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A REVISION OF THE SPIDER CRABS OF THE GENUS *PARATYMOLUS* MIERS, 1879, WITH DESCRIPTIONS OF TWO NEW GENERA AND SIX NEW SPECIES (CRUSTACEA: DECAPODA: BRACHYURA: MAJIDAE)

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ABSTRACT. - The taxonomy of the spider crab genus *Paratymolus* Miers, 1879 (Majidae) is revised. Nine species of *Paratymolus* s. str. are recognised, six of which are new (*P. barnardi*, *P. coccus*, *P. cygnus*, *P. griffini*, *P. prolatus* and *P. vannus*). Two previously doubtful species, *P. bituberculatus* Haswell, 1880, and *P. hastatus* Alcock, 1895, are clarified and regarded as distinct taxa whilst *P. bituberculatus* var. *gracilis* Miers, 1884, is synonymised under *P. bituberculatus*. The generic affinities of two species are clarified; *P. latipes* Haswell, 1880, is referred to *Dumea*, new genus, whilst *P. sexspinosus* Miers, 1884, is transferred to *Litosus*, new genus. A recently described species, *P. taiwanicus* Loh & Wu, 1998, is also referred to *Dumea*. A new *Litosus* species, *L. giraffus*, is described from Japan. The classification of *Paratymolus*, *Dumea* and *Litosus* as majids and their placement in the subfamily Inachinae is discussed. Keys are provided for all taxa.

KEY WORDS. - Revision, taxonomy, new genera, new species, Crustacea, Majidae

INTRODUCTION

Paratymolus Miers, 1879 (Majidae: Inachinae) is a genus of small and rather unusual majids known from a wide area in the Indo-West Pacific. Three species are currently recognised, viz. *P. pubescens* Miers, 1879 (type species), *P. latipes* Haswell, 1880, and *P. sexspinosus* Miers, 1884. Several other nominal species and subspecies have been synonymised under *P. pubescens* (see Ortmann, 1894; Barnard, 1955; Griffin & Tranter, 1986).

In examining the *P. pubescens* material at their disposal, Griffin & Tranter (1986) realised that the structures of male first pleopods from specimens collected from various localities in the West Pacific, including Singapore, were very different despite their similar external appearances. They, however, decided against naming the various taxa. The status of two

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doubtful species, *P. bituberculatus* Haswell, 1880, and *P. hastatus* Alcock, 1895, was also not resolved, and Griffin & Tranter (1986) left both taxa in the synonymy of *P. pubescens*.

The present study revises *Paratymolus* and clarifies the identities of the various nominal taxa. New characters are determined and the taxonomy of the genus is resolved. The genus *Paratymolus* is separated into three genera, of which two, *Dumea* and *Litosus* are described as new. Six new species of *Paratymolus* s. str. are also described. The familial classification of *Paratymolus* is also discussed.

MATERIALS AND METHODS

The material examined is deposited in the following repositories: Australian Museum, Sydney (AM); Western Australian Museum, Perth (WAM); Northern Territories Museum, Darwin, Australia (NTM); Chiba Museum, Chiba, Japan (CBM); Zoologisk Museum of Copenhagen, Denmark (ZMUC); Natural History Museum, London, England (NHM); South African Museum, Durban (SAM); Senckenberg Museum, Frankfurt am Main, Germany (SMF); and Zoological Reference Collection of the Raffles Museum, National University of Singapore (ZRC).

Carapace length (cl) is the post-rostral carapace length which was determined as the distance from a line joining the preorbital angle of the supraorbital eave or region of both sides, to the centre of the posterior margin of the carapace. The length of ambulatory legs was considered to be that of only the merus, carpus, propodus and dactylus. This was determined by adding up the maximum length of each individual segment. For the figures for *Paratymolus*, *Dumea* and *Litosus*, only the salient or key characters have been illustrated. All structures are drawn in their denuded state except for parts of the carapace in certain cases. The abbreviations G1 and G2 are used for the male first and second pleopods respectively. Pubescence is used here to denote the presence of a continuous layer of fine setation.

TAXONOMY

Key to *Paratymolus* and allied genera

1. Carapace and posterolateral margin tuberculated; eyestalks moderately long (Fig. 1A); chelipedal carpal spine long, slender; lateral margins of fused abdominal segments 3-5 straight ..... *Paratymolus* Miers, 1879b
- Carapace and posterolateral tubercles devoid of tubercles; eyestalks short (Fig. 11A); chelipedal carpal spine short, stout; lateral margins of fused male abdominal segments 3-5 concave .. 2

2. Anterolateral margin with three large spines and two small spines in between; subhepatic region spinulate; cheliped with closely set acute granules along entire length of outer surface ..... *Dumea*, new genus
- Anterolateral margin with one broadly triangular tubercle followed by a anteriorly-directed spine; subhepatic region smooth; cheliped without granules along outer surface ..... *Litosus*, new genus

Key to species of *Paratymolus*

1. Carapace with one posterolateral tubercle 2
- Carapace with two or more posterolateral tubercles 8

2. Third antennal segment more than 0.2 times postrostral carapace length 3
- Third antennal segment less than 0.2 times postrostral carapace length 4

3. Carapace with a weak posterior gastric tubercle and three to four prominent dorsal branchial tubercles on distinct ridge; cheliped with three to four small spines on posterior border; G1 with broadly truncate distal tip, developed apically into a trough-like structure (Fig. 1) ..... *P. pubescens* Miers, 1879b
- Carapace with a strong posterior gastric tubercle and two weak dorsal branchial tubercles on faint ridge; cheliped without spines, with four large setae on posterior border; G1 tapered distally, with four small subapical teeth and curved apical flare (Fig. 8) ..... *P. griffini*, new species

4. Carapace clearly longer than broad, pentagonal; dorso-ventrally compressed, not markedly inflated or hunched anteriorly; G1 long, slender distally 5
- Carapace almost as broad as long, squarish or rounded; dorso-ventrally inflated, anterior region moderately or markedly hunched anteriorly; G1 broad, folded distally 6

5. Adult male with moderately low anterior gastric tubercles, posterior gastric tubercle moderately prominent; distal tip of G1 developed into a large, toothed fan (Fig. 10) ..... *P. vannus*, new species
- Adult male with very low anterior gastric tubercles, posterior gastric tubercle faint or indistinguishable; distal tip of G1 simple, flared (Fig. 7) ..... *P. cygnus*, new species

6. Carapace ovate, all tubercles faint but distinguishable (Fig. 6) ..... *P. coccus*, new species
- Carapace broadly pentagonal, anterior gastric tubercles moderately to markedly strong 7

7. Carapace slightly hunched, anterior gastric tubercles moderately high, posterior gastric and cardiac regions elevated, without tubercles, supraorbital eave poorly developed (Fig. 5) ..... *P. barnardi*, new species
- Carapace markedly hunched, anterior gastric tubercles high, acutely conical, posterior gastric and cardiac region elevated, with moderately high tubercles, preorbital angle of supraorbital eave developed as a spine or sharp tooth (Figs. 2, 3) ..... *P. bituberculatus* Haswell, 1880

8. Gastric tubercles strong, dorsal branchial region with two to three well defined tubercles; distal portion of G1 with broad dorsal hump, apically drawn into a neck, broadening terminally (Fig. 4) ..... *P. hastatus* Alcock, 1895
- Gastric tubercles low or indistinct, dorsal branchial region with two to three poorly defined tubercles; distal portion of G1 folded to form cylindrical, tube-like structure (Fig. 9) ..... *P. prolatus*, new species

Key to species of *Dumea*

1. No spinule present at base of emargination of rostrum; inner spinule of rostral lobe subequal in size to outer spinule; orbital region not distinctly toothed (Fig. 11) ..... *Dumea latipes* (Haswell, 1880)
- Spinule present at base of emargination of rostrum; inner spinule of rostral lobe considerably smaller than outer spinule; orbital region distinctly toothed, appears serrated (Fig. 12) ..... *Dumea taiwanicus* (Loh & Wu, 1998)

Key to species of *Litosus*

1. Male chela robust, not bulbous, surface of inner surfaces plain; cutting edges of fingers evenly toothed, without large posteriorly-directed tooth on dactylus or deep notch on pollex; G1 moderately long, straight, apical tip with a convoluted, narrow, slit-like aperture (Figs. 13, 14) ..... *L. sexspinosus* (Miers, 1884)
- Male chela robust, bulbous, with pattern of numerous small patches on surface of inner surface; cutting edges of fingers unevenly toothed, dactylus with one large medial tooth, pollex with matching notch; G1 long, slender, tapered, apical tip with simple, distinct, rounded aperture (Fig. 15) ..... *L. giraffus*, new species

TAXONOMY

Genus *Paratymolus* Miers, 1879b

Paratymolus Miers, 1879b: 45; 1884: 261; Haswell, 1880: 303; 1882: 142; Alcock, 1895: 163, 173; Hale, 1927: 122 (in key); Balss, 1929: 3; Sakai, 1938: 204; Barnard, 1955: 8; Griffin, 1966a: 276 (in key); Griffin & Tranter, 1986: 3, 38, 42.

Type species. - *Paratymolus pubescens* Miers, 1879b, by monotypy.

Diagnosis. - Carapace ovoid to distinctly pentagonal; covered with scale-like pubescence; rostrum and preorbital angle of supraorbital eave with few club-shaped sensory setae, such setae sometimes present on spines or tubercles of lateral carapace margin. Antorbital angle of supraorbital eave poorly formed or absent. Rostrum emarginated, lobes with a short inner lateral spinule each. Gastric and cardiac tubercles present. Dorsal branchial region with tubercles, often coalescing to form ridge. Subhepatic region smooth. Anterolateral margin of carapace with two spines or tubercles; posterolateral margin with one or two tubercles. Third maxilliped longer than broad, ischium length ca. 1.9 times width; inner margin bluntly angular to strongly convex; exopodite reaching to distal border of merus. Anterior margin of merus of cheliped tuberculated, posterior margin with three to four spinules or stout sensory setae; male chela not distinctly elongated or bulbous, outer surface with two or three tubercles; fingers relatively stout, straight; both cutting edges with squarish molariform teeth. Dactylus of ambulatory legs with denticles and two or three large curved teeth along ventral margin. Male abdomen relatively broad; proximal margin of fused segments 3 to 5 straight; sixth segment broadly rectangular.

Remarks. - Miers (1879b) described this genus based on a single female specimen of *Paratymolus pubescens*. Subsequently, four species and two varieties were described viz. *P. bituberculatus* Haswell, 1880, *P. latipes* Haswell, 1880, *P. bituberculatus* var. *gracilis* Miers, 1884, *P. sexspinosus* Miers, 1884, *P. hastatus* Alcock, 1895, and *P. latipes* var. *quadridentata*, Baker, 1906.

Paratymolus bituberculatus was synonymised under *P. pubescens* by Ortmann (1894). Subsequently Barnard (1955) synonymised *P. bituberculatus* and *P. hastatus* under *P. pubescens*. Barnard also identified specimens collected from Mozambique as *P. pubescens*, which we in this study recognise as a new species, *P. barnardi*, instead. More recently, Griffin & Tranter (1986), documented the considerable variation in gonopodal structure (apparently drawn in situ) of specimens from many parts of the Indo-Pacific, but concluded that "..... there is no good purpose to be served in trying to assign these specimens to previously described species or to describe new species from this small and confusing sample" (Griffin

& Tranter, 1986: 42). In none of these previous studies, however, were the type specimens examined.

In this revision, nine species are recognised, six of which are described as new, viz. *P. pubescens* Miers, 1879b, *P. bituberculatus* Haswell, 1880, *P. hastatus* Alcock, 1895, *P. barnardi*, new species, *P. cygnus*, new species *P. griffini*, new species, *P. prolatus*, new species, *P. coccus*, new species, and *P. vannus*, new species. There is no geographical overlap except in two species, *P. griffini* and *P. bituberculatus*. Previous records of *P. bituberculatus* from Japan by Takeda (1977) are considered to be merely large specimens of *P. pubescens*. The status of *P. bituberculatus* var. *gracilis* is still questionable as the holotype of *P. bituberculatus* is lost and there are no known male specimens of the latter species available for study. The holotype of *P. bituberculatus* var. *gracilis* is currently considered to be the only known male specimen of *P. bituberculatus*.

Paratymolus latipes Haswell, 1880, and *P. sexspinosus* Miers, 1884, are found to be sufficiently different from *Paratymolus* s.str. and from each other in the tuberculation and lateral armature of the carapace as well as in the morphology of the chelipeds, mouthparts, abdomen and G1. As such, two new genera are established for them; *Dumea* for *P. latipes*, and *Litosus* for *P. sexspinosus*. A new species of *Litosus*, *L. giraffus*, is described from Japan.

The present study of *Paratymolus* retains the genus for a very conservative group of species which closely resemble each other in external morphology. The structures of the chelipeds and armatures of the dactyli of the ambulatory legs are highly conservative. The most effective character that can be used to distinguish between them is the structure of the G1, which corresponds consistently with slight external differences in the external morphology. The G1 follows a generalised structure across the genus, being stout proximally and varied in shape distally.

There is also considerable sexual dimorphism observed in *Paratymolus* species. Males tend to have flatter, relatively narrower carapaces, blunter and relatively indistinct tubercles and lower gastric, cardiac and branchial regions. In males, the anterior-most lateral spine is often reduced to a tubercle, sometimes indistinct, whereas this is always prominent in females. The supraorbital eave also tends to be more developed in females, which is produced into a strongly acute spine in some species (e.g. *P. bituberculatus*). Perhaps the most marked sexual dimorphic character is the chelipeds. In males, the chelipeds are usually inflated and smooth, with low to almost undiscernible tubercles on the external surfaces of the carpus and merus. The anterior dorsal angle of the palm, before the insertion of the dactylus is hardly produced whereas in females, it is often expanded laterally into an acute angle or sharp spine. The fingers of male specimens tend to be straight and stout, with smooth external margins and large squarish molariform teeth. In females, however, the fingers are longer and more slender, curved at the tips and are armed with small teeth along the cutting edges. Griffin & Tranter (1986) had previously also noted that the cheliped and ambulatory legs of females to be shorter than those of males in relation to the carapace length.

Miers (1879b) in describing *Paratymolus* placed the genus with some uncertainty in the "Anomuran Maiidican family Homolidae" based on the similarly deflexed frontal and post frontal region as well as the flat post-hepatic region. He noted that unlike the genus *Homola*, the peduncles of the eyes were not divided into two portions and also that the third maxillipeds were less pediform than in *Homola*, although less operculiform than most majids. In describing

P. bituberculatus and *P. latipes*, Haswell (1880) disagreed with Miers (1879b), arguing that *Paratymolus* did not have its last pair of legs elevated on its back, and in addition possessed antennular fossae and operculiform third maxillipeds. He placed the genus instead, in the Corystidae, believing its nearest ally to be *Telmessus*. He reasoned that *Telmessus* could be classified together with *Paratymolus* in a distinct family, with affinities with both the Homolidae and Corystidae. To this effect, Haswell (1882) later established the family Paratymolidae for *Paratymolus*, placing it under the "tribe Anomura, section Anomura Superiora, sub-tribe Dromidea", stating that the general form of the carapace was like that of the Maioidea. However, he expressed uncertainty over the validity of the family, stating that "... the position of this family is uncertain. It is perhaps better placed among the Corystoidea" (Haswell, 1882: 142).

Alcock (1895), in re-establishing the family Majidae, agreed with Ortmann's (1893, 1894) placement of *Paratymolus* with the "*Achaeus*-like Majidae" on the basis of the presence of the female gonopore on the sternum instead of the base of the third pair of ambulatory legs, and subsequently referred it to the subfamily Inachinae. Balss (1929) proposed two further divisions of the Inachinae into the more primitive Macrocheiroidea and the more advanced Camposcioidea (based on the absence or presence of an intercalated supraorbital spine), the latter in which *Paratymolus* was placed. This system of classification was disputed by Sakai (1938) who considered it unnatural. Thus the genus was retained in the subfamily Inachinae s. lato. Barnard (1955) subsequently placed *Paratymolus* in the family Inachinae Miers, 1879a.

Sakai (1938) suggested *Paratymolus* was a primitive genus derived together with *Achaeus* from the purportedly more plesiomorphic *Oncinopus*. However, the placement of *Paratymolus* in Inachinae, its relation to other inachines and its position within the Majidae itself was questioned by Griffin & Tranter (1986) on the basis of the unusual G1 structure of the various species of the genus, which deviates from the general majid form of being long, slender (straight or curved) and apically tapering (see also Stephensen, 1946; Griffin, 1966a).

The length of the first pair of ambulatory legs relative to the carapace length of five males from different localities was tabulated by Griffin & Tranter (1986). Those of *P. vannus* and *P. griffini* seemed to be diagnostically different from those of the other males in being thrice or more the length of their carapaces. In this study, the reliability of this character for use was examined. It was found that in *P. cygnus*, for which the largest number of specimens were examined, this length was variable (1.6-2.5 times cl), with no particular trend in terms of allometric variation or sexual dimorphism. In the *P. hastatus* specimens examined, the length of the first pair of ambulatory legs in the four specimens was also found to be variable. The usefulness of this character for other species in this genus is therefore rather doubtful.

***Paratymolus pubescens* Miers, 1879b**
(Fig. 1)

Paratymolus pubescens Miers, 1879b: 45, pl. 2, figs. 6, 6a,b; Ortmann, 1893: 35, pl. 3, figs. 2, 2i; 1894: 38; Doflein, 1902: 655; Sakai, 1934: 293; Sakai, 1938: 208, text fig.4, pl. 21, fig 1; Sakai, 1965: 66, pl. 26, figs. 3, 4; Sakai, 1976: 156, pl. 48, fig.3; Griffin & Tranter, 1986: 38, pl. 7c [part].

Paratymolus bituberculatus - Takeda, 1977: 121, pl. 1B [not *P. bituberculatus* Haswell, 1880].

Material examined. - Holotype - female (4.4 mm) (NHM 1878.11), Matoya, Japan.

Others - 1 ovigerous female (NHM 1894.7.8.21-25), Japan; 1 male, 1 female (SMF G468, TS 00157 Box 4 sh33.10.24), 31°37' N, 130°32' E, coll. Strasbourg Museum; 1 male, 2 females (CBM ZC 2973) Tatsushima, Uchibo coast of Boso Peninsula, Japan/ Western Pacific, Lat. 1. Lon. 1, 2-3 m, trap, coll. T. Komai, 28 Aug.1996; 2 females (CBM ZC 2976), Tatsushima, Uchibo coast of Boso Peninsula, Japan/ Western Pacific, Lat. 1. Lon. 1, 2-3 m, trap, coll. T. Komai, 22 Aug.1996; 1 male (ZMUC CRU 2725), Aburatzebo, Misake, Japan; 5.5m dredge, sand, alga, coll. Th. Mortensen, 2 May.1914.

Diagnosis. - Carapace pentagonal, not broad; dorso-ventrally compressed, not hunched in appearance from lateral view. Third segment of antenna 0.24-0.27 times cl. Supraorbital eave weak, preorbital angle in females sometimes slightly developed laterally. Anterior gastric tubercles of moderate height; posterior gastric region weakly elevated, sometimes with a faint tubercle; cardiac region with broad, low elevation, with moderately prominent tubercle; dorsal branchial region with three to four tubercles on a distinct ridge, anterior two tubercles most prominent. Anterolateral margin with two spines, anterior spine sometimes reduced to a tubercle in males; posterior lateral margin with one strong tubercle. Merus of cheliped with three short spinules; outer surfaces of carpus and palm with two to three low tubercles; carpal spine long, slender, hidden behind palm when cheliped apposed against carapace. First ambulatory leg ca. 2.1-2.5 times cl; dactylus of legs with denticles and two larger curved teeth. G1 broad, stout, inner margin almost straight, distal part bent perpendicularly outwards; dorsal fold developed distally into trough-like structure; distal tip broadly truncate, margin slightly concave. Female gonopore round.

Description. - Carapace distinctly pentagonal; lateral margins straight (broader in females), dorso-ventrally compact; anterior surface not sloped downwards towards rostrum to form hunched appearance. Rostral lobes short, broadly triangular, each with one lateral spinule, fused proximally, emarginate distally, arched medially. Eyestalks moderately long. Basal antennal article moderately short, third segment of antenna 0.24-0.27 cl. Supraorbital eave weakly developed; in females, preorbital angle slightly produced. Subhepatic region smooth. Anterior gastric region with two moderately high tubercles; posterior gastric region flat to weakly elevated, faint tubercle sometimes discernible; cardiac region distinctly convex, with a moderately prominent tubercle; well defined oblique crest with four strong tubercles on dorsal branchial region. Anterolateral region armed with two spines; posterior one approximately twice size of anterior one, broad, curved forwards, somewhat depressed laterally; in males anterior spine sometimes reduced to a low tubercle; posterior lateral margin with one well defined tubercle. Third maxilliped longer than broad; ischium length ca. 1.9 times width; exopodite reaching to distal border of merus.

Cheliped of adult male with inflated palm; fingers stout with molariform teeth; fingers in female long, curved distally at tips, with small, sharp, conical teeth. Merus with three short spinules, hidden under dense pubescense, appearing tubercle-like. Carpus with one large tubercle on outer surface, carpal spine moderately long, hidden behind palm when palm apposed against carapace. Outer surface of palm smooth, with two to three low tubercles.

First ambulatory leg approximately 2.0 times cl; dactylus of ambulatory legs with denticles, obscured by simple and sensory setae, and two larger curved teeth.

Abdomen in male broadly triangular with segments 3 to 5 fused; edges of proximal margin of fused segments straight; sixth segment broadly rectangular; telson short; abdomen with seven free segments in females.

G1 broad, distal portion bent perpendicularly outwards, inner margin almost straight. Dorsal fold developed into trough-like structure distally. Distal tip broadly truncate, margin slightly concave. Female gonopore round, with pectinated rim.

Habitat. - The species is known from sandy bottoms with algae and reefs, up to 50 m deep.

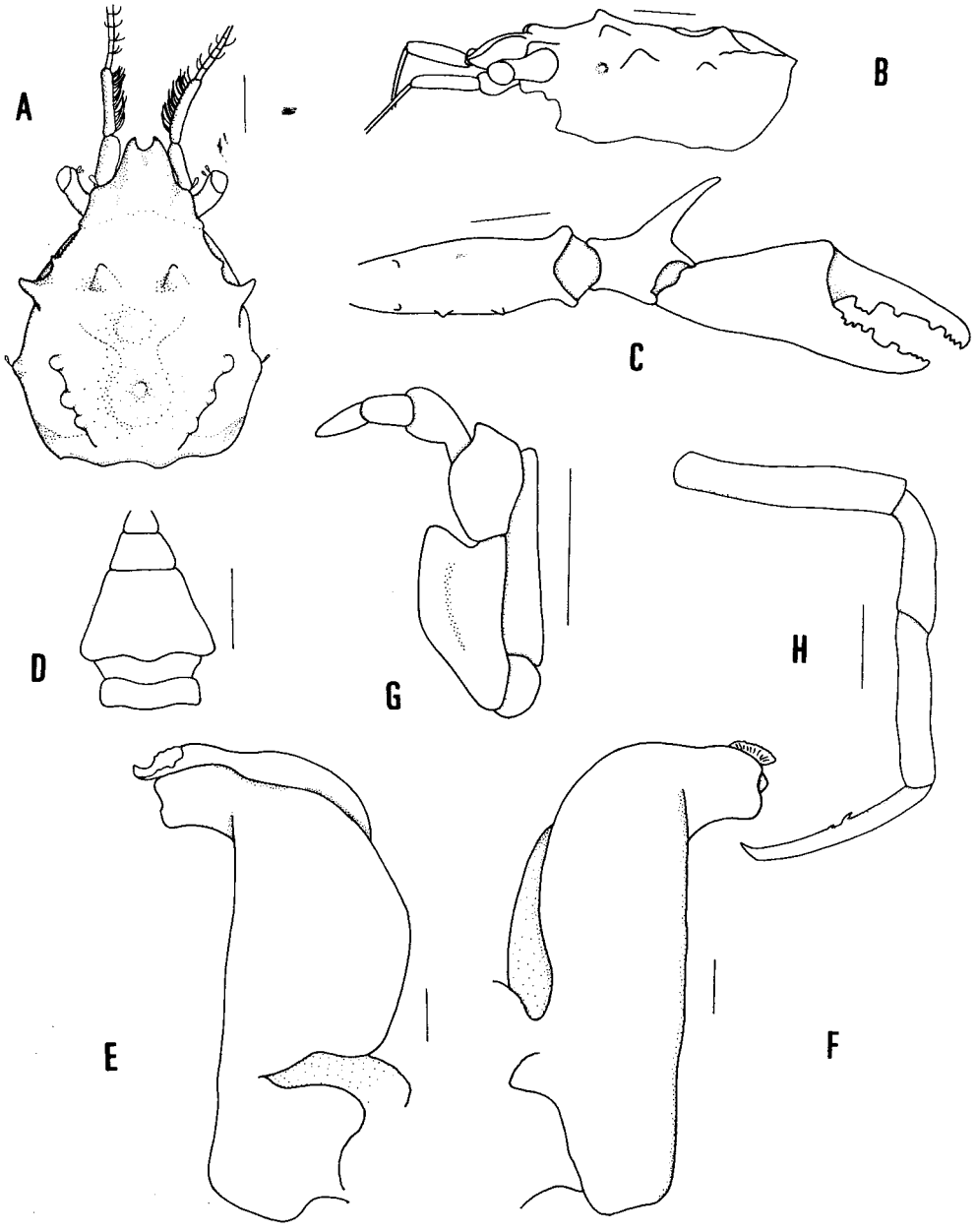

Fig. 1. *Paratymolus pubescens* Miers, 1879b. CBM ZC 2973; male; cl 4.8 mm. A. Carapace, dorsal surface. B. Carapace, lateral view. C. Left cheliped, inner surface. D. Abdomen E. Left G1, sternal surface F. Left G1, abdominal surface G. Left third maxilliped H. First left ambulatory leg. Scales = 1.0 mm in A-D, G, H; 0.1 mm in E-F.

Distribution. - This species is known from numerous locations in Japan.

Remarks. - The description given by Miers (1879b) is rather vague, with no mention of the distinct carapace tuberculation and little attention was given to the cheliped armature. Miers (1879b) described the ambulatory leg dactylus (= tarsal joints) as being long, straight and unarmed but this is inaccurate. Specimens examined (including his holotype) possess small, straight teeth as well as large curved ones, and this is also true for congeners. Miers' probably missed the teeth on the holotype because of the setae and debris. Most of the specimens examined had to be cleaned before the teeth on the dactylus could be seen.

The specimens of *P. pubescens* examined in this study were of similar size and little variation was seen. However, the females typically appeared to be broader and somewhat more tuberculate. The normal sexual dimorphism observed is in the cheliped structure, with the males possessing robust chelipeds with squarish teeth on their stout fingers, whereas the females have more slender chelipeds with long, curved fingers armed with small teeth. The distal portion of the G1 is actually flared and not truncated as depicted by Griffin & Tranter (1986). The shape of the G1 is consistent for all the males examined.

Paratymolus pubescens strongly resembles *P. cygnus* and *P. vannus* in the carapace shape and number of lateral tubercles. However, *P. pubescens* can easily be distinguished from these two species by its proportionately longer third antennal segment. It differs from *P. griffini* which also has a long third antennal segment in having a poorly defined posterior gastric tubercle, whereas *P. griffini* possesses a very prominent posterior gastric tubercle. Moreover, the G1s of *P. griffini* and *P. pubescens* are distinctly different.

Takeda (1977) recorded a female specimen from the Ogasawara Islands, Japan, which he identified as *P. bituberculatus*. Taking into consideration the findings of the current study, it is believed that the specimen in question is just a large mature female of *P. pubescens*. Takeda (1977) also considered a figure by Sakai (1965) to be of *P. bituberculatus* as well. In our opinion, however, Sakai's (1965) specimen is correctly identified as *P. pubescens*. While Takeda's (1977) female specimen is supposed to possess a markedly broader carapace with a sunken anterior portion, the photograph shows its carapace characters to be within the degree of variation seen in the series of specimens of *P. pubescens* at hand. *Paratymolus bituberculatus* which has an Australian and Javan distribution, possesses sharp conical posterior gastric tubercles. Takeda's specimen on the other hand, appears to have moderately broad, low posterior gastric tubercles. The extent of sloping in the anterior portion of the carapace is also not to the degree seen in *P. bituberculatus* s. str.

The cheliped characters of Takeda's specimen are doubtful for his identification of *P. bituberculatus*. The documented tubercles on the external surface of the carpus and palm are typically seen in female *P. pubescens*, but less obvious in male specimens with which Takeda compared his to. Moreover, the sharp spines seen on the posterior border of the merus of the specimens of Takeda (1977) and Sakai (1965) are also found in all specimens of *P. pubescens* at hand, although they are often obscured and look like tubercles because of the pubescence. The measurement of the length of the third antennal segments of Sakai and Takeda's figures of the species cannot be satisfactorily measured as it is uncertain whether the antennae were level when they were been photographed. Takeda (1977) also mentioned that a male *P. bituberculatus* specimen was examined, however, its morphology was not documented.

Paratymolus bituberculatus Haswell, 1880
(Figs. 2, 3)

Paratymolus bituberculatus Haswell, 1880: 302, pl. 16, figs. 1, 2; Haswell, 1882: 142; Griffin, 1966a: 276 (in key).
Paratymolus bituberculatus var. *gracilis* Miers, 1884: 261.
Paratymolus sexspinosus - Miers, 1884: 261 [part].
Paratymolus pubescens - Ortmann, 1894: 38; Barnard, 1955: 11.

Material examined. - 1 male (NHM 1882.7) (cl 3.0) (holotype of *Paratymolus bituberculatus* var. *gracilis* Miers, 1884), Prince of Wales channel, Australia; 1 female(NHM 1882.7) (labeled as *Paratymolus sexspinosus* 'TYPES'), Friday Island, Australia; 1 gravid female (NHM 1882.7), Thursday Island, Australia; 1 gravid female (WAM 9727), 22°52' S, 113°29' E, Station 178, 134m, NW Pt. Cloates, Australia, coll. C. S. R. O., 6 Oct.1963; 1 ovigerous female (WAM 1255), Bandicoot Bay, Station 1, 20°52' S, 115°19' E, sheltered intertidal sand and mudflats high up on intertidal sand flat, Australia, coll. Barrow I., WAM Expedition, 31 Aug.1966; 1 female (ZMUC CRU-2727), 8°23' S, 114°24' E, ca. 50m, Hard bottom, trawl, dredge Station 8, Java, coll. Mortensen Java South Africa Expedition, 6 Apr.1929.

Diagnosis. - Carapace pentagonal, box-like, inflated; anterior region strongly swollen, sloping steeply towards rostrum, with strongly hunched appearance. Third segment of antennae 0.16-0.18 times cl. Preorbital angle of supraorbital eave strongly developed into a spine or acute tip in female, inconspicuous in males. Anterior gastric tubercles tall, acutely conical; posterior gastric and cardiac regions elevated, with distinct, moderately high tubercles of similar sizes; dorsal branchial region with two to three poorly defined tubercles, faint ridge being present. Anterolateral margin with two tubercles, posterior one slightly to markedly larger than anterior one; posterior lateral margin with one tubercle. Merus of cheliped with three to four strong spinules on posterior margin; carpus and palm each with three to four conical tubercles on outer aspect; carpal spine relatively long, slender at base, not hidden behind palm when cheliped is apposed against carapace; distinct spine or acute tooth on palm just before insertion of dactylus; borders of palm and dactylus somewhat tuberculate; in males, cheliped robust, smoother, less tuberculate, spines on carpus less prominent. First ambulatory legs 2-2.5 times cl; dactylus with denticles and one or two larger curved teeth. G1 moderately stout, hooked in appearance, with terminal segment bent down obtusely relative to subterminal portion; terminal portion swollen basally, tapering to a blunt distal tip.

Habitat. - *Paratymolus bituberculatus* is found in the upper reaches of the intertidal zone, on sand and mudflats, also at depths up to 134 m. This species of *Paratymolus* could be confused with *Litosus sexspinosus*, as the type series of the latter includes a female specimen of *P. bituberculatus*.

Distribution. - Western Australia along the Torres Strait and Indonesia. This is a new record for Indonesia (Java).

Remarks. - Ortmann (1894) considered *P. bituberculatus* as a junior synonym of *P. pubescens*. Likewise, in his account on *Paratymolus* specimens from Mozambique which are here referred to new species, *P. barnardi*, Barnard (1950) discussed at some length the similarities of his specimens with those of *P. bituberculatus* by Haswell (1880, 1882), *P. pubescens* by Miers (1879b) and *P. hastatus* by Alcock (1895). He concluded that the three were conspecific. Both authors, however, did not examine any of the type specimens. In the current study, all three species are recognised as valid.

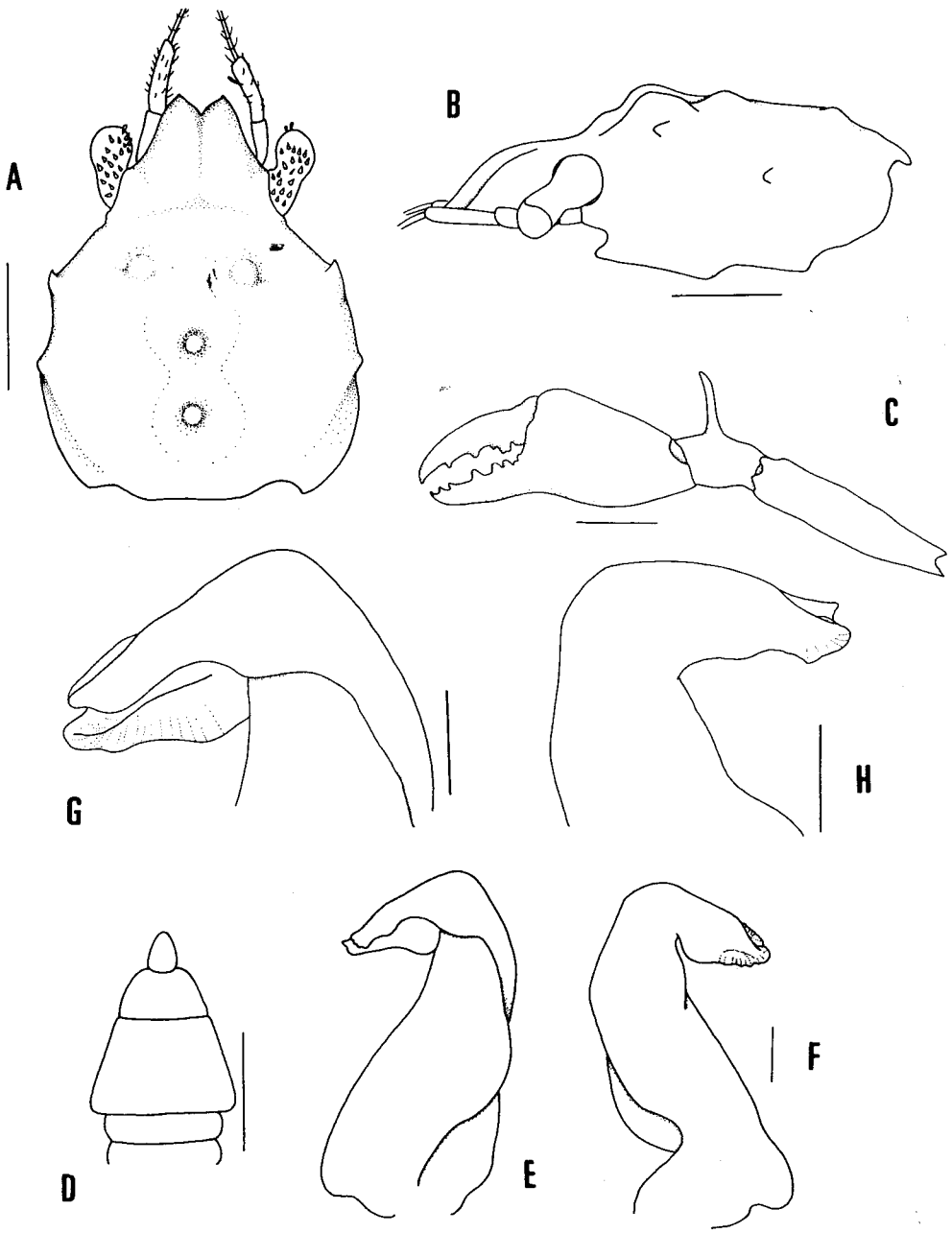

Fig. 2. *Paratymolus bituberculatus* Haswell, 1880. NHM 1882.7; male; cl 3.0 mm. A. Carapace, dorsal view. B. Carapace, lateral view. C. Right cheliped, inner surface. D. Abdomen. E. Left G1, sternal view. F. Left G1, abdominal view. G. Apex of left G1, sternal view. H. Apex of left G1, abdominal view. Scales = 1.0 mm in A-D; 0.1 mm in E-H.

Miers (1884) had noted from the description by Haswell (1880, 1882) that *P. bituberculatus* was distinguishable as a separate species from *P. pubescens* by the presence of a short spine above the eye, presence of four small teeth on the posterior border of the arm (merus), the subtriangular shape of the hand with a prominent tooth above the insertion of the dactylus and the two fasciculi of stiff setae (seen in the current specimens as conical tubercles) on the outer surface of the palm.

The holotype of *P. bituberculatus* is missing (Springthorpe & Lowry, 1994). However, the diagnostic characters of Haswell's (1880) type specimen as discussed by Miers (1884) suggest that the specimen was a female (except for the description of the hand as being subtriangular, which is considered inaccurate, as discussed below). Therefore the characters used to diagnose *P. bituberculatus* are mainly female ones and appear to be at the extreme end of what is known for the females of this sexually dimorphic genus. Nevertheless, since these characters seem consistent in the series of specimens examined, they are considered to be reliable. Males of the species are rare. The only male specimen collected to date is the holotype of *P. bituberculatus* var. *gracilis* Miers, 1884 (now regarded as synonymous with *P. bituberculatus*).

There is some amount of variation in the characters in the series of females recognised here as *P. bituberculatus*. The female from Bandicoot Bay (WAM 1255, cl 6.5 mm) is exceptional in having prominent dorsal branchial tubercles, a more defined dorsal branchial ridge, a relatively weak supraorbital spine and a third antennal segment which is notably broader than the rest. These differences, however, can be accommodated within the species' intraspecific variation. In the female specimen from Java (ZMUC CRU-2727), the posterior gastric tubercle is exceedingly high. There is also an additional posterior lateral tubercle on the right while the dorsal branchial characters, similar to those of the Bandicoot Bay female, are prominent. Moreover, unlike other specimens, the carpal spine is hidden behind the palm when the cheliped is retracted and apposed against the carapace. The inclusion of the Javanese female stretches the known distribution of this species substantially to include Indonesian

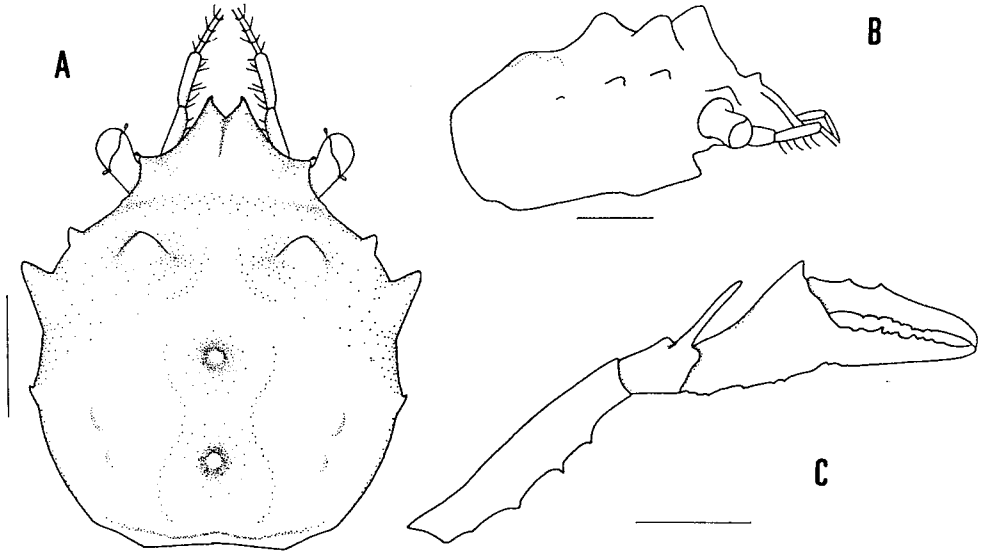

Fig. 3. *Paratymolus bituberculatus* Haswell, 1880. WAM 9727; female; cl 3.48 mm. A. Carapace, dorsal view. B. Carapace, lateral view. C. Left cheliped, inner surface. Scale = 1.0 mm.

waters, a species which is otherwise Australian in distribution. Considering its atypical characters, there is every possibility that the Javanese specimen belongs to a separate species. For the moment, in the absence of a closely corresponding male or more specimens, the Javanese female is tentatively assigned to *P. bituberculatus*. The visibility of the carpal spine from the dorsal view as a character, which was first used by Griffin & Tranter (1986) is not reliable due to the subjectivity of its use. Problems with the use of this character have likewise been encountered in other members of the genus.

In describing *P. bituberculatus* var. *gracilis*, Miers (1884) concluded that his male specimen differed from Haswell's (1880, 1882) in that instead of teeth, the merus and palm margins of the variety have only "... small tuberculiform setigerous prominences". This discrepancy can be resolved by taking into account the occurrence of marked sexual dimorphism in the genus as discussed earlier, if Haswell's type of *P. bituberculatus* (of unstated gender) is female, as believed. This would be contrary to Ortmann (1894), who concluded that Haswell's specimen was a male, based on its subtriangular chela. However, Haswell's illustration is too schematic to be useful and there is an obvious discrepancy between the chela depicted in Haswell's fig. 1 (attached to crab), which appears very robust, as seen in other congeneric males, and that of fig. 2 (detached) which is depicted as having more slender fingers with small teeth, as typically seen in female specimens. The rest of the chela morphology also fits well into what is known for female specimens.

In *Paratymolus*, the number and strength of chelipedal spines and tubercles varies to some within a species. This is sometimes due to the extent to which the spine has been obscured by pubescence or sensory setae, as they often are. Moreover, Miers' type specimen of *P. bituberculatus* var. *gracilis* is exceedingly soft. This has made the closely packed pubescence on its carapace and arms very distinct, and discerning the presence of spines on the merus of the chela becomes almost impossible.

In comparing the specimens of small males from Thailand and the Philippines with their conspecific females, the absence of anterior-most lateral spine in *P bituberculatus* var. *gracilis* as a diagnostic character, as suggested by Miers (1884), is considered unusable. In these species, the spine is likewise absent or very obscure but distinct in the females. Also, in *P. pubescens* and *P. cygnus*, several fully mature male specimens possess only faint tubercles where the anterior-most spine usually is.

While the holotype of *P. bituberculatus* var. *gracilis* is unlike female specimens of *P. bituberculatus* examined in this study in that its gastric tubercles are not as high or as conical, this discrepancy is considered to be caused by the poor condition of the specimen, which appears to be somewhat compressed. Both male and female specimens of *P. bituberculatus* have been figured to show this difference, and in the case of the illustration of the female specimen, to also illustrate the sexual dimorphism that exists in both the species and the genus as a whole.

In view of this, and considering its presence in the Torres Straits, where most other known specimens of *P. bituberculatus* have been collected, *P. bituberculatus* var. *gracilis* is considered to be a male specimen of *P. bituberculatus*. We have decided against choosing the male holotype of *P. bituberculatus* var. *gracilis* Miers, 1884, as the neotype of *P. bituberculatus* Haswell, 1880, as it is in very poor condition. An intact and better specimen of *P. bituberculatus* should be selected for this purpose once such specimens are known.

***Paratymolus hastatus* Alcock, 1895**
(Fig. 4)

Paratymolus hastatus Alcock, 1895: 174, pl. V, figs. 4, 4a.; Laurie 1906: 370.
Paratymolus pubescens - Barnard, 1955: 9 [not *P. pubescens* Miers, 1879b].

Material examined. - 3 males, 1 female (NHM 1907.5.22.98-100), Gulf of Manaar, Ceylon, coll. Herdman, 1902; 1 ovigerous female (ZMUC CRU-2728), Pamban Pass, South India, 5 m, coll. H. Lemche, 9 Oct.1951.

Diagnosis. - Carapace moderately inflated, broadly pentagonal; anterior portion slightly hunched, not markedly swollen. Third antennal segment 0.13-0.16 times cl. Supraorbital eave not produced in males and females. Anterior gastric tubercles high, acutely conical; posterior gastric tubercle moderately high, prominent; cardiac region moderately elevated with a well defined tubercle; dorsal branchial region with three tubercles somewhat coalesced to form a distinct ridge, anterior two tubercles taller and more prominent. Anterolateral margin

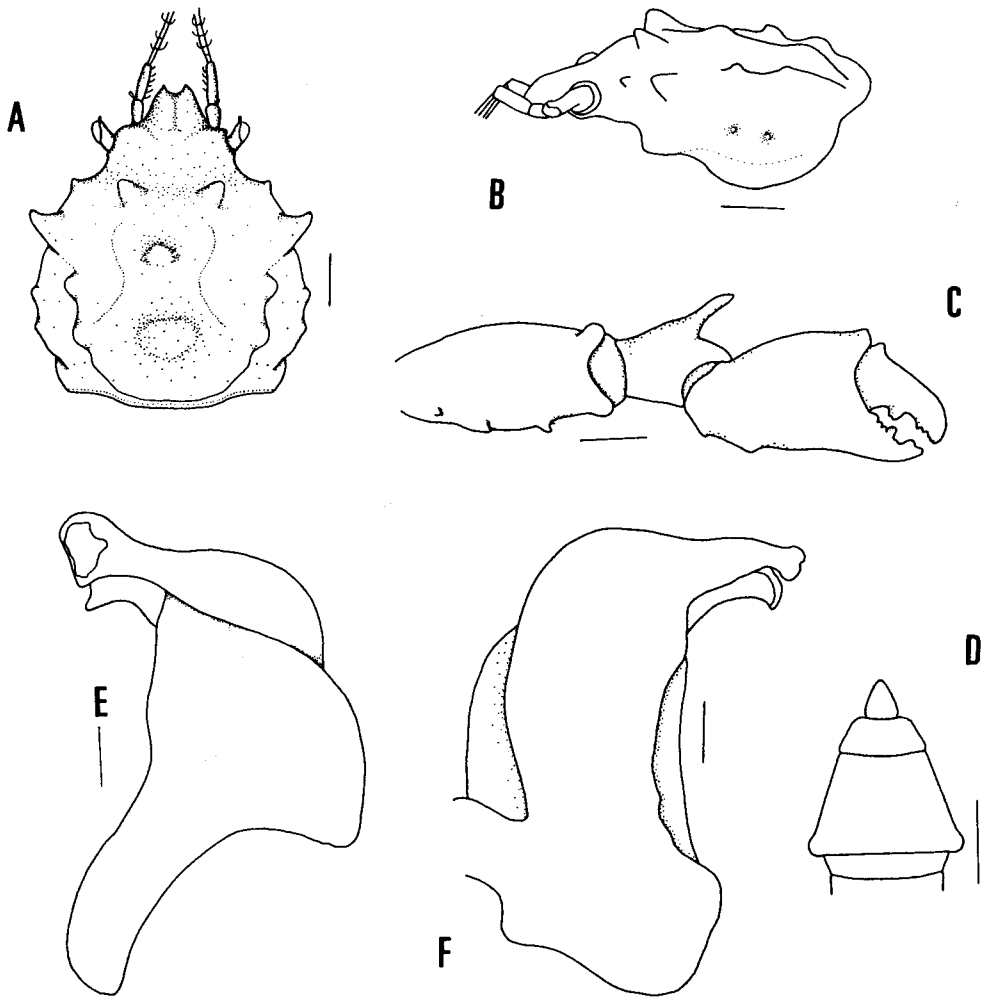

Fig. 4. *Paratymolus hastatus* Alcock, 1845. NHM 1907.5.22.98; male; cl 4.7 mm. A. Carapace, dorsal view. B. Carapace, lateral view. C. Left cheliped, inner surface. D. Abdomen E. Left G1, sternal view. F. Left G1, abdominal view. Scale= 1.0 mm in A-D; 0.1 mm in E, F.

armed with two spines, anterior spine subequal or smaller in size; posterior lateral margin with two to three closely spaced tubercles. Chelipeds robust with stout fingers in both male and females; merus with three prominent spinules; external surface of carpus with one or two prominent conical tubercles; carpal spine moderately long, stocky, hidden behind palm when cheliped apposed against carapace; outer surface of palm with two to four spines or with prominent conical tubercles. First ambulatory legs 1.5-2.4 times cl; dactylus of legs with numerous denticles and two larger curved teeth. G1 very broad, distal part with broad hump visible from dorsal view, bent perpendicularly in relation to proximal part, apically drawn out as a narrow neck, broadening terminally. Female gonopore well defined, circular, with sternal plate produced as a sloping roof above and a curved ridge below.

Habitat. - Unknown.

Distribution. - Andaman Sea, Sri Lanka, South India.

Remarks. - Alcock (1895) described *Paratymolus hastatus* based on a single ovigerous female from the Andaman sea. The holotype, presumably in the Indian Museum, was not available for study. Alcock's (1895) account of *P. hastatus*, while generally detailed, however, did not sufficiently describe the prominence of the carapace tubercles, which is an important taxonomic character. Alcock's (1895) drawing is also too small and schematic to be very helpful while the structure of the female gonopore is not known. However, the specimens from Ceylon and South India at hand fit the species well both in terms of morphology and the distribution, although none are as ovoid as the ovigerous female depicted by Alcock (1895).

Paratymolus hastatus was synonymised under *P. pubescens* with *P. bituberculatus* by Barnard (1955) who considered the descriptions and illustrations of the three species to be indistinguishably close. The type specimen of *P. hastatus*, however, was not examined by Barnard. *Paratymolus hastatus* can, however, be clearly diagnosed by the presence of more than one tubercle on its posterior lateral margin and its moderately inflated carapace with three prominent gastric tubercles, described as being "... disposed in a triangle, base forwards" by Alcock (1895: 174). In any case, the G1s of the three male specimens examined are consistently different from those of males of all other *Paratymolus* species.

***Paratymolus barnardi*, new species**
(Fig. 5)

Paratymolus pubescens - Barnard, 1955: 9, fig. 1a-h; Griffin & Tranter 1986: 40 [not *Paratymolus pubescens* Miers, 1879b].

Material examined. - Holotype - male (4.5 mm) (SAM-A 10901), across *Zostera* beds at Linga Linga, Morrumbene Estuary, Mozambique, coll. UCT Ecological Survey, 14 Jul.1954.

Paratype - 1 female (4.6 mm) (SAM-A 43343), across *Zostera* beds at Linga Linga, Morrumbene Estuary, coll. UCT Ecological Survey, 14 Jul.1954.

Others - 3 females (2 ovigerous) (SAM-A 39538), Station no. MOR 43B, 6-9m, north of wrecked schooner at Linga-Linga Morrumbene, coll. UCT Ecological Survey (Dredge), 20 Jan.1954.

Diagnosis. - Carapace broadly pentagonal, moderately inflated. Third antennal segment 0.16-0.18 times cl. Supraorbital eave poorly developed. Anterior gastric tubercles prominent, with

gentle slope, moderately high; posterior gastric and cardiac regions with broad, marked elevations, tubercles not discernible; dorsal branchial region with faint ridge, two poorly defined tubercles being present. Anterolateral margin with two short spines, posterior one slightly larger, anterior spine reduced to low tubercle in male; posterior lateral margin with one tubercle. Merus of cheliped with three short spinules on posterior border; outer surfaces of carpus and palm with two to three low to moderately prominent tubercles; carpal spine not hidden behind palm when chelipeds apposed against carapace; in female, dorsal anterior angle of palm before insertion of dactylus produced acutely. Dactylus of ambulatory leg with denticles and two larger curved teeth. G1 broad at base, with outer margin longer than

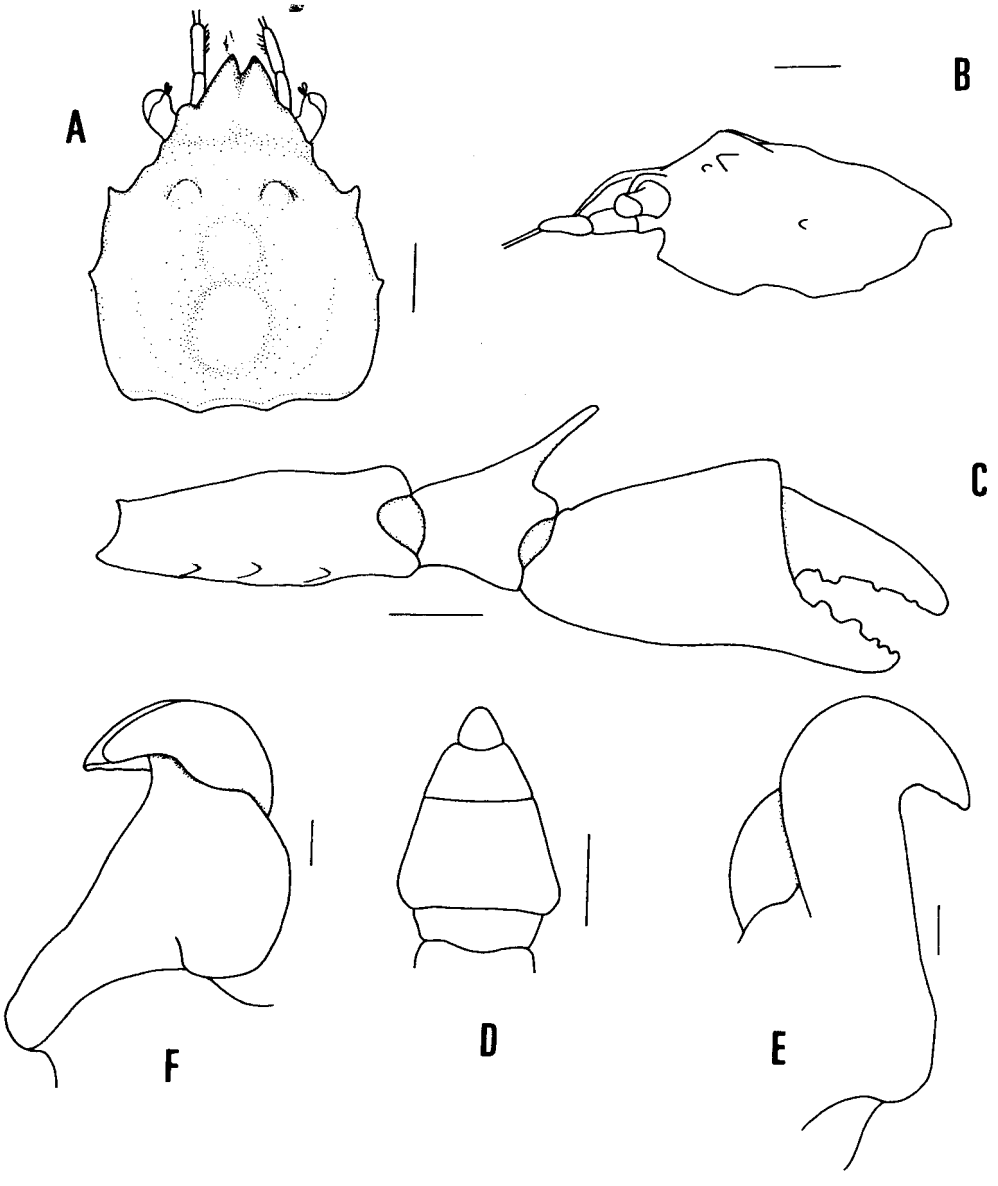

Fig. 5. *Paratymolus barnardi*, new species. SAM-A 10901; holotype male; cl 4.5 mm. A. Carapace, dorsal view. B. Carapace, lateral view. C. Left cheliped, inner surface. D. Abdomen. E. Left G1, sternal view. F. Left G1, abdominal view. Scale= 1.0 mm in A-D; 0.1 mm in E, F.

inner, distal portion simple, bent approximately perpendicular in relation to proximal portion, rounded anteriorly. Female gonopore circular, rim of inner half distinctly pectinated.

Habitat. - Not known

Distribution. - The only known specimens are from Morrumbene, Mozambique but the species could possibly extend further along the coast of the African continent.

Etymology. - This species is named after the late Dr. K. H. Barnard who contributed significantly to the knowledge of South African carcinology.

Remarks. - Although there is no known data accompanying the specimens of lot SAM-A 10901, from which both the holotype and paratype of *P. barnardi* have been designated, there is considerable circumstantial evidence that these specimens and those of lot SAM-A 39538 were the ones which were described by Barnard (1955) from Portuguese East Africa.

Firstly, the number and type of specimens that comprise the two separate lots, if taken together, correspond to the one male, two young females and two gravid females in Barnard's (1955) account. Secondly, the detailed descriptions and illustrations (albeit rather schematic ones) do correspond to the specimens at hand. Also, one of the two ovigerous females in the current series has measurements matching those of the ovigerous female described by Barnard (1955). Therefore, while the locality data given by Barnard (1955) for the entire series of *Paratymolus* specimens was simply ' Inhambane, Portuguese East Africa. ... in *Zostera* beds (University of Cape Town Jan and July 1954)', it is possible that Barnard was merely reflecting the general vicinity from which all five of the specimens were collected. This does not conflict with the known locality from which the three female specimens of SAM-A 39538 was collected (Linga-Linga, north of Inhambane). Additionally, the label reflects that the three specimens were collected during the very expedition that Barnard's (1955) account was based on.

The curator of the collection, Michelle van der Merwe writes that she was "... in agreement [with us] (given all the evidence) that the 2 specimens comprising SAM A 10901 (presently without any data), were amongst the 5 specimens looked at and published on by Barnard in 1955. Often Bernard retained material for later accessioning from a batch identified and returned to UCT. Although he knew exactly what was going on, these were probably accessioned after his death (the entry is not in his handwriting), hence the cataloguer would not have known that these formed part of the Morrumbene batch" (in litt. 18 June 1998). She adds that "... The date [of collection] is not certain – obviously Barnard looked at the entire batch and selected the best 2, but I suspect that the remaining July specimen was added to the [station] MOR 43B jar (January) [SAM-A 39538], so we will use 14 July 1954" (in litt. 18 June 1998).

It is interesting to note that Ortmann (1894) reported a male and a female *Paratymolus* (identified as *P. pubescens*) from Kilwa (Kivinjie). Although we have not examined these specimens, from what is now known, we believe that these specimens are probably *P. barnardi* as well, as it is the only species known from the western Indian Ocean. *Paratymolus pubescens* is only known from Japan.

The external morphology of *P. barnardi* is similar to its congeners. The structure of the G1 is also consistent with that of the genus, being broad proximally, but significantly different

in its distal portion. In comparing it with the description by Miers (1879b), Haswell (1880) and Alcock (1895), Barnard (1955) noted that the South African specimens were closest to Haswell's *P. bituberculatus* in having "broader shoulders". The resemblance continues in the somewhat inflated carapace, weak dorsal branchial tubercles and the strongly developed anterior dorsal angle of the palm in females of *P. barnardi*. However, unlike *P. bituberculatus*, its supraorbital eave is consistently poorly developed in both the male and female. Barnard (1955) also noted that the angle of the palm in his specimens was weaker than that of *P. bituberculatus* depicted by Haswell and approximated it to that in Alcock's specimen.

Whilst previously considered indistinguishable from the earlier described species, it is clear that *P. barnardi* is a distinct species from *P. bituberculatus* based on the characters discussed above. From *P. hastatus*, it is also easily diagnosed by the presence of only one tubercle on the posterior lateral margin, and from *P. pubescens*, by its markedly broader carapace, more distinct dorsal tubercles and a shorter third antennal segment. The structure of the G1s, remains the strongest diagnostic character among the four species, being very different.

An inaccuracy noted in Barnard's (1955) description of his specimens is his comment on the lack of teeth on the posterior border of the merus which he states as possessing large clavate setae instead. We have examined the specimens and found that three short spines are present. As all the legs of all the specimens are detached as was already the case in Barnard's account, the ratio of the first ambulatory leg length to the post rostral carapace length could not be determined.

In his account, Barnard (1955) also documented in detail the setation covering his specimens and questioned the suitability of the term 'pubescence' to describe the condition, suggesting instead that 'lepidosis' would be more apt, as they are scale-like in appearance. These leaf-like scales are similarly found on all other *Paratymolus* specimens that we have examined and appear to be unique to the genus.

***Paratymolus coccus*, new species**
(Fig. 6)

Material examined. - Holotype - ovigerous female (5.0 mm) (ZRC 1993.613), Horikawa reef flat (Tamagusuka Village) Okinawa, Japan, coll. P.K.L. Ng, Apr.1992.

Paratype - 1 ovigerous female (5.7 mm) (ZRC 1993.614), Horikawa reef flat (Tamagusuka Village) Okinawa, Japan, coll. P.K.L. Ng, Apr.1992.

Diagnosis. - Carapace moderately inflated, globose, smooth; tubercles low, with fine velvet-like appearance. Third antennal segment 0.18 times cl. Supraorbital eave not produced. Anterior gastric tubercles very low, small; posterior gastric and cardiac regions not elevated, with very faint tubercle each; dorsal branchial region with two low, broad tubercles, posterior one very faint, ridge not discernible. Anterolateral margin with one very faint tubercle followed by a short, slightly curved spine; posterior lateral region with one low tubercle. Cheliped merus with three short spinules, outer surfaces of carpus and palm with three to four low tubercles; carpal spine not hidden behind palm when cheliped apposed against carapace. First ambulatory leg 1.6-1.8 times cl; ambulatory legs stoutly built, with 2 large curved teeth, denticles not discernible. Female gonopore round, with pectinated inner rim.

Habitat and Ecology. - The two specimens of *Paratymolus coccus* were found on a dead coral head from a reef flat. It is likely therefore that the species is also a coral dweller.

Distribution. - Okinawa, Japan

Etymology. - The name refers to the rounded, globose shape of the crab carapace and is derived from the Latin word for berry alluding to this peculiarity. It is used as a noun in apposition.

Remarks. - The two ovigerous females examined are consistently distinct from all congeners, even in the absence of a male specimen. It most closely resembles *Paratymolus prolatus*, new species, in its low, poorly defined dorsal carapace tubercles including those of the branchial region. However, *P. coccus* can be easily differentiated from the latter by the presence of only one posterior lateral tubercle (two in *P. prolatus*) and its proportionately shorter and stouter ambulatory legs. *Paratymolus coccus* is also quite unlike its Japanese congener, *P. pubescens*, in having a shorter third antennal segment, lower dorsal tubercles, and conspicuously less acute lateral spines.

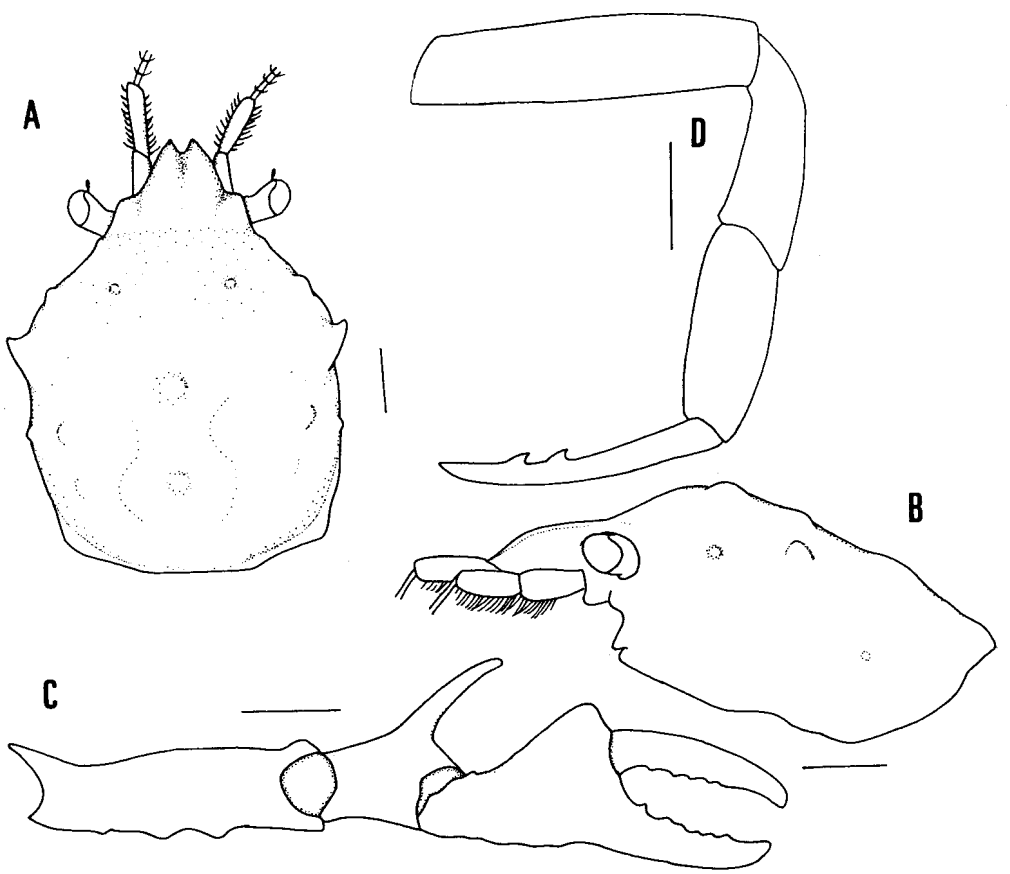

Fig. 6. *Paratymolus coccus*, new species. ZRC 1993.613; holotype female; cl 5.0 mm. A. Carapace, dorsal view. B. Carapace, lateral view. C. Left cheliped, inner surface D. First ambulatory leg. Scale = 1.0 mm.

While the carapace of the crab is covered with a thick velvety 'pubescence' consisting of finer than usual scales, it is uncertain as to whether this character is reliably diagnostic or if it is simply a reflection of the good condition of the specimen in contrast to the majority of the others examined. This is especially apparent since several of the more recently collected specimens of *P. cygnus* also have a similar appearance.

***Paratymolus cygnus*, new species**
(Fig. 7)

Paratymolus pubescens - Rathbun, 1910: 317 [part]; Griffin & Tranter, 1986: 38, fig. 7d [part].

Material examined. - Holotype - male (3.0 mm) (ZRC 1984 5581), Sentosa reef, Singapore, coll. P. K. L. Ng, 29 Apr.1982.

Paratypes - 3 males, 2 females (ZRC 5582-5586), Sentosa reef, Singapore, coll. P. K. L. Ng, 29 Apr.1982.

Others - 1 female (ZRC 1985.1782) Labrador Beach, Singapore, coll. P. K. L. Ng, Dec.1983; 2 females (ZRC 1989.3483-3484) Labrador Beach, Singapore, coll. P.K.L. Ng, 14 Dec.1989; 1 male (ZRC 1997.915), Labrador Rocky Beach, Singapore, coll. P. K. L. Ng, 22 Nov.1995; 5 males, 4 females (1 gravid) (ZRC 1997.916) Labrador Rocky Beach, Singapore, coll. L.W. Loh et al., 25 Jul.1997; 1 female (ZRC 1993.4194), Pulau Pawai, Singapore, coll. R. Serène, 15 Apr.1964; 2 females (ZRC 1995.397), Semakau (dredged), Singapore, coll. P.K.L. Ng, Oct.1992; 1 ovigerous female (ZMUC CRU-2724), Mortensen Siam Expedition: Singapore, 4-5m, coll. Th. Mortensen, 4 Dec.1899; 1 ovigerous female (AM P 34568), Mortensen Java - S. Africa Expedition: Singapore, low water, coll. Th. Mortensen, 22 Jul.1907.

Diagnosis. - Carapace longitudinally pentagonal, dorso-ventrally compact; proportionately broader, slightly inflated in females. Third antennal segment 0.14-0.18 times cl. Supraorbital eave poorly developed, preorbital angle in females sometimes slightly produced. In males, anterior gastric tubercles very low, posterior gastric region flat or with a faint small elevation, cardiac region with a low, broad elevation, sometimes with a low tubercle; in females, anterior gastric tubercles moderately high, posterior gastric and cardiac regions not elevated, with a moderately prominent tubercle each; dorsal branchial region with four tubercles on a distinct ridge, anterior two to three stronger. Anterolateral region with two spines, anterior spine sometimes reduced to a low tubercle in males, posterior one always larger; posterior lateral margin with one tubercle. Cheliped merus with three short spinules, external surfaces of carpus and palm with two to three low tubercles each; carpal spine lying just above palm when cheliped is apposed against carapace, nearly or completely hidden. First ambulatory leg 1.6-2.5 times cl; dactylus of ambulatory legs with denticles and two to three moderately large to large curved teeth. G1 distal half long, slender, slightly curved, apex expanded, in juveniles moderately long, straight and slender with stump on apex. Female gonopore round, with thin inner pectinated rim, surrounded by a faint circular thickening of sternite.

Habitat and Ecology. - Specimens of *Paratymolus cygnus* have been collected from the intertidal to low water zones, along sandy-rocky beaches with exposed coral heads or coral rock as that found along Labrador Beach, and previously Siloso Beach on Sentosa Island, Singapore. Smaller specimens tended to be found higher up the littoral zone than larger ones. This species was often found crawling on coral rock with growths of algae (usually filamentous green algae), with their chelae held almost vertical, if threatened. Most crabs would tend to either jettison off the rock to safety or scurry to the under surface of the rock when it was lifted out of the water. It was thus useful to place a net under the rock immediately

as the rock was being lifted to capture them. The animals were greyish-brown in colour when alive.

Distribution. - Currently only known from Singapore.

Etymology. - The Latin word 'cygnus' means swan, alluding to the structure of the G1 in mature males which distally resembles a swan's neck. The name is used as a noun in apposition.

Remarks. - A good series of *Paratymolus cygnus* is available for study, spanning a size range of 1.7 to 4.6 mm. This has allowed allometric variations in growth to be studied. Whilst the general carapace features between small and large crabs do not vary to a great degree for both male and female specimens, young females tend to resemble males in general,

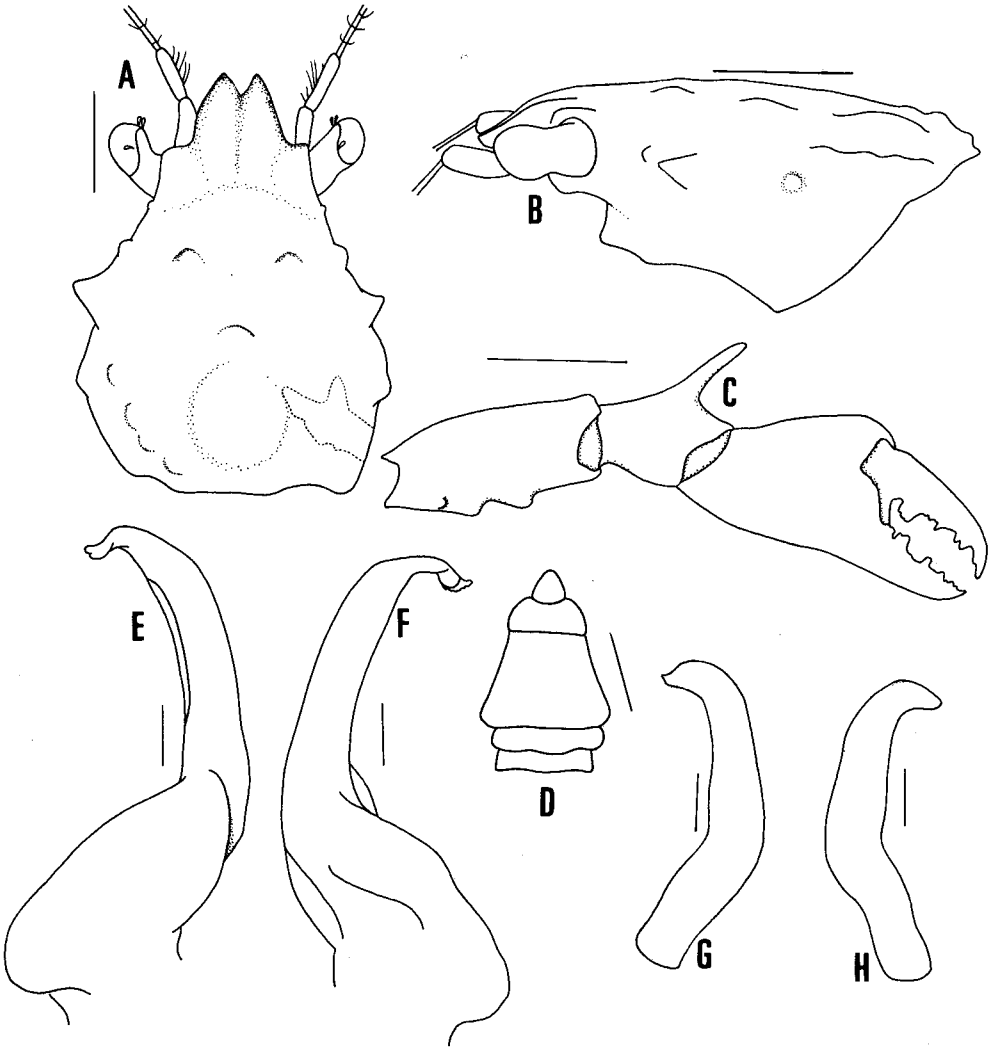

Fig. 7. *Paratymolus cygnus*, new species. ZRC 1984.5581; holotype male; cl 3.0 mm. A. Carapace, dorsal view. B. Carapace, lateral view. C. Left cheliped, inner surface. D. Abdomen E. Left G1, sternal view. F. Left G1, abdominal view. ZRC 1997.916; juvenile male; cl 1.7 mm. G. Left G1, sternal view H. Left G1, abdominal view. Scales = 1.0 mm in A-D; 0.1 mm in E-H.

by having the fore spine of the anterolateral region poorly developed as a tubercle and their carapaces proportionately narrower than in adults. However, unlike males, juvenile females possess prominent gastric and cardiac tubercles. In the immature crabs of both sexes, the carpal spine of the cheliped is noticeably shorter and stouter while the meral spinules are already prominent. It is also noted that whereas larger specimens visibly possess small teeth on the dactylus of the ambulatory legs, this is not clearly visible in smaller crabs.

In males, there is obvious morphological variation in the structure of the G1 from small to large crabs. The G1 figured by Griffin & Tranter (1986) is that of a juvenile. As the crab matures, the proximal portion broadens whilst the distal part lengthens and expands apically into a short flared structure.

Paratymolus cygnus closely resembles *P. vannus*, new species, from Thailand, with regard to the carapace characters and the possession of a slender G1. In addition, *P. vannus* resembles male *P. cygnus* in that the carpal spine on the cheliped is long, nearly vertical or directed forward, but not hidden by the chela. Also, instead of tubercles or spinules, the males of both species possess three curved spinules on the posterior border of the cheliped merus. However, as with *P. prolatus*, the carpal spine character has been found to be unreliable as those of *P. cygnus* seem to either be hidden by the palm, or almost so. The cheliped merus of both species on the other hand have similar looking spinules which are not truly curved. Rather, the spinules are finer apically than those of some other congeners (e.g. those found in *P. pubescens* or *P. hastatus*).

The male of *P. cygnus* can be distinguished from *P. vannus* by the lack of a prominent posterior gastric tubercle and substantial difference in the structure of the distal tip of the G1. The females of the two species on the other hand are difficult to tell apart as *P. cygnus* is quite strongly sexually dimorphic, and the female of *P. cygnus* closely resembles that of *P. vannus* in having considerably more prominent carapace tubercles. More female specimens of *P. vannus* would be required before further conclusions can be made.

Also of interest is a large female (4.6 mm) collected from Singapore during the Mortensen Siam Expedition (see Rathbun, 1910) which possesses a prominent preorbital angle and a well developed posterior gastric tubercle. Like Takeda's (1977) female specimen which had been misidentified as *P. bituberculatus*, this specimen shows the extent of ontogenic variation in the species and the trend within the genus for females to resemble one another, especially with maturity.

The holotype designated is a male which is slightly damaged on the right side of the carapace. In all other respects, it is a good specimen and is chosen because of its relatively large size.

***Paratymolus griffini*, new species**
(Fig. 8)

Paratymolus pubescens - Griffin & Tranter, 1986: 39, fig. 7b [part].

Material examined. - Holotype - male (3.0 mm) (AM P 34564), Station 133, anchorage off Lirung up to 36m, North Sulawesi, Salibabu Island, Indonesia, trawl, dredge and reef exploration, mud and hard sand, coll. Siboga Expedition, 25/27 Jul.1899.

Paratype - 1 female (3.5 mm) (AM P34565), Banda, Indonesia, coll. Siboga Expedition.

Diagnosis. - Carapace pentagonal, moderately broad; in female rounded, box-like, inflated anteriorly, with hunched appearance. Third antennal segment 0.23 times cl in male, 0.21 times cl in female. Supraorbital eave poorly developed. Anterior gastric tubercles moderately high, conical; posterior gastric and cardiac region elevated, with a moderately high tubercle each; dorsal branchial region with two faint tubercles on an ill-defined ridge. Anterolateral margin with two spines, anterior one smaller, indistinct in male; posterior lateral margin

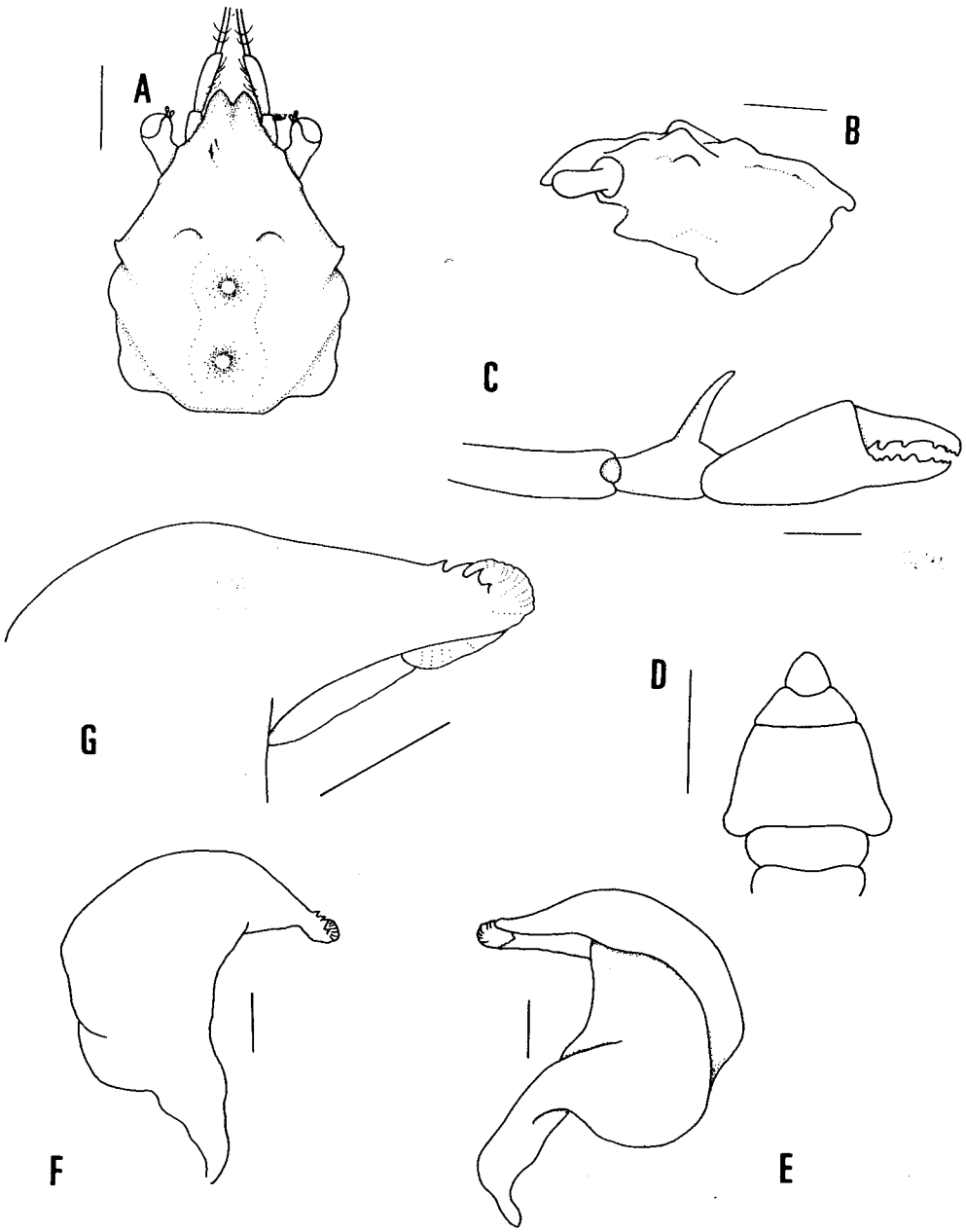

Fig. 8. *Paratymolus griffini*, new species. AM P34564; holotype male; cl 3.0 mm. A. Carapace, dorsal view. B. Carapace, lateral view. C. Left cheliped, inner surface. D. Abdomen. E. Left G1, sternal view. F. Left G1, abdominal view G. Apex of left G1, abdominal view. Scales = 1.0 mm in A-D; 0.1 mm in E-G.

with one broad to conical tubercle. Merus of cheliped with no obvious tubercle, but with four large sensory setae arranged at regular intervals; palm and carpus with two to three sensory setae on outer surfaces; carpal spine long, slender, hidden behind palm when cheliped apposed against carapace. First ambulatory leg 4.4 times cl; dactylus of legs with numerous denticles in male and one or two additional large curved teeth in female. G1 broad, rounded in appearance, distal part bent almost perpendicularly in relation to proximal portion, tapering towards apex; with four small subapical teeth, distal tip with rounded flare. Female gonopore round, rim lightly pectinated.

Habitat. - The species is found in coral, mud and hard sand bottoms to 36 m deep.

Distribution. - North Sulawesi, Banda, Indonesia.

Etymology. - This species is named after Dr. D. J. G. Griffin who has contributed much to the study of majid crabs, especially of the Indo-Pacific region.

Remarks. - The only published account of these specimens from Salibabu and Banda by Griffin & Tranter (1986) did not recognise them as being conspecific. A character that suggests that these two specimens, here referred to a new species, *P. griffini*, are conspecific is the possession of long third antennal segments, a condition that is seen in only one other species, *P. pubescens*.

The male holotype of *P. griffini* has only four setae on the posterior border of the cheliped merus. In all other known species, the small spinules which are often hidden under pubescence are present instead. It is unlikely that the occurrence of setae instead of spinules in *P. griffini* is a juvenile trait as in other species, for example *P. cygnus*, specimens of this size (3.0 mm) and smaller already possess small spines on the merus. This is thus considered to be a good diagnostic character for *P. griffini*.

There is no description by Griffin & Tranter (1986) of the cheliped merus of the Banda female which now has both chelipeds missing. However, the carpal spine is stated to be long, horizontal and concealed behind the palm. In this feature, and with the presence of a small or indistinct "mesogastric tubercle" (posterior gastric tubercle), one or two indistinct tubercles on the dorsal branchial margin and very small straight teeth with one or two slightly larger curved teeth on the dactylus of the ambulatory legs, it supposedly resembles five other females from the Aru and Kai Islands. These specimens, although not examined, together with the Banda female, are considered to be similar to both the Japanese and Sulawesian males. However, Griffin & Tranter (1986) considered these specimens to have too few distinguishing characters to assign them to either species.

In examining the Banda female, it was found that the posterior gastric tubercle is moderately strong, contrary to Griffin & Tranter's comments. This tubercle is weak or indistinct in the Japanese species. Moreover, the two weak dorsal branchial tubercles of the female also render it closer to the Sulawesian male, as those of *P. pubescens* are more in number (usually four) and always prominent. Noteworthy too is the unusually straight and long rostrum of the Banda female, which is most likely due to intraspecific variation.

***Paratymolus prolatus*, new species**
(Fig. 9)

Paratymolus pubescens - Griffin & Tranter, 1986: 38, fig. 7a [part].

Material examined. - Holotype - male (3.9 mm) (AM P34566), Mortensen Pacific Expedition: Philippine Islands, Zamboanga, 5-9m, sand, coll. Dr. Th. Mortensen, 1 Mar.1914.

Paratype - 1 female (4.6 mm) (ZMUC CRU-2726), Mortensen Pacific Expedition: Philippine Islands, Zamboanga, 5-9m, sand, coll. Dr. Th. Mortensen, 1 Mar.1914.

Diagnosis. - Carapace subpyriform in male, broadly pentagonal in female. Third antennal article 0.18 times cl in male, 0.17 times cl in female. Supraorbital eave not developed. Anterior gastric tubercles low but distinct; posterior gastric region not elevated, tubercle absent; cardiac region with a broad, slight elevation; dorsal branchial region with two broad, poorly defined tubercles, ridge not discernible. Anterolateral region with two low conical tubercles or short, blunt spines, posterior one larger; posterior lateral region with two closely spaced tubercles. Merus of cheliped with three moderately prominent tubercles on posterior margin, outer

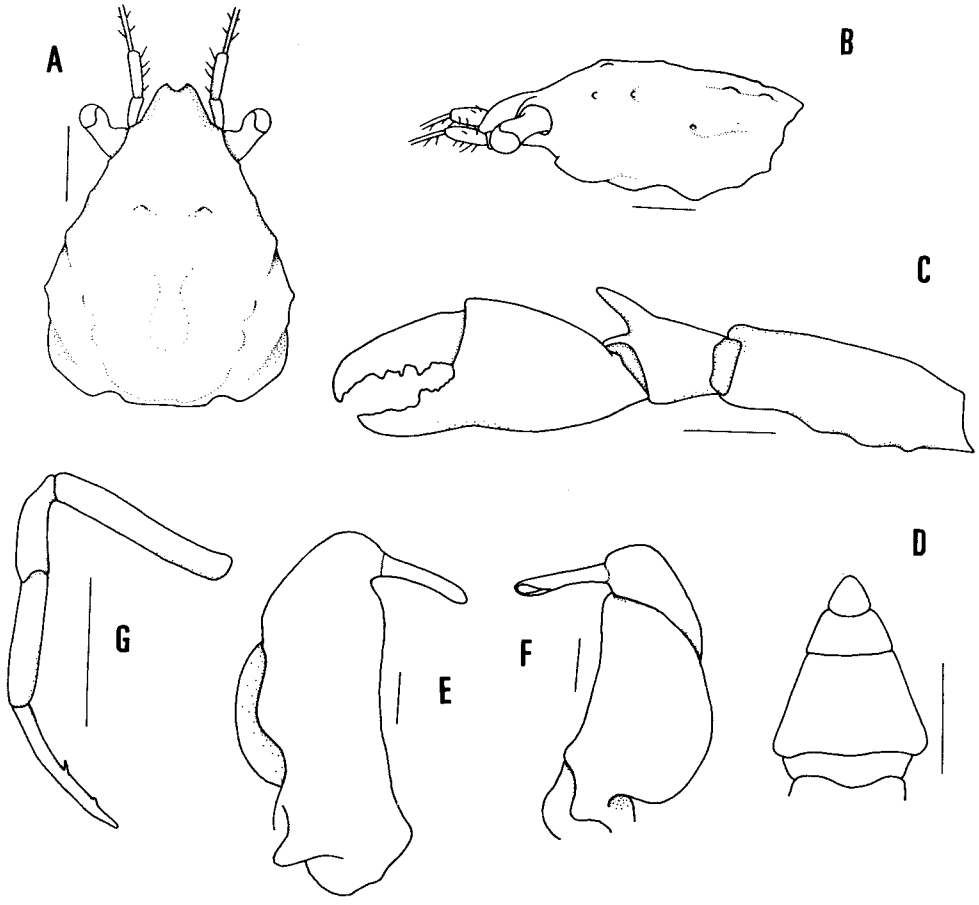

Fig. 9. *Paratymolus prolatus*, new species. AM P34566; holotype male; cl 3.9 mm. A. Carapace, dorsal view B. Carapace, lateral view. C. Right cheliped, inner surface. D. Abdomen E. Left G1, sternal view. F. Left G1, abdominal view G. First right ambulatory leg. Scales = 1.0 mm in A-D, G; 0.1 mm in E, F.

surfaces of carpus and palm with two to three faint tubercles, indiscernible in male; carpal spine not hidden when cheliped apposed against carapace. First ambulatory leg about 2.4 times cl; dactylus of legs with denticles and two large curved teeth. G1 moderately stout, distal portion folded to form a thin cylindrical, tube-like structure directed almost perpendicularly in relation to subterminal part. Female gonopore round, inner half of rim pectinated, surrounded by a thickened ring on the sternum.

Habitat. - The two known specimens are from the same location, sandy bottom at 5-9m depth.

Distribution. - Currently known only from the Philippine island of Zamboanga.

Etymology. - The name is derived from Latin, meaning extended or elongated, alluding to the long tube-like distal structure of the male G1. The name is used as a noun in apposition.

Remarks. - *Paratymolus prolatus* bears some resemblance to *P. coccus* in that they both have poorly tuberculated carapaces. However, the Philippine species is easily differentiated by the presence of two tubercles on the posterior lateral margin. The only other congener known to have more than one such tubercle is *P. hastatus*, which unlike the former, also possesses prominent gastric and cardiac tubercles. There is also just one obvious tubercle on the left posterior margin of the male specimen at hand, which suggests intraspecific variation. The carpal spine was described by Griffin & Tranter (1986) as being long and directed forward or slightly upward and concealed behind the palm. However, we find the converse is true. This character is considered unreliable.

Paratymolus vannus, new species
(Fig. 10)

Paratymolus pubescens - Rathbun, 1910: 317 [part]; Barnard, 1955: 11; Griffin & Tranter, 1986: 39, fig 7e [part].

Material examined. - Holotype - male, soft (3.3.0 mm) (ZMUC CRU 2722), Mortensen Siam Expedition, Tung Kaben, Thailand, 11m, sand, mud, phanerogams, coll. Th. Mortensen, 22 Feb.1900.

Paratype - 1 female (3.5 mm) (ZMUC CRU 2723), Mortensen Siam Expedition, Koh Kahdat, Thailand, 7-9m, sand, stones coral, coll. Th. Mortensen, 15-18 Feb.1900.

Diagnosis. - Carapace pentagonal, distinctly longer than broad in male, rounded and box-like in female; in both sexes, dorso-ventrally compressed. Third antennal segment 0.16-0.17 times cl. Supraorbital eave not produced. Anterior gastric tubercles moderately low; posterior gastric region slightly elevated, with prominent tubercle; cardiac region with rounded elevation, no tubercle discernible. Anterolateral margin with two spines; in male, anterior spine markedly smaller, poorly defined; posterior lateral margin with one tubercle; dorsal branchial margin with three to four tubercles, forming moderately strong to strong ridge. Cheliped inflated in male; merus with three to four moderately prominent spinules, posterior-most smallest; in male, carpus and palm smooth externally, tubercles indistinct; female with at least two spinules on external surface of carpus and three spinules on outer surface of palm; carpal spine nearly vertical, not hidden behind palm when chelipeds apposed against carapace. Dactylus of legs with two large curved teeth. G1 broad at base, distal half very slender, straight, obliquely bent, developed distally as a large, toothed fan-like structure;

small flap present subdistally. Female gonopore imperfectly round, inner half with thin pectinated rim.

Habitat. - This species is found in sand, stone, coral or mud bottoms with algae, 3-11 m in depth.

Distribution. - Gulf of Thailand.

Etymology. - The name is derived from the Latin for fan, alluding to the fan-like structure of the distal tip of the male G1. It is used as a noun in apposition.

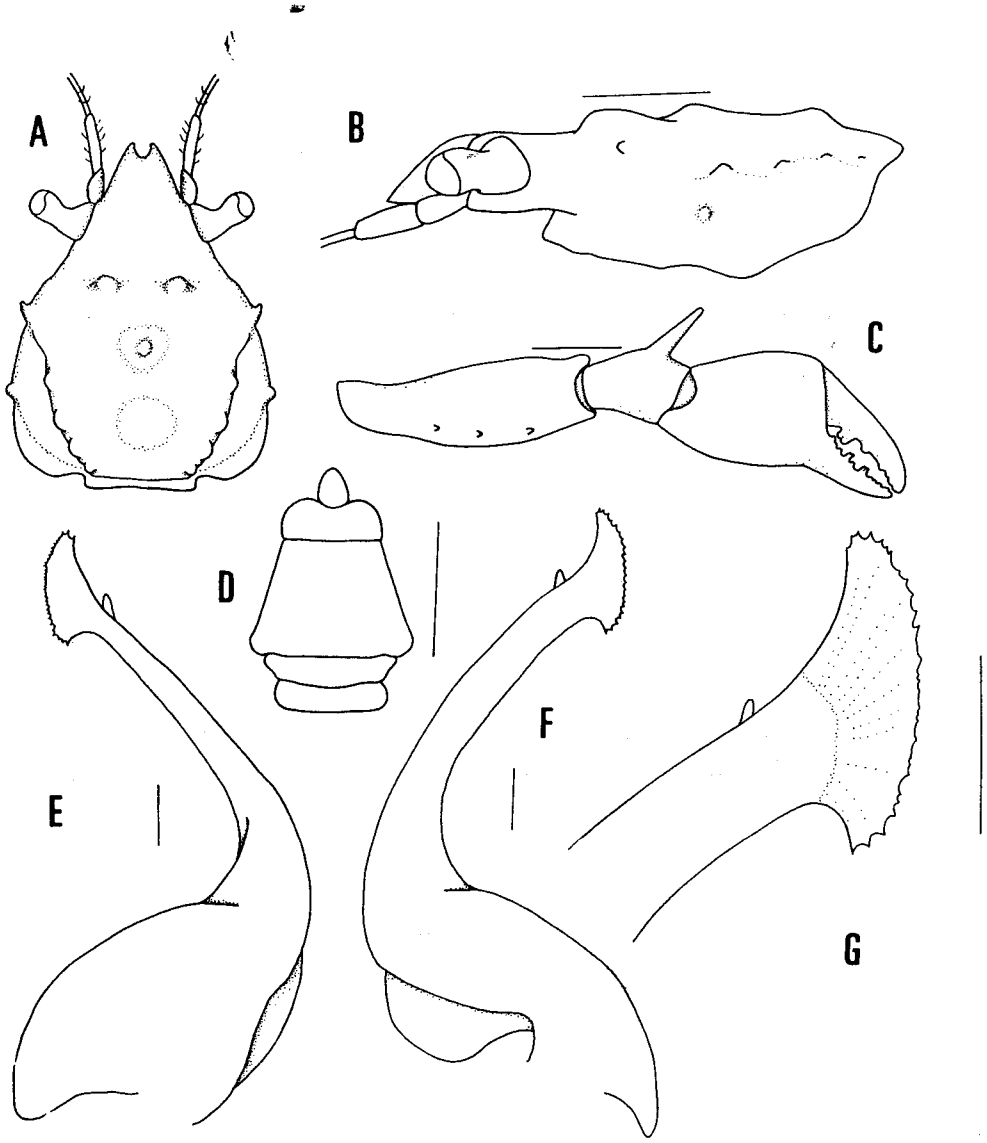

Fig. 10. *Paratymolus vannus*, new species. ZMUC CRU 2722; holotype male; cl 3.3 mm. A. Carapace, dorsal view. B. Carapace, lateral view. C. Left cheliped, inner surface. D. Abdomen. E. Left G1, sternal view. F. Left G1, abdominal view. G. Apex of left G1, abdominal view. Scales = 1.0 mm in A-D, G; 0.1 mm in E-G.

Remarks. - While only two of the specimens collected from Thailand during the 1899-1900 Danish Expedition to Siam by Dr. Th. Mortensen were examined in this study, it is likely that the one other ovigerous female obtained from Koh Kahdat during the same expedition and similarly described by Rathbun (1910), is a conspecific to *Paratymolus vannus*. These specimens were previously identified as *P. pubescens* by Rathbun (1910), Barnard (1955) and Griffin & Tranter (1986).

The male from Tung Kaben is soft and in poor condition and is considered a juvenile by Rathbun (1910) whereas the female of similar size is not. However, as gravid females of its congener are known from cl 3.5 mm and above (e.g. in *P. bituberculatus*), it is possible that the male specimen is small but sexually mature. As with the case of male *P. bituberculatus*, the absence of the anterior most lateral spine in the Thai male is not considered a significant character (see *P. bituberculatus*).

Paratymolus vannus is closely related to *P. cygnus*. Morphologically, the two are similar in their generally elongated pentagonal shape, dorso-ventrally compressed carapace and the possession of two anterolateral spines and one posterior lateral tubercle. Moreover, both species possess G1s which are unique, being long and slender distally. However, unlike the G1 of *P. cygnus*, which has a simple flare at the distal tip of the terminal segment, the terminal segment of the G1 in *P. vannus* is developed into a large toothed fan. Both the left and right G1s of the *P. vannus* holotype were checked and found to be of the same form. It is thus unlikely that this unusual structure is an artifact of regrowth or due to injury. On examination of the G1s of a series of Singapore males of different sizes, it is also apparent that the G1 structure of *P. vannus* does not represent a stage of development in the males of *P. cygnus* as its form is beyond the range of the allometric variation seen in the latter species.

While the male of *P. vannus* appears to be easily distinguished from those of *P. cygnus* by a distinct fold that extends from the dorsal branchial region and continues as a more typical-looking ridge around the posterior border of the carapace, this is most probably an artifact caused by the poor condition of the specimen. It is possible that the ridge is natural as it appears well formed and of equal prominence throughout. If so, the ridge can be a strong diagnostic character for the males of the species. Due to the lack of more male specimens, this character is not emphasised in its diagnosis. The distinctive difference in the G1 structure remains the most diagnostic character separating *P. vannus* and *P. cygnus*. It is noted that the single female of *P. vannus* is very similar to those of *P. cygnus*, and currently no good characters can be found to distinguish between them. It would be necessary to obtain more female specimens before this can be resolved.

***Dumea*, new genus**

Paratymolus - Haswell, 1880: 303 (part); Haswell, 1882: 142 (part); Baker, 1906: 107 (part); Hale, 1927: 123 (part); Griffin, 1966a: 276 (in key) (part), Griffin & Tranter 1986: 38 (part).

Type species. - *Paratymolus latipes* Haswell, 1880, by present designation.

Diagnosis. - Carapace broadly pentagonal; covered with coarse, long ovate setae; rostrum, anterior part of carapace (especially on most convex part) and dorsal branchial region with numerous sensory setae. Antorbital angle of supraorbital eave present. Rostrum acutely emarginated, lobes with two moderately long lateral spinules each. Gastric and cardiac

tubercles absent. Dorsal branchial region with faint striae. Subhepatic region spinulate. Anterolateral margin of carapace with three large spines and two smaller ones in between; posterolateral margin unarmed. Third maxilliped distinctly longer than broad, ischium length ca. 2.4 times width; inner margin gently convex; exopodite usually reaching beyond distal border of merus. Anterior and posterior margins of merus of cheliped with closely spaced acute granules; male chela elongated or bulbous, outer surface with numerous conical tubercles; fingers relatively slender; both cutting edges with sharp triangular teeth, tips often pectinated, distinctly curved, crossing over when fingers closed. Dactylus of ambulatory legs mildly granulated along ventral margin. Male abdomen relatively elongate; proximal margin of fused segments 3 to 5 slightly angular; sixth segment longitudinally rectangular.

Etymology. - The name '*Dumea*' is derived from the Latin for bramble, alluding to the spiny carapace and chelipeds of the crab. Gender feminine.

Remarks. - *Paratymolus latipes* Haswell, 1880, differs from species of *Paratymolus* s. str. in numerous important characters with regards to the eyestalk length, as well as structure of the antennae, carapace, chelipeds, ambulatory legs, maxillipeds and male abdomen. The form of the G1 of *P. latipes* also differs from typical *Paratymolus* species in being almost uniformly stout throughout, with only a minute hood-like structure on the apex. These differences are also valid for the recently described *P. taiwanicus* Loh & Wu, 1998, which is closely related to *P. latipes*. We are of the opinion that these differences are sufficiently substantial to require the establishment of a separate genus, *Dumea*, for *P. latipes* and *P. taiwanicus*.

Haswell (1880) considered *P. latipes* to be quite different from *P. pubescens*, but Miers (1884) was of the opinion that *P. latipes* and *P. sexspinosus* were closely affiliated. However, *P. sexspinosus* itself differs considerably from *Paratymolus* s. str. as well as *P. latipes*. We feel there are also sufficient differences to remove *P. sexspinosus* to its own genus (*Litosus*, see later). The differences between the three genera *Paratymolus* s. str., *Dumea* and *Litosus* are enumerated in Table 1. Currently, *Dumea* remains a monotypic species confined to Australia.

Miers (1884) also commented that the ambulatory legs of *L. sexspinosus* are less dilated and compressed than those depicted by Haswell (1880) for *D. latipes*. In specimens examined, the two species appear to have legs which are very similar. However, they differ somewhat in the ratio of the different segments with respect to one another. In *D. latipes* (and *D. taiwanicus*), the ratio of merus: carpus: propodus: dactylus is approximately 2:1:1:2 whereas in *L. sexspinosus*, it is 1:1:1:2.

Dumea latipes (Haswell, 1880)
(Fig. 11)

Paratymolus latipes Haswell, 1880: 303, pl. XVI figs. 3-5; Haswell, 1882: 143; Griffin, 1966: 27 (in key); Griffin & Tranter, 1986: 38, figs. 7h, 11b.
Paratymolus latipes var. *quadridentata* Baker, 1906: 107, pl. 1 fig. 2; Hale, 1927: 123, fig. 119.

Material examined. - Lectotype -male (6 mm) (AM P 91), Port Jackson, New South Wales, Australia, 33°51'S, 151°16' E, coll W. A. Haswell.

Paralectotypes - 1 male, 2 females, Port Denison, New South Wales, Australia, 33°51'S, 151°16' E, coll W. A. Haswell.

Others - 4 males, 4 ovigerous females (WAM 23223), Port Denison (Dongara), crawling on weeds at night (9.30pm) as tide began flowing, coll. B. R. Wilson, 24 Aug.1958; 1 male(WAM 23221) , W. A.: 7 miles SW of Bunbury, 20m, coll, F. M. 'Lancelin', 13 Apr.1963; 1 male (WAM 23201), King George's Sound, 31m, coll. B. R. Wilson & G. W. Kendrick, 21 Jul.1963; 1 male (WAM 23197) 26km SW of Dongara, W. A.,29°23'S: 114°42'E, 33 m, coll. Sprightly, 17 Nov.1976; 1 male (WAM 23204), W. A.: Off Carnac I., in sand, in craypots, 4m, coll. CSIRO on 'Lancelin', 3 Jul.1963; 1 male (WAM 23228), W. A.: Cottesloe; 1 female (WAM 23212), W. A.: Eagle Bay, cape Naturaliste, coll. L. Marsh & A. Baker, 25 Feb.1975; 1 female (WAM 23226), W. A.: Cottesloe; 2 males, 1 ovigerous female (WAM 23205), W.A.: Between Rottnest Is. and Fremantle, Stn. 2, dredge, coll. FRV 'FLINDERS', 24 Jun.1975; 1 male (WAM 3013) Garden Is.; 1 male, 1 ovigerous female (WAM 23211) W.A.: between Rottnest Is. and Fremantle, Stn. 13, triangular dredge, coll. M. Clark on "Flinders", 27 Jun.1975; 1 female (WAM 23225), W.A.: Yanchep reef flat, coll. B. R. Wilson et al., 27 Jan.1959; 1 ovigerous female (WAM 23210), W. A.: Fremantle,31°56'50"S: 115°42'30"E, Stn 13B, triangular dredge, coll. FRV FLINDERS, 27 Jun.1975; 1 female (WAM 23227), W.A.: Cottesloe; 1 female (WAM 23214), W.A.: W. of Stragglers Rocks, Stn. 8, 32°5.2'S: 115°36'E, 20m, coll. S. Slack-Smith & L. Baxter, 28 Jun.1977; 1 female (WAM 23220) W.A.: 5 mile NW of Gun Is, South Group, Houtman Abrolhos Is., coll. R. W. George on 'Davena', 11 May.1960; 1 male, 1 ovigerous female (WAM 23202), W.A.: Between Rottnest I and Fremantle, Stn. 4, triangular dredge, coll. FRV FLINDERS, 24 Jun.1975; 1 female (AM E 4442), Spencers Gulf, South Australia, Australia, 34°30'S, 136°30'E, 3.6m, coll. FIS "Endeavour" Expedition, 1909-14; 1 male, 1 female (ZRC 1965.7.1.9-10), Pittwater N.S.W. (Australia), coll. Australian Museum, 12/1932; 1 male, 1 female (NHM 1895.11.14.13-14), Port Jackson.

Diagnosis. - Carapace very broadly pentagonal; with thick layer of pubescence, numerous prominent tubular sensory setae present on anterior region of carapace, orbital region, rostrum and along most convex anterior part of carapace; dorsal surface without tubercles; anterior region gently sloped. Rostral lobes short, broadly triangular; inner spinule of each lobe subequal to outer one; base of emargination unarmed. Orbital region toothed; preorbital spine present on supraorbital eave, with single process posterior to eave; postorbital spine not cupped. Sensory setae on eyestalk distinct. Subhepatic region distinctly spinulate. Anterolateral margin with two additional spinules (sometimes more as tubercles) between first and second, as well as second and third lateral spines respectively. Inner surface of cheliped coarse or pitted; granulations on outer surface of palm extensive, continuing onto inner surface; two prominent spinules present on ventral surface of ischium of cheliped, third spinule largest; carpal spines relatively long; palm elongate. Proximal margin of fused male abdominal segments 3-5 angular; telson relatively elongate.

Description. - Carapace very broadly pentagonal, covered with thick layer of pubescence comprising moderately long ovate hairs; dorsal surface smooth, devoid of tubercles. Anterior region gently sloped from anterior-most spine towards rostrum. Rostral lobes short, broadly triangular, each with two straight, moderately long, lateral spinules. Eyestalks short, non-retractile, base almost visible from ventral view, with distinct setae. Antenna short, basal antennal article moderately short, broad, not fused anteriorly with carapace, movable; second antennal segment short, rounded, similar in length to basal segment; third segment longest, 0.12-0.14 times cl. Subhepatic region spinulate. Supraorbital eave slightly developed laterally, preorbital angle developed into a spine, antorbital angle mildly developed. Anterior region of carapace with numerous tubular sensory hairs on orbital region, rostrum, and in straight row along most convex part of carapace. Anterolateral region with three short, large, broadly triangular spines, anterior-most smallest, posterior-most largest; smaller spine present dorsal to and between first and second main spines, with another between second and third spines; anterolateral spines smooth in small crabs, tuberculations visible on larger ones. Dorsal

branchial region with row of tubular hairs, faint striae underneath pile. Third maxilliped longer than broad, ischium rectangular (length ca. 2.4 times width), inner margin gently convex; exopodite usually exceeding distal border of merus.

Cheliped and ambulatory legs covered with thick pubescence; distal tip of leg dactyli bare. Cheliped robust, with closely spaced, acute granules along entire outer surface, extending slightly into inner surface. In smaller specimens, anterior and posterior borders with spinules. Carpus with short, robust spine. In male, palm inflated, elongated, ca. equal in length to cl, fingers possessing ridge with, sharp, triangular teeth; tips curved, often pectinated, crossing over each other when fingers closed. In female, palm rounded, fingers more slender, slightly curved.

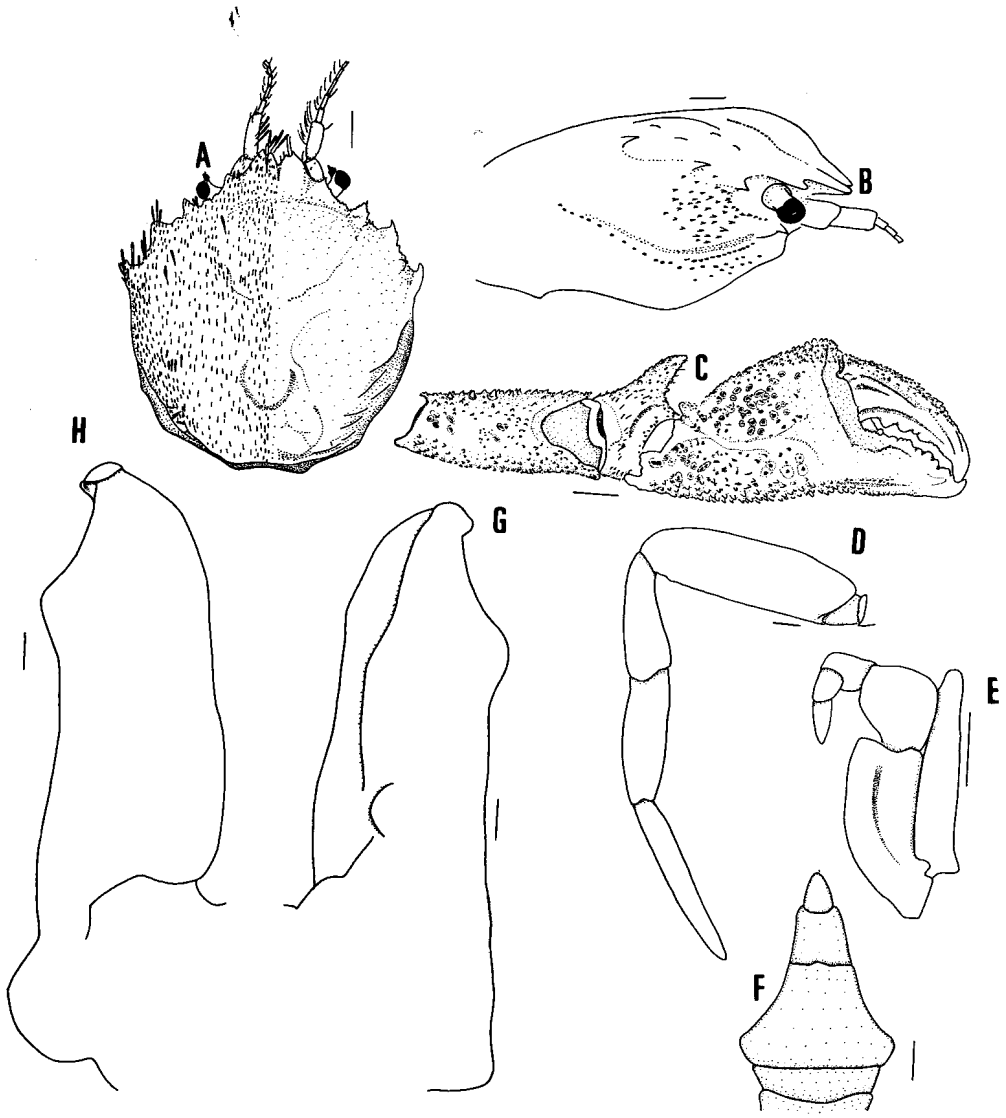

Fig. 11. *Dumea latipes* (Haswell, 1880). WAM 23223; male; cl 11.5 mm. A. Carapace, dorsal view (right side denuded). B. Carapace, lateral view. C. Left cheliped, inner surface. D. first right ambulatory leg. E. third maxilliped. F. abdomen. G. Left G1, abdominal view. H. Left G1, sternal view. Scales = 1.0 mm in A-F; 0.1 mm in G-H.

Ambulatory legs stout, segments broad, dorso-ventrally flattened; inner surface flattened. First ambulatory leg ca. 1.7-2.0 times cl, slightly longer than chelipeds. Dactyli of ambulatory legs slightly granulated, obscured by dense long setae.

Abdomen relatively elongated; segments 3-5 fused, proximal margin of fused segments slightly angular; sixth segment rectangular; telson moderately long. G1 short, stout, with slight swelling on medial to distal position, distal part tapered, tip folded to form small hood-like structure, less conspicuous in small specimens. Female gonopore round.

Habitat. - This species is known from seaweed and reef flats in waters up to 4 m.

Distribution. - Thus far this species seems to be confined to Australia.

Remarks. - In the original account of *Paratymolus latipes*, Haswell (1880) described each of the rostral lobes as possessing only one small lateral spinule each. Subsequently, Baker (1906) described *P. latipes* var. *quadridentata* in more detail, based on a male with two spines on each rostral lobe and no other distinguishing differences. Baker's taxon was later synonymised by Griffin (1966a) under *P. latipes*. Although Baker's type was not examined, we agree with the synonymy as the type specimens of *P. latipes* from Port Jackson as well as all other *P. latipes* specimens we have examined possess two spines on each rostral lobe. Similarly Griffin & Tranter (1986) stated that all the specimens in the Australian Museum "... have two spines on each rostral lobe, one lateral and one medial or else it can be seen obviously where they have been broken off". Haswell's observation on the condition of the rostral lobe thus seems to be mistaken. In all other respects, Haswell's (1880, 1882) and Baker's (1906) descriptions agree well with one another.

Unlike typical *Paratymolus* species, *D. latipes* does not show obvious sexual dimorphism in its carapace characters and only its chelipeds are distinctly different in males and females. Large specimens of *D. latipes* possess additional granulation on the anterolateral spines of the carapace. The anterior and posterior margins of the merus of the chela also lack the more acute spinules found in smaller specimens. These differences, however, can be attributed to allometric growth as the G1 of the males of either size are very similar. To this effect, a large male (cl 11.5 mm) is figured instead of the lectotype. Even larger specimens are known (largest known male cl 13 mm). The lectotype chosen is the syntype male which is in better condition.

Dumea taiwanicus (Loh & Wu, 1998)
(Fig. 12)

Paratymolus taiwanicus Loh & Wu, 1999: 609, Figs. 1, 2.

Material examined. - Holotype - male (cl 7.4 mm) (ZRC), Two Lion Rock, Lan Yu (= Orchid) Island, Taiwan; coll. S.-H. Wu, 29 Mar.1998.

Others - 1 female (cl 9.0 mm) (ZRC 1999.110), rocky reef, Xiao Su-Ao, Taiwan, coll. J.-F. Huang.

Diagnosis. - Carapace broadly pentagonal; dorsal surface smooth, without tubercles, covered with thick layer of fine pubescence, tubular setae undiscernible on most convex parts. Rostral lobes broadly triangular with two spinules, inner one markedly smaller than outer; base of emargination of lobes with one minute spinule; lateral spinules moderately long. Orbital

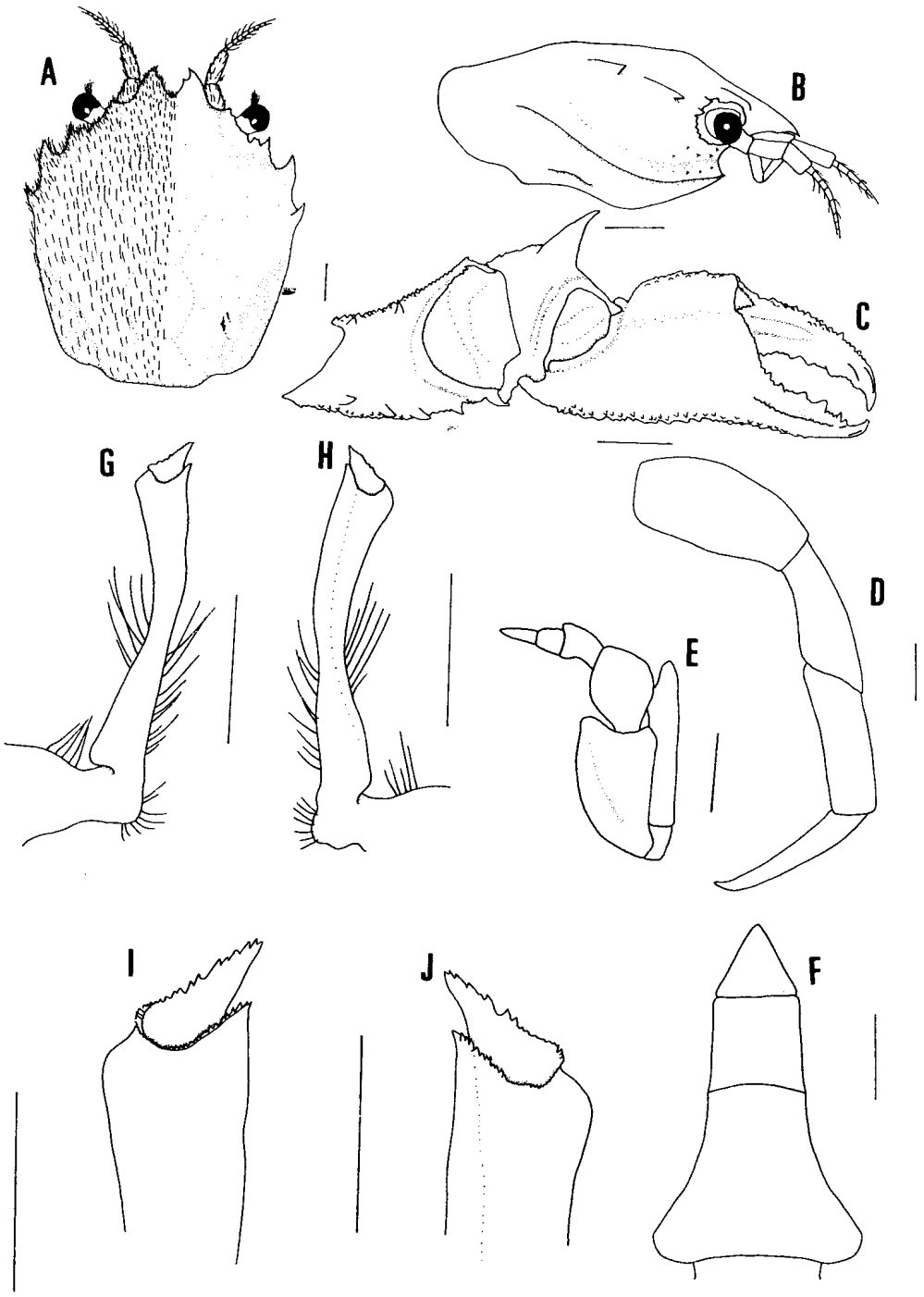

Fig. 12. *Dumea taiwanicus* (Loh & Wu, 1998). Holotype male (cl 7.4 mm) (ZRC). A. Carapace, dorsal view (right side denuded). B. Carapace, lateral view C. Left cheliped, inner aspect D. Left first ambulatory leg. E. Left third maxilliped. F. Abdomen. G. Left G1, abdominal view H. Left G1, sternal view I. Apical tip of left G1, abdominal view, J. Apical tip of left G1, sternal view. Scales = 1.0 mm in A-H; 0.5 mm in I, J. (after Loh & Wu, 1998)

region finely toothed; with blunt preorbital angle on weakly developed supraorbital eave, angle followed posteriorly by broad toothed process and slightly cupped postorbital spine. Subhepatic region spinulate. Sensory setae on eyestalk prominent. Anterolateral region with three large spines, anterior-most smallest, posterior-most largest; without spinules between spines. Inner surface of cheliped mostly smooth except for margins; outer surface of palm with numerous distinct conical granules, continuing onto margins of inner surface; three prominent spinules present on ventral surface of ischium of cheliped, second spinule largest; carpal spines relatively long; palm elongate. Proximal margin of fused male abdominal segments 3-5 rounded; telson elongate.

Habitat. - The only known specimen was obtained from among brown algae at night from shallow reefs of about 0.5 m depth.

Distribution. - Known only from Taiwan.

Remarks. - This recently described species resembles *D. latipes* but *D. taiwanicus* differs in that the inner spinule of each rostral lobe is smaller than the outer one (vs. subequal); presence of an additional spinule at the base of the emargination of the rostrum (vs. absent); orbital region more distinctly toothed; absence of a preorbital spine on the supraorbital eave with a process posterior to this eave; postorbital spine slightly cupped (vs. not cupped); tubular sensory setae present on the anterior part of the carapace and along the most convex part of the carapace are relatively smaller, less tubular in appearance and less prominent, with setae on most convex part almost undiscernible; sensory setae on the eyestalk considerably longer; the subhepatic region is less strongly spinulate; no spinules present between the first and second, and second and third lateral spines (vs. present); the inner surface of the hand is generally smooth (vs. coarser surface which may appear pitted); the ventral surface of the ischium of the cheliped has three distinct spinules (vs. two prominent spinules); the second spinule on anterior margin of the ischium of the cheliped is enlarged (vs. third spinule largest); the proximal margin of the fused male abdominal segments 3-5 is rounded (vs. angular); the male telson is proportionately longer and narrower; and the G1 is elongate and relatively slender with the tip flared and serrated apically (vs. relatively short and stout, with small hood-like structure at the apex) (cf. Loh & Wu, 1998).

The present female specimen is larger than the holotype male and agrees with it in most respects. Each rostral lobe, however, lacks an inner spinule, although the right one is slightly damaged; and there is no spinule at the emargination of the rostrum. These are regarded as variations for the time being.

In life, the carapace is mottled bright reddish orange and white, with the appendages similarly striped.

Litosus, new genus

Paratymolus sexspinosus - Miers, 1884: 261; Henderson, 1893: 352; Calman, 1900: 33; Sakai, 1935: 81; Sakai, 1938: 209; Sakai, 1976: 157; Griffin, 1966a: 276 (in key); Griffin & Tranter, 1986: 42, Dai & Yang, 1991: 119.

Type species. - *Paratymolus sexspinosus* Miers, 1884, by present designation.

Diagnosis. - Carapace broadly pentagonal; covered with moderately coarse, long, ovate setae; rostrum, orbital regions and area along anterolateral margin with few sensory setae. Antorbital angle of supraorbital eave absent. Rostrum acutely emarginated, lobes with two moderately long lateral spinules each. Gastric and cardiac tubercles absent. Dorsal branchial region smooth. Subhepatic region smooth. Anterolateral margin of carapace with one broadly triangular tubercle followed by anteriorly-directed spine; posterolateral margin unarmed. Third maxilliped relatively broad, ischium length ca. 1.7 times width; inner margin strongly convex; exopodite usually not reaching distal border of merus. Anterior margin of merus of cheliped smooth, posterior margin with three small spinules; male chela robust to bulbous, inner surface sometimes with pattern of numerous patches, outer surface with two or three small tubercles; fingers relatively slender, cutting edge with distinct triangular teeth, either continuous or with one large medial, posteriorly-directed tooth on dactylus fitting into notch on pollex, tips distinctly curved, crossing over when fingers closed. Dactylus of ambulatory legs finely granulated along ventral margin. Male abdomen relatively elongate; proximal margin of fused segments 3 to 5 rounded; sixth segment squarish.

Etymology. - The name 'Litosus' is derived from the Greek word 'litos', meaning plain or simple, alluding to the simple structure of the carapace and chelipeds in contrast to *Paratymolus* and *Dumea*, largely lacking in both spines and tubercles. Gender masculine.

Remarks. - *Paratymolus sexspinosus* has been placed in the genus because of its long third antennal segment, two anterolateral protrusions on the carapace and form of the chelipeds. The chelipeds of *P. sexspinosus* are similar to those of *Paratymolus*, especially in the case of the female - the chela is not granulated externally but instead possesses only several tubercles on the outer surfaces of the carpus and palm. Moreover, the merus is armed on the posterior margin with three small distinct spinules. In females, the fingers are long and curved at the tips, and are only distinguishable from those of *Paratymolus* females by the absence of tubercles on the anterior border of the merus and the presence of toothed ridges instead of distinctly separate teeth.

Paratymolus sexspinosus, however, differs substantially from species of *Paratymolus* s. str. in many characters of the carapace, antennal, eyestalks, chelipeds, ambulatory legs, third maxillipeds and male abdomen (Table 1).

Two species of *Litosus* are currently distinguishable. The characters that distinguish *L. giraffus*, new species, from Japan, and the type species, *L. sexspinosus*, are entirely masculine - the G1 and male cheliped structure. No satisfactory characters have been found to differentiate female specimens of *Litosus*.

Litosus sexspinosus (Miers, 1884)
(Figs. 13, 14)

Paratymolus sexspinosus Miers, 1884: 261, pl. 27, fig. B; Henderson, 1893: 352; Calman, 1899: 33; Griffin, 1966: 276 (in key); Griffin & Tranter, 1986: 42, fig. 7f, g; Dai & Yang, 1991: 120.

Material examined. - Lectotype - ovigerous female (5.7 mm) (NHM 1882.7), HMS "Alert", Expedition, Friday Island, 18m (No. 153), Australia, coll. R. W. Coppinger.

Paralectotype - 1 female (4.3 mm) (NHM 1882.7), HMS "Alert", Friday Island, 18m (No. 153), Australia, coll.R. W. Coppinger.

Others - 1 male (NTM Cr 0003091), Oxley Island, Cobourg Peninsular, Northern Territories, Australia; 1 female (NHM 1954.9.14.139), IV Torres Straits, Australia; 1 female (AM P 17254), Lady Elliot Island, South of bunker Group, Coral Sea, Queensland, Australia, 24°07'S, 152°43'E, coll. C. Wright, 1964; 1 male (AM P13985) near entrance to Roebuck Bay, Western Australia, Australia, 18°06'S, 122°20'E, 15m, coll. A.A. Livingstone, 26 Sep.1929; 1 male (juvenile) (AM P25101), south of Carnarvon, Western Australia, Australia, 24°53'S, 113°40'E, 7.5m, from algae, coll. N. Coleman, 17 Jun.1972; 1 female (ZRC 1985.1625), Sentosa coral reef, Singapore, coll. P.K.L. Ng, 17 May.1983.

Diagnosis. - Carapace broadly pentagonal, with thick layer of pubescence, hunched anteriorly; dorsal surface without tuberculations; regions poorly defined. Rostral lobes short, broad, faintly emarginate. Male chela robust but not inflated nor bulbous, inner surface plain, without pattern of numerous small patches. Cutting edges of fingers with numerous teeth; dactylus without large posteriorly-directed tooth, pollex without notch. G1 moderately long, straight. Apical tip with a hood-like structure surrounding convoluted, narrow, slit-like aperture.

Description. - Carapace broadly pentagonal, with layer of thick pubescence; dorsal surface smooth, without tuberculations; regions poorly defined. Anterior region inflated, sloped from line of anterior lateral tubercle towards rostrum, appearing hunched. Rostral lobes short, broad, faintly emarginate, rounded, generally without lateral spinules. Eyestalks short, non-retractile, base almost visible ventrally. Basal antennal article moderately short, not fused anteriorly to carapace, second segment of antenna short, rounded, third segment 0.18-0.24

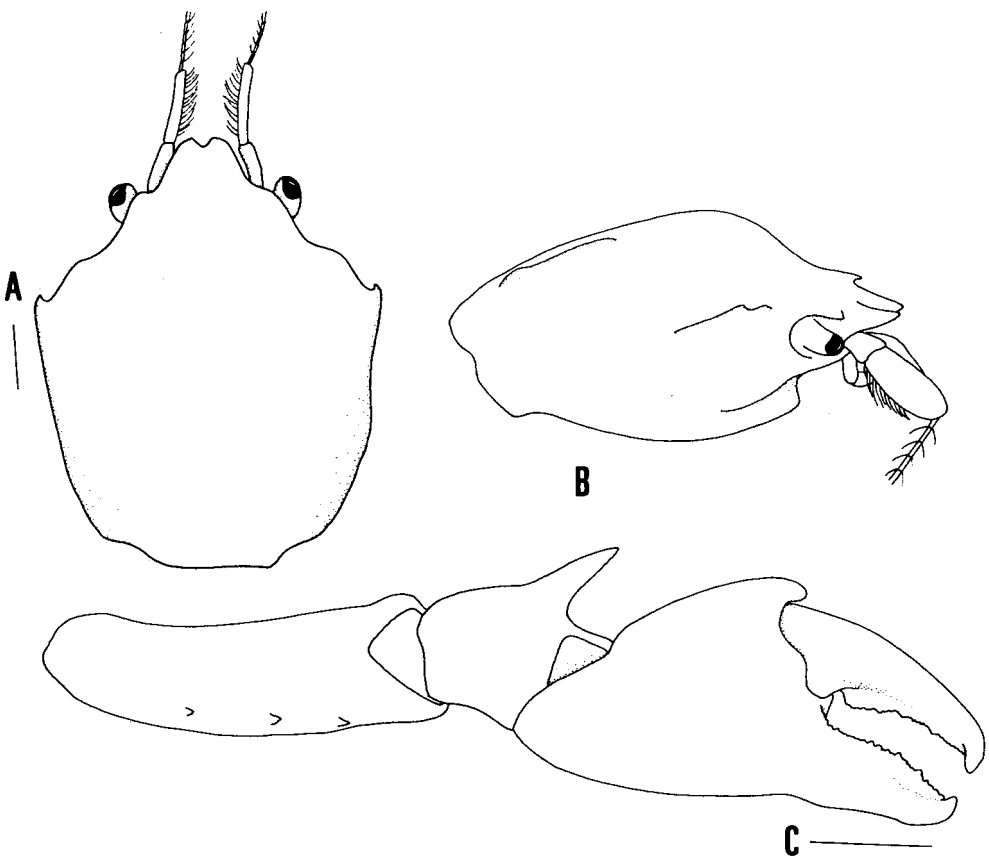

Fig. 13. *Litosus sexspinosus* (Miers, 1884). NTM Cr 0003091; male; cl 5.53 mm. A. Carapace, dorsal view (denuded). B. Carapace, lateral view. C. Left cheliped, inner surface. Scale = 1.0 mm in A-C.

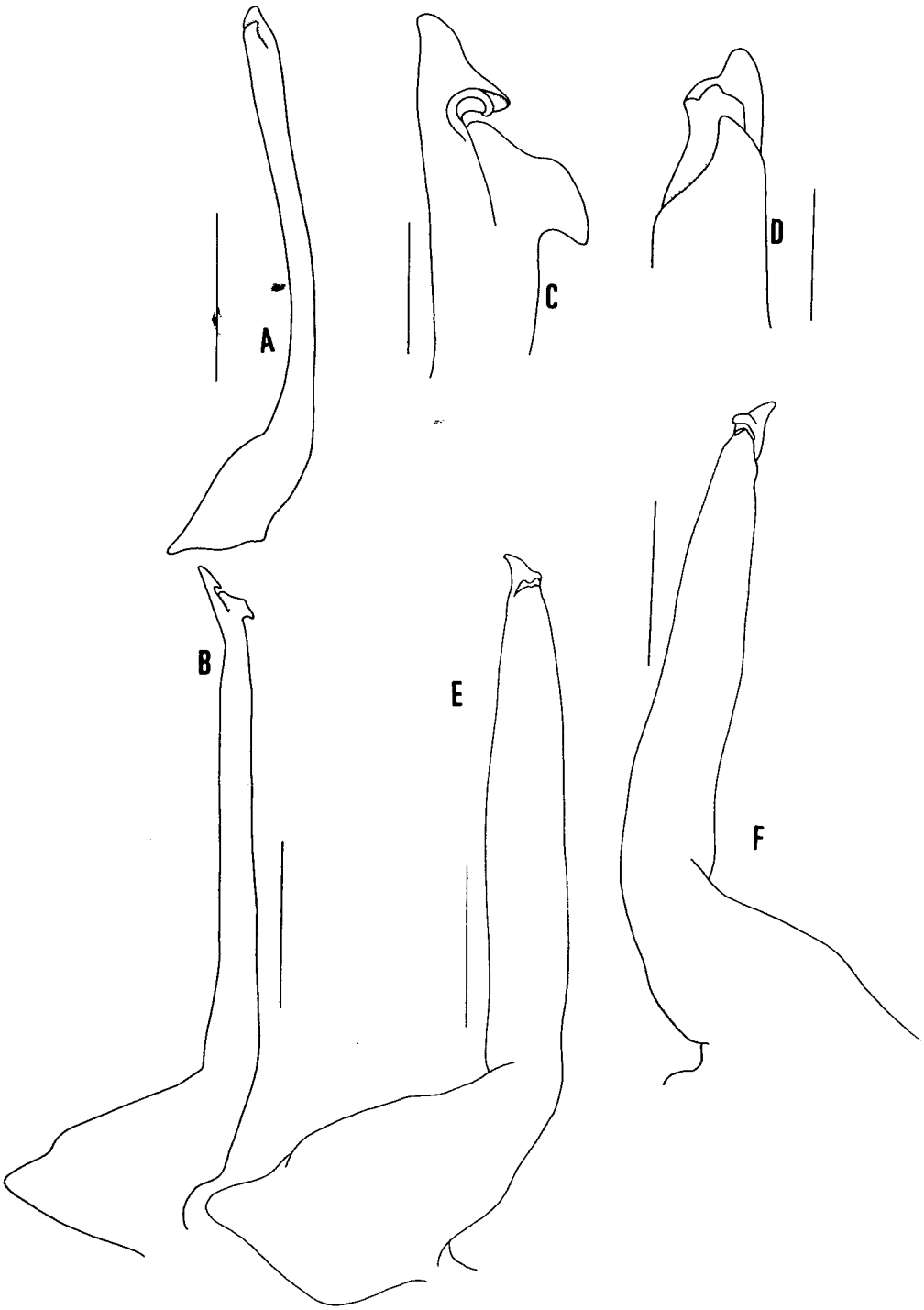

Fig. 14. Left G1 of *Litosus sexspinosus* (Miers, 1884). A - AM P25101; male; cl 3.5 mm; B-D - AM P13985; male, cl 4.3 mm; E-F - NTM Cr 0003091; male; cl 5.53 mm. A, B, E. Left G1, sternal view. C. Apex of left G1, sternal view. D. Apex of left G1, abdominal view. F. Left G1, abdominal view. Scales = 0.5 mm in A, B, E, F; 0.1 mm in C, D.

times cl. Antennal fossae straight, parallel. Subhepatic region broad, smooth, without spines. Supraorbital eave poorly developed, margin straight, preorbital angle sometimes slightly produced laterally, antorbital angle absent. Anterolateral margin with broadly triangular tubercle, with a small spinule apically, followed by an anteriorly-directed, short, apically rounded spine. Third maxilliped broad, ischium rectangular, strongly convex (length ca. 1.74 times width); exopodite usually not reaching beyond distal border of merus.

Chelipeds and ambulatory legs smooth, covered with thick pubescence. Merus of cheliped with 3 short spines on posterior margin. Outer surfaces of carpus and palm with two to three tubercles, carpus with short, stout spine. Male chela robust, non-bulbous, 4.5-6.2 times cl. Female chela slender, fingers long, slender, curved, with evenly toothed cutting edges.

Ambulatory legs short, stout, segments rounded in cross-section, inflated, dorso-ventrally flattened. First ambulatory leg 1.7-1.9 times cl. Dactyli of ambulatory legs with finely granulated margins, obscured by dense setae, inner margin somewhat flattened.

Abdomen relatively elongated in males; segments 3-5 fused, edges of proximal margin of fusion rounded; sixth segment squarish; telson relatively short. G1 moderately long, margins straight. Apical tip with a convoluted hood-like structure surrounding a narrow slit-like aperture. Female gonopore round.

Habitat. - This species has been collected from the littoral zone, on seaweed and coral rocks, also in shallow offshore areas from sandy beds, seaweed and coral reefs (up to 15 m).

Distribution. - This species is known from Australia, Indonesia, China, Singapore and India

Remarks. - Calman (1900) noted that a single specimen from Mabuiag in the Torres Straits possessed a hardly emarginated rostrum and a second anterolateral tooth (including preorbital spine) that was less prominent than that in Miers' (1884) figure. However, these differences easily fall within the range of variation seen in specimens of this species at hand.

The G1 figured by Griffin & Tranter (1986) of a male from Aru Island, Indonesia, closely resembles those belonging to the Australian specimens that have been examined, and we agree that it is conspecific with *L. sexspinosus*. Another male examined from Roebuck Bay, Australia, unlike all the other specimens examined, possessed two minute acute submedial processes on each of the rostral lobes. In all other respects, it resembled the other specimens and agrees well with previous descriptions of the species as well. It is therefore also considered to be conspecific with *L. sexspinosus*.

Some degree of sexual dimorphism is encountered in *Litosus*, although not as pronounced as that seen in *Paratymolus* s. str. The females of *L. sexspinosus* have proportionately more inflated carapaces than males, but are not noticeably broader laterally. The palms of the female are slender and possess slim and curved fingers with toothed cutting edges. The males instead have broad palms with robust fingers.

The lectotype designated from Miers' two female syntypes is a gravid specimen. A series of G1s from males at different stages of maturity have been figured to document the variation in the G1 structure of this species.

Litosus sexspinosus is newly recorded for Singapore. A single female specimen was collected from the Siloso coral reef on Sentosa island before it was reclaimed. There have been no known records of this species since.

Litosus giraffus, new species
(Fig. 15)

Paratymolus sexspinosus - Sakai, 1935: 81, pl. 17, fig. 3; Sakai, 1938: 209, pl. 21, fig. 2; Sakai, 1976: 157, pl. 48, fig. 2.

Material examined. - Holotype - 1 male (6.5 mm) (CBM ZC 2587), Kami-Nishinoomote Fishery Port, Tanegashima Island, subtidal, coll. T. Komai, 1 Jun.1996.

Paratype - 1 male (6.8 mm), (SMF), Kii, Nagashima, Japan, coll. T. Sakai, 18 Nov.1966.

Diagnosis. - Carapace broadly pentagonal with thick layer of pubescence; hunched anteriorly; dorsal surface without tuberculations; regions poorly defined. Rostral lobes short, broad, faintly emarginate. Male chela inflated, bulbous, with pattern of numerous small patches on inner surface. Fingers with discontinuous, unevenly toothed cutting edges; dactylus with one large posteriorly-directed medial tooth, pollex with matching notch and a small proximal tooth near insertion of dactylus. G1 long, broad basally, tapered, slender distally; apical tip with hood-like structure surrounding a simple, distinct, rounded aperture.

Habitat. - Found among rocks and seaweed near shoreline.

Distribution. - Currently known only from Japan.

Etymology. - The name 'giraffus' is derived from the New Latin word 'giraffa' which in turn arose from the Arabic 'zarafa', meaning giraffe, alluding to the long, straight and slender G1 of the male. Gender masculine.

Remarks. - The only specimens previously known from Japan were three documented by Sakai (1935, 1938, 1976); a female from Shimoda (1935) and a male and female from Kii Nagashima (1976). Only the female from Shimoda has been depicted. In the current study, two Japanese males have been found to possess G1s which are distinctly different from those of Australian ones. The G1 of *L. giraffus* is long and clearly more slender in the distal portion than along the basal part whilst the apical tip possesses an obvious aperture that is simple and rounded. This is in contrast to that of *L. sexspinosus* in which the G1 is only of moderate length, less obviously tapered and has a slanted, narrow slit-like aperture instead.

While the structure of the carapace, male abdomen and third maxilliped are indistinguishable between the two species, the form of the male chelipeds appear to be species specific. Males of *L. giraffus* possess chelae that are swollen in appearance with the inner surfaces possessing a patch-like pattern. The dactylus possesses a large, rounded, posteriorly-directed medial tooth while the pollex has a matching notch. In *L. sexspinosus*, the male chelae are robust without being swollen or bulbous. Also unlike the former species, the inner surfaces of the hands do not have a patch-like pattern and the cutting edges of the fingers lack distinct individual teeth or notches, being lined with a continuous row of small teeth instead. The females of the two species are indistinguishable.

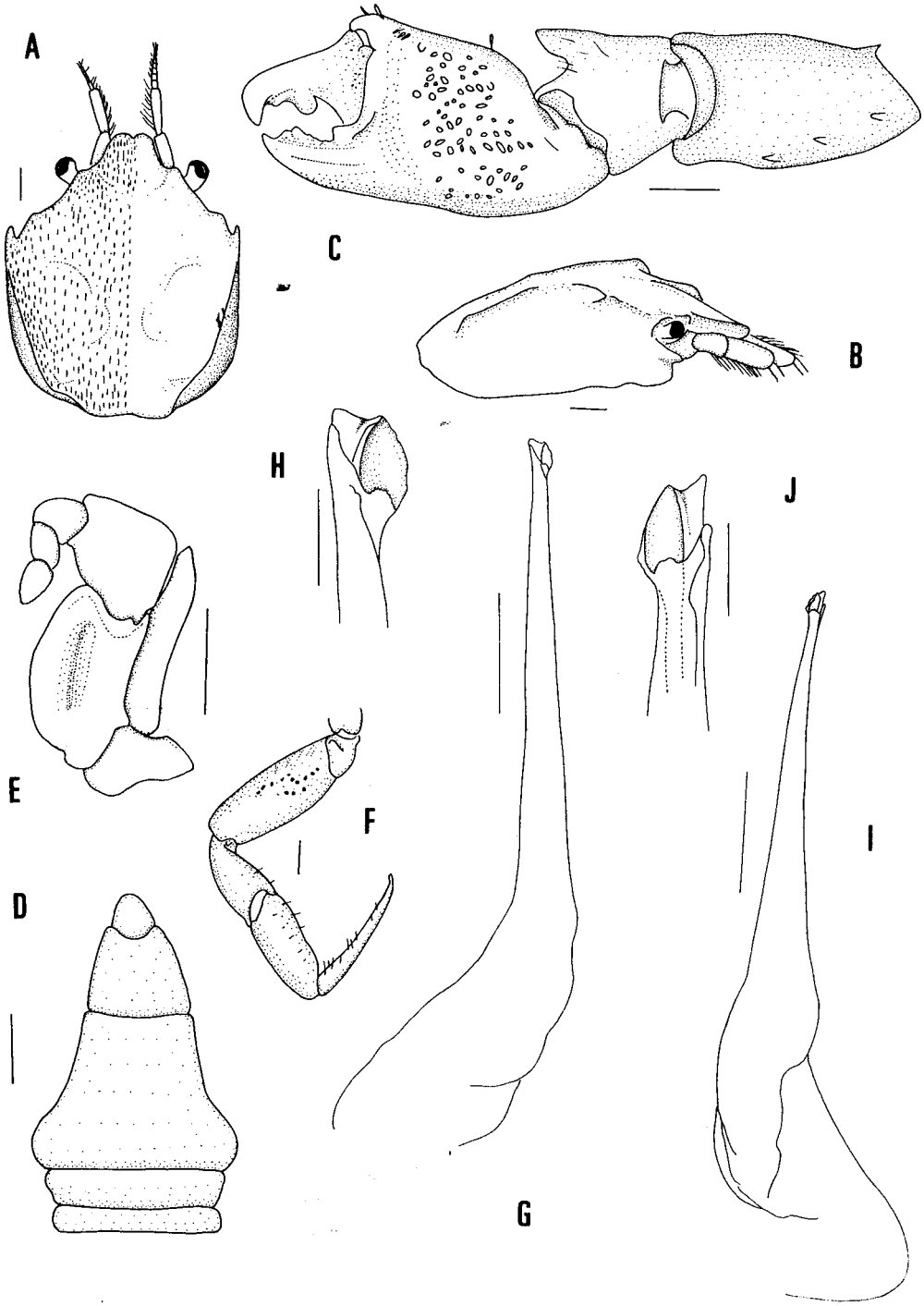

Fig. 15. *Litosus giraffus*, new species. CBM ZC 2587; male; cl 6.9 mm. A. Carapace, dorsal view (right side denuded). B. Carapace, lateral view. C. Right cheliped, inner surface. D. Abdomen. E. Third maxilliped. F. First right ambulatory leg. G. Right G1, sternal view. H. Apex of right G1, sternal view. I. Right G1, abdominal view. J. Apex of right G1, abdominal view. Scales = 1.0 mm in A-D; 0.5 mm in G, I; 0.1 mm in E, F, H, J.

DISCUSSION

Whilst Griffin & Tranter (1986) question the validity of *Paratymolus* (including *Dumeia* and *Litosus*) as a majid on the basis of its unusual G1 structure, we consider the three genera to fit well into the family. Like other majids, they possess well-developed basal antennal articles (Alcock, 1895), fusion of the basal antennal article to the epistome, the articulation of the palps of the third maxillipeds are at the anteromedial angle of the merus, the especially mobile chelipeds, and the possession of comparatively incomplete orbits (see Griffin, 1966a). Although the G1 structure of many species of *Paratymolus* s. str. are peculiar in being very short and stout, the range of form in G1 across the family structure is very diverse. As such, the form of the G1 is not a character that should be stringently applied in the diagnosis of a majid. Moreover, in the examination of the specimens at hand, it has been found that the G1s of the various species are not always stout and broad. Longer and more slender G1s are also present in *P. cygnus*, *P. vannus* and in *Litosus* species as well.

It is uncertain whether the slender or stout form of G1 is the more plesiomorphic condition in the three genera. If those of the more slender variety reflect that of the ancestral form, while the stout ones are in fact the derived condition, it would even more strongly support the present contention that the three genera belong to the Majidae. Such an argument could likewise be applied to the relative length of the eyestalks, in which case *Paratymolus* s. str. would be the most primitive majid-like form of the three.

In contrast to their place in the Majidae, the position of *Paratymolus*, *Dumeia* and *Litosus* in the subfamily Inachinae is quite dubious. In certain respects the three genera seem to agree well with the criteria set in previous work for the subfamily - they possess eyes with poorly formed orbits and have non-retractile eyestalks (Alcock, 1895; Hale, 1927; Balss, 1929; Garth, 1958). Also, the third maxilliped of *Paratymolus* has an ischium that is wider than the merus, while the males possess subtriangular telsons which are not deeply inserted into the sixth male abdominal segment (Griffin & Tranter, 1986). However, unlike typical inachines in which the basal antennal article is characteristically long and extremely slender (Alcock, 1895; Garth, 1958; Dai & Yang, 1991), that of *Paratymolus*, *Dumea* and *Litosus* are very short and broad. Moreover, these are at best weakly fused to the epistome and the front of the carapace, and are slightly mobile. This is similar to the condition in *Oncinopus* (Sakai, 1939). Likewise, species of the three genera possess short, somewhat broad and dorso-ventrally flattened legs, unlike the typical inachine condition of having extremely long and slender legs (Griffin, 1966a; Griffin & Tranter, 1986). Additionally, *Dumea* and *Litosus* possess eyestalks that are markedly shorter than those of *Paratymolus*, which itself possesses only moderately long ones. This is in sharp contrast to the very long eyestalks diagnostic of the Inachinae (Alcock, 1895; Garth, 1958; Griffin, 1966a, 1966b; Dai & Yang, 1991).

Due consideration of these characters suggests that the retention of *Paratymolus*, *Dumeia* and *Litosus* in the Inachinae s. str. is probably untenable. Griffin & Tranter (1986) had noted that the Inachinae has over time, become cluttered with various species with long eyestalks but which do not resemble other inachines in other characters. The problem with *Paratymolus*, *Dumeia* and *Litosus* as inachines is thus not unique. In view of the above observations, it seems more parsimonious to eventually remove these three genera from the Inachinae and place them in their own subfamily. This would thus partially support the taxonomic scheme of Haswell (1880), who established a new family, Paratymolidae (here Paratymolinae), for *L. sexspinosus* and *D. latipes*.

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