

Halacaridae (Acari) amongst the epiflora and fauna on trunks, branches, roots, and pneumatophores on the coast of Singapore: A survey

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Abstract. In coastal areas of Singapore, representatives of eight halacarid genera have been found amongst the epibios on trunks, branches, roots, and pneumatophores. The genera and the number of species (in parentheses) are: *Acarothrix* (3), *Actacarus* (1), *Agauae* (1), *Agauopsis* (2), *Copidognathus* (7), *Isobactrus* (1), and *Rhombognathus* (3). Keys to these species are presented. Four new species are described, namely *Agauopsis longirostris*, *Copidognathus latusculus*, *C. mollis*, and *C. riguus*. Taxonomical, distributional and biological data are given to all species. Less than half of the 18 species may be restricted to mangrove areas, whilst the other species have or are expected to be found on and in various substrata outside mangroves. Eight of the species have at present no records from outside Singapore, but these species are certainly no Singapore endemics; their absence is the result of restricted sampling activities in the Indo-West Pacific region.

Key words. Mangrove, Halacaroidea, keys, descriptions, biology, distribution.

INTRODUCTION

The intertidal zone is an environment with extremes, emerged during low tide but flooded by brackish or seawater at high tide. In this zone the ultraviolet radiation and temperature is high when exposed to sun, the salinity may be raised during air exposition or lowered to almost fresh during heavy rain, and periods of anoxia may occur. Under the canopy of the foliage of trees, sun radiation is reduced, amplitudes of environmental parameters dampened, substratum still wet or at least moist at the end of the low tide, in contrast to the microclimate on sun-exposed rocks.

The intertidal zone is inhabited by both aquatic and terrestrial organisms. Of the taxon Acari, the major orders are represented amongst the epiflora and fauna in stands of trees. Aquatic mite species are known to survive desiccation, terrestrial groups survive in air-filled crevices or show morphological adaptation to survive when flooded (plastron structures—Crowe & Magnus, 1974; Pugh et al., 1987, 1990; Pflingstl & Krisper, 2014). The paper presents a key and short outline of the major mite groups but concentrates on the prostigmatid mite taxon Halacaridae, the only exclusively aquatic mite family which inhabits all benthic zones in the sea, from the upper tidal fringe to deep sea trenches. Keys are presented to the halacarid species collected amongst the epibios on parts of trees. The morphological characters of these species are outlined, illustrated and compared with

similar species. Juveniles are presented if available and not described before. In addition, notes on distribution, biology and ontogeny are given.

MATERIAL AND METHODS

The mites described have been collected by the author during two stays in Singapore, the first in October 2004, the second in October/November 2012 during the Johor Strait Workshop (15 October–2 November 2012), a part of the international Workshop ‘The Comprehensive Marine Biodiversity Survey of Singapore’. Organisers of the Workshop were Tan Koh Siang, National University of Singapore, Peter K. L. Ng, National University of Singapore, Tan Heok Hui, National University of Singapore, Joelle Lai, National University of Singapore, Wong Tuan Wah, National Parks Board, Lena Chan, National Parks Board, Linda Goh, National Parks Board.

Epiflora and epifauna, growing on leaves, branches, trunks and pneumatophores as well as on bales of uprooted palms, were collected by hand during low tide. This substratum was washed over a 100 µm net and sorted while the mites were still alive. The mites were preserved in 70% ethanol. For microscopical studies the halacarids were cleared in lactic acid, dissected and mounted on slides in glycerine jelly. Slides with the holotypes and voucher specimens are deposited in the Arachnid Collection of the Zoological Reference Collection in The Lee Kong Chian Natural History Museum (ex Raffles Museum of Biodiversity Research) (ZRC.ARA), further material in the author’s collection (IB) and in the Senckenberg Museum in Frankfurt (SMF).

Abbreviations used in the descriptions are: AD, anterior dorsal plate; AE, anterior epimeral plate; AP, anal plate;

ds-1 to ds-6, first to sixth pair of dorsal setae of idiosoma, numbered from anterior to posterior; EI to EIV, epimeral plates I to IV; GA, genitoanal plate; glp, gland pore(s), numbered glp-1 to glp-4, from anterior to posterior; GO, genital opening; GP, genital plate; 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 to posterior; sgs, subgenital setae. The legs, their segments and claws are numbered I to IV, from anterior to posterior. The segments of leg I are trochanter (I-1), basifemur (I-2), telofemur (I-3), genu (I-4), tibia (I-5), and tarsus (I-6).

The keys and diagnoses refer to adults; these and the descriptions and drawings of the species are prepared on the basis of specimens from Singapore. Data on the colour is given, though this generally is that of the gut content, accordingly dependant of the food items. The colour may fade when the mites are stored in ethanol. In the descriptive part, rare variants are in parentheses, these variants are omitted in the diagnoses. The length of a specimen is that of the idiosoma. The position of setae is presented in a decimal system, with reference to the length of a given structure from its anterior to posterior or basal to distal end. The length of the rostrum is the distance between the tip of the rostrum and an articulating process adjacent to the basis of the first palpal segment (cf. Fig. 4J). The length of a palp or leg segment is that along the dorsal margin. The setation formula of the legs starts with the trochanter; in the number of setae of the tarsi the solenidion is included, the famulus and parambulacral setae are omitted. In the illustrations marginal setae of the idiosoma are shown either in the ventral or dorsal aspect but not in both. The drawings were done with a drawing tube.

To each of the known species the reference with the original description is given as well as papers which add morphological details. Several species have been recorded from Singapore before and only the new records are mentioned in the paragraph 'Material and collecting sites'.

RESULTS

Amongst the epiflora and fauna on trunks, branches, roots, and pneumatophores of trees all major mite groups, Astigmata, Mesostigmata (Gamasida), Prostigmata, and Oribatida (Cryptostigmata), have been found. Mites are primarily terrestrial, but all these groups have representatives in marine habitats.

Key to most abundant mite groups

1. Legs I and II inserted close together; gap between legs II and III almost or more than one third the width of the idiosoma (Fig. 1K, L)Halacaridae (Prostigmata)
 - No marked gap between legs II and III (Fig. 1B, F, H, I) ...2
2. Tarsi I and II end with a minute claw on a long, flexible stalk (pulvillus) and a sessile, solid spiniform one (Fig. 1D)Hyadesiidae (Astigmata)
 - Tarsi I and II end with one to three sessile claws (Fig. 1E, J). No flexible stalk with minute claw present3

3. Idiosoma soft-skinned. Leg IV about as long as or longer than idiosoma (Fig. 1G)Pontarachnidae (Hydrachnidia, Prostigmata)
 - Integument well-sclerotised. Leg IV shorter than idiosoma..4
4. Integument generally dark, rarely light-brown. Gnathosoma not or hardly visible in dorsal aspect. Notogastral shield large, covering major part of dorsum (Fig. 1E). Without pair or marginal peritremes. Pairs of genital and anal sclerites large, both almost similar in outline (Fig. 1F). Legs with five segments..... Ameronothroidea (Oribatida)
 - Integument light-brown. Gnathosoma visible in dorsal aspect (Fig. 1J). Dorsum with a single large or an anterior and posterior shield. With pair or marginal peritremes and stigmata. Ventral shields rarely paired (Fig. 1I). Legs with six or more segments Mesostigmata

The Hyadesiidae (Astigmata) are soft-skinned, the plates on the idiosoma delicate. The colour of the integument is light-brown. The legs are shorter than the idiosoma, five-segmented and situated close together in the anterior and middle part of the idiosoma, the apertures of legs III and IV are only seen in ventral aspect (Fig. 1B, C). All tarsi bear a solid, spiniform claw, tarsi I and II an additional minute claw on a long, flexible stalk (pulvillus) (Fig. 1D). The palps are short, two-segmented. Hyadesiid mites are slow-moving. They often are found in dense aggregations amongst algae and barnacles in tidal and shallow water zones. The taxon illustrated is larviparous.

The Mesostigmata are terrestrial though several of the families have a few representatives in the intertidal area. The body may be slender or wide, its length more than 2× to less than 1.5× the width, slightly or distinctly flattened. The integument of the Mesostigmata is in general light-brown; the dorsum is covered by one or more shields; a pair of stigmata and peritremes are in marginal or ventro-marginal position. The gnathosoma, with its long palps, surpasses the idiosoma. The legs have at least six segments, but further division of one or more segments are common. Most of the mesostigmatid mites become active when the water recedes, some are slow-moving, others rather quick.

The majority of the Oribatida are terrestrial, but species of the superfamily Ameronothroidea are often found in marine habitats, in and above the middle tidal area. The ameronothroids are heavily sclerotised, the integument is light- or dark-brown, legs and idiosoma have the same colour. A major part of the idiosoma is covered by a single large shield, the notogastral shield (Fig. 1E). The legs are short, five-segmented and arranged close together in the anterior and middle part of the body (Fig. 1F); the apertures of legs III and IV are in ventral position. The tarsi end with one or three large claws. The mouthparts are short and mainly covered by the frontal part of the idiosoma. The aquatic and semi-aquatic oribatid species may locally be abundant. The movements of oribatid mites are slow.

The suborder Prostigmata includes two taxa which are truly aquatic, the Hydrachnidia, basically spread in freshwater, with the marine family Pontarachnidae, and the Halacaroida with the family Halacaridae which includes more than 1000 marine species. Beside these aquatic families some few

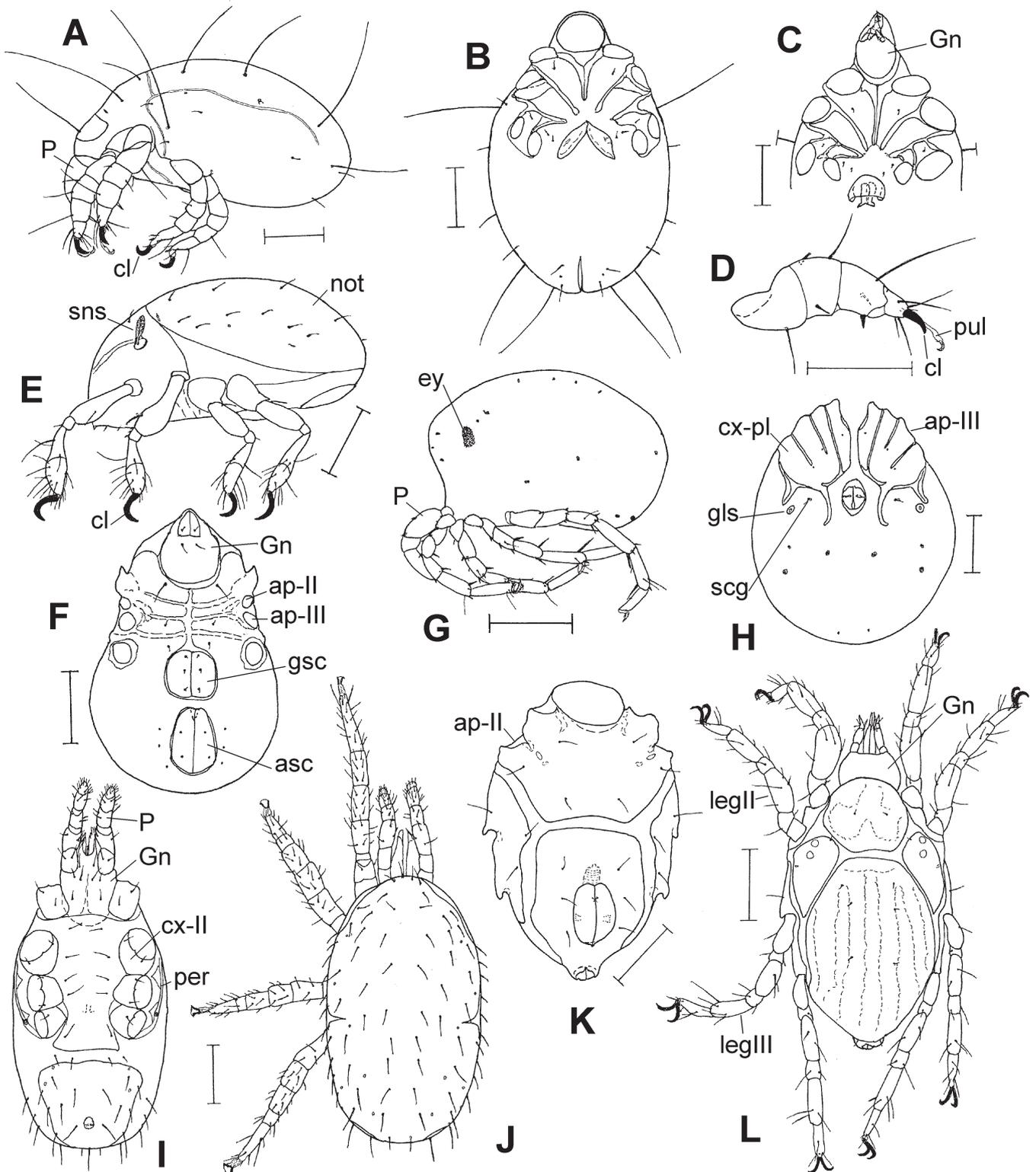


Fig. 1. Representatives of Astigmata, Oribatida, Mesostigmata, and Prostigmata. A–D, Astigmata: Hyadesiidae: *Hyadesia* sp.: A, body, lateral, female; B, idiosoma, ventral, female; C, gnathosoma and anterior part of idiosoma, ventral, male; D, leg I, lateral, female (basal segment omitted). E, F, Oribatida: Ameronothroidea: E, body, lateral, female; F, gnathosoma and idiosoma, ventral, female. G, H, Prostigmata: Hydrachnidia: Pontarachnidae: *Litarachna bartschae* Smit, 2003 and *L. curtipalpis* Smit, 2003: G, *Litarachna bartschae*, body, lateral, deutonymph; H, *Litarachna curtipalpis*, idiosoma, ventral, female (from Smit, 2009b). I, J, Mesostigmata: Ascidae: I, gnathosoma and idiosoma, ventral, female; J, body, dorsal, female. K, L, Prostigmata: Halacaridae: *Copidognathus rhombognathoides* Bartsch, 2006: K, idiosoma, ventral, female; L, body, dorsal, female. Scale bars = 100 µm. (ap-II, ap-III, aperture of leg II and III; asc, anal sclerite; cl, claw; cx-II, coxa of leg II; cx-pl, coxal plate IV; ey, eye pigment; gls, glandularium-like structure; Gn, gnathosoma; gsc, genital sclerite; not, notogastral shield; P, palp; per, peritreme with stigma; pul, pulvillus; scg, sclerite with glandularium and seta; sns, sensilla).

terrestrial prostigmatid mites may be found in an upper tidal area, e.g., the rather large-sized and markedly red coloured Bdellidae, Erythraeidae and Trombidiidae. The idiosoma of the Pontarachnidae is globular, the gut content more or less intensely shining through the transparent integument, the pair of eye spots dark and conspicuous (Fig. 1G). Pontarachnids are soft-bodied, there are no large dorsal shields or plates embedded in the integument. The legs are rather long, leg IV about as long or longer than the idiosoma. The legs are six-segmented and inserted, adjacent, in the anterior and middle part of the body. The mouthparts are large, the palps long, five-segmented. The claws are not heavily sclerotized. Pontarachnids move rapidly, when disturbed they often leave the substratum and swim in the water column. Pontarachnids are aquatic, found from constantly waterlogged zones to a depth exceeding 50 m (Pešić et al., 2012), present in the benthos or hyperbenthos but also in the water column, e.g., associated with jellyfish (L. Gershwin, personal communication) and gills of fish (Smit, 2008b). Two species are known from Singapore, another two from the adjacent Malaysia (Smit, 2008a, 2009). The deutonymph illustrated (Fig. 1G) (ZRC.ARA.1350) is a representative of a third Singaporean species. Characters of this species are: coxal plates I separated medially; suture line between coxal plates II and III short, line between plates III and IV slightly interrupted; medial pair of apodemes of coxal plates IV more slender and slightly longer than lateral pair; glandularium-like structure on coxal plate IV, pair of sclerites with coxoglandularium and seta posterior to coxal plates IV; spiniform process on second palpal segment large, almost one-third of height of palpal segment; fourth segment with small peg-like process; tibiae III and IV with one and two long setae, respectively. This combination of characters is present in *Litarachna bartschae* Smit, 2003, a species already recorded from tropical Western Australia and Brunei Darussalam (Smit, 2003, Pešić et al., 2013). The present new record extends the known range of distribution to Singapore.

The Halacaridae (Prostigmata) have a slightly or distinctly flattened body. The dorsum bears four plates (Fig. 1L) of which two or more may be reduced or enlarged and fused to a shield. The two anterior pairs of legs are directed forward, the posterior ones backward, there is a distinct gap between the aperture of the second and third leg pair (Fig. 1L), this distance generally equals more than one third of the width of the idiosoma. The legs are inserted marginally, sometimes dorsomarginally, not ventrally. In adults the legs are six-segmented, in the first two juvenile stages all legs (in larvae) or legs IV (in protonymphs) are five-segmented. The tarsi end with one, two or three large claws; in the majority of species the shape of the claws on tarsus I differs slightly or distinctly from that on the following tarsi. The palps are two- to four-segmented. Halacarids are exclusively aquatic, they are benthic, they cannot swim but crawl amongst the substratum. The majority of species are slow-moving, though a few species may be rather agile. Halacarids are found in perennial habitats, they colonise a system of small crevices and microcavernes amongst an epiflora and fauna, surface structures or gill chambers of a macrofauna, they inhabit the interstitia amongst coarse sandy deposits and flocculent

debris. Halacarid mites are not found in habitats clogged up with silt or with long-term absence of oxygen. The majority of the more than 1000 species is free-living, only a few species seem to be closely associated with a macrofauna or show morphological transformations and are or may be parasites.

The Halacaridae proved to be a diverse aquatic taxon in the samples taken on the coast of Singapore. Eighteen species in seven genera have been found amongst an epiflora and fauna on trunks, branches, roots, and pneumatophores of seashore trees. The genera, and the number of species (in parentheses) are *Acarothrix* (3), *Actacarus* (1), *Agauopsis* (2), *Agauae* (1), *Copidognathus* (7), *Isobactrus* (1), and *Rhombognathus* (3).

Key to the halacarid genera

1. Gnathosoma in dorsal aspect largely concealed by idiosoma, only apical parts of palps recognisable *Isobactrus*
 - Gnathosoma extends beyond idiosoma, in dorsal aspect palps and part of gnathosomal base visible (Fig. 1L) 2
2. Leg I markedly wider and longer than following legs; telofemur I bears three to four short truncate spines (Figs. 6L, 7I) *Agauopsis*
 - Leg I not or only slightly wider than following legs; telofemur I with one or zero spiniform setae 3
3. Tibia I with six slender ventral setae (Fig. 5A) *Agauae*
 - Tibia I with two, three or four ventral setae 4
4. OC reduced in size, length less than 1/10 of idiosomal length (Fig. 3I) *Actacarus*
 - Length of OC at least one-fifth of idiosomal length 5
5. Tibiae I and II with three ventral setae each (Figs 9H, 11H, 15A) *Copidognathus*
 - Tibiae I and II with two ventral setae 6
6. Colour of idiosoma green (gut content), legs transparent. Tarsus I without ventral seta (Figs 18K, 19C, L) *Rhombognathus*
 - Colour of idiosoma pale, white or faintly brown. Tarsus I with ventral setae (Figs 2E and O, 3F) *Acarothrix*

Acarothrix Bartsch, 1990

Diagnosis. Plates AD, OC and PD present. Dorsum with up to four pairs of gland pores and five to six pairs of idiosomal setae; sixth pair (adanal setae) on anal plate. AE with pair of epimeral pores and three pairs of ventral setae. PE with one dorsal seta and three ventral setae. Female GA with three pairs of perigenital and one pair of subgenital setae. Male GA with numerous pgs, its genital sclerites with four pairs of sgs and a pair of external genital acetabula.

Gnathosoma with laterally attached four-segmented palps. In ventral aspect rostrum triangular. Gnathosomal base and rostrum each with a pair of maxillary setae. Rostral tip with two pairs of rostral setae. P-2 with one dorsal seta. No seta on P-3. P-4 with three setae in basal whorl.

Genua of legs shorter than telofemora and tibiae. Basifemora I to IV with 2, 2–3, 2, 2 setae. Tibiae I to IV with 3–4, 3–4, 3, 3 dorsal and 2, 2, 2, 2 ventral setae. On tibiae I to III ventromedial seta bipectinate. Solenidion on both tarsus I and II in dorsolateral position. Tarsi I to IV with 2–3, 0, 0, 0 ventral and 4, 4, 4, 3 dorsal setae. All tarsi with paired claws. Central sclerite with small, bidentate median claw.

With a larval and a single nymphal stage.

Three species have been collected in Singapore.

Key to the adult *Acarothrix* species

1. OC oblong (Figs 2A, 3A). Basifemur II with three setae2
 – OC triangular (Fig. 2H). Basifemur II with two setae
 *A. grandocularis*
2. PD with cerotegumental ribs and two pairs of cones with gland pores. OC with the two setae ds-2 and ds-3 (Fig. 3A)
 *A. palustris*
 – PD with pair of costae but without cerotegumental ribs. On PD only posterior pair of gland pores on cones. OC with one seta (Fig. 2A) *A. ampliomeris*

***Acarothrix ampliomeris* Bartsch, 2006**
(Fig. 2A–G)

Acarothrix ampliomeris Bartsch, 2006b: 84–87, figs 1–16.

Material and collecting site. One protonymph, ZRC.ARA.1351, Singapore, end of Lim Chu Kang Road, 1°27'N, 103°42'E, green (Cladophorales) and red algae (*Catenella* sp., Gigartinales) on pneumatophores of *Avicennia* sp. (Avicenniaceae), 28 October 2012.

Colour. Idiosoma light brown or colourless, spots of eye pigment minute, black.

Short description. Adults. Length of female 294–309 µm, of male 314–325 µm. AD somewhat longer than wide, with triangular posterior margin (Fig. 2A). OC and PD elongate, OC more than twice as long as wide, PD 1.7× longer than wide. Anterior margin of PD rounded. PD without marked costae. Anterior (on AD) and posterior (on PD) pair of gland pores on cones; glp on OC present but not on cones; pores of glands in middle of PD minute. Dorsal setae on AD, OC and PD on small peduncles; pair of ds-2 in striated integument anterior to OC, ds-3 in middle of OC, ds-4 and ds-5 on PD. AE wide, its truncate lateral margins in almost parallel arrangement (Fig. 2B). Female GO large, distance between anterior margin of GO and that of GA equalling 0.3× length of GO. Female GA with three pairs of pgs, anterior pair close to anterior margin of GA. Male GO smaller than in female, in middle of GA (Fig. 2D); GA with 10–11 pairs of pgs. Gnathosoma about 1.4× longer than wide (Fig. 2C). Tectum truncate. Leg chaetotaxy: leg I, 1, 2, 5, 4, 6, 6 (Fig. 2E); 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. Tibia I to IV with 4/2, 4/2, 3/2, 3/2 dorsal/ventral setae, one of ventral setae bipectinate, that ventral seta on tibia II conspicuously long, on tibia III and IV short and wide. Paired claws with accessory process.

Protonymph. Length of idiosoma 200 µm. OC as in adults elongate, length more than twice the width. PD shorter than in adults (Fig. 2F); surface faintly reticulated. Idiosomal setae on AD, OC and PD on small peduncles; pair of ds-6 in ventral position, on peduncles. AE with very wide, truncate posterior margin (Fig. 2G). Each PE with three setae, one dorsal and two ventral. Outline of gnathosoma same as in

adults. Leg chaetotaxy, from trochanter to tibia: legs I and II, 1, 2, 3, 4, 5; leg III, 1, 1, 2, 3, 5; leg IV, 0, 1+2 (basal and telofemur), 3, 5. On tibia III ventromedial seta wide and bipectinate (as in adult), on tibia IV that seta short, slender and smooth.

Distribution and biology. Singapore. All present records are from muddy algal tufts growing on the sediment between and on pneumatophores of *Avicennia* sp.

***Acarothrix grandocularis* Chatterjee, Marshall, Guru, Ingole & Pešić, 2012**
(Fig. 2H–O)

Acarothrix grandocularis Chatterjee et al., 2012a: 542–546, figs 1A–D, 2A–D.

Material and collecting site. One female, ZRC.ARA.1352, Singapore, Kranji, 1°25'N, 103°45'E, landward edge of mangrove area, green and red algae on trunk, high water edge, 30 October 2012.

Colour. Body (gut content) conspicuously pale; no eye pigment present. Integument of legs transparent.

Short description. Female. Length of idiosoma 272 µm. Dorsal plates reticulate, each polygon with small foveae, mainly in peripheral arrangement (Fig. 2K). Foveae 1–2 µm in diameter, polygons in median part of PD 10–11 µm in diameter, in lateral part 6–8 µm. Anterior margin of AD with short epicuticular villi (Fig. 2J); posterior margin of AD wide and triangular. OC elongate triangular with rounded medial corner (Fig. 2H). Each plate with two large corneae. PD with single pair of longitudinal costae, their surface delicately punctate, rarely parts of costae reticulate. Remainder of plate reticulate. Gland pores small, not on cones, one pair on AD, one pair on OC lateral to posterior cornea, both removed from lateral margins of plates. On PD gland pores obscured by ornamentation of plate, one pore may be present in posterior part of PD, immediately lateral to costae. Pair of ds-1 in posterior half of AD, ds-2 in medial part of OC, ds-3 to ds-5 on PD; pair of ds-6 on anal cone. Surface of ventral plates delicately punctate. Epimeral pore opening with slit (Fig. 2I). Female GA longer than AE. Area around GO somewhat raised. Pair of pgs-2 closer to pgs-3 than to pgs-1. Gnathosoma slender. Tectum truncate (Fig. 2L). Rostrum extending to the level of seta on P-2. Dorsal flank of gnathosomal base foveate, ventral flank punctate. Seta on P-2 wide. Ventral margins of telofemora I and II with short, delicate villi (Fig. 2O). Telofemur and tibia I equal in length. Telofemora 1.9–2.1× longer than wide. Leg chaetotaxy, from trochanter to tarsus: leg I, 1, 2, 5, 4, 6, 6; leg II, 1, 2, 5, 4, 6, 4; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 2, 2, 3, 5, 3. Dorsal seta on basifemora plumose. Each of tibiae I to III with short, bipectinate ventromedial (Fig. 2N) and slender ventrolateral seta; on tibia IV both setae slender. On tarsi I and II dorsomedial fossary seta almost level with dorsal fossary seta; dorsolateral fossary seta distinctly moved towards apex of tarsi. Famulus on tarsus I on digitiform lamella (Fig. M). On tarsi III and IV dorsal fossary seta in

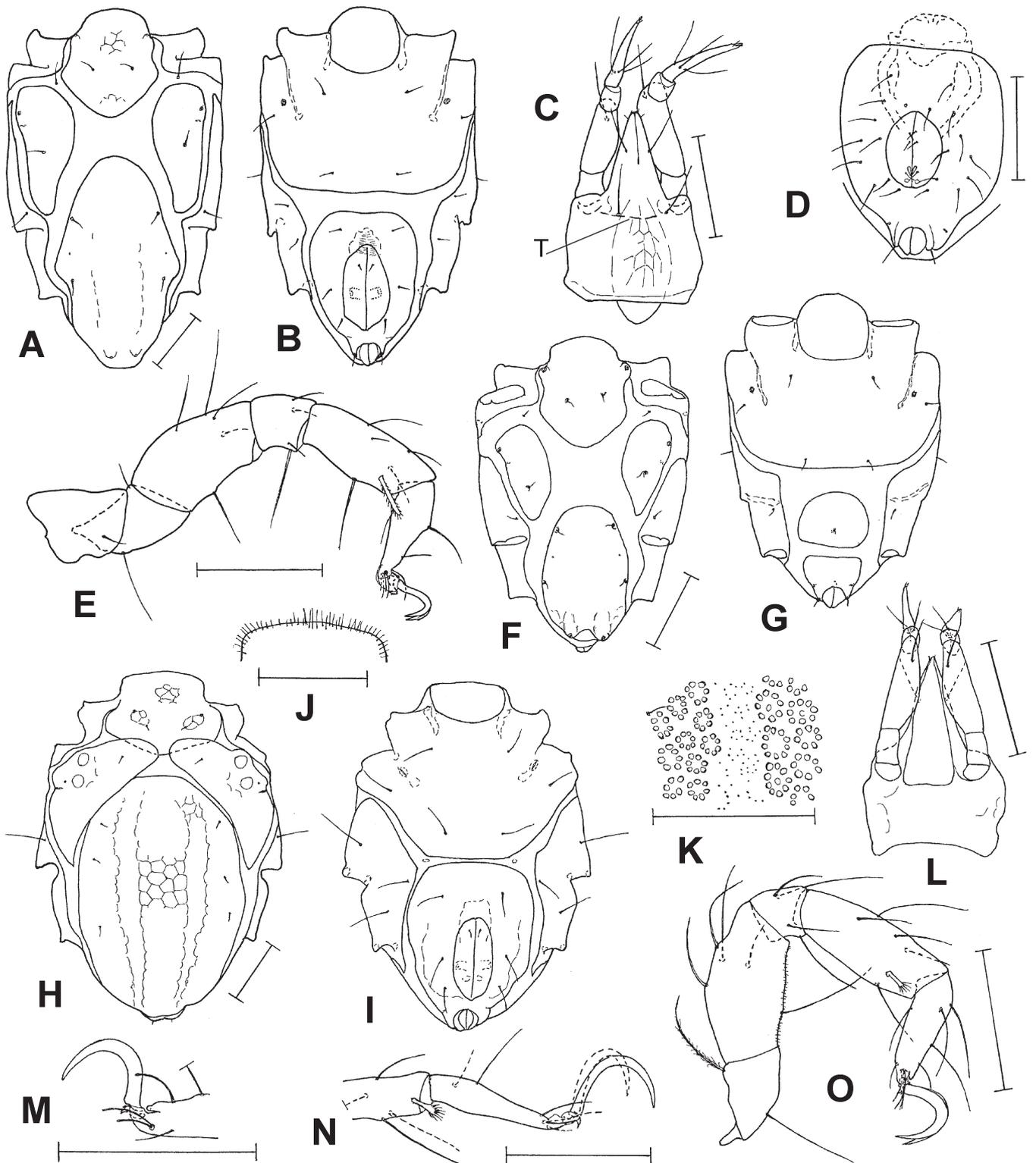


Fig. 2. *Acarothrix ampliuneris* Bartsch, 2006 and *Acarothrix grandocularis* Chatterjee et al., 2012. A–G, *Acarothrix ampliuneris*: A, idiosoma, dorsal, female; B, idiosoma, ventral, female; C, gnathosoma, ventral, female; D, genitoanal plate, ventral, male; E, leg I, medial, female; F, idiosoma, dorsal, protonymph; G, idiosoma, ventral, protonymph. H–O, *Acarothrix grandocularis*, female: H, idiosoma, dorsal; I, idiosoma, ventral; J, anterior margin of AD; K, part of posterior dorsal plate and left costae at the level of ds-4; L, gnathosoma, dorsal (chelicerae omitted); M, tip of tarsus I, lateral (medial setae and claw omitted); N, part of tibia and tarsus III, medial (lateral setae and claw in broken line); O, basifemur to tarsus I, medial. Scale bars = 50 μm. (T, tectum).

basal half, pair of distal fossary setae near tarsal tip. Tarsus I with pair of pas doublets, tarsus II with singlets; all these pas eupathid. On tarsus III medial pas eupathid, lateral pas slender, on tarsus IV both pas slender. Paired claws smooth, claws on tarsi II to IV conspicuously slender.

Remarks. *Acarothrix grandocularis* has unusually large, triangular OC which include the ds-3 and the major parts of the dorsal plates are coarsely reticulated. Similar characters are found in *A. umgenica* Procheş, 2002, known from South Africa (Procheş, 2002). The most marked difference between *A. grandocularis* and *A. umgenica* is the absence (*A. grandocularis*) versus presence (*A. umgenica*) of a pair of gland pores in the anterior half of the PD (cf. Procheş, 2002: fig. 4A).

There are a few differences between the female from Singapore and the specimens described by Chatterjee et al. (2012a) on the basis of material from Brunei Darussalam and Goa. In those latter specimens the pair of costae on the PD are abruptly widened between the level with setae ds-4 and ds-5 (Chatterjee et al., 2012a: fig. 1A), the medial edge of the OC is not distinctly protruding, the anterior margin of the PD is ovate, the ds-3 and ds-4 are near the lateral margins of the PD and the claws are not markedly slender, in contrast, in the Singaporean material the costae of the PD are evenly decreasing in width towards posterior end of plate (Fig. 2H), the OC are conspicuously wide, the anterior margin of the PD is truncate, the ds-3 and ds-4 are removed from the margins of the PD, and the claws are slender. These differences may partly be due to that the female from Singapore had hatched recently, its idiosoma was still flattened whereas older, ovigerous females have an arched dorsum. Measurements of length and width of the dorsal plates (e.g., the OC) are always influenced by the convexity of the dorsum. Moreover, the range of character variability in this species is not known. More material from different localities may prove the individuals from the South China Sea and Indian Ocean to belong to *A. umgenica* or to several cryptic species.

Distribution and biology. Brunei Darussalam, North Goa (India), Singapore. All present records are from mangals, those by Chatterjee et al. (2012b) are from algal turf on pneumatophores; in Singapore the species was extracted from green and red algae from a trunk, upper tidal zone (Bartsch, 2013).

The female bears seven thecae of suctorians fixed to the dorsum and legs III and IV. The thecae are 23–32 µm long, 11–18 µm wide, the surface is almost smooth. Remnants of the macronucleus have a diameter of 6–7 µm. The stalk is up to 13 µm long. The suctorians are moribund and tentacles no more present. These suctorians are similar to the protozoa found on *Agave galatea* Otto, 1999, which for the present are identified as *Praethecacineta halacari* (Schulz, 1933) (see below).

Acarothrix palustris Bartsch, 1990

(Fig. 3A–F)

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

Acarothrix palustris, Bartsch, 2006b: 87, figs 17–20.

Colour. Gut content slightly brown. Dorsum with three small black eye spots.

Short description. Length of females 294–320 µm, of male 280 µm. AD with rounded posterior margin (Fig. 3A). OC about as long as AD and 1.8× longer than wide. PD with pair of hardly raised costae, separated from reticulated remainder of plate by delicate cerotegumental ribs. Lateral margins of AE converging, posterior margin concave (Fig. 3B). In female distance from anterior margin of GO to GA distinctly less than half length of GO. In male GO in middle of GA and flanked by 11–12 pairs of pgs (Fig. 3D). Gnathosoma about 1.7× longer than wide. Tectum slightly truncate. Rostrum almost reaching to level of seta on P-2 (Fig. 3C). P-4 somewhat longer than P-2; basal whorl with three setae removed from basis of P-4 (Fig. 3E). Leg chaetotaxy: leg I, 1, 2, 5, 4, 6, 6 (Fig. 3F); 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. Ventral setae long and stout, several of dorsal setae wide, ‘hollow’. Tibiae I to III each with a short, wide and bipectinate ventromedial seta, that seta on tibia IV slender. Claws smooth.

Distribution and biology. Southern China (Hong Kong), Singapore and India (Goa) (Bartsch, 1990, 2006b; Chatterjee et al., 2013).

Most records are from mangroves, from green and red algae growing on the surface of a mud flat surrounding the trees. In Hong Kong the species was found in the upper sediment layer of a shallow tidal pool, between Juncaceae (Bartsch, 1990).

Actacarus Schulz, 1937

Diagnosis. Plates AD and PD large, OC minute, sometimes fused with PE. Dorsum with four pairs of gland pores, one each on AD and OC and two on PD, and six pairs of idiosomal setae; adanal setae on PD adjacent to anal sclerites. AE with three to four pairs of setae; PE with a dorsal and two to three ventral setae. Membraneous integument between AE and GA with zero to one pair of setae. Female with three (rarely up to five) pairs of pgs, though posterior pair may be minute or concealed by genital sclerites; sgs lacking. Male with 7–18 pairs of pgs and one to three pairs of sgs.

Both pairs of maxillary setae inserted on rostrum. Palps four-segmented, attached laterally and extending beyond rostrum. P-2 with a distal seta. P-3 short, with medial spur. P-4 with three to four basal setae and a spur.

Genua of legs shorter than adjoining leg segments. Basifemora I to IV with 2, 2, 1–2, 1–2 setae. Tibia I with two to four ventral bristle-like setae, tibiae II, III and IV each with two ventral setae. Tarsus I with large lateral membrane of claw

fossa. Tarsi I to IV with 4, 4, 3–4, 3–4 dorsal and 3, 0, 0, 0 ventral setae. All tarsi with pair of parambulacral setae. Paired claws of tarsus I smaller than those of following tarsi. On all tarsi median claw small.

With one larval and two nymphal stages.

***Actacarus minor* Bartsch, 1996**
(Fig. 3H–M)

Actacarus minor Bartsch, 1996: 231–234, figs 13–25.

Material and collecting site. One male, ZRC.ARA.1353, Singapore, end of Lim Chu Kang Road, 1°27'N, 103°42'E, red algae on stilt roots of *Rhizophora* sp. (Rhizophoraceae), 7 October 2000. One female, IB, Singapore, OBS Camp NW, 1°26'N, 103°56'E, algae on root bale of uprooted coconut palm, 21 October 2012.

Colour. Pale, without any eye spots. Gut content with lightly brown.

Short description. Length of male 163 µm. Idiosoma almost twice as long as wide. Surface of AD evenly punctate, porosity of PD slightly more delicate, canaliculi not as deep as on AD. Integument between plates coarsely striated. PD more than three times longer than AD. Opposing margins of AD and PD slightly concave and arched, respectively (Fig. 3I). OC narrow, in present male in marginal position; each plate with gland pore and canaliculus. PD with two pairs of gland pores, anterior pair immediately posterior to the level of insertion of leg IV. Integument between plates coarsely striated. Opposing margins of AE and GA convex and concave, respectively. AE and GA 1.3× and 1.4× longer than wide, respectively, and AE 1.4× longer than GA. GA anteriad extending to or slightly beyond the level of insertion of leg IV (Fig. 3J). AE with four pairs of setae and PE with one dorsal and two ventral setae. GO in ventral position, with one pair of outlying pgs and 12 pairs of long setae lateral and posterior to GO (Fig. 3H). Rostrum slender, triangular. Tectum slightly arched (Fig. 3K). P-2 flattened, 1.8× longer than high (Fig. 3L), integumental punctation on lateral flank somewhat coarser than that on PD. Punctation on lateral flank of telofemur I present, its density similar to that of PD. Leg chaetotaxy, leg I, 0, 2, 3, 5, 7, 7 (Fig. 3M); leg II, 0, 2, 3, 4, 5, 4; legs III and IV, 1, 2, 2, 3, 5, 3.

Remarks. Five of the 24 *Actacarus* species listed in Bartsch (2009a) are known to bear four pairs of setae on the AE, i.e., *A. latus* Newell, 1984, *A. minor* Bartsch, 1996, *A. nanus* Otto, 2000, *A. pacificus* Bartsch, 1979, and *A. spinosus* Otto, 2000. Records of *A. latus* are from the south-eastern Pacific, from Chile, of *A. minor* from the Caribbean area, of *A. nanus* and *A. spinosus* from the tropical Pacific, from Queensland, Australia, the Society and Hawaiian Islands (Newell, 1984; Bartsch, 1996a; Otto, 2000); *A. pacificus* is wide-spread in the Pacific and Indian Ocean (Bartsch, 2009a).

Actacarus minor and *A. nanus* are most similar, both have a remarkably long PD and AE, compared to the AD and GA, respectively. The single male from Singapore is slightly smaller but still within the expected length range of these two species. A difference between males of *A. minor* and *A. nanus* is the distance between the anterior margin of the GA and that of the GO, in *A. minor* less (0.6–0.7×) than, in *A. nanus* the same as the length of GO. The second palpal segment is not cylindrical but flattened, this may explain the difference in the length:height ratio between the descriptions of the Singaporean and the Caribbean specimens.

Characters of the three other species which can be used for discrimination are, in *A. latus* the length, with 334–355 µm distinctly more than in the others, the wide dorsal and ventral plates, the AE and GA are 0.8× and 1.2× longer than wide, and the AE 1.0–1.1× longer than the GA. The AE of *A. pacificus* is only slightly longer than the GA and in the males the distance from the anterior margin of the GA to that of the GO equals 1.2× the length of GO. Unique in *Actacarus spinosus* is the coarsely bipectinate ventral seta on leg I, this seta is smooth in its congeners.

Distribution and biology. The geographical range of *Actacarus minor* extends from the Caribbean area (Colombia) to Singapore (new record). Another two Singaporean species have records from the same areas, namely *Arhodeoporus bonairensis* (Viets, 1936) and *Simognathus fuscus* Viets, 1936 (Bartsch, 2009b). *Actacarus minor* has been extracted from sandy deposits and algal cover on roots.

***Agau* Lohmann, 1889**

Diagnosis. Plates AD and PD and pair of OC present. Plates and integument in general with cerotegumental membranes. PE with one to three dorsal setae anterior to leg III, zero to one seta anterior to leg IV. Female GA with three to ten (rarely more) pairs of pgs and zero to two pairs of sgs. Male GA with more than 50 pgs densely arranged around GO; genital sclerites with five pairs of scale-like sgs.

Rostrum long, almost parallel-sided, palps slender, four-segmented, attached laterally. Tectum with scaliform lamella. Maxillary setae inserted close together, one pair on gnathosomal base, one pair in basal portion of rostrum. Distal pair of maxillary setae shorter than basal pair. Rostral setae minute, spur-like or divaricate.

Legs slender; often with cerotegumental lamellae. Genua much shorter than telofemora and tibiae. Tibiae cylindrical or clavate, with four to six slender, usually smooth and bristle-like ventral setae. Tarsi with membranes of claw fossa. Tarsi III and IV with three dorsal setae. Solenidion on tarsus I in dorsolateral, on tarsus II in dorsomedial position. Tip of tarsus I with a cluster of 10–30 ventral eupathidia. Paired claws large, median claw present but small.

With a larval and two nymphal stages.

A single species was regularly taken in mangrove areas.

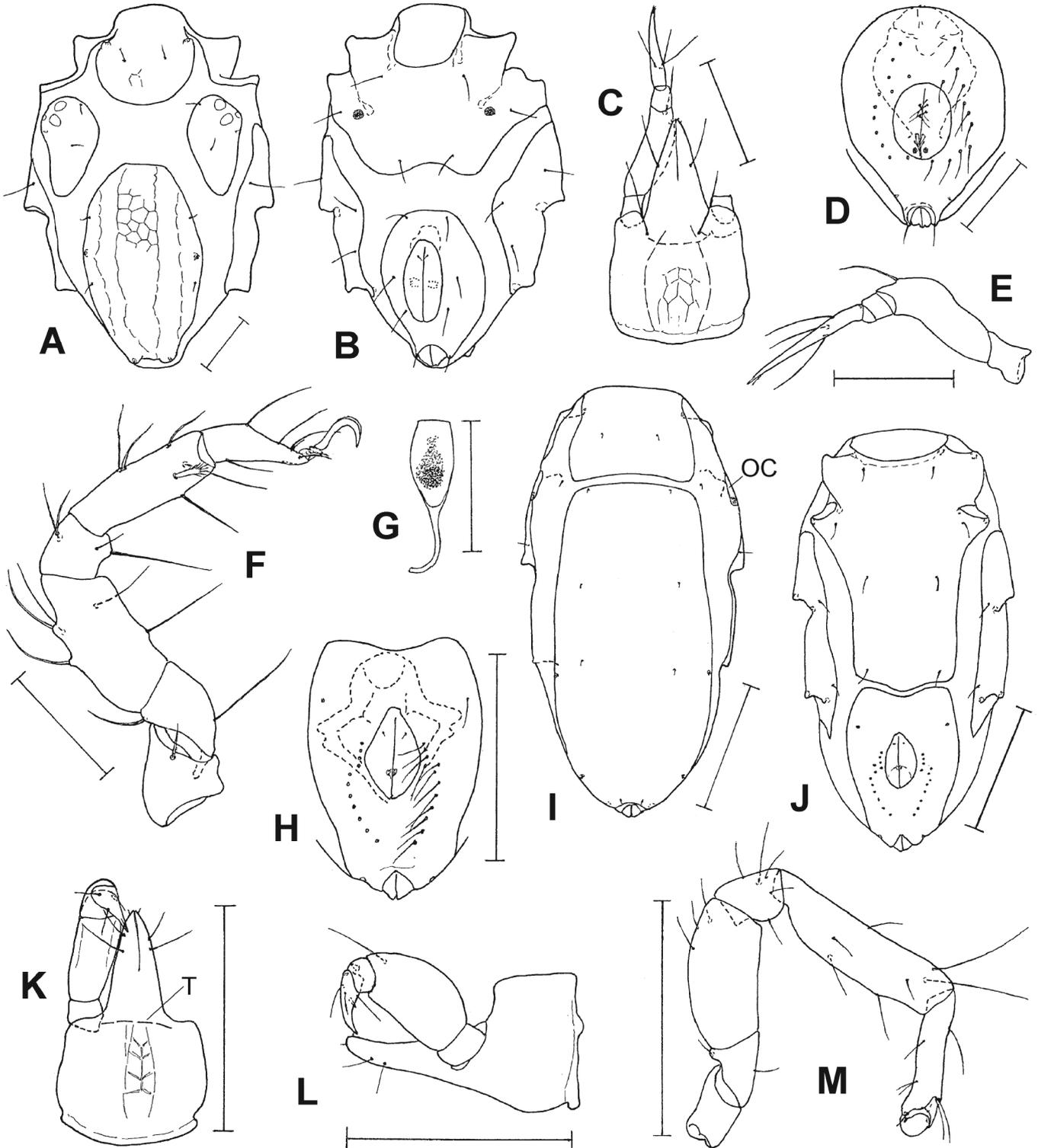


Fig. 3. *Acarothrix palustris* Bartsch, 1990, *Praethecacineta* sp. (Suctoria) and *Actacarus minor* Bartsch, 1996. A–F, *Acarothrix palustris*: A, idiosoma, dorsal, female; B, idiosoma, ventral, female; C, gnathosoma, ventral, female; D, genitoanal plate, ventral, male; E, palp, lateral, female; F, leg I, medial, female; G, *Praethecacineta* sp.; H–M, *Actacarus minor*, male: H, genitoanal plate; I, idiosoma, dorsal; J, idiosoma, ventral; K, gnathosoma, ventral; L, gnathosoma, lateral; M, leg I, medial. Scale bars = 50 μ m. (OC, ocular plate; T, Tectum).

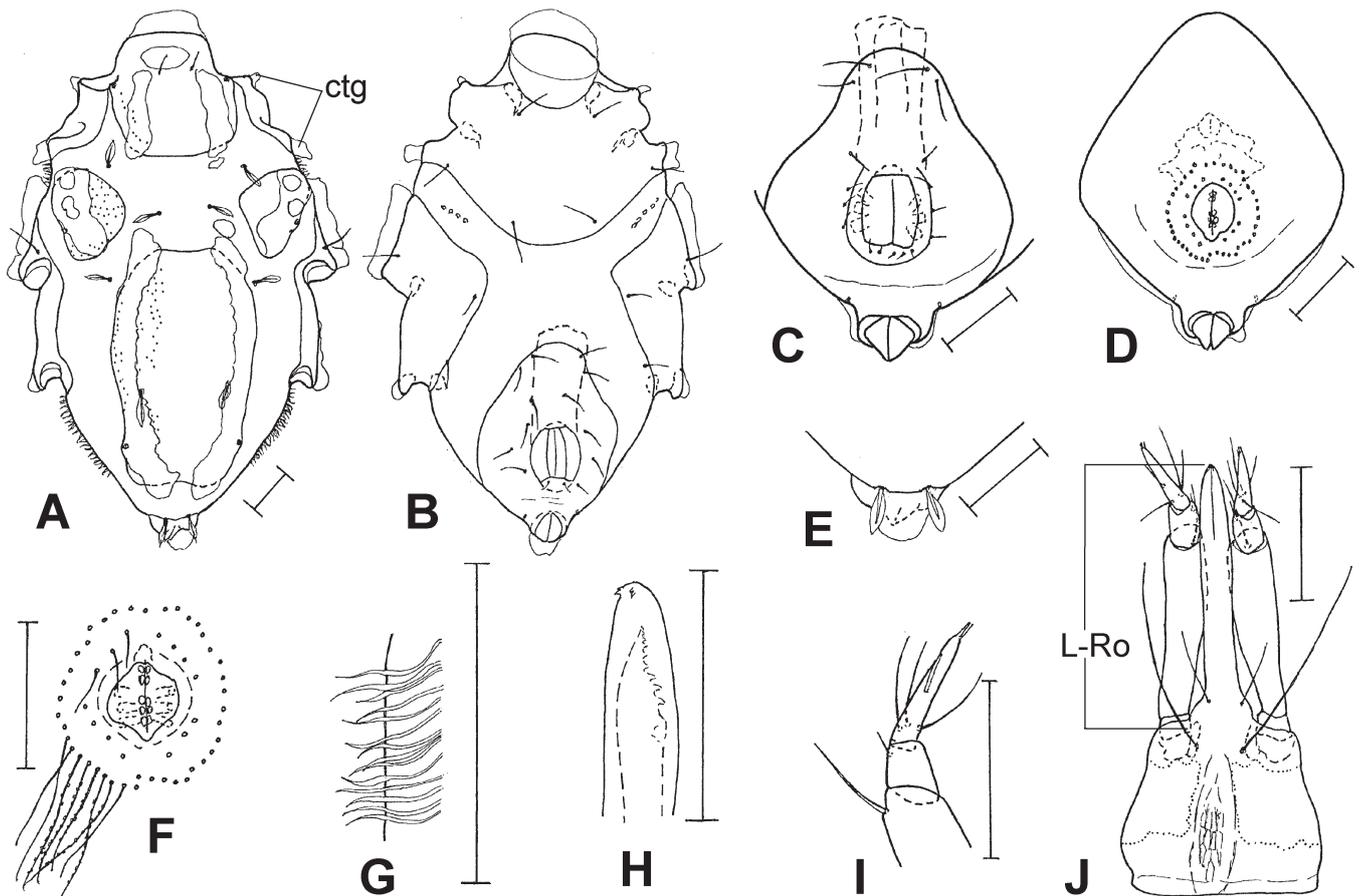


Fig. 4. *Agaue galatea* Otto, 1999. A, idiosoma, dorsal, female; B, idiosoma, ventral, female; C, genitoanal plate, ventral, female; D, genitoanal plate, ventral, male; E, anal cone and adanal setae, female; F, genital area, ventral, male; G, posterior idiosoma, part of left margin with striated integument, female; H, tip of rostrum, lateral, female; I, posterior part of palp, lateral, female; J, gnathosoma, ventral, male (porose areolae marked by dotted lines). Scale bars = 50 μm . (ctg, cerotegument; L-Ro, length of rostrum).

***Agaue galatea* Otto, 1999**
(Figs 4A–J and 5A–M)

Agaue galatea Otto, 1999: 276–278, figs 5A–D, 6A–F.

Agaue galatea, Bartsch, 2008: 112–113, fig. 5A, B.

Material and collecting sites. One female, 1 male, ZRC.ARA.1354, Singapore, mangrove area in edge of West Coast Park, 1°17'N, 103°45'E, *Bostrychia* mats (Ceramiaceae, Rhodophyta) on pneumatophores of *Avicennia* sp., 5 October 2004; 1 deutonymph, 1 larva, ZRC.ARA.1355, same collecting data as above; 4 females, 1 deutonymph, IB, same collecting data as above; 1 female, 1 male, IB, same site as above but 25 September 2009. One female, ZRC.ARA.1356, Singapore, Pulau Ubin, Chek Jawa, 1°24'N, 103°59'E, seaward edge of mangrove, epibios (mainly Ceramiaceae, Rhodophyta) on pneumatophores of *Sonneratia* sp. (Sonneratiaceae), 16 October 2012; 1 female, 1 deutonymph, 1 larva, IB, same collecting data as above.

Colour. Body content mainly pale. AD with median and each of OC with spot of black eye pigment. Major part of integument transparent but cerotegumental ribs on dorsal plates faintly brown, hence visible at low magnification.

Description. Adults. Idiosoma slender, 1.6–1.7 \times longer than wide. Length of female 500–550 μm , of male 460–485

μm . Dorsal plates with smooth cerotegument, remainder of plates without marked ornamentation. Integument between plates densely striated and with cerotegument. Along marginal parts this cerotegument extending beyond margin of idiosoma (Fig. 4A, G); though this may be an artefact due to clearing and mounting. AD rectangular, anterior margin truncate, posterior margin slightly arched. Plate with transverse ovate and pair of longitudinal cerotegumental ribs, the latter in parallel arrangement and 20–25 μm wide. OC slightly longer than wide, triangular, with rounded corners, with two corneae and black eye pigment between corneae, and with cerotegumental rib extending along lateral margin from anterior to posterior part of plate. PD 1.6–1.7 \times longer than wide; its anterior margin truncate. Pair of longitudinal ribs extending beyond anterior and posterior margin of PD, width of ribs same as those on AD. Dorsal idiosomal setae short, none markedly longer than the others, setae ds-2 to ds-6 often covered with cerotegumental sheet (Fig. 4E). Pair of ds-1 on AD immediately anterior to the level of gland pores. Pairs of ds-2 to ds-4 in striated integument. Pair of ds-5 on PD, at 0.6–0.7 (relative to length of PD) and level with insertion of leg IV, ds-6 on anal plate, in dorsal position. One pair of gland pores on AD, OC and PD; pair on PD halfway between ds-5 and end of PD.

Cerotegumental cover of ventral plates smooth; cerotegumental lamellae marginally extending beyond margins of plates. PE

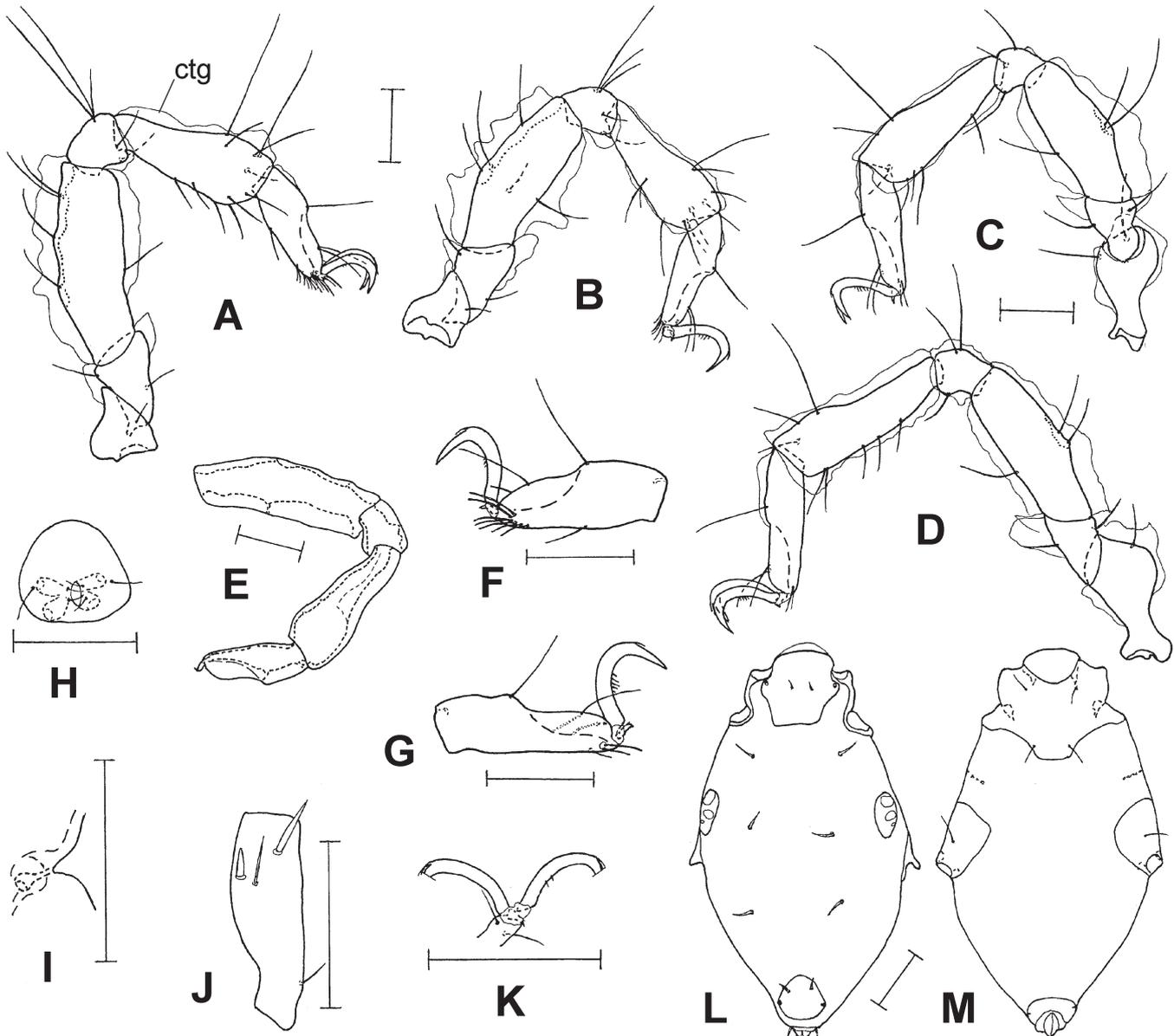


Fig. 5. *Agaua galatea* Otto, 1999. A, leg I, medial, female (porose areola marked by dotted line); B, leg II, medial, female; C, leg III, medial, female; D, leg IV, medial, female; E, telofemur to tarsus I, optical section, female; F, tarsus I, lateral, female (medial fossary seta, parambulacral setae and claw omitted); G, tarsus II, medial, female (dorsolateral seta, lateral parambulacral setae and claw omitted); H, genitoanal plate, deutonymph; I, anterior epimeral plate with epimeral tube, ventral, larva; J, femur I, dorsal, larva; K, claws of tarsus III, ventral, larva (tip of claws broken); L, idiosoma, dorsal, larva; M, idiosoma, ventral, larva. Scale bar = 50 μ m. (ctg, cerotegument).

with single dorsal and three ventral setae, posterior-most seta either in margin of PE or immediately adjacent in striated integument. Female GA oviform; GO in about middle of plate. Genital foramen with anterior and posterior lamella. Posterior lamella with one to four pairs of short pgs (Fig. 4B, C), further six pairs of pgs situated on either side and anterior to GO. No sgs on female genital sclerites; three pairs of genital acetabula shining through these sclerites. Ovipositor at rest extending to or somewhat beyond anterior margin of GA. Anterior margin of male GA more slender than that of female, oviform and extending antieriad halfway between level of insertions of legs III and IV. Male GO smaller than that of female, situated in posterior half of GA; distance between anterior margin of GO and margin of GA equalling $3.0\times$ length of GO (Fig. 4D). Perigenital setae arranged in two rings close around GO, inner ring

with 7–9 pairs of setae, outer ring with 19–23 pairs. Often debris fixed to slender pgs (Fig. 4F). Each genital sclerite with five scaliform sgs. Genital acetabula somewhat smaller than in female.

Gnathosoma long and slender, $2.1\text{--}2.3\times$ longer than wide or $0.3\times$ the length of idiosoma. Integument of dorsal, marginal and major part of ventral gnathosomal base punctate (Fig. 4J). Rostrum basally widened, else narrow, parallel-sided, $1.6\text{--}1.7\times$ longer than gnathosomal base and extending beyond basal part of P-4. Tip of rostrum with minute divaricate spurs (Fig. 4H). Lamellar tectum scaliform. Basal pair of maxillary setae much longer than apical pair. P-2 with one slender and smooth, ‘hollow’ dorsal seta, P-3 with a short dorsal seta, P-4 with three setae in basal whorl, a lateral solenidion, apical setula and two spurs (Fig. 4I). Cheliceral claw with 8–9 tines (Fig. 4I).

Legs slender. Tibiae slightly clavate, cuticle rather thin in apical part of segment (Fig. 5E). Telo femora I and II longer than the legs' tibiae, telofemur III somewhat shorter than tibia III, telofemur and tibia IV almost equal in length. Telo femora I and IV about three times (3.0–3.2×) longer than high, telofemora II and III shorter, 2.7–2.8× longer than high, respectively. Leg segments with cerotegumental patches (Fig. 5A–D), on telofemora patches half or less as thick as height of segments. Outline of cerotegument often obscured by layers of debris. Chaetotaxy of legs I to IV, of trochanter — basifemur — telofemur — genu — tibia (number of observations of a given state in square brackets): leg I: 1[20] — 2[20] — 4[2],5[18] — 5[20] — 6[1],9[2],11[7],12[10]; leg II: 1[20] — 2[20] — 5[20] — 5[19],6[1] — 7[2],8[2],9[14],10[2]; leg III: 2[18],3[1] — 2[19] — 3[19] — 3[19] — 7[18],8[1]; leg IV: 0[17],1[2] — 2[20] — 2[1],3[19] — 3[20] — 5[1],6[1],7[14],8[4]. All setae slender and smooth. Tarsi I to IV each with three fossary setae; paired fossary setae on enlarged fossa membranes. Solenidion on tarsus I short, setiform, on lateral fossa membrane (Fig. 5F), on tarsus II on inside of medial membrane (Fig. 5G). Tarsus I with one tapering ventral seta, tip with 13–15 eupathidia, pair of doubled pas included. Tarsus II with three ventral eupathidia, pair of doubled pas included. Tarsi III and IV with pair of setiform pas.

All tarsi with small median claw and distinct, paired claws. Accessory process of the latter claws with two minute tines, shaft of claws with two to five tines.

Deutonymph. Length 334–475 µm. Plates with cerotegumental lamellae. Shape of AD similar to that of adults. OC somewhat smaller and PD distinctly smaller than in adults. GP and AP separated. GP with one pair of pgs, two pairs of small sgs immediately adjacent to primordial genital opening and two pairs of internal genital acetabula (Fig. 5H). No pgs in striated integument. Gnathosoma 2.1× longer than wide. Leg chaetotaxy, from trochanter to tibia: leg I, 1, 2, 5, 5, 8(–9); leg II, 1, 2, 5, 5, (5–)6; leg III, 2, 2, 3, 3, 5(–6); leg IV, 0, 1, 3, 3, 5. Tarsus I with a slender ventral seta and apically with 11 eupathidia (pas included). Tip of tarsus II with pair of pas singlets; no further eupathidia present.

Larva. Length 200–305 µm. AD anteriorly with small cerotegumental lamella but dorsal plates without ribs. PD much smaller than in adults (Fig. 5L). Pairs of ds-2, ds-3, ds-4, and ds-6 in one larva slightly longer and wider than ds-1 and ds-5, in another larva these setae distinctly larger than ds-1 and ds-5. AE with two pairs of setae and a pair of tube-like internal epimeral pores (Fig. 5I). Each PE with single ventral seta. Genital plate lacking (Fig. 5M). Gnathosoma 1.9× longer than wide (e.g., length 97 µm, width 50 µm, length of idiosoma 305 µm); its shape similar to that of adults. Legs five-segmented; without marked patches of cerotegument. Leg chaetotaxy: leg I, 1, 1+3 (basi- + telofemur), 4, 5, 7; leg II, 1, 1+3 (basi- + telofemur), 4, 5, 4; leg III, 1, 1+2, 3, 5, 3. Two of dorsal setae on telofemur I (Fig. 5J) and one seta on each of telofemora II and III wide and 'hollow'. Tarsus I with slender ventral seta and six eupathidia, pair of doubled pas included. Tip of tarsus

II with pair of pas singlets. Fossary membranes of tarsi II to IV narrow. Paired claws with zero to two tines (Fig. 5K).

Anomalies. One of the females (ZRC.ARA.1356) has a five-segmented leg III with a reduced number of setae (chaetotaxy similar to that expected to be present in protonymphs).

Remarks. Forty-four valid *Agauae* species (Bartsch, 2008, 2009a) exist. Adults of the species can roughly be separated on the basis of (1) the cerotegument on the dorsal plates which may have the form of wide and ornamented lamellae, low and smooth ribs or be largely reduced, (2) the cerotegumental lamellae or patches on the telofemora which are either as high as the height of the telofemora, narrow and their height distinctly less than that of the segment, or are lacking, and (3) the number of the dorsal setae on the PE anterior to insertions of legs III and IV, either a single seta or three setae and zero or one seta, respectively. Females can be separated on the basis of the arrangement of the GO on the GA; namely the distance between the anterior margin of the GO and that of the GA which is either less, the same or more than the length of the GO. *Agauae galatea* has smooth cerotegumental ribs on the dorsal plates, the height of the patches on the telofemora is less than that of the segment and each PE bears one dorsal seta; in the females the GA extends anteriorly distinctly beyond the GO. *Agauae chevreuxi* (Trouessart, 1889), *A. panopae* (Lohmann, 1893) and *A. polynesia* Bartsch, 1992 are most similar to *A. galatea*. The two first-mentioned species are known from the Atlantic Ocean and the adjacent basins, the last-mentioned species from south-western Pacific (Society Islands) (Bartsch, 2009a). *Agauae chevreuxi* has a longer, more slender rostrum, its length is more than twice the length of the gnathosomal base, and the claws have long pectines with numerous tines (Mari & Morselli, 1990; Bartsch 1998a). Females of *A. panopae* are characterised by the short, wide and bifid seta on P-2, other easily recognised characters are, the ovipositor extends distinctly beyond the anterior margin of the GA and the claws have long pectines with numerous tines (Viets, 1940; Morselli & Mari, 1985; Mari & Morselli, 1990). The females of *A. polynesia* are slender, 1.8× longer than wide, the ventral plates have a markedly structured epicuticula, the females have a long ovipositor, a single pair of pgs close to the anterior margin of the GA, and a long anal cone (Bartsch, 1992).

Agauae debilis (Lohmann, 1907) and *A. hamiltoni* Womersley, 1937, with records from southern South Africa and St. Paul (*Agauae debilis*) and Macquarie Islands (*A. hamiltoni*), demonstrate an overall similarity with *A. galatea*, but the descriptions are far from being detailed. Both species may have three setae on the PE, at least two setae are illustrated in *A. debilis* (Lohmann, 1907: fig. 1) and *A. hamiltoni* (Womersley, 1937: plate 4, fig. 1), and moreover *A. hamiltoni* has a converging structure on the AD, no parallel ribs as present in *A. galatea*.

Distribution and biology. Eastern Australia (Queensland) (Otto, 1999; Bartsch, 2008) and Singapore (new record).

All present records of *Agauae galatea* are from shallow water, mainly from the intertidal zone (Otto, 1999; Bartsch, 2008, present records). In Singapore the species was extracted from the epibios growing on pneumatophores (*Avicennia* sp., *Sonneratia* sp.), from tufts of algae on root bales of uprooted coconut palms, but also on the algal cover on rocks.

On one of the females from West Coast Park four suctorians were fixed to the ventral side of the posterior part of the idiosoma. The almost smooth thecae have a length of 32–33 μm and a width of 17–18 μm , the stalk is about 10 μm long. Approximately 40 tentacles are arranged in a single group on the upper part of the cell. The suctorians are most similar to *Praethecacineta halacari* (Schulz, 1933). The suctorian is wide-spread, records are from the eastern and western North Atlantic Ocean, the adjacent basins Baltic, North Atlantic, and Black Sea, the western South Atlantic, the Indian Ocean, and the western Pacific (East China Sea) (Dovgal et al., 2008; Dovgal et al., 2009). *Copidognathus* is the halacarid genus most frequently infested. Another genus known to bear suctorians is *Halacarellus* Viets, 1927. *Praethecacineta halacari* was identified by Dovgal et al. (2008) on the basis of an illustration of a suctorian on *Halacarellus hyrcanus* (Viets, 1928). *Agauae*, as well as the above mentioned *Acarothrix*, are further hosts of *Praethecacineta*. These are the first records of this suctorian genus from Singapore.

Agauopsis Viets, 1927

Diagnosis. Body flattened and intensely armoured. AD, pair of OC and PD present. AD and PD with raised longitudinal costae. AE large, generally extending dorsad and together with AD forming anterior margin of idiosoma. AE mostly with a pair of epimeral pores which open with a slit at the surface. Female GA with three pairs of perigenital setae; genital sclerites with zero to one subgenital seta. Male GA with 10–50 pgs; often one pair of setae outlying. Each genital sclerite with four to five subgenital setae.

Gnathosoma longer than wide. Gnathosomal base sub-quadrangular; rostrum parallel-sided. Basal (first) pair of maxillary setae on gnathosomal base, near rostrum; second pair of setae in distal third of rostrum. Palps four-segmented, lateral to gnathosoma. P-2 with a distodorsal seta. P-3 short, with median, often spiniform seta. P-4 with one to three setae in basal whorl.

Leg I wider and longer than following legs and bearing conspicuous spines, viz. three to five spines on telofemur, two (rarely one) on genu, (two to) five on tibia, and one on tarsus. Spines blunt and delicately dentate at their tip. Tibiae II to IV with two to three ventral spines or bristles. Solenidia on tarsi I and II in dorsolateral and dorsomedial position, respectively. Paired claws of posterior legs longer than those of tarsus I, median claw small.

With one larval and two nymphal stages.

Two species were found in the mangroves.

Key to adult *Agauopsis* species

1. Length of gnathosoma less than twice the width (Fig. 6G). Length of P-2 less than three times the height (Fig. 6H). Tibiae III and IV with two smooth, tapering ventral setae *A. arborea*
2. Gnathosoma at least 2.1 \times longer than wide (Fig. 7D). Length of P-2 approximately four times the height (Fig. 7E). Tibiae III and IV with two (to three) blunt, dentate ventral setae *A. longirostris*

Agauopsis arborea Bartsch, 2003

(Fig. 6A–P)

Agauopsis arborea Bartsch, 2003b: 242–247, figs 1A–K, 2A–K.

Agauopsis arborea, Bartsch, 2005b: fig. 8B.

Material and collecting site. One female, ZRC.ARA.1357, end of Lim Chu Kang Road, 1°27'N, 103°42'E, algal turf on pneumatophores, 7 October 2004; 1 male, ZRC.ARA.1358, same collection data as above; 5 females, 1 male, IB, same collection data as above.

Colour. Integument of idiosoma, gnathosoma and legs slightly brown. AD and OC each with brown eye spots.

Short description. Idiosoma flattened and wide, 1.3–1.4 \times longer than wide. Length of female 415–434 μm , of male 392–395. Dorsal plates with porose costae (Fig. 6A). Integument of both costae and areas outside costae panelled; polygons within medial costae of PD mostly with about 9–12 canaliculi, polygons between costae with 5–8 canaliculi (Fig. 6C). Length of AD 0.7 \times that of PD. Anterior margin of AD with minute frontal spine, posterior margin truncate to slightly concave. Transverse bar of H-shaped costa at 0.5–0.6. OC elongate, 1.5 \times longer than wide, and extending posteriad beyond the level of ds-4. Gland pore close to posterior cornea (Fig. 6A). Female PD 1.2 \times longer than wide, anterior margin somewhat protruding (six females examined) and slightly extending antieriad beyond the level of ds-4. Male PD 1.4 \times longer than wide, its anterior margin ovate (Fig. 6D). Medial costae on PD approximately three porose panels wide. Pair of ds-5 in lateral margin of medial costae, at about 0.5 relative to length of PD, in both female and male. Ventral plates with canaliculi; about 8–16 in each polygon, preliminary in peripheral arrangement. AE with three pairs of ventral setae and pair of epimeral pores; opening of pore slit-like, internal part tube-like (Fig. 6K). Female GA about as long as wide and as long as AE (Fig. 6B). Anterior margin of GA wide. Length of GO 0.6 \times length of GA. Male GA longer than AE and about as long as wide, anterior margin slightly arched; 43–49 pgs arranged around GO, 29–31 setae in an outer ring, 14–18 setae in an inner ring, one pair outlying (Fig. 6E). That pair removed from margins of plate. Spermatopositor (Fig. 6F) almost extending to anterior margin of GA.

Length of gnathosoma 0.3–0.4 \times length of idiosoma. Gnathosoma 1.7 \times longer than wide. Gnathosomal base punctate (Fig. 6G). Tectum with short, almost truncate

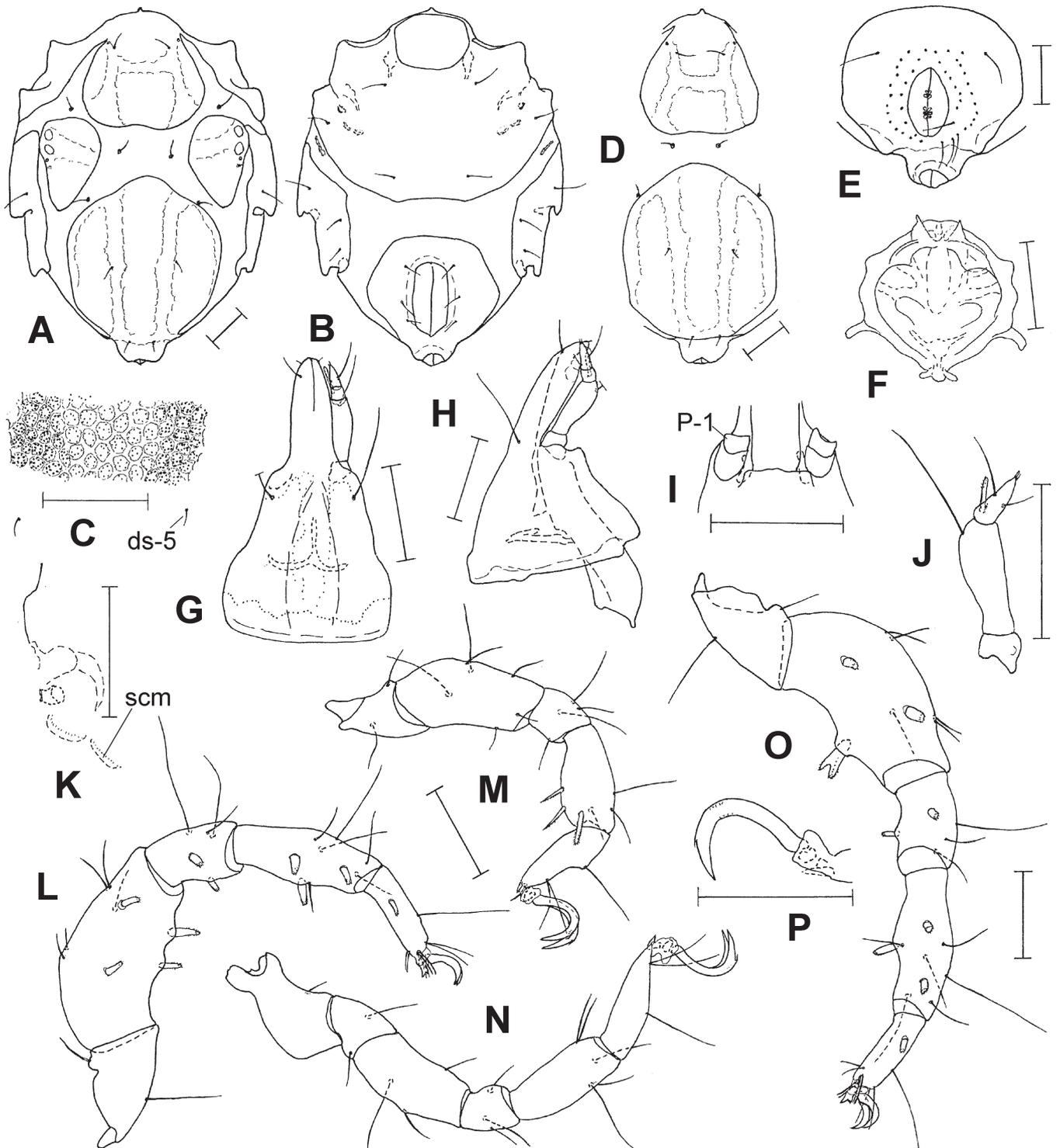


Fig. 6. *Agauopsis arborea* Bartsch, 2003. A, idiosoma, dorsal, female; B, idiosoma, ventral, female; C, median part of PD anterior to ds-5, female; D, AD and PD, male; E, GA, male; F, spermatopositor, ventral, male; G, gnathosoma, ventral, female (porose areolae marked by dotted lines); H, gnathosoma, lateral, female; I, gnathosomal base, dorsal, female; J, palp, lateral, female; K, right part of anterior epimeral plate, ventral, male; L, basifemur to tarsus I, medial, male; M, basifemur to tarsus II, medial, male; N, leg III, medial, male; O, basifemur to tarsus I, medial, female; P, claw of tarsus IV, female. Scale bars = 50 μ m. (ds-5, fifth dorsal idiosomal seta; P-1, first palpal segment; scm, scar from muscle strings).

lamella (Fig. 6I). Rostrum shorter than gnathosomal base. P-2 cylindrical, 2.7× longer than high. Spine on P-3 1.5× longer than this segment, P-4 short, its length (without apical spurs) 0.4× that of P-2; with one long and one short seta in basal third (Fig. 6H). Telofemur, genu, tibia, and tarsus I ventrally with 4(–3), 2, 3, 1 dentate, bluntly ending spines, respectively (Fig. 6L, O). Ventromedial spine on genu I longer than ventral one. Tibia II with wide bipectinate ventromedial seta and one to two ventral setae (Fig. 6M). Tibiae III (Fig. 6N) and IV with pair of long, tapering setae, length of setae same as height of tibiae. Length:height ratio of telofemora III and IV 2.2–2.3:1. Tarsi III and IV without fossa membranes. Claws on tarsus II with line of minute tines along outer and inner flank of claw arc. Claws III and IV with accessory process, the few very small (<1 µm) tines (Fig. 6P) seen only at high magnification (1000×, oil immersion).

Remarks. *Agauopsis arborea* belongs to the *brevipalpus* group. The species of the group are characterised by a combination of: (1) ventral plates almost uniformly porose; (2) P-3 with blunt, apically denticulate spine; (3) P-4 with two setae in a basal whorl, rarely with a single seta; (4) telofemur I with one to five dentate spines; (5) tibia I with three dentate spines; (6) tibia II with two to three spiniform bipectinate or dentate ventral setae; (7) tarsi II to IV without ventral setae; (8) tarsi III and IV with three dorsal setae each; (9) tip of tarsus II medially with spur-like pas, laterally with setiform (rarely spur-like) pas; (10) tarsi III and IV each with spur-like lateral but no medial pas (cf. Bartsch, 1986, 2003b). The *brevipalpus* group includes species with one to five spines on telofemur I, the species collected around Singapore have four spines, rarely unilaterally three or five spines. The most marked character of *Agauopsis arborea* is the pair of tapering ventral setae on tibiae III and IV. Additional characters used to identify *A. arborea* are, the surface of the porose costae is panelled, the rostrum short, the tectum truncate, the two setae on the short P-4 are unequal in length, and the pectines on claws III and IV are very faintly developed.

In the material from the type locality (tropical Western Australia), one out of nine individuals had on one of the legs I five spines on the telofemur and four spines on the tibia. On tibia II either two or three ventral setae were found, unilaterally or on both legs (Bartsch, 2003b). In the present material, one of the females had no more than three dentate spines on telofemur I (Fig. 6O); in four of the eight adults both tibiae II had three ventral setae, in two individuals both tibiae II had two ventral setae, in one specimen a combination of two and three setae was found. In one female only one of legs II was present, on this leg the tibia had two ventral setae. On all tibiae III and IV there are two slender, tapering ventral setae.

Anomalies. In one of the females (ZRC.ARA.1357) the palp is three-segmented, the third and fourth segments are fused (Fig. 6J).

Distribution and biology. Dampier, Western Australia; Singapore (new record). All present records are from algal

turf of green (Cladophorales) and red algae (*Bostrychia* sp., *Caloglossa* sp.) growing in mangroves on trunks and pneumatophores.

Agauopsis longirostris, new species
(Figs 7A–M; 8A–J)

Material and collecting sites. Holotype female, ZRC.ARA.1359, Singapore, end of Lim Chu Kang Road, 1°27'N, 103°44'E, mangrove, green algae (Cladophorales), 7 October 2004; paratype male, ZRC.ARA.1360, deutonymph, ZRC.ARA.1361, and protonymph, ZRC.ARA.1362, same collection data. One male, IB, Labrador Park, *Catenella* sp. (Rhodophyta) and other small algae on concrete piling, mid-tide, 28 October 2004.

Diagnosis. Length of female 510 µm, of male 450 and 460 µm. AD with H-like costae; PD with two pairs of costae. PD in female 1.1× longer than AD, in male 1.3×. Length of OC 0.6× length of AD. Anterior margin of female and male GA truncate. Male GA with 38–40 pgs. Length of gnathosoma 0.4× that of idiosoma. Rostrum longer than gnathosomal base. Tectum with scaliform lamella. P-2 4.1–4.2× longer than high. Two setae on P-4 almost equal-sized. Telofemur to tarsus I with 4, 2, 3, 1 blunt, denticulate spines. Tibiae II to IV with 3, 2, 2 spiniform, pectinate or dentate setae. Telofemora III and IV 2.1–2.2× longer than high. Claws II to IV with numerous delicate tines along medial flank.

Etymology. The name is derived from longus (L.) and rostrum (L) as the species has a long rostrum.

Colour. Integument of idiosoma, gnathosoma and legs slightly brown.

Description. Female. Length 510 µm, width 362 µm. Dorsal plates with raised costae, AD with H-shaped costa, OC with oblique one, PD with pairs of longitudinal medial and marginal costae (Fig. 7A). Costae with deep canaliculi, three to six arranged in groups; these groups hardly delimited and, accordingly, surface of integument within costae without panelling (Fig. 7F). Pair of medial costae in anterior half about 22 µm or three to four canaliculi groups wide. Remainder of plate panelled, each polygon with about 5–8 delicate canaliculi. Length of AD 200 µm, width 167 µm. Transverse bar of H-shaped costa at 0.5. Pair of gland pores level with anterior end of costae. Length of OC 115 µm, width 82 µm, i.e., 0.6× length of AD. OC with two corneae, a gland pore adjacent to posterior cornea and a canaliculus. PD 1.1× longer than AD and 1.1× longer than wide, its length 217 µm, width 202 µm. Medial pair of costae fused in posterior part of PD. Pair of ds-1 on AD medial to gland pores, ds-2, ds-3 and ds-4 on minute sclerites within striated integument, ds-5 on PD, in lateral margin of medial porose costae, at 0.4 relative to length of PD. Pair of ds-6 in posterior margin of PD.

Ventral plates with numerous canaliculi arranged within polygons; 9–15 canaliculi per polygon; canaliculi both along periphery and in centre of each polygon. AE twice as wide

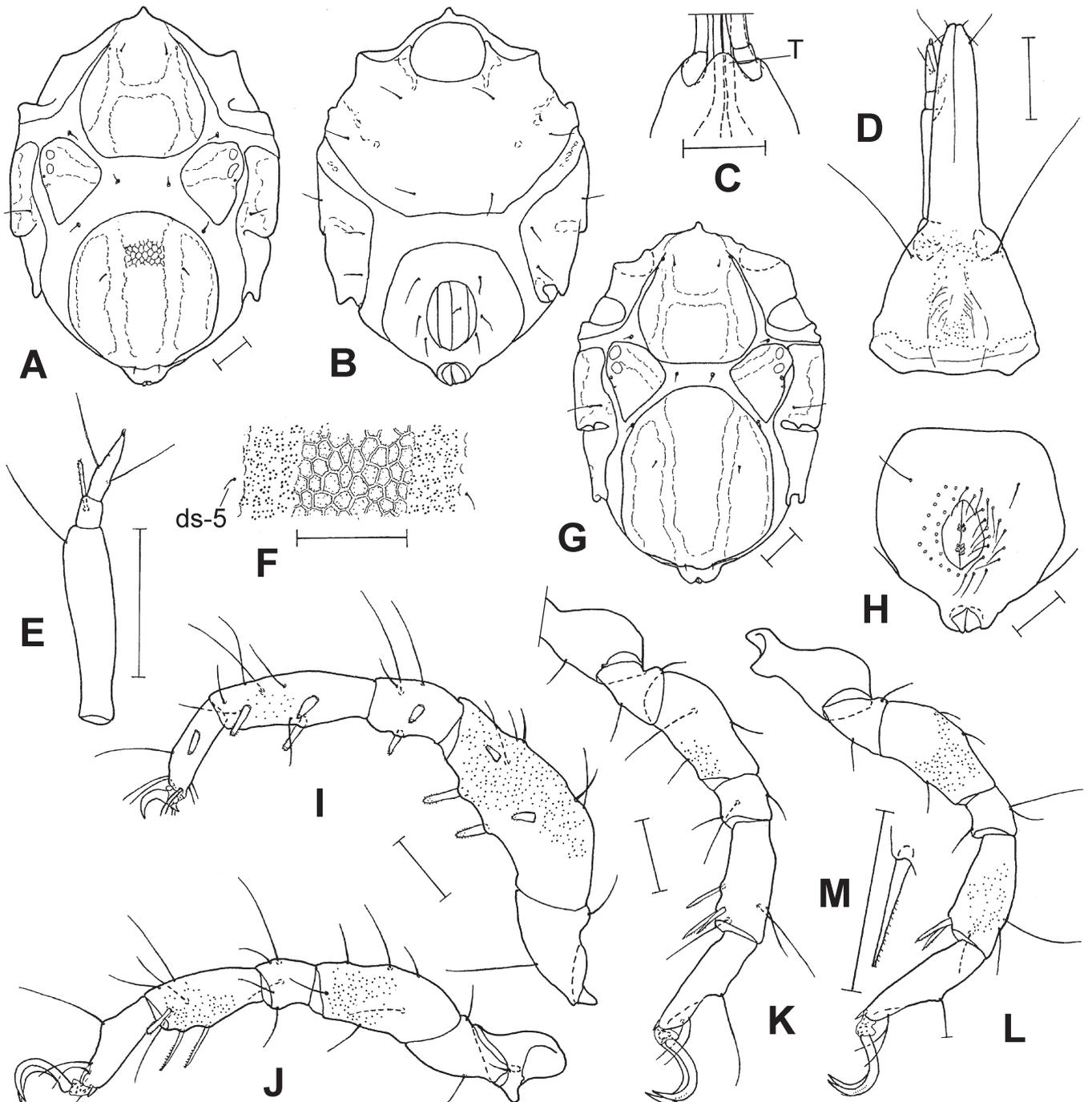


Fig. 7. *Agauopsis longirostris*, new species. A, idiosoma, dorsal, female; B, idiosoma, ventral, female; C, gnathosomal base, dorsal, female; D, gnathosoma, ventral, female; E, P-2 to P-4, lateral, female; F, median part of PD level with ds-5, female; G, idiosoma, dorsal, male; H, genitoanal plate, male; I, basifemur to tarsus I, medial, female; J, leg II, medial, female; K, leg III, medial, female; L, leg IV, medial, female; M, ventral spiniform seta of tibia IV, female. Scale bars = 50 μ m. (ds-5, fifth dorsal idiosomal seta; T, tectum).

as long, its length 182 μ m, width 360 μ m. Lamelliform epimeral processes flanking base of trochanters I and II. AE with three pairs of setae and pair of epimeral pores, the latter with inner tube-like structure and slit-like opening at the surface. Length of PE 225 μ m, not markedly extending beyond aperture of leg IV. PE with one dorsal seta and three ventral setae. Length of GA 195 μ m, width 190 μ m, its anterior margin slightly arched. Length of GO 95 μ m, width 67 μ m. Interval between anterior margin of GA and that of GO equalling 0.6 \times length of GO. GA with three pairs of pgs, anterior pair about level of anterior margin of GO (Fig. 7B). One of genital sclerites with, the other without a seta.

Length of gnathosoma 215 μ m, width 104 μ m, i.e., 2.1 \times longer than wide (Fig. 7D). Rostrum longer than gnathosomal base. Integument of major part of dorsal, lateral and ventral flank of gnathosomal base with canaliculi, area of reticulate pharyngeal field without canaliculi. Tectum scaliform (Fig. 7C). One pair of maxillary setae on gnathosomal base, the other pair in posterior third of rostrum. Tip of rostrum with two pairs of short, slender rostral setae. Palps elongate. P-2 4.1 \times longer than high; its length 63 μ m (Fig. 7E). P-3 slightly longer than wide, its length 10 μ m. P-3 with blunt, delicately dentate spine, 15 μ m long. Length of P-4 23 μ m, i.e. more than twice length of P-3. Two setae in

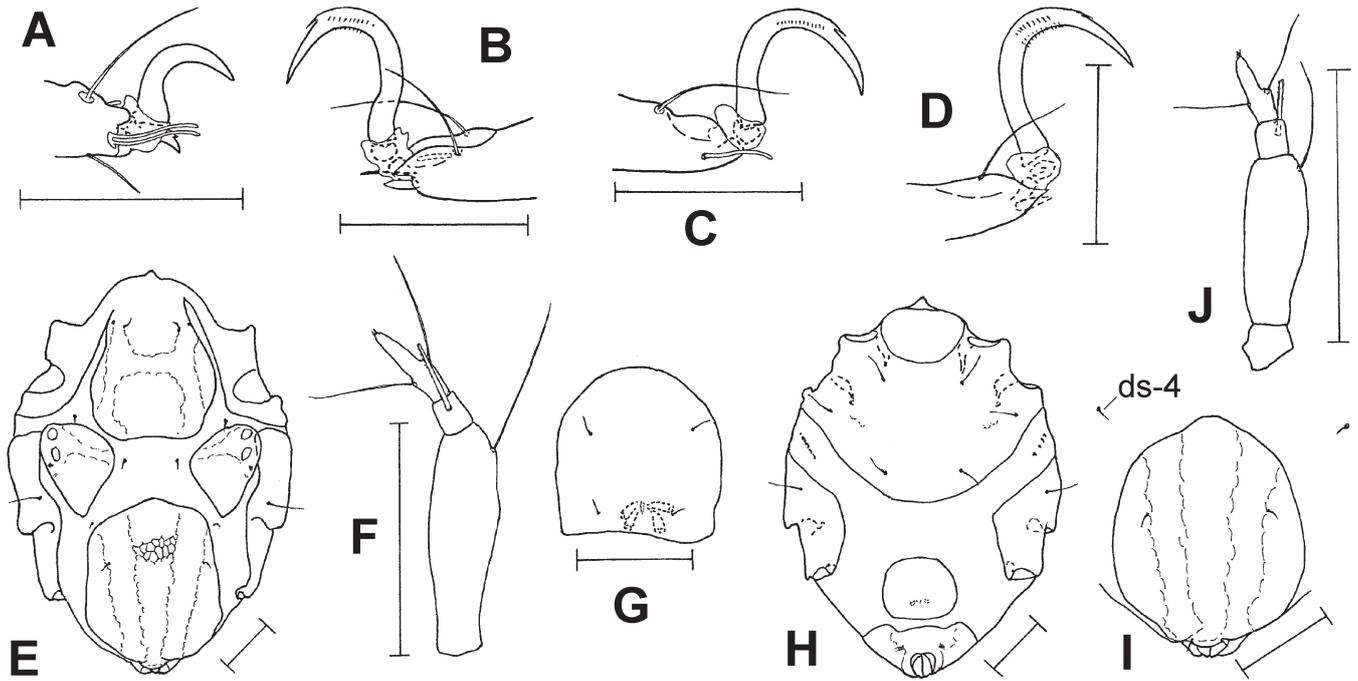


Fig. 8. *Agauopsis longirostris*, new species. A, tip of tarsus I, lateral, female (medial setae and claw omitted); B, tip of tarsus II, medial, female (lateral claw omitted); C, tip of tarsus II, lateral, female (medial setae and claw omitted); D, tip of tarsus III, medial, male (lateral fossary seta and claw omitted); E, idiosoma, dorsal, deutonymph; F, P-2 to P-4, medial, deutonymph; G, genital plate, deutonymph; H, idiosoma, ventral, protonymph; I, posterior dorsal plate, protonymph; J, palp, medial, protonymph. Scale bar = 50 μm . (ds-4, fourth dorsal idiosomal seta).

about middle of segment equal-sized. Apex of P-4 with setula and two spurs.

Integument of lateral flank of trochanters III and IV and basitrochanters I to IV almost evenly pierced by numerous canaliculi (Figs 7I–L). Canaliculi on medial flanks more delicate and in less dense arrangement than on lateral flanks. Telfemora II to IV 2.3, 2.1 and 2.2 \times longer than high, respectively (Fig. 7J–L). Leg chaetotaxy (on leg I setae in Arabic, spines in Roman numerals): leg I, 1, 2, 5+IV, 3+II, 6+III, 6+I; leg II, 1, 2, 6, 5, 7, 4; leg III, 1, 2, 3, 3, 5–6, 3; leg IV, 0, 2, 3, 3, 5, 3. Ventral seta on telfemur III and IV closer to apical than to basal end of segment. Ventrolateral and -medial spine on genu I almost equal-sized (Fig. 7I). Tibia II with three spiniform setae, setae similar in length but ventromedial seta bipectinate and somewhat wider than two dentate ventral setae. Tibiae III and IV each with two (to three) spiniform, delicately dentate ventral setae (Figs 7K–M). Tarsi with narrow membranes of claw fossa. Lateral fossa membrane slightly larger than medial membrane. Tarsus I with pair of doubled pas; solenidion 5 μm long, on lateral fossa membrane (Fig. 8A). On tarsus II lateral pas setiform, medial pas spiniform (Fig. 8B, C); solenidion on inner flank of medial fossa membrane. Tarsi III (Fig. 8D) and IV each with spiniform lateral pas; medial pas lacking.

Paired claws I shorter than following claws, median claw bidentate. Claws II to IV with accessory process and pectines. Pectines on claws II to IV with delicate, 2 μm -long tines on lateral and medial flank of claw arc. Median claw without dent-like process.

Male. Length 450 and 460 μm . Dorsal aspect similar to that of female, but transverse bar of H-shaped costa at 0.6 and anterior part of PD prolonged; that plate 1.2 \times longer than wide and 1.3 \times longer than AD (Fig. 7G) and anterior extending distinctly beyond the level of ds-4. Anterior margin of GA truncate (Fig. 7H). Distance between anterior margin of GO and that of GA slightly less than length of GO. With 36–38 perigenital setae arranged in two rings around GO and a pair of outlying setae distinctly separated from rings of pgs. Each genital sclerite with four (rarely five) short, spur-like sgs. Spermatopositor 127 μm long and wide and extending to anterior margin of GA; its outline similar to that of *A. arborea*. Gnathosoma slightly more slender than in female, 2.3 \times longer than wide; its length equalling 0.4 \times that of idiosoma. P-2 3.9 \times longer than high.

Deutonymph. Length 377 μm . PD shorter than in adults (Fig. 8E). GP with two pairs of pgs and two pairs of internal acetabula (Fig. 8G). Subgenital setae lacking. Gnathosoma shorter than in adults, length 145 μm , width 75 μm , i.e., 1.9 \times longer than wide. P-2 three times longer than high (Fig. 8F). Leg chaetotaxy (on leg I setae in Arabic, spines in Roman numerals): leg I, 1, 2, 5+III, 3+II, 6+III, 6+I; leg II, 1, 2, 5, 5, 7, 4; leg III, 1, 2, 3, 3, 5–6, 3; leg IV, 0, 2, 3, 3, 5, 3.

Protonymph. Length 295 μm . PD more slender than in female (Fig. 8I). AE with three pairs of ventral setae; PE with one dorsal and one ventral seta. Genital plate quadrangular, with single pair of internal acetabula; pgs and sgs lacking (Fig. 8H). Length of gnathosoma 107 μm , width 55 μm , i.e. 1.9 \times longer than wide. P-2 2.7 \times longer than high (Fig. 8J). Leg chaetotaxy (on leg I setae in Arabic, spines in Roman

numerals): leg I, 1, 2, 3+II, 2+II, 4+III, 6+I; leg II, 1, 2, 4, 4, 5, 4; leg III, 1, 2, 2, 3, 5, 3; leg IV, 0, 0+2 (basitelson + telofemur), 3, 5, 3.

Remarks. *Agauopsis longirostris* belongs to the *brevipalpus* group, namely to the group of species with four spines on telofemur I. Amongst the Indo-Westpacific species, *Agauopsis longirostris* is the one with the longest rostrum and palps; the P-2 are at least four times longer than high.

Of the presently known 14 species with four spines on telofemur I only one, *A. legionium* Pepato & Tiago, 2005, has a similar elongate gnathosoma with slender palps and rostrum. Differences between the two species are in (1) the shape of the AD and its anterior margin (in *A. longirostris* AD 1.2× longer than wide and with median spinelet; in females of *A. legionium* AD more slender, 1.3× longer than wide, and anterior margin almost ovate), (2) the distance between the posterior cornea and the gland pore (almost adjacent versus removed by the diameter of the cornea), and (3) the width of the medial costae on the PD (equalling three to four versus two groups of canaliculi). The GA of the *A. longirostris* male is slightly longer than wide, that plate in *A. legionium* is wider than long and its anterior margin conspicuously wide. Records of *A. legionium* are from south-eastern Brazil (Pepato & Tiago, 2005a).

Distribution and biology. Singapore. The present records are from algal turf from sheltered areas (mangroves) as well as from a moderately exposed coastal site.

The adults of *A. longirostris* are characterised by the slender rostrum and palps, especially the P-2 are elongate. In the nymphs the P-2 are distinctly shorter. Such an allometry during halacarid ontogeny is also known from other halacarid species (Bartsch, 2007, 2011).

Copidognathus Trouessart, 1888

Diagnosis. Plates AD, pair of OC and PD present. With two to four pairs of gland pores which may be small, almost inconspicuous, or large and situated on cones. With six pairs of dorsal setae; sixth pair (adanal setae) on anal plate. AE with pair of epimeral pores and three pairs of ventral setae. PE with one dorsal seta and three ventral setae. Female GA with three (rarely up to five) pairs of perigenital setae and one pair of sgs. Male GA with 4–40 pairs of pgs; genital sclerites with three to four (rarely two) pairs of sgs.

In the majority of species gnathosoma longer than wide. With two (to eight) pairs of maxillary setae, one pair (rarely up to seven pairs) inserted on gnathosomal base, one pair on rostrum. Palps four-segmented, attached laterally and at least slightly surpassing rostrum. P-2 with one distal seta. No seta on P-3. P-4 with three setae in basal whorl.

Genua of legs shorter than telofemora and tibiae. Basifemora I to IV with 2, 2, (1–)2, (1–)2 setae. Genua I to IV with 4(–)3, 4(–)3, 3, 3–4(–)5 setae. Tibia I with three ventral setae. Tibia II with three (rarely two) ventral setae, one slender

and smooth, two bipectinate. Tibia III generally with one slender and smooth and one bipectinate ventral seta. Tibia IV either with one smooth and one bipectinate or with two smooth ventral setae. In general, tibiae I and II with four dorsal setae and tibiae III and IV with three such setae. Tarsi I to IV with 4, 4, 3–4, 3–4 dorsal and 3, 0, 0, 0 ventral setae. Solenidion on tarsus I and II in dorsolateral position. Paired claws large; median claw present, though small. Claws of leg I often shorter than those of following tarsi.

With a larval and a single nymphal stage.

Seven species were found in samples from the epibios in mangrove stands.

Key to adult *Copidognathus* species

1. Gnathosoma short, about 1.3x longer than wide. Colour of gut content (idiosoma) green to greyish-green *C. rhombognathoides*
- Gnathosoma 1.5 or more times longer than wide. Colour of gut content pale (white) to dark brown 2
2. Porose areolae on dorsal plates with canaliculi arranged within polygons. PD with single pair of gland pores, situated on slightly raised cones. Rostrum awl-shaped (Fig. 9F). P-4 shorter than P-2 (Fig. 9G) *C. glandulifer*
- Porose areolae on dorsal plates with rosette pores or porose foveae, each with ostium at the surface and more or less distinct canaliculi in deeper layers. With either zero or two pairs of gland pores. Rostrum triangular. P-4 as long as or longer than P-2 3
3. Tibiae I and II with dentate ventral lamellae (Fig. 15A) *C. dentipes*
- No such lamellae present 4
4. PD with two pairs of gland pores situated close together near posterior margin of PD (Figs 11A, 16A). Tibia I ventrally with two tapering, setiform and one short, bluntly ending and slightly pectinate seta (Figs 11H, 16C) 5
- PD with zero to one pair of gland pores. Tibia I ventrally with one slender, setiform and two bluntly ending bipectinate setae (Figs 12H, 13G) 6
5. AD with large, dumbbell-shaped porose areola (Fig. 16A) ... *C. riguus*
- AD with pair of crescentic porose areolae (Fig. 11A) *C. latusculus*
6. OC posteriorly tail-like elongated; extending far beyond level with insertion of leg III. PD with pair of porose costae approximately three pores wide (Fig. 12A) *C. mangrovorum*
- OC not tail-like prolonged; extending to level with insertion of leg III. PD with two pairs of porose costae, one to two porose foveae wide (Fig. 13A) *C. mollis*

Copidognathus glandulifer Bartsch, 1996 (Figs 9A–N; 10A–L)

Copidognathus glandulifer Bartsch, 1996c: 57–60, fig. 1A–F, 2A–G.

Material and collecting sites. One female, ZRC.ARA.1363, West Coast Park, Cladophorales (green algae) on *Avicennia* pneumatophores, 25 September 2004; 1 female, IB, same collecting data. One female, ZRC.ARA.1364, West Coast Park, algal turf (red and green algae) on *Avicennia* pneumatophores, 5 October 2004; 8 females, IB, same

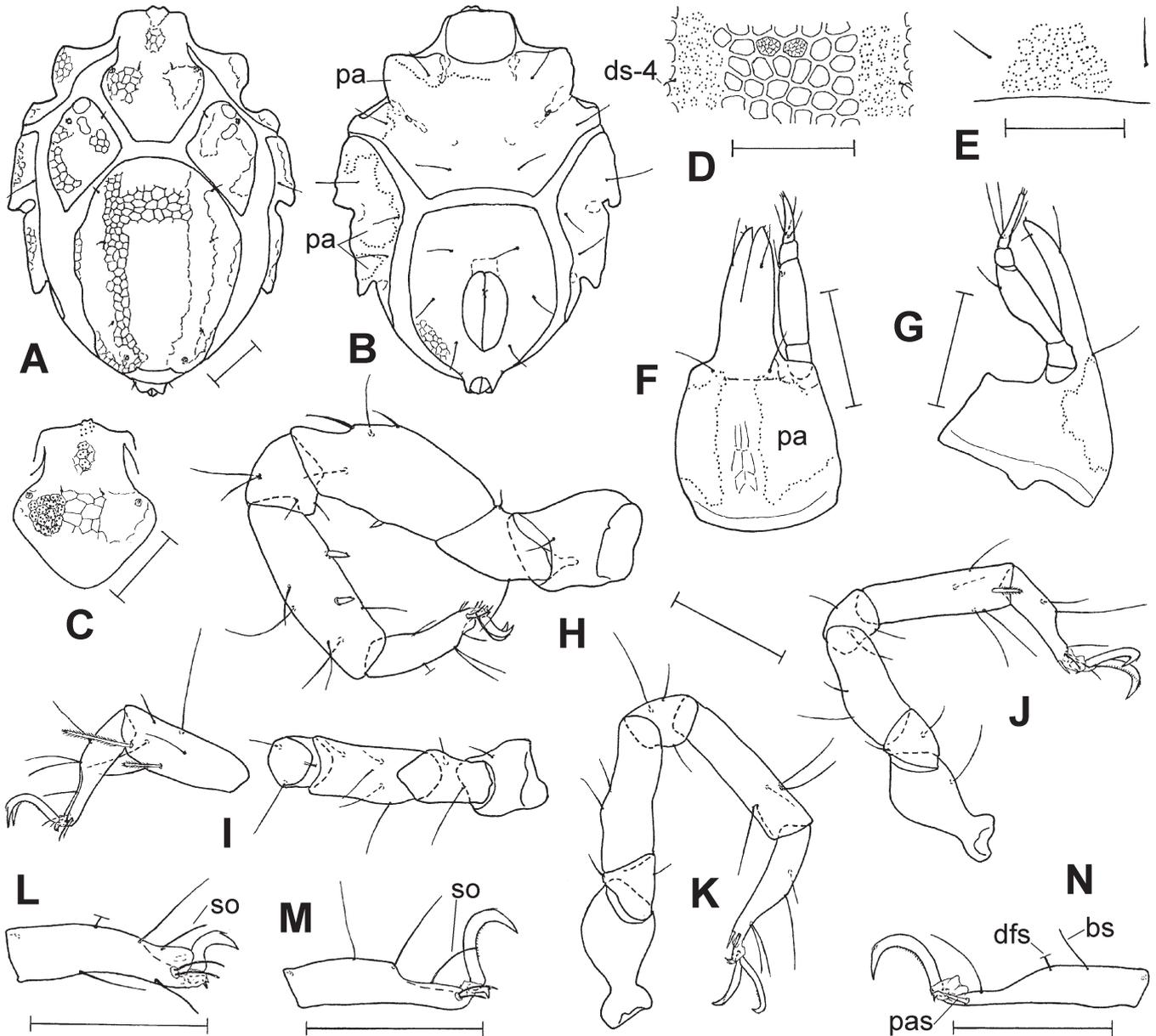


Fig. 9. *Copidognathus glandulifer* Bartsch, 1996, female. A, idiosoma, dorsal; B, idiosoma, ventral; C, anterior dorsal plate; D, part of PD at the level of ds-4; E, part of AE, ventral; F, gnathosoma, ventral; G, gnathosoma, lateral; H, leg I, medial; I, leg II, ventral and medial; J, leg III, medial; K, leg IV, medial; L, tarsus I, lateral (medial fossary seta, parambulacral setae and claw omitted); M, tarsus II, lateral (lateral fossary seta, parambulacral setae and claw omitted); N, tarsus III, lateral (medial fossary seta, parambulacral seta and claw omitted). Scale bar = 50 μ m. (porose areolae in B, F and G marked by dotted lines; bs, basal seta; dfs, dorsal fossary seta; ds-4, fourth dorsal idiosomal seta; pa, porose areola; pas, parambulacral seta; so, solenidion).

collecting data. One male, ZRC.ARA.1365, 1 protonymph, 1 larva, ZRC.ARA.1366, end of Lim Chu Kang Road, 1°27'N, 103°44'E, Cladophorales (green algae) around *Avicennia* sp., 10 October 2004. Two females, IB, St John's Island, sediment amongst colonies of polychaete tubes (Sabelliariidae), 2 October 2004.

Colour. Idiosoma with slightly red-brown particles in gut and with light-brown glands shining through integument.

Description. Adults. Length of females 314–372 μ m, of male 300 μ m. Porose areolae of dorsal plates slightly raised and with canaliculi arranged within polygons (porose panels), remainder of plates reticulated; each polygon in turn divided by minute bars (Fig. 9D). Integument between AD and PD

with anastomosing, lateral to PD with parallel striae. AD hexagonal, rarely pentagonal, longer than wide; anterior margin with minute either blunt or pointed protuberance, posterolateral margins converging, posterior margin of AD truncate (Figs 9A, 10A), slightly rounded or, rarely, ovate (Fig. 9C). Anterior part of AD with elongate, bipartite porose areola, middle part with pair of almost circular areolae. In eight of specimens studied, one or several porose polygons (panels) present along posterior margin (Fig. 10A), in eight specimens such porose panels lacking (Fig. 9A, C). OC 1.7 \times longer than wide and reaching to the level of insertion of leg III. Plate with two corneae and garland-like porose areola extending along anteromedial and lateral margin. PD with pair of longitudinal, posteriorly hooked costae; longitudinal part two to three porose polygons wide. Costae along lateral

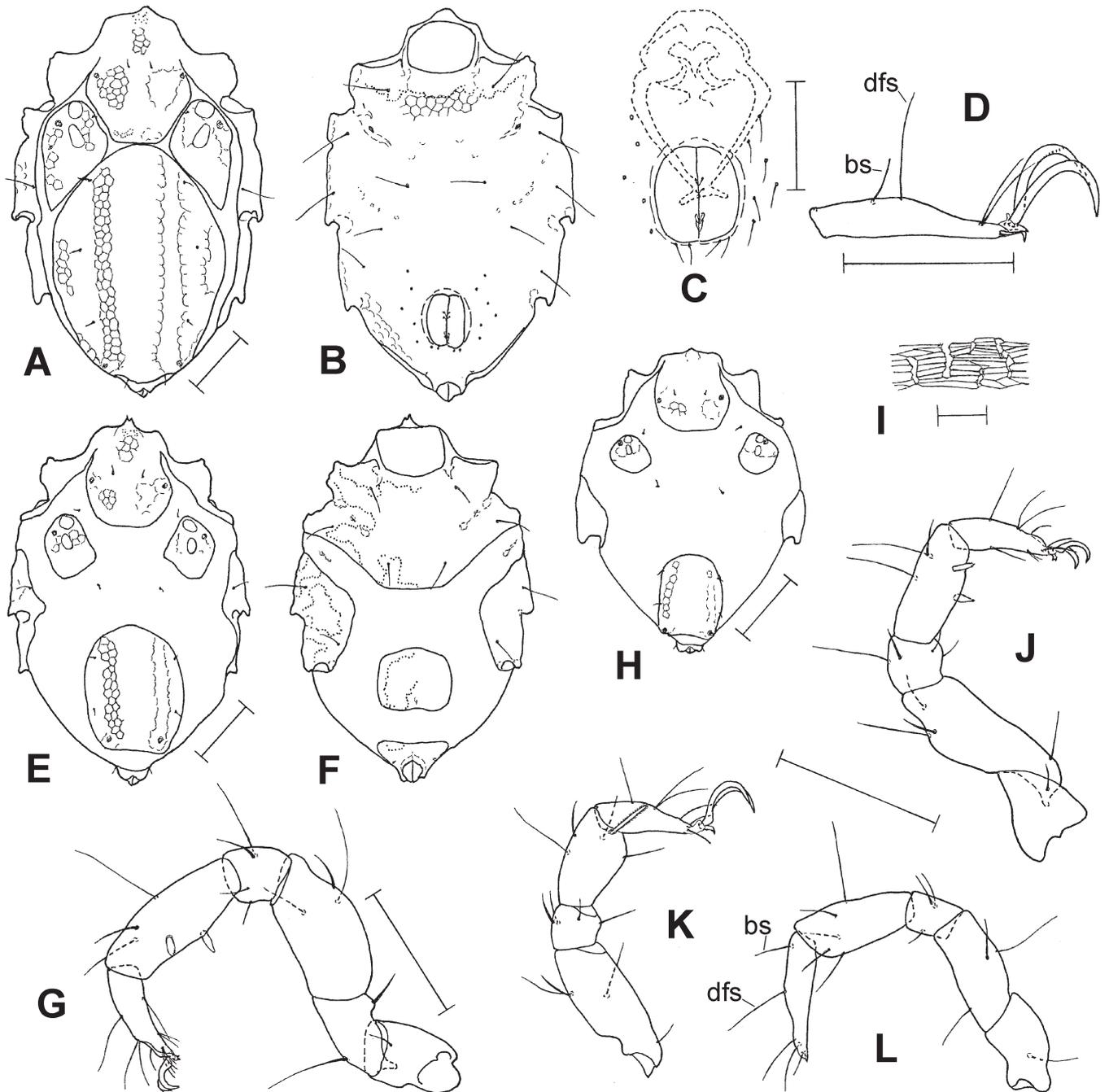


Fig. 10. *Copidognathus glandulifer* Bartsch, 1996. A, idiosoma, dorsal, male; B, idiosoma, ventral, male; C, genital area and spermatopositor, male; D, tarsus IV, medial, male; E, idiosoma, dorsal, protonymph; F, idiosoma, ventral, protonymph; G, leg I, medial, protonymph; H, idiosoma, dorsal, larva; I, striated integument between anterior and posterior dorsal plate, larva; J, leg I, medial, larva; K, femur to tarsus II, medial, larva; L, leg III, medial, larva. Scale bars = 50 μ m (A–H, J–L), scale bar = 10 μ m (I). (porose areolae in B and F marked by dotted lines; bs, basal seta; dfs, dorsal fossary seta).

margins short, two polygons wide. Dorsal setae short; pair of ds-1 immediately adjacent and anterior to pair of porose areolae, ds-2 in margin of OC, ds-3 to ds-5 on PD lateral to porose costae. Gland pores distinct, on slightly raised cones; one pair on AD within lateral corners of pair of porose areolae, one pair on OC lateral to corneae and level with anterior margin of second cornea, and one pair on PD in posterior end of longitudinal costae. Posterior pair of internal glands ovoid, length 55 μ m, width 32 μ m.

Major part of ventral plates with porose polygons; each with peripherally arranged canaliculi (Fig. 9E). Marginal

parts of AE, PE and GA (or areas representing these plates) with polygons replaced by shallow foveae with canaliculi. Porose polygons absent just posterior to camerostome and immediately around ventral setae (Fig. 9B). Posteromarginal parts of GA slightly raised. AE without conspicuous epimeral processes. Female with AE, PE and GA separated (Fig. 9B). Posterior margin of AE slightly concave. PE somewhat extending beyond the level of insertion of legs IV. Anterior margin of GA arched to truncate. Distance between anterior margin of GO and that of GA 0.7 \times length of GO. Ovipositor slightly extending beyond GO. In males all ventral plates fused (Fig. 10B). Area representing GA with seven to eight

pairs of rather short pgs. Genital sclerites with four pairs of sgs. Spermatopositor 85 µm long, 67 µm wide, and extending far beyond GO (Fig. 10C).

Gnathosoma almost twice as long as wide. Marginal parts of gnathosomal base punctate (Fig. 9F, G). Tectum truncate. Stout rostrum about as long as gnathosomal base. One pair of setae on gnathosomal base near basis of rostrum, one pair in posterior third of rostrum. Rostral sulcus extending beyond that pair of setae. Palps short and slender. Rostrum reaching beyond P-3. P-4 shorter than P-2 (Fig. 9G).

Leg I longer and wider than following legs. All setae short. Legs I and II with their telofemora and tibiae almost equal in length, telofemora III and IV slightly shorter than tibiae. Telofemur I 2.3–2.4× longer than high. Leg chaetotaxy: leg I, 1, 2, 5, 4, 7, 7; leg II, 1, 2, 5, 4, 7, 4; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 2, 2, 3, 5, 4. Telofemur I with short spur-like ventral seta (Fig. 9H). Tibia I with two spur-like setae with a few apical tines and a short, slender ventral seta. Tibia II with one slender and two bipectinate setae, these latter setae unequal in length (Fig. 9I). Tibiae III and IV with 1, 0 bipectinate setae and 1, 2 slender, smooth ventral setae (Fig. 9J, K), respectively. Paired fossary setae on tarsi I and II situated adjacent, immediately outside claw fossa, setae on tarsi III and IV within area of claw fossa. Basal seta (solenidion) on tarsi III and IV removed from tarsal basis; distance to dorsal fossary seta almost the same or slightly less than height of tarsus (Figs 9N, 10D). Tarsi I and II each with pair of doubled pas, tarsus III with setiform medial pas and flattened, spiniform lateral pas; on tarsus IV both pas short and flattened. Tarsus I widest at its base; at the level of paired fossary setae tarsus slender and reduced in height (Fig. 9L).

Paired claws I distinctly shorter than following claws and with accessory process but no pecten. Claws on tarsi II to IV with pectines (Fig. 9M, N); tines of pectines numerous but delicate. Claws of male (Fig. 10D) more slender and longer than those of female.

Protonymph. Length 264–280 µm. Plates smaller than in adults; striated integument between plates anastomosing, in young individuals both ventral and dorsal striae with raised connective bars (cf. Fig. 10I). AD with frontal lamella and three raised porose areolae; part posterior to paired areolae short. OC and PD short (Fig. 10E). Middle pair of costae of PD two porose polygons wide; lateral costae lacking. Pairs of ds-2 and ds-3 in striated integument. Ventral plates with canaliculi arranged within polygons, plates smooth around setae (Fig. 10F). PE with one pair of dorsal and two pairs of ventral setae. Gnathosoma similar to that of adults. Leg chaetotaxy: leg I, 1, 2, 3, 4, 5, 7; leg II, 1, 2, 3, 4, 5, 4; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 1+2 (basi- + telofemur), 3, 5, 4. Telofemora I (Fig. 10G) and II with three dorsal setae but without ventral spine or seta. The two ventral setae on tibia I short, spur-like (Fig. 10G). On tibia II one of ventral setae bipectinate and one smooth. Bipectinate seta longer than slender seta. Tarsi III and IV with four dorsal setae. On tarsus III distance between basal seta and tarsal basis

less than that between basal seta and dorsal fossary seta. On tarsus IV basal seta closer to basis of tarsus than to dorsal fossary seta.

Larva. Length 197–215 µm. Dorsal plates smaller than in protonymph (Fig. 10H). Striated integument as in protonymph with connective bars (Fig. 10I). AD with frontal lamella and three porose areolae. PD narrow, single pair of costae near margin of plate. Pairs of ds-4 and ds-5 in margin of PD, pairs of ds-2 and ds-3 in striated integument. Gnathosoma smaller, else similar to that of adults. Leg chaetotaxy (Fig. 10J–L): leg I, 1, 1+3, 4, 5, 7; leg II, 1, 1+3, 4, 5, 4; leg III, 1, 1+2, 3, 5, 4. Shape of ventral setae on tibiae I and II same as in protonymph. Bipectinate seta on tibia II slightly longer than smooth ventral seta. Tibia III with two ventral setae, one short, the other slightly longer and smooth. Tarsus III with four dorsal setae; basal seta (solenidion) close to basis of tarsus (Fig. 10L), its distance to dorsal fossary seta more than height of tarsus.

Remarks. The present species belongs to the *Copidognathus curassiviensis* group which is characterised by the combination: (1) dorsal plates with sharply delimited areolae with canaliculi arranged within polygons, (2) AD elongate with three such porose areolae, (3) gland pore on OC about the level halfway between corneae, (4) PD with single pair of enlarged gland pores, (5) ventral plates with canaliculi arranged within polygons, (6) gnathosoma with stout rostrum and short slender palps, (7) P-4 shorter than P-2, (8) telofemur I with ventral spur, (9) tibia I with two spurs and one short, slender seta, (10) tarsi III and IV with four dorsal setae. At present four species are known with this character combination, namely *Copidognathus curassiviensis* Viets, 1936, *C. glandulifer* Bartsch, 1996, *C. kenyae* Chatterjee & De Troch, 2000, and *C. philippinensis* Chatterjee & De Troch, 2003.

The specimens from Singapore have been assigned to *C. glandulifer*, a species described from the Great Barrier Reef (Bartsch, 1996c), though, according to the description there are small differences in the outline and partly in the ornamentation of the AD. In most of the Singapore specimens the AD has a truncate posterior margin and often the posterior porose panels are lacking, whereas in specimens from the Great Barrier Reef the posterior part of the AD is narrowly rounded and bears a few porose panels (Bartsch, 1996c: fig. 1A). The material collected in Singapore held 13 females, in 12 the posterior margin of the AD is more or less truncate, in one it is ovate, similar to that of the Great Barrier Reef specimens, in seven females there are no, in six there are one or more porose panels along the posterior margin of the AD. Aside the shape and porose panels of the AD, which obviously can vary, there seems to be no marked difference in the external characters of specimens from Singapore and the Great Barrier Reef, accordingly they are conspecific.

Copidognathus curassiviensis, the first described species of this group, is known from the Caribbean area and Florida (Viets, 1936; Newell, 1947). The OC are 1.3× longer than wide, the posterior corner not elongate or pointed, and

the telofemur I is more slender than in the other species (length:height 2.6:1).

Records of the two other species, *C. kenya* and *C. philippinensis* are from eastern Africa and the Philippines, respectively (Chatterjee & De Troch, 2000, 2003b). In the three species (*C. glandulifer*, *C. kenya*, *C. philippinensis*), the AD of some specimens have a few porose panels (or rosette pores(?)) along the posterior margin of the AD, in others these are absent (Chatterjee & De Troch, 2000: fig. 3A and p. 182; 2003b: fig. 5A and p. 105). According to Chatterjee & De Troch (2000: p. 182 and fig. 3D), *C. kenya* bears rosette pores, but according to Chatterjee & De Troch (2003b: p. 106), these are no rosette pores but porose panels. In *C. kenya* the PE extend far beyond the insertion of leg IV (but the individual illustrated seems to be distorted). *Copidognathus philippinensis* is said to differ from the other species of this group because of 'an elevated ridge below the middle two areolae on AD area (Chatterjee & De Troch, 2003b: p. 106). But this 'elevated ridge' may be an artefact in the mounted specimen. An examination of specimens from the type localities of these two species (Gazi Bay, Kenya, and Pujada Bay, The Philippines) may prove them and *C. glandulifer* to be conspecific.

Distribution and biology. South-western Pacific Ocean, Australia, Great Barrier Reef (Bartsch, 1996c) and Singapore (new record). In case the two species *C. kenya* and *C. philippinensis* prove to be junior synonyms, then the geographical area of this species extends to the western part of the Indian Ocean.

The Australian individuals of *Copidognathus glandulifer* have been extracted from fine to coarse sand, from 1 to 12 m depth. The Singapore specimens are from muddy and sandy deposits in mangroves, but also from polychaete colonies (Sabellariidae) from a sandy beach. Records of *C. kenya* and *C. philippinensis* are from shallow water seagrass flats (Chatterjee & De Troch, 2000, 2003b).

In the course of the ontogeny of *Copidognathus* species, the number of ventral setae on tibiae I and II increases from two to three (cf. Bartsch 1972, 1998b). In the majority of *Copidognathus* species the tibiae I and II of the larvae and protonymphs bear one bipectinate and one smooth seta, the adults two bipectinate setae and one smooth seta. In the juveniles of *C. glandulifer* both setae on tibia I are spur-like, in the adults two are spur-like, one slender and smooth. Tibia II of the juveniles bears one bipectinate and one smooth seta, the former is slightly longer than the other. In the adults there are two bipectinate setae and one smooth seta, the apical bipectinate seta is longer than the other two setae, the basal bipectinate seta is the shortest one.

In *Copidognathus* there is, if at all, only a moderate change in the shape and length ratios of setae during the ontogeny. Accepting the constancy of the shape of setae as a rule in this genus (but not in all halacarid genera), then in adults on tibia I it is the apical seta, on tibia II the basal seta that has been added. In respect to tibia I, the same was found

in *C. vulgaris* Bartsch, 1998 (Bartsch, 1998b: 1979, though contradicted by the generalised presentation, Bartsch, 1998b: fig. 6C). In contrast, in other halacarid genera, in several (but not all) *Halacarellus* species (e.g., *H. balticus* (Lohmann, 1889), *H. capuzinus* (Lohmann, 1893), *H. chersonesus* Bartsch, 1998, *H. discretus* Bartsch, 1998, *H. procerus* Viets, 1927, *H. micropectinatus* Bartsch, 1972) tibiae I of the larvae bear a pair of slender ventral setae; the deutonymphs and adults also spur-like basal setae, in addition to the slender apical seta (Bartsch, 1972, 1976, 1998a). In these species, as also in the freshwater species *Porolohmannella violacea* (Kramer, 1879) and *Soldanellonyx chappuisi* Walter, 1917 (Bartsch, 2007, 2011), the basal-most ones of the ventral setae have been added to tibia I during the ontogeny. Further investigations may prove that a difference in the position of the setae added during the ontogeny is a reliable generic character.

In respect to tibia II, most species have one or more ventral setae obviously added in the basal part of that segment. Examples are, beside the above described *Copidognathus glandulifer*, *Agauopsis legionum* Pepato & Tiago 2005, *Halacarellus balticus*, *H. capuzinus*, *H. discretus*, *Porolohmannella violacea*, and *Soldanellonyx chappuisi* (Pepato & Tiago 2005a; Bartsch, 1972, 1998a, 2007, 2011, unpublished). Noteworthy is that in *C. pumicus* Bartsch, 1999, which has no more than two ventral setae on tibia II, the basal one of the ventromedial setae is lacking (Bartsch, 1999).

Differences in the relative position of setae are documented. In many species with four dorsal setae on tarsus III (and IV) the position of the basal seta changes from larva to adults (e.g., in *C. glandulifer*, described above).

Though unknown in *Copidognathus*, changes in the size relation and shape of setae are documented in other genera. Larvae and protonymphs of *Halacarellus subterraneus* Schulz, 1933 bear a long ventral spine on genu I, in deutonymphs and adults this spine is shorter (Bartsch, 1972, 1998a). In adults of the above mentioned *Acarothrix ampliomeris* one of the ventral setae on tibia III and IV is wide and bipectinate, on tibia IV of the protonymph and tibia III of the larva this seta is slender.

Copidognathus latusculus, new species

(Fig. 11A–N)

Material and collecting site. Holotype male, ZRC.ARA.1367, Singapore, Pulau Ubin, Chek Jawa, 1°24'N, 103°59'E, epibios (mainly red algae) on pneumatophores of *Sonneratia* sp., 16 October 2012. One male, IB, Singapore, Pulau Ubin, Chek Jawa, 1°24'N, 103°59'E, from pneumatophores of *Sonneratia* sp., 18 October 2012. One male, ZRC.ARA.1368, Singapore, Lazarus Island, 1°13'N, 103°51'E, unsorted sediment, low water edge, 3 October 2004.

Diagnosis. Length of male 317–360 µm. AD with pair of crescentic porose areolae. Prolonged OC with porose areolae in anterior and posterior part of plate. PD wide, with two

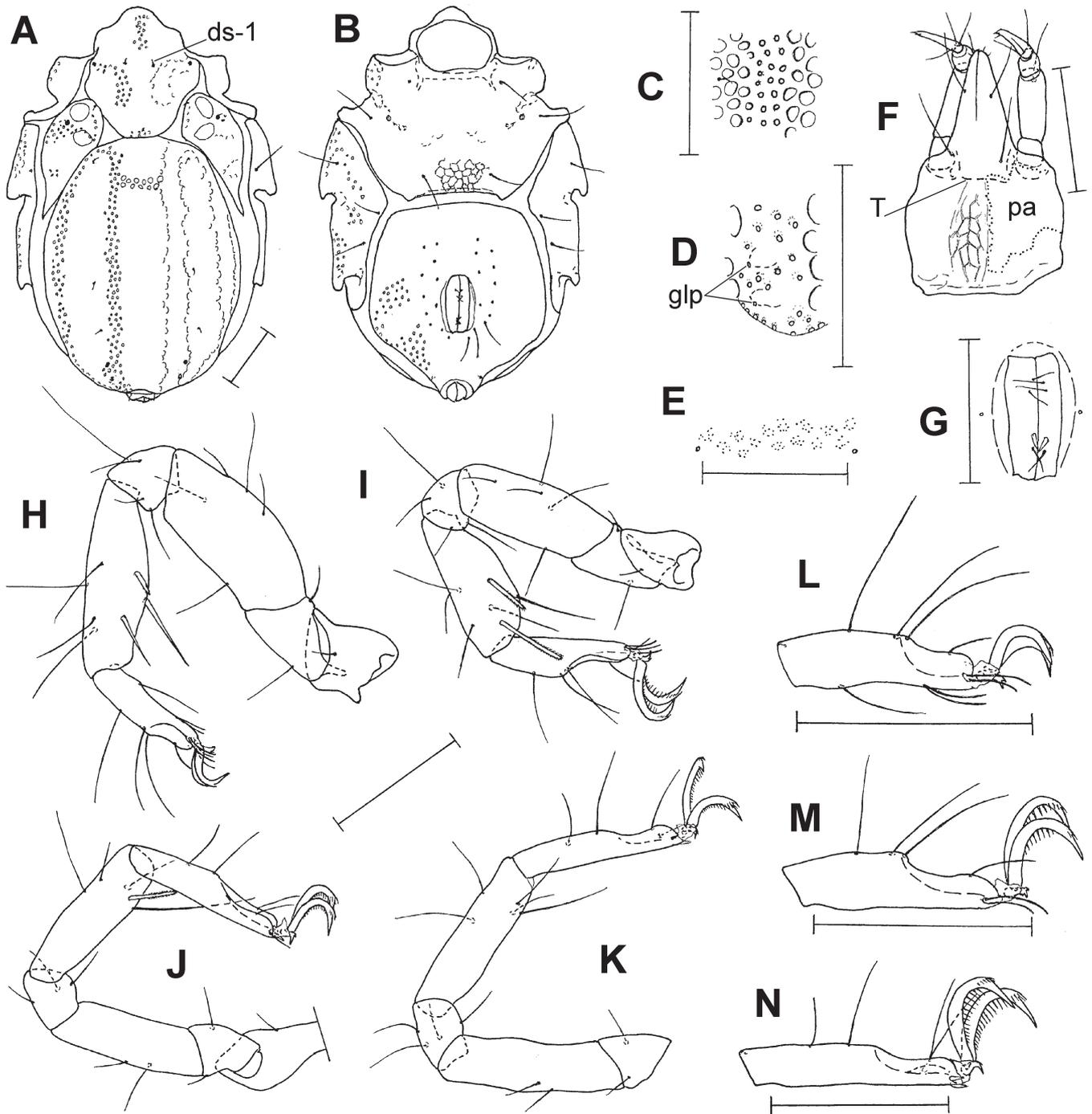


Fig. 11. *Copidognathus latusculus*, new species, male. A, idiosoma, dorsal; B, idiosoma, ventral; C, part of posterior dorsal plate, level with ds-4; D, part of PD level with gland pores; E, basal part of anterior epimeral plate; F, gnathosoma, ventral (porose areola marked by dotted line); G, genital opening, ventral; H, leg I, medial; I, leg II, medial; J, leg III, medial; K, basifemur to tarsus IV, medial; L, tarsus I, lateral (medial parambulacral setae omitted); M, tarsus II, lateral (medial parambulacral setae omitted); N, tarsus IV, lateral. Scale bars= 50 µm (ds-1, first dorsal idiosomal seta; glp, gland pores; pa, porose areola; T, tectum).

pairs of longitudinal costae and two pairs of gland pores, these situated close together. Male GA with pair of distinctly demarcated, semicircular porose areolae. Gnathosoma 1.5× longer than wide; rostrum shorter than gnathosomal base. Leg segments without prominent lamellae. Tibia I with one short, bluntly ending and two longer, tapering setae. Both ventromedial setae on tibia II bipectinate, distal seta longer than basal one. Tibiae III and IV ventrally with 1, 0 bipectinate and 1, 2 smooth setae, respectively. Tarsi III and IV with four dorsal setae.

Etymology. The specific name *latusculus* is a diminutive of *latus* (L) which means wide. The idiosoma of this species is rather wide.

Colour. Body content light brown. Eye pigment beneath AD and OC red-brown.

Description. Length of male 317 and 360 µm; holotype 317 µm long, 214 µm wide. Idiosoma wide. Dorsal plates large (in mounted specimen plates slightly overlapping),

areas with striated integument between plates narrow (Fig. 11A). Porose areolae on dorsal plates with rosette pores, each pore with central ostium, 2 µm in diameter, and four to five delicate canaliculi immediately adjacent to alveoli (Fig. 11C). Remainder of plates foveate. AD 105 µm long, 93 µm wide; with oblong anterior, pair of crescentic and a small transverse posterior areola. AD somewhat heptagonal, longer than wide, anteriorly lamelliform protruding, middle part parallel-sided, posterior part broadly oviform. OC 105 µm long, 50 µm wide; with two large corneae, areolae with rosette pores lateral and medial to corneae; a few rosette pores in posterior half of OC. OC extending posteriad beyond insertion of leg III. PD 205 µm long, 160 µm wide, its anterior margin widely arched. PD with four longitudinal costae, in each half costae fused anteriorly and posteriorly. Both medial and lateral costae two to three rosette pores wide. Dorsal idiosomal setae very short, ds-1 immediately medial to crescentic areolae, ds-2 in margin of OC, ds-3 to ds-5 on PD, lateral to medial costae. Gland pores rather small. Glands oblong, 45 µm in length and 20–25 µm in width. Anterior pair of glp in lateral margin of AD, second pair on OC removed from lateral margin and close to end of anterior cornea, third and fourth pair in posterior part of PD situated close together, with two rosette pores between. Gland pores recognisable because of smooth surface of integument (surface without canaliculi of rosette pores) and large alveoli beneath external pori of glands (Fig. 11D).

Ventral parts of plates with shallow canaliculi arranged within polygons (Fig. 11E). Porose areolae on marginal parts of AE, PE and GA with ostia and distinct canaliculi; towards ventral parts ostia reduced in size and canaliculi arranged within groups. Epimeral processes I and II rather inconspicuous. AE 97 µm long, 187 µm wide; its posterior margin slightly concave (Fig. 11B). PE 157 µm long, extending somewhat beyond insertion of leg IV. Marginally with two porose areolae anterior to insertions of legs III and IV and elongate areola medial to leg III. GA 160 µm long, 142 µm wide, with slightly arched anterior margin. Plate marginally with pair of semicircular, distinctly demarcated porose areolae (Fig. 11B). GO small, in about middle of plate; with 24 pgs scatteredly around and anterior to GO. Each genital sclerite with three slender and one spur-like seta (Fig. 11G). Spermatopositor extending just beyond anterior pgs but not reaching to anterior margin of GA. In 360 µm-long male spermatopositor 90 µm long, 62 µm wide.

Gnathosoma 82 µm long, 60 µm wide; 1.5× longer than wide. Marginal parts of gnathosomal base delicately and almost uniformly punctate, dorsal parts foveate. Tectum almost truncate (Fig. 11F). Rostrum triangular, 0.8× length of gnathosomal base and extending beyond end of P-2.

Leg I longer and wider than leg II. Telofemora I to IV 2.3, 2.5, 3.1, and 3.4× longer than high, respectively. Telofemur and tibia of each leg almost similar in length. Tibiae with small articular membranes. All tarsi with fossa membranes; medial membranes smaller and shorter than lateral ones. Leg chaetotaxy: leg I, 1, 2, 5, 4, 7, 7; leg II, 1, 2, 5, 4, 7, 4; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 2, 2, 4, 5, 4. Tibia I with one

spiniform and two tapering ventral setae (Fig. 11H). On tibia II ventral seta smooth and tapering, two ventromedial setae bipectinate and bluntly ending, basal seta shorter than apical seta (Fig. 11I). Tibia III with bipectinate ventromedial and slender, smooth ventral seta, the latter twice as long as the former (Fig. 11J). On tibia IV both ventral setae smooth and slender (Fig. 11K). Dorsomedial and -lateral fossary setae on tarsi I and II situated at basis of claw fossa, on tarsi III and IV on fossa membranes. Tarsi III and IV with four dorsal setae; distance between two basal setae almost equalling height of tarsi. Tarsi I and II with doubled pas (Fig. 11L and M); tarsus III with setiform medial and flattened, spiniform lateral pas; tarsus IV with pair of spiniform pas (Fig. 11N).

Paired claws on tarsus I shorter than claws of tarsi II to IV. Claws on tarsus I with accessory process; the other claws with pectines extending to basis of claw shaft. Tines up to 4 µm long, decreasing in length towards claw basis (Fig. 11N).

Remarks. The most obvious character combination of *Copidognathus latusculus* is: (1) AD with a pair of crescentic porose areolae, (2) OC somewhat prolonged and with porose areolae in the anterior and posterior part, (3) PD with four longitudinal costae, costae of either side fused anteriorly and posteriorly, (4) both pairs of gland pores situated close together in posterior part of PD, (5) ventral plates with demarcated porose areolae, (6) male GA with pair of semicircular areolae, (7) leg segments without prominent lamellae, (8) tibia I with one short, bluntly ending and two long, tapering setae, (9) tibia II with two bipectinate ventromedial setae being unequal in length, (10) tibiae III and IV with 1, 0 bipectinate and 1, 2 smooth ventral setae, respectively, and (11) both tarsus III and IV with four dorsal setae.

Species in the Indo-Pacific which are very similar to *C. latusculus* are *C. arabicus*, known from the coasts of Mumbai and Goa (Chatterjee & Chang, 2004a, Chatterjee & Guru, 2011), *C. euryalus* Bartsch, 1997, from northern Australia and Thailand (Bartsch, 1997; Chatterjee & Chang, 2002), *C. grandiculus* Bartsch, 1977 from the Galapagos Islands (Bartsch, 1977b), *C. pseudosidellus* Chatterjee, 1997, from the Andaman Islands (Chatterjee, 1997), *C. pujadus* Chatterjee & De Troch, 2003, and *C. sidellus* Bartsch, 1985, both from the Philippines (Bartsch, 1985; Chatterjee & De Troch, 2003b), *C. sideus* Bartsch, 1982, from the Mozambique Channel and southwest India (Kerala Chilka Lagoon) (Bartsch, 1982b; Chatterjee & Sarma, 1993), and *C. ungujaensis* Chatterjee, De Troch & Chang, 2006, from Zanzibar (Chatterjee et al., 2006).

Copidognathus arabicus and *C. euryalus* share most of their characters with *C. latusculus*. *Copidognathus arabicus* has, in contrast to *C. latusculus*, a pentagonal AD with parallel-sided lateral margins and a wide, truncate posterior margin (versus approximately heptagonal outline, posteriorly ovate and with converging margins, though, according to Chatterjee & Guru (2011: fig. 1B and C), posterior margin of AD not as wide as in the description of the type), its telofemur I bears a ventral lamella (versus without such a lamella), the

pgs of males are densely arranged around the GO (versus scatteredly). In *C. euryalus* the distance between the two pairs of gland pores is wider than in *C. latusculus*, the ds-5 insert at the level of the anterior pair of gland pores, and the walls of the polygons outside the costae are formed by epicuticular droplets. The AD of *C. pujadus*, *C. sidellus* and *C. sideus* has circular porose areolae, whereas in *C. latusculus* these areolae are crescentic. In *C. pseudosidellus* the ornamentation of both the dorsal and ventral plates is similar to that of the just mentioned species. The two pairs of gland pores on the PD are not mentioned in the former species but may have escaped notice. Other differences between these two species are in the length relation of telofemur to tibia I as well as telofemur to tibia IV (in *C. pseudosidellus* I-5 shorter than I-3, but IV-5 longer than IV-3, in *C. latusculus* I-3 and I-5 equal in length and IV-3 somewhat longer than IV-5), the ventromedial setae on tibiae I and II (almost equal-shaped in *C. pseudosidellus* but different in length and shape in *C. latusculus*), and the shape of the ventromedial, ventral and lateral seta on tibia III (three spiniform setae versus one short bipectinate and two slender setae, the latter different in size).

Distribution and biology. Singapore. *Copidognathus latusculus* has been collected both in and outside mangroves.

***Copidognathus mangrovorum* Chatterjee, Marshall & Pešić, 2012**
(Fig. 12A–L)

Copidognathus mangrovorum Chatterjee, Marshall & Pešić, 2012b: 19–23, figs 2A–J, 3A–D.

Material and collecting site. One female, ZRC.ARA.1369, end of Lim Chu Kang Road, 1°27'N, 103°42'E, red and green algae (Ceramiales and Cladophorales) on basal part of *Avicennia* trunk, mid-tide zone, 28 October 2012.

Colour. Integument transparent. OC with tiny spots of eye pigment. Gut content pale, almost white.

Description. Length of female 325 µm. Porose areolae of dorsal and ventral plates with shallow foveae, 3–5 µm in diameter, each with very delicate canaliculi (porose foveae) (Fig. 12 E, F). Integument with delicate epicuticular villi both inside and outside porose areolae. Villi within foveate areolae somewhat longer, up to 4 µm in length (Fig. 12G). Areolae on dorsal plates raised but not distinctly delimited. Remainder of plate with 6 µm-wide foveae, these without canaliculi (Fig. 12F). AD with small frontal protrusion; plate 1.2× longer than wide, outline heptagonal, posterior margin truncate. An oblong raised areola in anterior part of AD, a transverse median areola in middle of plate and a narrow areola along truncate posterior margin (Fig. 12A, E). OC large, wide anterior part reduced in width at the level of insertion of leg III. Tail-like posterior part of OC extending halfway between the level of insertion of leg III and IV. OC with two large corneae. Raised porose areolae around corneae, another small areola in lateral margin. PD elongate, 1.6× longer than wide, anterior margin rounded; with single pair of longitudinal costae. Costae about three ostia wide. First pair

of gland pores on AD slightly removed from lateral margins. Pair of glp-2 on OC immediately lateral to posterior cornea. Dorsal idiosomal setae long. Pair of ds-1 in anterior margin of median porose areola. Pair of ds-2 in anterior margin of OC; ds-3 to ds-5 on PD, in lateral margin of costae, ds-3 in anterior part of PD, ds-4 and ds-5 somewhat anterior and posterior to level of insertion of leg IV.

Large ventral parts of AE and GA almost evenly pierced by minute canaliculi; when focussed on deeper layers a reticulation seen (Fig. 12B). Marginal parts of AE, PE and GA with porose foveae with delicate villi. Posterior margin of AE slightly concave. Epimeral processes I and II large and wide. Female GA longer than AE. Anterior margin of GA faintly arched. Distance from anterior margin of GA to that of GO somewhat more than length of GO. Ovipositor extending far beyond margin of GO and also beyond anterior pair of pgs.

Gnathosoma slender, 1.8× longer than wide. Gnathosomal base ventrally with canaliculi, marginally with foveae (Fig. 12 C and D); gnathosomal base with delicate villi. Rostrum elongate, triangular in ventral aspect, 1.8× longer than gnathosomal base and extending beyond P-2. Tectum with short triangular process. Basal pair of maxillary setae almost in middle of gnathosomal base (Fig. 12C). P-4 longer than P-2.

Legs shorter than idiosoma. Surface of trochanters, basi- and telofemora with delicate villi; tibiae and tarsi without conspicuous filamentous cover. Lateral, medial and ventral flank of telofemora I and II foveate, foveae most markedly developed on ventral flank (Fig. 12H). Tibiae I to IV with 2, 2, 1, 0 wide, bipectinate and 1, 1, 1, 2 slender, smooth ventral setae. Telofemora and tibiae I and II with very delicate, narrow articular lamellae. All tarsi with fossa membranes; lateral somewhat larger than medial membrane. All tarsi with four dorsal setae. Both paired fossary setae on tarsus I similar-sized, both situated in almost middle of fossa membrane (Fig. 12I). On tarsus II paired fossary setae situated near basis of claw fossa, close to dorsal fossary seta (Fig. 12J); dorsomedial one of paired fossary setae somewhat shorter and more slender than dorsolateral seta. Solenidion in apical part of lateral fossa membrane. On tarsus III (Fig. 12K) and IV distance between basal seta and dorsal fossary seta equalling height of tarsal segment. Tarsus I with eupathid doubled pas, tarsus II with singlets. On tarsi III (Fig. 12L) and IV medial pas setiform, lateral pas flattened, spiniform.

All paired claws with accessory process. Claws II and III with pectines extending from claw arc almost to middle of claw shaft, pecten on claw IV slightly longer. Tines of pectines up to 2 µm long. Median claw small, bidentate.

Remarks. There are a few differences between the Singaporean specimen and those from Brunei Darussalam, described by Chatterjee et al. (2012b), namely in the number and outline of the areolae on the AD, anterior one ovate (versus rounded in type material), median areola extending to gland pores (versus not reaching to that pair of pores)

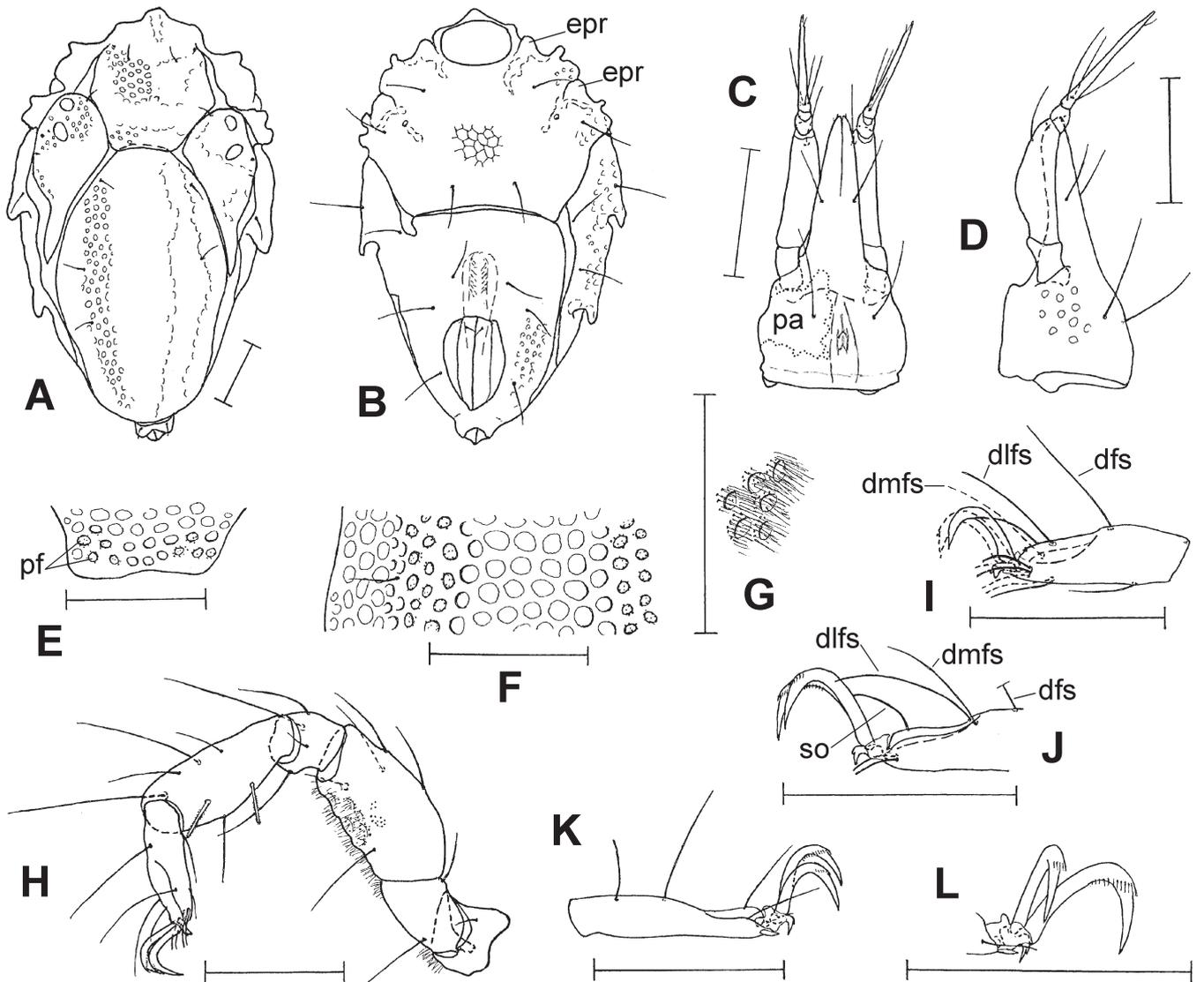


Fig. 12. *Copidognathus mangrovorum* Chatterjee, Marshall & Pešić, 2012, female. A, idiosoma, dorsal; B, idiosoma, ventral; C, gnathosoma, ventral (porose areola marked by dotted line); D, gnathosoma, lateral; E, posterior part of AD; F, part of PD, level with ds-4; G, detail of marginal GA between pgs-1 and pgs-2; H, leg I, medial; I, tarsus I, lateral (medial setae and claw in broken line); J, tip of tarsus II, medial; K, tarsus III, lateral; L, tip of tarsus III, medial. Scale bars = 50 μ m. (dfs, dorsal fossary seta; dlfs, dorsolateral fossary seta; dmfs, dorsomedial fossary seta; epr, epimeral process; pa, porose areola; pf, porose foveae; so, solenidion).

and presence (versus absence) of a transverse posterior areola, presence of porose foveae on the ventral flank of telofemora I and II (versus a few rosette pores on the dorsal side of telofemora I and II—cf. Chatterjee et al., 2012b: p. 22, though according to Chatterjee et al., 2012b: fig. 3A, only the ventral flank bears foveae). As long as the range of variability is not known, the Singaporean specimen is attributed to *C. mangrovorum*. According to the descriptions of the species, *C. mangrovorum* does not belong to the *oculatus* group, characterised by Bartsch (1977a, 1999). The AD of species of the *oculatus* group has a small anterior and a large median porose areola but no transverse raised areola along the posterior margin. Males of the medium- and large-sized species of the *oculatus* group (>200 μ m length) have a postgenital papilla (in *C. ypsilophorus* described as ‘a distinct shelf just anterior to the anal foramen’—Newell, 1984: 156), the pgs are close to the GO and each of the genital sclerites bears three sgs (one anterior, two posterior

setae). According to the description of *C. mangrovorum* by Chatterjee et al. (2012b), a postgenital papilla is lacking, the pgs are arranged in a rather wide ring around the GO, and there are four pairs of sgs. The postgenital papilla may be absent in small-sized (e.g., *C. rasilis* Bartsch, 1999) and deep-sea species. The number of sgs is known to vary, but within the *oculatus* species group only a few have four instead of three sgs and the higher number seems to be restricted to just one genital sclerite, examples are *C. hureaui* Newell, 1984, *C. levigatus* Bartsch, 1999, and *C. rasilis* Bartsch, 1999 (Newell, 1984; Bartsch, 1999).

Anomalies. In the present specimen leg IV and the posterior part of the PE are lacking on the right side, the GA and the PE are partly fused.

Distribution and biology. Brunei Darussalam (Chatterjee et al., 2012b) and Singapore (new record).

The present individual was conspicuously pale, the gut content white, the spots of eye pigment small, though the species has distinct corneae. Most *Copidognathus* species have brown or beige particles in the gut. The other halacarids in that sample, *C. rhombognathoides* Bartsch and *Rhombognathus bulbosus* Bartsch, 2005, had a green or grey-green gut content, they are expected to be algivorous. A pale, white colour is not restricted to *C. mangrovorum*, another example is *Copidognathus dubiosus* Bartsch, 1994, collected in Western Australia, near Esperance, from samples with *Posidonia* rhizoms (seagrass, Alismatales) and muddy debris amongst algal turf growing on a rock (unpublished). This very conspicuous white colour raises the question, what do these species feed on?

***Copidognathus mollis*, new species**
(Fig. 13A–O)

Material and collecting site. Holotype female, ZRC.ARA.1370, Singapore, Pasir Ris Park, 1°23'N, 103°58'E, small algal film (*Bostrychia* sp. and other algae) and sediment on remnants of a trunk, upper tidal area, 27 October 2012; paratype female, ZRC.ARA.1371, same collecting data; 2 females, IB, same collecting data.

Diagnosis. Length of female 320–342 µm. Surface of plates foveate, foveae within slightly raised areas with delicate pores (porose areolae). AD with three such areolae, OC with two porose areolae and PD with two pairs of longitudinal porose areolae. Gnathosoma 1.5× longer than wide, rostrum slightly longer than gnathosomal base and extending to end of P-2. Tectum truncate. Legs slender, without prominent lamellae. Tibia I with two short, slightly bipectinate ventromedial setae. Both ventral setae on tibia IV slender and smooth. Claw pectines II to IV with numerous distinct tines.

Etymology. Derived from mollis (L.) (= soft, weak, faint), because of the weak ornamentation of the plates.

Colour. Content of idiosoma light-brown. Distinct black pigment spots beneath corneae.

Description. Length of female 320–342 µm; holotype 320 µm long, 203 µm wide. Surface of dorsal plates foveate. Foveae within porose areolae faintly raised and with numerous delicate canaliculi, foveae in remainder of plate without marked ornamentation (Fig. 13D). Plates reticulated when focussing on deeper integumental layer, walls of polygons slightly thicker within than outside raised areolae. Integument between plates with parallel striae. Plates with delicate villi. AD 82 µm long, 82 µm wide, its anterior margin arched. Anteromarginal part, equalling dorsal part of AE, slightly protruding. AD with one round anterior areola and pair of slightly elongate and raised areolae in which foveae include numerous canaliculi (Fig. 13A and C). OC 85–90 µm long, 50 µm wide, about 1.7–1.8× longer than wide; reaching posteriad to the level of aperture of leg III. Each plate with two corneae. Porose foveae medial to corneae and in posterior part of plate. PD 190 µm long, 119 µm wide, 1.7× longer than wide; rather narrow anterior margin truncate,

posterior part ovate. PD with two longitudinal ‘costae’ with shallow, porose foveae; ‘costae’ slightly raised and margins of polygons including foveae thicker than in other parts of PD. Gland pores small, on AD in lateral margin; on OC immediately lateral to posterior cornea, on PD a single pair of pores recognised, this situated in posterior part of plate immediately lateral to ‘costae’. Dorsal idiosomal setae small; pair of ds-1 in anterior margin of pair of porose polygons, ds-2 in striated integument between AD and OC, ds-3 to ds-5 on PD as illustrated (Fig. 13A).

Marginal parts of epimera I, PE and posteromarginal parts of GA with shallow porose foveae (Fig. 13B), ventrad foveae replaced by groups with delicate canaliculi; in median parts of AE and GA canaliculi hardly discernable. AE 98 µm long, 180 µm wide; its posterior margin somewhat concave. Epimeral processes inconspicuous. Epimeral pores 5–6 µm in diameter. PE 150 µm long. Dorsal seta on PE wider and longer than dorsal idiosomal setae. GA slender, 143 µm long, 97 µm wide; anterior margin arched. GO 55 µm long, 32 µm wide and removed from anterior margin of GA by 1.7× length of GO. Ovipositor extending beyond GO and slightly beyond anterior-most pair of pgs.

Gnathosoma 93 µm long, 62 µm wide, 1.5× longer than wide. Marginal parts of gnathosomal base with delicate canaliculi, 12–40 arranged within polygons. Tectum truncate (Fig. 12E). Rostrum 50 µm long, 1.2× longer than gnathosomal base and extending to end of P-2 (Fig. 13E, F).

Legs rather similar in length, though leg I slightly wider than following legs. Ventrolateral flank of telofemora I to IV with few, scattered groups with canaliculi; ventral margin with densely packed epicuticular villi (Fig. 12K, L). Similarly, surface of trochanters and basifemora with villi. Telofemora II to IV 2.4, 2.6, 2.8× longer than high. Telofemora and tibiae of legs I and II almost equal in length; telofemora of legs III and IV shorter than these legs tibiae. Fossa membranes small, present only in apical part of claw fossa. Leg chaetotaxy: leg I, 1, 2, 5, 4, 7, 7; leg II, 1, 2, 5, 4, 7, 4; leg III, 1, 2, 3, 3, 5, 4; leg IV, 0, 2, 3, 3, 5, 3. Two bipectinate spiniform setae on tibia I much shorter than these setae on tibia II (Fig. 13G, H). Bipectinate spiniform seta on tibia III short and wide (Fig. 13I). On tibia IV both ventral setae smooth and slender (Fig. 13J). Tarsi I and II with four dorsal setae; dorsomedial and -lateral fossary setae not in paired arrangement, dorsomedial seta close to dorsal fossary seta, dorsolateral seta on fossa membrane (Fig. 13O). Solenidion on tarsus I 11 µm long, famulus within minute bud-like membrane (Fig. 13M), solenidion on tarsus II 14 µm long. Pairs of pas on tarsi I and II doubled; medial pas on tarsus III eupathid, lateral pas setiform; pair of pas on tarsus IV setiform. Tarsus III with four dorsal setae, two basal ones separated by a width equalling height of tarsus.

Claws I smaller than claws of following legs. Claw I with accessory process and a few very delicate tines on inner flank of claw shaft (Fig. 13N) (discernable only in medial aspect of claw). Claws on following tines with pectines extending to basis of claw, tines up to 4 µm long.

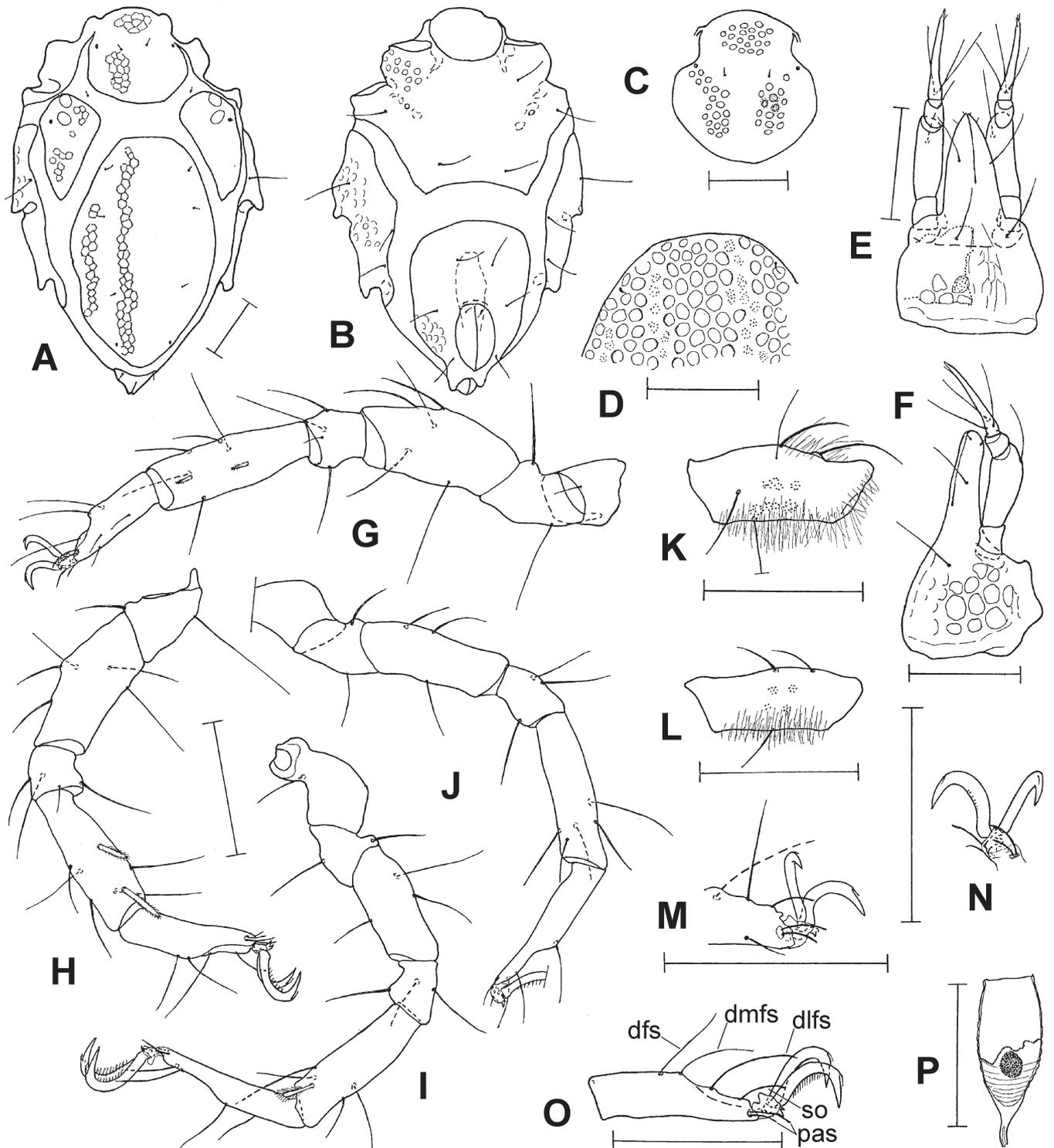


Fig. 13. *Copidognathus mollis*, new species and *Praethecacineta* sp. (Suctoria). A–O, *Copidognathus mollis*, female: A, idiosoma, dorsal; B, idiosoma, ventral; C, anterior dorsal plate (porosity shown in three foveae); D, anterior part of PD; E, gnathosoma, ventral; F, gnathosoma, lateral; G, leg I, medial; H, basifemur to tarsus II, medial; I, leg III, medial; J, leg IV, medial; K, telofemur II with porose foveae and villi, lateral; L, telofemur IV with porose foveae and villi, lateral; M, tip of tarsus I, lateral (medial fossary seta in broken line, medial eupathidia omitted); N, tip of tarsus I, ventral; O, tarsus II, lateral. P, theca of *Praethecacineta* sp. Scale bars = 50 μ m. (dfs, dorsal fossary seta; dlfs, dorsolateral fossary seta; dmfs, dorsomedial fossary seta; pas, parambulacral setae; so, solenidium).

Remarks. *Copidognathus mollis* differs from the other species collected on the shores of Singapore because of the ornamentation of the dorsal plates. The porose areas are not markedly raised, accordingly the plates only slightly thicker in these areas. The ornamentation resembles that present in *C. brevirostris* Viets, 1927, *C. hylandi* Bartsch, 1979, and *C. paluster* Bartsch, 1991, but in these species the legs I and II are short, the telofemora of all legs shorter than in *C. mollis* (in *C. brevirostris*, *C. hylandi* and *C. paluster* length:height ratios of telofemora II and IV 1.6–2.1:1 and 2.1–2.4:1, respectively, in *C. mollis* 2.4 and 2.8:1). The three just mentioned species are inhabitants of lenitic brackish water areas, *C. brevirostris* has been found along the coastline of northern Europe, from Norway to southern Spain (Viets, 1927; Cadiz, coll. T. Buchegger, unpublished record), *C. hylandi* on the other side of the North Atlantic, in Rhode Island, US (Bartsch, 1979), and *C. paluster* Bartsch, 1991 amongst turfs of Cladophorales (green algae) and muddy sediment in Hong Kong mangroves (Bartsch, 1991).

Distribution and biology. Singapore. A rather uniform ornamentation of the dorsal plates, as present in *C. mollis*,

is often found in brackish water *Copidognathus* species (Bartsch, 1996b: p. 707).

Copidognathus mollis and the above described *C. mangrovorum* bear delicate epicuticular villi, best developed within the porose areolae. These villi are no fouling but present already in just hatched specimens. Delicate epicuticular villi may reduce the impact of sun radiation and evaporation but also prevent severe biofouling (Bartsch, 2000b).

The holotype was infested by seven thecate suctorians, situated marginally on the AE, GA and PD and on the telofemora III and IV. The thecae are 50 µm long and 21–23 µm wide, the stem up to 30 µm long, the size of the macronucleus 6×8 µm (Fig. 13P). The basal part of the theca is slightly annulated. All suctorians were moribund, without tentacles.

***Copidognathus pesident* Bartsch, 1992**
(Figs 14A–J and 15A–H)

Copidognathus pesident Bartsch, 1992: 483–485, figs 59–66.

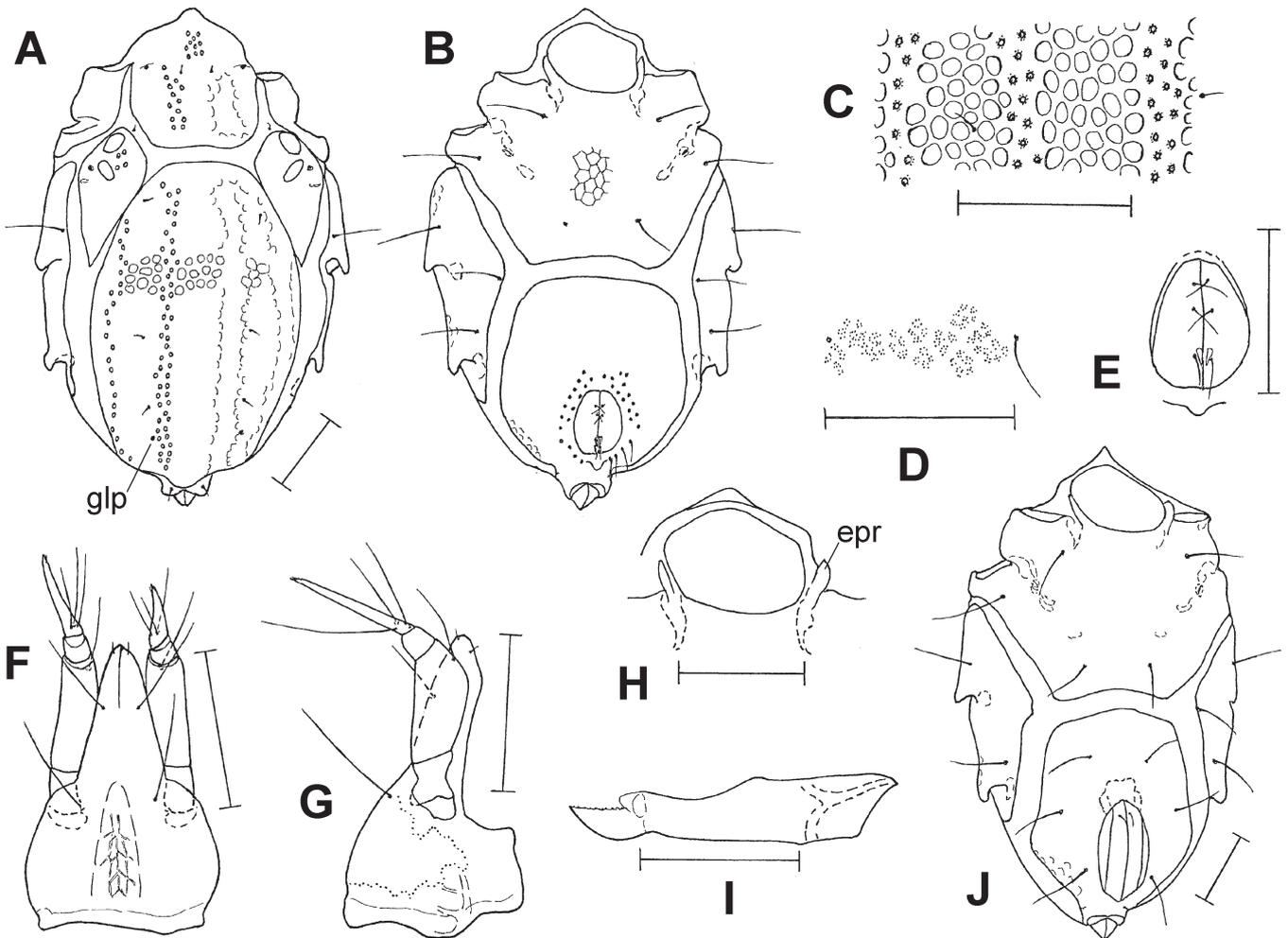


Fig. 14. *Copidognathus pesident* Bartsch, 1992. A, idiosoma, dorsal, male; B, idiosoma, ventral, male; C, median part of PD, level with ds-4, male; D, basal part of AE, male; E, genital opening, male; F, gnathosoma, ventral, male (porose areolae not illustrated); G, gnathosoma, lateral, male (porose areola marked by dotted line); H, camerostome, male; I, chelicera, male; J, idiosoma, ventral, female. Scale bars = 50 µm. (epr, epimeral process; glp, gland pore).

Material and collecting sites. One female one male, ZRC.ARA.1372, Singapore, Pulau Ubin, Chek Jawa, 1°24'N, 103°59'E, epibios (mainly red algae) on pneumatophores of *Sonneratia* sp., 16 October 2012; 1 male, IB, same collecting data. One female, 1 protonymph, ZRC.ARA.1373, Pulau Ubin, OBS Camp NW, 1°26'N, 103°56'E, algae on root bale of uprooted coconut palm, 21 October 2012; 1 female, 1 protonymph, IB, same collecting data. One female, IB, Pulau Ubin, Pasir Ris Park, 1°23'N, 103°58'E, *Bostrychietum* and mud on dead trunk, 27 October 2012. One male, SMF, Singapore, Pulau Ubin, west of OBS Camp 1, 1°25'N, 103°56'E, small algal tufts on rocks, midwater, 28 October 2012.

Colour. Content of gut with brown particles. Large spots with black-brown eye pigment beneath corneae.

Description. Adults. Length of female 339–349 μm , of male 304–306 μm . Dorsal plates with raised areolae with rosette pores, remainder of plates reticulate. Integument between plates striated. Anterior margin of AD with small, obtuse frontal process; posterior margin truncate. AD with three

porose areolae, a small anterior one and a pair of elongate, sometimes slightly crescentic areolae in posterior half of plate (Fig. 14A). These areolae often extending to posterior margin of AD. Rosette pores within areolae with 5 μm wide ostia, each ostium with approximately 15 canaliculi. OC elongate, length about twice the width, with about five rosette pores medial to two corneae. PD with two pairs of longitudinal costae; medial costae two rosette pores wide, lateral ones a single pore, posteriorly often two pores wide. Ostia on PD 2–3 μm wide, each rosette pore with 7–12 canaliculi (Fig. 14C). Setae ds-1 on AD immediately anterior to crescentic porose areolae, ds-2 in striated integument between AD and OC; ds-3 to ds-5 on PD, ds-4 and ds-5 slightly anterior and posterior to the level of insertion of leg IV. Gland pores small, one pair close to lateral margin of AD about level with ds-1; one pair on OC, immediately lateral to posterior cornea, and one pair in posterior part of PD adjacent to medial costae (Fig. 14A).

Ventral plates punctate, namely groups of 5–8 canaliculi, 4–7 such groups in turn united within polygons; the wide walls of the polygons forming a reticulum (Fig. 14D). Marginal

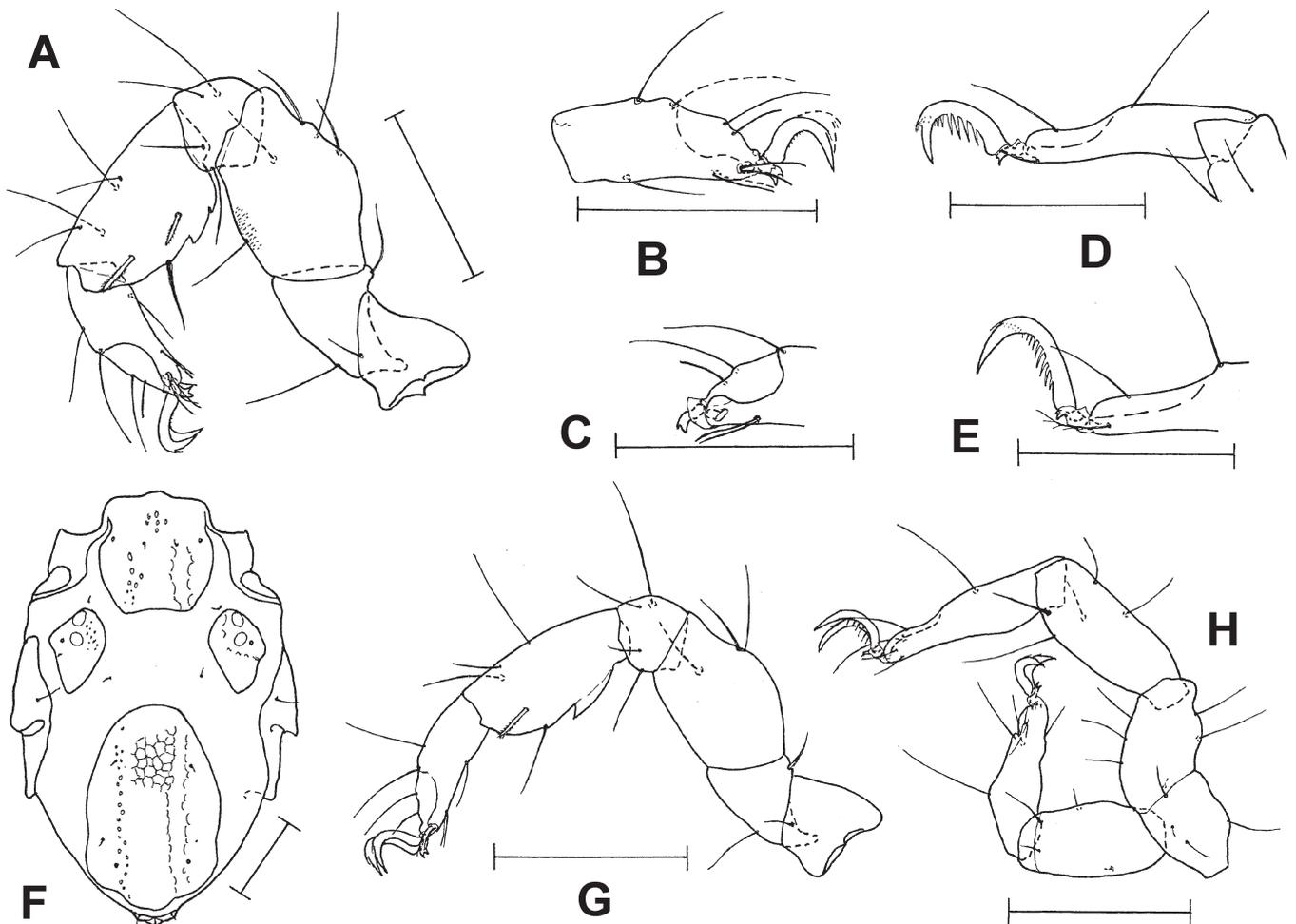


Fig. 15A–H. *Copidognathus pesident* Bartsch, 1992. A, leg I, medial, male; B, tarsus I, lateral, male (medial setae and claw in broken line); C, tip of tarsus I, medial, male (parambulacral setae omitted); D, tarsus and tip of tibia IV, lateral, female (medial setae and claw omitted); E, tip of tarsus IV, lateral, male (medial setae and claw omitted); F, idiosoma, dorsal, protonymph; G, leg I, medial, protonymph; H, anomalous leg IV, female. Scale = 50 μm .

parts of AE and PE and posterolateral parts of GA with a few punctate foveae. Large epimeral processes flanking camerostome (Fig. 14B, H); no enlarged epimeral process within area of EII. Posterior margin of AE almost truncate. PE extending beyond insertion of leg IV. Anterior margin of female GA slightly arched; pgs-2 about level with anterior end of GO and closer to lateral margins of GA than to GO; distance between anterior margin of GA and GO slightly less than length of GO; ovipositor short, extending halfway between pgs-1 and pgs-2 (Fig. 14J). Male GO in posterior half of GA, distance to anterior margin of GA equalling 1.7× length of GO; genital sclerites with three slender and one spur-like sgs (Fig. 14E). With minute papilla posterior to GO arising from perigenital ring. GO with 34–36 pgs densely arranged around GO.

Gnathosoma 1.5× longer than wide (Fig. 14F). Gnathosomal base punctate (Fig. 14G). Tectum truncate. Rostrum 1.4× longer than gnathosomal base; extending to the level of end of P-2. Claw of chelicerae with delicate tines (Fig. 14I).

Tibiae I and II with two spiniform ventral lamellae (Fig. 15A). Articular lamellae on telofemur and genu of leg I small, on leg II slightly larger, on legs III and IV lamellae triangular, lateral lamellae larger than medial ones. Tibiae with triangular articular lamellae (Fig. 15D), medial lamellae somewhat smaller than lateral ones, this difference in size most marked on tibiae I. Tarsi I and II with large lateral and small medial fossa membranes (Fig. 15B, C); on tarsi III and IV medial fossa membrane almost as large as lateral one. Within small ventral part integument of telofemora I and II with numerous canaliculi. Telofemora III and IV 1.8 and 2.0× longer than high, respectively. Leg chaetotaxy: leg I, 1, 2, 5, 4, 7, 7; leg II, 1, 2, 5, 4, 7, 4; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 2, 3, 3, 5, 3. Tibiae I to IV ventrally with 2, 2, 1, 0 bipectinate and 1, 1, 1, 2 slender and smooth setae. On tarsus I (Fig. 15B) and II lateral fossary seta on fossa membrane, close to solenidion, medial fossary seta at basis of claw fossa. Solenidion on tarsus I 11 µm long; famulus small, in posterior edge of fossa membrane. Solenidion on tarsus II 14 µm long. In males pas on tarsus IV delicately plumulose (Fig. 15E), in females pas short, setiform (Fig. 15D). On tarsus III distance between two basal setae equalling height of tarsus; basal-most seta halfway between tarsal basis and dorsal fossary seta.

Claws I smaller than following claws; claws I with few short tines at shaft; claws II to IV with strong tines (Fig. 15D, E). Range of length of tines 4–7 µm.

Protonymph. Length 260 µm. OC and PD smaller and narrower than in adults (Fig. 15F). Porose areolae with ostia of rosette pores but also with groups of small pores instead of single ostium. Remainder of dorsal plates panelled. PD with single pair of costae, about one rosette pore wide. Setae ds-3 in striated integument. Ventral plates punctate, delicate canaliculi within pits, without reticulation (as present in adults). Shape of gnathosoma same as in adults. Tibiae I (Fig. 15G) and II with spiniform ventral lamella and one smooth and one bipectinate ventral seta. On tarsus III

distance between two basal setae equalling height of tarsus, and basal-most seta situated halfway between dorsal fossary seta and tarsal basis.

Anomaly. One of the females has on one side a deformed leg IV. From the basifemur arises both a three- and two-segmented leg, the former with segments corresponding to a telofemur-genu combination, a tibia and tarsus, the latter with segments similar to tibia and tarsus (Fig. 15H). Both the basifemur and telofemur-genu combination have an unusual number and arrangement of setae.

Remarks. The most obvious characters of this species are: (1) AD with an anterior and a pair of oblong porose areolae, (2) PD with two pairs of porose costae; (3) AE with prominent epimeral processes; (4) female pgs-2 generally close to lateral margins of GA; male pgs in a dense ring around GO; (5) tibia I with two spiniform ventral lamellae; (6) telofemora III and IV with two and three setae, respectively. At present eight species have an almost similar character combination, these species are united in the *Copidognathus punctatissimus* group.

There is a small difference between the descriptions based on the Singaporean specimens and the holotype from the Society Islands. The lateral porose costae are one or two pores wide in the male from the Society Islands but one pore wide in the material from Singapore. This difference seems to be negligible (the single type specimen of *C. pesident* is lost, personal communication, J. Altmann, Forschungsmuseum Senckenberg, Frankfurt).

Species from the Indo-Pacific region similar to *C. pesident* are *C. eblingi* Chatterjee, 1991 (India, Bay of Bengal), *C. dentipes* Bartsch, 1989 (Hawaiian Islands), *C. jejuensis* Chatterjee & Chang, 2004 (South Korea), *C. mumbaiensis* Chatterjee & Chang, 2004 (India, Arabian Sea) (Bartsch, 1989; Chatterjee, 1991; Chatterjee & Chang, 2004a, b).

In contrast to *C. pesident*, the OC of *C. dentipes* are shorter, the anteriorly ovate PD and the medial costae are narrow. Telofemur I of *C. jejuensis* and *C. mumbaiensis* bears a conspicuous ventral lamella, such lamella is small or absent in the other species. According to the original and re-description of *C. eblingi* (Chatterjee, 1991; Chatterjee & Annapurna, 2003), the epimeral processes on either side of the camerostome are present though very small (Chatterjee & Annapurna, 2003: p. 53, fig. 2E), the ornamentation of the ventral plates is very coarse (Chatterjee, 1991: fig. 2), the basal pair of maxillary setae in a very basal position (Chatterjee, 1991: fig. 7), the spiniform ventral lamellae on tibia II are larger than on tibia I (Chatterjee, 1991: figs 8 and 9), and the telofemora I and II lack the ventral patches with canaliculi (Chatterjee, 1991: figs 8 and 9, Chatterjee & Annapurna, 2003: fig. 2G, H).

Four resembling species from the Atlantic are *C. biscoyneus* Newell, 1947 and *C. punctatissimus* (Gimbel, 1919), both with records from the north-western Atlantic, United States, *C. dentatus* Viets, 1940, from the north-eastern Atlantic

and Mediterranean, and *C. tupinamborum* Pepato & Tiago, 2005, from the south-western Atlantic, Brazil (Gimbel, 1919; Viets, 1940; Newell, 1947; Bartsch, 1982a; Green & MacQuitty, 1987; Bartsch & Smit, 2006; Pepato & Tiago, 2005b). *Copidognathus biscoyneus* differs from *C. pesident*, and all other species of this group, because of its slender AD (1.4× longer than wide versus hardly longer than wide) with a pair of unusual elongate porose areolae, its posteriorly wide OC, and its dorsal plates bearing no typical rosette pores. Instead of several canaliculi opening into a central ostium there are irregular groups of canaliculi and small ostia. *Copidognathus dentatus* and *C. punctatissimus*, as also *C. biscoyneus*, have three setae (2/1 dorsal/ventral) on both telofemur III and IV, instead of 2/0 and 2/1 dorsal/ventral setae, respectively, as in *C. pesident* and most of the other species. *C. tupinamborum* can be distinguished from *C. pesident* because of the former's very wide costae on the PD (the lateral costae are at least two and major part of the medial ones three rosette pores wide) and the different size of the bipectinate setae on tibiae I and II (setae on tibia I smaller than on tibia II).

Distribution and biology. Moorea, Society Islands (Bartsch, 1992) and Singapore (new record). Extracted from sandy deposits and tufts of small algae growing on rocks or mangrove trees. All present records are from shallow water.

One of the females had 13 suctorians fixed to the posterior part of the idiosoma and the basal leg segments. All protozoans were moribund, without tentacles. The thecae have a length of 40–47 µm and a width of 11–15 µm, one of the thecae is slightly waisted. These suctorians, too, are expected to belong to the wide-spread species *Praethecacineta halacari*.

***Copidognathus rhombognathoides* Bartsch, 2006**
(Fig. 1K, L)

Copidognathus rhombognathoides Bartsch, 2006b: 88–92, figs 21–41.

Copidognathus rhombognathoides Chatterjee et al., 2012b: 27–29, figs 7A–F, 8A–C.

Material and collecting sites. One female, 2 protonymphs, 1 larva, ZRC.ARA.1374, Singapore, Pulau Ubin, Chek Jawa, 1°24'N, 103°59'E, *Chthamalus* sp. (Cirripedia) on stilt roots of *Rhizophora* sp. (Malpighiales), 16 October 2012. One female, IB, Singapore, end of Lim Chu Kang Road, 1°27'N, 103°44'E, green algae (*Chaetomorpha* sp., Cladophorales) on trunk of *Avicennia* sp., splash zone, 28 October 2012.

Colour. Integument transparent or slightly brown. Idiosoma greyish-green, gut content green, showing outline of gut diverticula. At low magnification this species is easily mistaken for a *Rhombognathus* species.

Short description. Length of female 370–414 µm, of male 353–370 µm. Dorsal plates with delicately and evenly punctate areolae. AD with three contiguous areolae. PD with truncate anterior margin and two pairs of longitudinal

areolae (costae) (Fig. 1L). Pairs of ds-3 to ds-5 immediately lateral to pair of medial costae; ds-5 at 0.5 (relative to length of PD). Ventral plates uniformly porose. Epimeral pores on AE ovate, about 10 µm long. Adjacent margins of AE and GA truncate (Fig. 1K). In female interval between anterior margin of GO and that of GA slightly less than length of GO. In male GO in more posterior position, distance from anterior margin of GO to that of GA equalling 1.3× length of GO. Spermatopositor large, extending to anterior margin of GA. Gnathosoma short (Fig. 1L), 1.3× longer than wide; rostrum in ventral aspect triangular, distinctly shorter than gnathosomal base. Legs I and II almost equal-sized, legs III and IV more slender (Fig. 1L). Telofemora I and II 2.2× longer than high. 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. Tibiae I to IV with 2, 2, 1, 1 bipectinate setae, these setae on tibiae I and II wide, on tibiae III and IV distinctly shorter. On tarsus I and II dorsal and dorsomedial fossary setae at almost same level, dorsolateral fossary seta close to tip of tarsus. On both tarsus I and II solenidion baculiform. Paired claws slender, smooth.

Distribution and biology. Singapore and Brunei Darussalam (Bartsch, 2006b; Chatterjee et al., 2012b).

All records of *Copidognathus rhombognathoides* are from algal turf in mangroves.

***Copidognathus riguus*, new species**
(Figs. 16A–M, 17A–D)

Material and collecting sites. Holotype male, ZRC.ARA.1375, Singapore, end of Lim Chu Kang Road, 1°27'N, 103°42'E, mats of green algae amongst mangrove trees (*Avicennia* sp.), 7 October 2004; paratype female, ZRC.ARA.1376, same collecting data; 3 males, IB, same collecting data. One male, one protonymph, ZRC.ARA.1377, Singapore, Pulau Ubin, OBS Camp NW, 1°26'N, 103°56'E, sediment from beach, 24 October 2012.

Diagnosis. Length of female 294 µm, of male 290–300 µm. AD with large, dumbbell-shaped porose areola. OC elongate, slender, extending beyond the level of insertion of leg III. PD with two pairs of costae; its two pairs of gland pores situated adjacent in posterior part. Male GA with 26–29 pgs arranged very scatteredly around GO. Gnathosoma slender, 1.5× longer than wide; rostrum somewhat longer than gnathosomal base. Tibia I with one flattened and bipectinate and two smooth, tapering ventral setae. Paired claws on tarsi II to IV with numerous tines; tines in basal part shorter than those in posterior part of claw.

Etymology. Derived from *riguus* (L), waterlogged, as the habitat of the species is constantly wet.

Colour. With spots of eye pigment on AD and OC; spot on AD small, spots on OC large. Gut content with brown and orange particles shining through transparent integument. Large glands present beneath OC and posterior part of PD.

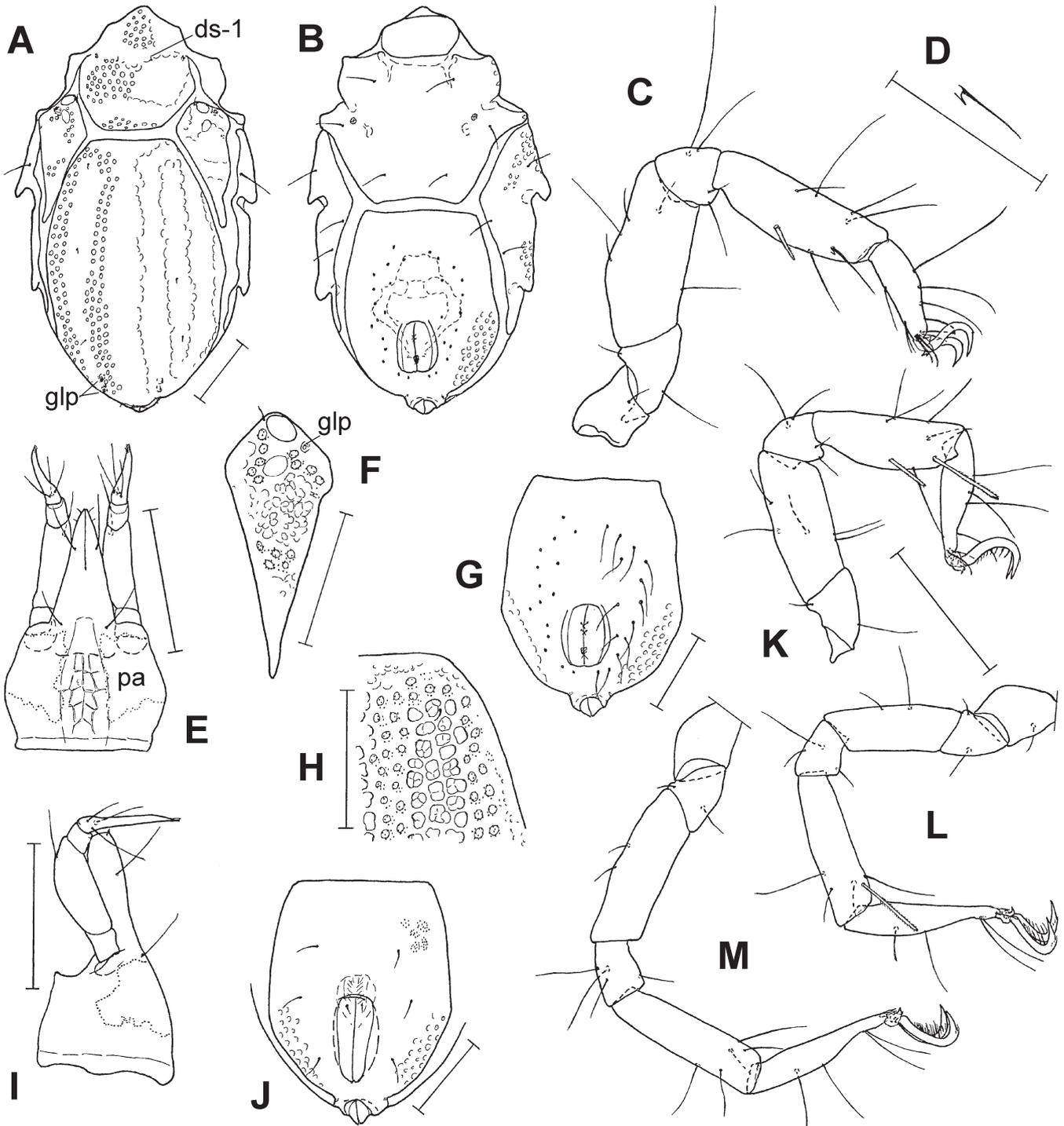


Fig. 16. *Copidognathus riguus*, new species. A. idiosoma, dorsal, male; B, idiosoma, ventral, male; C, leg I, medial, male; D, spine at basis of apical ventromedial seta, male; E, gnathosoma, ventral, male (porose areolae marked by dotted lines); F, right OC, male; G, genitoanal plate, ventral, male; H, anterior part of PD, male; I, gnathosoma, lateral, male (porose areola marked by dotted line); J, genitoanal plate, ventral, female; K, basifemur to tarsus II, medial, male; L, leg III, medial, male; M, leg IV, medial, male. Scale bars = 50 μm . (ds-1, first dorsal idiosomal seta; glp, gland pores; pa, porose areola).

Description. Male. Length of idiosoma 290–300 μm ; length of holotype 294 μm , width 174 μm . Idiosoma 1.7 \times longer than wide. Dorsal plates with large raised porose areolae, each porus equalling a fovea-like ostium with 9–10 canaliculi. Rather narrow areas outside porose areolae foveate, foveae subdivided (Fig. 16H). AD 90 μm long, 82 μm wide; with rounded frontal protuberance and truncate posterior margin. AD with wide ovate anterior, transverse, dumbbell-shaped median and narrow, transverse posterior

porose areola (Fig. 16A). OC elongate, 95 μm long, 40 μm wide; its narrow posterior end extending beyond the level of insertion of leg III. Anterior cornea distinctly delimited, posterior cornea represented by hyaline area. Anterior part of OC with semicircular and posterior part of plate with transverse porose areola (Fig. 16F). PD 195 μm long, 132 μm wide; its anterior margin wide and truncate. Plate with two pairs of longitudinal costae; medial costae anteriorly mostly two, posteriorly three (to four) rosette pores wide.

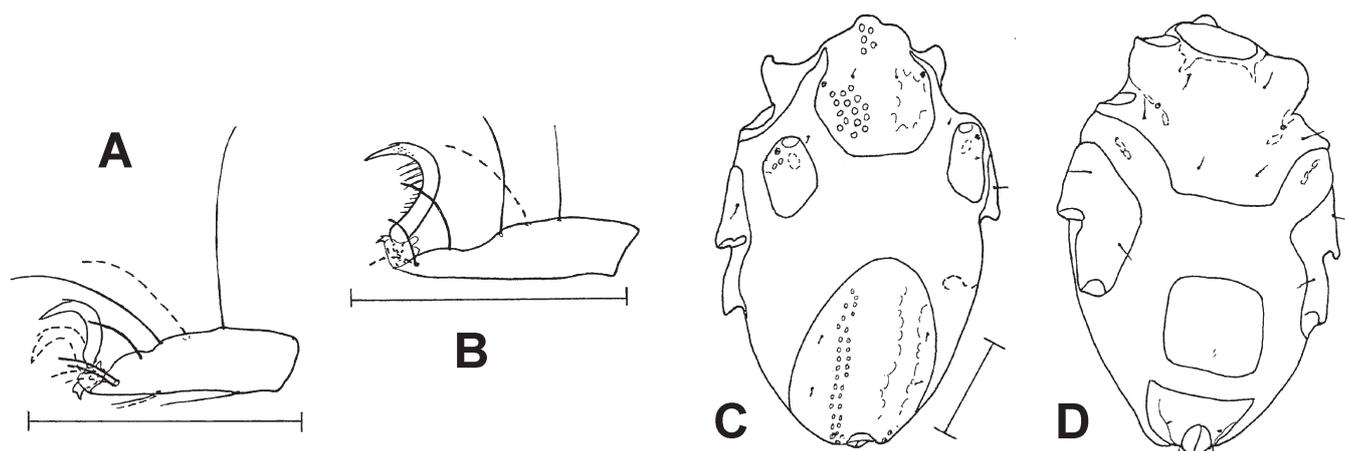


Fig. 17. *Copidognathus riguus*, new species. A, tarsus I, lateral, male (medial setae and claw in broken line); B, tarsus II, lateral, male (medial fossary and parambulacral seta in broken line; medial claw omitted); C, idiosoma, dorsal, protonymph; D, idiosoma, ventral, protonymph. Scale bars = 50 μm .

Costae of either side anteriorly contiguous. Dorsal setae short, pair of ds-1 in anterior margin of dumbbell-shaped areola; ds-2 in anteromedian margin of OC, ds-3 to ds-5 on PD, within elongate area between lateral and medial costae. Pair of ds-6 on anal plate. First pair of pores in anterolateral corners of dumbbell-shaped median porose areola; second pair on OC, slightly raised and immediately posterolateral to anterior cornea. PD with two pairs of gland pores; pores of either side close to posterior margin of plate and situated adjacent. Areas with pores raised, surface of integument smooth, no rosette pores between these two gland pores. Glands beneath OC 50–70 μm long, 22–32 μm wide.

Ventral parts of ventral plates punctate, delicate canaliculi in polygonal arrangement; marginal part of PE and posteromarginal parts of GA with porose foveae (Fig. 16B). AE 100 μm long, 150 μm wide; posterior margin slightly concave. AE without marked epimeral processes. PE 147 μm long; extending beyond insertion of leg IV. GA 148 μm long, 112 μm wide. Anterior margin of GA truncate. GO 37 μm long, 28 μm wide, in posterior half of GA. Distance between GO and anterior margin of GA about twice the length of GO. With 29 pgs very scatteredly arranged around GO (Fig. 16G). Anterior pgs removed from GO by more than length of GO. Spermatopositor 74 μm long, 60 μm wide, extending beyond GO and reaching to the level of anterior-most pgs. Two pairs of anterior sgs setiform, one of posterior pairs of sgs spini-, the other setiform.

Gnathosoma 87 μm long, 1.5 \times longer than wide and 0.3 \times length of idiosoma. Ventromarginal parts of gnathosomal base with pair of uniformly porose areolae (Fig. 16E, I). Rostrum slightly (1.1–1.2 \times) longer than gnathosomal base, extending antiad just beyond middle of P-3. Tectum truncate. One pair of maxillary setae inserted on basis of rostrum rather than on gnathosomal base, one pair in apical third of rostrum. P-4 and P-2 almost equal in length (Fig. 14I).

Leg I somewhat wider than the other legs but not as long as leg IV (Fig. 16C, M). Telfemora I, II and IV as long or slightly longer than these legs tibiae, telfemur III shorter than tibia. Telfemora I to IV 2.4, 2.7, 2.9, and 3.3 \times longer

than high. Tibiae I to IV medially with very narrow articular lamella; lateral lamellae slightly longer than medial ones. 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, 4, 5, 4. Tibia I with three ventral setae, basal seta short, bluntly ending and delicately pectinate, two other setae longer, tapering and smooth. The apical one of these setae with a pointed basal process (Fig. 16D). Tibia II with one slender, smooth ventral seta and two bipectinate, bluntly ending ventromedial setae (Fig. 16K). Apical one of two latter setae distinctly longer (26 μm) than basal seta (18 μm). Tibia III with one slender, smooth ventral and one bipectinate, bluntly ending ventromedial seta. On tibia IV both ventral setae short and slender. On tarsi I and II dorsolateral and -medial fossary setae not in paired arrangement (Fig. 17A, B), on tarsus I slightly unequal in shape. Both tarsus III and IV with four dorsal setae; distance between basal seta (solenidion) and dorsal fossary seta almost same as height of these tarsi at the level of the latter seta; distance between basal seta and tarsal basis more than that between basal seta and dorsal fossary seta (Fig. 16L, M). Dorsolateral and -medial fossary setae thin, in paired position in apical part of claw fossa. Tarsus I with doubled pas; tarsus II with singlets (Fig. 17B), tarsus III with short, flattened lateral and setiform medial pas, and tarsus IV with pair of flattened pas. Tarsi without fossa membranes.

Paired claws I with accessory process; claws II to IV with processes and pectines, the latter extending from apical process along shaft of claw. Tines in posterior part of pectines large, in basal part shorter (Fig. 17B). Median claw small.

Female. Length of idiosoma 294 μm . Gnathosoma 93 μm long, 63 μm wide, 1.5 \times longer than wide. OC with two corneae. GA with truncate anterior margin (Fig. 16J). Length of GA 144 μm , width 107 μm . Length of GO 52 μm , width 27 μm . Distance between anterior margin of GA and GO 1.3 \times length of GO.

Protonymph. Length of idiosoma 216 μm . Slightly raised areolae of dorsal plates with porose foveae. AD with an anterior and pair of posterior porose areolae. Pair of large

gland pores in margin of plate. OC without tail-like posterior part (Fig. 17C). Plate with distinct anterior and faint posterior cornea; gland pore large, posterolateral to anterior cornea. PD much shorter than in adults; single pair of costae two punctate foveae wide; remainder of plate with coarse reticulation, each polygon subdivided, as in adults. Dorsal setae very delicate, ds-3 not observable because of rupture in striated integument. Ventral plates pitted, each pit with canaliculi. PE with one dorsal and two ventral setae (Fig. 17D). Shape of gnathosoma same as in adults. Leg chaetotaxy: leg I, 1, 2, 3, 4, 5, 7; leg II, 1, 2, 3, 4, 5, 4; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 1+2 (basi- + telofemur), 4, 5, 4. Ventromedial seta on tibia I with minute spiniform process. Tibiae II and III each with one bipectinate and one smooth ventral seta, tibia IV with two slender setae. Tarsi III and IV with four dorsal setae; on tarsus IV basal seta close to tarsal basis. Claws II to IV with coarse tines.

Remarks. The most obvious characters of this species are the large, dumbbell-shaped porose areola on the AD, the elongate OC with a gland pore immediately posterolateral to the anterior cornea, the two pairs of gland pores adjacent in the posterior part of the PD, the scatteredly arranged pgs on the male GA, and the single flattened and bipectinate seta but two smooth, tapering ventral setae on tibia I, the apical seta with a basal process. A similar dumbbell-shaped porose areola is present in *C. coalescens* Newell, 1984 and *C. andamanensis* Chatterjee & De Troch, 2003.

Copidognathus coalescens Newell, 1984 lives in the south-eastern Pacific, on the coast of Chile, Arica, in the low tide zone (Newell, 1984). Differences between *C. riguus* and *C. coalescens* are in the position of the ds-1 (in *C. riguus* in the anterior margin of the median porose areola, in *C. coalescens* in the posterior part of that areola), the size of the OC (elongate versus short), the width of the medial porose costae on the PD (no more than three versus up to five rosette pores or porose foveae wide), the number of gland pores on the PD (two pairs in *C. riguus* versus one pair in *C. coalescens*), the size of the porose areolae on the AE (marginal and small versus enlarged and anterior pair almost meeting in the midline).

Records of *C. andamanensis* are from the Bay of Bengal, the Andaman Islands, from the tidal zone (Chatterjee & De Troch, 2003a). In *C. andamanensis* the OC and rostrum are shorter than in *C. riguus*, the OC do not markedly extend beyond the insertion of leg III (versus extending distinctly beyond that level) and the rostrum is shorter than the gnathosomal base (versus slightly longer). A basal process on one of the setae on tibia I, as present in *C. riguus*, is not mentioned in the description of *C. andamanensis*.

Distribution and biology. Singapore. All presently collected specimens are from algal turf around *Avicennia* trees.

Isobactrus Newell, 1947

Diagnosis. Plates AD, OC and PD present. OC with single cornea and two gland pores. Dorsum with (two to) five pairs

of dorsal idiosomal setae; adanal setae absent. Ventral plates delicate, generally reduced to small platelets. Female GP represented by pair of crescentic plates; three (rarely four) pairs of pgs situated either on the plate or within the striated integument. Genital sclerites with one to two sgs. Male GP larger than in female, completely enclosing GO; GP with 32–98 pgs and three (rarely four) pairs of sgs.

Gnathosoma short, almost equal in length and width, directed ventrad, in dorsal aspect of mite often concealed by anterior part of idiosoma. Gnathosomal base globular. Rostrum conical; both pairs of maxillary setae on rostrum. Four-segmented palps laterally attached. One seta on P-2, none on P-3, three (rarely four) setae on P-4.

Legs short. Legs I and II similar in shape. Genua shorter than adjoining segments. Tibiae I and II with pair of ventral setae; tibiae III and IV with one to two ventral setae. Solenidia on both tarsus I and II short and in dorsolateral position. Tarsi without ventral setae. All tarsi with carpite between tip of tarsus and central sclerite. The two claws on tarsi I to IV smooth or with accessory process, the latter with small or strong tines. No claw on central sclerite.

With one larval and the three nymphal stages proto-, deuto- and tritonymph.

Two species live on the coast of Singapore, but only one was found within mangrove stands.

Isobactrus ponapensis Abé, 1996

(Fig. 18A–E)

Isobactrus ponapensis Abé, 1996: 17–24, figs 1A–E, 2A–E, 3A–D, 4A–D.

Isobactrus ponapensis, Bartsch, 2000a: 166–167, fig. 1A–E.

Material and collecting sites. One female, 1 tritonymph, ZRC.ARA.1378, Singapore, Pasir Ris Park, 1°23'N, 103°58'E, from dead branch with shells of barnacles, 27 October 2012; 1 female, 1 tritonymph, 2 deutonymphs, ZRC.ARA.1379, same collecting data; 5 females, 3 tritonymphs, IB, same collecting data. One female, IB, Singapore, Pulau Ubin, OBS Camp NW, 1°26'N, 103°56'E, amongst root bale of uprooted palm, 21 October 2012.

Colour. Gut content green, integument of idiosoma, gnathosoma and legs transparent and colourless.

Short description. Length of female 250–310 µm. Idiosoma 1.4–1.5× longer than wide. Striated integument with delicate villi, their length 1–2 µm. AD and OC wider than long (at least 1.2×), PD long and wide, extending anterior to the level of OC (Fig. 18A). AD and PD marginally with squamose ornamentation. Gland pores on AD anterior to level with aperture of leg I, glp-2 and glp-3 on OC, a fourth pair of pores in posterior part of PD. All dorsal setae short, peg-like. Pair of ds-1 in line posterior to glp-1, ds-2 in striated integument anterior to OC, ds-3 on PD, rarely immediately anterior to PD, ds-4 and ds-5 on PD, ds-5 just posterior to the level

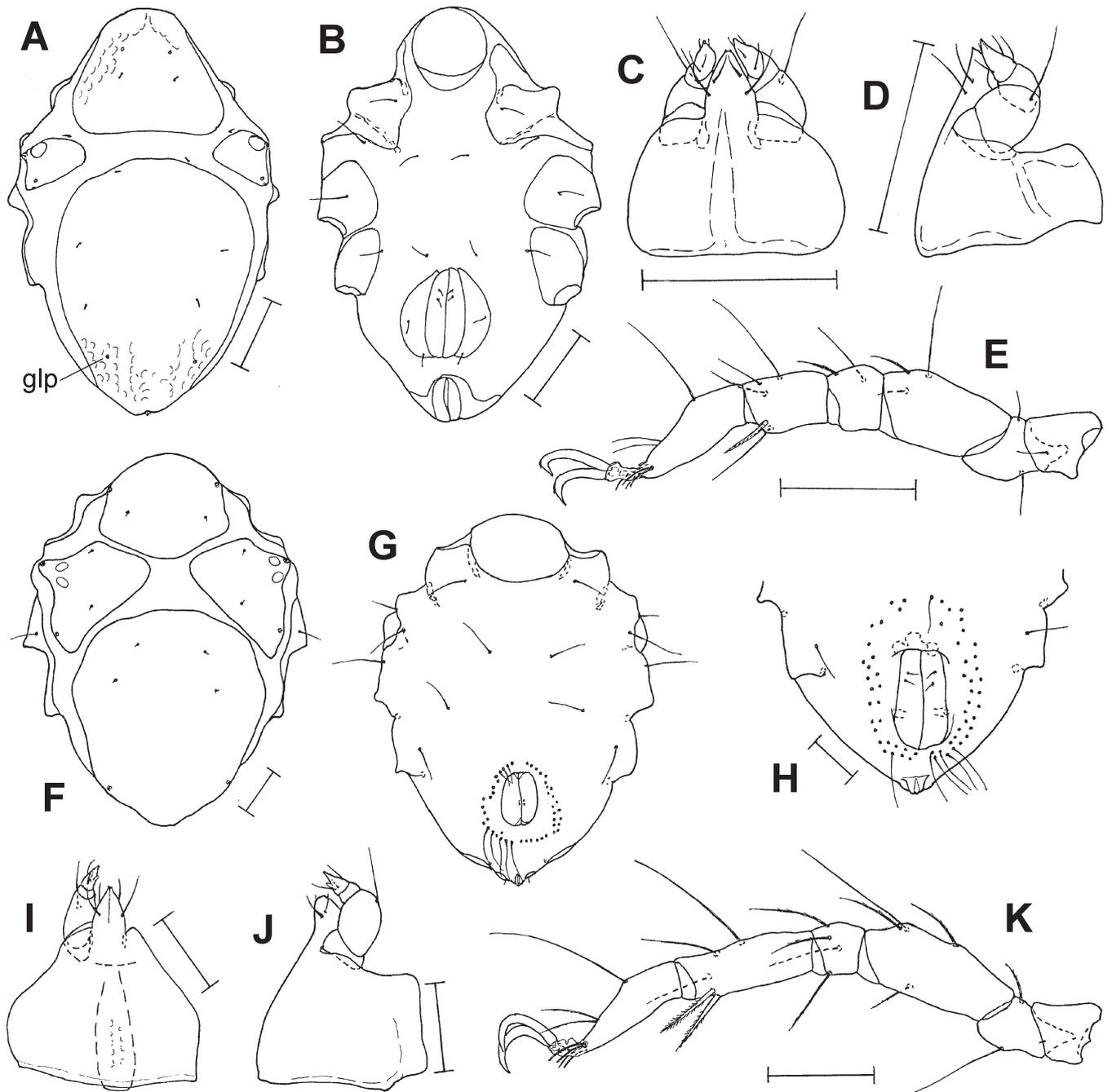


Fig. 18. *Isobactrus ponapensis* Abé, 1996 and *Rhombognathus amplus* Bartsch, 2013. A–E, *Isobactrus ponapensis*. Female: A, idiosoma, dorsal; B, idiosoma, ventral; C, gnathosoma, ventral; D, gnathosoma, lateral; E, leg I, medial. F–K, *Rhombognathus amplus*: F, idiosoma, dorsal, male; G, idiosoma, ventral, male; H, posterior part of idiosoma, ventral, female; I, gnathosoma, ventral, female; J, gnathosoma, lateral, male; K, leg I, medial, female. Scale bars = 50 μm . (glp, gland pore).

of insertion of leg IV. EI and EII fused to pair of plates, EIII and EIV separated by a few striae of soft integument (Fig. 18B). Camerostomal plate small. Female GO flanked by narrow crescentic plates. Insertion of ventral setae as illustrated. Anal plate and posterior PD fused. Gnathosoma slightly wider than long (Fig. 18C). Seta on P-2 long (Fig. 18D). Telfemora I to IV with 3, 3, 2, 2 setae; genua I to IV with 2, 2, 2, 1 setae; tibiae with 5, 5, 4, 4 setae. Tibiae I (Fig. 18E) and II with bipectinate ventromedial seta; on tibiae III and IV none of setae bipectinate. Tarsi I and II with pairs of doubled pas. On tarsus III and IV laterally a short, flattened pas; on tarsus III medially two eupathid,

setiform pas, one half as long as the other, on tarsus IV a single eupathid pas. Claws with minute accessory process.

Remarks. Eight *Isobactrus* species are now known from the tropical Indian Ocean to the western Pacific, within an area between 25°N and S (Bartsch, 2010, 2012). The species most similar to *I. ponapensis* are *I. australiensis* Bartsch, 2003 and *I. similis* Bartsch, 2005. Records of the former are from tropical Western Australia, of the latter from Singapore (Bartsch, 2003a, 2005a). The most marked difference is in the outline of the AD, in *I. ponapensis* the plate is distinctly wider than long, in *I. australiensis* and *I.*

similis almost as long as wide. Noteworthy is that the AD in the type specimens of *I. ponapensis* (from Micronesia) is wider than in individuals from Singapore and the Great Barrier Reef (Abé, 1996: fig.1A versus Bartsch, 2000a: fig.1A and present paper: Fig. 18A). Moreover, tarsus III of the type specimens bears medially a single eupathid pas (Abé, 1996: 22, fig. 3C), whereas in the present material there are doubled pas, one about half as long as the other.

Distribution and biology. Records of *Isobactrus ponapensis* are from the western Pacific, from Pohnpei (Micronesia) and the Great Barrier Reef (Australia) (Abé, 1996; Bartsch, 2000a), this is the first record from Singapore. The species was extracted from both coarse sediment and barnacle shells on dead branches, all records are from the upper half of the tidal area. No males were found in the material from Singapore.

***Rhombognathus* Trouessart, 1888**

Diagnosis. Dorsal plates AD, OC and PD present, two or more plates may be fused. Dorsum with five to six pairs of idiosomal setae; adanal setae on anal plate. OC with two dorsal setae, two gland pores and often two corneae. Ventral plates generally fused. AE and PE often with marginal adjunct setae. Female with 1–45 pairs of pgs and two pairs (rarely one pair) of sgs. Males with 7–25 pairs of pgs and two pairs of sgs; perigenital setae often plumose and in trapezoidal arrangement.

Gnathosoma in general longer than wide. Both pairs of maxillary setae on rostrum. Palps four-segmented, extending just beyond rostral tip. P-2 with one distal seta; no seta on P-3; three setae in basal whorl of P-4.

Legs I and II similar in their shape. Tibiae I to IV normally with two ventral bristle-shaped setae. Ventral setae of tibia I bipectinate. Dorsolateral solenidion of tarsi I and II setiform. Parambulacral setae on tarsi I and II setiform, on tarsi III and IV seti- or scaliform. In males medial pas on tarsus IV often long and plumose. Claws paired, either smooth, with a J-shaped pecten or with an accessory process which may be widened and armoured with more than 20 tines. Central sclerite without large claw-like hook. Rod-like carpite between tip of tarsus and central sclerite.

All species known from Singapore assumedly have one larval and the three nymphal stages proto-, deuto- and tritonymph.

Three species have been found in mangroves of Singapore.

Key to adult *Rhombognathus* species

1. All dorsal plates fused to a shield; this shield with foveate areas (Fig. 19A)*R. aspidotus*
- AD, OC and PD separate plates; plates without foveae or reticulation2
2. Dorsum with cones (Fig. 19G). Posterior margin of AD truncate (Fig. 19H). Genua I and II with three setae.....*R. bulbosus*
- Dorsum rather smooth. Posterior margin of AD slightly triangular (Fig. 18F). Genua I and II with four setae.....
..... *R. amplus*

***Rhombognathus amplus* Bartsch, 2013**

(Fig. 18F–K)

Rhombognathus amplus Bartsch, 2013: 306–312, figs 1a–I, 2a–h, 3a–g.

Colour. Gut content irregularly green, with dark-green spots. Integument transparent, often slightly brown.

Short description. Length of female 390–415 µm, of male 364–400 µm. Idiosoma rather wide, length 1.3× the width, and without markedly raised areas. Posterior margin of AD triangular (Fig. 18F). OC about as long as wide; both corneae close to lateral margin; two setae on OC arranged along a median line. PD wide, with two pairs of setae, both removed from margin of plate. All ventral plates fused (Fig. 18G). AE with pair of adjunct setae; no adjunct setae on PE. Both female and male with long, slender pgs arranged in a ring around GO, female with at least 60 pgs (Fig. 18H), male with 38–47 setae, none separated as basilar seta (Fig. 18G). Gnathosoma short, hardly longer than wide (Fig. 18I), its basis globular, rostrum conical. P-4 with three basal setae and spiniform process (Fig. 18J). Legs almost equal in length. Telofemora I to IV with 3(–4)/1, 3/1, 2/0, 2/0 dorsal/ventral setae, genua with 4, 4, 3, 3 setae, tibiae I to IV each with 3/2 dorsal/ventral setae. Pair of ventral setae on tibiae I and II bipectinate, on tibiae III and IV long and slender and slightly plumulose. Parambulacral setae of male and female tarsus IV rather similar in length and shape. Paired claws smooth (Fig. 18K).

Remarks. *Rhombognathus amplus* is most similar to *R. bulbosus* Bartsch, 2005 which lives in similar habitats on the shores of Singapore (Bartsch, 2005a). Distinguishing characters are mentioned below.

Distribution and biology. Singapore. All present records are from patches of green algae growing near the high water level on trunks of *Rhizophora*.

***Rhombognathus aspidotus* Bartsch, 2006**

(Fig. 19A–F)

Rhombognathus aspidotus Bartsch, 2006a: 43–48, figs 1–18.

Material and collecting sites. Two females, 1 male, 1 tritonymph, ZRC.ARA.1380, Singapore, Pulau Ubin, OBS Camp NW, amongst algae on root bale of uprooted palm, 21 October 2012. Three females, IB, Singapore, Pulau Ubin, Chek Jawa, 1°24'N, 103°59'E, epibios (mainly red algae) on pneumatophores of *Sonneratia* sp., 16 October 2012. One male, IB, Singapore, Pulau Ubin, west of OBS Camp 1, 1°25'N, 103°56'E, small algal tufts on rocks, midwater, 28 October 2012.

Colour. Gut content uniformly green, integument of gnathosoma and legs transparent.

Short description. Length of female 316–344 µm, of male 310–330 µm. Idiosoma slender, about 1.5× longer than wide.

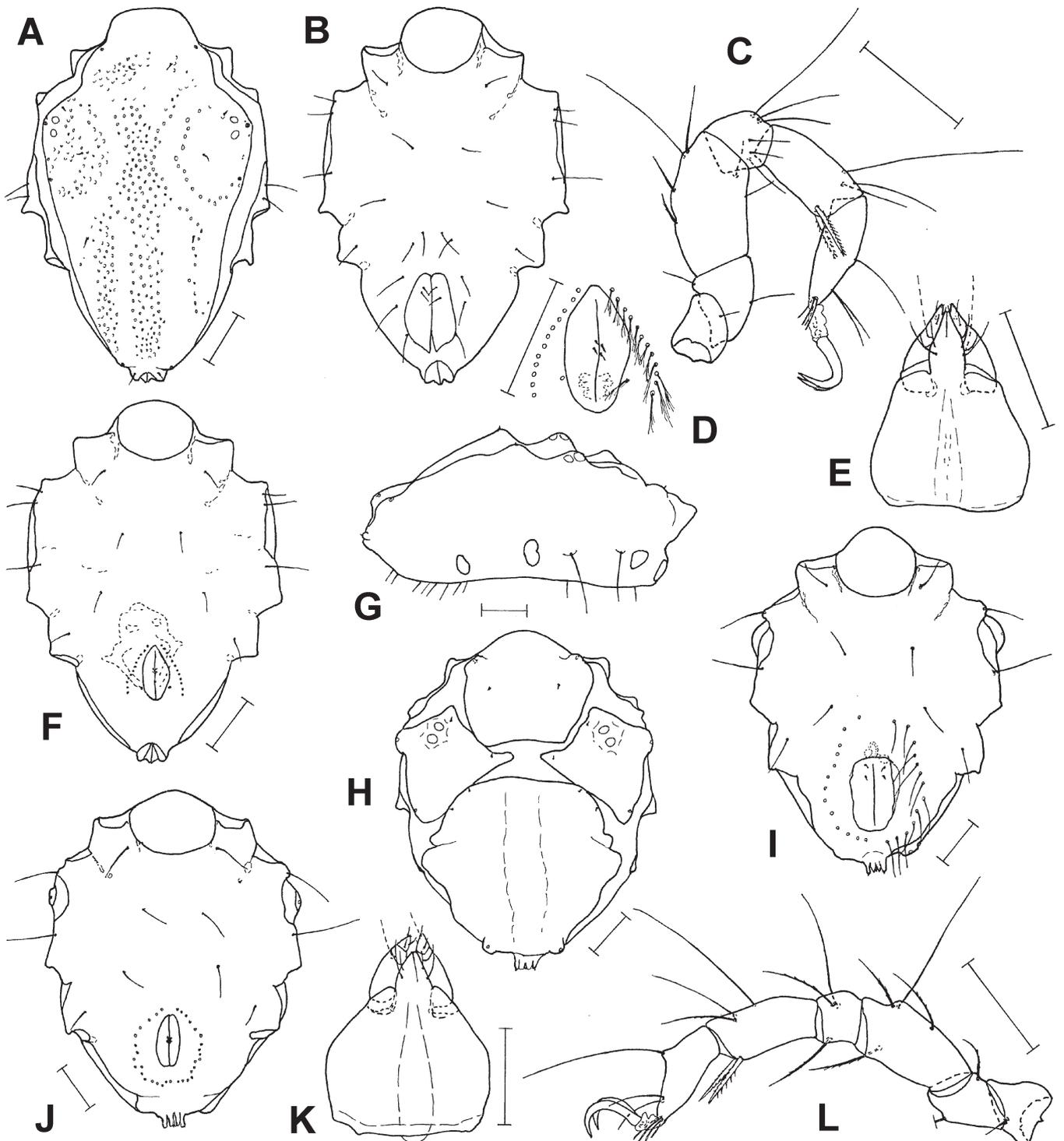


Fig. 19. *Rhombognathus aspidotus* Bartsch, 2006 and *R. bulbosus* Bartsch, 2005. A–F, *Rhombognathus aspidotus*: A, idiosoma, dorsal, female; B, idiosoma, ventral, female; C, leg I, medial, female; D, genital area, male; E, gnathosoma, ventral, female; F, idiosoma, ventral, male. G–L, *Rhombognathus bulbosus*: G, idiosoma, lateral, female; H, idiosoma, dorsal, male; I, idiosoma, ventral, female; J, idiosoma, ventral, male; K, gnathosoma, ventral, female; L, leg I, medial, female. Scale bars = 50 μm. (in E and K seta of P-2 in broken line).

AD, OC and PD fused to a dorsal shield (Fig. 19A). This shield with foveate ornamentation within demarcated areolae. Area representing PD with single pair of setae. In female and male all ventral plates fused to a shield (Fig. 19B and F). Areas of AE and PE with single pair of adjunct setae. Female with five pairs of slender pgs, males with 11–14 pairs of plumulose pgs (pair of basilar setae included) (Fig. 19D). Basilar setae at 0.7 to 0.8 relative to length of GO. Gnathosoma 1.2–1.3× longer than wide (Fig. 19E). Legs slender; telofemora I to IV 2.0–2.2× longer than high. Telofemora I to IV with 4/1–2, 4/1–2, 2–3/0, 3/0 dorsal/ventral setae. All tibiae with 3/2 dorsal/ventral setae; on tibiae I (Fig. 19C) to IV 2, 1, 1, 2 of ventral setae bipectinate. Medial pas on male tarsus IV strongly plumulose. Paired claws with one to four delicate tines.

Remarks. *Rhombognathus aspidotus* is characterised by its dorsal and ventral shield, the former includes the AD, OC and PD, the latter the AE, PE and GA, and the few tines on the claws. At present five *Rhombognathus* species are known with such dorsal and ventral shields, namely *R. conjunctus* Bartsch, 1986, *R. parvulus* Viets, 1939, *R. peltatus* Viets, 1939, *R. scutulatus* Bartsch, 1983, *R. similis* Bartsch, 1977, but only two have a coarse foveate ornamentation on the dorsal shield. These two species are *R. aspidotus* and *R. scutulatus*, both live on the coast of Singapore (Bartsch, 2006a). These two species can be separated on the basis of their claws, in *R. aspidotus* they bear a few tines, in *R. scutulatus* the claws are apically widened and are provided with 16–20 tines.

Distribution and biology. At present only known from Singapore. Regularly found amongst upper and mid-tidal algae, often in mangrove stands but also amongst algae on a hard substratum on sheltered beaches.

Basifemur IV of one of the males carried a suctorian. The theca is almost smooth, 37 µm long, 19 µm in diameter and has remnants of a single tentacle bundle. The theca is similar to that of *Praethecacineta halacari*. This is the first record of a suctorian from a rhombognathine mite.

***Rhombognathus bulbosus* Bartsch, 2005**
(Fig. 19G–L)

Rhombognathus bulbosus Bartsch, 2005a: 277–282, figs 15–37.

Material and collecting site. One female, IB, end of Lim Chu Kang Road, 1°27'N, 103°42'E, green algae (Cladophorales) on trunk of *Avicennia* sp., splash zone, 28 October 2012.

Colour. Gut content irregularly green, OC with small spots of red eye pigment. Idiosoma, gnathosoma and legs often covered by a biofilm.

Short description. Idiosoma 1.2–1.4× longer than wide and with conspicuously cone-like raised parts on the dorsum (Fig. 19G). Idiosomal length of female 334–370 µm, of male 349 µm. AD almost rectangular, posterior margin truncate (Fig. 19H). OC with protruding medial corner;

corneae removed from lateral margin. PD wider than long, its anterior margin truncate. Both pairs of setae on PD near anterior margin of plate. All ventral plates fused (Fig. 19I, J). Neither AE nor PE with adjunct setae. Perigenital setae long and smooth in both female and male and arranged in a ring around GO, female with 19–31 pgs, male with 34 pgs. Gnathosoma slightly longer than wide (Fig. 19K). P-4 with three basal setae and spiniform process. Telofemora I to IV with 3/1, 3/1, 2/0, 2/0 dorsal/ventral setae (Fig. 19L); genua I to IV with 3, 3, 2, 3 setae; all tibiae with 3/2 dorsal/ventral setae; two ventral setae on tibia I and II wide and pectinate, on tibia III and IV long and slender. Majority of setae distinctly plumulose.

Remarks. In its general shape *Rhombognathus bulbosus* is similar to the above mentioned *R. amplus*. Differences are: (1) the surface of the dorsum, bulbous in *R. bulbosus* versus rather smooth in *R. amplus*; (2) the shape of the posterior margin of the AD, rectangular versus triangular; (3) the shape of the OC, protruding medial corner slender versus evenly rounded; (4) the position of the corneae, removed from the lateral margin of the OC versus near the lateral corner; (5) the position of the setae on the OC, one seta near the anterior and one near the medial corner versus setae in an almost median line; (6) the position of the setae on the PD, close to margins versus removed; (7) the number of dorsal setae on the PE, zero versus one; (8) the number of pgs in female, 19–31 versus 60–69; and (9) the number of setae on the genua I and II, three versus four setae.

Distribution and biology. Singapore. According to present collecting data, the species is restricted to delicate patches of green algae growing near the high water edge and under the canopy of the foliage of trees. Most individuals were scratched off trunks of *Rhizophora* sp., one from *Avicennia* sp.

BIOGEOGRAPHY AND DISTRIBUTION

Eighteen species have been extracted from an epiflora and fauna growing on trunks, branches, roots, and pneumatophores in the tidal area of Singapore (Table 1). To the list of halacarid species collected around Singapore (Bartsch, 2009b: Table 1), another 13 species have been added. More species will certainly be found in future investigations, in other localities and habitats. Ten of the 18 species from the epibios on parts of trees have records from other geographical regions, mostly from the Indian and/or Pacific Ocean (Table 1), the other eight are at present only known from Singapore but are expected to be found both in the tropical and warm-temperate western Pacific and Indian Ocean.

Only a few of these 18 species are expected to be bound to the tidal zone and/or to mangroves. According to present records, the genus *Acarothrix* is restricted to a muddy vegetation in the tidal or shallow water zone of lenitic brackish water areas, but not to mangroves. *Agauopsis arborea*, *Copidognathus mangrovorum*, *C. mollis*, and *C. rhombognathoides* may basically be inhabitants of the epibios in mangrove stands. *Rhombognathus amplus* and *R. bulbosus* are classified as inhabitants of a sun-sheltered upper tidal zone, as it is

Table 1. Halacarid species extracted from the epibios on trunks, branches, roots, and pneumatophores on the coast of Singapore and the geographical distribution of these species. (—, no further record)

Singapore Species	Additional Records	References
<i>Acarothrix</i>		
<i>amplimeris</i>	—	Bartsch, 2006b
<i>grandocularis</i>	Brunei-Darussalam, W India	Chatterjee et al., 2012a
<i>palustris</i>	S China	Bartsch, 1990, 2006b
<i>Actacarus</i>		
<i>minor</i>	Colombia (Caribbean Sea)	Bartsch, 1996
<i>Agaue</i>		
<i>galatea</i>	NE Australia	Otto, 1999; Bartsch, 2008
<i>Agauopsis</i>		
<i>arborea</i>	NW Australia	Bartsch, 2003b
<i>longirostris</i>	—	
<i>Copidognathus</i>		
<i>glandulifer</i>	NE Australia	Bartsch, 1996c
<i>latusculus</i>	—	
<i>mangrovorum</i>	Brunei-Darussalam, W India	Chatterjee et al., 2012b
<i>mollis</i>	—	
<i>pesident</i>	Society Islands	Bartsch, 1992
<i>rhombognathoides</i>	Brunei-Darussalam	Bartsch, 2006b; Chatterjee et al., 2012b
<i>riguus</i>	—	
<i>Isobactrus</i>		
<i>ponapensis</i>	Micronesia, NE Australia	Abé, 1996; Bartsch, 2000a
<i>Rhombognathus</i>		
<i>amplus</i>	—	Bartsch, 2013
<i>aspidotus</i>	—	Bartsch, 2006a
<i>bulbosus</i>	—	Bartsch, 2005a

found under the canopy of trees. At present there are no records of these two species from shadowy habitats outside mangrove stands. *Isobactrus ponapensis* is in its distribution restricted to the upper tidal zone but not to mangroves. The remaining species have been found in a variety of substrata, in sheltered as well as semi-exposed areas, in the upper, middle and lower tidal and also subtidal zone. Assumedly, the majority of mangrove-inhabiting halacarid species are not directly specialised for life in and restricted to this habitat.

Studies on the meiofauna in and outside mangrove stands generally concentrated on the sediment fauna with nematodes and harpacticoid copepods being the dominant taxa. In general, no strong correlation has been found between the composition of these taxa and presence or absence of a mangrove vegetation (Nagelkerken et al., 2008). Independent if it is a typical sediment- (nematodes and harpacticoids) or epibios-inhabiting (halacarids) meiofauna, the majority of the species are no strict mangrove specialists.

ACKNOWLEDGEMENTS

The Johor Straits marine biodiversity workshop on Pulau Ubin, Singapore was organised by the National Parks Board and National University of Singapore and held from 15 October to 2 November 2012 at Outward Bound School. The workshop, as part of the Comprehensive Marine Biodiversity Survey (CMBS) was supported by generous contributions

from Asia Pacific Breweries Singapore, Care-for-Nature Trust Fund, Shell Companies in Singapore and The Air Liquide Group. Thanks are due to the management and staff of the Outward Bound School for kindly accommodating our special needs for a successful workshop. The collecting of halacarid mites in Singapore in 2004 was financed by a grant of the National University of Singapore. Thanks are due to the staff of the Raffles Museum of Biodiversity Research (2004), and to two referees who carefully read a previous version of this manuscript.

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