Notes on the freshwater Crustacea of Malaya. I. The Atyidae

By D. S. JOHNSON, M.A., PH.D.
Department of Zoology, University of Malaya
(Received May, 1957)

Introduction

WHILST THE FRESHWATER CRUSTACEA of neighbouring countries such as Sumatra and Thailand, including those of peninsular Thailand, are tolerably well known, those of Malaya are almost unknown. The present series of papers is an attempt to remedy this deficiency.

The present paper deals with the prawns of the family Atyidae. It is based almost entirely on collections made by members of the Department of Zoology of the University of Malaya during the years 1952 to 1957, and in large part on my own collecting. I wish to thank the authorities of the University for providing me with facilities for collecting trips up-country; the members of staff of this department, in particular Professor R. D. Purchon and Dr. J. R. Hendrickson, who have handed over to me collections of prawns made at various localities; Mr. E. R. Alfred, of the Raffles Museum and all others who have assisted me in any way.

Members of the family Atyidae are apparently rather rare in Malaya. Despite rather intensive collecting my collections are few in numbers of individuals, though rich in species. Only 2 species of this family have been recorded previously from Malaya: *Atya spinipes* Newport and *Caridina nilotica* var. *brachydactyla* de Man. The former is represented in my collections by numerous individuals. The latter was recorded from Penang by Kemp (1918), but I have failed to rediscover it.

The species recorded in the present paper bring the total number of species known from Malaya to 9. These are:—

Caridina nilotica var. *brachydactyla* de Man
Caridina gracilirostris de Man
Caridina excavatoides sp. nov.
Caridina propinqua de Man
Caridina tonkinensis Bouvier
Caridina cf. *babaulti* Bouvier
Caridina thambipillaii sp. nov.
Caridina weberi var. *sumatrensis* de Man
Atya spinipes Newport.

Bouvier's monograph (1925) is still the basic work on the family; but more recent papers have added considerably to our knowledge. Many new species have been described and there have been several changes in synonymy. Bouvier's monograph must be used with caution since it contains several rather peculiar interpretations of the nature of the species, and also contains a number of obvious errors and misprints, particularly in the key to the genus *Caridina*. A further revision of the family is very necessary; but this can only be undertaken by a worker with adequate access to the large collections contained in European museums.

The following list of new species described from the Indo-Pacific region which are not included in Bouvier's monograph may be of use to future workers. In its compilation I have taken the Indo-Pacific region to include the area stretching from Madagascar and India to Japan, Australasia and Polynesia inclusive. I have made no attempt to evaluate these species critically. It is almost certain that, when a thorough revision is undertaken, several of them will fall as synonymys of other species.

Indo-Pacific species of the family Atyidae not included in Bouvier's monograph

Paratya annamensis Balss, 1924	Annam.
Paratya martensi Roux, 1925	Adenara Island near Flores.
Paratya (Xiphatyoida) howensis Roux, 1926a	Lord Howe Island.
Paratya (Xiphatyoida) bouvieri Roux, 1926b	New Caledonia.
also var. *ngoiensis*, Roux, 1926b	New Caledonia.
Paratya (Xiphatyoida) caledonica Roux, 1926b	New Caledonia.
also var. *magna* and var. *intermedia* both Roux, 1926b	New Caledonia.
Paratya (Xiphatyoida) typa Roux, 1926b	New Caledonia.
Mesocaris lauensis Edmondson, 1935a	Fiji.
Caridinides wilkinsi Calman, 1926	North Queensland.
Caridina gregoriana Kemp, 1924	Yunnan.
Caridina mc.cullochi Roux, 1926a	New South Wales.
Caridina vitiensis canacorum Roux, 1926b	New Caledonia.
Caridina nilotica meridionalis Roux, 1926b	New Caledonia.
Caridina weberi longicarpus Roux, 1926b	New Caledonia.
Caridina novae-caledoniae Roux, 1926b	New Caledonia.
Caridina indistincta Calman, 1926	Queensland.
Caridina gladiifera Roux, 1929b	Madagascar.
Caridina bouvieri Roux, 1929b	Madagascar.
Caridina petiti Roux, 1929b	Madagascar.
Caridina cavaleriei industana Roux, 1931a	South India.
Caridina carli Roux, 1931a	South India.
Caridina pristis Roux, 1931b	Ceylon.
Caridina bühleri Roux, 1934b	New Ireland.
Caridina rapaensis Edmondson, 1935b	Rapa Island.
Caridina lanceifrons Yu, 1936	Hainan.
Caridina lingkonae Woltereck, 1937a & b	L. Towutti, Celebes.
Caridina towutensis Woltereck, 1937a & b	L. Towutti, Celebes.
Caridina spinata Woltereck, 1937a & b	Lakes Towutti & Matanno, Celebes.
Caridina loéhae Woltereck, 1937a & b	Lakes Towutti & Matanno, Celebes.
Caridina mesapi Woltereck, 1937a & b	Lakes Towutti & Matanno, Celebes.
Caridina lanceolata Woltereck, 1937a & b	Lakes Towutti, Matanno, & Mahalone, Celebes.
Caridina tenuirostris Woltereck, 1937a & b	L. Towutti, Celebes.
Caridina japonica sikokuensis Kubo, 1938	Sikoku coast, Japan.
Caridina cantonensis Yu, 1938	Near Canton, China.
Caridina pingi Yu, 1938	Fukien, China.
Caridina pingioides Yu, 1938	China.
Caridina babaultioides Yu, 1938	Yunan, China.
Caridina yunanensis Yu, 1938	Yunan, China.
Caridina villadolidi Blanco, 1939	Luzon, Philippines.
Caridina laoagensis Blanco, 1939	Luzon, Philippines.
Caridina leytensis Blanco, 1939	Leyte, Philippines.
Caridina celestinoi Blanco, 1939	Leyte, Philippines.
Caridina microphthalma Fage, 1946	Madagascar.
Caridina palmata Shen, 1948	S.W. China.
Caridina elongata Shen, 1948	S.W. China.
Caridina hofendopoda Shen, 1948	S.W. China.
Caridina excavatoides Johnson, sp. nov.	Kedah, Malaya.
Caridina thambipillaii Johnson, sp. nov.	Malacca, & N.W. Johore, Malaya.
Neocaridina denticulata koreana Kubo, 1938	Korean coast.
Pseudatya beauforti Roux, 1928	Batian Isle.

The Indo-Pacific genera of Atyinae

In his monograph, Bouvier refers four genera to the sub-family Atyinae: *Caridina; Ortmannia; Atya;* and *Micratya*. He places Indo-Pacific species in the first three of these genera. Since that date three genera have been added to the sub-family, all of which are from the Indo-Pacific area. These are: *Caridinides* Calman, 1926; *Pseudatya* Roux, 1928; and *Neocaridina* Kubo, 1938.

Of these *Caridinides* is very close to *Caridina*, being distinguished solely by the presence of an exopodite on the first cheliped. In other respects it does not differ from primitive members of the genus *Caridina*. Whilst the presence or absence of an exopodite is commonly given generic status in the classification of Decapod Crustacea, it is doubtful if this feature alone is sufficient to justify the erection of the genus *Caridinides*. Such an exopodite is presented by larval stages of prawns and there is a strong presumption that its presence in *Caridinides wilkinsi* is a neotenic rather than a truly primitive feature. If this is so the true relationships of the species will be best shown by retaining it in the genus *Caridina*.

Neocaridina Kubo was established for the species *Caridina denticulata*. This is in most respects a very ordinary *Caridina* though it does show a number of specialized features. I have been unable to consult the publication in which the genus was proposed or to find any statement of the characters on which it was based. The genus has been consistently ignored by non-Japanese workers; but Kubo in 1941 transferred several other species to it, including *Caridina brevirostris*. As I shall demonstrate below (page 135) the *brevirostris* group of *Caridina* is scarcely separable from the *laevis* group of this genus. Thus if Kubo is followed the *laevis* group must also be removed to *Neocaridina*. This would leave behind in the genus *Caridina* a miscellaneous rump of species, which would form an unnatural and almost undefinable grouping. Rather than take this course I prefer to adopt a conservative viewpoint and treat *Neocaridina* as a synonym of *Caridina*.

Pseudatya is a very distinct genus. Here the chelipeds are much as in *Ortmannia;* but the Vth. pleurobranch is lacking (as in *Micratya*); and the rostrum is of very unusual form.

It is now considered that only two of the four genera which Bouvier originally included in the Atyinae occur in the Indo-Pacific region. These are *Caridina* and *Atya*. Bouvier referred three Indo-Pacific species to *Ortmannia* but it is clear, even from his own account, that one of these is merely an Ortmannioid form of a species of *Caridina* whilst the other two are Ortmannioid forms of species of *Atya*. Bouvier's own experiments showed these correspondences for two of the species concerned, and subsequent work has amply established such a correspondence for the third species. *Ortmannia** (which is in many features intermediate between *Caridina* and *Atya*) is thus restricted to a small and natural group of American prawns.

---

* The *Ortmannia* sp. described by Blanco (1935) from the Philippines is based on a young specimen of a species of *Atya*, probably *A. spinipes*.

The following key will serve to distinguish the Indo-Pacific genera of Atyinae:—

1. Second cheliped little specialized; differing in both size and structure from the first cheliped, and with the distal end of the carpus entire .. .. *Caridina* (includes *Caridinides*).

–. Second cheliped specialized and resembling the first in size and structure; with the distal end of the carpus deeply emarginate .. .. .. 2.

2. Fifth pleurobranch present. Rostrum, though short, of normal form. Chelae cleft to the base at least in some individuals .. .. *Atya*.

–. Fifth pleurobranch absent. Rostrum with a very deep unarmed ventral keel. Chelae, though deeply cleft, never cleft to the base .. .. .. *Pseudatya*.

Systematic account

Caridina

The Malayan species of this genus are all distinct from each other, though certain of them are not very easily distinguished from some non-Malayan species. It is not improbable that future work will reveal the presence of more species of this genus in Malaya. Thus it would be premature to offer a key to the Malayan species. Previously known species can be identified by means of Bouvier's key, provided that the obvious errors this contains are allowed for. I have endeavoured to indicate where the new species described in this paper are likely to run out if this key is used.

Caridina nilotica var. **brachydactyla** de Man

Synonymy: *Caridina brachydactyla* subsp. *peninsularis* Kemp, 1918, 270, fig. 10.
Caridina nilotica var. *brachydactyla* Bouvier, 1925, 155, figs. 321 & 322.

I have not seen specimens of this species, which was recorded from Penang by Kemp. Judging from published descriptions and figures the Malayan species with which the present variety is most likely to be confused is *Caridina excavatoides*, in which the rostrum and antennal region are somewhat similar. This latter species differs in numerous details, of which the most readily observed are the more sinuous form of the rostrum, which has a toothless distal region lacking a sub-apical tooth, and the much smaller number of spines on the dorsal surface of the telson. *C. excavatoides* also differs fundamentally from *C. nilotica* in lacking epipodites on the 3rd and 4th pereiopods.

It is possible that other forms of *C. nilotica* may subsequently be found in Malaya. In some of these the rostrum is much longer than it is in the present variety. Such forms might be confused with *C. gracilirostris;* but they can easily be distinguished by the features mentioned under that species.

Distribution: C. nilotica is a protean species with a very wide distribution. It ranges throughout East and Central Africa and Madagascar eastwards to Shanghai, New Caledonia, and the Mariannas. The variety *brachydactyla* is not known in Africa or on the mainland of Asia but is spread over the whole of the remainder of the range of the species.

Caridina gracilirostris de Man (Figures 1, 2).

Synonymy: *Caridina gracilirostris* de Man, 1892, 399, pl. XXV, fig. 31; Bouvier, 1925, 142, figs. 305–307; Blanco, 1935, 32, pl. 2, figs. 11–17; Woltereck, 1937a, 232–236, 243–244, & 252–257, figs. III & IV; Woltereck, 1937b, 213.

Caridina gracillima Lanchester, 1901, 560, pl. IV, fig. 1; Kemp, 1918, 285; Bouvier, 1925, 140, figs. 301–304.

nec. *Caridina gracillima* Blanco, 1935, 32, pl. 11, figs. 5–10 (= *C. modiglianii*).

Material examined: 1 ♂, length 23·1 mm., including rostrum of 6·9 mm., Sungei Seletar at Nee Soon Village, Singapore; 11.11.56; collector, D. S. Johnson.

Systematic notes: This specimen is a very typical example of *C. gracilirostris*. The rostrum (figure 1) is twice as long as the carapace, and shows the characteristic armature of the species. The rostral formula is $\frac{8+1}{4}$.

I obtain the following ratios* for the proportions of the appendages:—

$\frac{pa\ 1}{c}$	·77	$\frac{6sa}{c}$	·87
$\frac{pr.p3}{c}$	·40	$\frac{d.p3}{pr.}$	·28
$\frac{d.p5}{pr.}$	·44		

The dactylus of the 3rd pereiopod of one side has 7 spines; that of the other side has 8. These spines increase gradually in length distally, the most distal being slightly larger than its size would be if it fell on the linear series formed by the lengths of the other spines. There are 7 uropodial spines.

These figures agree well with Bouvier's data. The 1st antenna is a little shorter than it is in Bouvier's specimens, being closer to that of *female C. gracillima*. The relative length of the dactylus and propodus of the 3rd pereiopod is also nearer to the figures Bouvier gives for *C. gracillima*. On the other hand the 6th abdominal segment is considerably longer than that of *C. gracillima*, though well within the range of *C. gracilirostris*.

The armature of the dactyli of the 3rd and 4th pereiopods is intermediate between the types given by Bouvier for *C. gracillima* and *C. gracilirostris*. Similarly intermediate, on the basis of Bouvier's account, is the pre-anal carina. *C. gracilirostris* is said to have a prominent pre-anal carina, 'saillante en pointe'; whilst *C. gracillima* is included in Bouvier's key as a species lacking a pre-anal carina. My specimen has a well-marked pre-anal carina; but this terminates in a right-angled corner bearing only a very minute tooth.

These resemblances to *C. gracillima* raise the question of the validity of that species. This is particularly pertinent to the present investigation since the type-locality for *C. gracillima* is the Tale Sap in Peninsular Thailand†, so that the species, if valid, would be expected to occur in Malaya.

* Here and elsewhere the ratios used are those used in Bouvier's monograph. Some of these are more fully explained by E. Woltereck (1937a).

† The restricted type-locality is given on the authority of Kemp who states that the species is abundant in the Tale Sap.

Lanchester (1901) gives the following distinctions which are supposed to distinguish his species from *C. gracilirostris*:—

(*a*) the rostrum is shorter (from 1 to 1½ times the carapace length) and has fewer ventral teeth (12 to 23);

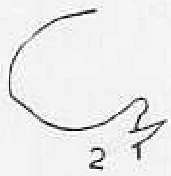
(*b*) there are fewer teeth on the dorsum of the telson (only 4 pairs); and

(*c*) the legs of the first and second pairs (i.e. presumably the first and second chelipeds) are slightly shorter (the first only reaching to the middle of the penultimate joint of the antennular peduncle and not to its end; and the second just over-reaching this joint instead of nearly attaining the end of the last joint). The spacing of the basal teeth of the upper margin of the rostrum is supposed to be more nearly uniform.

Bouvier (1925) adds the following differences: the antennulary acicle and the spine on the end of the first joint of the antennulary peduncle are somewhat less elongate in *C. gracillima* than in *C. gracilirostris;* the carpus of the first cheliped is somewhat stouter in *C. gracillima;* and the terminal setae of the telson are somewhat more elongate in *C. gracillima*. Bouvier records slight presumptive differences in proportions for some of the other segments and appendages. In his key Bouvier includes *C. gracillima* amongst species in which the pre-anal keel is lacking; but oddly enough he does not mention this feature in his description.

Kemp (1918) decided after careful study that the two species were distinct; but his only real reason for this decision seems to have been an observation that the eggs of individuals of *C. gracillima* from brackish water were twice as large as those of individuals from freshwater, whilst such differences are not known for *C. gracilirostris*.

Woltereck (1937b, 213), in discussing the distribution of species of the genus *Caridina*, comments on *C. gracillima*, 'scheint identisch mit *gracilirostris*'. In my opinion this view is correct.



Figs. 1, 2. *Caridina gracilirostris*. 1, rostrum; 2, orbit and suborbital spine.

Of Lanchester's original distinctions (*c*) is clearly unimportant; (*b*) is at best an average difference, since Bouvier records specimens of *C. gracilirostris* with only four pairs of dorsal teeth (including the terminal teeth) though saying that five pairs is the usual number. This only leaves the length and armature of the rostrum as a possible distinguishing feature. In view of the very great variations in length and armature of the rostrum in the closely related species *C. nilotica*, the comparatively small differences between *C. gracilirostris* and *C. gracillima* can scarcely be considered as being of specific status. Further Woltereck (1937a) has shown that in forms of *C. gracilirostris* from Celebes and the Philippines the rostrum is almost as variable in length and form as it is in corresponding races of *C. nilotica*.

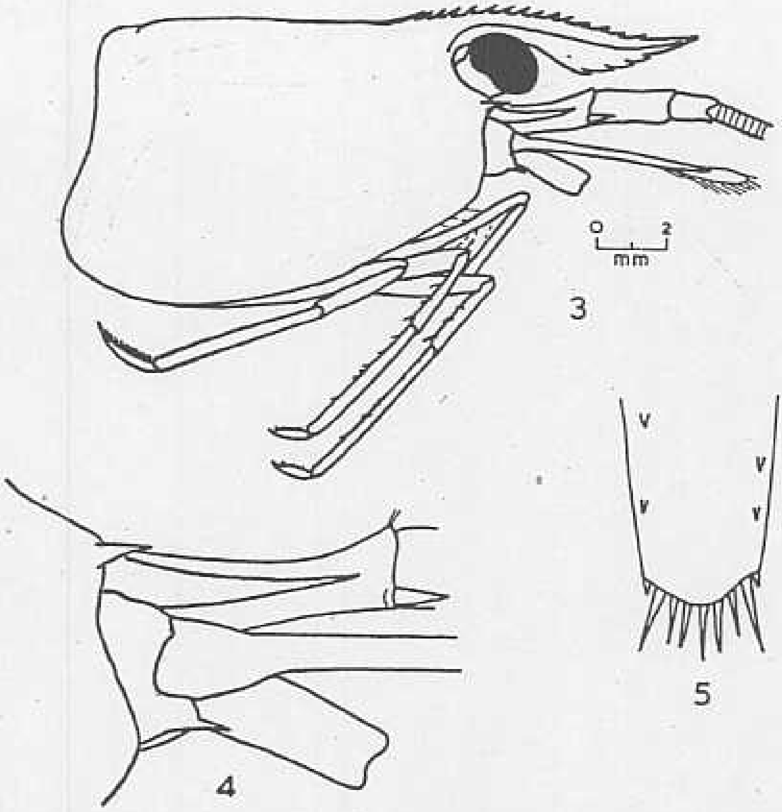
Thus the last of Lanchester's distinctions proves to be untenable. There remain only the additional differences pointed out by Kemp and Bouvier. The majority of these are clearly unimportant. The stoutness of the carpus of the first cheliped has been shown by Woltereck (1937a) to be a very variable character in *C. gracilirostris;* and it cannot be used as a specific criterion. The differences in the detailed armature of the 3rd pereiopod are very small and my specimen proves to be intermediate in this character. The only remaining possible distinctions are, the presence or absence of a pre-anal keel, and Kemp's egg-size criterion. The latter can scarcely be used as more than supplementary evidence in defining the species. If the former difference were both real and clear-cut it would form a valid distinction between the two species. Unfortunately little is known of possible variation in the degree of development of the pre-anal keel in *C. gracilirostris;* the condition in my specimen indicates that divergences from Bouvier's description do occur. Furthermore Bouvier does not refer to this distinction in his text. It seems very odd that he should have omitted such an easy distinguishing character if it really existed. Bouvier's key does contain many errors and oversights; and it is my opinion that his inclusion of *C. gracillima* amongst the species which lack a pre-anal keel is such an oversight. This opinion is strengthened by the fact that neither Lanchester nor Kemp refer to the absence of a pre-anal keel in their specimens of *C. gracillima*. Should such a distinction between the two species be really possible then it is unlikely that they would both have overlooked it.

The form which Blanco (1935) names *C. gracillima* has nothing to do with Lanchester's species. I cannot see any real reason for distinguishing it from *C. modigliani*. It is certainly not *C. gracilirostris*.

There is no other Malayan species with which *C. gracilirostris* can be confused, with the possible exception of long-rostrumed forms of *C. nilotica*. In the latter species the uropodial spines (10–12) and the spines on the comb of pereiopod 5 (50 to 60) are more numerous than they are in *C. gracilirostris*. *C. nilotica* also has the 6th abdominal segment somewhat shorter; and has somewhat longer pereiopods. In most forms of *C. nilotica* the rostrum differs sufficiently from that of any form of *C. gracilirostris* to eliminate any possibility of confusion. From other Malayan species *C. gracilirostris* can be distinguished by: (*a*) its extremely long, upturned, slender rostrum; (*b*) the very pronounced lobe into which the infra-orbital angle is produced (figure 2); and (*c*) the extremely compressed, slender, and graceful body.

Caridina excavatoides sp. nov. (Figures 3 to 11).

Type: An ovigerous ♀, 18·7 mm., from a small, slow, stream running between rubber plantations and rice-fields, about nine miles from Alor Star, Kedah, on the Pokok Sena Road; 5.12.55; collector, D. S. Johnson. ZRC. 1979. 4. 10. 14



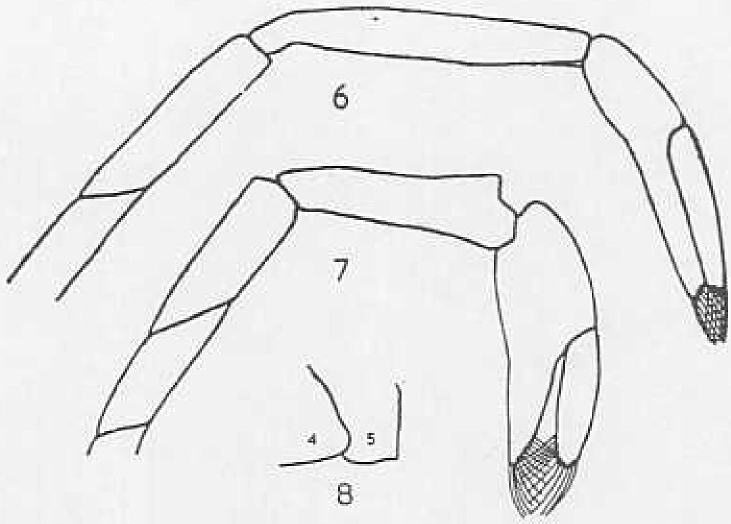
Figs. 3–5. *Caridina excavatoides*. 3, cephalothorax of ♀; 4, base of 1st and 2nd antennae; 5, end of telson.

Other specimens examined: one ovigerous ♀, 17·4 mms. long, from a drainage dyke with clear water, in rice-field country, about eight miles from Alor Star, Kedah, on the Pokok Sena Road; 7.12.55; collector, D. S. Johnson. ZRC. 1979. 4. 10. 15

If the length of the 6th abdominal segment be ignored these specimens will run down in Bouvier's key to *C. excavata* Kemp. Whilst they are very close to that species, the length of this segment, combined with other less obvious characters, makes it necessary to place them in a new species.

Diagnosis: A small species resembling *C. excavata* Kemp in general facies and in epipodite formula; rostrum as long as the antennular peduncle with teeth on both margins and the distal fifth unarmed dorsally, 4 of the dorsal teeth being post-orbital; antennules just less than 2/3rds of the carapace length; telson with 3 or 4 pairs of dorsal spines in addition to the terminal spines; uropodial spines 12 or 13.

Description: The rostrum (figure 3) is approximately as long as the antennular peduncle. The rostral formula is $\frac{15}{4}$, with 4 of the dorsal teeth post-orbital. The terminal fifth of the dorsal margin is toothless, and there is a similar toothless region on the ventral margin. The rostrum is sigmoid with the basal region slightly arched, and the distal region slightly upturned.



Figs. 6–8. *Caridina excavatoides.* 6, 2nd cheliped; 7, 1st cheliped; 8, epimera of abdominal segments 4 and 5.

The infra-orbital angle is distinct from the sub-orbital spine; but it is feebly developed and rounded, having much the same shape as in *C. demani.* The sub-orbital spine is well-developed. The pterygostomial angle is smoothly and broadly rounded, and it does not possess a spine.

The antennules (figure 3) have peduncles which are a little less than 2/3rds of the length of the carapace. The 2nd joint of the antennulary peduncle equals about 2/3rds of the length of the visible portion of the first joint. The third joint is about 1/2 the length of the second. The basal acicle over-reaches the cornea and attains about 2/3rds of the length of the first segment of the antennular peduncle. The terminal spine of this latter segment is just over 1/3rd of the length of the second segment.

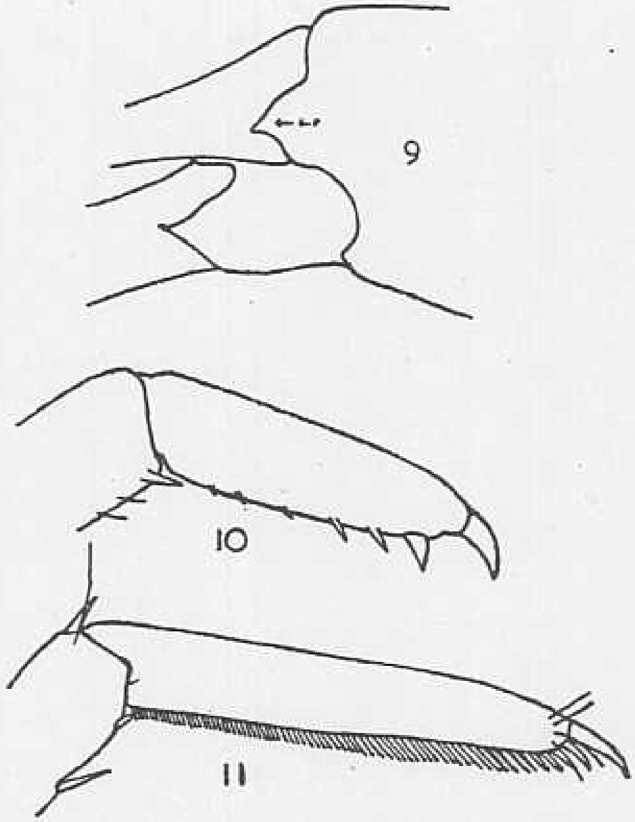
The corneae are rather large; their greatest diameter is approximately equal to the remainder of the short eye-stalk.

The spine of the antennal scale just over-reaches the tip of the antennular peduncle. The scale itself is longer than this peduncle by a length about equal to its third joint. The antennal peduncle reaches approximately to the end of the 1st joint of the antennular peduncle. The ventral antero-external angle of the antennal peduncle is produced into a pronounced acute point (figure 4).

The first chelipeds (figure 6) are rather slender and little specialized. The chela is a little less than 3 times as long as broad. The carpus is slightly shorter than the chela, and about 3 times as long as broad. Its distal margin is excavated but the excavation is small and shallow. The fingers are a little longer than the palm.

The second chelipeds have the chela a little more than 4 times as long as broad. The fingers are distinctly longer than the palm. The slender carpus is about 7 times as long as broad, and is a little more than 1/8th as long again as the chela.

The walking-legs are long and slender. The propodus of the third pereiopod is about 2/5ths of the length of the carapace, and about 3·75 times as long as the dactylus. The dactyli of pereiopods 3 and 4 bear 6 to 8 spines (figure 10), of which the most distal is longer and more prominent than the rest. These appendages are completely devoid of epipodites.



Figs. 9–11. *Caridina excavatoides*. 9, end of abdomen and base of uropod; 10, dactylus of 3rd pereiopod; 11, dactylus of 5th pereiopod.

The propodus of pereiopod 5 is about ½ as long as the carapace. It is about 3 times as long as the dactylus. The comb of the dactylus consists of about 60 spines (figure 11).

The epimerite of the 4th abdominal segment is broadly rounded. That of segment 5 is sub-acute (figure 8). The lateral process of the 6th abdominal segment is mucronate (figure 9, L.P.). There is no pre-anal keel. The ratio $\frac{6\,sa}{c} = \cdot 50$ in the type and ·61 in the other specimen.

The telson is about $1\frac{1}{4}$ times as long as the 6th abdominal segment. In both specimens there are 3 dorsal spines on one side and 4 on the other (in addition to the terminal spines). The posterior margin of the telson (figure 5) is strongly convex. One specimen bears 3 pairs of terminal setae. In the other specimen there is in addition a median seta. In both specimens the outermost setae are much longer and stouter than the others.

The uropods are about $1\frac{1}{3}$ times as long as the telson, the exopod being somewhat longer than the endopod. There are 12 or 13 uropodial spines. The posterior angle of the basal segment of the uropod (the uropodial angle) ends in a short acute point (figure 9). Its dorsal margin is very slightly sinuous, being concave distally.

The eggs are of moderate size, being approximately ·78 mm. × ·48 mm.

Affinities: C. excavatoides resembles *C. excavata* Kemp. in most features including: the nature of the epipodial apparatus; the character of the 1st chelipeds; the general characters of the antennae and antennules; and the shape of the anterior border of the carapace. The principal differences between the two species are tabulated below.

C. excavata	*C. excavatoides*
Rostrum markedly upturned distally; distal half of the upper margin unarmed.	Rostrum slightly upturned distally; only the distal fifth of the upper margin unarmed.
Rostral formula $\frac{9-16}{2-8}$ of which 1 to 3 are post-orbital.	Rostral formula $\frac{15}{4}$ of which 4 are post-orbital.
$\frac{pa\ 1}{c}$ = ·72.	$\frac{pa\ 1}{c}$ = ·63 to ·64.
Spine of antennal scale reaching well beyond the end of the antennular peduncle.	Spine of antennal scale only just over-reaching the antennular peduncle.
$\frac{6sa}{c}$ = ·66 or slightly more.	$\frac{6sa}{c}$ = ·50 & ·61.
Carpus of 2nd chelipeds equal to chela; only times as long as broad.	Carpus of 2nd chelipeds 1/8th as long again as the chela; about 7 times as long as broad.
$\frac{pr.p3}{c}$ = ·42.	$\frac{pr.p3}{c}$ = ·39 to ·45.
$\frac{d}{pr}$. p3 = about ·33.	$\frac{d}{pr}$. p3 = ·29.
$\frac{pr.p5}{c}$ = ·55.	$\frac{pr.p5}{c}$ = ·50.
$\frac{d}{pr}$. p5 = about ·33.	$\frac{d}{pr}$. p5 = about ·33.
Spines on dactylus of p5 = 40 to 50.	Spines on dactylus of p5 = 60.
Telson with 2 pairs of dorsal spines.	Telson with 3 or 4 pairs of dorsal spines.
Uropodials 7 to 8 (?).	Uropodials 12 to 13.
Telson with 4 pairs of terminal setae.	Telson with 3 pairs of terminal setae and with or without an additional median seta.
Eggs 1 mm. × ·68 mm.	Eggs ·78 × ·48 mm.
Maximum recorded size 25 mm.	Largest individual 18·7 mm.

Thus *C. excavatoides* can be distinguished from *C. excavata* by: (*a*) the different shape of the rostrum; (*b*) the much shorter antennules and 6th abdominal segment; (*c*) the more slender carpus of the 2nd chelipeds; (*d*) the greater number of spines in the comb of the dactylus of pereiopod 5; and (*e*) the greater number of dorsal spines on the telson. The egg-size also appears to be very distinct. The difference in the number of uropodial spines is striking; but there is apparently some doubt as to the true number of uropodials in *C. excavata*.

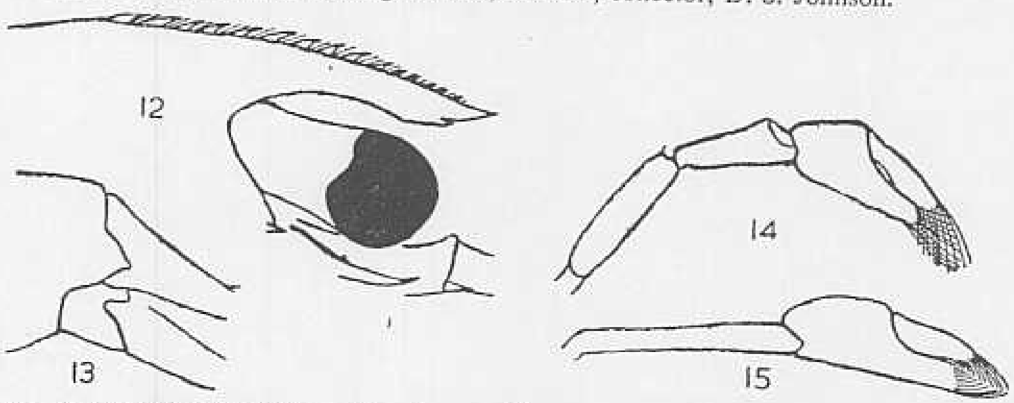
In form and armature of the rostrum *C. excavatoides* bears some resemblance to *C. demani;* which it also resembles in the shape of the anterior border of the carapace, and the relative lengths of the antennular peduncle and antennal scale. *C. demani* differs strikingly from *C. excavatoides* in possessing well-developed epipodites on pereiopods 3 and 4. It has longer antennules. The 6th abdominal segment is longer. The dactyli of the 3rd pereiopods are shorter and bear fewer spines. Bouvier has already noted the resemblance between *C. excavata* and *C. demani*. In several features *C. excavatoides* is intermediate between the two species. It is possible that *C. demani* is derived from the primitive stock which gave rise to *C. excavata* and *C. excavatoides;* but these latter species are considerably more advanced in their epipodial apparatus.

The shape and armature of the rostrum will distinguish *C. excavatoides* from other species known to occur in Malaya. Nevertheless, since *C. demani* may yet be found there, it will always be necessary to check other features, including the degree of development of the epipodites, in order to arrive at a certain identification. Two other Malayan species have a reduced epipodite formula. Of these *C. tonkinensis* has no epipodite on the 2nd pereiopod; has more numerous spines in the comb of the dactylus of the 5th pereiopod; and has more numerous uropodial spines. *C. propinqua* has very different proportions and a very different type of rostrum. It can be readily distinguished by its much longer antennular peduncles and 6th abdominal segment.

Caridina propinqua de Man (Figures 12 to 15).

Synonymy: *C. propinqua* de Man, 1908, 227, pl. XXXIX, fig. 6; Kemp, 1915, 309, and 1918b, 274; Bouvier, 1925, 181, figs. 375 to 381.

Material examined: 18 individuals, 2·2 to 17 mm. long, the two largest ♀♀ of 16½ and 17 mm. ovigerous, and the two largest ♂♂ of 14½ and 15½ mm. with fully developed male pleopods; from a semi-stagnant drainage dyke with clear water at Tenglu, about two miles north of Mersing, Johore; 25.8.55; collector, D. S. Johnson.



Figs. 12–15: *Caridina propinqua*. 12, rostrum and base of 1st antenna; 13, end of abdomen and base of uropod; 14, 1st chelipea; 15, 2nd cheliped.

One non-ovigerous ♀ 12·5 mm. long from the Sungei Seletar at Nee Soon Village, Singapore; 11.11.56; collector, D. S. Johnson.

17 individuals *circa* 8 to 18·3 mm. long, including one ovigerous ♀ 17·8 mm. long, from moderately fast-flowing, peaty, weed free ditches with sandy to gravelly bottom, and with a salinity of 1·5 per thousand, draining coconut plantations at mile 12 Jurong Road, Singapore; 16.1.57; collector, D. S. Johnson.

Two ovigerous ♀♀ 16·2 and 20·3 mm. long and 2 non-ovigerous ♀♀ 19·5 and 21·9 mm. long, from pools in mangrove swamp above level of high water neap tides, at mile 3 Jalan Scudai, Johore Bahru; 7.2.57; collector, E. R. Alfred. According to the collector the water was brackish and the species was abundant.

13 individuals 11·2 to 20·3 mm. long including 2 ovigerous ♀♀ of 16·4 and 20·3 mm., the largest ♂ being 18·5 mm. long, from a fast-flowing tidal stream draining into the Sungei Scudai at the 11th mile Johore Bahru-Scudai Road; 9.2.57; collector, E. R. Alfred; according to the collector the locality was not brackish at the time the collection was made; the species was abundant.

Systematic notes: These specimens agree in all essentials with *C. propinqua* but show a few minor variations amongst themselves.

The rostrum shows considerable variation in relative length; and is proportionally shorter on the average in smaller individuals. Thus in the Mersing specimens (figure 12) it is noticeably short, in some individuals only attaining the end of the first segment of the antennular peduncle, and in most failing to reach beyond the middle of the second segment. On the other hand the largest Malayan individuals agree with the typical form in possessing a rostrum which reaches to or beyond the end of the second segment of the antennular peduncle. In all my specimens the dorsal margin of the rostrum is armed almost to the tip, agreeing in this feature with de Man's specimens, but not with those of Bouvier. The number of dorsal teeth varies from 13 to 29 but the highest numbers are rare. Only 2 specimens have more than 22 dorsal teeth and both of these show evidence that individual teeth have been reduplicated. In all save one specimen the teeth of the ventral margin are 0 to 3 in number. This single specimen, from Johore Bahru, has 4 teeth and a rudiment of a fifth.

The form and proportions of the first cheliped agree with Bouvier's description save that the ischium and merus are almost equal in length. In the Mersing specimens the chela is rather long, being about 1·5 times the length of the carpus. The other specimens agree with Bouvier's description in having the chela about 1·3 times the length of the carpus.

In my specimens $\frac{pr.p3}{c}$ varies from ·38 to ·52, so that the propodus of this limb is often longer than is suggested by Bouvier's simple ratio of·39. Similarly the ratio $\frac{pr.p5}{c}$ varies from ·50 to ·65, so that in most individuals the propodus of the 5th pereiopod is distinctly longer than is implied by Bouvier's ratio of ·50.

The relative lengths of dactylus and propodus of pereiopod 3 are somewhat more variable than is implied by the published descriptions. The propodus varies from 2·4 to 3·8 times the length of the dactylus. The total range in relative length of these two segments in the 5th pereiopod covers almost the same range (propodus 2·5 to 3·8 times the length of the dactylus) though in any one individual the ratios shown by legs 3 and 5 may be very different. For this ratio Bouvier gives 2·7 and de Man 2·38. Thus the dactylus is relatively shorter in most Malayan specimens than it is in those specimens previously described.

According to de Man the dactylus of pereiopod 3 is armed with 4 to 6 spines. In my specimens there are 3 to 6 spines, though most individuals have 4 spines. In my specimens the number of spines in the comb of pereiopod 5 may be as low as 40 and thus distinctly less than the figure of 50 given by de Man.

My specimens agree with those of Bouvier in having 3 pairs of dorsal spines on the telson in addition to the terminal spines; but in a few individuals there are only 2 such pairs (as given by de Man), or as many as 4 such pairs. One anomalous specimen has 4 spines on one side of the telson and 5 on the other.

The setation of the posterior margin of the telson agrees essentially with Bouvier's account but there may be as many as 11 terminal setae. The smallest number of setae (7) is the commonest.

The following additional data will help to characterize the Malayan population:—

$\frac{pal}{c}$ = ·78 to 1·0, the ratio tending to be larger in the males;

$\frac{6sa}{c}$ = ·68 to ·82 (exceptionally ·64);

Uropodial spines = 13 to 16.

Eggs = ·54 × ·36 mm.

Though very variable this small and slender species is easily recognized. It can be distinguished from other species by: (*a*) its small size; (*b*) the form of the rostrum; (*c*) the long antennular peduncles and 6th abdominal segment; (*d*) the rather primitive first chelipeds; (*e*) the reduced epipodite formula; and (*f*) the armature of the dactyli of pereiopod 5.

Distribution and Ecology: This species has previously been known from a number of localities scattered around the northern end of the Bay of Bengal and the Ganges Delta area, from Lake Chilka to Chittagong. It has also been found in abundance in the Tale Sap, and in the Patani River near the town of Patani, both localities being in Peninsular Thailand (Kemp 1918). The species appears to be characteristic of low salinity brackish waters though it has been recorded from freshwaters. The records indicate that such freshwater habitats are normally in close proximity to extensive brackish water areas.

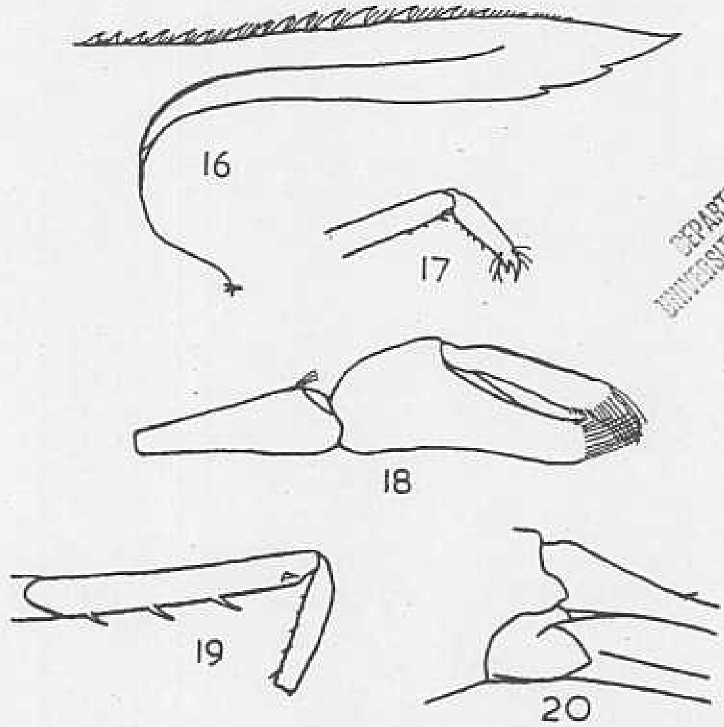
The habitats in which *C. propinqua* occurs in Malaya correspond with those recorded in the literature. All are in flat country near the sea, and two are distinctly brackish. A third may well be brackish at high tide, though the water was fresh at the time the specimens were collected. The two remaining habitats are permanently fresh. Of these the Sungei Seletar at Nee Soon is in open connection with nearby brackish waters and its fauna and flora show a strange mixture of freshwater and brackish-water elements. Amongst the latter the presence of an errant polychaete and of *Oryzias javanicus* is particularly noteworthy. The Tenglu habitat shows no obvious brackish indications but it lies sufficiently close to the sea to have rendered a salinity determination worthwhile. The habitat is highly calcareous having an alkalinity of 178 pts CaCO3 per million. It is well known that high alkalinity often favours the spread of otherwise brackish water organisms into freshwater, and this appears to be a further instance of the phenomenon.

Caridina tonkinensis Bouvier (Figures 16 to 20)

Synonymy: *C. tonkinensis* Bouvier, 1919, 331; 1925, 223, figs. 494–496.

Material examined: 4 ovigerous ♀♀, 18·0 to 19·0 mm. long from the Sungei Seletar at Nee Soon Village, Singapore; 11.11.56; collector, D. S. Johnson.

Systematic notes: These specimens agree closely with Bouvier's description of *C. tonkinensis;* but show some differences in details. In my specimens the rostrum only reaches to 1/3rd or 1/2 the length of the 2nd antennular segment, whereas in Bouvier's specimens it overreaches this segment. In my specimens the rostrum is only very slightly upturned at the tip, much less so than it is in Bouvier's figure. The unarmed region is very short or absent in my specimens. Their rostral formula is $\frac{15\text{–}20}{1\text{–}2}$ with 3 to 5 of the dorsal teeth post-orbital. Bouvier gives a rostral formula of $\frac{14}{2}$ with 3 of the dorsal teeth post-orbital. In view of the small number of specimens involved this difference is of no importance.



Figs. 16–20. *Caridina tonkinensis.* 16, rostrum; 17, dactylus of 3rd pereiopod; 18, 1st cheliped; 19, merus of 3rd pereiopod; 20, end of abdomen and base of uropod.

The antennules appear to be a little shorter in my specimens than they are in Bouvier's specimens, being only ·69 to ·70 of the carapace length as a opposed to ·72 of the carapace length. In my specimens the spine of the antennal scale slightly exceeds the antennular peduncle rather than being somewhat shorter than this peduncle.

Bouvier states that the infra-orbital spine is 'nette'. However, this spine is not very conspicuous in his figure; and in my specimens it is small, and, though always present, it may be overlooked on casual examination.

The chelipeds (figure 18) of my specimens agree with Bouvier's figure; but they do not entirely agree with his description. According to Bouvier the carpus of the cheliped is not emarginate terminally. This is true of the external margin but the internal margin is slightly but distinctly emarginate. Indeed the form of this region of the carpus is almost identical with that of the same region of the carpus in *C. propinqua*. In his key Bouvier states that this carpus is about 4 times as long as broad, whereas in his text he merely states that the carpus is at least 3 times as long as broad. His figure shows a carpus 3·8 times as long as broad. These discrepancies are somewhat surprising in view of the fact that Bouvier's account was based on only two specimens. In my specimens the carpus varies from 3·2 to 3·4 times as long as broad. Owing to the discrepancies in Bouvier's account it is impossible to be certain that this joint is stouter in the Singapore specimens than it is in the Tonkin specimens; but this seems to be probable.

The propodus of the 3rd pereiopod agrees reasonably well with Bouvier's account; in my specimens the ratios $\frac{pr.p3}{c}$ and $\frac{pr.p3}{d}$ are ·42 to ·43 and ·30 to ·34 respectively. Bouvier gives ·44 and ·29. The propodus of the 5th pereiopod appears to be slightly shorter in my specimen, but the ratio in length of dactylus and propodus is the same as in Bouvier's specimens. The ratios for my specimens are ·50 to ·53 and ·32 to ·35 respectively; for Bouvier's specimens they are: ·55 and ·35. I can only detect 6 or 7 spines on the dactylus of the 3rd. pereiopods; not 10 or 11 as found by Bouvier.

Bouvier states that the posterior margin of the telson is armed with 4 or 5 pairs of setae of which the median or the 2 median are much shorter than the others. In my specimens I find 3 or 4 such pairs with or without a median seta, and with the median pair or 2 median pairs much shorter than the others.

Most of the apparent differences between my specimens and Bouvier's specimens probably stem from the difficulty of defining species characteristics on the basis of a few specimens. Others, such as the length of the rostrum, the armature of the dactyli of the 3rd pereiopods, and the length of the propodus of the 5th pereiopods may represent true differences between the local populations. These differences do not appear to be sufficient to justify the setting up of a new variety.

Affinities: Bouvier tentatively places *C. tonkinensis* in the *C. brevirostris* group, whilst suggesting that it has evolved independently from primitive members of the genus. This conclusion seems to be unjustified. In my opinion the affinities of *C. tonkinensis* are best expressed by placing it in association with such forms as *C. propinqua*. The extreme reduction of the epipodites in *C. tonkinensis* places it apart from these species, and indeed from all other species of the genus with the exception of *C. sarasinorum*. I agree with Bouvier in considering that *C. tonkinensis* has no close affinity with the latter species. The condition of the epipodites in *C. tonkinensis* is only an extreme expression of a tendency shown by most members of the *C. propinqua*–*C. laevis* series; and I can find nothing in the general characters of *C. tonkinensis* which would prevent it being included in that series.

The extreme reduction of the epipodites at once distinguishes *C. tonkinensis* from all other Malayan members of the genus. In other respects the species shows a rather close similarity to *C. propinqua*. *C. tonkinensis* can be distinguished from that species by: (*a*) its distinctly shorter 1st antennae and 6th abdominal segment; (*b*) the larger number of spines in the comb of the dactylus of the 5th pereiopod (about 80); (*c*) its generally stouter appearance; and (*d*) the detailed form and armature of the merus of the 3rd pereiopod (figure 19).

Distribution: This species has only been recorded previously from Tonkin where two females were obtained. Bouvier gives no details of the exact nature of the habitat. The Singapore specimens were associated with *C. propinqua* and *C. gracilirostris*. It is of interest that all six known specimens are females.

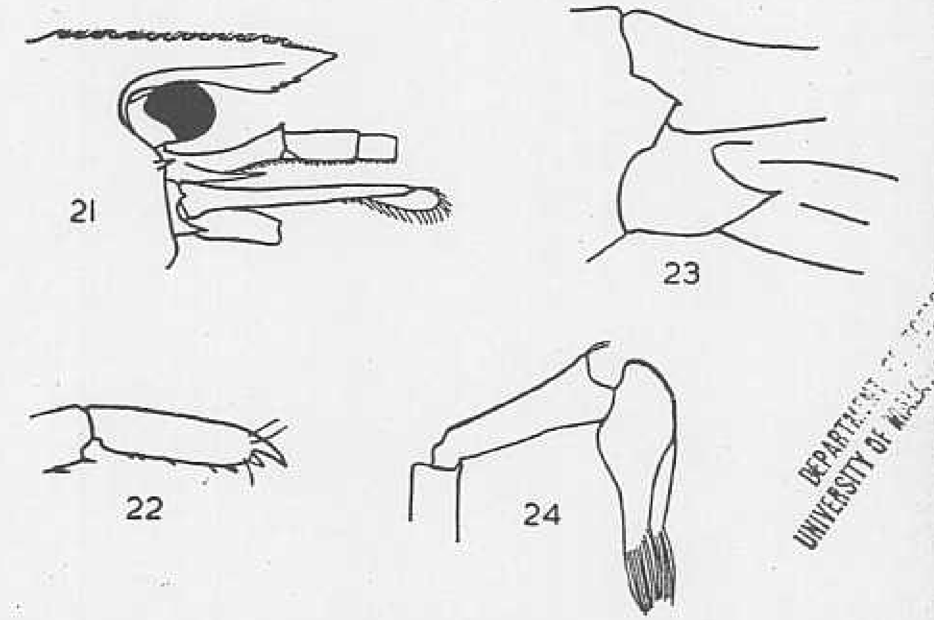
Caridina cf. **babaulti** Bouvier (Figures 21 to 24).

Synonymy: cf. *C. babaulti* Bouvier, 1918, 388, figs. 4, 5, & 6 and 1925, 231, figs. 524 to 552.

Material examined: 1 ovigerous female, length 16·9 mm. and 1 non-ovigerous ♀ (damaged), from a rather fast stream flowing out of Ayer Keroh Reservoir, Malacca; 6.1.56; collector, D. S. Johnson.

Systematic notes: Both specimens were slightly damaged in collection. In almost all features they agree with *C. babaulti* or approach it very closely; but the carpus of the 1st chelipeds is much more slender than in the typical form of that species; the rostrum is shorter; and there are some other more minor differences. Since *C. babaulti* is so far only known from Central India, it is probable that my specimens are at least sub-specifically distinct but since my material is somewhat unsatisfactory I prefer to treat them as an un-named variety.

The rostrum (figure 21) shows much the same form as in Bouvier's figure 525; but it is shorter, only just reaching to the end of the 2nd segment of the antennulary peduncle. The form and armature of the anterior margin of the carapace agrees with those specimens of *C. babaulti* which lack a pterygostomian spine. The antennules and antennae agree in almost all features with those of *C. babaulti;* but the antennular peduncle averages slightly shorter (in my specimens $\frac{\text{pal}}{\text{c}}$ ·54 to ·58 as opposed to Bouvier's figures of ·56 to ·63). In my specimens the general form of the carapace is comparable to that of *C. brevirostris* Stimpson. Bouvier does not describe the general carapace form in *C. babaulti* but since he considers *C. babaulti* and *C. brevirostris* to be closely allied it seems probable that the carapace is similar in form in these two species.



Figs. 21–24. *Caridina* cf. *babaulti*. 21, rostrum and anterior appendages; 22, dactylus of 3rd pereiopod; 23, end of abdomen and base of uropod; 24, 1st cheliped.

The 1st chelipeds (figure 24) of my specimens differ considerably from those of typical *C. babaulti*. The carpus is strongly excavated, but is much less so, especially externally, than it is in the typical form. This joint is about 2·8 times as long as broad. It is thus very much more slender than it is in typical *C. babaulti*, where it is only about 1·5 times as long as broad. The carpus shows comparable variation in the allied species *C. brevirostris*, so that this large apparent difference is less important than it appears to be at first sight. The chela in my specimens is 1·2 times as long as the carpus and 2·4 to 2·7 times as long as broad. The figures are about 1·2 times as long as the palm. Bouvier states that in the typical form the palm is almost as long as the fingers.

Bouvier describes the carpus of the 2nd chelipeds as being 'grele' and as long as, or ordinarily longer than, the chela. In my specimens this carpus is slender, being 6·3 times as long as broad, and it is from 1·1 to 1·2 times as long as the chela. According to Bouvier the palmar portion of this chela is much shorter than the fingers. This is not true in my specimens, where the proportions of the palm to the fingers are almost identical with those found in the first cheliped.

In my specimens the propodus of the 3rd pereiopod averages slightly longer than that of the typical form ($\frac{pr.p3}{c}$ = ·40 to ·45 as opposed to ·36 to ·42). The dactylus in my specimens agrees in relative length with that of the male of the typical form; but it is relatively much longer than in the female of the typical form ($\frac{d}{pr.}$.p3 = ·31 to ·34 as opposed to ·25 for females and ·31 for males).

I can only find 6 spines on the dactylus of pereiopod 3 (figure 22), whereas Bouvier records 7 or 8 spines; but in other respects the armature of the dactyli of the walking-legs agrees with Bouvier's description. The epimera of the abdominal segments are essentially as in Bouvier's description. The length of the 6th abdominal segment falls well within the range given by Bouvier ($\frac{6sa}{c}$ = ·40 to ·48 compared with ·43 to ·55).

The characters of the telson and the uropods, including the number of uropodial spines (15), and the shape of the basal angle of the uropods (figure 23) agree in general with Bouvier's description. However, there are only 3 pairs of dorsal spines on the telson, not 4 or 5, and there is a median seta in addition to the 3 pairs of paired setae on the posterior margin of the telson.

This is a small species comparable in size and general build to *C. propinqua*, but definitely stouter than that species. The characteristic rostrum; the form of the dactyli of the 3rd pereiopods; the deep carapace; the form of the uropodial angle, and the presence of a complete series of epipodites should readily distinguish this species from other Malayan species.

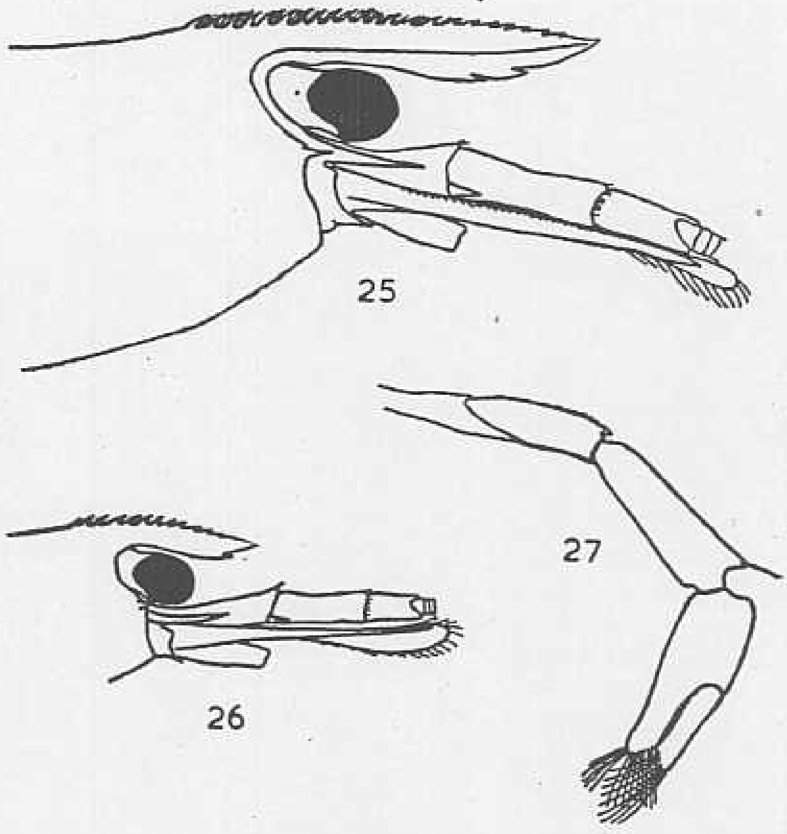
Distribution: C. babaulti is only known from central India. Thus if these specimens really belong to the same species they represent a great extension to its known range.

This is the only species of the genus which I have found in permanently fast-flowing streams. *C. propinqua* may sometimes occur in streams which are fast-flowing at certain states of the tide; but the other Malayan species are inhabitants of still or very slowly-flowing waters.

Caridina thambipillaii* sp nov. (Figures 25 to 35).

Type: a ♂ 18 mm. long: *Allotype:* a ♀ 27·8 mm. long: both specimens from the Sungei Putat near the pumping Station, Malacca; 6.1.56; collector, D. S. Johnson.

Other specimens examined: One non-ovigerous ♀ and 1 ♂ 15·9 mm. and 15·5 mm. from the same collection.



Figs. 25–27. *Caridina thambipillaii.* anterior portion of carapace and anterior appendages of (25) ♀ allotype and (26) small ♂ from Muar; 27, 1st cheliped, ♀ from Muar.

Two ovigerous ♀ ♀ 23·7 mm. and 22·7 mm. long, one non-ovigerous ♀ 11·3 mm. long, and two ♂ ♂ 11·0 and 13·8 mm. long from a brackish ditch crossing the Muar-Batu Pahat Road about 4 miles S. of Muar; 29.9.55; collector, D. S. Johnson.

Diagnosis: A *Caridina* of the *C. laevis* group with the epipodial apparatus completely developed. The sexes differ considerably in details of limb and segment proportions. The rostrum is shorter than the antennular peduncle. The antennules are long, from ·61 to ·75 of the carapace length in females, and from ·83 to ·98 in males. The

* This species is named in honour of Dr. S. Thambipillai of Malacca, and in appreciation for his hospitality and assistance during my visits to Malacca.

6th abdominal segment is of moderate length from ·47 to ·53 of the carapace length in the females, and ·58 to ·62 in males. The dactylus of the 5th pereiopod varies between ·25 and ·40 of the length of the propodus, and its comb bears about 80 spines. The dactylus of the 3rd pereiopod has the last tooth much larger than the rest. The uropodial angle is concave dorsally.

Description: The carapace is rather slender. The rostrum is much shorter than the antennular peduncle. It may fail to reach the end of the first joint of this peduncle (figure 26); but normally exceeds this joint, and may attain the distal margin of the 2nd joint (figure 25). The rostrum is normally directed straight forwards, with or without a very slight upturning at the tip (figure 25); but in one small male from Muar (figure 26) the whole rostrum is markedly deflexed. The rostral formula is $\frac{14\text{–}21}{1\text{–}4}$ with 3 or 4 of the dorsal teeth posterior to the orbit. The number of rostral teeth is greatest in the larger individuals.

The orbital margin is rather deeply excavated. The infra-orbital angle is feebly developed and rounded. There is a strong sub-orbital spine (figure 25). The pterygostominal angle is almost a right angle, and scarcely rounded; but it does not bear a spine.

When compared with the carapace length the 1st antennae are relatively longer in the male than they are in the female (see diagnosis). They are thus very long in the male and moderately long to long in the female. The 1st segment is 1·1 to 1·2 times as long as the second; and the 2nd segment is 1·3 to 1·4 times as long as the third. The basal acicle reaches far beyond the eyes; but it only attains to 2/3rds or 3/4 of the length of the first segment (figures 25 and 26). The terminal spine of the first antennular segment equals or slightly exceeds 1/3rd of the length of the second segment.

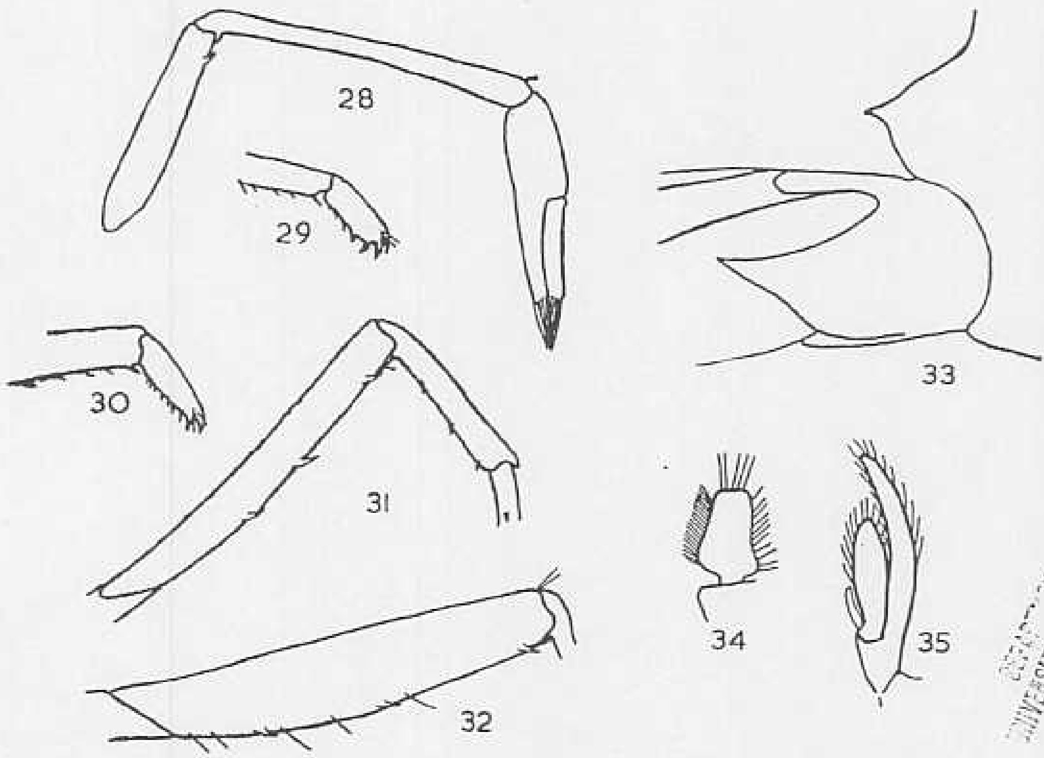
The distal ventral corner of the basal segment of the 2nd antenna is prolonged into a long spiniform projection. The spine of the antennal scale just over-reaches the peduncle of the 1st antennae; and is itself considerably over-reached by the scale proper. The peduncle of the 2nd antenna is slightly longer than the 1st segment of the peduncle of the 1st antenna.

The 3rd maxillipedes closely resemble those of *C. mertoni*. The number of spines on the terminal segment increases with increasing size of the individual. In the smaller individuals it is 6 increasing to about 10 in the largest individuals.

The carpus of the 1st cheliped is moderately slender, being from 2·2 to 3·0 times as long as broad. Distally it is distinctly excavated both internally and externally; but the excavation is rather shallow (figure 27). The chela is about 1/3rd longer than the carpus. It is about 2·5 to 3·0 times as long as broad. The fingers are slightly longer than the palm (from 1·1 to 1·3 times as long). The ischiopodite is almost as long as the meropodite.

In the 2nd chelipeds (figure 28) the carpus is very long and slender being some 11 times as long as broad. The chela is only about ·82 to ·86 of the length of the carpus. The merus is distinctly shorter than the carpus. It bears a strong spine near its distal ventral corner. The ischium is nearly as long as the merus.

As compared with the carapace the 3rd pereiopods are slightly longer in the male than they are in the female, though the measurements for the two sexes overlap. These pereiopods are also distinctly stouter in the male. In the female the merus is about 8·5 times as long as broad whilst it is only about 5·4 times as long as broad in the largest male (figures 31 and 32). In the female the propodus varies from ·39 to ·48 of the carapace length, whilst in the male it varies from ·45 to ·52. The ratio $\frac{d}{pr}$.p3 differs in the two series of specimens. In the Sungei Putat series this ratio is about 1/4 in the females but only 1/5 or slightly less in the males. In the Muar series the same ratio varies from just under 1/5th to just over 1/4 in the females, and from 1/4 to 3/10 in the males. In general the dactyli can be described as of moderate length. The dactyli of the two sexes differ in shape (figures 29 and 30) these differences paralleling those found in *C. denticulata*. In the female the dactylus is rather slender and tapering. The last ventral spine is much larger than the rest; but it is less broad at its base than the terminal claw. The remaining spines increase regularly in length distally. In the male the dactylus is broader and does not taper. The most distal spine is very large and considerably larger than the terminal claw. This feature is very rare in the family Atyidae and apparently unique in the genus Caridina. The two next most distal spines are also large and stout, though much less so than the most distal spine. The remaining spines are small and slender.



Figs. 28–35. *Caridina thambipillaii*. 28, 2nd cheliped of ♂ type; dactylus of 3rd pereiopod of (29) ♂ type and (30) ♀ allotype; merus and carpus of 3rd pereiopod of (31) ♀ allotype and (32) ♂ type; 33, base of uropod, ♀ allotype; endopodite of (34) 1st pleopod and (35) 2nd pleopod of ♂ type.

The 5th pereiopod is considerably longer than the 3rd. It is longer in the male than in the female, when compared with the carapace length. In the female the ratio $\frac{pr.p.5}{c}$ is ·50 to ·61, whilst in the male it is ·64 to ·68. In the specimens from Sungei Putat the dactylus is about 1/4 the length of the propodus; but in the specimens from Muar the dactyli are longer, from 1/3rd to 2/5ths of the length of the propodus. The number of spines in the dactylar comb is very large (about 70 to 85), and higher than in any other species of the genus with the exception of *C. laevis* Heller. As a consequence these spines are very fine and closely set.

The epimerites of abdominal segments 4 and 5 are rounded posteriorly. The lateral process of the 6th abdominal segment is mucronate. This segment is moderately long. When compared with the carapace it is distinctly longer in the male than it is in the female (see diagnosis). There is a well-developed pre-anal keel.

The uropods are longer than the telson, and the exopod is longer than the endopod. The uropodial angle is acute, with its dorsal margin concave and its ventral margin markedly sinuous (figure 33). In all save the smallest male the number of uropodial spines is high (16 to 19).

The telson bears 3 or 4 pairs of dorsal spines in addition to the terminal spines. In most of the specimens there are 6 terminal setae which are all long and sub-equal, the outermost setae being slightly longer than the rest. The largest male from Muar has 7 terminal setae; and the two largest females from that locality have 8 and 9 such setae respectively. In these individuals the extra setae are medianly placed and distinctly shorter and more slender than the rest.

The endopodite of the 1st pleopod of the male (figure 34) is broadly trapezoidal, and bears setae all along its free margins. There is no terminal prolongation. The *appendix masculina* of the 2nd pleopod is large, oval and setose (figure 35). It is about half the length of the main branch of the endopodite, and about 2½ times as long as the *appendix interna*.

The eggs are small (·39 × ·26 mm.).

In the above description I have followed the standard practice of using the carapace length as base line for comparative measurements. In discussing *Atya spinipes* (page 145) I shall show that this measurement may not be a satisfactory basis for comparison in that species. I have not sufficient material of *C. thambipillaii* to test the adequacy of carapace length as reference datum in the present species. Nevertheless the consistency with which very diverse structures appear to be comparatively longer in the male than they are in the female, when carapace length is used as comparison base, raises strong doubts as to its validity for this purpose. Unfortunately the only, readily available, alternative basis for comparison, the overall length, cannot easily be measured accurately in the present species. Thus carapace length must be retained as the standard for practical purposes, though from a theoretical standpoint overall length would be a preferable basis for comparisons.

Discussion: This species belongs to the group of forms centering around *C. laevis* Heller; but I cannot identify it with any previously described species. It is also noteworthy that *C. thambipillaii* shows some resemblance to *C. denticulata* de Haan. De Man (1908, p. 227) considered that *C. denticulata* and *C. laevis* were very closely allied; but Bouvier does not accept this view and treats *C. denticulata* as a close ally of

C. babaulti. It is thus of interest that *C. thambipillaii* whilst clearly a member of the *C. laevis* group does resemble *C. denticulata* in several rather striking features. The pronounced sexual dimorphism is particularly noteworthy. This is somewhat unusual in the genus and follows an almost identical pattern in *C. thambipillaii* as it does in *C. denticulata*.

Nevertheless these two species differ in many important features including: the length of the antennular peduncle and 6th abdominal segment; both of which are much shorter in *C. denticulata* than they are in *C. thambipillaii;* the number of teeth in the comb of the dactylus of pereiopod 5 (only 50–60 in *C. denticulata*); and the nature of the male pleopods, which are very unusual in *C. denticulata*.

In general features *C. thambipillaii* comes much closer to *C. laevis* Heller. That species is distinguished at once by the degree of epipodite reduction. The 6th abdominal segment is longer in *C. laevis* ($\frac{6sa}{c}$ = ·67); the spines on the comb of the dactylus of pereiopod 5 (90–100) are even more numerous; and the uropodials are fewer in number (9 to 13).

Of the other species in the *C. laevis* group, *C. thambipillaii* is most closely allied to *C. mertoni* Roux, to which species it runs down in Bouvier's key. *C. mertoni*, which is known from the Kei Islands, is one of a small group of apparently related species, including *C. timorensis* de Man and *C. vitiensis* Borradaille, which have a restricted insular distribution. In my opinion *C. thambipillaii* is a further member of this group. Whilst *C. thambipillaii* most closely resembles *C. mertoni*, in some features it more nearly approaches *C. timorensis* or *C. vitiensis*, whilst in other features it differs from all three of these species.

The rostrum agrees essentially with that of *C. mertoni* but has somewhat fewer teeth on the average (*C. mertoni* has $\frac{17\text{–}27}{3\text{–}5}$). The carapace form, and especially the form of the orbit, is almost identical in the two species. Bouvier only gives the length of the antennular peduncle for males of *C. mertoni;* this agrees with that which I have found in the same sex in *C. thambipillaii*. In *C. thambipillaii* the first segment of the antennular peduncle is relatively slightly shorter than it is in *C. mertoni* where it is 1·5 times as long as the 2nd segment.

In *C. thambipillaii* the carpus of the 1st cheliped is distinctly more slender than that of *C. mertoni* (2·3 to 2·8 times as long as broad as compared with twice as long as broad), agreeing in this respect with *C. vitiensis*. The general form of this carpus is also very similar to that of *C. vitiensis*. In *C. mertoni* the ischium of this appendage is much shorter than the merus, whereas in *C. thambipillaii* these two segments are almost equal in length.

The 2nd chelipeds of *C. thambipillaii* agree well with those of *C. mertoni;* but again the ischium is nearly as long as the merus, not much shorter than this segment.

It is somewhat difficult to compare the 3rd pereiopods of my species with those of *C. mertoni* and its allies owing to inadequacies in the descriptions of these species. *C. vitiensis* is only known from a single damaged specimen. Bouvier's account of *C. timorensis* is based on the female only; whilst he only examined the male of *C. mertoni*. Whilst neither de Man (for *C. timorensis*) nor Roux (for *C. mertoni*) mention the occurrence of sexual dimorphism in this appendage, it is nevertheless possible that such dimorphism exists. In the length of the propodus *C. thambipillaii* appears to be intermediate between *C. timorensis* ($\frac{pr.p3}{c}$ = ·26) and *C. mertoni* ($\frac{pr.p3}{c}$ = ·52 in the male); but it is distinctly closer to *C. mertoni*. In the relative length of dactylus and propodus *C. thambipillaii* males agree with *C. mertoni*, males, as also with Roux's figures (? for both sexes); but the females show a ratio approaching that given for *C. timorensis*. In the general spination of this limb *C. thambipillaii* agrees with *C. mertoni*.

In *C. thambipillaii* the propodus of pereiopod 5 is slightly shorter than it is in the males of *C. mertoni;* but the difference is not very large. The dactylus is relatively much longer ($\frac{d}{pr}$p5 = ·25 to ·40) than in *C. mertoni* ($\frac{d}{pr}$.p5 = ·18 to ·20). In this feature *C. thambipillaii* agrees better with *C. timorensis* ($\frac{d}{pr}$.p5 = ·33). In *C. thambipillaii* the spines of the comb on the dactylus of leg 5 are much more numerous than in either *C. mertoni* (30 to 35) or *C. timorensis* (45).

Unfortunately Bouvier's description of the number of uropodial spines in *C. mertoni* contains an obvious error. Thus an exact comparison with my species is impossible. Bouvier does state, however, that the uropodial spines of *C. mertoni* are more numerous than those of *C. vitiensis*. Thus in this feature *C. mertoni* would appear to be closer to my species than are either *C. vitiensis* (11 uropodials) or *C. timorensis* (only 9 uropodials).

The endopodite of the 1st pleopod of the male of *C. thambipillaii* completely lacks the attenuated distal portion found in *C. mertoni*. This difference is in itself sufficient to establish that these two species are really distinct.

The uropodial angle of *C. thambipillaii* is quite different in form from those of *C. mertoni* and *C. timorensis*, in both of which species this angle is scarcely pointed, and has the dorsal margin convex. In *C. vitiensis* the uropodial angle is closer to that of *C. thambipillaii;* but it has a sinuous rather than concave dorsal margin. Indeed in this feature, as also in the number of uropodial spines, *C. thambipillaii* resembles *C. denticulata* more closely than it does the members of the *C. mertoni* assemblage.

In the totality of its features *C. thambipillaii* most closely approaches *C. mertoni;* but it should be readily distinguishable from that species by: (*a*) the more slender carpus of the 1st cheliped; (*b*) the longer dactyli and much more numerous dactylar spines of the 5th pereiopod; (*c*) the entirely different uropodial angle; and (*d*) the different form of the 1st male pleopod. The resemblances which *C. thambipillaii* shows to *C. denticulata* may be fortuitous; but they are worthy of note in view of Kubo's attempt to establish a new genus *Neocaridina* for *C. denticulata* and species which he considers to be allied to it.

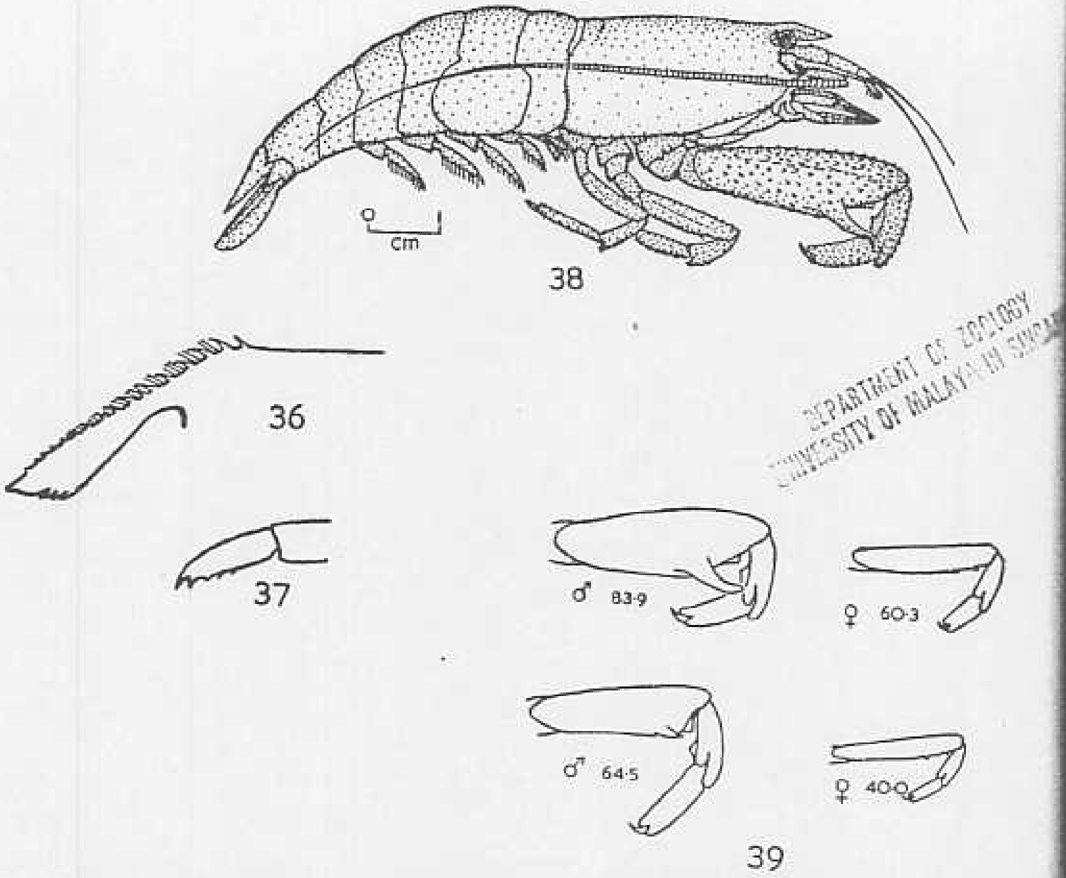
Amongst Malayan species *C. thambipillaii* can only be confused with *C. babaulti*. It can be distinguished from that species by its much shallower carapace, and by the proportions given in the species diagnosis.

Ecology: Both localities in which I have found this species are very slow-flowing waters in open country at or about sea-level. In both the water is very turbid. The Muar habitat is distinctly brackish; but the Sungei Putat is always fresh at the collecting station.

Caridina weberi de Man var. **sumatrensis** de Man (Figures 36 and 37).

Synonymy: *Caridina weberi* var. *sumatrensis* de Man, 1892, 375, pl. xxii, fig. 23; Bouvier, 1925, 247, fig. 571; Woltereck, 1937b, 311 and 314 (distribution).

Material examined: One non-ovigerous ♀, about 14 mm. long, from a small, clear semi-stagnant, weedy ditch, with much *Blyxa* about 4 miles from Batu Pahat on the Yong Peng Road, Johore; 28.9.55; collector, D. S. Johnson.



Figs. 36, 37. *Caridina weberi* var. *sumatrensis;* 38, 39. *Atya spinipes.* 36, rostrum; 37, dactylus of 3rd pereiopod; 38, male from Tahan River, about natural size; 39, distal portions of 3rd pereiopod of four individuals, drawings reduced to standard overall length of individuals, a figure for which accompanies each drawing.

Systematic notes: This specimen is a perfectly typical example of the variety. This variety cannot be confused with any other Malayan species. The rostrum (figure 36) is alone sufficiently characteristic for identification. This is also the only species so far known from Malaya in which the outermost setae of the posterior margin of the telson are shorter than the more internal setae.

Distribution: C. weberi has an extensive distribution from Arabia and the Comoro Islands to New Guinea. Over the whole western and northern portion of its range as far east and south as Engano and Sumatra it is represented by forms which have been assigned to the variety *sumatrensis*. It is possible that the forms occurring in Arabia, India and the Comoros will subsequently be regarded as representing distinct varieties. *C. weberi* var. *sumatrensis* has not previously been recorded from the Malay Peninsula but its occurence there was to be expected.

Atya spinipes Newport (Figures 38 to 42).

Synonymy: *Atya spinipes* Newport, 1847, 159; Miers, 1880, 42, pl. 15, figs. 5 & 6; Bouvier, 1925, 304 (partim); Roux, 1925, 145–154, & 1928, 208.
Atya moluccensis de Haan, 1850, 186, pl. 0; Bouvier, 1925, 299, fig. 672; Tiwari, 1951, 208; etc.
Atya armata A. Milne-Edwards, 1864, 149, pl. 3, fig. 3; Lanchester, 1901, 559.
Atya gustavi Ortmann, 1890, 467, pl. xxxvi, figs. a, b, & c.
Atya dentirostris Thallwitz, 1891, 26, fig. 7.
? *Ortmannia* sp. Blanco, 1935, 36, pl. 3, figs. 33–40.

Specimens examined: One non-ovigerous ♀, length 40·6 mm., Hubback's Camp, Kuala Kenyam Kechil, Pahang, 24.8.54; collector, J. R. Hendrickson.

Three ♂♂, length 54·6 to 64·5 mm., three non-ovigerous ♀♀, length 60·3 to 63·3 mm., and ten ovigerous ♀♀, length 45·0 to 67·1 mm., Tahan River near Kuala Tahan; 1955; collector, R. D. Purchon.

Two ♂♂, 49·7 and 83·9 mm. long, one non-ovigerous ♀, 74·2 mm. long, and four ovigerous ♀♀, 60·4 to 76·6 mm. long, from the River Tahan about 2 miles upstream from Kuala Tahan; March 1956; collector, E. R. Alfred.

One ♀, 15·9 mm., from torrent stretch of large stream (about 3 to 5 yards wide), tributary of Johore River, about 7½ miles East of Kota Tinggi, Johore, on Mersing Road; 22.2.57; collectors, E. R. Alfred and D. S. Johnson.

General Systematic Notes: A. spinipes (figure 38) is one of the more specialized members of its genus and cannot easily be confused with any other prawn. The species is adequately described by Bouvier. The extremely pronounced lateral angles of the telson, and the great reduction of the lateral spines of the telson, distinguish this species from its congeners. The form and armature of the rostrum and the anterior carapace margin are also characteristic. In the field the characteristic body form, and the striking, though variable, colour pattern of pale and dark longitudinal stripes serve to identify this prawn at a glance.

The rostrum of my specimens differs slightly from Bouvier's description. The ventral teeth are much less prominent than they are in Bouvier's figure, and the excavations at the sides of the rostral carina are tolerably well marked. The rostrum is somewhat variable in length (from about 1/5th to about 4/5ths of the post-orbital carapace length). This variation does not appear to be correlated with sex or size.

In its general form and structure *A. spinipes* is well adapted for life in torrent streams. The body is compact, robust, and semi-streamlined. The legs are short and stout, they are normally held tucked under the body and their dactyli are furnished with powerful claws. The deep abdominal epimera, together with the pleopods, completely enclose the brood-chamber. The short telson can also be regarded as a torrent stream adaptation.

The deepest portion of the body is the 3rd abdominal segment, its depth varies between ·18 and ·22 of the overall length in the female; and between ·17 and ·18 of the overall length in the male. In full-grown females this is also the thickest region of the body, but in younger females the thickest region lies further forward, and in males it lies in the posterior third of the carapace region. The thickness is always noticeably less than the depth, varying between ·14 and ·18 of the carapace length.

The 6th abdominal segment and the telson are both variable in length. As a result of this, although the telson is normally considerably longer than the 6th abdominal segment, it is sometimes of almost the same length. The uropods are approximately half as long again as the telson, or somewhat longer than this.

Roux (1925 and 1928) has dealt with the synonymy of this species and shown that despite the general use of the name *A. moluccensis*, the correct name is *A. spinipes*. Blanco in 1935 described a prawn from a stream on Luzon as *Ortmannia* sp. He suggested that it represented a variety of *O. mexicana*. It is very difficult to understand Blanco's reasons for this assignation. It is very unlikely that *O. mexicana* would be found in the Philippines since it is a purely Central American species. Moreover in all the characters available for distinguishing the genera *Atya* and *Ortmannia*, Blanco's specimen agrees with the genus *Atya*. This is true particularly of the chelipeds which are fully atyiform. The specimen is clearly a young individual of either *Atya spinipes* or *Atya pilipes* and Blanco's, admittedly inadequate, description, suggests the former.

Variations with age and sex: Atya spinipes shows marked changes in proportions associated with age and sex. Though the existence of some of these has long been recognized, they have never been fully analysed.

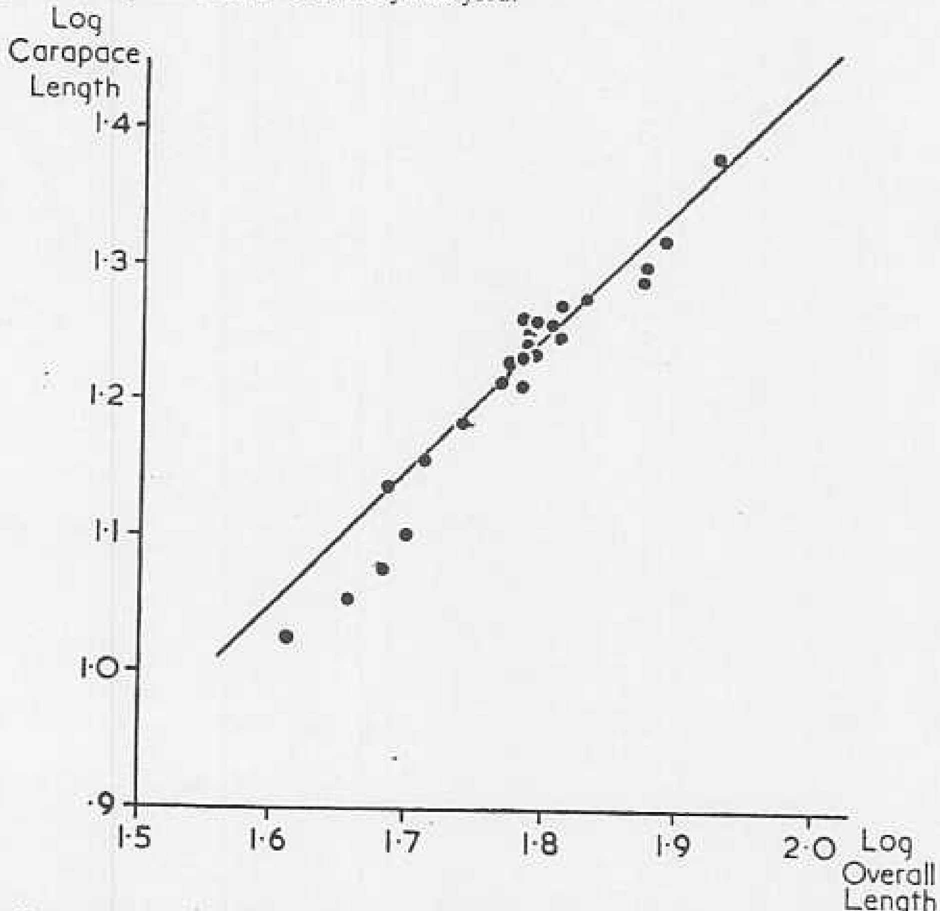


Fig. 40. *Atya spinipes*. Graph showing the relation between log, carapace length and log, overall length in individuals from the Tembeling River System.

In the Caridea it is usual to take the length of the carapace as the datum in expressing proportions. This length is preferred to the overall length since it is easier to measure it accurately. The use of this length can only be justified if with increasing size its length relative to the overall length remains constant. In my investigations it has become clear that this assumption is invalid for *Atya spinipes* (figure 40). It is true that if attention is confined to individuals which exceed 50 mm. in overall length the carapace shows no significant change in relative length with increasing size. In such individuals the carapace length varies slightly around a mean of ·28 of the total length. This relation no longer holds for individuals of less than 50 mm. overall length. In these individuals the relative length of the carapace appears to be more variable, and the available evidence indicates that there is progressive increase in the relative length of the carapace in individuals between 40 and 50 mm. in overall length. Interpolation from the graph suggests that at 40 mm. overall length the main carapace length would only average about ·24 of the overall length. Thus I have been compelled to use overall length as reference datum.

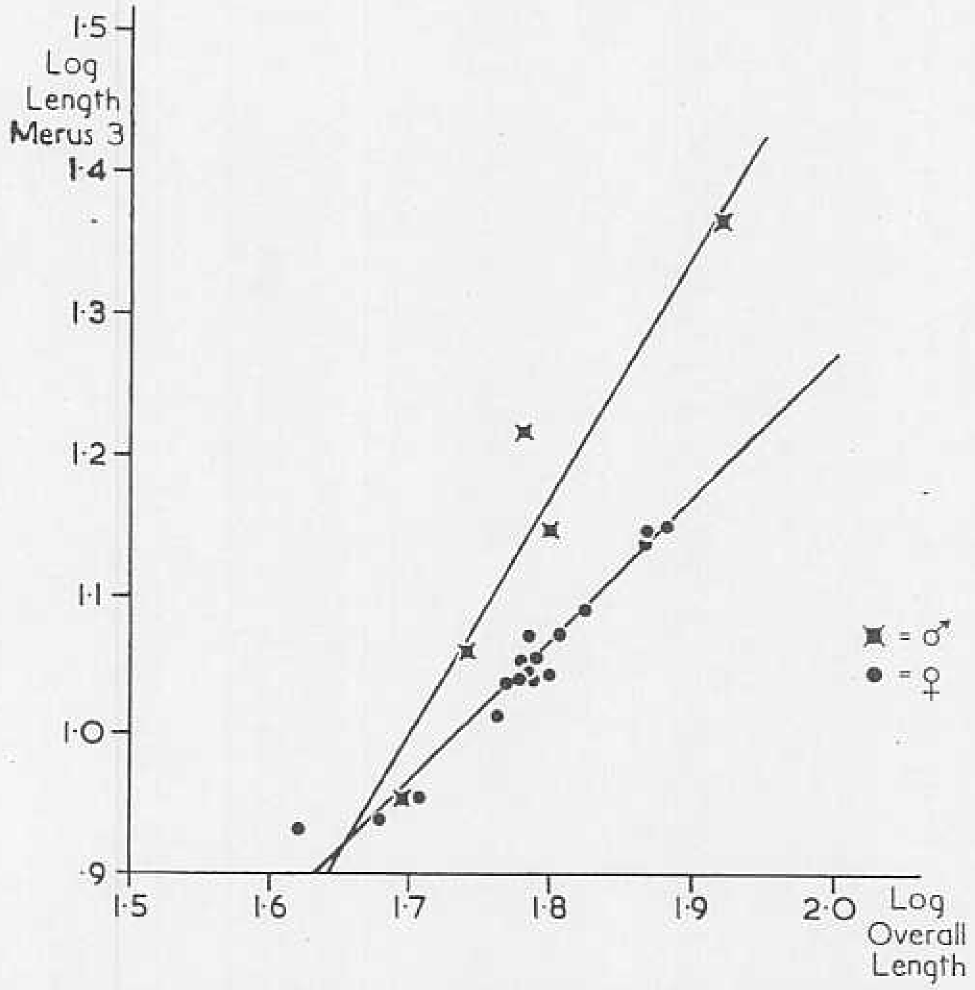


Fig. 41. *Atya spinipes*. Graph showing the relation between log, length of merus of 3rd pereiopod and log, overall length in individuals from the Tembeling River System.

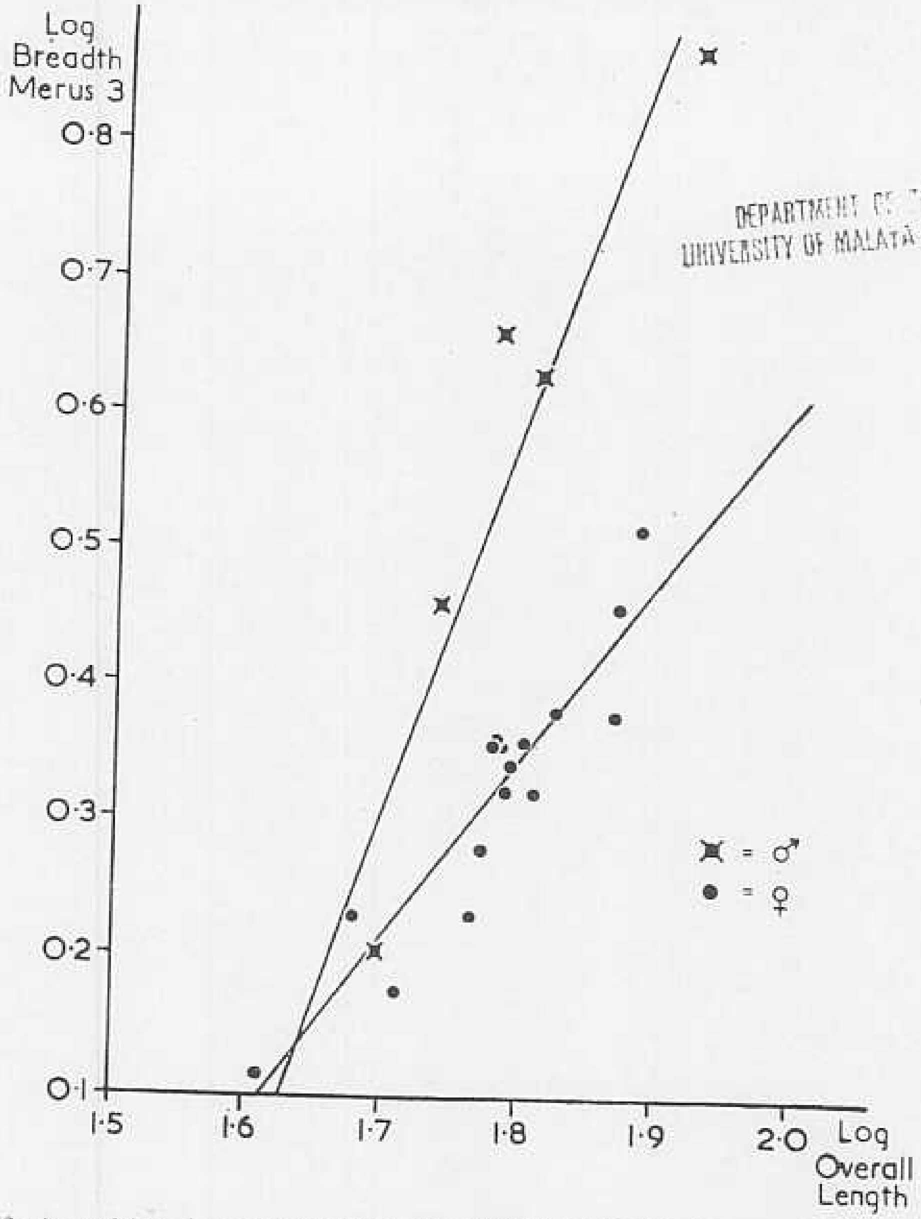


Fig. 42. *Atya spinipes*. Graph showing the relation between log. breadth of merus of 3rd pereiopod and log. overall length in individuals from the Tembeling River System.

It is well-known that in *A. spinipes* the 3rd pereiopods are distinctly stouter than the succeeding pairs. It is also well-known that this feature is particularly well-marked in old males. These facts suggest that, in respect to this feature, the males show positive allometry. It is of interest to try and determine whether any such allometry is shown by the females; and whether or no there is any similar allometry in respect to the length of this appendage. The changes in form and relative size of this appendage with sex and overall length are shown in figure 39. Though it is probable that all the more distal joints of the appendage are affected by these changes, I have concentrated my attention on the merus, as being the largest and hence the most easily measured.

Table 1. Measurements of Carapace and Pereiopod 3 for individuals of *Atya spinipes* Newport, from the Tembeling River System

Sex	Overall Length	Carapace Length	Merus of Pereiopod 3	
			Length	Breadth
♂	83.9	24.1	23.1	7.5
♂	64.5	18.5	14.0	4.3
♂	60.5	18.2	16.5	4.6
♂	54.6	15.3	11.5	2.9
♂	49.7	12.6	9.0	1.6
♀	76.6	20.9	14.1	3.3
♀	74.2	19.9	14.0	2.9
♀	74.0	19.4	13.7	2.4
♀	67.1	18.9	12.3	2.4
♀	64.3	17.6	11.8	2.1
♀	63.3	18.0	11.0	2.3
♀	62.0	18.1	11.4	2.2
♀	61.5	17.1	11.0	2.1
♀	61.0	17.5	11.1	2.3
♀	61.0	17.6	11.8	2.3
♀	60.4	16.2	11.3	2.3
♀	60.3	17.0	11.0	2.3
♀	59.1	16.9	10.9	1.9
♀	58.1	16.3	10.3	1.7
♀	51.0	14.3	9.0	1.5
♀	48.2	13.7	..	..
♀	47.7	11.9	8.7	1.7
♀	45.0	11.3	..	..
♀	40.6	10.6	8.4	1.3

The results of this investigation are shown in the graphs (figures 41 and 42) and in tables 1 and 2.

Table 2. Regressions of log carapace length, log length merus 3, and log breadth merus 3, on log overall length, for a population of *Atya spinipes* Newport, from the Tembeling River System

Character	Number of Observations	Regression Coefficient (b)	Variance of b	Standard Error of b	Probability if $b=$ 1.0000	a†
Log. carapace length* ..	20	.9337	.0034	.0582	.2 to .3	.28
Log. length merus 3, ♀♀ ..	16	1.07016	.0023	.0535	.1 to .2	.18
Log. length merus 3, ♂♂ ..	5	1.7010	.1106	.3326	.01	.013
Log. breadth merus 3, ♀♀ ..	16	1.3228	.0200	.1447	.05	.0093
Log. breadth merus 3, ♂♂ ..	5	2.8504	.0944	.3072	.001	.0015

* Individuals of less than 50mm. overall length ignored in this calculation.
† Obtained by substitution in the formula $\log y = \log a + b \log x$.

In respect of merus length there is no significant allometry shown by females of overall length 50 mm. or more. The measurements indicate that females of less than 50 mm. overall length may show negative allometry for this feature; but there are insufficient small individuals in my collections to establish this with certainty. In contrast with the females, the males show a marked and significant increase in relative length of the merus with increasing size. The relation between overall length (x) and merus length (y) in the male can be expressed by the equation $\log. y = \log. a + b \log. X$, where a = ·013 and b = 1·70 ± ·33. The graph for the males intersects that for the females at a point corresponding to an overall length of 45 mm.

The positive allometry shown by the breadth of the merus when it is compared with overall length is more marked than that shown by the length of the merus. Even in the females there is a slight but significant positive allometry, which can be expressed by the above equation where a = ·009 and b = 1·32 ± ·15. In the males there is a very marked positive allometry with a = ·0015 and b = 2·85 ± ·31. The difference between this value for b and that obtained in respect of merus length is highly significant. The regressions of log. merus breadth on log. overall length for males and females intersect at a point corresponding to an overall length of approximately 43·6 mm. In view of the uncertainties involved this value can be considered substantially the same as the length of 45 mm. obtained for the intersection of the regressions for log. merus length on log. overall length.

One consequence of the higher degree of allometry shown by merus breadth compared with merus length is that the merus becomes progressively stouter with increasing overall length (figure 39).

In Decapod Crustacea the intersection points for such regressions as these correspond with the age at which sexual maturity is attained. This indicates that, in Malaya, *A. spinipes* becomes sexually mature at a overall length of just under 45 mm. General observations tend to confirm this conclusion. Thus in my collections, the smallest male (of 49·7 mm.) has fully developed sexual pleopods; but the smallest ovigerous female is 45·0 mm. long, the smaller females being non-ovigerous. Records in the literature also agree with this conclusion. Lanchester (1901) does refer to individuals of 47 to 57 mm. taken at Belimbing as being young; but he does not elaborate this statement, and it is probably that he was merely contrasting them with the very large male of 81 mm. overall length which he obtained from the Selama River. The only record in the literature which seriously conflicts with the view that sexual maturity is attained at a length of approximately 45 mm. is de Man's record (*fide* Bouvier 1925) of an ovigerous female of only 23 mm. overall length. This length is so very small that it is almost certain that some error is involved; unless indeed de Man's specimen belonged to an otherwise unknown dwarf race. This point can only be fully settled by a re-examination of de Man's specimen; but it clearly has no relevance to the question of the normal size at which sexual maturity is attained.

Distribution: Atya spinipes has a wide range in the central Indo-Pacific region. It is known from southern Japan; from southern India; in scattered localities throughout the Indo-Australian Archipelago, including New Guinea; and from New Caledonia and southern Polynesia (Bouvier, 1925; Roux, 1925 & 1928; Tiwari, 1951; and Edmondson, 1935). This is the only species of the genus *Atya* which occurs on the Asiatic mainland. There it is confined to the two humid, southernmost peninsulas. It is not easy to understand why the species is restricted in this way; but the restriction agrees with the general distribution of the genus, which, although pan-tropical, is represented only on islands and in those portions of the continental masses which have a very humid and equable climate.

In Malaya *A. spinipes* was recorded by Lanchester from the Selama River in N.W. Perak, and also from Belimbing. I have not been able to trace the latter locality. The area of the Selama River is comparable topographically with the Upper Tembeling area from which most of my specimens have been obtained. The rivers in which the species occurs are more or less torrential rivers flowing through moderately low-lying forest country (a few hundred feet above sea-level) surrounded by mountains, which in the Tembeling area rise to over 7,000 feet. The Johore locality, which is probably marginal for the species, shows similar features in a less exagerrated form.

A. spinipes is an abundant and well-known species in the Tembeling area, and is collected for food by some of the local inhabitants. It is normally found clinging to the underside of underwater rock projections in the most torrential portions of the rivers, often in the full force of the current. In parallel with many torrenticolous fish found in such habitats it is apparently absent from the torrent streams of the high mountain country.

References

Bouvier (1925) gives an extensive bibliography. Works which are included in his list are only cited below where they are of particular relevance to the present paper. The list includes all works known to me which refer to Indo-Pacific Atyidae (as defined in the text), published in the period 1924 to 1956 inclusive.

Works which I have not been able to consult are indicated by an asterisk.

BALSS, H., 1924. Östasiatische Decapoden V. Die Oxyrhynchen und Schlussteil (Geographische Uebersicht der Decapoden Japans). *Arch. Naturg. Berlin*, **90**: 20–84.

BLANCO, G. H., 1935. The Atyidae of the Philippine Islands. *Philipp. J. Sci. Manila*, **56**: 29–39.

——————, 1939. Four new Philippine species of fresh-water Shrimps of the genus *Caridina*. *Philipp. J. Sci. Manila*, **70**: 389–395.

BOUVIER, E.-L.,* 1918. Sur quelques Crustacés décapodes recueillis par M. Guy Babault dans les eaux douces de l'Inde anglaise. *Bull. Mus. Hist. nat. Paris*, **1918:** 386–393.

————,* 1919. Quelques espèces nouvelles de Caridines. *Bull. Mus. Hist. nat. Paris*, **1919:** 330–336.

————, 1925. Recherches sur la Morphologie, les Variations et la Distribution systématique des crevettes d'eau douce de la famille des Atyidés. *Encyclopédie Entomologique*, **4:** 0–370.

CALMAN, W. T., 1926. On freshwater Prawns of the family Atyidae from Queensland. *Ann. Mag. N.H. London* (9), **17:** 241–246.

CHOPRA, B. & TIWARI, K. K.,* 1949. Decapoda Crustacea of the Patna State, Orissa. *Rec. Ind. Mus. Calcutta*, **45:** 213–224.

EDMONDSON, C. H., 1929. Hawaiian Atyidae. *Bull. Bishop Mus. Honolulu*, **66:** 1–36.

————, 1930. Effect of ultra-violet rays in regeneration of Chelipeds (*Atya*). *Occ. Pap. Bishop Mus. Honolulu*, **9**, 7: 1–7.

————, 1935a. New and rare Polynesian Crustacea. *Occ. Pap. Bishop Mus. Honolulu*, **10**, 24: 1–40.

————, 1935b. Atyidae of southern Polynesia. *Occ. Pap. Bishop Mus. Honolulu*, **11**, 3: 1–19.

————, 1936. Effect of X-rays on regeneration of chelipeds of *Atya bisulcata*. *Occ. Pap. Bishop Mus. Honolulu*, **11**, 16: 3–15.

FAGE, L.,* 1946. Sur une Caridine nouvelle cavernicole de Madagascar, *Caridina microphthalma*, nov. sp. *Bull. Mus. Hist. nat. Paris* (2), **18:** 324–327.

FRASER-BRUNNER, A.,* 1951. Nile Aquarium Novelty. *Aquarist*, **16:** 33.

DE HAAN, W., 1850. Crustacea. in: von Siebold. *Fauna Japonica*.

HARA, J.,* 1952. On the hormones regulating the frequency of heart beat in the shrimp *Paratya compressa*. *Annot. zool. Jap.*, **25:** 162–171.

KEMP, S., 1915. Fauna of the Chilka Lake. Crustacea Decapoda. *Mem. Ind. Mus. Calcutta*, **5:** 199–325.

————, 1918. Zoological results of a tour in the Far East. Crustacea Decapoda and Stomatopoda. *Mem. Asiat. Soc. Bengal*, **6:** 274–293.

————, 1924. Zoological results of the Percy Sladen Trust expedition to Yunan under the leadership of J. W. Gregory, F.R.S. (1922). Decapod Crustacea. *J. Proc. Asiat. Soc. Beng. Calcutta*, **19**, 437–445.

KUBO, I.,* 1938. On the Japanese Atyid Shrimps. *J. Imp. Fish. Inst. Tokyo*, **33:** 67–100.

————,* 1941. On some freshwater shrimps from the Ryukyu Islands. *Trans. biogeogr. Soc. Japan Tokyo*, **3:** 303–318.

KUMITA, T.,* 1950. Studies on the decapod crustacea of the Oki Isles, Japan Sea. First report, On the shrimps of Atyidae and Palaemonidae of Dozen Isles. *Zool. Mag. Tokyo*, **59:** 214–217 (Japanese with English summary).

————,* 1951. Studies on the decapod crustacea of Oki Isles, Japan Sea. II On the shrimps of Atyidae and Palaemonidae. *Zool. Mag. Tokyo*, **60:** 215–219 (Japanese with English summary).

LANCHESTER, W. F., 1901. On the Crustacea collected during the "Skeat" Expedition to the Malay Peninsula. *Proc. Zool. Soc. London*, **1901:** 533–574.

MAHADEVAN, P., 1948. The development of the arterial system of *Caridina*. *Ceylon J. Sci.* B Zool., **23:** 125–134.

DE MAN, J. G., 1892. Decapoden des Indischen Archipels. *Max. Weber Zool. Ergeb.*, **2:** 295–527.

————, 1908. The Fauna of Brackish Ponds at Port Canning, Lower Bengal. Part X. *Rec. Ind. Mus. Calcutta*, **2:** 211–231.

MIERS, E. J., 1880. On a collection of Crustacea from the Malaysian Region. Part III. *Ann. Mag. N.H.* (5), **5:** 30–44.

MILNE-EDWARDS, A.,* 1864. Révision des Crustacés macroures de la famille des Atyidés. *Ann. Soc. ent. de France* (4), **4:** 145–152.

MIYAKE, S.,* 1938. Notes on Decapod Crustaceans collected by Prof. Teiso Esaki from Micronesia. *Annot. zool. Jap.*, **17:** 107–112.

NAGAMO, T.,* 1943. Physiological studies on the pigmentary system of crustacea. I. The colour change of a shrimp *Paratya compressa* (de Haan). *Sci. Rep. Tohoku Univ.* (4) Biol., **17:** 223–245.

NATARAJAN, S.,* 1942. On the occurrence of *Caridina* (Atyidae, Decapoda) in Travancore. *Current Sci. Bangalore,* **11:** 245.

NAIR, K. B.,* 1944. A note on the cephalic segments of the embryo of *Caridina laevis* Heller. *Proc. Indian. Sci. Congr.,* **31:** 92.

NEWPORT, G., 1847. Note on the genus *Atya* of Leach. *Ann. Mag. N.H.,* **19:** 158–160.

ORTMANN, A.-E., 1890. Die Decapoden-Krebse des Strassburger Museums. *Zool. Jahrb. Syst.,* **5:** 463–467.

ROUX, J., 1925. Ueber einige Süsswasser Dekapoden (Atyidae) des Berliner Zoologischen Museums. *Zool. Anz. Leipzig.,* **62:** 145–154.

———,* 1926a. Crustaces décapodes d'eau douce de la Nouvelle-Caledonie en: F. Sarasin and J. Roux. *Nova Caledonia München Zool.,* **4:** 181–240.

———, 1926b. An account of Australian Atyidae. *Rec. Australian Mus. Sydney,* **15:** 237–254.

———, 1928. Notes carcinologiques de l'Archipel Indo-Australian. I Décapodes macroures d'eau douce. *Treubia, Buitenzorg,* **10:** 197–224.

———, 1929a. Süsswasserdekapoden von den Sunda-Inseln gessamelte durch die Sunda-Expedition Rensch. *Sitz. Ber. Ges. naturf. Berlin,* **1928:** 235–237.

———,* 1929b. Crustacea III. Atyidae in: Contribution à l'étude de la faune de Madagascar. *Faune Colon. franc. Paris,* **3:** 293–319.

———, 1931a. Crustacés Décapodes d'eau douce de l'Inde méridionale. *Rev. suisse Zool. Genève,* **38:** 31–62.

———, 1931b. Sur une nouvelle Caridine de Ceylan. *Rev. Suisse Zool.,* **38:** 63–66.

———, 1932. Süsswassermacruren der Deutschen Limnologichen Sunda-Expedition. *Arch. Hydróbiol Stuttgart* Suppl. **11:** 563–574.

———, 1933. Crustacés Décapodes d'eau douce en: Résultats scientifiques du Voyages aux Indes Orientales Néerlandaises de la Prince Leopold de Belgique. *Mem. Mus. Roy. Hist. nat. Belg.* (3), **14:** 1–18.

———,* 1934a. Macroures d'eau douce de Madagascar et des iles voisines (Palémonides et Atyidés). *Faune Colon. franc. Paris,* **5:** 529–547.

———, 1934b. Notes de Carcinologie mélanesienne. *Rev. Suisse Zool.,* **41:** 217–234.

SHEN, C. J.,* 1939. The larval development of some Peiping Caridea—The *Caridina* (Atyidae), the *Palaemonetes* and the *Palaemon* (Palaemonidae). *40th Anniv. Pap. Nat. Univ. Peking,* **1:** 169–201.

———, 1948. On three new species of *Caridina* (Crustacea Macrura) from South-West China. *Contr. Inst. zool. Peiping,* **4:** 119–125.

THALLWITZ, J., 1891. Decapoden-Studien. *Abh. Ber. K. zool. anthr. ethn. Mus. Dresden,* 1890–1891, no. **3:** 1–55.

TIWARI, K. K.,* 1951. Occurrence of the genus *Atya* Leach (Crustacea: Decapoda; Atyidae) in the Indian Mainland. *Current Sci. Bangalore,* **20:** 208.

UENO, M., 1935. Inland water fauna of Formosa. I Crustacea Decapoda. *Trans. Nat. Hist. Soc. Formosa,* **25:** 270–276 (In Japanese with English summary).

WOLTERECK, E., 1937b. Systematisch-variationsanalytische Untersuchungen über die Rassen und Artbildung bei Süsswassergarneelen aus der Gattung *Caridina* (Decapoda Atyidae), *Int. Rev. Hydrobiol. Stuttgart,* **34:** 208–262.

———, 1937b. Zur Systematik und geographischen Verbreitung der Caridinen. *Int. Rev. Hydrobiol. Stuttgart,* **34:** 208–262.

YASAKI, Y.,* 1927. Bacteriological studies on bioluminescence. I Cause of luminescence in the freshwater Shrimp *Xiphocaridina compressa* (de Haan). *J. Infect. Dis. Chicago,* **40:** 404–407.

YOKOYA, Y.,* 1931. On the metamorphosis of the two Japanese Freshwater Shrimps, *Paratya compressa* and *Leander paucidens* with reference to the development of their appendages. *J. Coll. Agric. Tokyo,* **11:** 75–150.

YU, S. C., 1936. Report on the macrourous Crustacea collected during the Hainan biological expedition in 1934. *Chinese J. Zool.,* **2:** 85–100.

———, 1938. Studies on Chinese Caridina with descriptions of five new species. *Bull. Fan. Memorial Inst. Biol. Peiping* Zool, **8:** 105–114.