

## COPIDOGNATHINES (ACARI: HALACARIDAE) IN MANGROVES OF SINGAPORE. I. DESCRIPTION OF THREE SPECIES

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**ABSTRACT:** – At least a dozen halacarid species inhabit algal mats on sediments, pneumatophores and stems in mangroves of Singapore. In this paper three of the six most abundant copidognathine species, *Acarothrix ampliomeris*, new species, *A. palustris* Bartsch and *Copidognathus rhombognathoideus*, new species, are diagnosed and the new species described. The genus *Acarothrix* is thought to be bound to tropical and warm-temperate areas with fluctuating salinity. The generic diagnosis is supplemented. *Copidognathus rhombognathoideus* is closely related to *C. lutarius* Bartsch, a species recorded from mangroves in the tropical eastern Indian Ocean.

**KEY WORDS.** – Singapore, mangrove, Halacaridae, Copidognathinae, new species, descriptions.

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### INTRODUCTION

Mangroves are characteristic elements in tropical intertidal estuaries and protected, muddy shores. Once 13% of the total land area of Singapore had been covered by mangroves, in the meantime only small patches remain (Liow, 2000). Mangroves are inhabited by a rich macro- and meiofauna, but the knowledge of the meiofauna is inadequate and the aquatic mite fauna almost unknown. Most studies on mangrove meiofauna deal with that of mudflats and/or leaf litter, with nematodes and harpacticoids generally being the dominant taxa (Sasekumar, 1994; Gee & Somerfield, 1997; Somerfield et al., 1998; Katiresan, 2000; Ólafson et al., 2000; Netto & Gallucci, 2003), and, if at all, only scattered records of mites. Whereas mites are rare on bare mudflats, they are abundant amongst the algal cover on pneumatophores, stems and branches (Gwyther, 2000; Proches et al. 2001, 2004; Proches & Marshall, 2002; Bartsch, 2003). Major elements of the mite fauna are the Halacaridae (Prostigmata), the only mite family completely adapted to life in the sea. The co-occurring Oribatida (Cryptostigmata), Astigmata and Mesostigmata are in the majority semiaquatic or terrestrial. The pontarachnids (Hydrachnidia, Prostigmata), truly aquatic and allied with fresh water mites, are present but in general rare in species. Six of the dozen most abundant halacarid species found in Singapore mangrove areas belong to the subfamily Copidognathinae, three are described below, descriptions of the others are in preparation.

### COLLECTING AREA, MATERIAL AND METHODS

Singapore lies in the tropics, at approximately 1°N. The island city-state is surrounded by the Johor Strait and Strait of Singapore which in turn are connecting the Straits of Malacca and the South China Sea. Mangrove areas studied on the southern coast are (1) in a small bay of the river Pandan (1°18'N 103°45'E) and (2) in a corner of the beach of the West Coast Park (1°18'N 103°46'E), on the northern coast (3) at the end of Lim Chu Kang Road (1°27'N 103°42'E) and (4) near an adjacent camp area (1°26'N 103°42'E).

The tide in Singapore is approximately semi-diurnal with considerable difference in the tidal amplitude (Hopper, 1998/99.). During the stay in Singapore in September/October 2004, the minimum and maximum tidal range varied from approximately 10 to 260 cm, respectively.

The samples were collected by the author. The mites were preserved and stored in ethanol and after clearing mounted in glycerine jelly. Holotypes and paratypes are deposited in Zoological Reference Collection of the Raffles Museum of Biodiversity Research (ZRC), additional material is deposited in the Senckenberg-Museum, Frankfurt (SMF) and Zoological Museum, Hamburg (ZMH).

Abbreviations used in the descriptions are: AD, anterior dorsal plate; ads, adanal setae; AE, anterior epimeral plate; ds-1 to

ds-5, first to fifth pair of dorsal setae of idiosoma, numbered from anterior backward; GA, genitoanal plate; GO, genital opening; OC, ocular plate(s); P-2 to P-4, second to fourth palpal segment; pas, parambulacral seta(e); PD, posterior dorsal plate; PE, posterior epimeral plate(s); pgs, perigenital setae, numbered from anterior backward; sgs, subgenital setae. The legs and their segments are numbered I to IV, leg segments are trochanter, basifemur, telofemur, genu, tibia, and tarsus.

In the descriptions, the position of a seta is given in a decimal system, with reference to the length of a plate from its anterior to posterior margin. The length of a leg segment is that along the dorsal margin. The setation formula of the legs starts with the trochanter, the parambulacral setae are excluded, the solenidia included. The diagnoses of the species are prepared on the basis of specimens from Singapore.

## SYSTEMATICS

### Genus *Acarothrix* Bartsch, 1990

**Diagnosis.** – Dorsum with five pairs of dorsal idiosomatic setae, pair of adanal setae on anal plate and three to four pairs of gland pores; posterior pair of pores on cones. Pair of ds-3 in about middle of OC. AE with epimeral pores. Male genital sclerites with pair of external genital acetabula. Palps four-segmented, second segment with one seta, third segment without setae, fourth segment with three setae in basal whorl. Genua shorter than telofemora and tibiae. Trochanters I to IV with one seta each. Basifemur II with three setae. Tibiae I to IV with two ventral setae each. Tarsus I with large ventral seta and one or two small apical setulae; tarsi II to IV without ventral setae. All tarsi with pair of parambulacral setae. Solenidion of both tarsus I and II in dorsolateral position. All tarsi with paired claws, central sclerite with claw-like process.

**Type species.** – *Acarothrix palustris* Bartsch, 1990.

### *Acarothrix ampliomeris*, new species

(Figs. 1-16)

**Material examined.** – Holotype: Female, ZRC.ARA.480, Singapore, northern coast, end of Lim Chu Kang Road, mangrove, *Cladophora* mat (Chlorophyta) on muddy and sandy sediment, coll. I. Bartsch, 7 Oct.2004.

Paratypes: One male, ZRC.ARA.481, collecting data as above; one larva, ZRC.ARA.482, collecting data as above; one male, SMF, collecting data as above; one female, ZMH, collecting data as above; one male, ZMH, collecting data as above.

**Diagnosis.** – Length of idiosoma 294-325  $\mu\text{m}$ . OC elongate; corneae lacking. PE more than half length of idiosoma. Pair of ds-2 in striated integument. Gland pores between ds-4 and ds-5 small, almost inconspicuous. AE very wide. Male with 20-22 pgs. All tibiae with one bipectinate ventromedial and one long, smooth ventral seta; bipectinate seta on tibia II much

longer than height of that segment; bipectinate seta of tibia III and IV wide. Claws with delicate accessory process but no pecten.

**Etymology.** – The anterior portion is unusual wide, hence the specific name *ampliomeris*, broad shouldered, derived from *amplus* (Latin), wide, broad and *umerus* (Latin), shoulder.

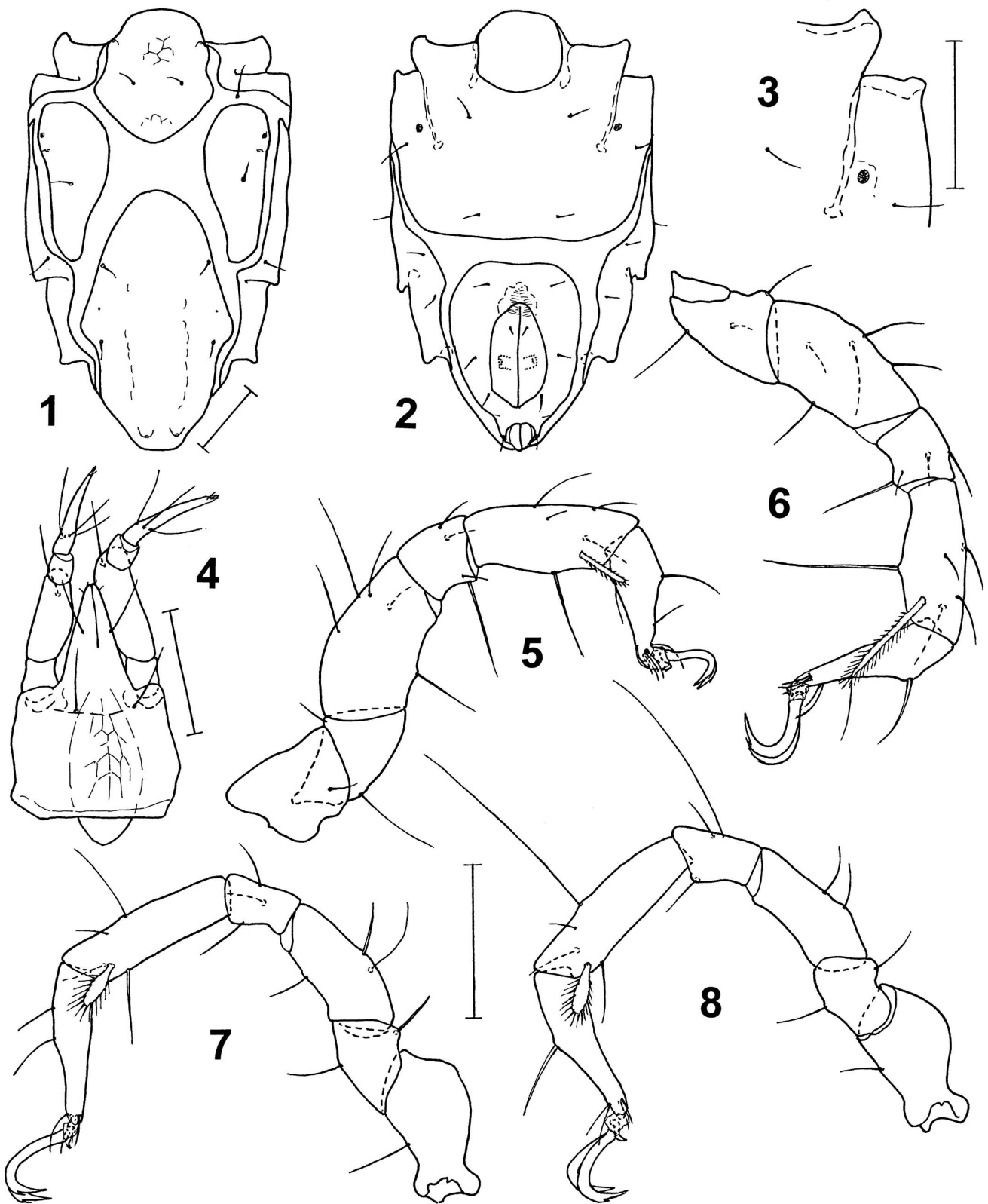
**Colour.** – Idiosoma pale or light brown. Eye spots small, black.

**Description.** – **Female:** Idiosoma short and wide, slightly flattened; with large interval between insertions of legs II and III. Length of idiosoma 294-309  $\mu\text{m}$ , length of holotype 294  $\mu\text{m}$ , width 175  $\mu\text{m}$ . Median portions of AD and PD delicately reticulate. Length of AD 87  $\mu\text{m}$ , width 78  $\mu\text{m}$ ; anterior margin arched, posterior margin triangular; pair of gland pores on minute cones at the level of insertion of leg I. OC elongate, but hardly reaching the level of insertion of leg III (Fig. 1), length 104  $\mu\text{m}$ , width 48  $\mu\text{m}$ . With dark eye pigment beneath anterior portion of plate but no distinctly delimited corneae; gland pore and adjacent pore canaliculus in anterolateral margin of OC. Length of PD 172  $\mu\text{m}$ , width 102  $\mu\text{m}$ ; anterior margin rounded; pair of delicate pores somewhat anterior to greatest width of PD, pair of gland pores on protuberances in posterior margin of PD. Pair of ds-1 on AD; ds-2 within striated integument between AD and OC (in holotype left ds-2 not seen); ds-3 in middle of OC (at 0.5 relative to length of OC); ds-4 and ds-5 on PD near lateral margin. Adanal setae in ventral position, adjacent to anal sclerites.

Integument of ventral plates almost smooth. AE wide and long, extending far beyond insertion of leg II, its length 100  $\mu\text{m}$ , width 175  $\mu\text{m}$ ; posterior margin very wide, truncate; three pairs of ventral setae only about as long as dorsal idiosomatic setae; pair of epimeral pores lateral to apodemes between epimera I and II (Fig. 2); diameter of pores 6  $\mu\text{m}$ , pores covered with numerous villi (Fig. 3). Length of PE 182  $\mu\text{m}$ , extending anteriorly far beyond insertion of leg III, posteriorly only slightly beyond insertion of leg IV; each plate with one dorsal seta and three ventral setae. Length of GA 122  $\mu\text{m}$ , width 87  $\mu\text{m}$ ; with three pairs of pgs. GO large, length 72  $\mu\text{m}$ , width 35  $\mu\text{m}$ , its distance to anterior margin of GA equalling 0.34 of length of GO. Genital sclerites with one pair of sgs. Ovipositor extending slightly beyond GO.

Length of gnathosoma 92  $\mu\text{m}$ , width 65  $\mu\text{m}$ ; pharyngeal field panelled, remainder of gnathosoma with almost smooth integument. Rostrum in ventral aspect triangular, almost as long as gnathosomal base (Fig. 4); extending almost to about the level of seta on P-2. Tectum truncate. One pair of maxillary setae on gnathosomal base, the other pair in distal half of rostrum; two pairs of rostral setae at tip of rostrum. P-4 with three basal setae removed from basis by about length of P-3.

Legs I and II (Figs. 5 and 6) almost equal-sized and shorter than legs III and IV (Figs. 7 and 8). Telofemora with delicate villi, though in general integument of legs almost smooth.



Figs. 1-8. *Acarothrix ampliomeris*, new species, female: 1. idiosoma, dorsal; 2. idiosoma, ventral; 3. left part of AE; 4. gnathosoma, ventral; 5. leg I, medial; 6. basifemur to tarsus II, medial; 7. leg III, medial; 8. leg IV, medial. Scale line = 50  $\mu$ m.

Tarsi without fossa membranes. Leg chaetotaxy (solenidia included, pas excluded): leg I, 1, 2, 5, 4, 6, 6; leg II, 1, 3, 5, 4, 6, 4; leg III, 1, 2, 3, 3, 5, 4; leg IV, 1, 2, 2-3, 3, 5, 3. Telfemur IV with the combinations 2/1 and 2/0 dorsal/ventral setae. Ventral seta of genu I very long, slightly longer than that seta on genu II as well as ventral seta of tibia I. Ventral setae of genua III and IV slender and short. Tibia I with long ventral and bipectinate ventromedial seta. On tibia II that bipectinate ventromedial seta conspicuously long, length about twice height of segment, ventral seta long, smooth. Bipectinate seta of tibia III and IV very wide and almost as long as height of segment. Dorsolateral and dorsomedial fossary setae of tarsus I almost equal-sized (Fig. 9); solenidion, length 10  $\mu\text{m}$ , immediately adjacent to dorsolateral fossary seta (Fig. 10); famulus represented by minute cap, length 1  $\mu\text{m}$ . Tarsus I with one long ventral seta in basal third and one small eupathid seta near its tip. Basidorsal fossary seta of tarsus II wider than that of tarsus I, dorsomedial fossary seta very slender (Fig. 11), dorsolateral fossary seta close to tip of tarsus, adjacent to solenidion. Tarsus III with four dorsal setae; pair of apical fossary setae slender. Basidorsal fossary seta of tarsus IV wider than corresponding seta of tarsus III; shape of apical fossary setae similar to setae on tarsi III. Tarsi I and II each with pair of doubled pas, tarsus III with eupathid medial and widened but tapering lateral pas, tarsus IV with pair of bristle-like pas.

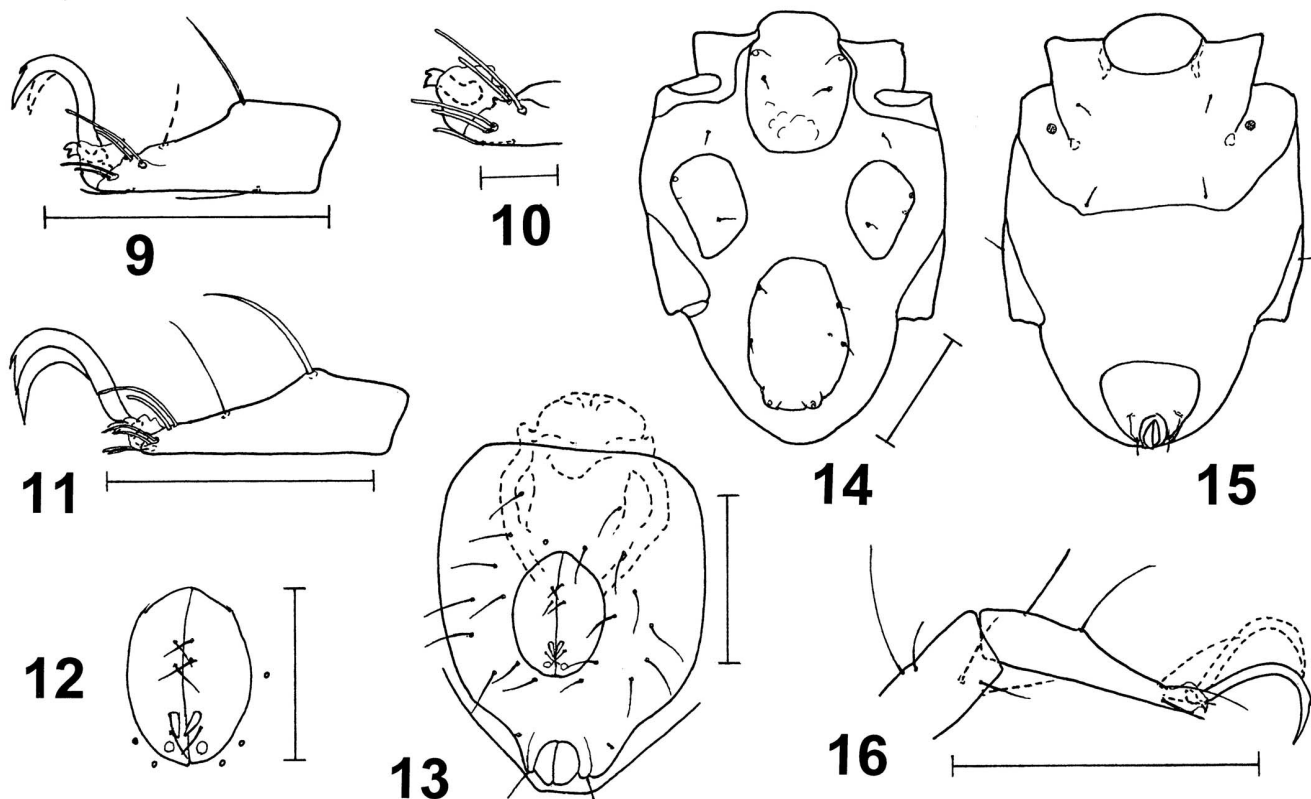
Claws with very delicate accessory process; pecten lacking. All tarsi with small median claw, that of tarsus I bidentate, on the other tarsi upper tooth almost reduced.

**Male:** Length of idiosoma 314-325  $\mu\text{m}$ . Dorsal aspect same as that of female. GA with rounded anterior corners; plate somewhat longer than but far from as wide as AE. GO in middle of GA, distance both to anterior margin of GA and end of genital sclerites slightly less than length of GO. Spermatopositor extending beyond GA, its length 95  $\mu\text{m}$ , width 72  $\mu\text{m}$ . GA with 10-11 pairs of pgs (Fig. 13). Genital sclerites with four pairs of sgs; three pairs of sgs setiform, one pair spur-like. A pair of foveae (external genital acetabula) immediately posterior to sgs (Figs. 12 and 13), foveae ca 4  $\mu\text{m}$  in diameter and obscured by villi.

**Protonymph:** Not seen.

**Larva:** Length of idiosoma 177  $\mu\text{m}$ . OC and PD distinctly shorter than in adults. Pair of ds-3 on OC, ds-4 and ds-5 in margin of PD (Fig. 14). AE wide; apodemes between epimera I and II extending backward beyond pair of epimeral pores (Fig. 15); plate with two pairs of ventral setae. PE short, with single pair of setae. Shape of gnathosoma similar to that of adults. With three pairs of five-segmented legs, basi- and telfemora fused. Leg chaetotaxy: leg I, 1, 1+3 (basi- plus telfemur), 4, 5, 6; leg II, 1, 1+3, 4, 5, 4; leg III, 1, 1+2, 3, 5, 4. Bipectinate seta of tibia II rather slender, much longer than that seta on tibia I. Both ventral setae on tibia III rather slender, none distinctly bipectinate (Fig. 16). Distance between two basal setae of tarsus III equalling height of tarsus.

**Remarks.** – Four species are at present known, all recorded



Figs. 9-16. *Acarothrix ampliuneris*, new species: 9, tarsus I, lateral, female (medial fossary seta and claw in broken line, medial parambulacral setae omitted); 10, tip of tarsus I, lateral, female; 11, tarsus II, lateral, female; 12, genital opening, male; 13, genitoanal plate, male; 14, idiosoma, dorsal, larva; 15, idiosoma, ventral, larva; 16, tibia and tarsus III, medial, larva (lateral setae and claw in broken line). Scale line = 50  $\mu\text{m}$ .

from tropical and warm-temperate shallow water habitats, from muddy areas periodically influenced by fresh water. *Acarothrix ampliata* Bartsch, 2004, was collected amongst the vegetation of a small river emptying into Tampa Bay, Florida, USA, *A. longiunguis* Bartsch, 1997, in soft mud in a northern Australian mangrove area, *A. palustris* Bartsch, 1990, amongst surface sediment and its cover by green and red algae (*Cladophora*, *Caloglossa*) in Hong Kong, China, and *A. umgenica* in *Avicennia* mangroves in KwaZulu-Natal, South Africa (Bartsch, 1990, 1997a, 2004; Proches, 2002).

Distinguishing characters between *A. ampliomeris* and the others are: the position of ds-2 (in *A. ampliomeris* within the striated integument anterior to the OC - in the other species in the margin or on the OC), the shape of the OC (in *A. ampliomeris* elongate, its posterior portion wide - in the other species either shorter or more slender), the gland pores on the PD (in *A. ampliomeris* one distinct pair on cones near posterior margin - in the other species two distinct pairs of pores, one pair between the ds-4 and ds-5, the other pair near the posterior margin), and the shape of the pectinate seta of tibia II (in *A. ampliomeris* long - in the other species short and wide).

**Distribution.** – Singapore, from algal mats in mangrove areas.

***Acarothrix palustris* Bartsch, 1990**

(Figs. 17-20)

*Acarothrix palustris* Bartsch, 1990: 205-207, figs. 1-14.

**Material examined.** – One female, ZRC.ARA.483, Singapore, northern coast, end of Lim Chu Kang Road, *Cladophora* mat on muddy and sandy sediment, coll. I. Bartsch, 7 Oct.2004; one larva, ZRC.ARA.484, collecting data as above; one female, SMF, collecting data as above; one female, ZMH, collecting data as above; one male, ZMH, collecting data as above; one protonymph, ZMH, collecting data as above. One larva, author's collection, Singapore, southern coast, river Pandan, sediment, green algae and epibiota on *Avicennia* pneumatophores in a rockpool, coll. I. Bartsch, 27 Sep.2004.

**Diagnosis.** – Length of idiosoma 280-320  $\mu\text{m}$ . PD with pair of longitudinal porose costae with narrow cerotegumental ridges, remainder of plate reticulate. OC with two corneae. PD with two pairs of gland pores. Pair of ds-2 in margin of OC. Pair of ds-4 and ds-5 in lateral margin of PD, almost equidistant relative to anterior pair of gland pores. Female and male GA almost ovate. Male GA with 11-12 pairs of pgs, interval between anterior margin of GA and that of GO equalling length of GO. Tibiae I and II with six setae each. Tibiae I to III each with one bipectinate and one smooth, slender ventral seta; on tibiae IV both ventral setae smooth and slender. Paired claws almost smooth.

**Colour.** – Gut content pale or slightly brown; the male examined darker than females. Dorsum with three small black eye spots.

**Complementary description.** – **Adults:** Length of female 294-320  $\mu\text{m}$ , of male 280  $\mu\text{m}$ . Shape of dorsal plates as illustrated (Fig. 17). Costae of PD approximately 20  $\mu\text{m}$  wide, with narrow cerotegumental borders. Pair of epimeral pores at end of apodemes between epimera I and II (Fig. 18); porus covered with numerous setiform tines. Male with 11-12 pairs of pgs; its GO large, distance to anterior margin of GA equalling length of GO (Fig. 19). Basi- and telofemora I and II with numerous filaments, trochanters, basi- and telofemora III and IV with filaments fused to cerotegumental lamellae. Leg chaetotaxy: leg I, 1, 2, 5, 4, 6, 6; leg II, 1, 3, 5, 4, 6, 4; leg III, 1, 2, 2-3, 3, 5, 4; leg IV, 1, 2, 2-3, 3, 5, 3. Telofemora III and IV in general with 2/1 dorsal/ventral setae, rarely ventral seta absent. Tibiae I, II and III each with short, wide bipectinate seta, on tibia IV this seta slender and smooth. Claws almost smooth though vestiges of accessory process present. Median claw of all tarsi bidentate, that claw of tarsus III and IV with long upper and lower tooth and therefore median claws somewhat larger than on tarsi I and II.

**Protonymph:** Length of idiosoma 217  $\mu\text{m}$ . Dorsal and ventral plates smaller than in adults. Leg chaetotaxy: leg I, 1, 2, 3, 4, 5, 6; leg II, 1, 2, 3, 4, 5, 4; leg III, 1, 2, 2, 3, 5, 3; leg IV, 0, 1+2 (basi- plus telofemur), 3, 5, 3. Tibiae I, II and III each with one of the two ventral setae being short, wide and pectinate, the other seta slender and smooth. Tibia IV with two smooth ventral setae. Both tarsi III in the protonymph examined with three instead of four dorsal setae.

**Larva:** Length of idiosoma 177  $\mu\text{m}$ . Shape of dorsal and ventral plates as illustrated in Bartsch (1990: figs. 8 and 9). PD with pair of cerotegumental ridges. Pair of epimeral pores at about the level of end of apodemes. Leg chaetotaxy: leg I, 1, 1+3 (basi- plus telofemur), 4, 5, 6; leg II, 1, 1+3, 4, 5, 4; leg III, 1, 1+2, 3, 5, 4. Pectinate seta of tibia I and II wide, less than height of each segment. Tibia III with two almost smooth ventral setae. Distance between two basal setae of tarsus III more than height of that segment (Fig. 20).

**Remarks.** – The PD and GA of the Singapore specimens illustrated are slightly more slender than in the holotype and paratype from Hong Kong. The width of the plates proved to vary slightly in the material from Singapore.

The adults of the two *Acarothrix* species (*A. ampliomeris* and *A. palustris*) present in Singapore mangroves can be distinguished on the basis of the length of OC, presence or absence of corneae, shape of AE, length of PE, and shape of ventral setae on tibiae II and IV. Juveniles which have small dorsal and ventral plates can be distinguished on the basis of presence or absence of corneae, position of epimeral pores relative to length of apodemes, and size of the median claws on the posterior tarsi. In addition, larvae can be distinguished on the basis of presence or absence of cerotegumental ridges on the PD and position of the basal seta on tarsus III.

**Distribution.** – *Acarothrix palustris* inhabits mangroves in Hong Kong and Singapore (Bartsch, 1990, and present record).

**Genus *Copidognathus* Trouessart, 1888**

**Diagnosis.** – Dorsum with five pairs of dorsal idiosomatic setae, pair of adanal setae on anal plate and four pairs of gland pores, the latter may be almost inconspicuous or large and opening on cones. Pair of ds-3 in striated integument or on PD. AE with pair of epimeral pores. Pair of genital acetabula internal. Palps four-segmented; P-2 with one seta; no seta on P-3 (there may be a small spiniform cuticular process); P-4 with three setae in basal whorl. Genua of legs shorter than telofemora and tibiae. Trochanters I to IV with 1, 1, 1, 0 setae. Basifemur II with two setae. Tibiae I and II with three ventral setae each (rarely two setae), tibiae III and IV with two ventral setae each. Tarsus I ventrally with one seta in about middle of segment and two small eupathid apical setae; tarsus II without ventral setae; both tarsus I and II with pair of parambulacral setae. Tarsi III and IV in general with pair of parambulacral setae but no ventral setae, rarely one of parambulacral setae moved to a ventral position or lacking. Solenidion of both tarsus I and II in dorsolateral position. All tarsi with paired claws, central sclerite with claw-like process.

**Type species.** – *Copidognathus glyptoderma* Trouessart, 1888.

***Copidognathus rhombognathoideus*, new species**  
(Figs. 21-41)

**Material examined.** – Holotype. Female, ZRC.ARA.485, Singapore, northern coast, end of Lim Chu Kang Road, coll. I. Bartsch, 7 Oct.2004.

Paratypes. One female, ZRC.ARA.486, collecting data as above;

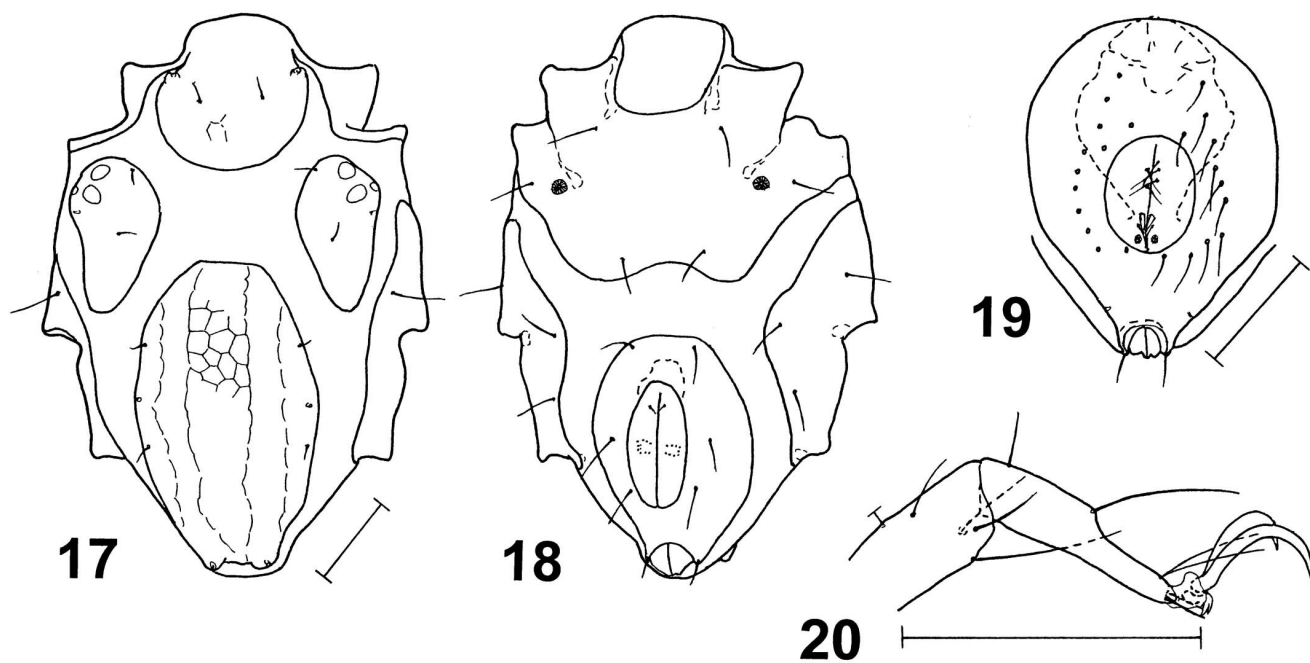
one male, ZRC.ARA.487, collecting data as above; one protonymph, ZRC.ARA.488, collecting data as above; one female, SMF, collecting data as above; one female, ZMH, collecting data as above; one protonymph, one larva, ZMH, collecting data as above.

**Diagnosis.** – Length of idiosoma 353-414  $\mu\text{m}$ . Dorsal plates with delicate porosity in large hardly raised areolae. OC about twice as long as wide, with two corneae. PD with two pairs of wide porose costae. Epimeral pores large, ovate, their margins smooth. Male GA with seven to eight pairs of pgs. Gnathosoma short, length of rostrum half that of gnathosomal base. Tibiae I to IV with 2, 2, 1, 1 bipectinate setae. Tarsi III and IV with lateral but no medial pas.

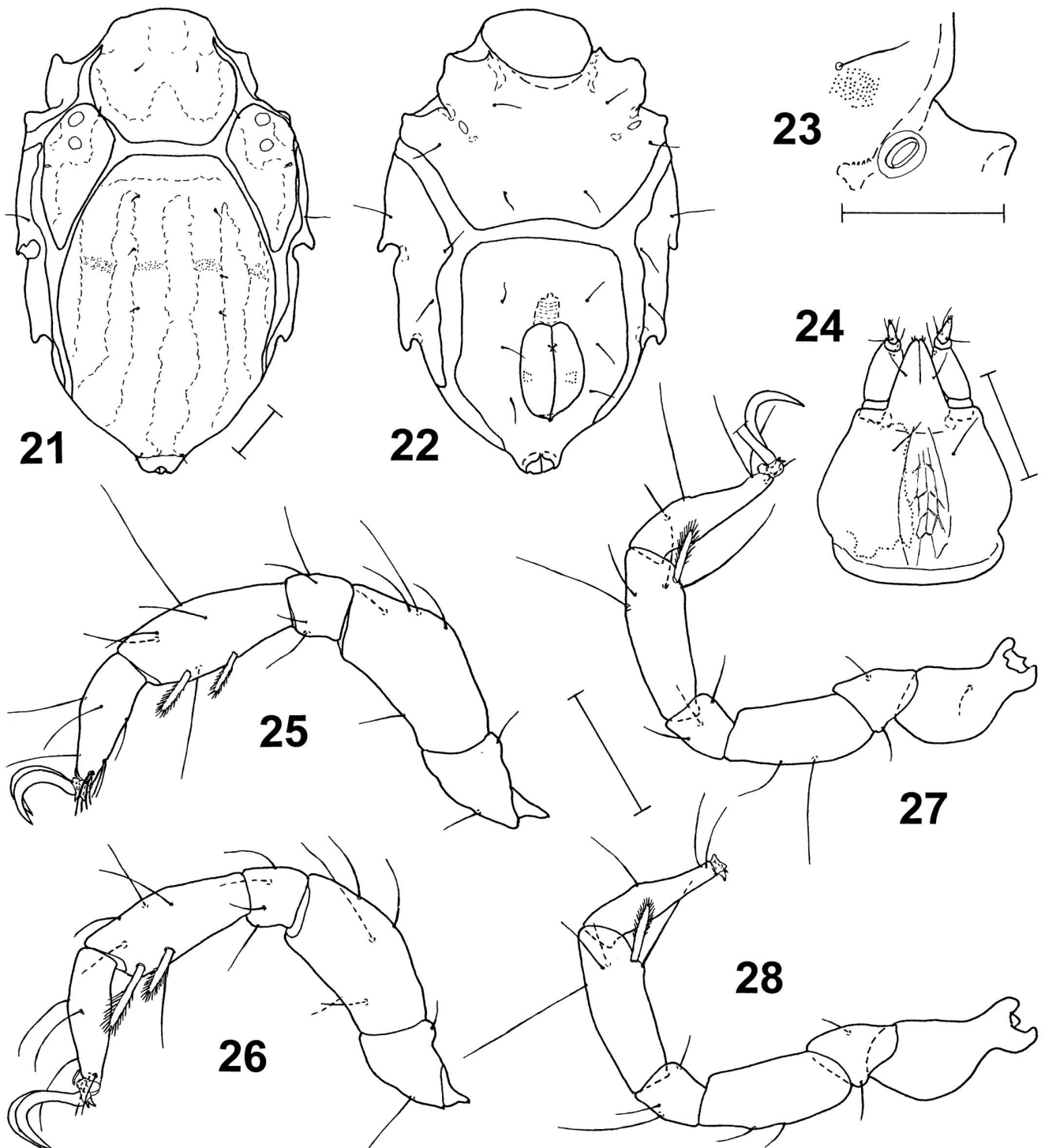
**Etymology.** – The species is characterized by a dark-green gut content and a gnathosoma with a short rostrum, hence, at low magnification (20-25x), it may easily be mistaken for a representative of the genus *Rhombognathus*. The specific name with the suffix -ides (Greek), Latinized -ideus, refers to this similarity.

**Colour.** – Content of idiosoma dark, green or grey-green. Idiosoma and legs generally fouled.

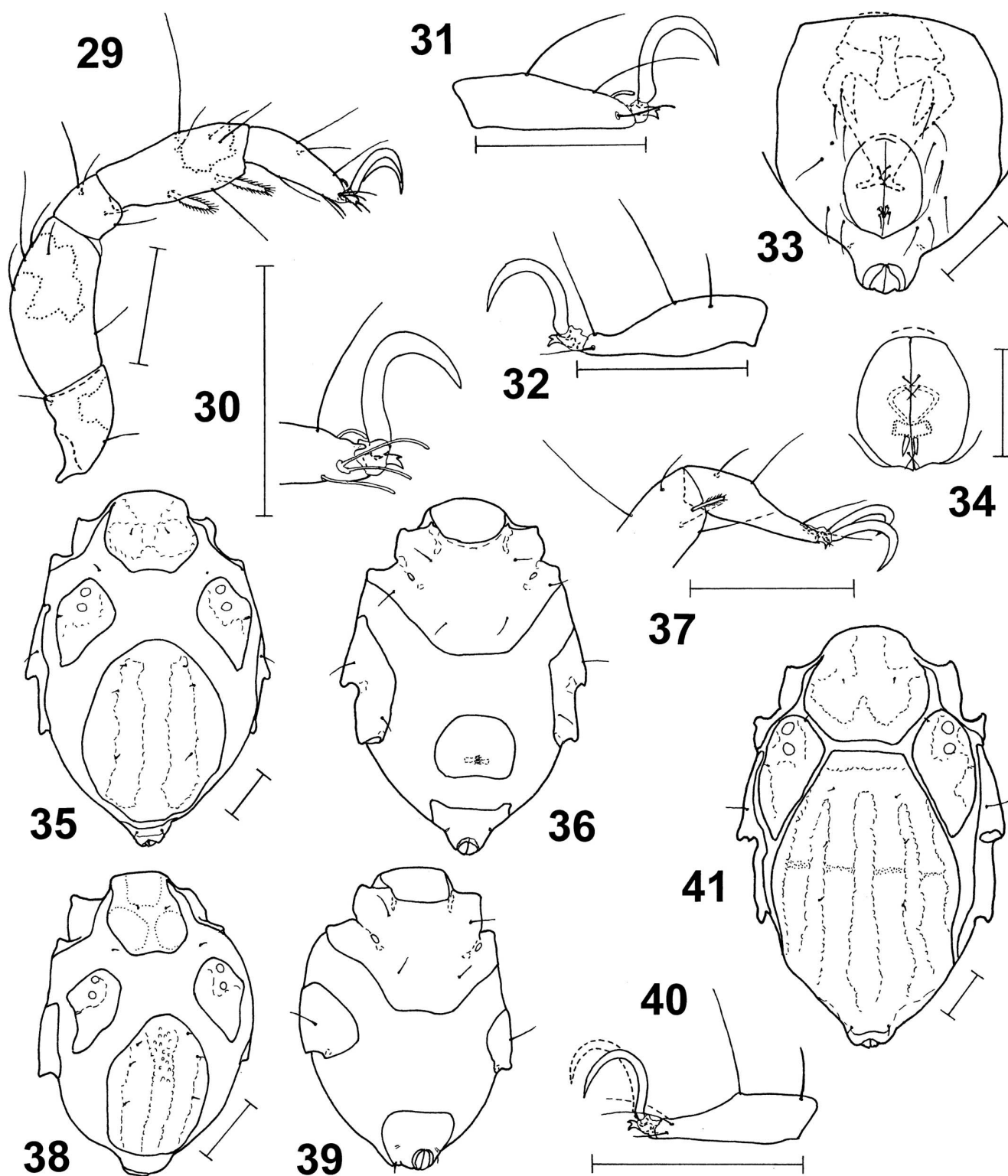
**Description.** – **Female:** Length of idiosoma 385-414  $\mu\text{m}$ , that of holotype 414  $\mu\text{m}$ , width 264  $\mu\text{m}$ . Porose areolae of dorsal plates hardly raised; areolae with delicate porosity. Length of AD 117  $\mu\text{m}$ , width 135  $\mu\text{m}$ . Posterior margin almost truncate. AD with three wide almost fused areolae (Fig. 21); anterior third of AD, the porose areola included, as well as paired areolae with delicate porosity. Length of OC 132  $\mu\text{m}$ , width 67  $\mu\text{m}$ . Plate around corneae slightly raised; integument within raised area and along lateral margin of OC porose. No distinct gland pore but small pore canaliculus in lateral margin. Triangular posterior portion of OC extending to the



Figs. 17-20. *Acarothrix palustris* Bartsch: 17, idiosoma, dorsal, female; 18, idiosoma, ventral, female; 19, genitoanal plate, male; 20, tibia and tarsus III, medial, larva. Scale line = 50  $\mu\text{m}$ .



Figs. 21-28. *Copidognathus rhombognathoideus*, new species, female: 21, idiosoma, dorsal; 22, idiosoma, ventral; 23, left part of AE; 24, gnathosoma, ventral; 25, basifemur to tarsus I, medial; 26, basifemur to tarsus II, medial (in holotype one of ventral setae of that telofemur lacking); 27, leg III, medial; 28, leg IV, medial (ambulacrum with claws broken). Scale line = 50  $\mu$ m.



Figs. 29-41. *Copidognathus rhombognathoides*, new species: 29, basifemur to tarsus I with porose areolae, lateral; 30, tip of tarsus I, lateral, female (medial setae and claw omitted); 31, tarsus II, lateral, female (medial setae and claw omitted); 32, tarsus III, lateral, female (medial fossary seta and claw omitted); 33, genitoanal plate, male; 34, genital opening, male; 35, idiosoma, dorsal, protonymph; 36, idiosoma, ventral, protonymph; 37, tibia and tarsus III, medial, protonymph; 38, idiosoma, dorsal, larva; 39, idiosoma, ventral, larva; 40, tarsus III, lateral, larva (lateral seta and claw in broken line), 41, idiosoma, dorsal, female. Scale line = 50  $\mu$ m.



level of insertion of leg III. Length of PD 274  $\mu\text{m}$ , width 197  $\mu\text{m}$ ; anterior extending far between OC. PD with two pairs of porose costae, 20-25  $\mu\text{m}$  wide, and five panels with small foveae. Distinct gland pores lacking. Dorsal idiosomatic setae short; ds-1 on AD, ds-2 within anteromedial margin of OC, ds-3 to ds-5 on PD within lateral margin of medial porose costae, ds-5 immediately anterior to the level of insertion of leg IV; ds-3 to ds-5 situated almost equidistant. Adanal setae close to anal cone.

Integument of ventral plates uniformly porose. Length of AE 127  $\mu\text{m}$ , width 238  $\mu\text{m}$ . Camerostome with lamella. Pair of small, lamellar epimeral processes in medial edge of insertion of leg I. Ventral setae longer than dorsal idiosomatic setae. AE with three pairs of setae; pair of ovate epimeral pores about 10  $\mu\text{m}$  in length (Fig. 22). Wall of epimeral porus slightly raised, smooth, without tines (Fig. 23). Length of PE 224  $\mu\text{m}$ , extending distinctly beyond insertion of leg IV. Length of GA 213  $\mu\text{m}$ , width 157  $\mu\text{m}$ ; anterior margin truncate; with three pairs of pgs inserted as illustrated. Length of GO 90  $\mu\text{m}$ , width 60  $\mu\text{m}$ ; ovipositor extending beyond GO to the level of anterior pair of pgs. Interval between anterior margin of GA and GO equalling 0.8 times length of GO.

Gnathosoma, rostrum and palps short; length of gnathosoma 112  $\mu\text{m}$ , width 87  $\mu\text{m}$ ; its length 0.27 times that of idiosoma. Rostrum triangular in ventral aspect, its length half that of gnathosomal base (Fig. 24). Palps slender, short, but extending beyond tip of rostrum. P-4 with three basal setae; apically with setula and two spurs. Tectum truncate.

Legs I and II almost equal-sized (Figs. 25 and 26). Telfemora I and II somewhat longer than these legs' tibiae; telfemora III and IV shorter than tibiae (Figs. 27 and 28). Length:height ratio of telfemora I and II 2.2, that of telfemora III and IV 2.3-2.4. Tarsi without fossa membranes. Integument of lateral flanks of basifemora, telfemora and tibiae I and II and those of trochanters, telfemora and tibiae III and IV with porose areolae (Fig. 29). Leg chaetotaxy: leg I, 1, 2, 5, 4, 7, 7; leg II, 1, 2, 4-5, 4, 7, 4; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 2, 2, 3, 5, 3. Telfemur I unilaterally with either 3/2 or 3/1 dorsal/ventral setae. Tibiae I and II each with two wide, conspicuously bipectinate ventromedial setae and one slender, smooth ventral seta; tibiae III and IV each with one bipectinate ventromedial and one long, slender ventral seta. Dorsal and dorsomedial setae of tarsi I and II at almost the same level, dorsolateral seta moved towards tip of tarsus, close to solenidion. Solenidia short, baculiform (Figs. 30 and 31), that of tarsus I 5  $\mu\text{m}$  in length, of tarsus II 7  $\mu\text{m}$ . Tarsus I with short lamelliform famulus. Tarsi III and IV with four (Fig. 32) and three dorsal setae, respectively. Tarsus I with three ventral setae, one level with dorsal seta and two eupathid setae near tip of tarsus, close to pair of doubled pas. Tarsus II with pair of pas singlets, tarsi III and IV with slender lateral pas; medial pas absent.

Paired claws slender, accessory process vestigial. Pecten lacking. Median claw bidentate.

**Male:** Length of idiosoma 353  $\mu\text{m}$ . Dorsal aspect similar to that of female. Anterior margin of GA wide, truncate, length of plate 179  $\mu\text{m}$ , width 150  $\mu\text{m}$ . Length of GO 62  $\mu\text{m}$ . Distance to anterior margin of GA 1.3 times length of GO. Seven to eight pairs of pgs arranged scatteredly around GO (Fig. 33). Spermatopositor large, length 115  $\mu\text{m}$ , width 86  $\mu\text{m}$ , extending to anterior margin of GA. Genital sclerites with four pairs of sgs, three of them setiform, one spiniform (Fig. 34). With single pair of internal genital acetabula.

**Protonymph:** Length of idiosoma 329-334  $\mu\text{m}$ . OC and PD distinctly shorter than in adults (Fig. 35). AD with three porose areolae. PD with pair of porose costae, about 25  $\mu\text{m}$  wide, and three longitudinal panels with small foveae. Pair of ds-2 within striated integument. Pairs of ds-3 to ds-5 on PD, ds-3 and ds-4 close together. AE with pair of ovate epimeral pores. PE shorter than in adults, with one dorsal and two ventral setae. Genital plate separated from anal plate (Fig. 36). Primordial genital slit with numerous papillae. Shape and setation of gnathosoma as in adults. Leg chaetotaxy: leg I, 1, 2, 3, 4, 5, 7; leg II, 1, 2, 3, 4, 5, 4; leg III, 1, 1, 2, 3, 5, 4; leg IV, 0, 1+2, 3, 5, 3. Ventromedial seta of tibia III short and slightly bipectinate (Fig. 37). Basalmost seta of tarsus III situated about halfway between segment's base and fossary seta.

**Larva:** Length of idiosoma 224  $\mu\text{m}$ . Shape of dorsal plates similar to those of protonymphs (Fig. 38). AE with pair of ovate epimeral pores and two pairs of ventral setae. PE with single seta (Fig. 39). Chaetotaxy of the three pairs of five-segmented legs: leg I, 1, 1+3, 4, 5, 7; leg II, 1, 1+3, 4, 5, 4; leg III, 1, 1+2, 3, 5, 4. Ventromedial seta of tibiae I and II large and distinctly bipectinate, that seta of tibia III short, slender, though bipectinate. Basalmost seta of tarsus III close to base of segment (Fig. 40).

**Variations.** – The anterior part of the PD is rather wide in the holotype female but less wide in a paratype female (Fig. 41). Telfemur II mostly bears 3/2 dorsal/ventral setae; in the holotype one ventral seta is lacking.

**Remarks.** – *Copidognathus rhombognathoideus* is most similar to *C. lutarius* Bartsch, 2003. They share characters such as the ornamentation of the dorsal plates, ovate epimeral pores, very short triangular rostrum and short palps, wide bipectinate setae on the tibiae, single pas on the tarsi III and IV, and dark, green gut content. Distinguishing characters are: the size of the porose areolae on AD (three large, fused areolae in *C. rhombognathoideus*, three small areolae in *C. lutarius*), the shape of the PD (anterior margin truncate in *C. rhombognathoideus* but ovate in *C. lutarius*), the position of the ventral seta on tarsus I (in basal half in *C. rhombognathoideus* but moved to distal half in *C. lutarius*).

*Copidognathus balakrishnani* Chatterjee, 2000, a species found amongst green algae in Cochin backwater, Kerala, India (Chatterjee, 2000), and *C. caloglossae* Proches, 2002, from Bayhead Lagoon, Durban Harbour and mangrove forests, KwaZulu-Natal and Inhambane, South Africa and

Mozambique (Proches, 2002), have similar short rostra and palps as the two above mentioned species, a PD with four wide porose costae, legs with porose integument, and conspicuously stout bipectinate setae on tibiae I and II. *Copidognathus balakrishnani* differs from *C. lutarius* and *C. rhombognathoideus* in that the PD outside the porose costae is reticulate (with delicate foveae in *C. lutarius* and *C. rhombognathoideus*), there are three panels outside the porose costae (five in *C. lutarius* and *C. rhombognathoideus*), and tarsi III and IV bear two pas (a single one in *C. lutarius* and *C. rhombognathoideus*). The anterior margin of the PD of *C. caloglossae* is much wider than in the other species, the ds-2 is near the medial corner of the OC instead of in the anteromedial margin as in the other species, and the GA in both female and male is very long compared to the AE.

*Copidognathus lutarius* and *C. rhombognathoideus* differ from *Copidognathus* congeners by the combination of (1) dark, green or grey-green gut content, (2) very short, triangular rostrum and small palps, (3) large ovate epimeral pores with smooth margins, (4) short solenidia, and (5) absence of a medial parambulacral seta on tarsi III and IV. The habitus as well as the collecting data of *C. balakrishnani* and *C. caloglossae* demonstrate relationship to *C. lutarius* and *C. rhombognathoideus*, but the remarkable colour of the gut content is not mentioned in the descriptions of *C. balakrishnani* and *C. caloglossae* (Chatterjee, 2000; Proches, 2002), the epimeral pores are not mentioned, in neither the text nor the illustrations (Chatterjee, 2000; Proches, 2002), and according to Chatterjee (2000), tarsi III and IV of *C. balakrishnani* bear both medial and lateral pas, and, according to Proches (2002: fig. 3G), at least tarsus III of *C. caloglossae* has both a lateral and medial pas. The similarity in the general shape may be purely accidental, comparable with the overall similarity demonstrated by some species of the *Copidognathus tricorneatus*-group and *Arhodeoporus eclogarius*-group (Bartsch, 1997b), but the four species may also be closely related and form a species group and the postulated differences the result of the somewhat cursory descriptions of *C. balakrishnani* and *C. caloglossae*.

**Distribution.** – Singapore, amongst muddy sediment and algal turf on pneumatophores.

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