

## THE FRESHWATER PRAWNS OF THE GENUS *MACROBRACHIUM* BATE, 1868 (CRUSTACEA: DECAPODA: PALAEMONIDAE) FROM BRUNEI DARUSSALAM

Daisy Wowor

Division of Zoology, Research and Development Center for Biology, Indonesian Institute of Sciences (LIPI), Jl. Raya Bogor Jakarta Km 46, Cibinong 16911, Indonesia. Current address: Department of Biological Sciences, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260

Satish C. Choy

Queensland Department of Natural Resources and Co-operative Research Centre for Freshwater Ecology, 80 Meiers Road, Indooroopilly, Queensland 4068, Australia

**ABSTRACT.** – The taxonomy of the Bruneian freshwater prawns of the genus *Macrobrachium* Bate, 1868 is treated. Material collected from throughout the country show that there are 11 species of *Macrobrachium* of which two [*M. lopopodus* and *M. leucodactylus*] are here described as new and seven [*M. clymene* (De Man, 1902), *M. equidens* (Dana, 1852), *M. idae* (Heller, 1862), *M. javanicum* (Heller, 1862), *M. lanchesteri* (De Man, 1911), *M. lar* (Fabricius, 1798) and *M. scabrificum* (Heller, 1862)] are new records for Brunei Darussalam. A key for the identification of the species is provided.

**KEY WORDS.** – Freshwater prawn, Palaemonidae, *Macrobrachium*, Brunei Darussalam, new species, new record, taxonomy.

---

### INTRODUCTION

According to Choy (1991), only three species of freshwater prawns of the genus *Macrobrachium* Bate, 1868 have been reported from Brunei Darussalam, viz. *Macrobrachium rosenbergii* (De Man, 1879), *M. pilimanus* (De Man, 1879) and *M. malayanum* (Roux, 1934). The largest and the most important commercial species is 'Udang Galah' (*M. rosenbergii*). So far, there has been no thorough systematic study of the genus *Macrobrachium* in Brunei Darussalam. This deficiency is now addressed in hope that once the systematics is reviewed more effort could go into studying the ecology of these species and subsequent sustainable management of the fished species.

The material examined is deposited in the Sabah State Museum (SSM), Kota Kinabalu, Sabah, Malaysia; Brunei Museum (BDM), Bandar Seri Begawan, Brunei Darussalam; Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore (NUS), Singapore; Division of Zoology, Research and Development Center for Biology, Indonesian Institute of Sciences [formerly Museum Zoologicum Bogoriense (MZB)],

Cibinong, Indonesia; Naturhistorisches Museum in Wien (NHMW), Vienna, Austria; Instituut voor Systematiek en Populatiebiologie [Zoologisch Museum Amsterdam (ZMA)], Universiteit van Amsterdam, Amsterdam and Nationaal Natuurhistorisch Museum [formerly Rijksmuseum van Natuurlijke Historie (RMNH)], Leiden, The Netherlands. Malay words used in the text are Sg. or Sungai [=River or stream], Kg. or Kampung [=Village] and Bukit [=Hill]. Although Brunei Darussalam is the proper name for the country, for convenience the rest of the paper will use its more widely known and shortened name of Brunei. All material from Brunei was collected by the second author unless otherwise stated, with exception of some specimens from Sabah for whom the name of the collector is unavailable. The abbreviations used are CL for carapace length, measured from the postorbital margin to the posterior median margin of the carapace; PL for postorbital teeth length, measured from the postorbital margin to the base of the last tooth on carapace; T4 for thoracic sternite 4. Descriptions are based on holotype specimens with paratypic variation included in parentheses. All synonymies provided are restricted, with readers requested to consult Holthuis (1950) and Chace & Bruce (1993) for details.

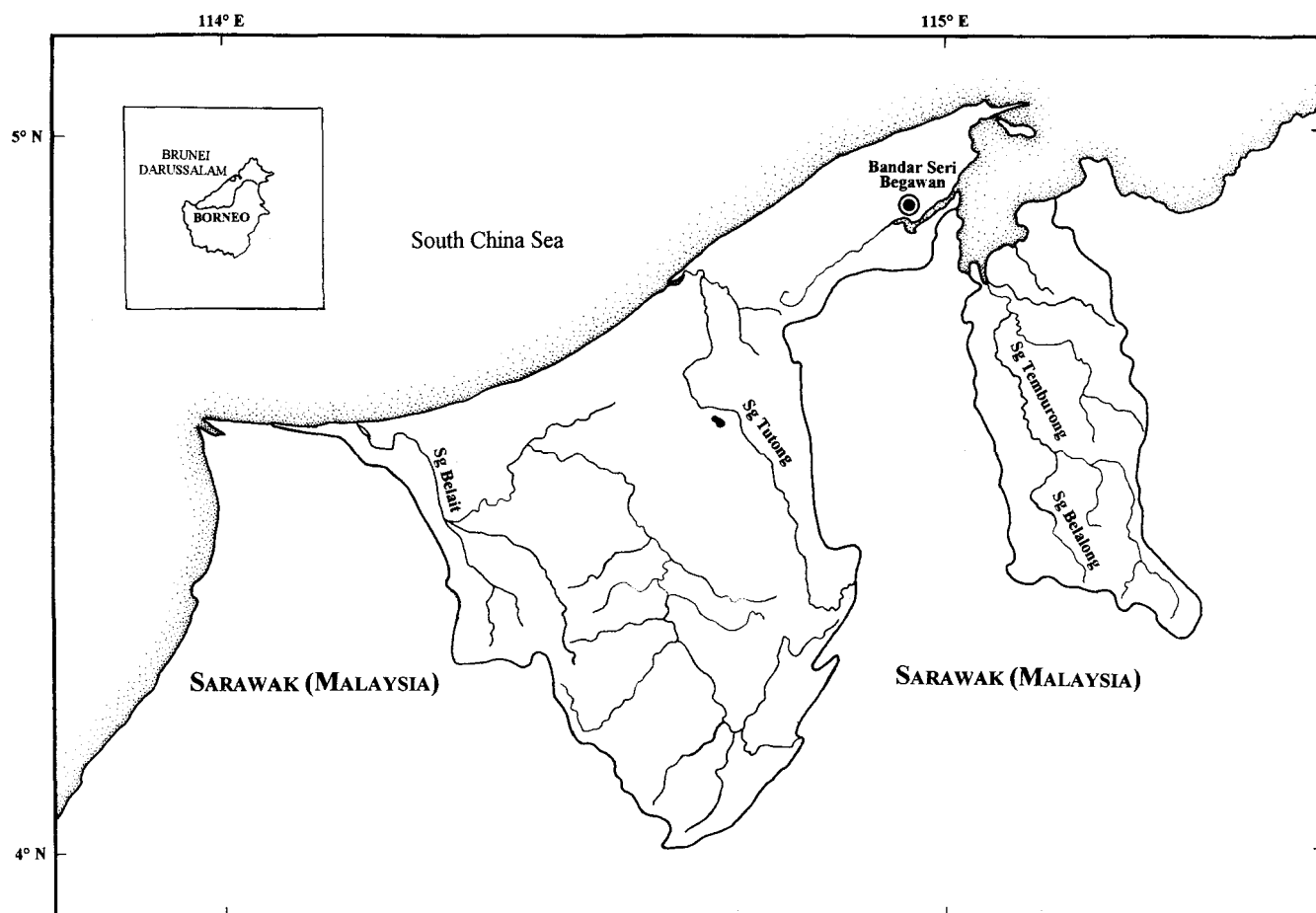


Fig. 1. Map of Brunei Darussalam showing drainages.

## TAXONOMY

### FAMILY PALAEMONIDAE RAFINESQUE, 1815

#### Genus *Macrobrachium* Bate, 1868

#### *Macrobrachium lopopodus*, new species (Figs. 2, 3)

**Material examined.** – Holotype - male (19.9 mm CL)(SSM 616), Ulu Sg. Sawatan, Kimanis, Papar District, Sabah, Malaysia, 3 Jun.1998.

Paratypes - 3 males (17.7–19.9 mm CL), 1 ovigerous female (13.7 mm CL)(SSM 616), same data as holotype; 2 males (16.1–16.7 mm CL)(SSM 622), Ulu Sg. Sawatan, Kimanis, Papar District, Sabah, Malaysia, 4 Jun.1998; 1 male (15.9 mm CL), 1 ovigerous female (10.0 mm CL)(SSM 639), Ulu Sg. Sawatan, Kimanis, Papar District, Sabah, Malaysia, 6 Jun. 1998; 26 males (5.8–20.7 mm CL), 5 females (5.8–13.6 mm CL), 8 ovigerous females (9.7–12.9 mm CL)(ZRC 2000.2409), Sg. Kimanis at Kp. Wolit, Ulu Kimanis, Papar District, Sabah, Malaysia, coll. R. Goh et al., 8 Dec. 2000; 5 ovigerous females (10.2–15.2 mm CL)(ZRC 2000.2410), Sg. Malamum, tributary to Sg. Mengalong, Sipitang District, Sabah, Malaysia, coll. R. Goh et al., 9 Dec.2000; 1 male (17.7 mm CL), 1 ovigerous female (16.1 mm CL)(MZB Cru 1457), Sg. Malamum, tributary to Sg. Mengalong, Sipitang District, Sabah, Malaysia, coll. R. Goh et al., 9 Dec. 2000; 6 males (7.0–21.7 mm CL), 1 female (9.1 mm CL), 9 ovigerous females (12.3–16.7 mm CL)(ZRC 2000.2411), Sg. Moyog at Kp. Kibunut, Petagas basin, Penampang District, Sabah, Malaysia, coll. R. Goh et al., 10 Dec.2000; 1 male

(11.9 mm CL), 1 ovigerous female (12.5 mm CL)(ZRC 2000.2412), Sg. Kinarom at Kp. Loguhang, ca. 6 km downstream of Serinsim Station, Kota Marudu District, Sabah, Malaysia, coll. R. Goh et al., 15 Dec.2000; 1 male (13.0 mm CL), 1 ovigerous female (8.8 mm CL)(ZRC 2000.2413), Sg. Belalong, Temburong District, 25 Aug.1990; 2 males (9.7–14.0 mm CL)(ZRC 2000.2414), Sg. Temburong at Batang Duri, Temburong District, 29 Aug.1990; 1 male (14.4 mm CL), 1 ovigerous female (9.3 mm CL)(RMNH), Sg. Temburong at Batang Duri, Temburong District, 29 Aug.1990; 1 male (8.5 mm CL)(ZRC 2000.2416), Sg. Engkabang, Temburong District, 8 Feb.1991; 1 male (19.2 mm CL)(BDM), Sg. Apan, Temburong District, 9 Feb.1991; 1 male (15.0 mm CL)(ZRC 2000.2415), Sg. Belalong at Batang Duri, Temburong District, 23 Jun.1991; 1 ovigerous female (9.9 mm CL)(BDM), Sg. Belalong at Kuala Belalong, Temburong District, 14–17 Jun.1995; 1 male (11.5 mm CL), 1 ovigerous female (11.3 mm CL)(ZRC 2000.2417), Sg. Belalong at Kuala Belalong, Temburong District, 14–17 Jun.1995.

**Diagnosis.** – A small-sized species with subcylindrical body form. Rostrum short, not reaching end of antennular peduncle, dorsal margin convex or slightly sinuous. Rostral formula: 5-6)10-12/1-3. Scaphocerite with outer margin slightly concave, about 2.4 times as long as wide. Second pereopods with carpus reaching beyond scaphocerite, carpus longer than merus, similar in form, unequal in size, covered by appressed scales. Major second pereopod of mature males bearing row of tubercles on fingers. Pre-anal carina present. Mobile mesial spine of exopod of uropod big and strong, longer than distolateral tooth. Eggs small (0.6x0.4 mm), numerous.

**Description.** – *Rostrum.* Short, 0.39 CL (0.37-0.50 in paratypes), reaching to or beyond second segment of antennular peduncle but never reaching end of third segment of antennular peduncle (Figs. 2A, B); moderately slender, maximum depth about equal to maximum dorsoventral diameter of cornea; lateral carina well developed, continuing almost to tip; dorsal carina distinctly bent downwards in front of orbit with tip directed anteriorly, armed with 12 teeth (10-12 in paratypes, mode 11), interspaces setose, teeth distributed subequally and tending to be more closely spaced above orbit than distally or post-orbitally, 5 teeth completely postorbital (5-6 in paratypes, mode 5), postorbital teeth on anterior 0.39 of carapace (0.35-0.43 in paratypes); ventral carina convex, armed with 2 teeth (1-3 in paratypes, mode 2), the first tooth at about proximal half.

*General cephalon.* Ocular cornea well developed, 0.13 CL (0.14-0.17 in paratypes), well pigmented, accessory pigment spot present. Inferior orbital margin moderately produced, obtuse, postantennular carapace margin evenly rounded. Antennal spine sharp, slender, continuing posteriorly as ridge, situated below lower orbital angle; hepatic spine smaller, situated behind and below antennal spine; branchiostegal suture running from hepatic spine to carapace margin. Carapace glabrous. Epistome trilobed, two lateral lobes separated by median lobe anteriorly, lobes bluntly rounded (Fig. 2C). Basal segment of antennular peduncle with sharply pointed stylocerite, stylocerite reaching to middle segment, anterolateral margin strongly produced as stout tooth, extending to almost end of second peduncular segment. Scaphocerite stout, reaching beyond rostrum, 0.45 times carapace length (0.46-0.54 in paratypes), length 2.37 times maximum breadth (2.30-2.57 in paratypes), lateral margin concave, distolateral tooth failing to reach end of lamella. Third maxilliped relatively stout, ultimate segment reaching beyond antennal peduncle; ultimate segment 0.77 (0.77-0.88 in paratypes) as long as penultimate and 0.60 (0.54-0.60 in paratypes) as long as antepenultimate; exopod shorter than ischiomerus (Fig. 2E).

*First pereopod.* Slender, exceeding scaphocerite by chela and distal half of carpus; fingers as long as palm; carpus 1.67 chela length (1.63-1.79 in paratypes), 1.08 merus length (1.04-1.18 in paratypes); scattered stiff setae present on all segments.

*Second pereopod.* Left and right pereopods similar in shape, unequal in size; not prominently elongated, moderately slender carpus, one-third distal merus of minor cheliped reaching beyond tip of scaphocerite; larger and more developed in males than females. *Major cheliped.* Appressed scales abundant in all segments; those on inner margin spiniform, pliable, like hard rubber; chela 1.87 CL (1.05-1.95 in male and 0.82 in female paratypes), length 6.83 times width (5.94-6.90 in paratypes); palm subcylindrical, somewhat broadened, width slightly greater than maximum merus width, length 4.10 times width (3.24-3.60 in male and 3.00 in female paratypes), slightly compressed, width 1.24 times depth (1.30-1.42 in male and 1.44 in female paratypes), outer and inner margins slightly convex to almost straight

and parallel, upper and lower margins rounded, outer margin more densely scaled than upper and lower margins, inner margin with more sparsely scattered big spines, scales of equal size on all surfaces; fingers 0.65 times palm length (0.71-0.85 in male and 1.10 in female paratypes), slightly gaping, cutting edges with well-developed teeth; dactylus with first big conical tooth at proximal 0.60, second at proximal 0.35, third at proximal 0.24, first and second teeth same size, third tooth smaller, 2 rows of tubercles along distal 0.40 with 8 and 2 tubercles on outer and inner side of cutting edges respectively, tubercles on outer side subequally distributed, tubercles on inner side distributed along distal 0.15; pollex with largest tooth of chela at proximal 0.50, other 6 smaller teeth distributed subequally between proximal 0.32 and articulation of fingers, size of small teeth decreases gradually towards articulation, 2 rows of tubercles along distal 0.50 with 8 and 6 tubercles distributed subequally on outer and inner side of cutting edges respectively; finger tips stout, strongly uncinat; carpus 1.19 palm length (1.18-1.24 in male and 1.72 in female paratypes), slightly subconical, length 5.85 times distal width (4.28-5.31 in male and 5.58 in female paratypes), 0.72 times chela length (0.64-0.69 in male and 0.82 in female paratypes), 1.43 times merus length (1.26-1.48 in male and 1.44 in female paratypes), outer margin more densely scaled than upper and lower margins, inner margin with more widely spaced big spines; merus subcylindrical, distribution and size of scales similar to carpus, ischium shorter than merus, strongly tapered, well developed median groove on upper margin, entire surface covered with equal sized scales. *Minor cheliped.* Generally resembling major cheliped; appressed scales abundant on all segments, those on inner margin spiniform, pliable like hard rubber; chela length 0.62 major chela (0.68-0.82 in male and 0.96 in female paratypes); palm length 1.10 fingers (1.01-1.09 in male and 0.95 in female paratypes), margins subparallel, width equal to maximum merus width; fingers slightly gaping, cutting edges with few scattered stiff setae; dactylus with first moderately large tooth at proximal 0.45, second is largest tooth of the chela at proximal 0.30, third at proximal 0.22; pollex with moderately large tooth at proximal 0.39, other 6 small teeth distributed subequally between proximal 0.33 and articulation of fingers with same structure as those on major cheliped; both fingers with oblique carina on about distal 0.60 of fingers; carpus shorter than chela, slightly subconical, 1.37 times palm length (1.33-1.44 in male and 1.59 in female paratypes) and 1.12 merus length (1.19-1.31 in male and 1.38 in female paratypes); merus subcylindrical; ischium shorter than merus, tapered, well developed groove on upper margin.

*Third pereopod.* Entire dactylus reaching beyond scaphocerite; appressed scales present on all segments; dactylus stout, curved, fringed with dorsolateral setae, tip claw type; propodus length 3.10 times dactylus (2.48-2.90 in paratypes), 5.91 times longer than wide (5.83-6.89 in paratypes); 9 ventral spines distributed along length of propodus, 2 distal most spines paired; carpus 0.62 times propodus length (0.56-0.63 in paratypes); merus 1.23 times propodus length (1.18-1.29 in paratypes), 1.78 times ischium length (1.93-2.25 in paratypes).

*Fourth pereopod.* Reaching by one-third dactylus beyond scaphocerite to just reaching by tip of dactylus at distal end of scaphocerite; appressed scales present on all segments; 9 ventral spines distributed along length of propodus, 2 distal most spines paired; merus 2.00 times ischium length (2.06-2.14 in paratypes).

*Fifth pereopod.* Tip of dactylus reaching three fourth proximal scaphocerite; appressed scales present on all segments; 6 ventral spines distributed along length of propodus; merus 1.05 as long as propodus (0.93-1.01 in paratypes), 2.05 longer than ischium (2.10-2.56 in paratypes).

*Abdomen.* Smooth, glabrous; pleurites 1-3 broadly rounded, pleurites 4 and 5 bluntly angular; sixth abdominal somite 1.36 times longer than fifth (1.09-1.69 in paratypes). *First pleopod.* Endopod kidney-shaped, inner margin concave, outer margin convex, apex rounded. *Second pleopod.* Appendices at about 0.3 of mesial margin length, endopod broadly rounded; appendix masculina about 1.5 times longer than appendix interna, more rigid than appendix interna, bearing numerous setae on anterior face. *Male abdominal sternites.* First three abdominal sternites with triangular median process; lateral margin of process on first sternite sloping ca. 50° from horizontal; process on second sternite similar in form but slightly larger than first, lateral margin sloping ca. 50° from horizontal; third same size and form to first (Fig. 2I). *Inter-uropodal sclerite.* Well developed, elevated as longitudinal pre-anal carina, carina medium-sized, slightly bigger than posterolateral teeth of sixth abdominal somite. *Telson.* Stout, 1.47 times sixth abdominal somite length (1.28-1.53 in paratypes), length 3.50 times median width (3.27-3.85 in paratypes), lateral margin straight, convergent, 2 pairs of dorsal spines at 0.52 (0.49-0.55 in paratypes) and 0.73 (0.71-0.77 in paratypes) respectively, posterior subventral margin sinuous with large rounded median point, median projection overreached by inner pair of posterior spines, inner pair of posterior spines about 2.5 times longer than outer pair, 10 pairs of long plumose setae between inner pair of spines. *Uropods.* Exceeding tip of telson, lateral margin of exopod straight, with acute distolateral tooth, mobile mesial spine slightly longer than distolateral tooth (Fig. 2K), exopod 1.87 times longer than broad (1.98-2.30 in paratypes), endopod smaller than exopod.

**Etymology.** – The specific name *lopopodus* is derived from Greek words *lopos* for scale and *podos* for foot, alluding to the scales present on pereopods. It is used as a noun in apposition.

**Size.** – Males reach larger sizes than females; the largest male recorded being 21.7 mm CL; the largest female 16.7 mm CL and ovigerous females are between 8.8 to 16.7 mm CL (n=30). The eggs are small, 0.6 by 0.4 mm, ovoid and numerous.

**Distribution and ecology.** – So far the species range is only known from Kota Marudu District, Sabah down to Temburong District, Brunei Darussalam. These sites are on

the northwest lowland of Borneo. Apparently, this species is common in lowland western Sabah, from 50 to 225 m above sea level, with the water neutral to slightly basic (pH 7.0-8.4). The small and young are found among vegetation along moderate flowing streams and the adults are hiding under big rocks in fast flowing rivers (H. H. Tan, pers. comm.). In Brunei, this species has been collected from only one river system and its lower tributaries. The altitudinal range is from about 20 m at Batang Duri (which is just above the tidal limit) to about 80 m at Sg. Apan and Sg. Engkabang. Stream orders range from 2-5 based on a 1:50, 000 topographic map with stream gradient of <10% and sandy to cobble and boulder substrate. Habitat and water quality were as follows: stream width 5-30 m, depth 0.2-1.5 m, velocity 0.1-0.5 m/s, water temperature 21-25°C and pH 5.4-6.5. The small egg size is typical of lowland species and suggests a planktonic larval stage. Most specimens were collected from the rocky areas, often among plant litter and were never found in high abundance, which may be due to either high competition and/or high predation pressures. At least 25 species of fish, many of which are predatory, have been recorded from these stream reaches (Choy, 1996; Choy et al., 1996).

**Remarks.** – *Macrobrachium lopopodus*, new species, belongs to the *M. horstii* group – a group whose members have pereopods 2-5 covered by scale-like spinules, the second pereopods similar in form but unequal in size, the cutting edges of the major second pereopod chela bearing rows of tubercles and the fingers being naked or bearing only few short stiff setae but not concealing the surface. However, *M. lopopodus* can be easily distinguished from *M. horstii* (De Man, 1892) by several characters. Examination of the syntypes of *M. horstii* shows that *M. lopopodus* has a shorter rostrum with its tip not reaching the end of the third segment of the antennular peduncle (vs. overreaching the end of the third segment of the antennular peduncle), longer postorbital teeth length (ratio of PL to CL 0.35-0.45 vs. 0.32-0.33), shorter and broader scaphocerite (ratio of scaphocerite to carapace length 0.45-0.54 vs. 0.54-0.58 and ratio of scaphocerite length to scaphocerite width 2.30-2.57 vs. 2.56-2.65 respectively), more robust third pereopod (ratio of propodus length to propodus width 5.83-6.89 vs. 7.78) with a relatively shorter merus (ratio of merus to ischium length 1.78-2.25 vs. 2.42), a fourth pereopod with a relatively short merus (ratio of merus to ischium length 2.00-2.14 vs. 2.53-2.56), and a fifth pereopod with a shorter merus (ratio of merus to ischium length 2.05-2.56 vs. 2.66).

Comparison of adult specimens of equivalent size (holotype of *M. lopopodus*, 19.90 mm CL and syntype of *M. horstii*, 20.00 mm CL) shows that the second pereopods of *M. lopopodus* (measured from tip of fingers to proximal margin of ischium) are distinctly longer than those of *M. horstii*; with the ratio of the major pereopod to carapace length being 4.63 vs. 2.86; and the ratio of the minor pereopod to carapace length being 2.87 vs. 1.98. The major second pereopod chela of *M. lopopodus* is also longer (ratio of chela to carapace length 1.87 vs. 1.18) and more slender (ratio of chela length to chela width 6.83 vs. 4.81). The carpus of the holotype

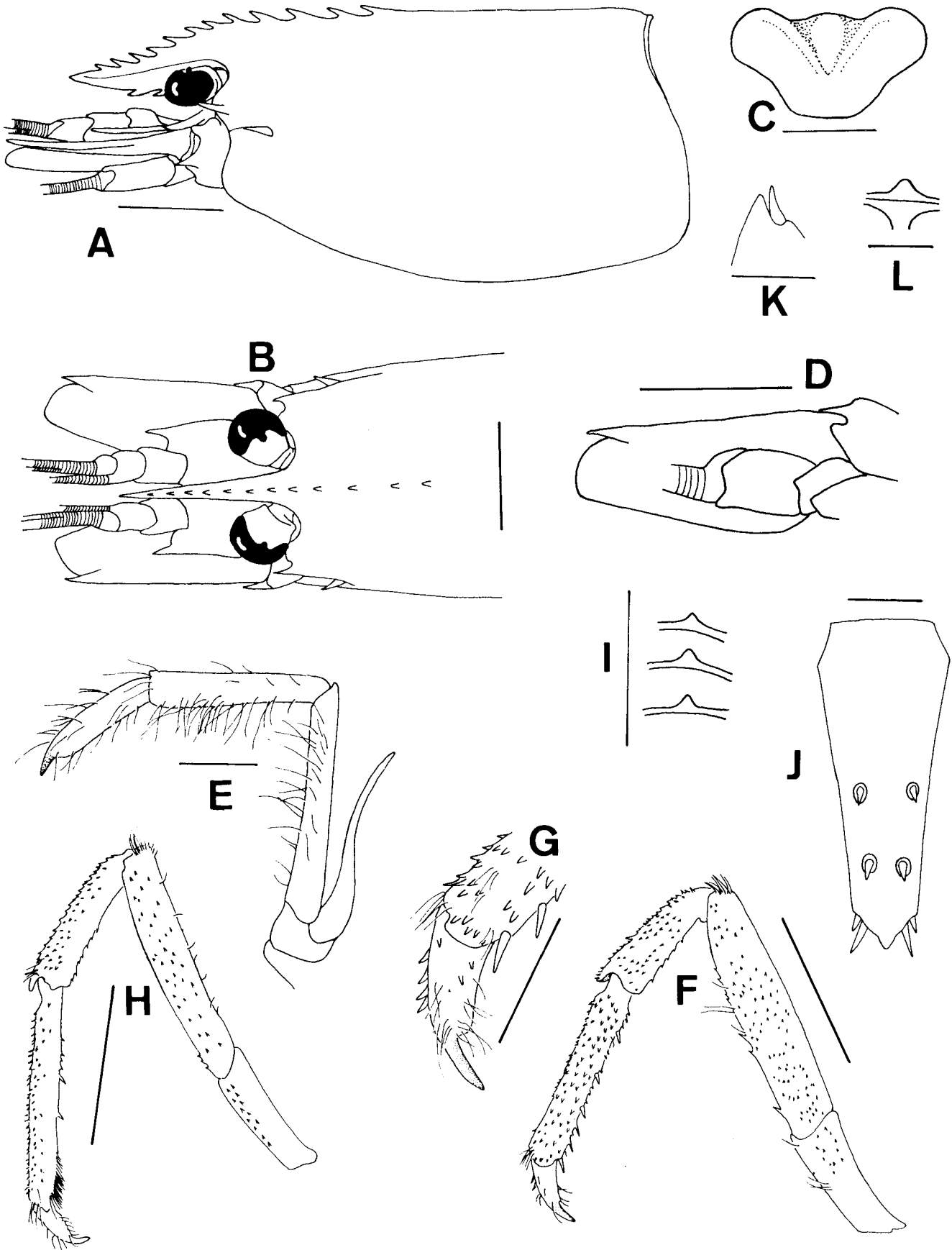


Fig. 2. *Macrobrachium lopodus*, new species. Holotype, male 19.9 mm CL, SSM 616. A, lateral view of carapace; B, dorsal view of carapace; C, epistome; D, scaphocerite; E, third maxilliped; F, third pereiopod; G, dactylus of third pereiopod; H, fifth pereiopod; I, abdominal sternite; J, telson; K, mobile mesial spine of exopod of uropod; L, T4. Setae omitted. Scales: A, B, D, F, H, I=5.0 mm; E, J=2.0 mm; C, G, K, L=1.0 mm.

of *M. lopopodus* is also longer (ratio of carpus to chela length 0.72 vs. 0.57), slightly longer than the palm (vs. slightly shorter than the palm), less conical (ratio of carpus length to distal carpus width 5.85 vs. 3.10) and longer than the merus (ratio of carpus to merus length 1.43 vs. 1.01). All *M. lopopodus* specimens examined show that the carpus of the major second pereiopod is distinctly longer than the merus; and that the minor second pereiopod chela has a shorter palm (ratio of palm to finger length 1.10 vs. 1.29) with the carpus longer than the palm (ratio of carpus to palm length 1.37 vs. 1.10).

The median process of the first three abdominal sternites of *M. lopopodus* male is much smaller than that of *M. horstii*; the lateral margin of the first process being relatively less steep (slope ca. 50° vs. 60° from horizontal); the second process with same angled lateral margin slope; the third process lateral margin is also relatively less steep (slope ca. 50° vs 65°). The pre-anal carina of *M. lopopodus* is also smaller and less steep than that of *M. horstii*.

*Macrobrachium lopopodus* also resembles *M. meridionalis* Liang & Yan, 1983, a member of the *M. horstii* group. The differences between *M. meridionalis* and *M. horstii* were discussed in detail by Yeo et al. (1999). The specimens of *M. meridionalis* from Hainan (type locality) and Tioman Island on hand for comparison agree quite well with the description and figures of that species by Liang & Yan (1983)



Fig. 3. *Macrobrachium lopopodus*, new species. Holotype, male 19.9 mm CL, SSM 616. A, first pereiopod; B, major chela of second pereiopod; C, carpus, merus and ischium of major cheliped of second pereiopod; D, minor cheliped of second pereiopod. Scales: 5.0 mm.

and Yeo et al. (1999). However, *M. lopopodus* can be differentiated from *M. meridionalis* by several characters, viz. i) shorter rostrum (tip does not reach vs. reaching end of third segment of antennular peduncle), ii) less dorsal and ventral teeth [10-12 (mode 11) vs. 11-14 (mode 13) and 1-3 (mode 2) vs. 2-4 (mode 3) respectively], iii) T4 (armed vs. unarmed), iv) major second pereiopod with relatively longer fingers (ratio of finger to palm length 0.65-0.85 vs. 0.53-0.56), longer carpus with regard to the palm and merus lengths (ratio of carpus to palm length 1.18-1.24 vs. 0.68-0.75 and ratio of carpus to merus length 1.26-1.48 vs. 1.08-1.22 respectively), relatively more slender carpus (ratio of carpus length to carpus distal width 4.28-5.85 vs. 2.79-3.05), v) absence of a longitudinal sulcus on the proximal part of the palm and carpus (vs. present), vi) fewer number of tubercles on the major second pereiopod chela (<9 tubercles vs. >9 tubercles), and vii) absence of appressed scales on all segments of the first pereiopods (vs. present on merus and ischium).

Besides *M. meridionalis*, there is also another species belonging to the *M. horstii* group in the region, i.e. *M. spinosum* Cai & Ng, 2001. This species is found in Halmahera, Bali and Sumatra, Indonesia (Cai & Ng, 2001). *Macrobrachium lopopodus* differs from *M. spinosum* by several characters, i.e. i) stouter scaphocerite (ratio of scaphocerite length to scaphocerite width 2.4 vs. 2.7), ii) major second pereiopod with the carpus longer than the palm (vs. shorter than the palm), relatively more slender carpus (ratio of carpus length to carpus distal width 5.9 vs. 4.3), and the carpus is distinctly longer than the merus (vs. slightly longer than the merus).

**Comparative material examined.** – *Macrobrachium horstii* - 3 males (16.7-20.0 mm CL) (ZMA De 102.555), syntypes, River near Palopo, Celebes (=Sulawesi). *M. meridionalis* - 11 males (11.3-21.0 mm CL)(ZRC), purchased, Qionghai Central Market, Hainan Province, China; 1 male (24.0 mm CL)(ZRC 1996.1719), Sg. Nipah, Tioman Island, Peninsular Malaysia.

#### *Macrobrachium leucodactylus*, new species

(Figs. 4-6)

**Material examined.** – Holotype – male (10.6 mm CL)(ZRC 2000.2418), tributary of Sg. Temburong-Machang, Temburong District, altitude 580 m, 27 Jun.1991.

Paratypes – 7 males (7.1-10.0 mm CL), 6 females (5.2-8.9 mm CL), 2 juveniles (4.5-5.0 mm CL)(ZRC 2000.2419), same data as holotype; 1 male (8.6 mm CL), 1 female (8.5 mm CL)(BDM), tributary of Sg. Temburong-Machang, Temburong District, altitude 580 m, 24 Jun. 1991; 2 females (6.3-10.1 mm CL)(ZRC 2000.2420), upper Sg. Babi, Temburong District, altitude 335 m, coll. S. Choy & S. Nyawa, 6 Jun.1991.

**Diagnosis.** – A relatively small-sized species with subcylindrical body form. Rostrum short, reaching to or slightly beyond second segment of antennular peduncle, dorsal margin faintly sinuous. Rostral formula: 2)7-9/2. Scaphocerite with outer margin straight, distolateral tooth



bent inwards, about 2.5 times as long as wide. Second pereopods with chela reaching beyond scaphocerite, carpus shorter than merus, similar form, unequal in size, covered by large spines. First abdominal sternite projection bilobed. Pre-anal carina absent. Mobile mesial spine of exopod of uropod smaller than distolateral tooth. The living specimens have white coloured fingers of the second pereopods (Fig. 4).

**Description.** – *Rostrum.* Short, 0.43 CL (0.38-0.51 in paratypes), reaching to or slightly beyond second segment of antennular peduncle but never reaching end of third segment of antennular peduncle (Figs. 5A, B); moderately slender, maximum depth slightly less than maximum dorsoventral diameter of cornea; lateral carina well developed, continuing almost to tip; dorsal carina bent downwards with tip slightly curved upwards, armed with 7 teeth (7-9 in paratypes, mode 7), interspaces setose, teeth distributed subequally (in holotype) and tending to be more closely spaced beyond orbit than above and post-orbitally (in paratypes), 2 teeth completely postorbital, postorbital teeth on anterior 0.27 of carapace (0.17-0.26 in paratypes); ventral carina convex, armed with 2 teeth, unarmed on proximal two-thirds.

*General cephalon.* Ocular cornea well developed, 0.19 CL (0.18-0.19 in paratypes), well pigmented, accessory pigment spot present. Inferior orbital margin moderately produced, obtuse, postantennular carapace margin evenly rounded. Antennal spine sharp, slender, situated below lower orbital angle; hepatic spine of similar size, situated behind and below antennal spine; branchiostegal suture running from hepatic spine to carapace margin. Carapace glabrous. Epistome completely divided into two lobes by median depression, depression broad anteriorly and gradually narrowing posteriorly, lobes bluntly rounded strongly divergent (Fig. 5C). Basal segment of antennular peduncle with sharply pointed stylocerite, stylocerite reaching to middle segment, anterolateral margin strongly produced as stout tooth, extending to almost end of second peduncular segment. Scaphocerite stout, reaching beyond rostrum, 0.52 CL (0.54 in paratypes), length 2.50 times maximum breadth (2.53-2.57 in paratypes), lateral margin straight, distolateral tooth bent inwards, not reaching end of lamella. Third maxilliped relatively stout, ultimate segment reaching beyond antennal peduncle; ultimate segment 0.91 (0.95 in paratypes) as long as penultimate and 0.54 (0.54-0.56 in paratypes) as long as antepenultimate; exopod longer than ischiomerus (Fig. 5E).

*First pereopod.* Slender, exceeding scaphocerite by chela; fingers as long as palm; carpus 1.50 chela length (1.35-1.39 in paratypes), 1.17 merus length (1.09-1.11 in paratypes); scattered stiff setae present on half proximal merus, ischium and basal segments.

*Second pereopod.* Left and right pereopods similar in shape, unequal in size; short, robust, about proximal half chela of minor cheliped reaching tip of scaphocerite; larger and more developed in males than females. *Major cheliped.* Spines abundant in all segments except ischium; chela 1.10



Fig. 4. Living colour of *Macrobrachium leucodactylus*, new species.

CL (paratypes same as holotype), length 5.07 times width (4.67-4.98 in paratypes); palm subcylindrical, somewhat broadened, width greater than maximum merus width, length 2.77 times width (2.56-2.57 in paratypes), slightly compressed, width 1.20 times depth (1.15-1.20 in paratypes), outer and inner margins almost straight to slightly convex and parallel, upper and lower margins rounded, outer margin more densely spinulose than upper and lower margins, inner margin least spinulose with more sparsely scattered large spines, spines on inner margin larger than those on other surfaces; fingers 0.75 times palm length (0.66-0.78 in paratypes), weakly gaping, cutting edges with developed teeth; dactylus with first tooth at proximal 0.57, remaining 3 small teeth distributed subequally between proximal 0.40 and 0.25; pollex with first tooth at proximal 0.48, remaining 5 smaller teeth distributed subequally between proximal 0.33 and articulation of fingers; both fingers with slightly oblique carina distally, fingertips stout, strongly uncinata; carpus 0.53 palm length (0.57-0.58 in paratypes), conical, length 1.84 times distal width (1.75-2.00 in paratypes), 0.30 times chela length (0.32-0.35 in paratypes), 0.73 times merus length (0.74-0.85 in paratypes), few widely spaced large spines present on all surfaces; merus subcylindrical, inner margin with few scattered smaller spines, other surfaces glabrous; ischium shorter than merus, strongly tapered, without median groove on upper margin, all surfaces glabrous except for few small spines on inner surface. *Minor cheliped.* Generally resembling major cheliped; spines abundant on all segments except ischium; chela length 0.89 major chela (0.91-0.94 in paratypes); palm length 1.10 fingers (1.10-1.16 in paratypes), margins subparallel, slightly convex, width greater than maximum merus width; fingers closing tightly without gap; dactylus with 5 small teeth distributed subequally along proximal 0.30 and articulation of fingers; pollex without tooth; both fingers with oblique carina distally; carpus shorter than chela, conical, 0.72 times palm length (0.65 in paratypes) and 0.79 merus length (0.70-0.76 in paratypes); merus subcylindrical; ischium slightly shorter than merus, tapered, without median groove on upper margin.

*Third pereopod.* Tip of dactylus reaching distal end of scaphocerite; short stiff setae present on all segments; dactylus stout, feebly curved, fringed with dorsolateral setae; propodus length 3.73 times dactylus (3.33-4.50 in paratypes), 8.20 times longer than wide (8.00 in paratypes); 12 ventral spines distributed along length of propodus, 2 distal most spines paired; carpus 0.54 times propodus length (0.44-0.45 in paratypes); merus 1.10 times propodus length (1.08-1.10

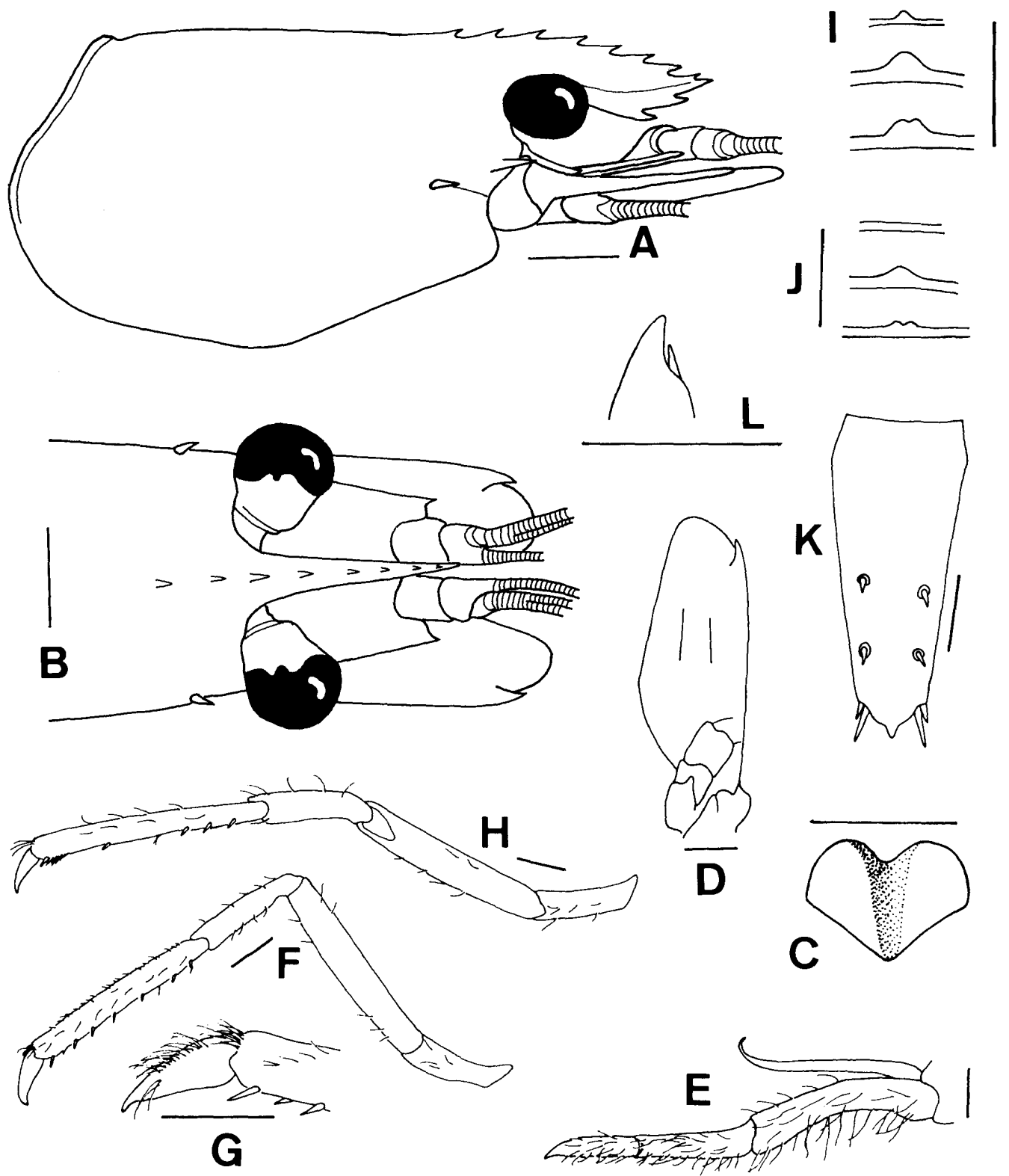


Fig. 5. *Macrobrachium leucodactylus*, new species. A, B, E-I, L, holotype, male 10.6 mm CL, ZRC 2000.2418; C-D, paratype, male 10.0 mm CL, ZRC 2000.2419; J, paratype, female 8.5 mm CL, BDM; K, paratype, female 10.1 mm CL, ZRC 2000.2420. A, lateral view of carapace; B, dorsal view of carapace; C, epistome; D, scaphocerite; E, third maxilliped; F, third pereiopod; G, dactylus of third pereiopod; H, fifth pereiopod; I, J, abdominal sternite; K, telson; L, mobile mesial spine of exopod of uropod. Setae omitted. Scales: A, B=2.0 mm; C-L=1.0 mm.



in paratypes), 2.05 times ischium length (2.10-2.29 in paratypes).

*Fourth pereopod.* Tip of dactylus reaching three fourths proximal scaphocerite; not covered with spines or scales, short stiff setae on all segments; 11 ventral spines distributed along length of propodus, 2 distal most spines paired; merus 2.09 times ischium length (1.95-2.22 in paratypes).

*Fifth pereopod.* Tip of dactylus reaching middle of scaphocerite; not covered with spines or scales, short stiff setae on all segments; 11 ventral spines distributed along length of propodus; merus 0.96 as long as propodus (0.93 in paratypes), 1.95 longer than ischium (2.21-2.24 in paratypes).

*Abdomen.* Smooth, glabrous; pleurites 1-3 broadly rounded, pleurites 4 and 5 bluntly angular; sixth abdominal somite 1.42 times longer than fifth (1.30-1.40 in paratypes). *First pleopod.* Endopod kidney-shaped, inner margin concave, outer margin convex, apex rounded. *Second pleopod.* Appendices at about 0.4 of mesial margin length, endopod

broadly rounded; appendix masculina about 2 times longer than appendix interna, more rigid than appendix interna, bearing numerous setae on anterior face. *Male abdominal sternites.* First three abdominal sternites with triangular median process; tip of first process bilobed, lateral margin sloping ca. 50° from horizontal; second process similar in size to first, tip unilobed, lateral margin sloping ca. 40° from horizontal; third much smaller but similar in form to second (Fig. 5I). In immature gonad female, first sternite with 2 low processes; second process triangular, lateral margin sloping ca. 30° from horizontal; third flat, without triangular median process (Fig. 5J). In young male, only first two abdominal sternites with triangular median process which resembles those of adult male but smaller in size. *Interuropodal sclerite.* Undeveloped, pre-anal carina absent. *Telson.* Stout, 1.35 times sixth abdominal somite length (1.29-1.50 in paratypes), length 3.33 times median width (3.23-3.46 in paratypes), lateral margin straight, convergent, 2 pairs of dorsal spines at 0.52 (0.52-0.53 in paratypes) and 0.74 in paratypes respectively, posterior subventral margin slightly convex to almost straight with acute median point,

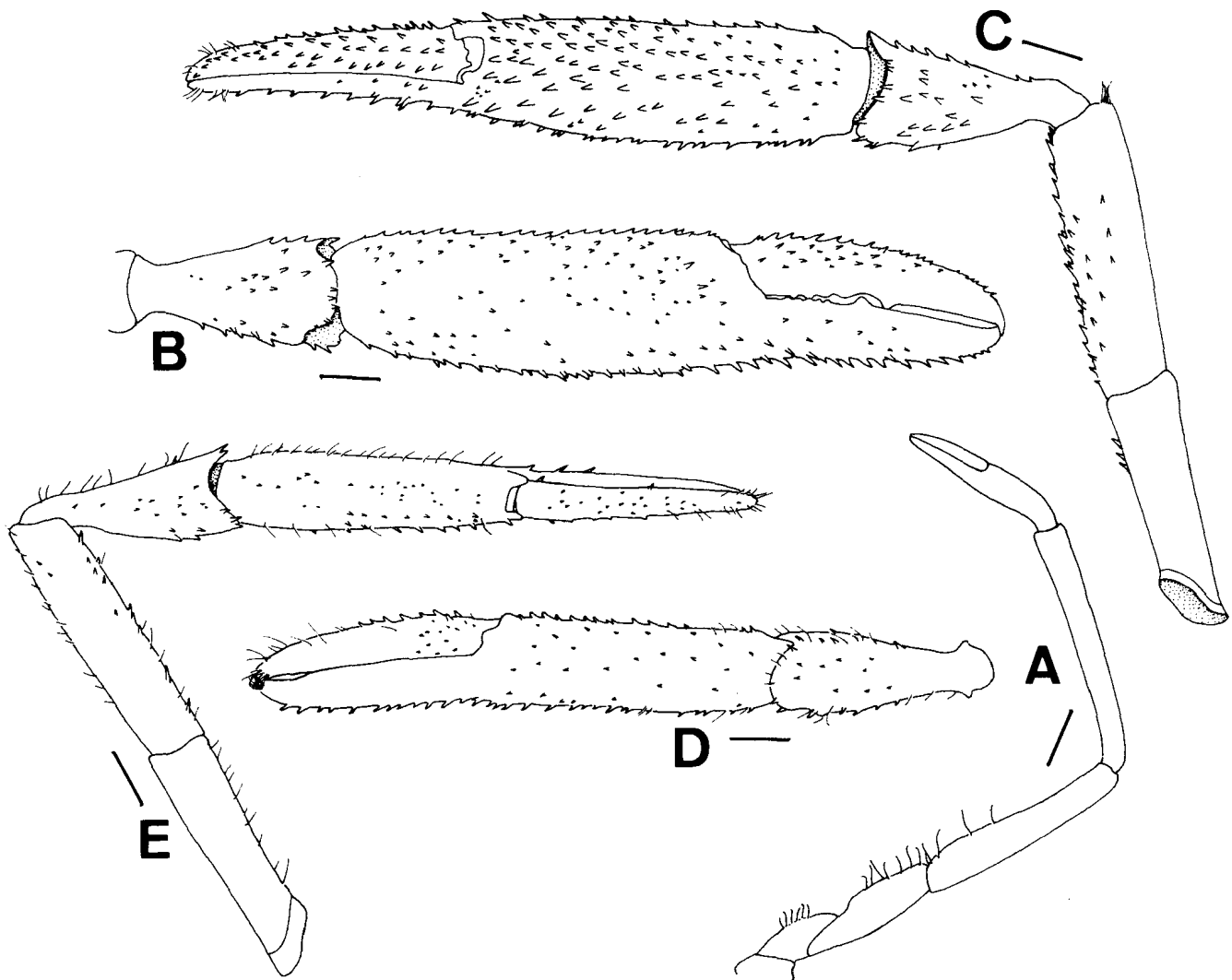


Fig. 6. *Macrobrachium leucodactylus*, new species. A, holotype, male 10.6 mm CL, ZRC 2000.2418; B-E, paratype, male 10.0 mm CL, ZRC 2000.2419. A, first pereopod; B, upper margin view of major chela of second pereopod; C, outer margin view of major cheliped of second pereopod; D, upper margin view of minor chela of second pereopod; E, outer margin view of minor cheliped of second pereopod. Scales: 1.0 mm.

median projection overreaching by inner pair of posterior spines, inner pair of posterior spines about 3 times longer than outer pair, 10 pairs of long plumose setae between inner pair of spines. *Uropods*. Exceeding tip of telson, lateral margin of exopod straight, with acute distolateral tooth, mobile mesial spine smaller than distolateral tooth (Fig. 5L), exopod 2.30 times longer than broad (2.05-2.14 in paratypes), endopod smaller than exopod.

**Etymology.** – The specific name *leucodactylus* is derived from the Greek words *leukos* for white and *dactylos* for finger, alluding to the white fingers of the species. It is used as a noun in apposition.

**Size.** – Males appear to reach larger sizes than females; the largest male recorded being 10.6 mm CL while the largest female recorded is 8.9 mm CL. Oviparous females are not available.

**Colour.** – Juveniles are translucent brown with reddish colouration between abdominal and appendage segments. Adults are either darker brown to blackish or brownish-red. The fingers of the chelae are white and the third to fifth pereopods are brownish white (Fig. 4).

**Distribution and ecology.** – So far, this species is only found from small headwater streams (stream orders 1-3) of the upper reaches of the Sg. Temburong-Machang in Temburong District, Brunei. These streams arise from near Bukit (Mt.) Belalong and flow northwards into Sg. Temburong at about 70 m above mean sea level. They occur in undisturbed dipterocarp rainforests with rocky substrates. Stream widths range from about 1-10 m, with a depth of 0.1-1.5 m, velocity of 0.1-0.3 m/s, and a water temperature of 23-26°C and pH of 5.8-6.2.

At Sg. Temburong-Machang, a spring-fed stream was surveyed from its source at about 610 m above sea level. No shrimps were collected from the source until about 580 m above sea level where they were found with three species of balitorid fish (*Gastromyzon lepidogaster*, *Neogastromyzon nieuwenhuisi* and *Glaniopsis hanitschi*), a species of freshwater snail (*Brotia* sp.), tadpoles and insect larvae. The shrimps are found in the pools and tributaries with slow flowing currents of the upper streams above waterfalls. This small-sized shrimp is not common in the streams below waterfalls where the water current is stronger and more species (up to 19 species) of fish occur. It may be that the shrimp prefers weaker currents and lower predation pressures. The three balitorids found above the waterfalls are mainly herbivores and/or insectivorous, while many of the species below the waterfalls are highly predacious (Choy et al., 1996).

**Remarks.** – This new species is close to *Macrobrachium clymene* (De Man, 1902), a species previously recorded from northern Sarawak, viz. the Baram River and Mulu National Park which borders Brunei Darussalam (De Man, 1902; Holthuis, 1950, 1979; Chace & Bruce, 1993; Ng, 1995). It is recorded from Brunei for the first time in this paper. The

*M. clymene* specimens examined for comparison study are from around Marudi, an area at the Baram River (type locality). They agree very well with the original description and figures of De Man (1902) and there is no reason to doubt their conspecificity.

Overall, *M. leucodactylus* looks like the long lancet rostral form of *M. clymene* (see discussion for *M. clymene*) with a subadult form (male juvenile form) of the second pereopod and the teeth on the cutting edges relatively small. However, *M. leucodactylus* can be easily separated from this form of *M. clymene* by several characters, viz. shorter rostrum (tip reaching to or slightly beyond second segment of antennular peduncle vs. overreaching end of third segment of antennular peduncle to almost reaching distal border of scaphocerite), fewer dorsal teeth [7-9 (mode 7) vs. 8-10 (mode 9)], shorter postorbital teeth length (ratio of PL to CL 0.17-0.27 vs. 0.29-0.35), third maxilliped with a longer ultimate segment (ratio of ultimate to penultimate length 0.91-0.95 vs. 0.78-0.89 and ratio of ultimate to antepenultimate length 0.54-0.56 vs. 0.45-0.50), first pereopods with a relatively shorter carpus (ratio of carpus to chela length 1.35-1.50 vs. 1.50-1.63), third pereopods with a relatively longer and broader propodus (ratio of propodus to dactylus length 3.33-4.50 vs. 2.85-3.15; ratio of propodus length to propodus width 8.00-8.20 vs. 8.33-11.75 respectively), and more slender telson (ratio of telson length to telson median width 3.23-3.46 vs. 2.67-3.18). Comparison of the holotype of *M. leucodactylus* and a male of the long lancet rostral form of *M. clymene* of 10.30 mm CL shows several character differences of the second pereopods, i.e. the major chela is relatively shorter (ratio of chela to carapace length 1.10 vs. 1.27), more slender (ratio of chela length to chela width 5.07 vs. 4.09; ratio of palm length to palm width 2.77 vs. 2.53) with relatively longer fingers (ratio of finger to palm length 0.75 vs. 0.52), and the minor chela has relatively longer fingers (ratio of finger to palm length 0.91 vs. 0.57).

The first three abdominal sternal projections of the *M. leucodactylus* male are different from that of all three forms of *M. clymene* (see *M. clymene*), viz. the first median abdominal process is bilobed and the lateral margin has a less steep slope (vs. unilobed and ca. 50° vs. 60° respectively), the first two processes are of the same size (vs. the second process is larger than the first one), the third process is the smallest with smaller lateral margin sloping (vs. the first and the third processes are same size and form and ca. 40° vs. 60° respectively).

*Macrobrachium leucodactylus* is also similar to the short high rostral form of *M. clymene*. However, in addition to differences in the form of their first three abdominal sternal projections, they can also be distinguished by their living colour (see below).

*Macrobrachium rhodochir* Ng, 1995, a sister species of *M. clymene*, is also similar to *M. leucodactylus*. However, comparison of a similarly sized paratype of *M. leucodactylus* (10.00 mm CL) (ZRC 2000.2419) and the holotype of *M. rhodochir* shows that there are several characters that can

be used to separate the two species, viz. shorter rostrum (tip slightly overreaching end of second segment of antennular peduncle vs. tip slightly overreaching third segment of antennular peduncle), shorter postorbital teeth length (ratio of PL to CL 0.22 vs. 0.35), and relatively more slender and longer scaphocerite (ratio of scaphocerite length to scaphocerite width 2.57 vs. 2.21; ratio of scaphocerite to carapace length 0.54 vs. 0.44 respectively), the second major pereopod chela is relatively more slender (ratio of chela length to chela width 4.98 vs 3.92) with longer fingers (ratio of finger to palm length 0.78 vs. 0.67), a more robust conical carpus (ratio of carpus length to carpus width 1.75 vs. 2.11) and shorter carpus (ratio of carpus to merus length 0.74 vs. 0.93). The second minor pereopod has longer fingers (ratio of finger to palm length 0.91 vs. 0.73) and a slightly shorter carpus (ratio of carpus to merus length 0.70 vs. 0.81), the third pereopods have longer and more slender propodus (ratio of propodus to dactylus length 3.33 vs. 2.78 and ratio of propodus length to propodus width 8.00 vs. 7.33 respectively), and a longer merus (ratio of merus to ischium length 2.10 vs. 1.61), the merus of the fourth and fifth pereopods is relatively longer (ratio of merus to ischium length 1.95 vs. 1.75 and 2.21 vs. 1.62 respectively), and the telson is proportionately more slender (ratio of telson length to telson median width 3.46 vs. 2.80) but shorter (ratio of telson to sixth abdominal segment length 1.29 vs. 1.62).

*Macrobrachium leucodactylus* appears to be a relatively small species compared to *M. clymene* and *M. rhodochir*. The largest male found so far is only 10.6 mm CL, while the largest male of *M. clymene* from Bukit Patoi, Temburong District is 18.3 mm CL (ZRC 2000.2440) and the largest male of *M. rhodochir* measures 11.4 mm CL (ZRC 1995.238, ZRC 1995.242).

The living colours of these three species also appear to be different. *M. leucodactylus* has the entire second pereopod brownish-red except for the white fingers but *M. clymene* has the entire leg brownish-purple to deep purple. In young males and females of *M. rhodochir*, the entire second pereopod is crimson to bright red while in large males these are reddish-purple to deep purple (Ng, 1995).

*Macrobrachium leucodactylus* also appears to occupy a more restricted habitat compared to *M. clymene* and *M. rhodochir*. It is found mainly in small streams with clear and slow flowing waters and the pH is more or less neutral. These streams are generally tributaries arising from the upper reaches of larger rivers in deep primary dipterocarp forest to an altitude of 335 to 580 m. *Macrobrachium rhodochir* on the other hand, occurs in lowland heath and peat swamp forests, in black waters with a relatively low pH (about 5.5) (Ng, 1995). While *M. clymene* inhabits a wide range of habitats, from lowlands to the middle stretches of rivers, from highly acidic to almost neutral waters (pH 3.4-6.9), in black and clear waters which are slow to moderate flowing. Sometimes, *M. clymene* is also found in disturbed areas such as streams near villages. *M. rhodochir* on the other hand, prefers faster flowing waters with rocky and/or sandy substrates (Ng, 1995).

**Comparative material examined.** – *Macrobrachium clymene* - 4 males (10.3-12.2 mm CL), 5 ovigerous females (6.5-7.5 mm CL), 55 specimens (ZRC), peat swamp forest at Marudi, Sarawak; 2 males (17.6 mm CL), 3 ovigerous females (6.4-13.5 mm CL), 20 specimens (MZB), stream nearby Ulu Linei, Marudi, Sarawak; 1 male (7.8 mm CL), 2 ovigerous females (8.3-8.5 mm CL)(ZRC), a stream nearby Rumah Gudang Garam school, Marudi, Sarawak; 2 males (13.2-13.3 mm CL), 11 specimens (ZRC), Sg. Poyut, Marudi, Sarawak; 1 male (11.2 mm CL), 1 ovigerous female (7.9 mm CL), 26 specimens (ZRC), a small stream nearby Telang Usan school, Marudi, Sarawak; 1 ovigerous female (7.9 mm CL), 24 specimens (ZRC), Sg. Dabai, Marudi, Sarawak; all materials were from streams of Baram river basin. *M. rhodochir* - male (9.5 mm CL)(ZRC 1995.236), holotype, small stream parallel to Tajur Waterfall, Sg. Tajur, Bako National Park, Sarawak; 1 male (11.4 mm CL), 1 female (9.2 mm CL), 2 ovigerous females (9.0-9.7 mm CL)(ZRC 1995.238), paratypes, Tajur Waterfall, Sg. Tajur, Bako National Park, Sarawak; 1 male (11.0 mm CL), 3 ovigerous females (8.9-9.9 mm CL)(ZRC 1995.240), paratypes, Tajur Waterfall, Sg. Tajur, Bako National Park, Sarawak; 2 females (9.7-9.8 mm CL), 1 ovigerous female (9.1 mm CL)(ZRC 1995.241), paratypes, waterfall at Sg. Seloar, Bako National Park, Sarawak; 7 males (8.1-11.4 mm CL), 1 ovigerous female (7.4 mm CL)(ZRC 1995.242), paratypes, upper stretches of Sg. Serait, Bukit Gondol, Bako National Park, Sarawak.

***Macrobrachium clymene* (De Man, 1902)**  
(Fig. 7)

*Palaemon* (*Macrobrachium*) *clymene* De Man, 1902: 794, Pl. 25 fig. 50.

*Macrobrachium clymene* – Holthuis, 1950: 210; 1979: 7; Chace & Bruce, 1993: 25.

**Material examined.** – 4 males (10.8-13.7 mm CL)(ZRC 2000.2421), Bumbungan Duabelas, Brunei Muara District, coll. Zohrah, 8 May.1996; 1 male (11.0 mm CL)(ZRC 2000.2422), stream near University of Brunei Darussalam Rest House, Jalan Recidency, Brunei Muara District, 20 Oct.1990; 1 male (12.1 mm CL), 2 females (6.2-7.9 mm CL), 1 juvenile (3.5 mm CL)(ZRC 2000.2423), stream near Bukit Saeh, near Bandar Seri Begawan, Brunei Muara District, 23 Apr.1989; 2 males (10.9-14.3 mm CL)(BDM), Jalan Kota Batu, half way between Bandar Seri Begawan and Muara, Brunei Muara District, 21 Jan.1991; 3 males (10.2-11.6 mm CL), 3 females (6.8-8.2 mm CL), 1 ovigerous female (8.2 mm CL)(ZRC 2000.2424), Jalan Kota Batu, half way between Bandar Seri Begawan and Muara, Brunei Muara District, 13 Mar.1991; 51 males (4.7-15.9 mm CL), 52 females (5.8-10.8 mm CL), 12 ovigerous females (6.0-11.7 mm CL), 15 juveniles (3.0-4.9 mm CL)(ZRC 2000.2425), Sg. Mengkubau, Mentiri Waterfall, two-thirds way from Bandar Seri Begawan to Muara, Brunei Muara District, coll. H. H. Tan, 14 May.1996; 1 male (15.4 mm CL), 1 ovigerous female (11.7 mm CL)(MZB Cru 1458), Sg. Mengkubau, Mentiri Waterfall, two-thirds way from Bandar Seri Begawan to Muara, Brunei Muara District, coll. H. H. Tan, 14 May.1996; 1 male (16.0 mm CL), 1 female (11.3 mm CL) (ZRC 2000.2426), Sg. Liang, Belait District, coll. Helen Pang, Aug.1992; 1 male (17.1 mm CL), 1 female (10.7 mm CL)(RMNH), Sg. Liang, Belait District, coll. Helen Pang, Aug.1992; 6 males (8.8-18.6 mm CL), 1 female (6.8 mm CL)(ZRC 2000.2427), Sg. Liang, Belait District, coll. Zohrah, 8 May.1996; 1 male (11.3 mm CL), 3 females (7.9-11.5 mm CL)(ZRC 2000.2428), stream near the foot of Bukit Teraja, Labi, Belait District, 18 Apr.1989; 19 males (5.0-11.6 mm CL), 5 females (5.0-6.7 mm CL), 3 ovigerous females (6.9-7.3 mm CL)(ZRC 2000.2429), Sg. Sepan drains to Sg. Ingei in heath forest, Belait District, coll. H. H. Tan, 11 May.1996; 7 males (5.1-8.2 mm CL), 2 females (7.0-7.4 mm CL), 1 ovigerous female (5.8 mm CL)(ZRC 2000.2430), small stream in Meranti/heath forest, Belait District, coll. H. H. Tan, 10 May.1996; 13 males (5.0-10.1 mm CL), 2 females (5.7-6.6 mm CL), 5 ovigerous females (6.8-

8.2 mm CL) (ZRC 2000.2431), peat swamp forest next to S. Sepan, Belait District, coll. H. H. Tan, 11 May.1996; 21 males (5.1-11.5 mm CL), 14 females (5.2-8.6 mm CL), 4 ovigerous females (6.3-7.3 mm CL), 4 juveniles (3.3-4.4 mm CL)(ZRC 2000.2432), Sg. Ingei, Belait District, coll. H. H. Tan, 9-11 May.1996; 3 males (5.8-6.4 mm CL), 3 females (7.4-9.6 mm CL), 1 ovigerous female (11.5 mm CL)(ZRC 2000.2433), small hill stream ca. 750 m after hot spring, Implasi Batu, Belait District, coll. H. H. Tan, 10 May.1996; 9 males (5.9-9.3 mm CL), 5 females (5.5-6.1 mm CL), 3 ovigerous females (6.9-7.4 mm CL), 2 juveniles (4.2-4.4 mm CL)(ZRC 2000.2434), Sg. Pelok drains to Sg. Ingei, Belait District, coll. H. H. Tan, 11 May.1996; 5 males (4.9-11.1 mm CL), 3 females (5.8-7.0 mm CL)(ZRC 2000.2435), Sg. Melilas in front of Kg. Melilas, tributary of Sg. Belait, Belait District, coll. H. H. Tan, 12 May.1996; 18 males (6.8-13.1 mm CL), 10 females (6.9-9.2 mm CL), 1 juvenile (3.5 mm CL)(ZRC 2000.2436), Sg. Jaung, stream below hot spring, Belait District, coll. H. H. Tan, 10 May.1996; 46 males (5.7-17.1 mm CL), 55 females (14.3 mm CL), 4 ovigerous females (5.7-12.8 mm CL), 4 juveniles (4.4-4.9 mm CL)(ZRC 2000.2437), Sg. Mendaram, Rampayoh, Labi, Belait District, coll. H. H. Tan, 19 May.1996; 8 males (8.4-13.5 mm CL), 2 females (7.4-9.5 mm CL), 1 ovigerous female (7.7 mm CL)(ZRC 2000.2438), Belait District, coll. K. K. P. Lim et al., May. 1993; 9 males (5.1-12.0 mm CL), 4 females (5.6-10.8 mm CL), 5 ovigerous females (6.6-8.0 mm CL), 4 juveniles (3.0-4.5 mm CL)(ZRC 2000.2439), Kg. Batang Tuan, Bangar, Temburong District, 9 Jan.1992; 1 male (18.3 mm CL), 1 ovigerous female (12.5 mm CL)(ZRC 2000.2440), Bukit Patoi, Temburong District, 17 Jan.1988; 1 male (15.7 mm CL), 1 ovigerous female (9.0 mm CL)(ZRC 2000.2441), stream at Bukit Patoi Forest Reserve, Temburong District, 17 Dec.1988; 6 males (8.0-14.8 mm CL), 2 juveniles (3.5-3.6 mm CL)(ZRC 2000.2442), Bukit Patoi Forest Reserve, Temburong District, 18 Dec.1988; 2 males (8.2-13.2 mm CL)(ZRC 2000.2443), a tributary of Sg. Belalong, Temburong District, 23 Jun.1991; 3 males (7.5-10.2 mm CL), 5 females (5.8-8.1 mm CL), 1 ovigerous female (9.4 mm CL), 3 juveniles (3.6-5.0 mm CL)(ZRC 2000.2444), a tributary of Sg. Belalong, Temburong District, 10 Feb.1991; 2 males (9.9-11.7 mm CL), 3 females (6.0-9.6 mm CL), 4 ovigerous females (9.7-11.4 mm CL)(ZRC 2000.2445), Sg. Apan, Temburong District, 9 Feb.1991; 3 males (12.2-13.9 mm CL), 3 ovigerous females (9.0-10.8 mm CL)(ZRC 2000.2446), upper Sg. Babi, Temburong District, 26 Jul.1992; 3 males (7.5-9.6 mm CL), 1 female (6.2 mm CL), 1 ovigerous female (9.3 mm CL), 1 juvenile (4.8 mm CL)(ZRC 2000.2447), upper Sg. Babi, Temburong district, coll. S. Choy & S. Nyawa, 6 Jun.1991; 2 males (9.5-11.1 mm CL)(ZRC 2000.2448), Sg. Esu, Temburong District, 8 Feb.1991; 1 male (9.1 mm CL)(ZRC 2000.2449), Sg. Temburong-Machang, Temburong District, altitude 400 m, 24 Jun.1996; 5 males (7.9-11.5 mm CL), 2 females (7.4-9.2 mm CL), 1 ovigerous female (9.5 mm CL)(ZRC 2000.2450), upper Sg. Sitam, below Pondok Busiri, Temburong District, 25 Jun.1991; 6 males (8.0-11.5 mm CL), 1 female (9.6 mm CL), 1 juvenile (4.2 mm CL)(ZRC 2000.2451), upper Sg. Sitam, below Pondok Busiri, Temburong District, 25 Jun.1991; 13 males (6.3-13.2 mm CL), 8 females (6.3-11.2 mm CL), 1 ovigerous female (9.7 mm CL), 1 juvenile (4.8 mm CL) (ZRC 2000.2452), Kuala Belalong, Temburong District, coll. Zohrah, 8 May.1996; 19 males (5.1-2.3 mm CL), 13 females (5.5-8.5 mm CL), 1 ovigerous female (8.4 mm CL), 11 juveniles (3.3-4.9 mm CL)(ZRC 2000.2453), stream near camp Kuala Belalong Field Study Centre, Temburong District, 10 Feb.1991; 5 males (5.3-13.6 mm CL), 6 females (5.0-9.3 mm CL), 1 ovigerous female (9.7 mm CL)(ZRC 2000.2454), Sg. Engkabang, Temburong District, 8 Feb.1991; 5 females (7.0-9.3 mm CL), 2 ovigerous females (8.5-9.3 mm CL), 1 juvenile (4.5 mm CL)(ZRC 2000.2455), Sg. Engkabang, Temburong District, 8 Feb.1991; 4 males (6.5-8.4 mm CL), 5 females (5.8-9.1 mm CL)(ZRC 2000.2456), Sg. Engkabang, Temburong District, 8 Feb.1991; 3 males (10.2-12.6 mm CL), 2 ovigerous females (9.1-9.4 mm CL)(ZRC 2000.2457), Sg. Engkabang, Temburong District, 8 Feb.1991; 1 male (8.7 mm CL)(ZRC 2000.2458), Sg. Belalong at Kuala Belalong, Temburong District, K. Lim, 14-17 Jun.1995; 1 ovigerous female (8.8 mm

CL)(ZRC 2000.2459), Sg. Belalong near Kuala Belalong Field Study Centre, Temburong District, 27 Jun.1991; 3 males (6.0-7.9 mm CL), 9 females (5.8-9.2 mm CL), 11 juveniles (3.0-4.8 mm CL)(ZRC 2000.2460), C/1 camp site, Kuala Belalong, Temburong District, 10 Feb.1991; 1 ovigerous female (8.2 mm CL)(BDM), C/1 camp site, Kuala Belalong, Temburong District, 10 Feb.1991; 5 males (7.2-13.9 mm CL), 1 female (8.8 mm CL), 2 juveniles (4.5-4.6 mm CL)(ZRC 2000.2461), C/3 camp site, Kuala Belalong, Temburong District, 10 Feb.1991.

**Remarks.** – This species has been described and figured very well by De Man (1902). The material from Brunei agrees with De Man's excellent work. According to De Man (1902), *M. clymene* varies to some degree, especially with regards to the rostrum. Generally his specimens from Baram River (see section *M. leucodactylus*) have lancet-shaped rostrums which is usually almost reaching the distal border of the scaphocerite, seldom shorter, and never shorter than the antennular peduncle. The rostral dorsal margin is slightly convex above the eye and the tip is directed horizontally forwards, but some of the specimens have the tip bent downwards and closely resembling that of *M. latimanus* (De Man, 1902: 794).

The *M. clymene* specimens with long lancet-shaped rostrums (Fig. 7A) have a dorsal margin with 7-10 teeth (mode 8-9), 3 of which are behind the orbit; while the ventral margin has 2-3 teeth (mode 2). Three males, one each from Sg. Pelok (9.3 mm CL) (ZRC 2000.2434), a stream in a peat swamp of Belait District (7.7 mm CL) (ZRC 2000.2431) and a stream at Kp. Batang Tuan of Temburong District (12.0 mm CL) (ZRC 2000.2439), have a long rostrum in which the tip reaches the distal border of the scaphocerite and has 10, 8 and 7 dorsal teeth respectively. The fully developed adult males have robust major second pereopods (ratio of chela length to chela width 4.09-5.22) and relatively short fingers (ratio of finger to palm length 0.52-0.81); with the fingers gaping and the large teeth on the dactylus and pollex well developed (Fig. 7F). However, most of these adult males have only one large tooth and two or three smaller teeth on the cutting edge of the dactylus, resembling that of a 50 mm long ovigerous female described by De Man (1902: 798). Only two adult males from Sg. Liang, Belait District [17.1 mm CL (RMNH) and 16.0 mm CL (ZRC 2000.2426)] have two large teeth on the dactylus, resembling De Man's pl. 25 fig. 50d. The major second pereopod of females and developing males also resemble the chelae figured by De Man (1902: pl. 25 figs. 50f, g). The other distinct character that De Man did not discuss is the form of the telson, which is relatively short, being 1.34-1.59 as long as the sixth abdomen somite. This form can be found in a wide range of habitats, from heath and peat swamp forests to disturbed areas such as streams near villages. All are in lowland areas at lower stretches of the river. The heath and peat swamp forests have black or clear waters with varying acidities (pH 3.7-5.5) such in Sg. Sepan, Sg. Melilas, Sg. Ingei and Sg. Pelok, all of which are at Belait District and disturbed forest in Bukit Patoi, Temburong District. In populated areas, the water is not so acidic (pH 5.7-6.6) such in several streams surrounding Bandar Seri Begawan, Brunei Muara District, Sg. Liang at Belait District, and Kp. Batang Tuan at Bangar, Temburong District. This form seems to inhabit slow moving

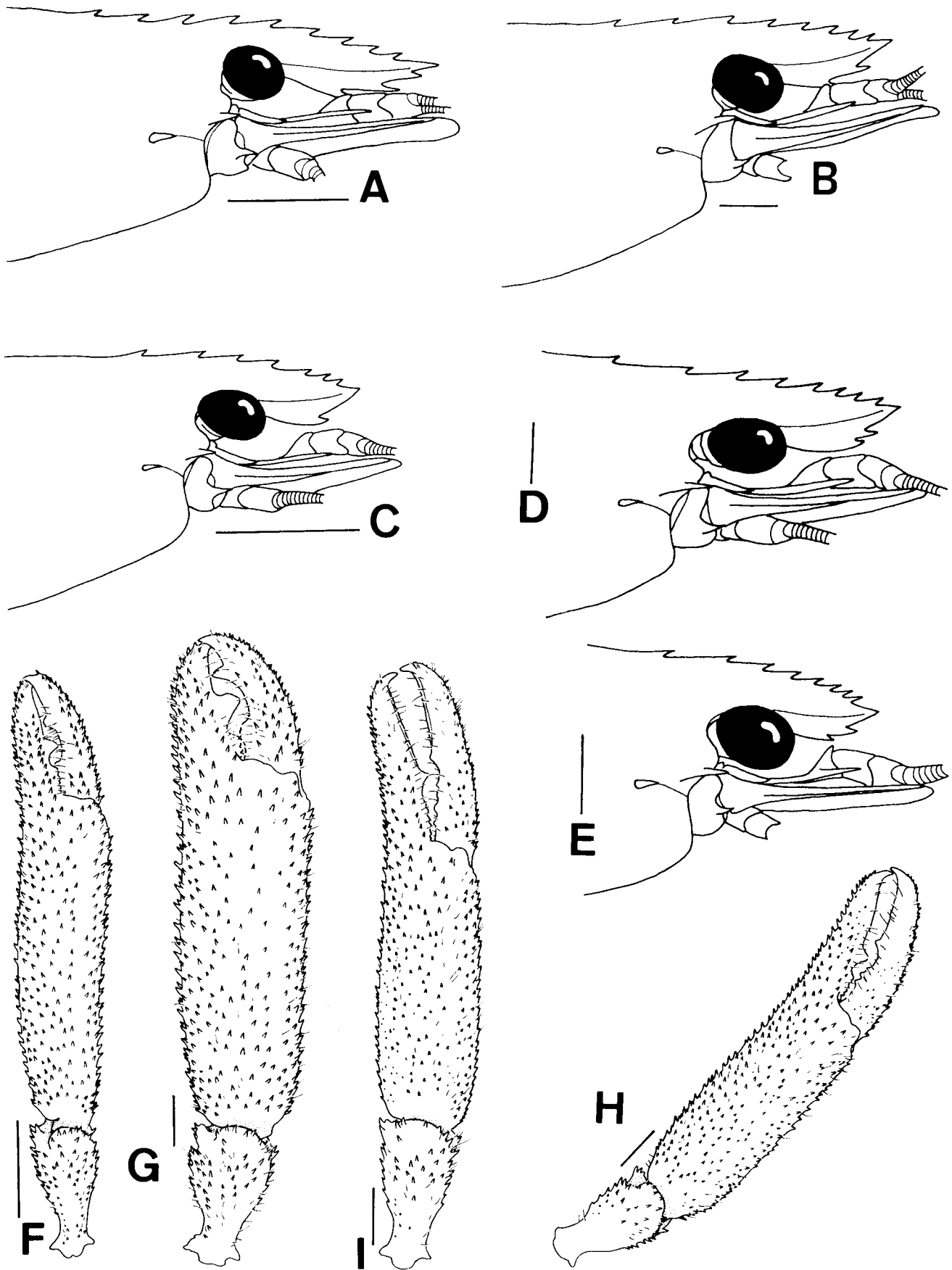


Fig. 7. *Macrobrachium clymene* (De Man, 1902). A, F, long lancet rostral form, male 15.7 mm CL, ZRC 2000.2441; B, H, short lancet rostral form, male 13.6 mm CL, ZRC 2000.2454; C, G, short high rostral form, male 13.2 mm CL, ZRC 2000.2443; D, I, short high rostral form, male 13.9 mm CL, ZRC 2000.2461; E, short high rostral form, male 10.1 mm CL, ZRC 2000.2450. A-E, lateral views of carapace; F, G, upper margin views of developed major chela of second pereopod; H, I, upper margin views of developing major chela of second pereopod. Scales: A, C, F=5.0 mm; B, D, E, G-I=2.0 mm.

waters, hiding among submerged root, leaf litter and fallen branches. Locals call it “Udang Kampung” which means village shrimp, and is an important part of their diet. We re-examined the “Udang Kampung” specimens identified by Choy (1991) as *M. malayanum* (Roux, 1934) and all are in fact *M. clymene* as presently defined. So far, *M. malayanum* is not known from Brunei Darussalam.

The *M. clymene* with short lancet rostral forms inhabit the middle stretch of the river. The rostrum does not extend or just reaches the end of the third segment of the antennular peduncle, the tip is directed horizontally forwards and the maximum depth is slightly higher than that of the typical long lancet rostral form (Fig. 7B). The dorsal margin of the rostrum has 8-9 teeth (mode 8), 1-2 (mode 2) of which are on the carapace, with the ventral margin having 1-2 teeth (mode 1). They are found in Sg. Belalong at Kuala Belalong and surroundings, lower parts of the upper Sg. Babi, Sg. Esu and Sg. Engkabang (all drain to Sg. Belalong and Sg. Temburong) which are typical lowland flowing rainforest streams at the middle stretch of the river. This form is also encountered at the cascades of Sg. Mendaram, hill streams near the foot of Bukit Teraja and Implasi Batu, and Sg. Jaung below the hot spring in Belait District. The water flow is slow to moderate. However, they also occupy lowlands at the lower stretches of the river where the water current is moderate such as in Sg. Mengkubau at Mentiri Waterfall. In this locality, the long lancet forms outnumber the short lancet forms. The water in Implasi Batu and Sg. Jaung is almost neutral (pH 5.7-6.6), and highly acidic in Sg. Mendaram and Sg. Mengkubau at Mentiri Waterfall (pH 4.4 and 3.7-3.9 respectively).

This short lancet rostral form of *M. clymene* is frequently found together with the short and high rostral form of the species. These two forms of *M. clymene* co-inhabit streams at Bukit Teraja and lower parts of the upper Sg. Babi. The three forms (long lancet, short lancet and short high) are also found together in hill streams at Implasi Batu, Sg. Mendaram at Rampayoh, Sg. Jaung and Sg. Belalong at Kuala Belalong, with the short high forms dominant. The opposite situation occurs in Sg. Mengkubau at Mentiri Waterfall, where both long and short lancet forms outnumber the short high form.

The rostrum of the short high rostral form of *M. clymene* does not extend or just reaches the end of the third segment of the antennular peduncle as in the short lancet form, but the tip is bent downwards (Figs. 7C-E). The dorsal margin of the rostrum has 7-8 teeth (mode 8), 1-2 (mode 2) of them are on the carapace, with the ventral margin having 1-2 teeth (mode 1). This short high rostral form of *M. clymene* is mainly found in small streams in pristine mixed dipterocarp forests such as in Sg. Apan, upper part of the upper Sg. Babi, Sg. Temburong-Machang and upper Sg. Sitam. All streams are in the Batu Apoi Forest Reserve at Sg. Belalong-Temburong watershed in Temburong District. The streams are at relatively high altitudes, typically torrential, with clear and neutral waters (pH 6-7). The substrate of the stream consists of stones, gravel and pebbles.

As discussed, between the two extreme (long lancet and short high) forms of rostrum present among the populations of *M. clymene*, there is an intermediate form, i.e. the short lancet rostral form. Although the lowland streams are occupied by the long lancet form and the relatively high altitude streams are dominated by the short high form, all three rostral forms of *M. clymene* are also found together in several places. The developed major male chelae of the long lancet and the short high forms closely resemble to each other, with a similar form and tooth structure (Figs. 7F, G). The same is also true of the developing major male chelae of the short lancet and the short high forms (Figs. 7H, I). Unfortunately, we do not have a developed male of the short lancet form which has a major second pereiopod. On the basis of the available information, it seems most rational to regard all three rostral forms present as belonging to one rather variable species, i.e. *M. clymene*, at least for the moment. The shape of the rostrum does appear to be associated with the habitat where the species lives and whether the water current is slow or fast.

**Distribution and ecology.** – So far this species is recorded only from the Baram River basin in northern Sarawak (De Man, 1902; Holthuis, 1979; Ng, 1995). This is the first time that *M. clymene* is reported from Brunei, which borders with Sarawak.

***Macrobrachium equidens* (Dana, 1852)**  
(Fig. 8)

*Palaemon equidens* Dana, 1852: 26.

*Palaemon* (*Eupalaemon*) *sundaicus* var. *baramensis* De Man, 1902: 770.

*Macrobrachium equidens* – Holthuis, 1950: 162, Fig. 36; Johnson, 1961: 56; Chace & Bruce, 1993: 25, Fig. 4; Naiyanetr, 1998: 32; Yeo et al., 1999: 226.

**Material examined.** – 2 females (7.3-7.9 mm CL), 1 juvenile (3.1 mm CL)(ZRC 2000.2462), Kg. Labu Piasau, Temburong District, 8 Jan.1992; 1 ovigerous female (13.5 mm CL)(ZRC 2000.2463), Sg. Barun at Lamunin, Tutong District, 14 May.1993; 1 male (13.0 mm CL)(ZRC 2000.2464), Sg. Melilas, tributary of Sg. Belait, Belait District, coll. H. H. Tan, 12 May.1996.

**Remarks.** – In Brunei, *M. equidens* occurs in two forms, i.e. with the rostrum curved upwards distally (Fig. 8A), or is almost straight (Fig. 8B). According to Holthuis (1950), based on the specimens of De Man (1902) from Sg. Baram and unpublished data of the first author, both forms are common in samples from Sg. Baram in nearby Sarawak where they show considerable variation in the shape of the rostrum. Apparently, the shape of the rostrum is not associated with age. The rostrum of the two forms in hand has 11 dorsal and 3-4 ventral teeth, which is in the range of the typical form, i.e. 9-13 and 4-7 teeth respectively.

In the present specimens, the fingers of the second pereiopods are as long as the palm and glabrous, the maximum width of the palm is greater than the width of distal end of the carpus and the carpus is slightly shorter than the chela (Fig. 8C). This form is common among small and young



specimens. In developed males, the fingers are about half of the palm and covered by pubescence. All the joints are spinulate and the maximum width of the palm is slightly smaller than the width of distal end of the carpus, as is evident in two males *M. equidens* specimens (22.6-28.4 mm CL) (ZRC 2001.2250) from Luzon, the Philippines. The form of the second pereiopods is strongly correlated with the age and size of the specimen.

In small and young ovigerous females, only the palm and the distal half of the carpus are covered with spinules. Overall, the second pereiopods are more slender compared with the typical developed male *M. equidens*.

Although *M. equidens* and *M. mamillodactylus* are easily confused, especially for females and subadult males or in absence of the second pereiopods (Chace & Bruce, 1993), they can usually be differentiated without too much trouble. Based on fresh material, Cowles (1914) recognised these two species by the colour pattern of the carapace and second pereiopods. There are also other characters that separate them. The maximum depth of the rostrum of *M. equidens* is slightly more than the maximum dorsoventral diameter of the eye cornea and the dorsal carina of rostrum is straight above the eye; whereas the maximum depth of the rostrum is distinctly more than the maximum dorsoventral diameter of the eye cornea and the dorsal carina of rostrum is slightly convex above the eye in *M. mamillodactylus* [10 males (23.1-27.5 mm CL)(MZB), Samarinda, East Kalimantan, Indonesia]. Other typical features of *M. equidens* include the inferior orbit being moderately produced, gently angular, the postantennular carapace margin being straight to slightly concave, the pre-anal carina is absent, and the mobile mesial spine of exopod of uropod is large and as large as the distolateral tooth.

**Distribution and ecology.** – The species has a wide distribution in Indo-West Pacific, from India to southern China, Southeast Asia, New Guinea, New Britain, the Solomon Islands, New Caledonia to Fiji (Choy, 1984). So far, this species had not been formally recorded from Brunei

Darussalam. Its presence, however, is expected.

*Macrobrachium equidens* is widely distributed in estuarine including mangroves. It prefers brackish water but sometimes penetrates beyond the tidal areas. The adult females need brackish or seawater to hatch their eggs.

***Macrobrachium idae* (Heller, 1862)**

*Palaemon idae* Heller, 1862b: 416, Pl. 2 figs. 40-41.  
*Macrobrachium idae* – Holthuis, 1950: 142, Fig. 33; Johnson, 1961: 56; 1963: 5; Chace & Bruce, 1993: 27; Naiyanetr, 1998: 32; Yeo et al., 1999: 226.

**Material examined.** – 1 male (21.0 mm CL)(ZRC 2000.2465), Sg. Barun at Lamunin, Tutong District, 14 May.1993.

**Remarks.** – Although the specimen examined has both second pereiopods missing, its identity can easily be determined by the presence of tubercles on the carapace, lower part of pleurites 1-6, uropods and telson. The inferior orbital margin is angular and the postantennular carapace margin is concave to almost straight, and the maximum depth of the rostrum is equal to the maximum dorsoventral diameter of eye cornea. It agrees very well with the syntype [*Palaemon idae* Heller, 1862: 1 male (22.4 mm CL) (NHMW Inv. 7696), Borneo]. Besides the long carpus which the width of distal end of the carpus being bigger than the maximum width of the palm (Heller, 1862b; Holthuis, 1950; Johnson, 1963; Chace & Bruce, 1993), this species is also characterized by the absence of the pre-anal carina and the mobile mesial spine of exopod of uropod being slightly smaller than the distolateral tooth.

**Distribution and ecology.** – The species is widely distributed in the Indo-West Pacific area, from Zanzibar to southern India, Thailand, Tioman Island, Singapore, Philippines, Indonesia and eastwards as far as the Admiralty Islands. It has been reported several times from Borneo, but this is the first time it is recorded from Brunei Darussalam.

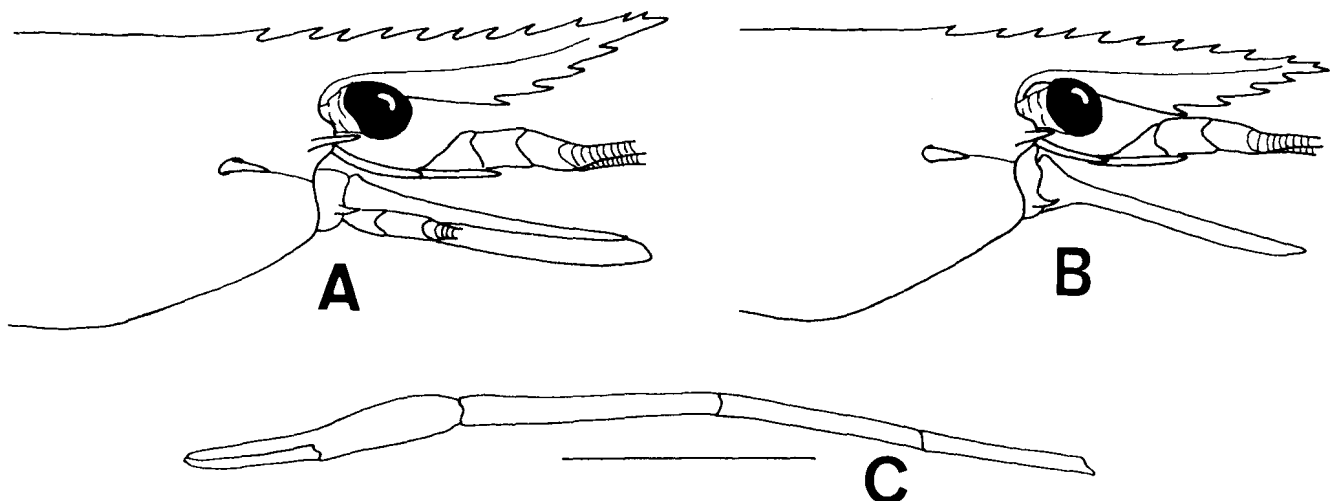


Fig. 8. *Macrobrachium equidens* (Dana, 1852). A, curved upward rostral form, female 7.9 mm CL, ZRC 2000.2462; B, C, almost straight rostral form, female 7.3 mm CL, ZRC 2000.2462. A, B, lateral views of carapace; C, chela of second pereiopod. Scales: A-C=5.0 mm.

This species occurs in large streams and rivers, from brackish to fresh waters where there is still tidal seawater influence. It prefers to hide under fallen trunks and is sometimes found amongst vegetation along the edges of streams where the water current is slow to almost stagnant (Johnson, 1966).

### *Macrobrachium javanicum* (Heller, 1862)

*Palaemon javanicus* Heller, 1862b: 421, Pl. 2 Fig. 48.

*Macrobrachium javanicum* – Holthuis, 1950: 190, Fig. 38 (part); Johnson, 1960b: 262 (part); 1963: 8 (part); Chace & Bruce, 1993: 29 (part).

**Material examined.** – 1 male (28.8 mm CL)(ZRC 2000.2466), Sg. Belalong at Kuala Belalong, Temburong District, coll. K. K. P. Lim, 14-17 Jun.1995.

**Remarks.** – This species was originally described by Heller (1862b) from Java. Its closely related species, *M. neglectum* (De Man, 1905) (found from Mergui Archipelago, Malaya, northeast Sumatra and west Borneo) was treated as a different species by De Man (1905) himself. It was later synonymed with *M. javanicum* by Holthuis (1950). However, Johnson (1960b) recognized *M. javanicum* as three sub-species, i.e. *M. javanicum javanicum*, *M. javanicum neglectum* and an unnamed taxon from Sulawesi. Ng & Choy (1990) recognised and treated *M. neglectum* as a distinct species from *M. javanicum*, noting that the characters cited by Johnson were diagnostic.

Overall, the present fully-grown adult male specimen on hand resembles *M. javanicum*. However, the number of the rostral tooth and the short carpus of the minor second pereopod are like those of *M. negelectum* described by Johnson (1960b). The dorsal margin of rostrum is slightly convex with 11 teeth, of which 3 of it are behind the orbit and the ventral margin with 3 teeth on it. The rostral armature is in the range of that of *M. javanicum* (9-14 dorsal, 3-3.5 post-orbital and 1-3 ventral teeth). The minor second pereopod has the carpus shorter than the palm. The specimen on hand can be distinguished from *M. neglectum* by the following characters: i) the distal tooth of the dactylus of the major second pereopod is situated at about distal one-third (vs. half), ii) the palm is somewhat stouter (vs. more slender) and more compressed (vs. subcylindrical) in comparing individuals of similar sizes, iii) all joints of second pereopods are provided with medium and small size spines (vs. large and medium size spines), the small spines of *M. javanicum* are appressed forwards while the medium size spines of *M. neglectum* are erected forwards, and iv) only the dorsal and branchiostegal areas of the carapace have small spines (vs. on whole surface of carapace).

Other specific characters of *M. javanicum* are, the inferior orbit is feebly produced, the postantennular carapace margin is straight to slightly concave, the pre-anal carina is present, and the mobile mesial spine of exopod of uropod is slightly smaller than the distolateral tooth.

**Distribution and ecology.** – This species is known from Java and south Sumatra. It was originally reported from Java, and was recorded from central Borneo by Von Martens (1868). His description however, is very short, and it is not possible to ascertain the identity of his specimens. His two specimens of 74 mm length had 10-11 dorsal and 4-6 ventral rostral teeth. Holthuis (1950) doubted about the identity of Von Marten's *M. javanicum* and thought his specimens were *M. trompii* instead. Unfortunately the specimens of Von Martens were lost during the wars (C. O. Coleman, pers. comm.) and therefore the presence of his *M. javanicum* in Borneo cannot be confirmed. So far, in Borneo, its closely related species, *M. neglectum*, is known only from Sarawak (Johnson, 1960; unpublished data of the first author). This is the first time this species is reported from Brunei and Borneo.

*Macrobrachium javanicum* occurs in large and small rivers in forested areas and where the water is fresh, but does not occur in high abundance. The river from where this species was collected in Brunei (Sg. Belalong) is in pristine rainforest and is a fourth order stream at an altitude of about 55 m and gradient of about 0.7%. It is about 15 m wide, 1.5 m deep, and with a sand-gravel-cobble-boulder substrate. Water velocity ranges between 0.3-2.5 m/s. Water quality is typical of a relatively unimpacted rainforest stream with temperature 24-25°C and pH 5.9-6.9.

### *Macrobrachium lanchesteri* (De Man, 1911)

*Palaemon paucidens* Lanchester, 1901: 568, Pl. 33 Fig. 4 (name preoccupied by *Palaemon paucidens* De Haan, 1844).

*Palaemon (Eupalaemon) lanchesteri* De Man, 1911: 264.

*Macrobrachium lanchesteri* – Holthuis, 1950: 139; Johnson, 1961: 56; 1963: 6; Chong & Khoo, 1988: 196; Naiyanetr, 1998: 32.

**Material examined.** – 1 female (6.9 mm CL)(ZRC 2000.2467), Kg. Balai, Temburong District, 9 Jan.1992; 1 female (7.7 mm CL), 1 juvenile (4.8 mm CL)(ZRC 2000.2468), Kg. Lepong Baru, Temburong District, 9 Jan.1992.

**Remarks.** – The specimens examined agree quite well with the description of this species by Chong & Khoo (1988), especially in the shape and dentition of the rostrum. The tip is armed with one or two apical teeth, which are separated from the rest by a distinct gap. The second pereopod has carpus that is longer than the chela and the merus. This is common among juveniles, females and young males. The inferior orbit is moderately produced and obtuse, the postantennular carapace margin evenly rounded, the pre-anal carina present, and the mobile mesial spine of exopod of uropod smaller than the distolateral tooth.

According to Ng (1994), the presence of this species in eastern Borneo (Sabah) is rather surprising, and it is possible that it was introduced from mainland Southeast Asia. The existence of this species in Brunei is also unexpected. It is found in villages where people grow fish in the ponds. The fingerling (fish stock) for the fishery activities may have come from Thailand or Peninsular Malaysia, and it is possible that this shrimp was accidentally mixed with the fish and

introduced together to Brunei.

**Distribution and ecology.** – This species is known from mainland Southeast Asia (Thailand and Peninsular Malaysia) and Singapore and the type locality is Singora (present Songkhla) in southern Thailand. It was recorded for the first time from Sabah, eastern Borneo by Ng (1994) and this is the second time it is being reported from Borneo and the first time from Brunei.

This species usually inhabits still or slow-moving waters in open country. It is thus a characteristic occupant of fish ponds, mine pools, rice-field ditches, drainage canals, and similar habitat. It has a wide temperature tolerance and can occur in habitats with very low oxygen content. However, it is not normally found in forested areas (Johnson, 1963, 1966). The streams from where the current specimens were collected are typical slow-flowing, lowland streams flowing through disturbed woodland. Water is coffee coloured due to high tannin content and other dissolved organic material. Dissolved oxygen and pH are generally low.

#### ***Macrobrachium lar* (Fabricius, 1798)**

*Palaemon Lar* Fabricius, 1798: 402.

*Macrobrachium lar* – Holthuis, 1950: 176, Fig. 37; Johnson, 1960a: 180; 1968: 220; Chace & Bruce, 1993: 31, Fig. 10; Naiyanetr, 1998: 32.

**Material examined.** – 1 male (8.6 mm CL)(ZRC 2000.2469), Tasek Lama, Bandar Seri Begawan, Brunei Muara District, coll. I. Das, 12 Jan.1992; 6 juveniles (2.5-4.8 mm CL) (ZRC 2000.2470), Kg. Bukit Labi, Belait District, coll. W. E. Booth & K. A. Salim, 9 Apr.1990; 1 male (8.8 mm CL)(ZRC 2000.2471), Kg. Lepong Baru, Temburong District, 9 Jan.1992; 1 ovigerous female (26.1 mm CL)(ZRC 2000.2472), Sg. Belalong, Temburong District, 24 Oct.1990.

**Remarks.** – Although juvenile and young *Macrobrachium lar* resemble *M. clymene* because of the similar shape and formula of their rostrum, they can be recognized easily by several other characters. The rostrum is relatively longer (greater than half vs. about half of the carapace length) and so is the carpus. In adults, the carpus of the second pereopod is as long as the merus, while in juveniles and young it is slightly shorter than the merus (vs. carpus distinctly shorter than the merus), the carpus has long conical shape (vs. short conical shape) and the palm is subcylindrical (vs. compressed), and also the pre-anal carina is present (vs. absent). However, the pre-anal carina is not yet developed in juveniles and young. The inferior orbital margin is moderately produced and obtuse, the postantennular carapace margin is evenly rounded and the mobile mesial spine of the exopod of the uropod is slightly smaller to almost as large as the distolateral tooth.

**Distribution and ecology.** – This species is one of the most common and widely distributed freshwater shrimps in the Indo-West Pacific region. It is known from East Africa to the Ryukyu Islands and the Marquesas Islands. De Man (1902) reported the species for the first time from Sg. Baram

under the name *Palaemon (Eupalaemon) lar*. The river is at the border of Brunei and therefore the presence of this species in Brunei is not surprising.

The sites from where the current material was collected are all wholly freshwater and range from rainforest to open woodland rivers and streams. This species inhabits freshwater, but the juveniles spend part of its life in brackish or saltwater. This evidence is supported by the places from where the juveniles and young are collected. While the ovigerous female was caught from a freshwater reach, it is expected to migrate to brackish water to release its eggs. However, it is also possible that the ovigerous female releases its eggs in the lower freshwater reaches and relies on river flow to transport the larvae to brackish water.

#### ***Macrobrachium pilimanus* (De Man, 1879)**

*Palaemon pilimanus* De Man, 1879: 181.

*Macrobrachium pilimanus* – Holthuis, 1950: 214 (part); 1979: 9, Fig. 1; Johnson, 1963: 10; Chong & Khoo, 1987a: 763; Choy, 1991: 126, 138; Chace & Bruce, 1993: 35 (part); Ng, 1995: 187.

**Material examined.** – 2 females (9.3-9.7 mm CL)(ZRC 2000.2473), Sg. Belalong, Temburong District, coll. J. Moran, 24 Oct.1990; 2 ovigerous females (8.4-9.7 mm CL) (ZRC 2000.2476), upper Sg. Babi, Temburong District, coll. S. Choy & S. Nyawa, 6 Jun.1991; 2 females (7.8-8.0 mm CL)(ZRC 2000.2474), Sg. Belalong near Kuala Belalong Field Study Centre, Temburong District, 27 Jun.1991; 1 ovigerous female (8.1 mm CL)(ZRC 2000.2475), Sg. Belalong at Kuala Belalong, Temburong District, coll. K. K. P. Lim, 14-17 Jun.1995.

**Remarks.** – The problem of the identity of the *M. pilimanus* species group is complex. Johnson (1960b) resurrected *M. leptodactylus* (De Man, 1892) and *M. malayanum* (Roux, 1934) from *M. pilimanus* in the context of Holthuis (1950), and considered the two species belonged to the *M. pilimanus* group. However, after a re-examination of the type of *M. malayanum* and other more recent material, Chong & Khoo (1987b) decided that *M. malayanum* does not belong to the *M. pilimanus* group and, is in fact, a senior synonym of *M. geron* Holthuis, 1950. Currently, there are 11 species known in this complex (Cai & Dai, 1999; Yeo et al., 1999).

The present specimens agree with the description of *M. pilimanus* sensu lato (Johnson, 1963; Chong & Khoo, 1987a; Ng & Choy, 1990). The rostrum is short and does not reach the end of the third segment of antennular peduncle and the carpus is cup-shaped and much shorter than the merus. However, the pubescence on the chela of the second pereopod is sparse and the merus is less inflated when compared with typical *M. pilimanus*. The chela is robust, half proximal of the fingers are covered lightly with pubescence while the rest of the fingers are glabrous with few scattered setae. The palm is provided with some scattered stiff setae with few spinules on its upper and lower margins. These characters are, however, generally common among young and developing females.

Although both *M. pilimanus* and *M. malayanum* have moderately produced and obtuse inferior orbital margin and evenly rounded postantennular carapace margin but *M. pilimanus* can be distinguished by the presence of pre-anal carina (vs. absent) and smaller mobile mesial spine of exopod of uropod than the distolateral tooth (vs. larger).

**Distribution and ecology.** – Members of *M. pilimanus* species complex are distributed throughout Sunda shelf, from northern Vietnam and southern Yunhan to Java and Borneo. *M. pilimanus* itself has been recorded from several areas in Borneo including Brunei (Holthuis, 1950, 1979; Johnson, 1963; Choy, 1991; Chace & Bruce, 1993; Ng, 1995). In Brunei this shrimp is called ‘Bengkutut’.

*Macrobrachium pilimanus* is an inhabitant of fast or torrential streams and is commonly found in both lowlands and hill country where such habitats are available (Johnson, 1966). It occurs in forested and less populated areas which are shaded, unpolluted, well-oxygenated and lower temperature waters. The current collection sites agree with the observations. It is a freshwater species which has large eggs and highly abbreviated larval development (Chong & Khoo, 1987a).

#### ***Macrobrachium rosenbergii dacqueti* (Sunier, 1925)**

*Palaemon carcinus* – Von Martens, 1868: 34; De Man, 1879: 165 (not *Cancer carcinus* Linnaeus, 1758).

*Palaemon (Eupalaemon) carcinus* – De Man, 1902: 763. (not *Cancer carcinus* Linnaeus, 1758).

*Palaemon whitei* (Guérin-Méneville MS) Sharp, 1893: 122. (nomen nudum).

*Palaemon d'Acqueti* Sunier, 1925: cxvii.

*Macrobrachium rosenbergii* – Holthuis, 1950: 111, Fig. 25 (part); Lindenfelser, 1984: 195; Chace & Bruce, 1993: 36, Fig. 15 (part); Naiyanetr, 1998: 33.

*Macrobrachium rosenbergii schenkeli* Johnson, 1973: 277.

*Macrobrachium rosenbergii dacqueti* – Holthuis, 1995: 148.

**Material examined.** – 2 males (69.2-80.9 mm CL), 2 ovigerous females (40.5-44.9 mm CL)(ZRC 1996.1682-1685), Bandar Seri Begawan, caught locally, Brunei Muara District, coll. H. H. Tan, 20 May. 1996.

**Remarks.** – Johnson (1973) separated *Macrobrachium rosenbergii* into two subspecies and named the western subspecies as *M. rosenbergii schenkeli*, which occurs on the Asiatic mainland and Malaysia, with the eastern subspecies being *M. rosenbergii rosenbergii*. The evidence for two subspecies was subsequently supported by allozyme work conducted by Lindenfelser (1984). This work extends the limit of the western subspecies to Borneo and Java. According to Holthuis (1995), the correct name of the western subspecies should be *M. rosenbergii dacqueti* (Sunier, 1925).

The present specimens have rostrums that exceed the scaphocerite by less to slightly more than one-third of its length. The rostrum is distinctly sigmoid and the dorsal basal crest is moderately high. The rostrum has 13-14 dorsal teeth, with three of them on the carapace and 13-14 ventral teeth.

The second pereopod has fingers which vary from 0.66-0.72 as long as the palm, and the carpus being slightly shorter to as long as the palm (0.94-1.02). The ratio of the second leg segments of the present specimens fit the eastern subspecies according to Johnson (1973), i.e. the dactylus is less than 0.75 of the palm length and the carpus is slightly longer than the palm and sometimes actually shorter than the palm. However, the first author's ongoing study on *M. rosenbergii* complex reveals that the relative length of dactylus and carpus is not a reliable character as the proportions of these segments varies with age and size. On the other hand, the spination of these legs and the dentition and basal shape of the rostrum agree well with the lectotype of *M. rosenbergii dacqueti* (Sunier, 1925) (male, 74.1 mm CL, RMNH D 1065, Java) and we are confident they are consubspecific.

Other specific characters of *M. r. dacqueti* are, the inferior orbit is moderately produced and obtuse, the postantennular carapace margin is evenly rounded, the pre-anal carina is present and the mobile mesial spine of exopod of uropod is smaller than the distolateral tooth (D. Wowor, unpublished data).

**Distribution and ecology.** – This subspecies occurs from the Asiatic mainland to the western border of Wallace's Line, i.e. Borneo and Java (Johnson, 1973; Lindenfelser, 1984; Holthuis, 1995). In Brunei (as elsewhere in the region), this large freshwater prawn is called ‘Udang Galah’ and is caught from most large rivers on a subsistence and small commercial scale and is also cultured locally for local consumption (Choy, 1991). This species is known to occur in all the major rivers in Brunei Darussalam (Brunei, Tutong, Belait and Temburong Rivers).

Although *M. r. dacqueti* is considered a freshwater species, occurring in rivers and lakes, it is also commonly collected in brackish/estuarine waters. Ovigerous females are seldom collected from fully freshwater habitats since breeding takes place in the estuarine stretches of rivers and perhaps sometimes in the sea. After breeding the females will return to freshwaters and the whole process is repeated several times (Johnson, 1973). The larvae also migrate upstream so that the juveniles inhabit the freshwaters until reaching the adult stage after which the breeding migration takes place.

#### ***Macrobrachium scabriculum* (Heller, 1862)**

*Palaemon scabriculus* Heller, 1862a: 527; Henderson & Matthai, 1910: 296, Pl. 17 figs. 7a-c, Pl. 18 Figs. 7a-p.

*Macrobrachium scabriculum* - Holthuis, 1950: 224 (part); Johnson, 1961: 57; 1963: 15 (part); Chace & Bruce, 1993: 37 (part); Yeoh et al., 1999: 231, Figs. 18-19, 20H.

**Material examined.** – 1 male (16.1 mm CL)(ZRC 2000.2477), Sg. Belalong, Temburong District, 25 Aug. 1990.

**Remarks.** – This species was originally described from Sri Lanka (formerly Ceylon). The present specimens on hand agree very well with the description given by Heller (1862a) and the syntypes examined [*Palaemon scabriculus* Heller,

1862: 1 male (10.05 mm CL), 1 female (10.00 mm CL) (NHMW Inv. 7705, Ceylon]. The present specimen is much larger than the largest male syntype and has more spinules on the carapace surface (dorsal and brachio-stegal regions). The syntypes only have spinules on the brachio-stegal area. The major second pereopod also has a more robust and relatively shorter carpus and merus compared to those of the syntypes, the spinules on these segments are more prominent, the palm and two-thirds of the proximal part of the fingers are completely covered in dense pubescence, the fingers are slightly shorter than the palm, and the carpus is shorter than the palm. In the syntypes, only the palm and one-fourth of the proximal part of the finger is covered by pubescence and the finger as long as the palm. This is not unexpected as the present specimen is larger than the syntypes. The inferior orbit is moderately produced and obtuse, the postantennular carapace margin is rounded, the pre-anal carina is absent and the mobile mesial spine of the exopod of the uropod is strong, being slightly larger than the distolateral tooth.

**Distribution and ecology.** – This species has been reported from the Indo-West Pacific region (Sri Lanka, southern India, Peninsular Malaysia, Tioman Island, Singapore, and Indian Ocean coast of Sumatra up to Sarawak in Borneo). It is now reported for the first time from Brunei. Generally this species occurs in riffle areas of streams and in flowing sections with cobble/boulder substrate. The present specimen was collected from a rainforest stream.

### GENERAL DISCUSSION

This is the first comprehensive study on the *Macrobrachium* species of Brunei Darussalam. It records 11 species of which two are new to science and seven are new records for the country. Based on their distribution, the *Macrobrachium* species of Brunei can be grouped into the following categories:

**Northwest Borneo:** *M. clymene*, *M. lopopodus* and *M. leucodactylus*. These species are distributed from northern Sarawak, Brunei Darussalam and up to northwestern Sabah. For the moment, *M. leucodactylus* is only known from the southeastern region of Brunei Darussalam. However, future surveys may reveal a wider distribution.

**South and Southeast Asia:** *M. scabriculum*, *M. rosenbergii dacqueti*, *M. lanchesteri*, *M. pilimanus* and *M. javanicum*. The first two species are found from Sri Lanka and India up to Borneo, while the other three species occur mainly in Southeast Asia, especially the last one which is known to inhabit only the eastern part of the Sunda Shelf.

**Indo-West Pacific:** *M. equidens*, *M. idae* and *M. lar*. These species are widely distributed throughout the Indo-West Pacific, from East Africa to Marquesas Islands in the central Pacific.

In the present study, *Macrobrachium mirabile* (Kemp, 1917) is not recorded from Brunei. However, this species has been reported from the Gangetic delta, Burma (=Myanmar),

Thailand, East Kalimantan and eastern Sabah (Kemp, 1917; Holthuis, 1950; Ng, 1994). The first author has also obtained this species from Sambas in West Kalimantan and Sg. Baram in Sarawak. It will thus not be a surprise if *M. mirabile* is recorded from Brunei in the future when more intensive work has been conducted.

### Key to the *Macrobrachium* species of Brunei Darussalam

1. Major second pereopod with carpus longer than merus; carpus subcylindrical ..... 2
  - Major second pereopod with carpus shorter than or equal to merus; carpus conical or cup-shaped ..... 6
2. Rostrum with 5-6 teeth on carapace; tip of rostrum not overreaching end of third segment of antennular peduncle; second pereopods covered by appressed scales; major second pereopod with each finger bearing row of tubercles (in developed males only) ..... *Macrobrachium lopopodus*, new species
  - Rostrum with 1-3 teeth on carapace; tip of rostrum overreaching end of third segment of antennular peduncle; second pereopods not covered by appressed scales; fingers of major second pereopod not bearing row of tubercles ... ..... 3
3. Post antennular carapace margin not rounded ..... 4
  - Post antennular carapace margin rounded ..... 5
4. Second pereopods with chela shorter than carpus; surface of carapace, telson and uropod tuberculate (in developed males only) ..... *Macrobrachium idae*
  - Second pereopods with chela longer than carpus; surface of carapace, telson and uropod spinulate (in developed males only) ..... *Macrobrachium equidens*
5. Rostrum straight; dorsal margin convex proximally, flattened distally; 6-11 dorsal teeth and 2-7 ventral teeth; dactylus and pollex of second pereopods covered by soft, dense pubescence (in developed males only); eggs medium sized (0.9x0.7 mm) ..... *Macrobrachium lanchesteri*
  - Rostrum sinuous with distal curved upwards; base of rostrum high; 11-14 dorsal teeth and 8-15 ventral teeth; dactylus of second pereopods covered by soft, dense pubescence; eggs small in size (0.6x0.5 mm) ..... *Macrobrachium rosenbergii dacqueti*
6. Rostrum with 4-6 teeth on carapace; major second pereopod with soft, dense pubescence on fingers and palm ..... 7
  - Rostrum with 1-3 teeth on carapace; second pereopods with chelae completely naked or bearing only a few scattered setae not concealing surface ..... 8
7. Tip of rostrum exceeding end of third segment of antennular peduncle; pre-anal carina absent; mobile mesial spine of exopod of uropod larger than distolateral tooth; rostrum with 14-16 dorsal teeth; carpus as long as or slightly shorter than merus; eggs small (0.6x0.4 mm) ..... *Macrobrachium scabriculum*
  - Tip of rostrum not exceeding or just reaching end of third segment of antennular peduncle; pre-anal carina present; mobile mesial spine of exopod of uropod smaller than distolateral tooth; rostrum with 9-13 dorsal teeth; carpus much shorter than merus; eggs large (1.7x1.2 mm) ..... *Macrobrachium pilimanus*
8. Pre-anal carina present; rostrum with 2-4 ventral teeth ..... 9
  - Pre-anal carina absent; rostrum with 1-2 ventral teeth ..... 10

9. Rostrum straight; chela of major second pereiopod subcylindrical; 1 big tooth on each finger .....  
 ..... *Macrobrachium lar*  
 - Rostrum convex; chela of major second pereiopod broad; 2 big teeth on each finger ..... *Macrobrachium javanicum*
10. Tip of rostrum reaching to or slightly beyond end of second segment of antennular peduncle; first abdominal sternal projection bilobed .....  
 ..... *Macrobrachium leucodactylus*, new species  
 - Tip of rostrum reaching mid point of third segment of antennular peduncle to anterior end of scaphocerite; first abdominal sternal projection unilobed .....  
 ..... *Macrobrachium clymene*

#### ACKNOWLEDGEMENTS

We would like to thank the staff of the Kuala Belalong Field Studies Centre and the Royal Geographical Society whom helped with logistics and sampling. Special thanks to Drs D.S. Edward, J.K. Charles and W. E. Booth for support and encouragement and to Mr Samhan Nyawa for his company on many of the challenging sampling trips. This research was partially funded by grant number UBD/T/RG.12 from Universiti Brunei Darussalam to the second author. Funding by NUS through a Raffles Museum fellowship and assistance by Dr. P.K.L. Ng is gratefully acknowledged. We also very grateful to Dr. P.K.L. Ng for his advice, encouragement and comments on the manuscript; to Dr. John W. Short of the Queensland Museum, Australia for the valuable comments and suggestions; to Mrs. Anna Wong (SSM), Dr. Peter C. Dworschak (NHMW), Dr. Charles H. J. M. Fransen (RMNH), Mr. Dirk Platvoet (ZMA), Mrs. C. M. Yang and Mr. K. L. Yeo (ZRC) for the loan of materials under their care; Mr. H. H. Tan and Mr. K. K. P. Lim (NUS) for obtaining specimens during their field work and providing information on their habitats; and Mr. Y. Cai (NUS) for the discussion.

#### LITERATURE CITED

Cai, Y. & A. Y. Dai, 1999. Freshwater shrimps (Crustacea: Decapoda: Caridea) from the Xishuangbanna region of Yunnan Province, southern China. *Hydrobiologia*, **400**: 211-241.

Cai, Y. & P. K. L. Ng, 2001. The freshwater decapod crustaceans of Halmahera, Indonesia. *Journal of Crustacean Biology*, **21**(3): 665-695.

Chace, F. A. & A. J. Bruce, 1993. The caridean shrimps (Crustacea: Decapoda) of the Albatross Philippine Expedition, 1907-1910, Part 6: Superfamily Palaemonoidea. *Smithsonian Contribution to Zoology*, **543**: vii + 152 pp, Figs. 1-23.

Chong, S. S. C. & H. W. Khoo, 1987a. Abbreviated larval development of the freshwater prawn, *Macrobrachium pilimanus* (De Man, 1879) (Decapoda, Palaemonidae), reared in the laboratory. *Journal of Natural History*, **21**: 763-774.

Chong, S. S. C. & H. W. Khoo, 1987b. *Macrobrachium malayanum* (Roux, 1934) stat. nov. (Decapoda, Palaemonidae) as a synonym of *M. geron* Holthuis, 1950, with notes on its distribution. *Journal of Natural History*, **21**: 903-913.

Chong, S. S. C. & H. W. Khoo, 1988. The identity of *Macrobrachium lanchesteri* (De Man, 1911) (Decapoda, Palaemonidae) from Peninsular Malaysia and Singapore, and a description of its first zoea. *Crustaceana*, **54**(2): 196-206.

Choy, S. C., 1984. On the freshwater palaemonid prawns from the Fiji Islands (Decapoda, Caridea). *Crustaceana*, **47**(3): 269-277.

Choy, S. C., 1991. The crustacean fauna of negara Brunei Darussalam. *The Brunei Museum Journal*, **7**(3): 117-153.

Choy, S. C., 1996. Distributional ecology of freshwater fishes in tropical rainforest streams of Borneo. In: Edwards D. S., W. E. Booth & S. C. Choy (eds.), *Tropical Rainforest Research-Current Issues*. Kluwer Academic Publishers, The Netherlands. Pp. 377-386.

Choy, S. C., S. A. Latif & Y. N. Yung, 1996. Resource use in a freshwater fish community of a tropical rainforest stream in northern Borneo. In: Edwards D. S., W. E. Booth & S. C. Choy (eds.), *Tropical Rainforest Research-Current Issues*. Kluwer Academic Publishers, The Netherlands. Pp. 307-314.

Cowles, R. P., 1914. Palaemons of the Philippine Islands. *The Philippine Journal of Science*, (D) **9** (4): 319-403, Fig. 1, Pls. 1-3.

Dana, J. D., 1852. Conspectus crustaceorum quae in orbis terrarum circumnavigatione, Carolo Wilkes e classe republicae foederatae duce, lexit et descripsit. *Proceedings of the Academy of Natural Sciences of Philadelphia*, **1852**: 10-28.

De Haan, W., 1833-1850. Crustacea. In: P. F. von Siebold, *Fauna Japonica sive Descriptio animalium, quae in itinere per Japoniam, jussu et auspiciis Superiorum, qui summum in India Batava Imperium Tenent, suscepto, annis 1823-1830 collegit, notia, observationibus et adumbrationibus illustravit*. 1-xxxii, 1x-xvi, 1-243, Pls. A-J, L-Q, 1-55, circ. Tab. 2. Lugduni-Batavorum. [Leiden].

De Man, J. G., 1879. On some species of the genus *Palaemon* Fabr. with descriptions of two new forms. *Notes from the Royal Zoological Museum of the Netherlands at Leyden*, **1**(41): 165-184.

De Man, J. G., 1892. Decapoden des Indischen Archipels. In: M. Weber, *Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien*, **2**: 265-527, Pls. 15-29.

De Man, J. G., 1902. Die von Herrn Professor Kükenthal in Indischen Archipel gesammelten Dekapoden und Stomatopoden. In: W. Kükenthal, *Ergebnisse einer zoologischen Forschungreise in den Molukken und Borneo. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft*, **25**(3): 467-929, Pls. 19-27.

De Man, J. G., 1905. Synonymical remarks about *Palaemon neglectus* nov. nom. and *Palaemon reunionnensis* Hoffm. *Notes from the Leyden Museum*, **26**: 201-205, Pl. 15.

De Man, J. G., 1911. On the West-African species of the subgenus *Eupalaemon* Ortm. *Notes from the Leyden Museum*, **33**: 261-264.

Fabricius, J. C., 1798. *Supplementum Entomologiae Systematicae*. Hafniae. 527 pp.

Heller, C., 1862a. Neue Crustaceen gesammelt während der Weltumseglung der k. k. Fregatte *Novara*: Zweiter vorläufiger Bericht. *Verhandlungen des Kaiserlich-königlichen Zoologisch-botanischen Gesellschaft in Wien*, **12**: 519-528.

Heller, C., 1862b. Beiträge zur näheren Kenntniss der Macrouren. *Sitzungsberichte der Akademie der Wissenschaften*, **45**(1): 389-426, Pls. 1-2.



- Henderson, J. R., & G. Matthai, 1910. On certain species of *Palaemon* from South India. *Records of the Indian Museum*, 4(4): 277-305, Pls. 15-18.
- Holthuis, L. B., 1950. The Decapoda of the Siboga Expedition, Part X: The Palaemonidae collected by the Siboga and Snellius Expeditions, with remarks on other species, Part I: Subfamily Palaemoninae. In *Siboga-Expeditie*, 39a<sup>9</sup>: 268 pp, 52 figs.
- Holthuis, L. B., 1979. Cavernicolous and terrestrial decapod crustacea from northern Sarawak, Borneo. *Zoologische Verhandelingen*, Leiden, 171: 1-47 pp.
- Holthuis, L. B., 1995. Notes on Indo-West Pacific Crustacea Decapoda III to IX. *Zoologische Mededelingen*, Leiden, 69(13): 139-151.
- Johnson, D. S., 1960a. Some aspects of the distribution of freshwater organisms in the Indo-Pacific area, and their relevance to the validity of the concept of an oriental region in zoogeography. *Proceedings of the Centenary and Bicentenary Congress of Biology*, Singapore, 1958: 170-181.
- Johnson, D. S., 1960b. Sub-specific and infra-specific variation in some freshwater prawns of the Indo-Pacific region. *Proceedings of the Centenary and Bicentenary Congress of Biology*, Singapore, 1958: 259-267.
- Johnson, D. S., 1961. A synopsis of the Decapoda Caridea and Stenopodidea of Singapore, with notes on their distribution and a key to the genera of Caridea occurring in Malayan waters. *Bulletin of the National Museum*, Singapore, 30: 44-79, Pl. 2.
- Johnson, D. S., 1963. Distributional and other notes on some freshwater prawns (Atyidae and Palaemonidae) mainly from the Indo-West Pacific region. *Bulletin of the National Museum*, Singapore, 32: 5-30.
- Johnson, D. S., 1966. Some factors influencing the distribution of freshwater prawn in Malaya. *Proceedings of Symposium on Crustacea*, Ernakulam, India, 1965, 1: 418-433.
- Johnson, D. S., 1968. The large freshwater prawn of Pulau Tioman. *Malayan Nature Journal*, 21: 220.
- Johnson, D. S., 1973. Notes on some species of the genus *Macrobrachium* (Crustacea: Decapoda: Caridea: Palaemonidae). *Journal of the Singapore National Academy of Science*, 3(3): 273-291.
- Kemp, S., 1917. Notes on crustacea decapoda in the Indian museum, IX: *Leander styliferus*, Milne-Edwards, and related forms. *Records of the Indian Museum*, 13(4): 203-231, Pls. 8-10, Figs. 1-7.
- Lanchester, W. F., 1901. On the crustaceans collected during the "Skeat" Expedition to the Malay Peninsula, together with a note on the genus *Actaeopsis*, Part I: Brachyura, Stomatopoda, and Macrura. *Proceedings of the Zoological Society of London*, 1901: 534-574, Pls.33-34.
- Liang, X. & S. Yan, 1983. New species and new records of freshwater shrimps (Crustacea Decapoda) from Hainan Island, China. *Oceanologia et Limnologia Sinica*, 14(3): 211-216.
- Lindenfelser, M. E., 1984. Morphometric and allozymic congruence: evolution in the Prawn *Macrobrachium rosenbergii* (Decapoda: Palaemonidae). *Systematic Zoology*, 33: 195-204.
- Linnaeus, C., 1758. *Systema naturae per Regna Tria Naturae, Secundum Classes, Ordines, Genera, Species, cum characteribus, differentiis, synonymis, locis*. Edition 10, 1: iii + 824 pp. Holmiae.
- Naiyanetr, P., 1998. *Checklist of crustacean fauna in Thailand*. Office of Environmental Policy and Planning, Bangkok, Thailand. 161 pp.
- Ng, P. K. L., 1994. On a collection of freshwater decapod crustaceans from the Kinabatangan river, Sabah, Malaysia, with descriptions of three new species. *Sabah Museum Journal*, 1(2): 73-92.
- Ng, P. K. L., 1995. The freshwater crabs and prawns (Crustacea: Decapoda) of Bako National Park, Sarawak, Malaysia, with descriptions of one new genus and three new species. *Raffles Bulletin of Zoology*, 43(1): 181-205.
- Ng, P. K. L. & S. C. Choy, 1990. Notes on some freshwater caridean prawn (Palaemonidae and Atyidae) from the Endau-Rompin area, Johore-Pahang, Peninsular Malaysia. *Raffles Bulletin of Zoology*, 38(1): 11-20.
- Roux, J., 1934. New freshwater decapod crustaceans from the Malay Peninsula. *Bulletin of the Raffles Museum*, 9: 28-33, Pl. 4.
- Sharp, B., 1893. Catalogue of the Crustaceans in the Museum of the Academy of Natural Sciences of Philadelphia. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 1893: 104-127.
- Sunier, A. L. J., 1925. Twee mededeelingen over Palaemoniden. *Tijdschrift Nederlandsche Dierkundige Vereeniging*, (2) 19: cxv-cxvii.
- Von Martens, E., 1868. Über einige Ostasiatische Süßwasserthiere. *Archiv für Naturgeschichte*, 34(1): 1-64, Pl. 1.
- Yeo, D. C. J., Y. Cai & P. K. L. Ng, 1999. The freshwater and terrestrial decapod Crustacea of Pulau Tioman, Peninsular Malaysia. *Raffles Bulletin of Zoology*, Supplement 6: 197-244.