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A NEW SPECIES OF FRESHWATER ATYID SHRIMP, *CARIDINA TEMASEK* (DECAPODA: CARIDEA: ATYIDAE) FROM SINGAPORE

Satish C. Choy and **Peter K. L. Ng**

ABSTRACT. - A new species of freshwater atyid shrimp, *Caridina temasek* from Singapore is described. *Caridina temasek* is characterized by a combination of the following features: presence of epipodites on the first four pairs of pereiopods, pereiopod shape, spination and segmental ratios, shape and spination on the posterior margin of the telson, large egg size and the presence of an appendix interna on the endopod of the first male pleopod. Six species of atyids, all belonging to the genus *Caridina*, are now known from Singapore.

INTRODUCTION

To date, nine species of *Caridina* have been reported from Peninsular Malaysia and Singapore (Johnson, 1961; Ng & Choy, 1990). Of these, *C. gracilirostris gracilirostris* De Man, 1892, *C. propinqua* De Man, 1908, *C. simoni peninsularis* Kemp, 1918, *C. tonkinensis* Bouvier, 1919 and *C. weberi sumatrensis* De Man, 1892 are known to occur in Singapore (Johnson, 1961, 1963; Ng 1990). Most of these species are euryhaline, inhabiting fresh and low salinity waters. They all produce relatively small-sized eggs, suggesting that larval development is somewhat prolonged.

In his review of the Singapore freshwater decapod crustaceans, Ng (1990) documented large numbers of an unknown *Caridina* from the Sime Road area (Fig. 1). Ovigerous females possessed relatively large eggs and further studies indicated that these specimens represented an undescribed species.

The stream from where the shrimps were collected runs through a secondary forest. It is non-tidal, has a clay-sand substratum and the water, which has a pH of about 6, is gently flowing in most areas. The main aquatic plant in the stream is the bladderwort, *Utricularia*; the shrimps are very common among them and other submerged vegetation, particularly along the banks. Although the stream is in a rather disturbed forest area with a golf course nearby, it has a rich and diverse fauna, including native fish rarities like *Rasbora heteromorpha* and *R. maculata*.

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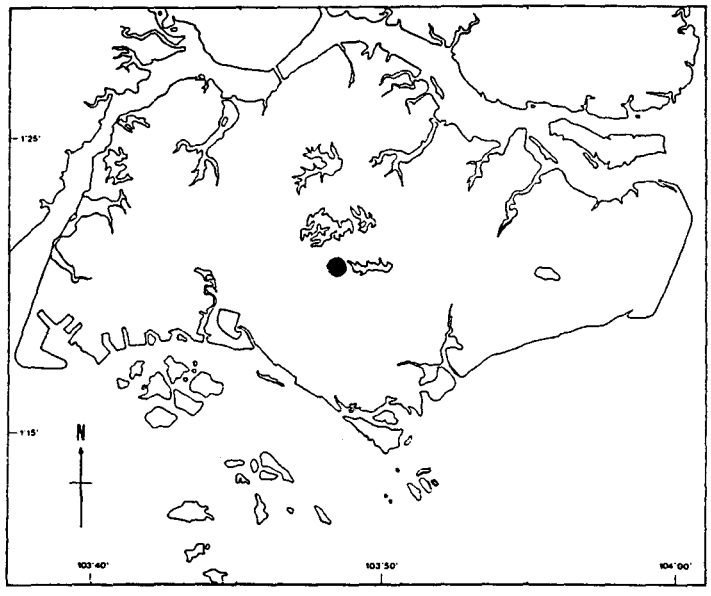

Fig. 1. Collecting site of *Caridina temasek*, new species.

Other fish include *Betta pugnax*, *Trichopsis vittata* and *Oxyeleotris marmorata*, as well as the introduced *Puntius partipentazona*, *Cyclocheilichthys apogon* and *Poecilia reticulata*. Other fauna found in the stream are the prawns *Macrobrachium malayanum*, *M. trompii* and the introduced *M. lanchesteri*, as well the crabs *Parathelphusa maculata* and *Irmengardia johnsoni*.

The primary type specimens have been deposited in the Zoological Reference Collection, Department of Zoology, National University of Singapore (ZRC). Representative paratypes have been deposited in the British Museum (Natural History), London (BMNH), the Brunei Museum, Negara Brunei Darussalam (MB), the National Museum of Natural History, Leiden, The Netherlands (RMNH), the Northern Territory Museum of Arts and Sciences, Darwin, Australia (NTM) and the Smithsonian Institution, Washington D.C., U.S.A (USNM).

SYSTEMATICS

Family Atyidae

Genus *Caridina* H. Milne Edwards, 1837

***Caridina temasek*, new species**
(Figs. 2-5, Tables 1, 2)

Caridina sp. - Ng, 1990: 200; Ng & Tan, 1991, in Ng, 1991: 120

Material examined. - Holotype: 1 ovigerous female (ZRC), total length (TL) 16.0 mm, post-orbital carapace length (CL) 3.5 mm, pre-orbital rostral length (RL) 2.0 mm, mean diameter of elliptical, non-eyed eggs 0.45 x 0.76 mm.

Allotype: 1 adult male (ZRC), TL 14.8 mm, CL 2.7 mm, RL 1.8 mm.

Paratypes: female #1-10, male #1-5 (ZRC); 10 females, 10 males (BMNH); 10 females, 10 males (BMNH); 10 females, 10 males (RMNH D 38562); 10 females, 10 males (NTM); 10 females, 10 males (USNM 243560); 12 females, 30 males (ZRC).

All specimens collected from freshwater stream near Sime Road, MacRitchie catchment area, Singapore, ca. 01 20'14"N, 103 48'47"E, leg. P. K. L. Ng & K. K. P. Lim, viii.1990.

Description. - Body: Small, slender, subcylindrical; males up to 17 mm TL, females up to 20 mm TL.

Rostrum (Fig. 2A-E): Slender, length 6-8 times breadth; generally shorter, narrower and either convex and straight (15%), curving downwards (74%) or sigmoid (11%) in males (N=54), reaching from just beyond base to tip of second antennular segment; either convex and straight (46%), curving downwards (22%) or sigmoid (32%) in females (N=92), reaching from just beyond base of second antennular segment to tip of antennlar peduncle; terminal 0.1-0.12 of both margins unarmed, may be directed from slightly upwards to slightly downwards; 14-18 dorsal rostral teeth, with 4-6 situated behind the posterior orbital margin, setation between each tooth; 2-6 ventral rostral teeth; lateral carina dividing rostrum into two equal parts, continuing posteriorly to orbital margin.

Eyes (Fig. 2A-E): Small, on short ocular peduncle; cornea globular, well developed.

Carapace (Fig. 2A-E): Smooth, glabrous; rostrum (RL) 0.50-0.77 of carapace length (CL). Pterygostomian angle acute to broadly rounded, slightly produced anteriorly. Antennal spine pointed sharply, placed below lower orbital angle, straight dorsally, slightly concave ventrally.

Antennule (Fig. 2F): Peduncle three-segmented; stylocerite 0.75 length of basal segment; pointed anterolateral angle of basal antennular segment acute, reaching about 0.33 length of second segment, which is about 0.6 length of basal antennular segment and about 1.2 times as long as the third. First two segments with submarginal plumose setae (setal terminology after Pohle and Telford, 1981); third segment fringed laterally and apically with similar setae. Flagella long, simple.

Antenna (Fig. 2G): Scaphocerite reaching beyond tip of antennular peduncle; outer margin straight or slightly convexed, without setae, ending in strong subapical tooth, the tip of which lies in line with or just beyond tip of the antennular peduncle, both being over-reached by the lamella which has plumose setae on inner and anterior margins. Antennal peduncle about 0.45 length of scaphocerite, in line with tip of basal antennular segment. Flagella long, simple.

Mandibles (Fig. 2H, I): Right mandible with 4-6 strong, sharp incisor teeth laterally; medially two groups of simple setae, one group being distinctly bent, the other straight; molar process ridged. Left mandible with 4-6 strong, sharp teeth separated by sharply ridged gap; adjacent setae finely serrated below, with simple setae adjacent to ridged molar process which has short brush-like setae.

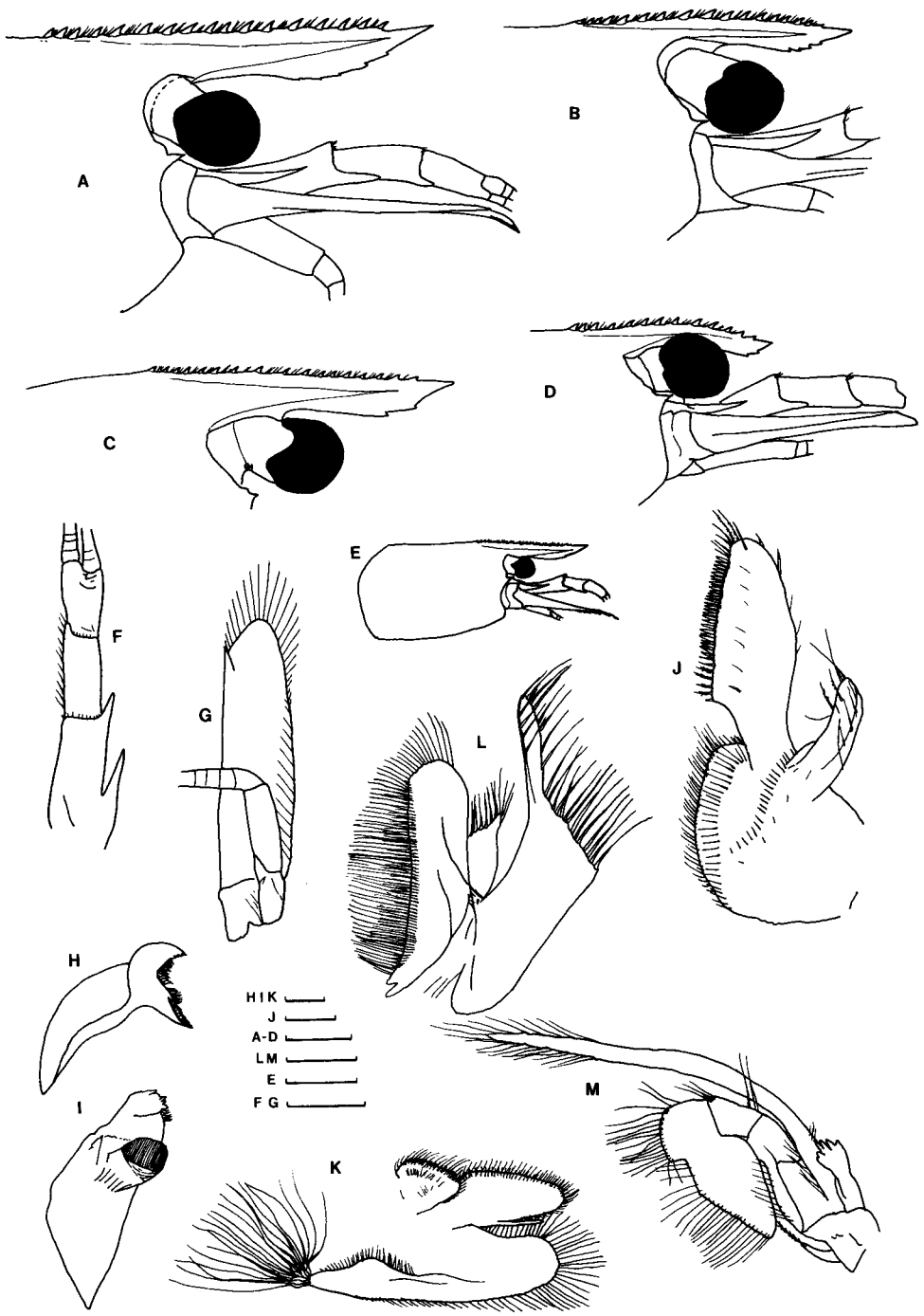

Fig. 2. *Caridina temasek*, new species. A, Paratype female #2: head region; B, Paratype male #2: head region; C, Paratype female #3: head region; D, Paratype male #3: head region; E, Paratype female #2: cephalothorax; F-M, Paratype male # 3: F, antennule; G, antenna; H, left mandible; I, right mandible; J, maxillula; K, maxilla; L, first maxilliped; M, second maxilliped. Scales = 0.1 mm (J), 0.2 mm (H, I, K-M) and 0.5 mm (A-G).

Maxillula (Fig. 2J): Lower lacinia with broadly rounded margin, bearing several rows of different types of setae (simple, denticulate and plumose); anteriorly long submarginal rows of denticulate and spatulate setae, lower ones more spinose; some setae placed proximally. Upper lacinia broadly elongate, inner edge straight with several rows of strong spines as well as short, simple, denticulate and plumose setae. Simple and plumose setae on outer and lower inner margins. Palp truncate with long plumose setae near tip and column of simple setae.

Maxilla (Fig. 2K): Upper and middle endite with marginal simple and denticulate setae, and submarginal plumose ones. Lower endite with simple setae; palp shorter than cleft of upper endite, narrow, simple. Scaphognathite with regular row of long plumose setae on distal margin, with shorter simple ones continuing down the proximal triangular process which has many long simple setae, most with prominent dilation near base.

First Maxilliped (Fig. 2L): Ultimate and penultimate segments of endopod indistinctly divided; inner margin of ultimate segment with marginal and submarginal long rows of plumose and simple setae plus transverse rows of plumose setae on lower portion. Palp broadly triangular with prominent finger-like tip, with terminal setae. Exopod flagellum distinct, well developed, with marginal plumose setae. Caridean lobe not broad, with marginal plumose setae and two rows of submarginal denticulate and pectinate setae.

Second Maxilliped (Fig. 2M): Ultimate and penultimate segments of endopod fused, reflected against basal segments. Inner margins of ultimate, penultimate and basal segments with long, plumose setae of various types. Exopod long, narrow with marginal plumose setae distally, and simple and plumose ones proximally (near base). Podobranch narrow, flat, with reduced branchial lamella.

Third Maxilliped (Fig. 3A): Reaching tip of antennular peduncle; endopod three-segmented, basal segment about 5 times as long as broad, with plumose marginal setae. Second segment about 10 times as long as broad and 1.27 times longer than basal segment; with 9 transverse rows of spine-like simple setae. Distal segment about 0.84 times length of second segment, ending in large claw-like apical spine surrounded by simple setae, behind which there are about 6-7 spines on distal third of posterior margin; proximally a clump of about 15 finely denticulate setae behind which are about 7 transverse rows of shorter setae. Exopod narrow, reaching about 0.33 of second endopod segment; distal margin with long plumose setae.

First Pereiopod (Fig. 3B): Reaching tip of basal segment of antennular peduncle in situ. Chela 2.4-2.5 times as long as wide, movable finger slightly longer than palm, 3.3-4.0 times as long as wide. Finger tips rounded, without hooks but with numerous setae of intermediate length, 0.7-0.8 times as long as finger. Carpus attached to chela ventrally, shallow excavation antero-dorsally, 0.85-1.0 times length of chela, about 1.1-1.4 times length of merus. Merus narrower than carpus. Ischium 0.65-0.85 length of merus, 1.5-2.0 times length of basis. One setobranch.

Second Pereiopod (Fig. 3C): Reaching from tip of second antennular peduncle segment to tip of antennular peduncle, more slender and longer than first pereiopod. Chela 3.0-3.5 times as long as wide, free finger longer than palm, 5-6 times as long as wide, very shallow excavation anteriorly; tips of fingers without hooks, but with numerous setae. Carpus may be slightly excavated anteriorly, about 6-7 times as long as wide, 1.3-1.5 times longer than chela and merus. Ischium 0.8-0.95 times length of merus and over 3 times that of basis. One setobranch.

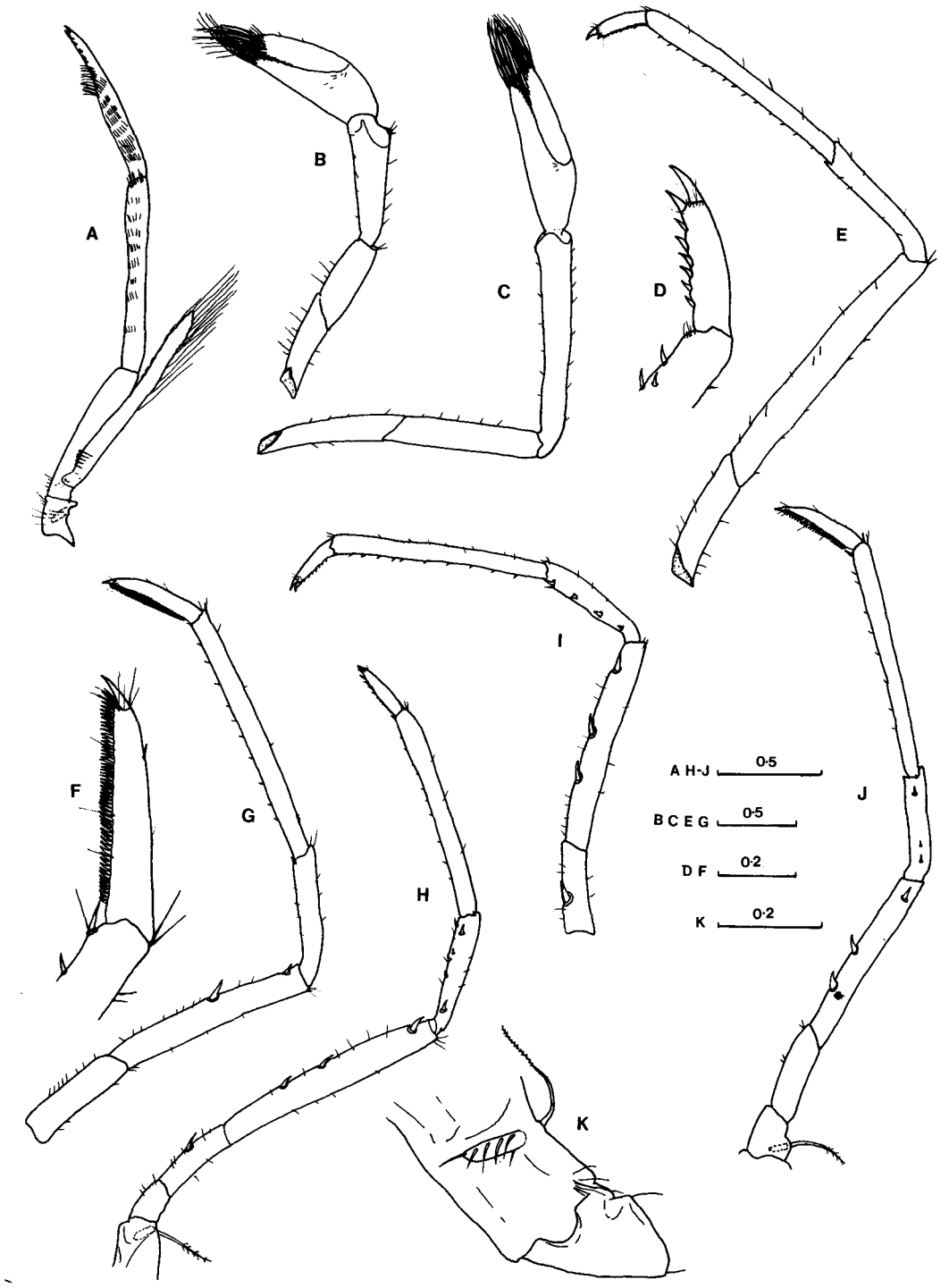

Fig. 3. *Caridina temasek*, new species. A, Paratype male #2: third maxilliped; B-G, Paratype female #3: B, first pereiopod; C, second pereiopod; D, dactylus of third pereiopod; E, third pereiopod; F, dactylus of fifth pereiopod; G, fifth pereiopod; H-K, Paratype male #3: H, third pereiopod; I, fourth pereiopod; J, fifth pereiopod; K, coxa and basis of fourth pereiopod showing the epipod and setobranch. Scales in mm.

Third Pereiopod (Fig. 3D, E, H): Reaching just beyond tip of antennular peduncle. Dactylus 3.5-4.0 times as long as wide, ending in prominent claw-like apical spine, behind which posterior margin bears 6-10 spines reducing in size proximally. Propodus about 3-5 times as long as dactylus, bearing 13-15 spines on posterior margin plus a few on anterior and lateral margins. Carpus 0.50-0.65 length of propodus, bearing a large anterior spine and up to 5 smaller spines on posterior margin of outer surface. Merus 1.7-2.0 times as long as carpus, slightly longer and broader than propodus, with up to 3 strong, movable spines on posterior margin of outer surface. Ischium about half length of propodus and twice that of basis, sometimes bearing a spine. One setobranch.

Fourth Pereiopod (Fig. 4I): Reaching tip of antennular peduncle. Somewhat similar to pereiopod 3. Dactylus about 0.2-0.3 times length of propodus, ending in prominent claw-like apical spine and 5-9 marginal spines reducing in size proximally. Propodus 1.6-1.8 times length of carpus, bearing 10-15 spines on posterior margin. Carpus with strong spine distally and 2-4 smaller spines running proximally. Merus 2.3-2.8 times length of ischium with 3 strong spines on latero-posterior. Ischium about twice length of basis, sometimes bearing a spine. One setobranch.

Fifth Pereiopod (Fig. 3F, G, J): Reaching tip of antennular peduncle. Dactylus long, slender, ending in a claw-like apical spine, bearing comb-like row of 55-65 spinules on posterior margin. Propodus about 2.6-3.0 times as long as dactylus, bearing a row of 9-12 spinules on posterior margin and a few on the anterior margin; a large spine at distal end may be present. Carpus about half length of propodus, with large spine distally and a couple of smaller ones proximally. Merus distinctly shorter but wider than propodus, bearing strong anterior spine on outer surface and 1 or 2 similar marginal ones behind it. Ischium about twice length of basis, no spination.

Table 1. Length (L) and width (W), in mm, of pereiopod segments of secondary type specimens of Caridina temasek, new species.

	Dactylus		Propodus		Carpus		Merus		Ischium	
	L	W	L	W	L	W	L	W	L	W
PARATYPE MALE #1										
Pereiopod I	0.35	0.10	0.71	0.29	0.61	0.22	0.57	0.18	0.39	0.18
Pereiopod II	0.43	0.10	0.81	0.24	1.18	0.20	0.78	0.16	0.75	0.16
Pereiopod III	0.39	0.10	1.27	0.12	0.78	0.16	1.33	0.20	0.61	0.22
Pereiopod IV	0.39	0.10	1.29	0.12	0.78	0.16	1.41	0.20	0.61	0.22
Pereiopod V	0.59	0.10	1.55	0.12	0.84	0.12	1.27	0.16	0.69	0.18
PARATYPE FEMALE #1										
Pereiopod I	0.57	0.20	0.90	0.37	0.82	0.27	0.69	0.22	0.59	0.18
Pereiopod II	0.65	0.10	1.08	0.31	1.47	0.15	0.98	0.18	0.90	0.16
Pereiopod III	0.35	0.10	1.61	0.12	0.88	0.16	1.90	0.20	0.78	0.21
Pereiopod IV	0.33	0.10	1.57	0.12	0.76	0.16	1.63	0.20	0.65	0.20
Pereiopod V	0.55	0.11	1.76	0.12	0.82	0.16	1.45	0.20	0.71	0.20

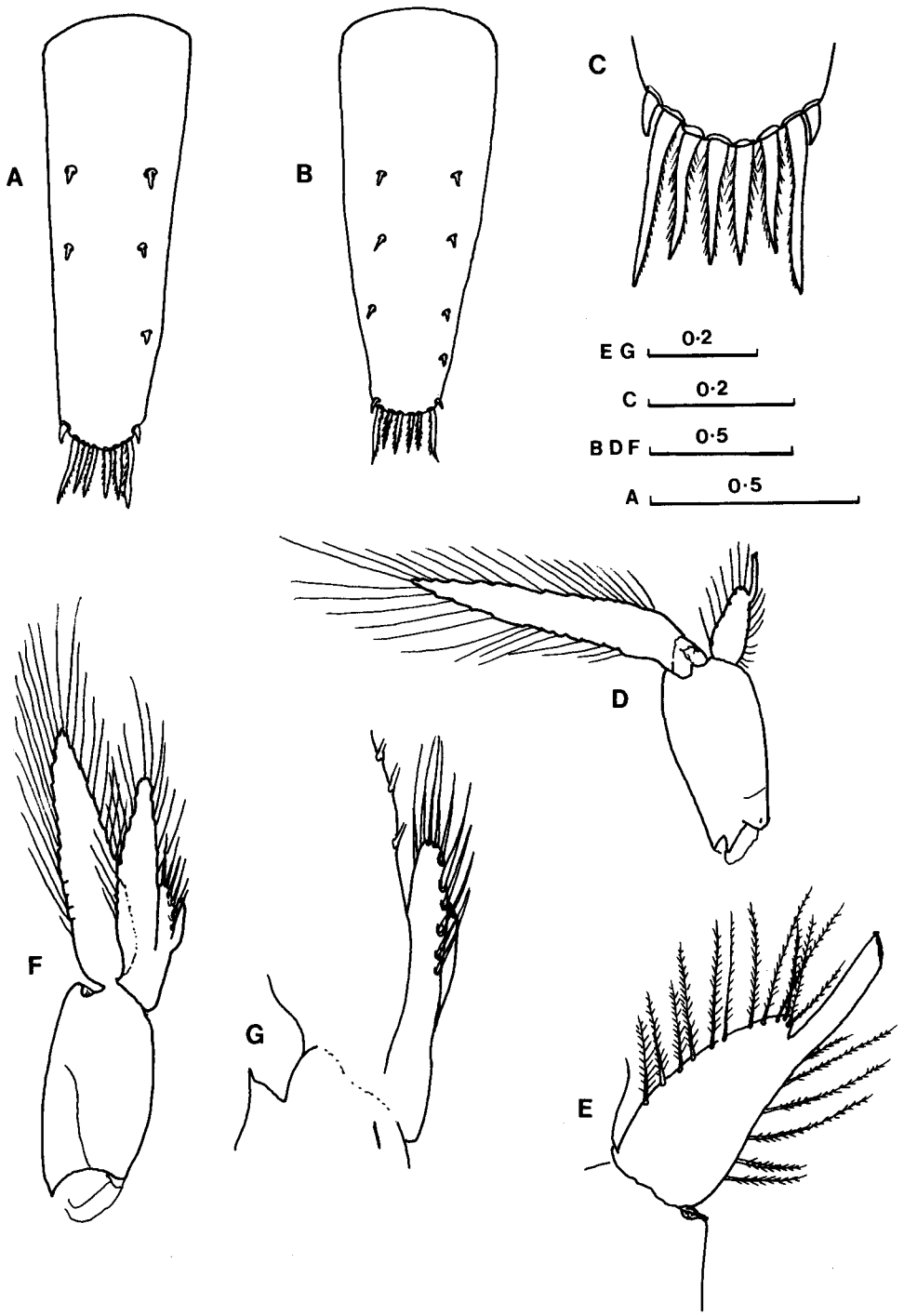

Fig. 4. *Caridina temasek*, new species. A, Paratype female #2: telson; B-G, Paratype male #3: B, telson; C, posterior margin of telson; D, first pleopod; E, endopod of first pleopod; F, second pleopod; G, appendix interna and appendix masculina near base of endopod of second pleopod. Scales in mm.

Branchial formula:

	Maxillipeds			Pereiopods				
	1	2	3	1	2	3	4	5
pleurobranchs	-	-	-	1	1	1	1	1
arthrobranchs	-	-	2	1	-	-	-	-
podobranchs	-	1	-	-	-	-	-	-
epipods	-	1	1	1	1	1	1	-
exopods	1	1	1	-	-	-	-	-

First Pleopod (Fig. 4D, E): Endopod in male about 0.25 times as long as exopod, both with marginal plumose setae; appendix interna well developed, reaching beyond top of endopod by about 0.5 length, many retinacula at tip.

Second Pleopod (Fig. 4F, G): Endopod in male about 0.82 length of exopod; both with marginal plumose setae. Appendix interna of endopod with many retinacula at tip. Appendix masculina strong, bearing about 12 long, spine-like setae distally and inner-laterally.

Telson (Fig. 4A-C): 0.53-0.66 length of post-orbital carapace, distinctly longer in males; similar in length to sixth abdominal segment, tapering posteriorly, ending in a rounded margin; with 3-4 pairs of submarginal spines on posterior two-thirds of dorsal surface. Posterior margin with one pair of very short, outermost spines, about 0.28 times as long as inward-curved or slightly sigmoid lateral pair; 4 or 5 intermediate posterior plumose spines; if present the middle one being thinnest and shortest, all distinctly shorter than lateral pair; none with chitinous plug. Exopod of uropod slightly longer and wider than endopod, both with marginal plumose setae; diaeresis bearing 12-16 spines. Pre-anal carina with about 10 setae.

Egg size: 0.44-0.50 by 0.70-0.77 mm (non-eyed), 0.51-0.54 by 0.75-0.80 mm (eyed).

Live colouration: Body pale green, dorsal parts and rostrum with scattered brown spots. See also colour photograph in Ng & Tan, 1991 (p. 120).

Etymology. - The specific epithet is given after "Temasek", the old Malay name for Singapore. It is used as a noun in apposition.

Remarks. - Of the nine species known from Singapore and Peninsula Malaysia, *C. temasek* can only be confused with *C. excavatoides* Johnson, 1961, *C. propinqua* and *C. tonkinensis*. *C. temasek* differs from these three species in that it has well developed epipods on all the first four pereiopods; the others have a reduced epipodial formula. The egg size of *C. temasek* is much larger than that of *C. propinqua* and *C. tonkinensis* but similar to that of *C. excavatoides*. *C. excavatoides*, however, does not possess a pre-anal carina and many of the segmental ratios of the pereiopods are quite different (see Johnson, 1961). *C. temasek* can also be readily distinguished from all other *Caridina* species - such as those described by Borradaile (1898), Bouvier (1925), Edmondson (1929, 1935), Blanco (1935, 1939), Kubo (1938), Johnson (1961), Arudpragasam & Costa (1962), Holthuis (1965, 1969, 1978), Kamita (1967), Tiwari & Pillay (1971), Fujino & Shokita (1975), De Silva (1982), Choy (1983, 1984, in press), Gurney (1984) and Jalihal *et al.* (1984) - on the basis of a combination of the following features: egg size, rostral and pereiopodal morphometry, placement of the antennal spine, spination of telsonic margin and diaeresis, and the presence of an appendix interna on the male first pleopod.

In addition to the different first and second pleopod structures, *C. temasek* is sexually dimorphic in other respects such as size (Fig. 5), the shape and length of the rostrum and certain morphometric ratios (Table 2). Males are generally smaller than the females. The size distribution and the absence of small females in the sampled population (Fig. 5) may suggest protandrous hermaphroditism. However, no size-related changes in the gonad and pleopod morphology were evident to support this. Thus, the observed pattern seems more likely to be a result of differential distribution of cohorts. Such temporal and spatial sex-related size differences have been reported for other *Caridina* species (e.g. see Shokita, 1979). In females, the rostrum is very similar to that of *C. excavatoides*, *C. tonkinensis* and *C. thambipillai* Johnson, 1961 while in males it is more like that of *C. propinqua*!

Table 2. Ratios (mean S.D.) of some morphometric characters of *Caridina temasek* selected from over 50 that were calculated.

	Males (N=10)	Females (N=10)
r/CL	0.59 0.07	0.63 0.02
t/CL	0.68 0.05	0.56 0.02
a/CL	0.96 0.11	0.69 0.01
s/CL	0.69 0.03	0.56 0.03
p3/CL	0.57 0.08	0.42 0.02
p5/CL	0.67 0.12	0.55 0.02
h1 l/w	2.42 0.02	2.43 0.02
h2 l/w	3.22 0.21	3.26 0.21
c1 l/w	3.51 0.39	3.43 0.35
c2 l/w	6.84 0.82	7.49 0.97
m1 l/w	3.26 0.04	3.00 0.19
m2 l/w	5.31 0.34	5.06 0.50
h1/c1	1.14 0.11	1.03 0.04
h2/c2	0.69 0.03	0.73 0.03
d3/p3	0.26 0.03	0.27 0.04
d4/p4	0.27 0.03	0.25 0.04
d5/p5	0.36 0.02	0.35 0.03
c3/p3	0.56 0.07	0.58 0.05
c4/p4	0.61 0.04	0.57 0.06
c5/p5	0.50 0.06	0.50 0.05
m3/p3	1.03 0.08	1.10 0.09
m4/p4	1.14 0.06	1.11 0.07
m5/p5	0.85 0.04	0.82 0.04

a, antennule peduncle length (from orbital margin); CL, post-orbital carapace length; s, sixth abdominal segment length; t, telsonic length; r, pre-orbital rostrum length; c, carpus length; d, dactylus length; h, hand (chela) length; m, merus length; p, propodus length; numbers refer to the corresponding pereiopods.

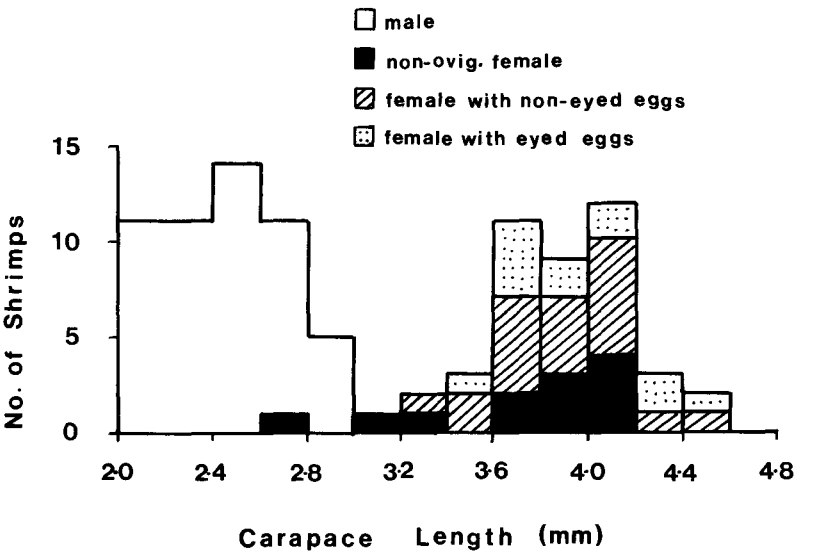

Fig. 5. Size distribution of *Caridina temasek*, new species, in the collection from Sime Road, Singapore.

Caridina temasek is the only known Malaysian species other than *C. excavatoides* which has relatively large eggs. The egg size suggests that these species exhibit abbreviated larval development. Preliminary rearings show that the eggs hatch into highly developed, non-feeding zoeae with yolk reserves with a development period not exceeding one month.

The sample sex ratio was 1.18M: 1F and of the females, 73% were ovigerous. Of these, 63% had eyed eggs while 37% had non-eyed eggs. The size range of the ovigerous females was from 3.15-4.45 mm CL and the number of eggs per female ranged from 22 to 113. The relationship between female size and the number of eggs carried was:

$$N = 0.076\ L^{4.096},\ r^2=0.90,\ P<0.01,\ n=14$$

where N = number of eggs and L = post-orbital carapace length.

Johnson (1961, 1963, 1969, 1973) carried out a rather detailed survey of the atyid shrimps of Peninsular Malaysia and Singapore, and the present discovery of the present new species comes somewhat as a surprise. Could it be that this species was recently introduced into Singapore? Many other freshwater organisms have been (see Johnson, 1973; Lim & Ng, 1990; Ng, 1990), including the palaemonid prawns *Macrobrachium lanchesteri* and *M. nipponense* (see Chong *et al.*, 1987). Johnson's collection of the Singapore *Macrobrachium* and *Caridina* is rather comprehensive, but admittedly, we have not been able to find any specimens of freshwater carideans in the ZRC which he might have collected from the Sime Road area, where the present specimens originated. None of his published records for *Macrobrachium* or *Caridina* mention this area. The present specimens were caught in enormous numbers and one scoop of the net can result in hundreds of specimens. This species is the only *Caridina* found in the Sime Road area and it has not yet been found anywhere else in Singapore. These observations make the 'introduction' theory probable. Nevertheless, the fact that these specimens do not fit the descriptions of any previously described species warrants their placement into a new species. Whether it was introduced into Singapore will remain unsettled for the time being.

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