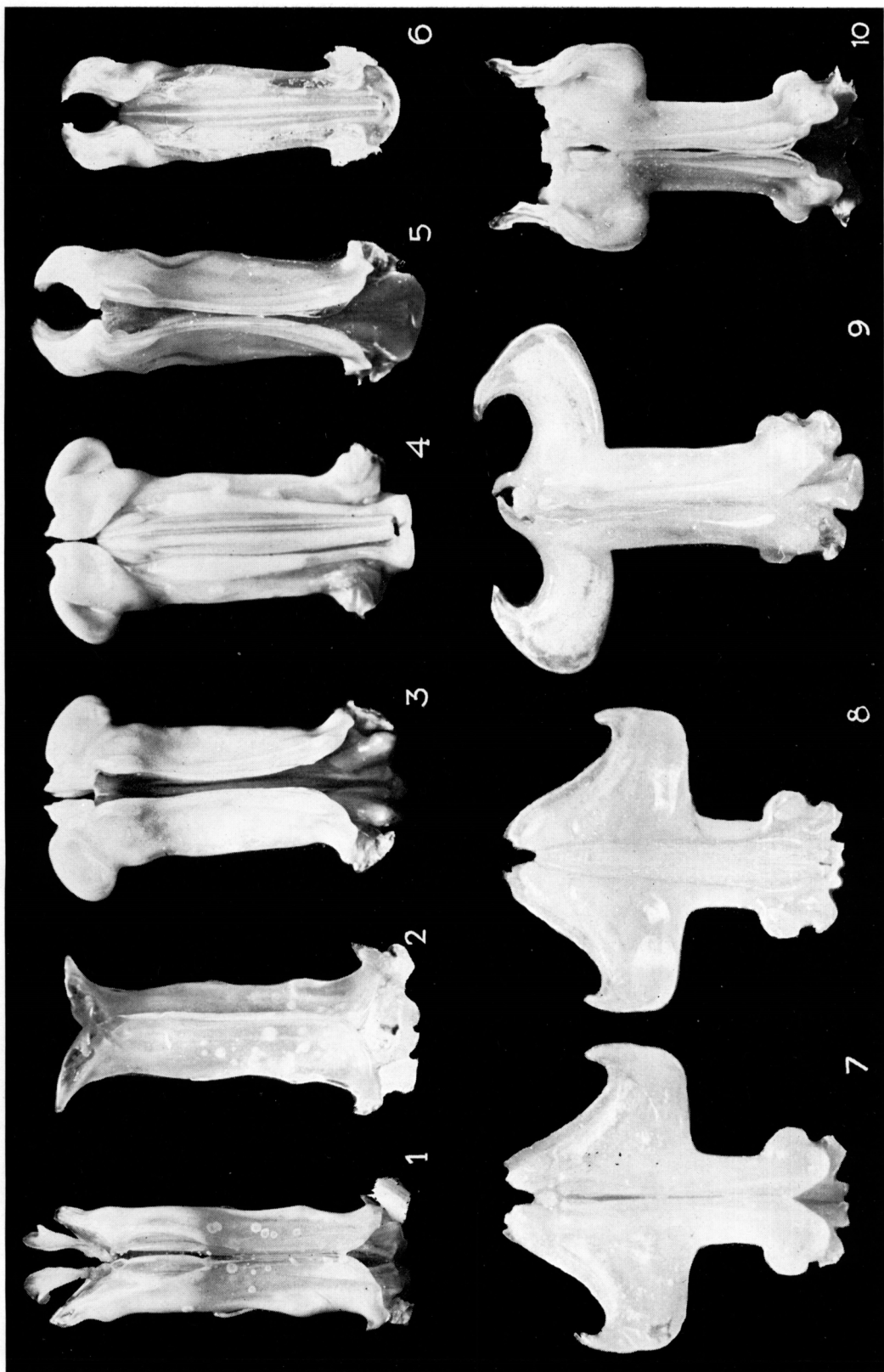


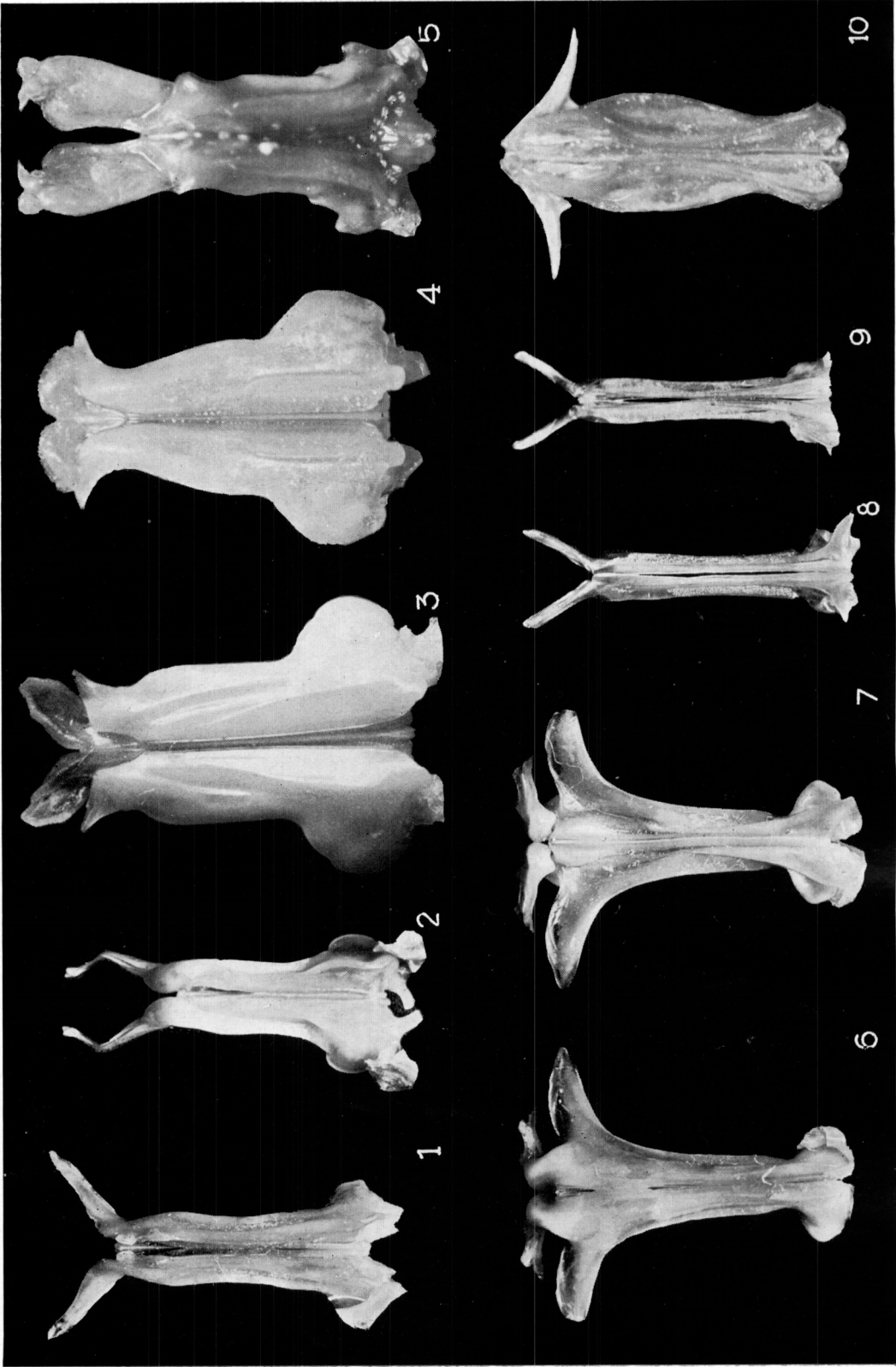


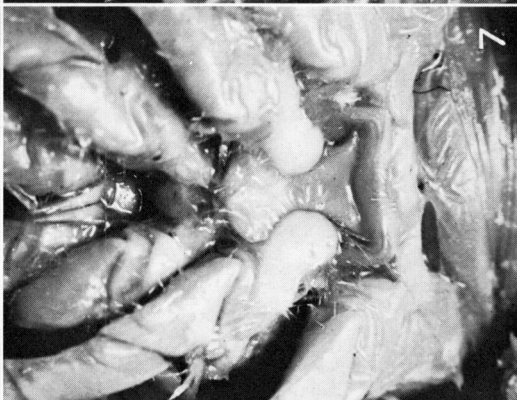


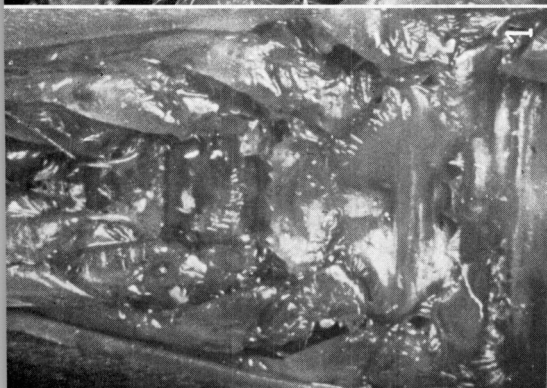
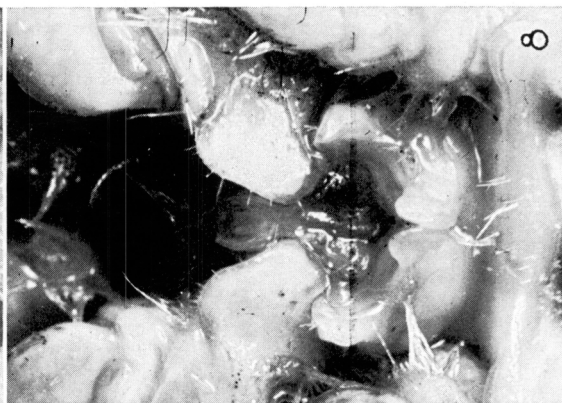




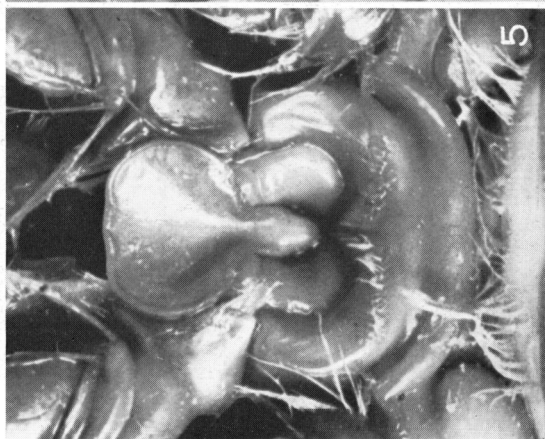
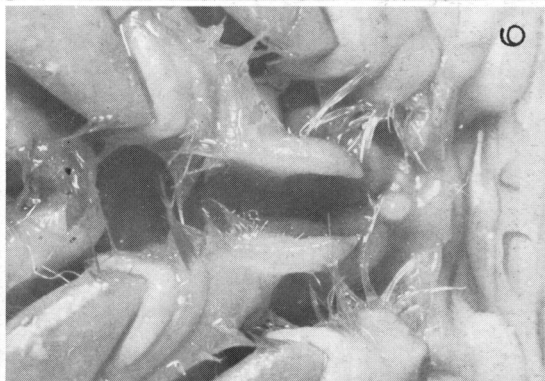
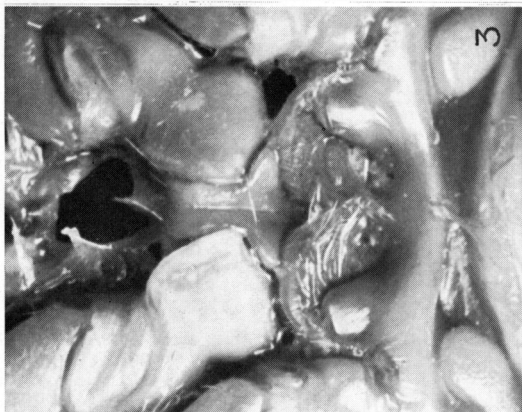


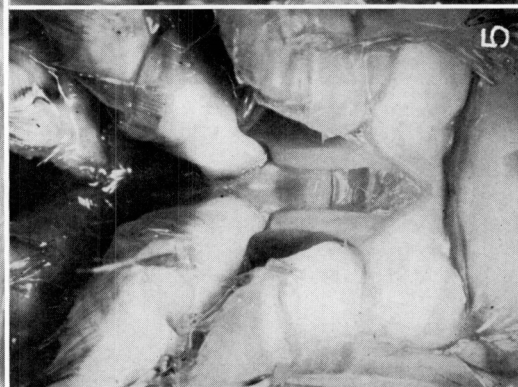
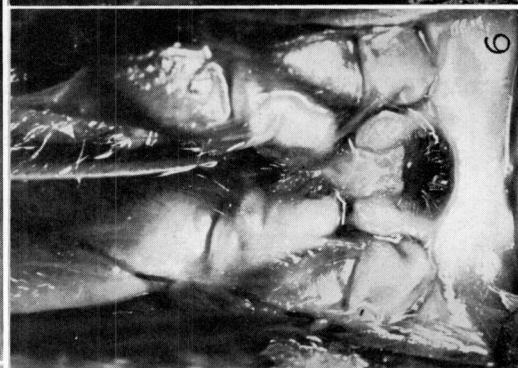
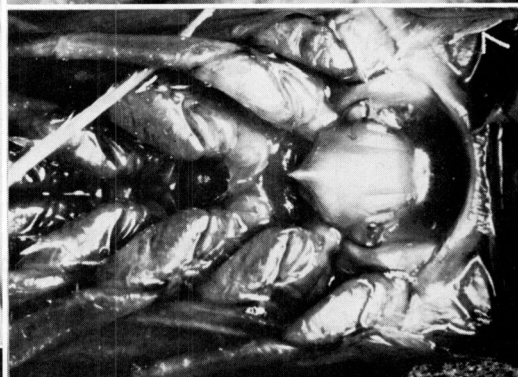
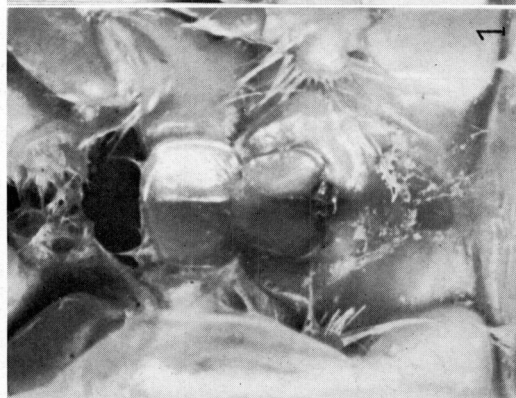
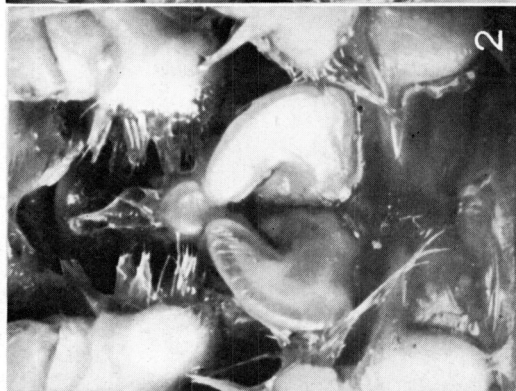
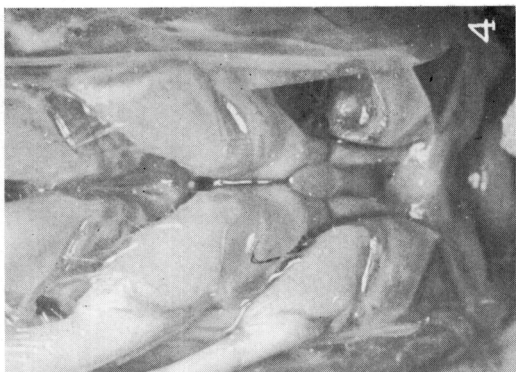


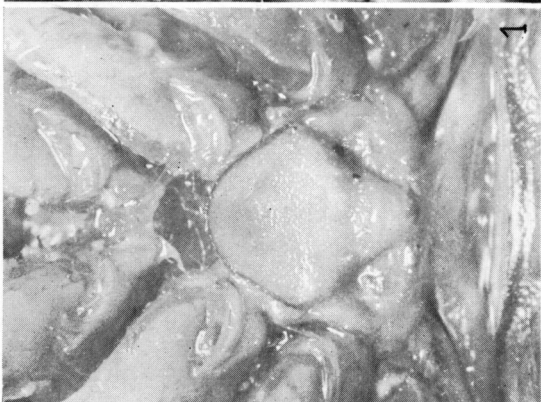
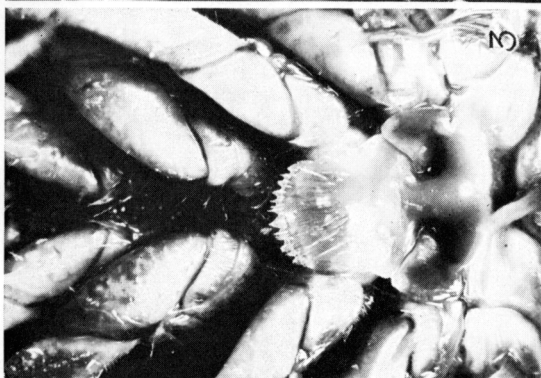
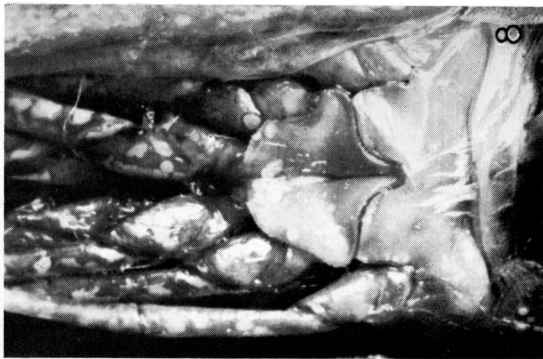
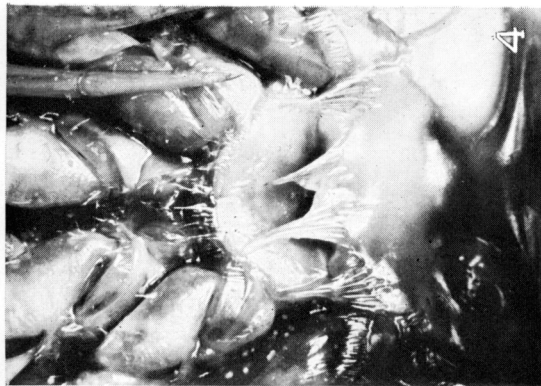


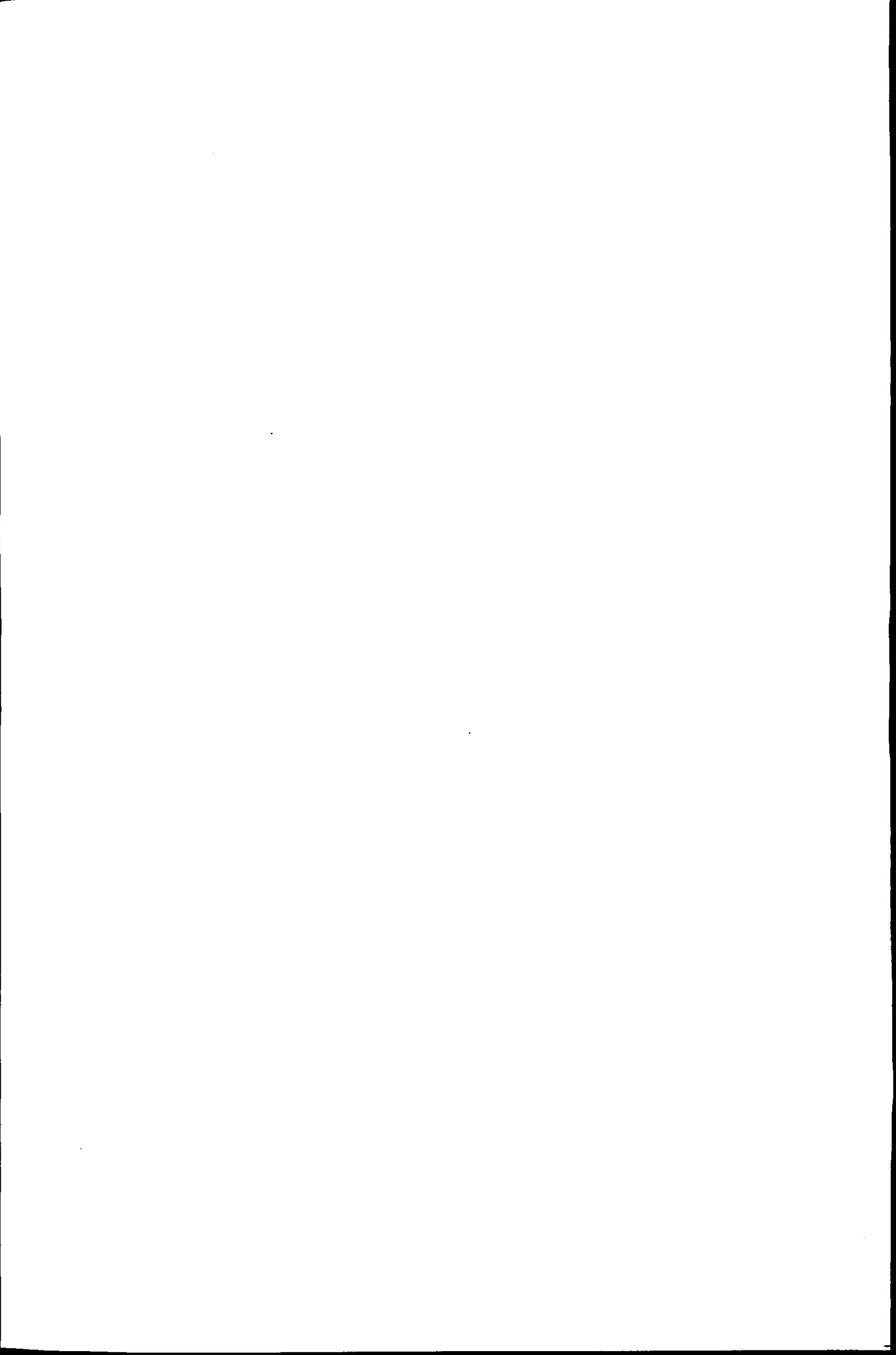














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