sulcus absent. Antennal spine large, the carina reaching $\frac{1}{2}$ distance between spine and hepatic spine. Cervical sulcus straight, feeble, wide, its upper end indistinct. Hepatic sulcus pronounced, $\frac{1}{3}$–$\frac{1}{2}$ length carapace, inclined downwards at angle of 15° to horizontal, sinuous, posterior end indistinct and curving upwards, ending at $\frac{1}{2}$ carapace at level of hepatic spine; hepatic carina distinct only for lower $\frac{1}{2}$ sulcus, starting below hepatic spine and running towards sharp pterygostomial angle. Feeble indications of a branchiocardiac sulcus usually present.

Antennules.—Flagella subequal, 0·85 length peduncle, and 0·6 length carapace in ♂, and $\frac{3}{4}$ length peduncle and $\frac{1}{2}$ length carapace in ♀. Prosartema reaching tip of junction of peduncle of eye with cornea, stylocerite attaining $\frac{1}{2}$ basal segment.

Thoracic appendages.—Third maxilliped reaching from $\frac{3}{4}$ to slightly exceeding carpocerite; 1st pereiopod reaching from pterygostomial angle, to base of carpocerite; 2nd reaching from base to $\frac{1}{2}$ carpocerite; 3rd reaching from tip to exceeding carpocerite by dactyl; 4th reaching base of, 5th reaching tip of carpocerite. Mastigobranchiae on 1st and 2nd pereiopods, ischial spines absent.

Abdomen.—Dorsally carinated from middle 4th somite, carinae of 4th and 5th ending in angular, sometimes very minutely spinous projections, that of 6th ending in large spine. The 3rd and anterior 4th somites with feeble dorsal sulcus or flat-topped strip indicating its position, often present on 1st and 2nd somites also. Fourth somite with 1, 5th with 1, 6th with 3 pairs of faint lateral cicatrices. Telson unarmed.

Gastric mill (Fig. 27*G*).—Cardiac plate with 17–21 spinules. Zygocardiac ossicle 3 principal + upper row of 7–8 smaller and lower cluster of about 25 teeth; 5 teeth on edge of cardiac plate; prepyloric with 9–12 lateral teeth.

Petasma (Fig. 27*D, E*).—Reaching basis of 4th pereiopods, with pair apical spout-like projections directed anterolaterally and opening ventrally, distance between their apices almost equal that of distolateral projections, which is $\frac{2}{5}$ total length petasma. Petasma constricted at 0·7 its length; a pair of very large prominent lateral proximal projections, slightly curved dorsally, ending posteriorly in knob-like processes.

Appendix masculina (Fig. 27*F*).—Distal piece with expanded, flattened distolateral region inclined at 45° to longitudinal axis and $\frac{1}{5}$ length basal piece.

Thelycum (Fig. 27*C*).—Anterior plate slightly concave, length 0·7–0·8 width; with 2 low tubercles on posterior edge separated by shallow median depression and articulating with corresponding pair of tubercles on rectangular posterior sternal plate, latter with tubercle bearing tuft of setae.

Colour (freshly preserved).—Four wide whitish transverse bands, evenly spaced along carapace and abdomen, edged with narrow pink bands, region between white and pink bands light to dark brown; appendages pink to red.

Distribution

Keppel Bay to Gulf of Carpentaria, Qld.; Indonesia, Singapore, Hong Kong, Gulf of Martaban, Bombay (Kubo 1949). Abundance in commercial quantities has been reported for Keppel Bay.

Discussion

Burkenroad (1934*b*) does not regard the shorter rostrum of ♂ as being even a variant of normal form, but "an adult instar ultimately attained by all males". While ♀♀ often seem to have damaged rostra, this apparently being a feature of slender, long rostra generally, none examined were as short as those of ♂♂, which seem to have been derived by the unarmed portion being broken off close to the last tooth. Tips of all ♂ rostra were variable and appeared slightly malformed. Alcock (1906) states that the unarmed portion is often lost, and presumably had examined intact adult ♂♂. It may be that ♂, just before reaching adult instar, is for some reason more likely to suffer rostral damage, possibly because ♂ rostrum is less robust than that of ♀.

Kubo (1949) elevates *P. sculptilis* var. *cultrirostris* to *P. cultrirostris* but it is significant that Kubo did not examine any ♂ *P. sculptilis* nor any ♀ *P. cultrirostris*. The description of the latter agrees well with that of ♂♂ described above. Position of epigastric tooth, sulcation of postrostral carina and 1st and 2nd abdominal somites, appear to be variable and therefore not valid for creating a distinct species.

Parapenaeopsis venusta de Man

Fig. 28

Parapenaeopsis venusta de Man, 1907, p. 134; 1911, pp. 93–5, pl. IX, fig. 30.

Material.—QUEENSLAND: Albany Passage, Cape York, Sept. 1928, coll. M. Ward, ♀, 45 mm.

Description

Rostrum.—Teeth 7 + epigastric. Rostrum slightly exceeding 1st antennular segment, distal $\frac{1}{3}$ free portion curving slightly ventrad, extreme tip upturned. Adrostral carina ending just behind 1st tooth; postrostral carina ending at $\frac{1}{2}$ carapace. Epigastric 0·36 length carapace, 1st tooth on carapace. Greatest depth of rostrum just in front of 2nd tooth.

Carapace.—Postocular sulcus present. Orbital angle not spinous. Longitudinal suture ending just behind level of hepatic spine, transverse suture at tip of coxae of 3rd pereiopods. Upper edge of antennal spine forming a right angle with border of carapace; carina not extending behind edge of carapace. Hepatic spine slender; cervical sulcus $\frac{1}{4}$ length carapace, slightly inclined upwards. Hepatic sulcus extending horizontally for $\frac{1}{2}$ length behind hepatic spine, its anterior $\frac{1}{2}$ inclined downwards towards pterygostomial angle. Hepatic carina along anterior $\frac{1}{2}$ sulcus, anterior edge with row of spinous setae. Pterygostomial angle sharp.

Antennules.—Flagella subequal and 0·8 length peduncle and $\frac{1}{2}$ length carapace. Stylocerite $\frac{1}{3}$ length 1st segment; prosartema reaching as far as tip of junction of peduncle of eye with cornea.

Thoracic appendages.—Third maxillipeds much stouter than pereiopods and reaching $\frac{1}{2}$ 2nd segment of antennular peduncle; 1st pereiopod reaching base of, 2nd reaching tip of carpocerite. 3rd exceeding it by dactyl; 4th reaching $\frac{1}{2}$ and 5th exceeding carpocerite by dactyl. No ischial spines and mastigobranchiae on pereiopods.

Abdomen.—Fifth and 6th somites dorsally carinated. Telson with 4 small lateral movable spines, most distal largest. Distal and penultimate spines close together, distance separating them less than $\frac{1}{2}$ that separating remaining 2.

Thelycum (Fig. 28).—Anterior plate mucronate, $\frac{2}{3}$ as long as wide, not including posterior extension. Posterior $\frac{1}{2}$ concave, concavity extending along a posterior extension, which lies in a rectangular incision of posterior plate. Distolateral extensions of posterior plate flat, enclosing posterior $\frac{1}{3}$ anterior plate; a transverse depression occupying middle region of posterior plate.

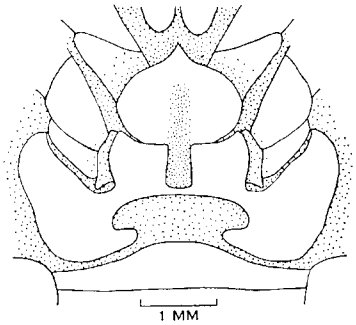

Fig. 28.—*Parapenaeopsis venusta* de Man. Thelycum, 45 mm ♀.

Distribution

So far known only from the type locality (13 m, east coast of Aru Is.) and from Albany Passage.

Discussion

The present specimen agrees in most respects with de Man's (1911) description, except that the anterior plate of thelycum is wider than that shown in de Man's figure.

The integument of the Albany Passage specimen is very soft and damaged, making it unsuitable for figuring. However, absence of mastigobranchiae on 1st and 2nd pereiopods, presence of an epigastric tooth, short rostrum and longitudinal suture, enables *P. venusta* to be readily separated from other species of the genus. ♂ is still unknown.

PARAPENAEOPSIS TENELLUS (Bate)

Fig. 29*A–G*

Penaeus tenellus Bate, 1888, pp. 270–1. Kishinouye, 1900, p. 22.
Penaeus cureifer Ortmann, 1890, p. 451.
Penaeus (Parapenaeopsis) tenellus de Man, 1907, pp. 435–6, 454.
Parapenaeopsis tenella de Man, 1911, pp. 9, 92.
Parapenaeopsis tenellus Kubo, 1949, pp. 371–4.

Material.—QUEENSLAND: Townsville, 20 fm, Aug. 1953, ♀, 44 mm; mouth Norman R., Gulf of Carpentaria, Aug. 1953, 2 ♂, 32 mm, 2 ♀, 36, 37 mm.

Description

Rostrum.—Teeth 6–8, epigastric absent; reaching almost to tip of 2nd segment of antennular peduncle, proximal $\frac{1}{3}$ rising from carapace, remainder more or less horizontal, tip with slight upward curve. Adrostral carina ending at $\frac{1}{4}$ carapace, postrostral carina broad, indistinct posteriorly, ending at $\frac{1}{2}$ carapace; 1st tooth at edge of carapace.

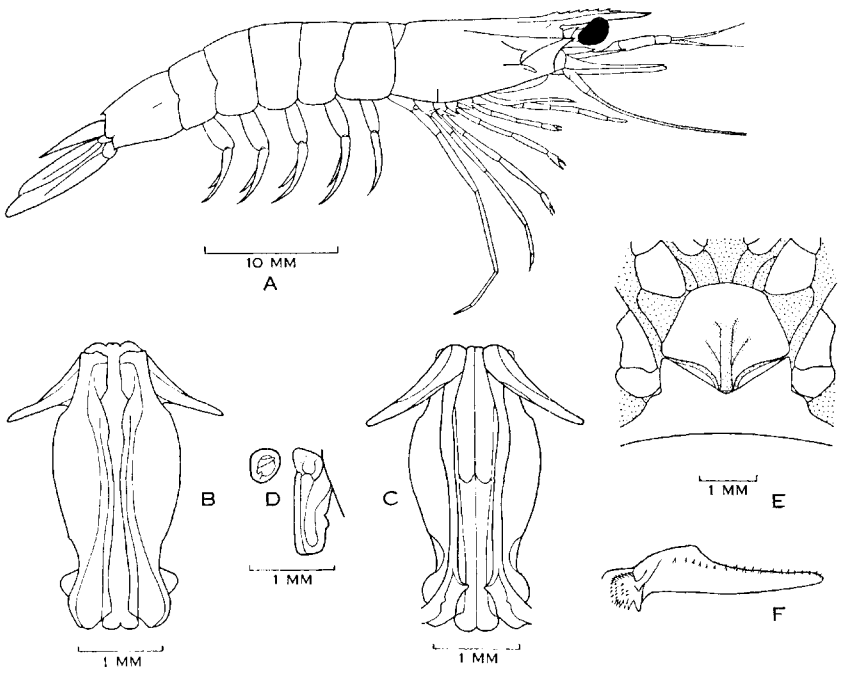

Fig. 29.—*Parapenaeopsis tenellus* (Bate). *A*, 44 mm ♀; *B*, ventral surface of petasma, 32 mm ♂; *C*, dorsal surface of petasma; *D*, appendix masculina and end view of distal piece; *E*, thelycum, 44 mm ♀; *F*, cardiac plate and zygocardiac ossicle.

Carapace.—Minutely punctate, with acute orbital angle and a postocular sulcus. Longitudinal suture reaching $\frac{2}{3}$ carapace from anterior edge. Antennal spine large, carina indistinct, occupying anterior $\frac{1}{4}$ distance between antennal and hepatic spines. Cervical sulcus feeble, wide, and reaching almost to longitudinal suture. Hepatic sulcus almost horizontal posteriorly, anterior $\frac{1}{2}$ inclined downwards towards acute pterygostomial angle; hepatic carina along anterior $\frac{1}{2}$ sulcus only.

Antennules.—Flagella subequal, equal to length peduncle and 0·8 carapace in ♂, 0·7–0·8 peduncle and 0·5 carapace in ♀. Prosartema reaching tip of junction of optic peduncle with cornea; stylocerite reaching $\frac{1}{2}$ basal segment.

Thoracic appendages.—Third maxillipeds reaching as far as or slightly exceeding basal segment of antennular peduncle; 1st pereiopod exceeding pterygostomial angle by dactyl; 2nd reaching $\frac{1}{2}$ carpocerite; 3rd reaching base of dactyl of 3rd maxillipeds; 4th reaching as far as tip of 1st, 5th reaching as far as tip of 2nd segment of antennular peduncle. No mastigobranchiae on 1st and 2nd pereiopods.

Abdomen.—Dorsally carinated from 4th somite. Exopods uropods $1\frac{1}{2}$ times length unarmed telson. Sixth somite with horizontal anterior lateral cicatrice, and horizontal suture on lower $\frac{1}{4}$ posterior edge.

Gastric mill (Fig. 29*F*).—Cardiac plate with 16–21 teeth. Zygocardiac ossicle 3 principal + upper row of about 6, and lower row of 3 4 teeth, and total of 15–20 in 4 vertical rows between ends of these rows. Prepyloric acute with 8–10 lateral teeth, most median 3–5 large and prominent.

Petasma (Fig. 29*B*, *C*).—Reaching basis of 3rd pereiopods, distolateral projections of lateral lobes slender, tapering, and reflected posterolaterally, making angle of 60° with longitudinal axis of petasma; distance between tips of projections $\frac{4}{5}$ total length petasma. Lateral lobes expanded laterally into elongate keeled projections, their length, and also distance across their most lateral extremities, $\frac{1}{2}$ length petasma. Peduncle of pleopod with mediodistal process, consisting of proximal sharp tubercle and distal larger, blunter tubercle.

Appendix masculina (Fig. 29*D*).—Distal piece broad, minutely setose, $\frac{1}{3}$ length basal piece, with posterodistal excavation with tongue-like process, and with tubercle on anterior rim of excavation.

Thelycum (Fig. 29*E*).—Anterior plate $1\frac{1}{2}$ times as wide as long, with median groove occupying posterior $\frac{2}{3}$; with a posterior tongue-like projection enclosed by large flat anterior processes of posterior plate, and with an accessory ridge on each side of front of posterior plate.

Distribution

Townsville and Norman River, Gulf of Carpentaria, Qld. Southern half of Japan (Kubo 1949).

Discussion

The above description is in close agreement with that of Kubo (1949) except that Kubo states that a postocular sulcus is absent. All specimens examined had a distinct, though shallow, postocular sulcus, and it is possible this was overlooked by Kubo, whose description was mainly based on 1 female.

P. tenellus is one of the 4 *Parapenaeopsis* spp. which lack mastigobranchiae on 1st and 2nd pereiopods, the others being *P. hungerfordi* Alcock, *P. venusta* de Man, and *P. acclivirostris* Alcock. Of these only the last lacks an epigastric tooth and is closely similar to *P. tenellus*. However, in *P. acclivirostris* the antennular flagella are $\frac{1}{2}$ length peduncle, and anterior plate of thelycum wants a posterior tongue-like extension, according to Alcock (1906). Both species are very small penaeids (♂ *P. tenellus* mature at 30 mm, ♀ 40 mm), and this may account for their apparent rarity and discontinuous distribution.

IV. Zoogeographical Distribution

The majority of Penaeinae are restricted to tropical and warm-temperate shallow seas, being most abundant in the former. Little collecting has been done in northern Australia and adjacent areas. There are few records from New Guinea and from most of the Pacific islands. There are a number of records from northern Queensland

and north-western Australia, but except for a few specimens from Darwin the region between these areas has been almost entirely neglected. Nevertheless, in spite of these shortcomings it is possible to integrate the zoogeography of the Australian Penaeinae. Of 28 species described above, 17 are considered in this respect. Five new species, with *Funchalia villosa*, *Metapenaeopsis borradailei*, *M. durus*, *M. mogiensis*, *Trachypenaeus granulosus*, and *Parapenaeopsis venusta*, comprise the remainder and are omitted from subsequent discussion.

(*a*) *Australian Distribution* (*Table* 1)

A cool-temperate Australian penaeinine fauna is virtually non-existent. Prawns are absent from the cold Maugean Province (as defined by Bennett and Pope (1953)), and *Penaeus latisulcatus* and *Metapenaeopsis novae-guineae* are rare in South Australia and confined to sheltered inlets (Hale 1927). Only *Penaeus plebejus* and *Metapenaeus macleayi* are not found in tropical waters and are confined to the region corresponding roughly to the Peronian Province (Bennett and Pope 1953). Decreasing temperature, in the vicinity of Twofold Bay (D. Rochford, personal communication), probably limits the southern distribution of these two species. On the other hand, *Penaeus plebejus* and *Metapenaeus macleayi* do not extend far into Queensland waters. This may be explained by regarding them as endemic Australian species. This is in accord with the general principle that species peculiar to Australia are found only in the colder southern regions (Bennett and Pope (1953), rocky shores; various authors quoted by them; Thomson (1947), chaetognaths; Thompson (1948), pelagic tunicates; Munro (1949), silver bream; Kott (1952), ascidians; Stephenson and McNeill (1955), stomatopods). As such species are lacking in the Penaeinae, it is likely that any endemic Australian species would be found in the adjacent warm-temperate Peronian Province. Stephenson and McNeill (1955) record one endemic species for this region. Thomson (1947) did not find any tropical species of chaetognath further south than 38° S. latitude (approximately Cape Howe) and Kott (1952) found the southern limit for tropical ascidians to be Sydney. It seems likely, therefore, that if endemic Australian species have evolved from typically tropical animal groups, they would be restricted to the Peronian Province.

Apart from *Penaeus plebejus* and *Metapenaeus macleayi*, only *M. endeavouri* and *Trachypenaeus anchoralis* are not also recorded outside Australian waters. It is likely that these species will be found in Indonesia, as *Penaeus esculentus*, while most common in Australian waters, has recently been recorded from Borneo (Kubo 1949). In addition to these four species, *P. latisulcatus*, *P. semisulcatus*, *P. merguiensis*, *Metapenaeopsis novae-guineae*, and *Trachypenaeus fulvus* are found across northern Australia. It is probable that further collecting will show a similar distribution for the widely ranging *Penaeus monodon*, *Metapenaeus monoceros*, *Trachypenaeus curvirostris*, and *Parapenaeopsis sculptilis*. The two remaining *Parapenaeopsis* spp. are rare as yet and predictions concerning their distribution cannot be made.

Thus in the Penaeinae there is little to substantiate the division of tropical and subtropical Australia into a Banksian Province, extending inside the Great Barrier Reef from Cape York to approximately Wide Bay, and a Dampierian Province from Geraldton to Cape York (Bennett and Pope 1953). A similar situation has been

found for chaetognaths (Thomson 1947), ascidians (Kott 1952), stomatopods (Stephenson and McNeill 1955), portunid crabs (Stephenson, unpublished data), and the dominant littoral molluscs and barnacles (Endean, Kenny, and Stephenson 1956; Endean, Stephenson, and Kenny 1956). Clark (1946) found it convenient to erect a division of the echinoderm fauna at Cape York, but admits to the paucity of records west of the Cape. It is probable that the proximity of Cape York to New Guinea is responsible for the concept of some kind of geographical barrier in this region, whereas most faunal evidence to date is to the contrary.

TABLE 1
DISTRIBUTION OF 17 PENAEIDAE WITHIN AUSTRALIA
? indicates probable occurrence

Species	N.S.W.	S. Qld.	N. Qld.	N.T.	W.A.	S.A.
Penaeus plebejus	+	+				
P. latisulcatus			+	+	+	+
P. monodon		+	+	?	+	
P. esculentus	+	+	+	+	+	
P. semisulcatus	+	+	+			
P. merguiensis	+	+	+	+	+	
Metapenaeopsis novae-guineae	+	+	+	+	+	+
Metapenaeus monoceros	+	+	+	?	+	
M. endeavouri	+	+	+	+	+	
M. mastersii	+	+	+	+	+	
M. macleayi	+	+				
Trachypenaeus curvirostris	+	+	?	?		
T. fulvus	+	+	+	+	+	
T. anchoralis		+	+	+	+	
Parapenaeopsis cornutus			+			
P. sculptilis			+			
P. tenellus			+			

(*b*) *Indo–West Pacific Distribution* (*Fig.* 30)

The tropical and subtropical oceans inhabited by the Penaeinae can be subdivided into three regions:

(i) The Atlantic and Mediterranean,

(ii) Pacific America,

(iii) Indo–West Pacific.

Each has a discrete fauna, none of the species in a given region so far being recorded from another, though the Suez and Panama Canals are possible avenues of migration from one region to another (Monod 1930). Most of the species of Penaeinae are found in the Indo–West Pacific.

The distribution and abundance of Penaeinae shown in Figure 30 indicates that Australian species of the subfamily are very largely a southern extension of the

Indonesian fauna. The two exceptions are *Penaeus plebejus* and *Metapenaeus macleayi* as noted above. Clark (1946) arrived at the same conclusion for echinoderms, and Stephenson and McNeill (1955) for stomatopods. This situation is to be expected in view of Australia's geographical position, with the continental shelf extending northwards into Indonesia.

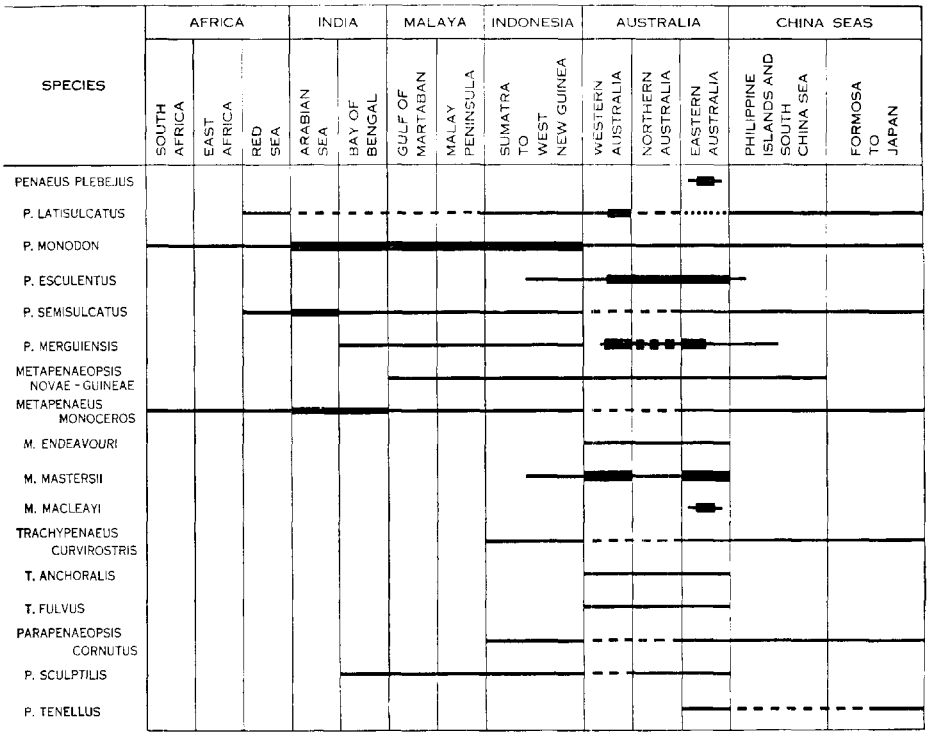

Fig. 30.—Indo–West Pacific distribution of 17 Australian Penaeinae. Heavy lines, commercial abundance; unbroken lines, recorded in the literature, but abundance not stated; broken lines, occurrence probable, but no actual record; dotted lines, present but rare.

In Figure 30 it can be seen that some species have very wide distribution while others are curiously restricted. *Penaeus latisulcatus* ranges from the Red Sea to Japan, and occurs in Western Australian waters in commercial quantities, but is rare on the east coast. The very closely related *P. plebejus*, on the other hand, is found only on the east coast where it is commercially abundant. Another example of one species breaking the distribution of another is shown by *P. esculentus* and *P. monodon*. The former occurs in commercial abundance across northern Australia, whereas the latter, which has an extremely wide distribution in large numbers, is not abundant on the east coast and probably will be found sparsely scattered on the north and west coasts of Australia. There is also the possibility of a similar relationship existing between the wide-ranging *Metapenaeus monoceros* and *Metapenaeus endeavouri*, though the abundance of the latter in northern Australia is unknown. In the Atlantic *Penaeus brasiliensis* Latreille is widely distributed but does not occur in the Gulf of Mexico, where the closely related *P. duoarum* Burkenroad and *P. aztecus*

Ives are found (Anderson and Lindner 1945). However, the two latter differ from *P. plebejus* in having a range similar to that of *P. brasiliensis*. The existence of some sort of mutual exclusion between certain penaeid species therefore seems possible. Summarizing the zoogeography of Australian Penaeinae, it is possible to state that:

(1) There are two endemic species, the southern limits of which are probably determined by hydrographical conditions, and the northern limits of which may be determined by either ecological or hydrographical factors, or a combination of both.

(2) The rest of the Australian species are a southern extension of the Indonesian fauna.

(3) Certain abundant species may interrupt the distribution of otherwise widely ranging closely related species elsewhere abundant.

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