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PSAMMOBIONT HALACARID MITES (ACARI: HALACARIDAE) FROM ST JOHN'S ISLAND, SINGAPORE AND REMARKS ON THE HALACARID FAUNA OF THE MALAY PENINSULA

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***ABSTRACT.* –** Sediment samples taken on St John's and Lazarus Islands, Singapore, contained representatives of the halacarid genera *Actacarus*, *Agauopsis*, *Arhodeoporus*, *Copidognathus*, *Halacarus*, *Rhombognathus*, *Scaptognathides*, *Scaptognathus*, and *Simognathus*. Three species are new to science: *Arhodeoporus nanus*, *Copidognathus macropus* and *C. viridulus*. Diagnoses to the genera and descriptions to the species are given. Almost 40 halacarid species were collected in the tidal area of Singapore, many of the species are remarkably widespread, with records from both in and outside the Indo-West Pacific. The number of species is within a magnitude commonly found in tropical and temperate shores. According to present data, the Indo-Malayan region cannot be considered to be a hotspot with unusual high halacarid diversity.

***KEY WORDS.* –** Halacaridae, new species, descriptions, biogeography, Indo-Malayan region, biodiversity.

INTRODUCTION

According to Ekman (1953) and Briggs (1995) the greatest wealth of marine animal life is found in the shelf area of the Indo-West Pacific, a region which includes the tropical and subtropical portion of the Indian Ocean, the western and central part of the Pacific, and extends longitudinally more than halfway around the globe. The species diversity of, e.g. molluscs, echinoderms, reef corals, and fishes, exceeds the total of the other tropical regions, namely eastern Pacific, western Atlantic and eastern Atlantic (Briggs, 1995, 1999). Within the Indo-West Pacific region the greatest concentration of species seems to be within a relatively small area that extends from about 10°S to 10°N and 100° to 140°E, or from the Malay Peninsula to the Philippines and New Guinea, an area referred to as the Indo-Malayan region, East Indies Triangle or Central Indo-Pacific hotspot (Ekman, 1953; Briggs, 1999, 2000, 2003; Hughes et al., 2002). Most of the biogeographical faunal analyses, revealing this immense number of species in the centre of the Indo-West Pacific region, are based on shelf macrofaunal taxa. Is there a similar species richness in respect to meiofaunal taxa, is there any remarkable concentration of halacarid species in the fauna of the Malay Peninsula? The information about the halacarid fauna in this part of the globe is sparse and a short stay in Singapore was meant to bring more data.

MATERIAL AND METHODS

The island city-state of Singapore, at the southern end of the Malay Peninsula, is surrounded by the Johor Strait and Strait of Singapore which in turn are connecting the Straits of Malaca and the South China Sea. The islands St John's and Lazarus are south of the main island Singapore. In the tidal area of these islands samples were taken by the author in October 2004, while staying on St John's Island at the Tropical Marine Science Institute, National University of Singapore.

Singapore lies in the tropics, at approximately 1°N, the climate is characterized by a low annual temperature amplitude, mostly cloudy sky with reduced solar radiation and regular rainfall. The tide in Singapore is approximately semi-diurnal, with a minimum and maximum tidal amplitude of approximately 10 to 260 cm (Hopper, 1998).

The samples collected in the tidal area or just below the low water edge were washed with fresh water, sorted, the halacarids preserved and stored in ethanol and after clearing mounted in glycerine jelly. Holotypes and paratypes are deposited in the Zoological Reference Collection of the Raffles Museum of Biodiversity Research (ZRC), additional material is deposited in the Senckenberg-Museum, Frankfurt (SMF) and Zoological Museum, Hamburg (ZMH).

Abbreviations used in the descriptions are: AD, anterior dorsal plate; ads, adanal setae (= sixth pair of dorsal setae of idiosoma); AE, anterior epimeral plate; ds-1 to ds-6, first to sixth pair of dorsal setae of idiosoma, numbered from anterior to posterior; GA, genitoanal plate; glp, (pair of) gland pore(s), numbered glp-1 to glp-5, from anterior to posterior; GO, genital opening; OC, ocular plate(s); P-2 to P-4, second to fourth palpal segment(s); 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, leg segments are trochanter, basifemur, telofemur, genu, tibia, and tarsus. In the generic diagnoses rare variants are in parentheses or excluded, unless documented from the Indo-Malayan region. In the descriptions the position of a seta is given in a decimal system, with reference to the length of a given structure from its anterior to posterior or basal to proximal margin. The length of a leg segment is that along the dorsal margin. The setation formula of the legs starts with the trochanter.

RESULTS

The sediment samples are from the upper and mid-tidal slopes, inhabited by interstitial taxa, and from the lower tidal flat, rich in organic material and a fauna mainly restricted to the surface layers of sandy deposits. The halacarid genera present are: *Actacarus*, *Agauopsis*, *Arhodeoporus*, *Copidognathus*, *Halacarus*, *Rhombognathus*, *Scaptognathides*, *Scaptognathus*, and *Simognathus*. In general only one or two psammophilous species of each genus were present, an exception is *Copidognathus*. This genus was represented with almost a dozen species, but several of them are expected to be euryvalent, in their life-style not restricted to sandy deposits.

SYSTEMATICS

Actacarus Schulz, 1937

Diagnosis. – AD and PD large, OC minute. Dorsal plates finely porose or foveate, never coarsely sculptured. Dorsum with 4 pairs of gland pores and 6 pairs of idiosomatic setae; ads adjacent to anal sclerite. AE with 3–4 pairs of setae; PE with 1 dorsal and 2–3 ventral setae. Membraneous integument between AE and GA with 0–1 setae. Female with 3 pairs of pgs, sgs lacking. Male with 7–18 pairs of pgs and 1–3 pairs of sgs. Gnathosoma longer than wide. Both pairs of maxillary setae on rostrum. Palps 4-segmented, attached laterally and extending beyond rostrum. P-2 with 1 distal seta. P-3 with medial spur. P-4 with 3–4 basal setae and a spur. Genua I to IV shorter than adjoining leg segments. Tibia I with 2–4 ventral bristle-like setae, tibiae II, III and IV each with 2 ventral setae. Tarsus I with large lateral fossa membrane. Solenidion on tarsus II large. Tarsus I with 3 ventral setae, tarsi II to IV lack ventral setae. All tarsi with paired pas and claws. Median claw small.

Type species. – *Actacarus pygmaeus* Schulz, 1937.

Actacarus chelonis Otto, 2000
(Figs. 1–6)

Actacarus chelonis Otto, 2000c: 112–114, Fig. 1a–g.

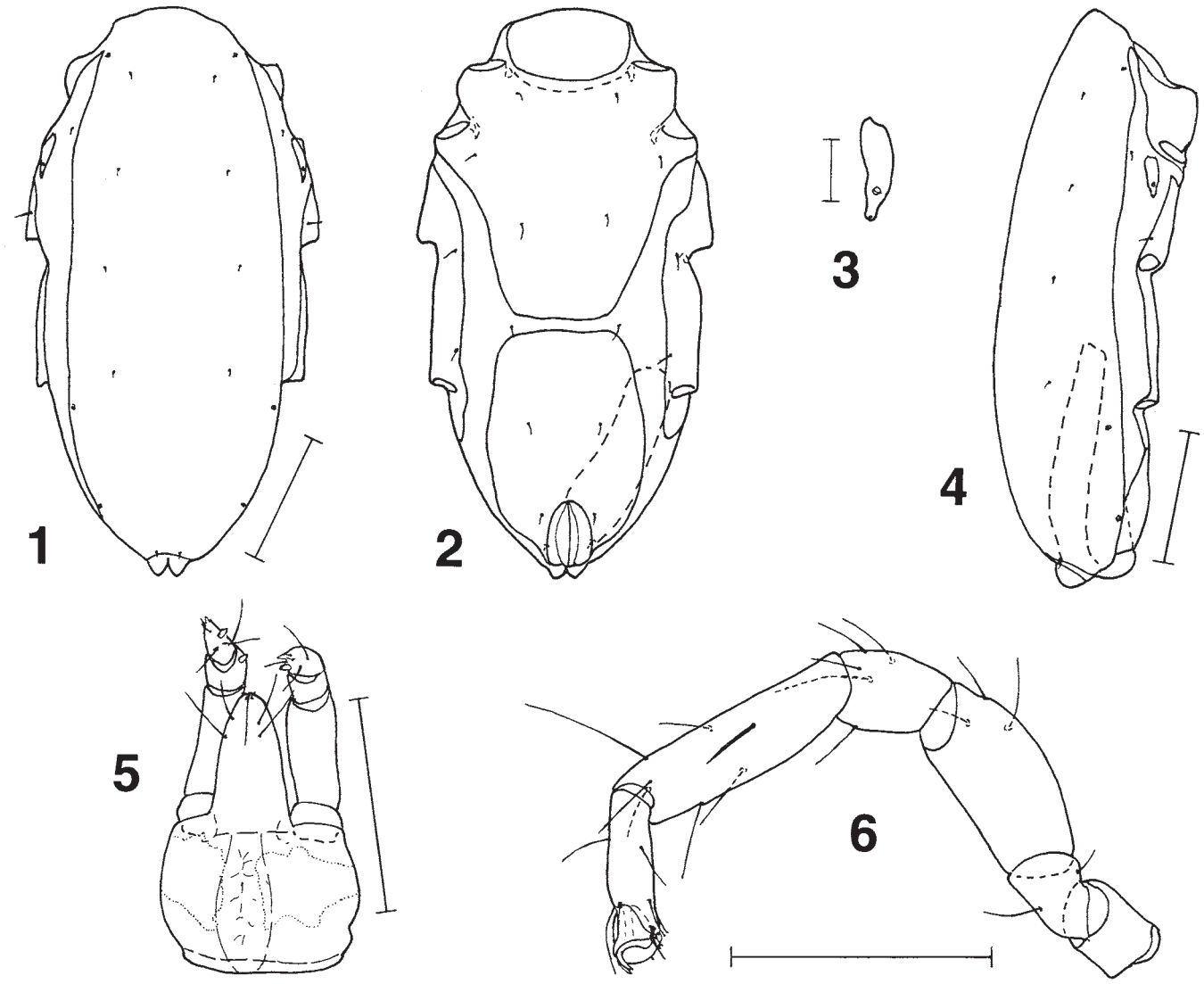
Material examined. – One female, ZRC.ARA.706, Singapore, St John's Island, southwestern shore, sediment from low water edge, 2 Oct.2004. One female, ZMH, Singapore, Lazarus Island, just south of dam between islands, low water edge, unsorted sediment rich in organic material, 2 Oct.2004.

Supplementary description. – Length of female 217–222 µm. AD and PD fused to a shield (Fig. 1). Dorsal and ventral plates minutely punctate. OC narrow, 3 times longer than wide; gland pore at 0.7 (Figs. 3, 4). AE with 3 pairs of setae, PE with 2 ventral setae. One pair of setae in membraneous integument between AE and GA. Ovipositor extending far beyond GO but not reaching to anterior margin of GA (Fig. 2). Length of gnathosoma 62–66 µm, 1.4 times longer than wide. Tectum truncate. Both pairs of maxillary setae in apical half of rostrum (Fig. 5). Telofemora minutely and delicately foveate, not porose. Tibia I with 3 ventral setae, basal seta wide, very delicately pectinate (Fig. 6). Tibiae II and IV with one slender and one slightly widened and delicately pectinate seta. Both ventral setae on tibia III delicately pectinate. Pectines on claws II to IV with large tines.

Remarks. – Two *Actacarus* species have the AD and PD fused to a shield, *A. chelonis* and *A. uniscutatus* Bartsch, 1977. The latter is recorded from the Caribbean coast of Colombia, the Galapagos and Hawaiian Islands (Bartsch, 1977, 1988, 1996). Females of the two species are easily identified, the ovipositor of *A. chelonis* hardly reaches the anterior margin of the GA whereas that of *A. uniscutatus* is very long and extends far beyond that margin. Independent of the length of ovipositor, the two species can be discriminated on the basis of (1) the ornamentation of the dorsal plates, densely punctate in *A. chelonis* and delicately but less densely pitted in *A. uniscutatus*; and (2) the shape of the OC, elongate in *A. chelonis* but triangular in *A. uniscutatus*.

Distribution and ecology. – French Polynesia (Moorea), Australia, Queensland (Great Barrier Reef and Coral Sea), Indonesia (SW Lombok) (Otto, 2000c) and Singapore. The records are from intertidal and shallow water sandy areas, from 0–10 m.

Actacarus *species in Singapore.* – Another species, undescribed, was found, in mangrove areas near the West Coast Park (southwestern Singapore) and near the end of the Lim Chu Kang Road (northwestern Singapore), amongst unsorted sediment beneath a cover of *Cladophora* (Chlorophyta). Adults of this species have the AD and the long PD (almost four times length of AD) distinctly separated by coarsely striated integument, and the AE is much longer than the GA and includes a fourth pair of ventral setae.



Figs. 1–6. *Actacarus chelonis* Otto, 2000, female: 1, idiosoma, dorsal; 2, idiosoma, ventral; 3, ocular plate; 4, idiosoma, lateral; 5, gnathosoma, ventral; 6, leg I, medial. Scale bars: 1, 2, 4–6 = 50 µm; 3 = 10 µm.

Agauopsis Viets, 1927

Diagnosis. – Idiosoma usually wide and flattened. In general AD and PD with slightly raised longitudinal costae; costae with dense porosity or rosette pores. Dorsum with 3–4 often small pairs of gland pores and 5–6 pairs of setae; ads close to anal cone. AE with 3 pairs of ventral setae and in the majority of species with a pair of epimeral pores (often opening with a slit). PE with 1 dorsal and 3 ventral setae. Female GA with 3 pairs of pgs; genital sclerites with 0–4 sgs. Male GA with 30–100 pgs, often one pair outlying, and 3–5 pairs of sgs. Gnathosoma longer than wide, its base often subquadrangular; rostrum almost parallel-sided. First pair of maxillary setae near base of rostrum, either on gnathosomal base or on rostrum; 2nd pair of maxillary setae in distal third of rostrum. Palps 4-segmented, lateral to gnathosoma. P-2 with a distodorsal seta. P-3 short, with median bristle- or spiniform seta, in some few species with denticulate divaricate spine. P-4 with 1–3 setae in basal half; apically with setula and 2 spurs. Genua I to IV distinctly shorter than adjoining segments. Leg I wider and longer than following legs, bearing conspicuous spines, (0–)1–5 spines on telofemur, 2 spines (or bristles) on genu, 3–5 spines on tibia, and 1 spine on tarsus. Spines delicately pectinate or conspicuously denticulate. Tibiae II to IV with 2–3 ventral spines or bristles. In the majority of species, tarsus I with 3 dorsal setae, dorsolateral solenidion, 1 ventromedial spine, and 2 (rarely 1) minute ventral setae; apically with pair of parambulacral setae. Tarsus II with dorsomedial solenidion, 3 dorsal and 0–1 minute ventral setae. Tarsi III and IV with 3–4 and 3 dorsal setae, respectively, and 0 ventral setae. Parambulacral setae often absent on one flank. Paired claws of posterior legs generally larger than those of tarsus I, median claw often small.

***Type species.* –** *Agauopsis brevipalpus* (Trouessart, 1889).

Agauopsis sp. A
(Figs. 7–11)

***Material examined.* –** One deutonymph, ZRC.ARA.707, Singapore, St John's Island, southwestern part, tidal beach, middle slope, about 40 cm sediment depth, just above ground water horizon, 2 Oct.2004. One protonymph, ZMH, same collection data.

***Description*. – Deutonymph**: Length of idiosoma 200 µm. Integument of idiosoma and legs roughly hirsute and covered with fine debris. AD and PD large, opposing margins almost truncate (Fig. 7). AD with minute, acute frontal spine. OC short, triangular, less than one third of length of AD. AD and PD with pair of slightly raised costae. Costae with wide polygons which include delicate porosity (Fig. 7). Dorsal setae short. Shape of ventral plates as illustrated (Fig. 8).

Gnathosoma with large pharyngeal field. Rostrum about as long as gnathosomal base. P-3 very short; with median seta. P-4 short, 5 µm in length, with 1 basal seta, 1 apical seta and 2 apical spurs, the latter 8 µm in length.

Leg I with conspicuous spines (Fig. 9), i.e. 2 ventral and 2 ventromedial spines on telofemur, a pair of spines on genu, a ventral and 2 ventromedial spines on tibia, and a ventromedial spine on tarsus. Tibiae II to IV each with a wide ventral fovea, formed by lamellar widened distolateral and distomedial part of segments. Both ventral setae on tibiae II to IV spiniform. On tibiae III and IV (Fig. 10) lateral spine larger than medial one. Tarsus I with 3 dorsal setae, short dorsolateral solenidion, medial spine, 2 ventral setulae, and pair of pas. Tarsus II with 3 dorsal setae, small solenidion (3 µm long) and single lateral pas (Fig. 11). Tarsi III and IV each with 3 dorsal setae and single medial pas; dorsal integument of basal part with spur-like ornamentation.

Paired claws on tarsus I robust, these claws on tarsi II to IV very slender, median claw of tarsi II to IV distinct.

Protonymph: Length of idiosoma 210 µm. Dorsal and ventral plates smaller than in deutonymph. Telofemur, genu and tibia I each with a pair of spines.

***Remarks*. –** Only deuto- and protonymphs were in the sample studied. The individuals of this new species from Singapore are similar to *A. arenaria* Bartsch, 1992 and *A. hastata* Newell, 1984, the former known from Hong Kong, the latter from the Chilean Pacific coast (Bartsch 1992; Newell, 1984). The most marked difference between the Singapore species and the two latter are: the very short P-3 and P-4, shorter than in *A. arenaria* and *A. hastata*, the number of spines on telofemur I (deutonymph with four spines versus adults of the other species with three spines), the number of ventral setae on tarsus II (none versus one seta), the shape of the ventral setae on tibiae II to IV (spiniform versus slender in *A. arenaria*) and the shape of the claws on tarsi II to IV (slender paired claws and distinct median claw versus *A. arenaria* with pectines on paired claws and claw-like process of central sclerite reduced).

***Distribution and ecology.* –** Singapore. This new species is expected to be an inhabitant of rather coarse subsurface sand in tidal beaches. Both *Agauopsis arenaria* and *A. hastata* have been found in such habitats.

Agauopsis *species in Singapore.* – Most *Agauopsis* species in Singapore were found in debris on the surface of sediment, amongst algae and colonial organisms. Algal turf, abundant along the low water edge on a nearby platform (southwestern part of St John's Island) was inhabited by *Agauopsis narinosa* Otto, 1999 (new record), whereas small algae in sheltered areas, both on St John's Island and Singapore, contained species of the *A. brevipalpus* group. These areas, in mangroves or in and near rain-water outlets, were often exposed to fluctuating salinity.

Arhodeoporus Newell, 1947

***Diagnosis.* –** Dorsal plates large, often reticulate and with porose areas; OC often tail-like extended. Majority of species with 4 pairs of gland pores; in some few species glands large, opening on cones. Dorsum with 6 pairs of dorsal setae; ads at anal cone. Ventral plates large, may be fused. AE with 3 pairs of ventral setae and a pair of epimeral pores. PE with 1–2 dorsal and 3 ventral setae. Female GA with 3 pairs of pgs and (0–)1–2 pairs of sgs. Male GA with 15–40 pgs and (3–)4–5 pairs of sgs. Gnathosoma longer than wide. Rostrum triangular or slender and almost parallel-sided. One pair of maxillary setae either on gnathosomal base or in basal part of rostrum, 1 pair on rostrum. Palps 4-segmented, attached laterally, extending beyond tip of rostrum. P-2 with 1 distal seta. No seta on short P-3. P-4 with 3 setae in basal whorl. Genua I to IV much shorter than adjoining segments. Tibia I with 2 pairs of bristle-like ventral setae, the ventromedial ones either smooth or bipectinate, the ventrolateral ones smooth. Tibia II with 3–4 ventral setae, the 2 ventromedial ones bipectinate. Tibiae III and IV with 2 ventral setae each. Tarsus I with 3 dorsal and 3(–2) ventral setae. Solenidion on tarsus II in dorsomedial position, often long. Tarsus II with 0–1(–2) ventral setae, tarsi III and IV with 0–1 ventral setae. Tarsi I and II each with pair of pas, tarsi III and IV either with pair of pas and 0 ventral setae or with single pas and 1 long ventral seta. All tarsi with large paired claws and small median claw.

***Type species.* –** *Arhodeoporus arenarius* Newell, 1947.

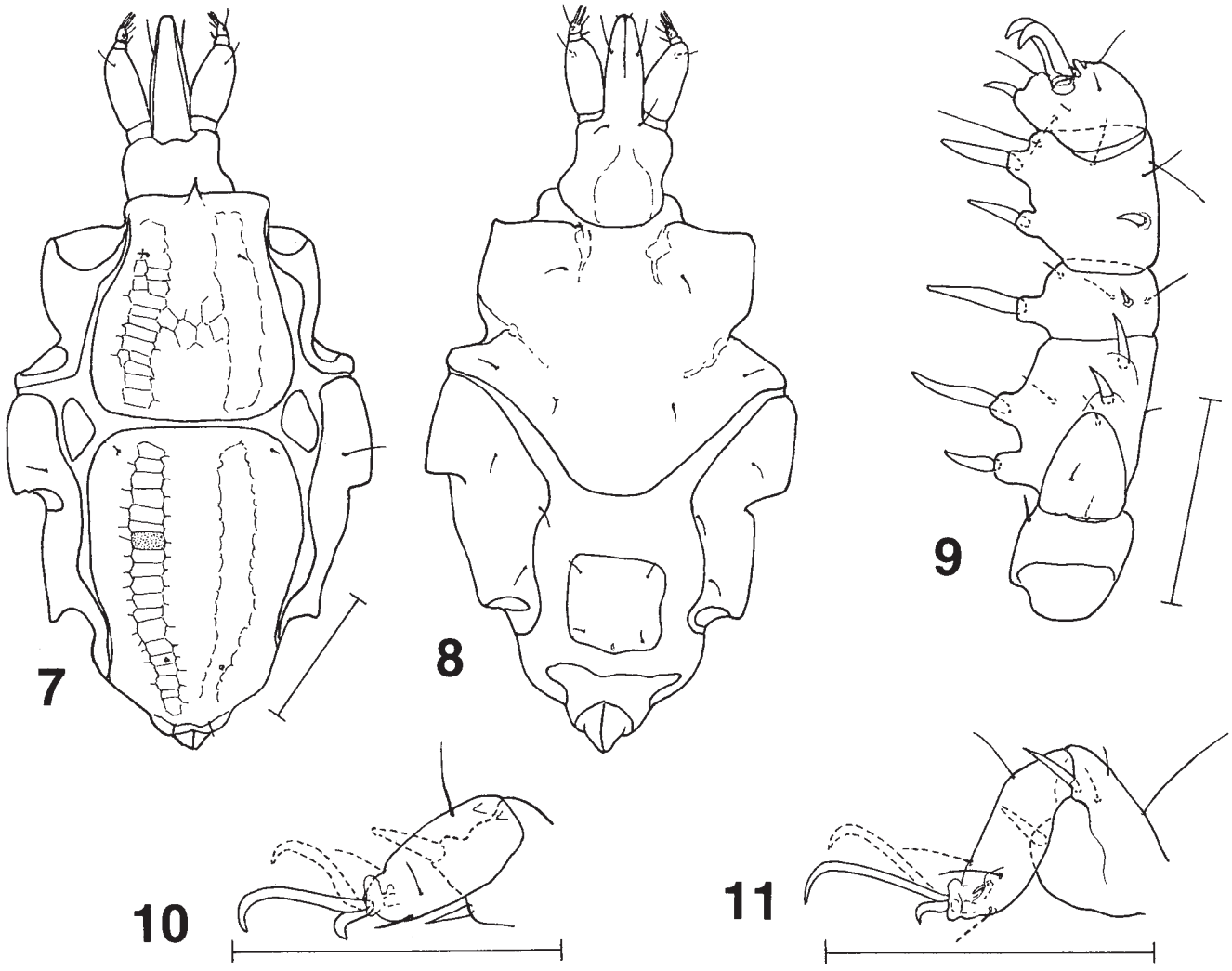
Arhodeoporus bonairensis (Viets, 1936)
(Figs. 12–16)

Copidognathopsis bonairensis Viets, 1936: 415–418, Figs. 41–44.
Copidognathus (s. str.) *bonairensis*, Newell, 1947: 172—173, Figs. 291, 292.
Arhodeoporus bonairensis, Bartsch, 1977: 60–61, Figs. 234–241; Sarma & Chatterjee 1993b: 417–418, Figs. 1–7.
Arhodeoporus ventromaculatus Otto, 2000d: 12–14, Fig. 9a–g. (new synonymy).

Material examined. **–** One male, ZRC.ARA.708, Singapore, St John's Island, southwestern part, hapteres and sediment, low water edge, 1 Oct.2004. One female, SMF, same collection data. One female, ZMH, Singapore, St John's Island, southwestern part, middle slope of tidal beach, ca. 30 cm sediment depth, 3 Oct.2004.

Supplementary description. **–** Length of idiosoma of female 210–236 µm, of male 225 µm. AD with porose costae in shape of inverted wine-glass (Fig. 12). PD with 2 pairs of costae. Costae with rosette pores, each pore including 5–8 canaliculi at the surface and a rectangular alveolus when focussed on procuticula. Costae in median part of AD 1 (Fig. 12) or 2 alveoli wide. Costae on PD in general 1 alveolus wide (Fig. 15). Plates between costae delicately pitted, each pit 1.5–2 µm in diameter, arranged within a very faint reticulum. OC extending backward more than halfway between levels of insertion of leg III and IV. Ventral plates AE, PE and GA in both female and male fused (Fig. 13). With delimited porose areolae, each areola with 8–18 canaliculi arranged in polygons. AE with pair of minute epimeral pores. Female with 2 pairs of sgs, males with 7–8 pairs of pgs and 5 pairs of sgs. Length of gnathosoma 62–65 µm; gnathosomal base ventromarginally with porose polygons, dorsally coarsely reticulate. Tectum slightly arched. Rostrum somewhat shorter than gnathosomal base, extending to level of P-4 (Fig. 14). All legs slender. Tibiae I (Fig. 16) to IV with 4, 1, 1, 2 slender and 0, 2, 1, 0 bipectinate setae. Paired claws large, with accessoy process. This process on tarsi II, III and IV with about 4 minute tines.

Remarks. **–** *Arhodeoporus bonairensis* has given name to a species group (cf. Bartsch 1983a) which includes, e.g. *A. bonairensis*, *A. thyreophorus* (André, 1959), *A. disparilis* Bartsch, 1997, and *A. robustus* Bartsch, 2007. *Arhodeoporus ventromaculatus* seems to be synonymous with *A. bonairensis*. Two of the just mentioned species, *A. disparilis* and *A. robustus*, have the AE and GA fused, but the PE are separate; both are known from Western Australia, from Rottnest Island and Esperance, respectively (Bartsch, 1997b, 2007). *Arhodeoporus bonairensis*, *A. thyreophorus* and *A. ventromaculatus* have the AE, PE and GA fused to a shield, the shape and ornamentation of the dorsal and ventral

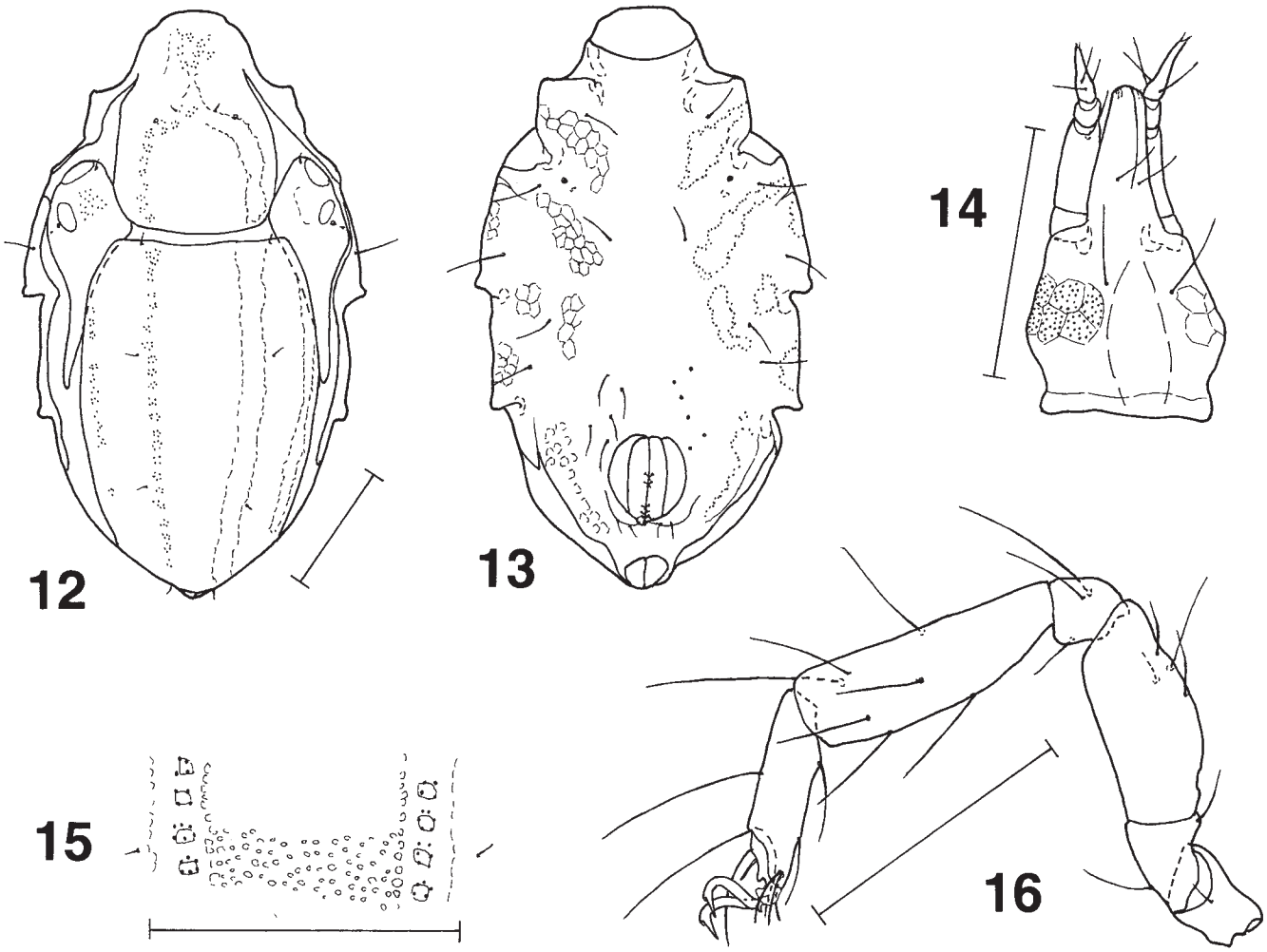


Figs. 7–11. *Agauopsis* sp. A, deutonymph: 7, idiosoma and gnathosoma, dorsal; 8, idiosoma and gnathosoma, ventral; 9, leg I, ventral; 10, tibia and tarsus IV, medial (lateral setae and claw in broken line); 11, tibia and tarsus II, ventromedial (lateral setae and claw in broken line). Scale bars = 50 µm.

plates are strikingly similar. *Arhodeoporus bonairensis*, *A. thyreophorus* and *A. ventromaculatus* were described on the basis of material from the Caribbean area, the Golf of Suez and the Western Pacific (Great Barrier Reef), respectively (Viets, 1936; André, 1959; Otto, 2000d). *Arhodeoporus thyreophorus* has an idiosomal length of 310 µm, hence it is somewhat larger than *A. bonairensis* (holotype female 228 µm, ZMH, Viets Collection Nr. 4823), the PD bears a single pair of costae and the foveae outside the costae are rather wide. A more detailed re-description, if possible based on material from the type locality, is necessary to evaluate the status of *A. thyreophorus*. Distinguishing characters between *A. ventromaculatus* and *A. bonairensis* are, according to Otto (2000d: 14), the lack of a bipectinate seta on tibia IV and the shape of the AD. On the tibiae I to IV of the holotype female of *A. bonairensis* there are 4, 1, 1, 2 slender and 0, 2, 1, 0 bipectinate ventral setae, respectively, in the shape of the AD there is no marked difference. In both the holotype female of *A. bonairensis* and the specimens from the Great Barrier Reef the number and arrangement of the costae on the PD and the porose areolae of the ventral shield (Viets, 1936: fig. 42; Otto, 2000d: fig. 9b) is the same; there seems to be no morphological difference and accordingly, *A. ventromaculatus* is classified as junior synonym. The female *A. bonairensis* mentioned from the Galapagos Islands agrees perfectly with the holotype, whereas the male described in Bartsch (1977: figs 234, 235) differs somewhat in the ornamentation of the costae and the number of ventral areolae.

Distribution and ecology. – *Arhodeoporus bonairensis* was first recorded from the Caribbean area, from Bonaire and Florida (Viets, 1936; Newell, 1947). The following records were from the eastern Pacific Ocean, from shores of Santa Cruz, the Galapagos Islands (Pacific Ocean) (Bartsch, 1977), the Indian Ocean, from the Bay of Bengal (Andaman and Nicobar Islands) and the Arabian Sea (Kerala coast and Goa) (Chatterjee & Sarma, 1993b). Unpublished findings are from the Philippines (Mactan Island, off Cebu), China (Hong Kong), northwestern Australia (Dampier Archipelago, Western Australia), and Hawaiian Islands (Oahu, Kauai).

Aside from sandy deposits, *A. bonairensis* was often extracted from tufts of small algae (corallines) and hapteres of macroalgae growing at or below the low tide edge.



Figs. 12–16. *Arhodeoporus bonairensis* Viets, 1936, male: 12, idiosoma, dorsal; 13, idiosoma, ventral; 14, gnathosoma, ventral; 15, portion of PD between ds-4; 16, leg I, medial. Scale bars = 50 µm.

Arhodeoporus nanus, new species
(Figs 17–28)

Material examined. – Holotype: Male, ZRC.ARA.709, Singapore, Lazarus Island, subsurface unsorted sediment, low water edge, 3 Oct.2004.

Paratypes: One female, ZRC.ARA.710, same collection data; one female, one deutonymph, SMF, same collection data; one female, one deutonymph, ZMH, same collection data. One female, one male, author's collection.

Diagnosis. – Length 152–160 µm. Dorsal and ventral plates punctate. Opposing margins of AD/PD and AE/GA straight. PD about twice as long as wide and almost 3 times longer than AD. OC slender, extending almost to level of insertion of leg IV. PD with pair of glp in margin of PD. Female GA with 3 pairs of pgs; sgs lacking. Male GA longer than AE, with 30–34 pgs. GO small, distance to anterior margin of GA equalling 2.7 times length of GO. Genital sclerites with 3 pairs of sgs. Length of gnathosoma 1.6 times its width. Rostrum triangular, almost half length of gnathosoma, not reaching end of P-2. Tectum truncate. Leg I larger than other legs. Telofemora shorter and more slender than tibiae. Telofemora I to IV 2.5, 2.1, 2.3, and 2.6 times longer than high, respectively. Tibiae I to IV ventrally with 4, 1, 1, 2 slender and 0, 2, 1, 0 bipectinate setae. Claws of tarsus with accessory process, claws of tarsi II to IV with large tines.

Etymology. – The specific name *nanus* is derived from nanus (Latin) dwarf, as this species is smaller than congeners.

Description. – **Male**: Length 157 µm, width 72 µm. Dorsal plates delicately punctate. Opposing margins of AD and PD truncate (Fig. 17), with a few membraneous striae between. Length of AD 37 µm, width 44 µm; anterior margin rounded, posterior margin slightly concave; surface almost uniformly punctate (Fig. 20); pair of glp near lateral margin level with insertion of leg I. OC slender, its tail-like posterior part extending to level with insertion of leg IV; length 73 µm, with gland pore and immediately posterior to this a pore canaliculus. PD elongate, about 3 times length of AD, its lateral margins in almost parallel arrangement. Length of PD 112 µm, width 54 µm. Within a pair of oblong areas (costae) surficial punctation weakly developed. One pair of glp in lateral margin just anterior to level with insertion of leg IV. Dorsal setae delicate. Pair of ds-1 on AD level with glp-1; ds-2 in anterior corner of OC (Fig. 22), ds-3 to ds-5 on PD, situated close to anterior margin, level with insertion of leg III and level with glp-4.

Ventral plates delicately punctate. Integument between plates coarsely striated. Length of AE 60 µm, width 68 µm; with epimeral pores and 3 pairs of ventral setae. Length of PE 64 µm; ending immediately posterior to insertion of leg IV. Length of GA 80 µm, width 43 µm; anterior margin slightly concave. GO small, length 16 µm, width 11 µm; its distance to anterior margin 2.7 times length of GO. GO surrounded by ring of 34 slender pgs. Genital sclerites with 3 pairs of sgs (Fig. 18), anterior pair somewhat spur-like, 2 posterior pairs setiform. Spermatopositor extending slightly beyond ring of pgs.

Length of gnathosoma 46 µm, width 29 µm. Rostrum triangular in ventral aspect, slightly shorter than gnathosomal base and not extending to the level of P-2 (Fig. 19). Tectum arched. Basal pair of maxillary setae close to base of rostrum, apical pair at about 0.5. Rostral sulcus extending to this pair of setae.

Leg I longer and wider than following legs. As in female (Figs 23–26) all telofemora shorter and more slender than tibiae. Tibia II clavate. Telofemora I to IV 2.5, 2.1, 2.3, and 2.6 times longer than high, respectively. Telofemora and tibia without articular membranes; tarsus I with enlarged lateral fossa membrane but no medial membrane; following tarsi without fossa membranes. Setae very delicate (misinterpretations cannot be excluded). Leg chaetotaxy, from trochanter to tibia: leg I: 1, 2, 3, 2, 7; leg II, 1, 2, 3, 2, 6; leg III, 1, 1, 2, 2, 5; leg IV, 0, 1, 2, 2, 5. Tibiae I to IV ventrally with 4, 1, 1, 2 slender and 0, 2, 1, 0 bipectinate setae. Two pectinate setae on tibia II situated rather close together. Tarsus I with 3 ventral setae, pair of doubled pas; 3 dorsal fossary setae and solenidion on dorsolateral fossary membrane. On tarsus II solenidion in dorsomedial position, its length 4 µm. Tarsi III and IV each with delicate ventral seta. Claws of tarsus I with accessory process, claws of tarsi II to IV each with process and about 5 large tines. Shaft of claws vacuolated. Central sclerite with minute claw-like process.

Female: Length of idiosoma 157–160 µm. Dorsal aspect same as that of male. GA not as slender as in male, its length:width ratio 1.6 (instead of 1.8). Distance between anterior margin of GO and that of GA 1.4 times length of GO. Anterior pair of pgs level with insertion of leg IV (Fig. 21). Ovipositor not extending markedly beyond GO. Subgenital setae lacking.

Deutonymph: Length 157 µm. AD shorter than in adults, posterior margin arched (Fig. 27). PD very long, anterior margin almost truncate, with pair of delicate costae. OC short, extending to level of insertion of leg III. Venter with rectangular genital plate, with 2 pairs of pgs (Fig. 28). Shape of gnathosoma as in adults.

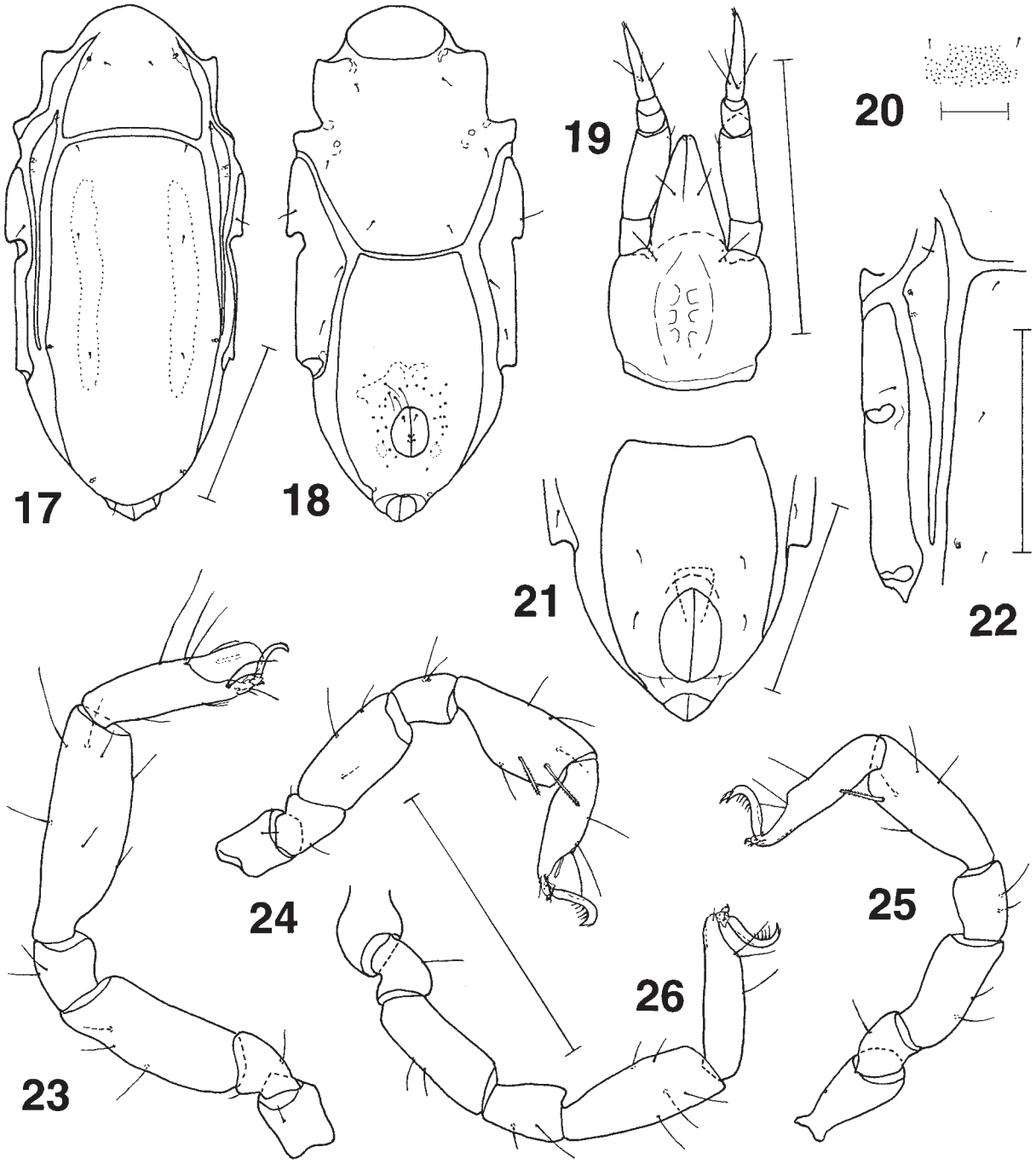
Remarks. – The known length range of *Arhodeoporus* species was between 200 µm (*A. disparilis*) and about 420 µm (*A. submarinus* Newell, 1947). *Arhodeoporus nanus* is smaller than these species. Specific characters of *A. nanus* are the almost uniformly and delicately punctate dorsal and ventral plates, a reduced number of setae on the telofemora and genua and the number of pgs in males. A similar reduced number of setae is present in *A. minusculus* Bartsch, 1991, a species of South China (Bartsch, 1991). In contrast to *A. nanus* the dorsal plates of *A. minusculus* have delimited areolae with coarse porosity, tibiae I and II are not as club-shaped as in *A. nanus* and their height is less than that of the telofemora.

Males of *A. nanus* and *A. minusculus* have the number of

sgs reduced to three pairs. Amongst the halacarid genera the genus *Winlundia* shares most of its characters with *Arhodeoporus*, and *Winlundia forcipata* Newell, 1984 has a similar reduced number of sgs. *Winlundia* is presently known only from the South American Pacific coast. Newell (1984) described the genus and two species and in these descriptions epimeral pores are not mentioned. The absence of such pores may be a character to distinguish between *Winlundia* and *Arhodeoporus*.

***Distribution and ecology*. –** At present known from Singapore, from Lazarus Island. Expected to be an interstitially living form.

Arhodeoporus *species in Singapore*. – Two species were present in the samples taken on the shores of Singapore. An unpublished record of a third species is from the Malay Peninsula (Island Babi Besar, Tioman Archipelago), Gulf of Thailand (coll. H.-G. Müller); that species is a member of the *Arhodeoporus eclogarius*-group, and is very similar to *A. leptopus* Bartsch, 1997 which is known from Western Australia (Bartsch, 1997b).



Figs 17–26. *Arhodeoporus nanus*, new species: 17, idiosoma, dorsal, male; 18, idiosoma, ventral, male; 19, gnathosoma, ventral, male; 20, portion of AD near ds-1, male; 21, genitoanal plate, female; 22, OC and adjacent plates, female; 23, leg I, medial, female; 24, leg II, medial, female; 25, leg III, medial, female; 26, leg IV, medial, female. Scale bars: 17–19, 21–26 = 50 µm, 20 = 10 µm.

Atelopsalis Trouessart, 1896

***Diagnosis.* –** Dorsal and ventral plates large, plates often with areolae with cup-like pores. Dorsum with 6 pairs of idiosomatic setae; ads on anal plate. AE with 3 pairs of ventral setae and a pair of large epimeral vesicles. PE with 1 dorsal and 3 ventral setae. Female GA with 3 pairs of pgs and 1–2 pairs of sgs. Males with 4–5 pairs of pgs, their genital sclerites with 4 minute sgs. Gnathosoma short, with wide, globular base and conical rostrum. One pair of maxillary setae in basal third of rostrum, the other pair minute, spur-like, near tip of rostrum. Palps 3-segmented (P-2 and P-3 fused), lateral to gnathosoma and hardly surpassing tip of rostrum. No seta on 2nd segment (corresponding to P-2 + P-3); 3rd segment (corresponding to P-4) with a basal seta, an apical setula and 2 spurs. Leg I much longer and wider than following legs. Genua I to IV shorter than telofemora and tibiae. Telofemur I large, often with cuticular spiniform lamellae. Tibia I with pair of ventral spines in middle and pair of ventral setae near distal end of segment. Tibia II with 1 dorsomedial spinelet and 2 ventral setae (1 pectinate, 1 smooth). Tibiae III and IV each with pair of ventral setae, 1 pectinate, 1 smooth. Tarsus I with 3 dorsal setae, dorsolateral solenidion and famulus, and 3 ventral setae. Tarsus II with 3 dorsal setae, dorsomedial solenidion, and 1 often long ventral seta. Tarsi III and IV with 4 and 3 dorsal setae, respectively, but no ventral setae. Each tarsus with a pair of pas. Paired claws much longer than minute median claw.

***Type species.* –** *Atelopsalis tricuspis* Trouessart, 1896.

Atelopsalis pacifica Bartsch, 1985
(Figs 27–33)

Atelopsalis pacifica Bartsch, 1985: 272–275, Figs. 12–23; Sarma & Chatterjee, 1993a: 117–119, Figs. 1–5; Bartsch, 2007: 371–372, Fig. 6A–D.

***Material examined*. –** One female, one male, ZRC.ARA.711, Singapore, Lazarus Island, coarse surface sediment, low water edge, 3 Oct.2004. One female, SMF, same collection data.

***Supplementary description*. –** Length of female 205–215 µm, of male 203 µm. Dorsal plates with slightly raised areolae with modified rosette pores; remainder of plates reticulate (Fig. 29), polygons subdivided. Each rosette pore with delicate ostium at surface, 1 µm in diameter, and wide alveolus in deeper integumental layers, 2 µm in diameter; canaliculi lacking; each rosette pore within a polygon. AD with rosette pores in small anterior areolae and in pair of costae; OC with about 4 rosette pores medial to 2 large corneae; PD with pair of costae, mostly 1 pore wide. Ventral plates with areolae with modified rosette pores, number and outline of areolae as illustrated (Fig. 30), remainder of plates almost smooth. Female genital sclerites with 2 pairs of sgs. Size of male GO similar to that of female; with 5 pairs of pgs, 2 pairs arising from large alveoli (Fig. 31). Genital sclerites with 4 pairs of sgs. Gnathosoma about 45 µm long, 38 µm wide. Gnathosomal base with pair of porose areolae with 8–10 rosette pores (Fig. 32). Tectum truncate. Telofemur I with pair of spiniform lamellae (Fig. 33). Tibiae III and IV each with delicately bipectinate ventromedial and smooth, slender ventral seta. Tarsi end with slender paired claws and minute median claw. Paired claws with very delicate tines.

***Remarks*. –** The genus *Atelopsalis* is spread in tropical and warm-temperate waters, from the tidal area to the bathyal (Bay of Biscay, 1410 m, Trouessart, 1896). Five of the seven species have distinct areolae with modified rosette pores, as described above, and all in a arrangement similar to that of *A. pacifica*. The other two species lack such areolae. *Atelopsalis meteorensis* Bartsch, 2002 and *A. tricuspis* Trouessart, 1896 bear a reduced number of rosette pores. The three species *A. aliger* Bartsch, 1977, *A. atlantica* Pepato & Tiago, 2004 and *A. pacifica* are rather similar and primarily differ in the number and size of the porose areolae. In *A. aliger* the posterior pair of areolae on the AE is lacking and the areolae on the GA extend anteriad only slightly beyond the level of anterior edge of GO, accordingly the porose areolae are smaller than in *A. atlantica* and *A. pacifica*. The porose areolae of *A. atlantica* are wider than in *A. pacifica*, the costae on the PD are two rosette pores wide (in *A. pacifica* are major parts just one rosette pore wide). Another distinguishing character of *A. aliger* is the absence of ventral lamellae on telofemur I.

***Distribution and ecology*. –** Records of *Atelopsalis pacifica* are from India (Bay of Bengal), the Philippines (Sulu Sea), Western Australia, Rottnest Island (Indian Ocean) and Esperance (Southern Ocean) (Bartsch 1985, 2007; Sarma & Chatterjee, 1993a), unpublished records from the Mirs Bay, Hong Kong, South China Sea and Oahu, the Hawaiian Islands, Pacific Ocean. The present record from Singapore lies within the geographical range known. The records are from sandy deposits, coralline algae and dead coral blocks, from tidal to shallow subtidal (15 m).

Atelopsalis *species in Singapore*. – No other representative of this genus was found.

Copidognathus Trouessart, 1888

***Diagnosis.* –** Dorsal and ventral plates generally large (or even fused). With 4(–5) pairs of gland pores; pores almost inconspicuous or large and opening on raised cones; rarely gland pores lacking. Dorsum with (5–)6 pairs of dorsal setae; ads on anal plate. AE with 3 pairs of ventral setae and pair of epimeral pores. PE in general with 1 dorsal and 3 ventral setae. Female GA with 3(–5) pairs of pgs and 1 pair of sgs. Male GA with 4–40 pairs of pgs; genital sclerites with 3–4 pairs of sgs. Gnathosoma in general longer than wide. One pair of maxillary setae on rostrum, 1 (rarely up to 7) pairs of setae on gnathosomal base. Palps 4-segmented, attached laterally and at least slightly surpassing rostrum. P-2 generally with 1 distal seta. No seta on P-3 (there may be a small spiniform cuticular process). P-4 with 3 setae in basal whorl; apically with setula and 2 spurs. Shape of legs from slender to wide and bearing conspicuous lamellae. Genua shorter than telofemora and tibiae. Tibiae I and II with 3

ventral setae, often 1 of these setae bristle-like and smooth and 2 setae pectinate. Tibia III with 2 ventral setae, often 1 slender and smooth and 1 bipectinate. Tibia IV either with a smooth and a bipectinate or with 2 smooth setae. Tarsus I with 3 dorsal setae, a dorsolateral seti- or baculiform solenidion, (2–)3 ventral setae, and a pair of pas. Tarsus II with 3 dorsal setae, setiform dorsolateral solenidion, no ventral seta but a pair of pas. Tarsi III and IV with 3–4 dorsal setae, no ventral setae, and pair of pas (rarely one of pas moved to a ventral position or lacking). All tarsi with large paired claws; median claw present, though small.

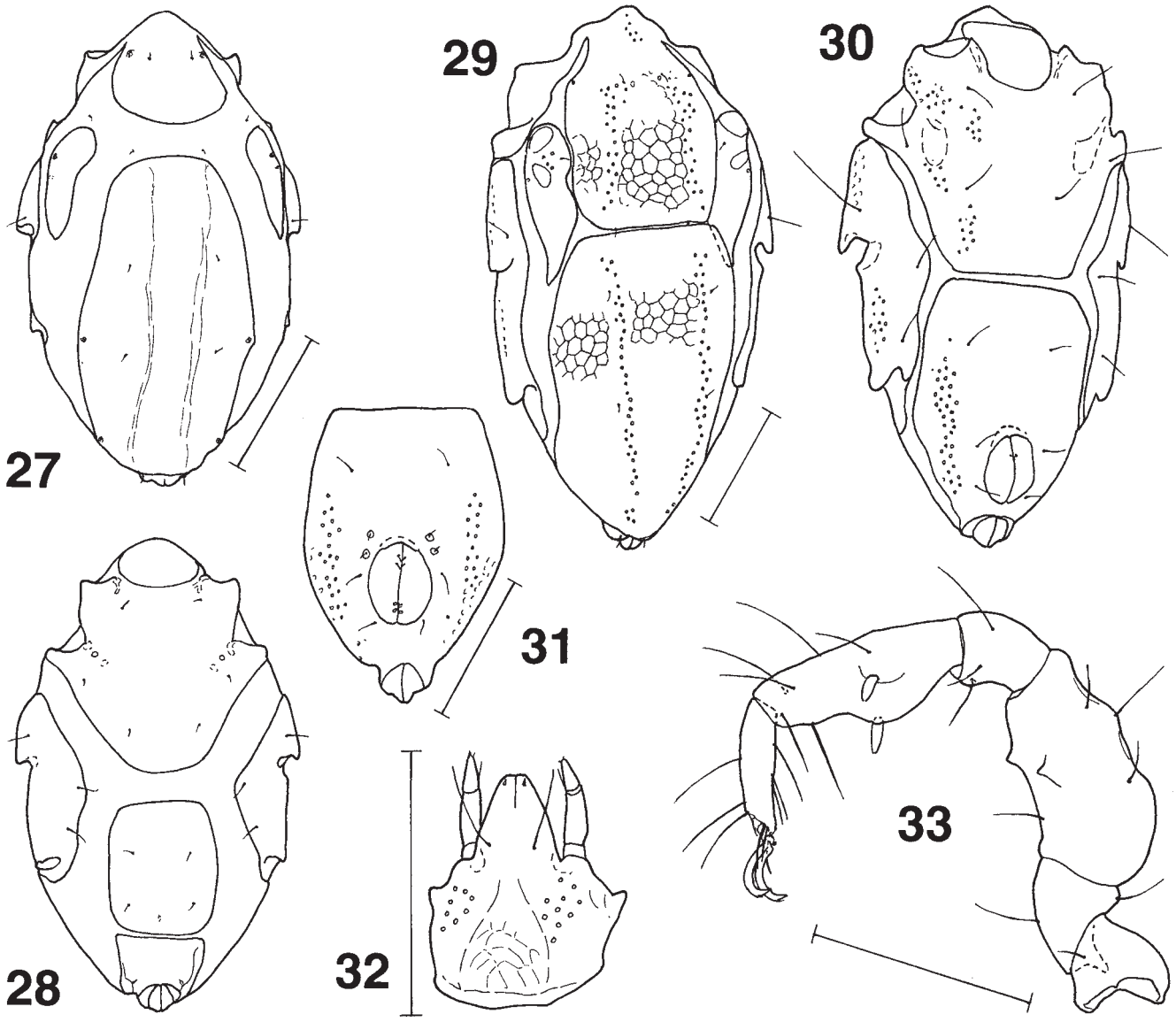
***Type species.* –** *Copidognathus glyptoderma* Trouessart, 1888.

Copidognathus bavayi (Trouessart, 1896)

(Figs 34–38)

Halacarus (*Copidognathus*) *bavayi* Trouessart, 1896a: 250, 251. *Copidognathus* (s. str.) *bavayi*, André, 1937: 206–208, Fig. 1.*Copidognathus bavayi*, Bartsch, 1993a: 46, 47, Figs. 1–6.

***Material examined.* –** One female, ZRC.ARA.712, Singapore, St John's Island, southwestern part, hapteres and sediment, low water edge, 1 Oct.2004. One female, ZMH, Singapore, collection data as above. One male, SMF, Singapore, St John's Island, northeastern shore, from dead coral block, 1 Oct.2004. One male, ZRC. ARA.713, Singapore, Lazarus Island, coarse surface sediment, just above low water edge, 3 Oct.2004.



Figs. 27–33. *Arhodeoporus nanus*, new species, deutonymph: 27, idiosoma, dorsal; 28, idiosoma, ventral. *Atelopsalis pacifica* Bartsch, 1985: 29, idiosoma, dorsal, female; 30, idiosoma, ventral, female; 31, genitoanal plate, male; 32, gnathosoma, ventral, female; 33, leg I, medial, female. Scale bars = 50 µm.

***Supplementary description*. –** Length of female 369–390 µm, of male 343–360 µm. Intensively sculptured. Anterior part of PD and part of OC with faint or distinct tinge of brown. Dorsal plates with porose areolae, remainder of plates coarsely foveate (Fig. 34). Rosette pores within porose areolae with large, shallow ostia, 4–5 µm in diameter, and more than 10 minute canaliculi. Shape of plates as illustrated. AD with 3 porose areolae; posterior pair of areolae oblong. Posterior margin of AD with 2 small lobes, lobes without rosette pores. OC with porose areola medial to 2 large corneae. Lateral margin of plate raised but without rosette pores. Pair of costae on PD 2 rosette pores wide. Gland pores on AD close to lateral margin. Setae ds-2 on OC. Ventral plates with marginal porose areolae; integument of large ventral portions of AE and GA delicately punctate. AE with large epimeral processes (Fig. 35). In female 2nd pair of pgs close to margin of GA (Fig. 36); ovipositor extending to the level of anterior pair of pgs. Male GA with about 20 pgs; genital sclerites with 2 pairs of setiform and 2 pairs of spur-like sgs. Spermatopositor slightly extending beyond GA (Fig. 35). Length of gnathosoma about 129–134 µm, and twice the width. Rostrum somewhat longer than gnathosomal base and extending to base of P-4 (Fig. 37). Tectum triangular. Telofemora, genua and tibiae with articular lamellae. Tibia I with small ventral lamella, telofemur I with small dorsal lamella and narrow ventrolateral lamella. Surface of telofemora with reticulate-foveate ornamentation (Fig. 38). Telofemora I and II almost as long as tibiae, telofemora III and IV shorter than these legs' tibiae. Telofemora with 3/2, 3/2, 2/0, 2/1 dorsal/ventral setae, respectively. Tibiae I to IV with 2, 2, 1, 0 bipectinate and 1, 1, 1, 2 slender, smooth ventral seta. Tarsi III and IV with 4 dorsal setae each. Claws with accessory process; pectines on claws II to IV with numerous delicate tines.

***Remarks*. –** The species was described by Trouessart (1896a) but not illustrated. André (1937) presented a re-description. Bartsch (1993a) compared the type specimens from Vietnam (Mekong Delta) with specimens from Malaysia and re-described the species on the basis of the latter specimens.

Copidognathus bavayi shares several characters with *C. angustus* Viets, 1936, *C. australiensis* (Lohmann, 1909), *C. floridensis* Newell, 1947, *C. lamellosus* (Lohmann, 1893), *C. peregrinus* Bartsch, 1977, and *C. scuna* Otto, 1994, characters such as: the shape and ornamentation of the dorsal and ventral plates; the arrangement of dorsal setae and gland pores; the arrangement of male pgs and size of spermatopositor; the size and ornamentation of the legs and their lamellae, the number, arrangement and shape of the setae on telofemora, tibiae and tarsi of legs III and IV. In most of these species the length of the gnathosoma is about twice the width, the rostrum is slender. The above mentioned species live in warm-temperate and tropical waters (Lohmann, 1893, 1909; Viets, 1936; Bartsch, 1977, 1999; Newell, 1947; Otto, 1994; Pepato & Tiago, 2005).

***Distribution and ecology*. –** Vietnam, Malaysia and Singapore. Present in lower tidal and shallow subtidal areas, amongst surface sediments and algae.

Copidognathus macropus, new species

(Figs. 39–48)

***Material examined*. –** Holotype: Female, ZRC.ARA.714, Singapore, St John's Island, southwestern part, sediment and tubes of polychaetes, low water edge, 2 Oct.2004.

***Diagnosis*. –** Length of female 267 µm. Idiosoma and gnathosoma slender. Dorsal and ventral plates evenly foveate, each fovea with numerous canaliculi. OC posteriorly tapering, extending to insertion of leg III. GO in female in posterior position. Ovipositor long. Gnathosoma 3.3 times longer than wide, rostrum 1.6 times longer than gnathosomal base. Leg I almost as long as idiosoma. Telofemora, genua and tibiae with pointed articular membranes. Tibia I with 3 slender ventral setae; tibiae I to IV with 2, 1, 1 coarsely bipectinate ventromedial and 1, 1, 1 smooth ventral setae. Tarsi III and IV with 4 and 3 dorsal setae, respectively. Claws with few large tines.

***Etymology*. –** The species is characterized by its very long first legs, hence the name *macropus*, derived from macros (Greek), long and pous (Greek), leg, foot.

***Description*. – Holotype female:** Length of idiosoma 267 µm, width 130 µm, length more than twice the width. Dorsal plates with foveae (Fig. 39), 3 µm in diameter, each fovea with 7–10 canaliculi in deeper integumental layer (Fig. 41). Length of AD 80 µm, width 72 µm. Length of OC 60 µm, plate tapering and extending to level of insertion of leg III. With very faint eye pigment, a cornea and a gland pore. Length of PD 175 µm, width 97 µm; anterior margin truncate. Gland pores inconspicuous. Dorsal setae short and delicate; pair of ds-1 on AD at 0.4; ds-2 in membraneous integument anterior to OC, ds-3 in anterior margin of PD. One pair of setae level with insertion of leg IV.

Ventral plates with foveae, 2–7 µm in diameter, each with 4–7 canaliculi. Length of AE 104 µm, width 115 µm. Epimeral pore opening with small slit at the surface; internal sacculus 4–5 µm in diameter. Length of PE 117 µm, extending beyond insertion of leg IV. Length of GA 129 µm, width 77 µm; anterior margin truncate. GO in posterior part of GA and in ventral aspect overlapping anal cone. First pair of pgs about level of posterior end of PE; 2nd pair halfway between this pair and anterior margin of GO, 3rd pair concealed by genital cone. Genital sclerites with pair of slightly flattened sgs. Ovipositor long; extending beyond anterior-most pair of pgs (Fig. 40).

Gnathosoma very slender (Fig. 42), length 150 µm, width 45 µm, 3.3 times longer than wide. Rostrum 92 µm long, 1.6 times longer than gnathosomal base and extending to basal whorl of setae on P-4. Gnathosomal base ornamented with foveae and canaliculi. Maxillary setae slender, apical pair at about 0.7. Rostral sulcus extending to this pair of setae. Tectum with very short, triangular process.

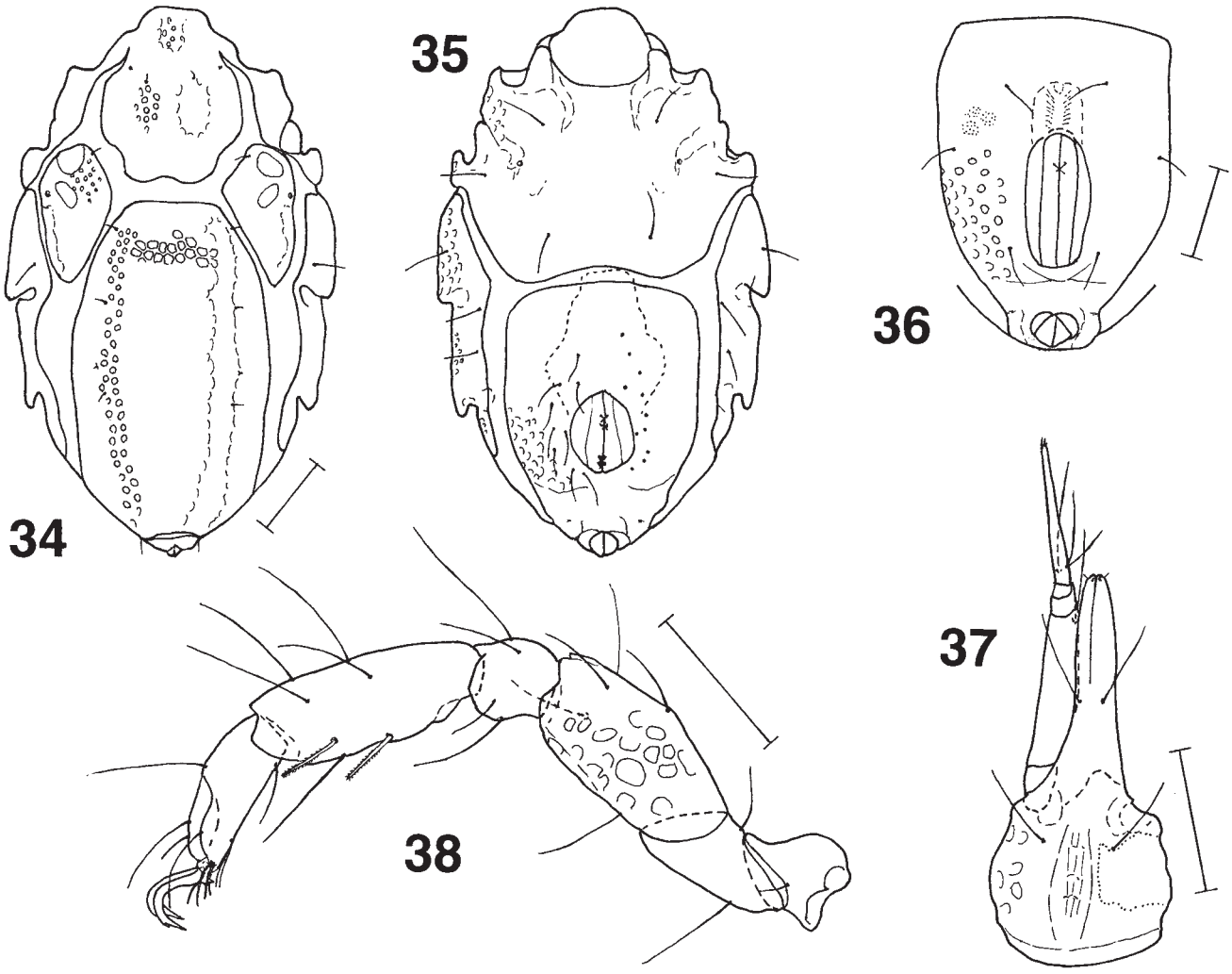
Leg I much longer than following legs (Fig. 44), its length 0.94 times that of idiosoma. Ventrolateral flank of

telofemur I with delicate foveae, ornamentation of the other telofemora inconspicuous. Telofemora I to IV: 2.9, 2.7, 2.6, and 2.9 times longer than high, respectively. Telofemora, genua and tibiae with pointed articular membranes (Figs 44, 46–48). Leg chaetotaxy, from trochanter to tibia: leg I, 1, 2, 3, 3, 7; leg II, 1, 2, 3, 3, 7; leg III, 1, 2, 2, 3, 5; leg IV, 0, 2, 3, 3, 5. Tibia I with 3 slender ventral setae; tibiae II to IV with 2, 1, 1 coarsely bipectinate ventromedial and 1, 1, 1 smooth ventral setae. Tarsus I with enlarged lateral fossa membrane including famulus, setiform solenidion and pair of doubled pas (Fig. 45). Tarsi II (Fig. 43) to IV each with pair of pas singlets. Tarsi III and IV with 4 and 3 dorsal setae, respectively.

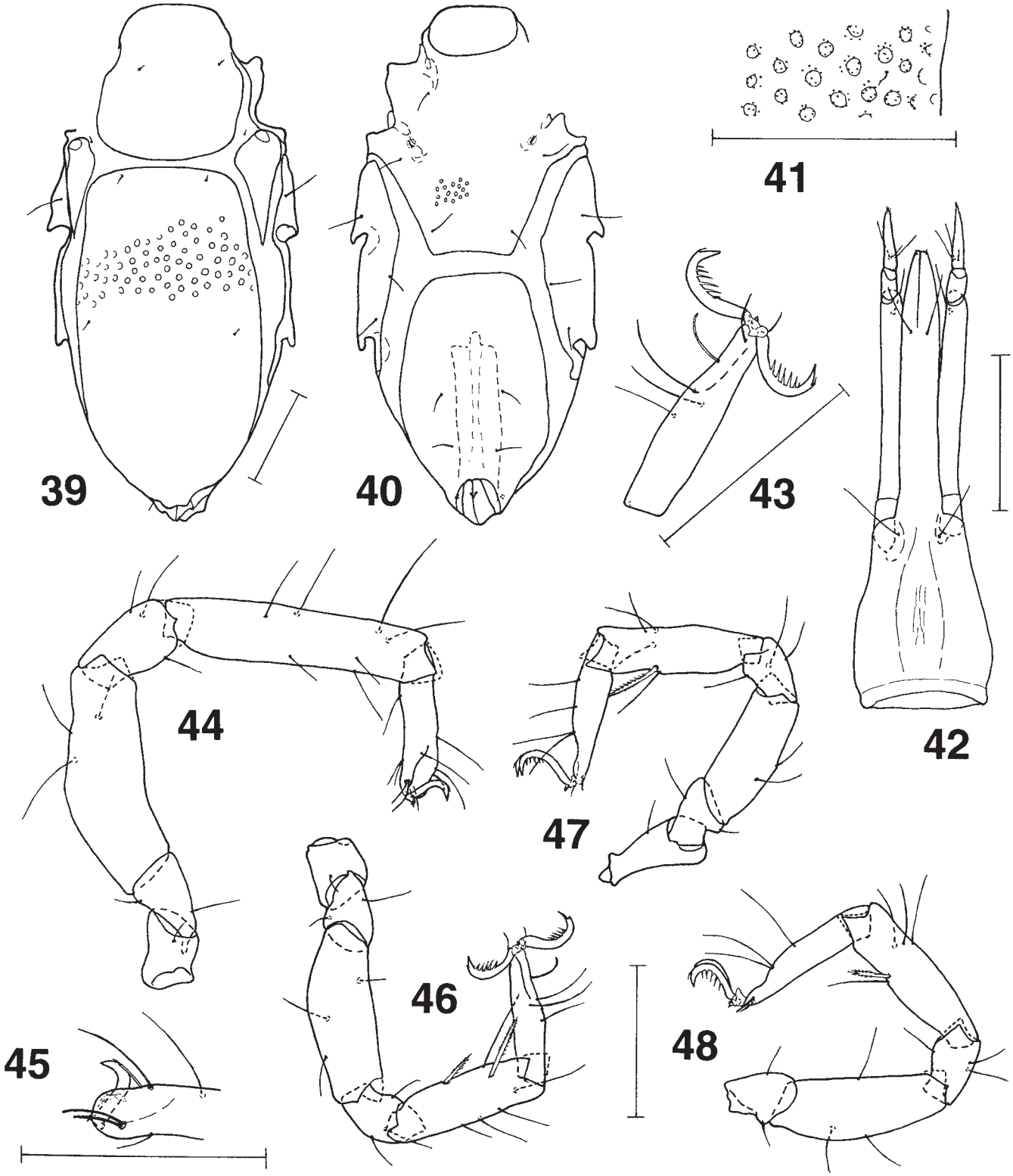
Claws on tarsus I short, with accessory process but without distinct pecten. Claws of tarsi II to IV with accessory process and 6 large tines.

Remarks. **–** *Copidognathus macropus* is similar to *C. thailandicus* Chatterjee & Chang, 2003, but tibia I of *C. macropus* has slender setae, none is bipectinate, whereas in *C. thailandicus* two of the setae are bipectinate. The ovipositor extends in *C. macropus* far beyond the anterior pair of pgs, in *C. thailandicus* just beyond that pair of setae. Other distinguishing characters are: (1) the length of PE and the position of the ventral setae on the PE, in *C. macropus* the PE extends beyond the insertion of leg IV by a distance equalling about half that between insertions of legs III and IV, in *C. thailandicus* the PE is longer; (2) the position of the GO, in *C. thailandicus* in a more ventral position than in *C. macropus*, and (3) the position of the pair of setae on AD, in *C. macropus* in the anterior half, in *C. thailandicus* in the posterior half. Some of these latter characters may prove to be inadequate in discrimination between these species as they may be the result of compression and deformation of the specimens illustrated.

The most conspicuous characters of this species are the slender gnathosoma, with a very long rostrum, and the long leg I which is almost as long as the idiosoma and distinctly longer than the other legs. A similar shape of idiosoma, gnathosoma and legs are found in species of the psammophilous *Arhodeoporus longirostris* group.



Figs. 34–38. *Copidognathus bavayi* (Trouessart, 1896): 34, idiosoma, dorsal, male; 35, idiosoma, ventral, male; 36, genitoanal plate, female; 37, gnathosoma, ventral, male; 38, leg I, medial, male. Scale bars = 50 µm.



Figs. 39–48. *Copidognathus macropus*, new species, female: 39, idiosoma, dorsal; 40, idiosoma, ventral; 41, portion of PD level ds-4; 42, gnathosoma, ventral; 43, tarsus II, lateral; 44, leg I, medial; 45, tip of tarsus I, lateral; 46, leg II, ventromedial; 47, leg III, medial; 48, basifemur to tarsus IV, medial. Scale bars = 50 µm.

Copidognathus viridulus, new species
(Figs. 49–58)

Material examined. – Holotype: Male, ZRC.ARA.715, Singapore, Lazarus Island, sediment between gravel, just above low water edge, 3 Oct.2004. Paratypes: One female, ZRC.ARA.716, same collection data; one male, ZMH, same collection data.

Diagnosis. – Length 174–186 µm. Dorsal and ventral plates uniformly and delicately punctate. Opposing margins of AD and PD truncate. OC extending to level of insertion of leg III. Palps short, hardly extending beyond tip of rostrum. P-4 very short, not as long as P-3. Telofemur I 1.8 times longer than high. Tarsus I with enlarged lateral fossa membrane; all other fossa membranes lacking. Mid-segmental ventral seta on tarsus I absent, pair of small setae present. Tibiae I to IV with 2, 2, 1, 1 bipectinate setae; bipectinate seta on tibia IV in almost mid-segmental position. Tarsi III and IV with 4 and 3 dorsal setae, respectively. Claw pectines on tarsi II to IV with coarse tines.

Etymology. – The specific name is derived from viridilus (Latin), greenish, because the gut contents of the specimens were dark-green, most intense in the posterior half of the idiosoma.

***Description*. – Holotype male**: Length of idiosoma 174 µm, width 87 µm. Gut contents dark-green, most markedly in posterior half of idiosoma. Faint spots of eye pigment beneath anterior part of OC. Dorsal plates uniformly and delicately punctate and pitted. Length of AD 55 µm, width 51 µm; with distinct transverse line of minute internal scars (Fig. 49). Posterior margin of AD truncate. Length of OC 38 µm, width 16 µm; posterior margin not acutely pointed, not reaching to level of insertion of leg III; with pore canaliculus but without gland pore. Length of PD 118 µm, width 64 µm; anterior margin truncate. Gland pores inconspicuous. Dorsal setae minute. Pair of ds-1 level with insertion of leg I, ds-2 in anterior corner of OC, ds-3 and ds-4 on PD, in anterior half of plate; pair of ds-5 not seen.

Length of AE 60 µm, width 82 µm; with minute pointed epimeral processes I. Epimeral pores with slit-like opening. Posterior margin of AE truncate (Fig. 50). Length of PE 90 µm. Length of GA 88 µm, width 56 µm; anterior margin truncate; posterior part with GO raised. Length of GO 23 µm, width 19 µm. Ten pairs of pgs close around GO. Genital sclerites with 4 pairs of sgs. Spermatopositor extending beyond ring of pgs, its length 42 µm. Distance between anterior margin of GO and GA 2.1 times length of GO.

Length of gnathosoma 60 µm, width 38 µm, 1.6 times longer than wide. Length of rostrum 28 µm. Tectum truncate. Maxillary setae short, basal pair near base of rostrum, apical pair in posterior third of rostrum (Fig. 51). Rostral setae spur-like. Palps short, hardly extending beyond rostrum. Seta of P-2 absent (or vestigial). P-4 shorter than P-3 (Fig. 52). P-4 with 2 short basal setae and spur-like medial seta; apically with setula and 2 spurs.

Leg I wider but not markedly longer than following legs (Figs 54-57). Telofemora shorter than tibiae. Telofemur I 1.8 times longer than high. Tarsus I with enlarged lateral membrane of claw fossa, the other tarsi without fossa membranes. Leg chaetotaxy, from trochanter to tibia: leg I, 1, 2, 4, 2, 6; leg II, 1, 2, 3, 2, 6; leg III, 1, 2, 2, 3, 5; leg IV, 0, 2, 2, 3, 5. Tibiae I to IV ventrally with 2, 2, 1, 1 bipectinate and 1, 1, 1, 1 slender smooth setae. Bipectinate seta on tibia IV in almost mid-segmental position (Fig. 57). Apical bipectinate seta on tibia II longer than the other rather short but coarsely pectinate setae. Tarsus I without mid-segmental ventral seta but with apical pair of short setae (Fig. 58). Dorsal and lateral fossary setae thicker than medial fossary seta. Solenidion very short, 2 µm in length. Apex with pair of doubled pas. Lateral and medial fossary setae on tarsus II equal in width and length; solenidion 5 µm long. Apex of tarsi II, III and IV with pair of pas. Claws on tarsus I with accessory process; claw pectines of the other tarsi with large tines. Median claw present, small.

Female: Length of idiosoma 180 µm, width 87 µm. Length of GA 85 µm, width 48 µm. GO in posterior raised part of plate. Distance between anterior margin of GO to that of GO equalling 1.7 times length of GO. Ovipositor hardly extending beyond GO (Fig. 53). Two pairs of pgs situated as illustrated, a third pair certainly present but covered by the raised posterior part of genital area. Genital sclerites with a pair of sgs.

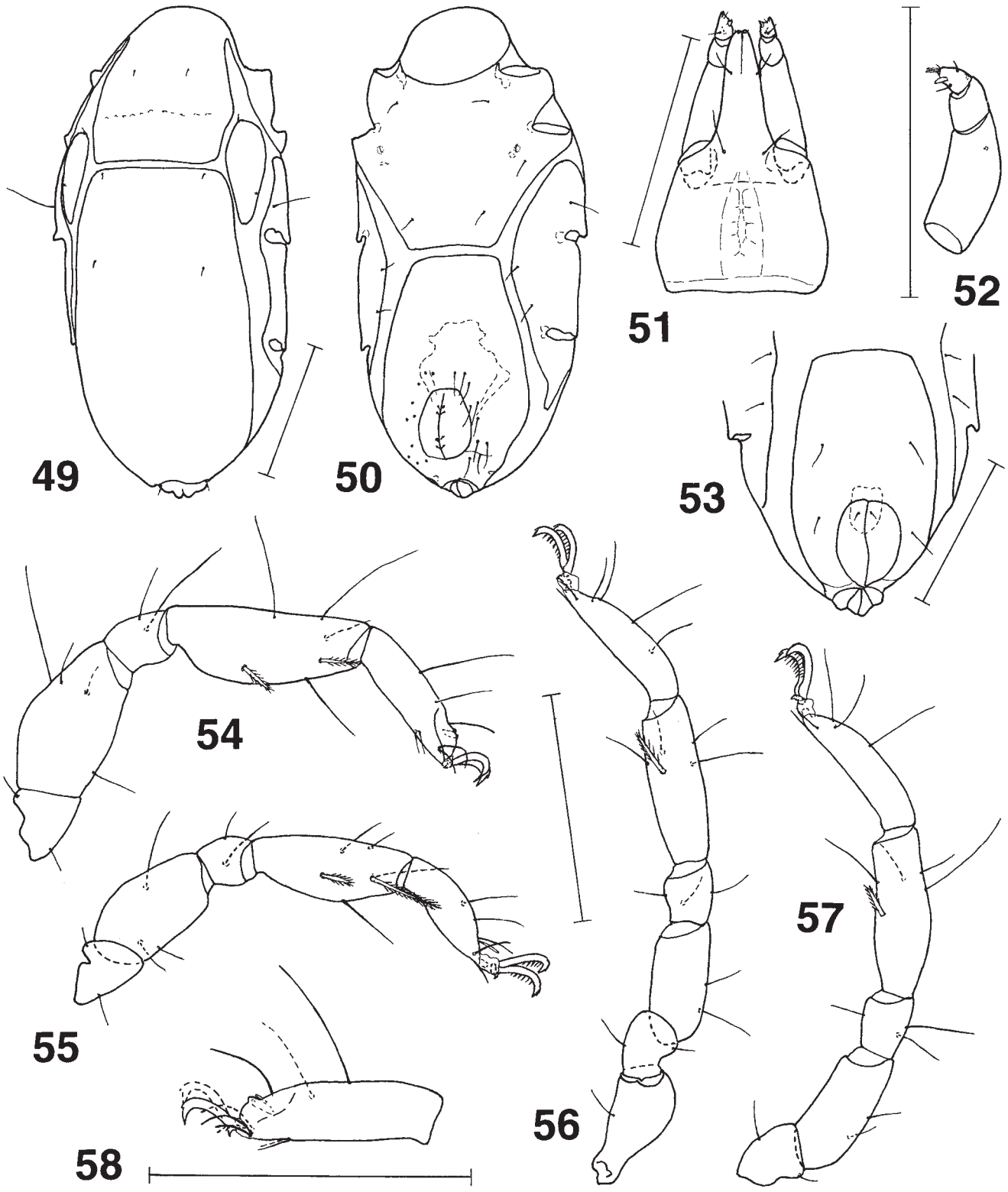
Remarks. – *Copidognathus viridulus* is most similar to *C. consobrinus* Bartsch, 1991, a species from South China (Bartsch, 1991). The two species differ in the shape of the gnathosoma. Rostrum and palps end at about the same level and the P-4 are very short in *C. viridulus*, whereas in *C. consobrinus* the palps extend beyond the rostrum, the length of P-4 is twice that of P-3 and there is a distinct interval between the basal whorl of setae and the apical spurs.

Copidognathus *species in Singapore.* – *Copidognathus* is a genus very rich in species, about one third of all halacarids belongs to this taxon, worldwide (Bartsch, 2004). One species has been described recently, *C. rhombognathoides* Bartsch, 2006, an inhabitant of mangroves (Bartsch, 2006b), three species are mentioned above. More than a dozen species are expected to be present in the samples, amongst others there are several species of the *bairdi* (s.l.) and *gibbus* group.

From north of Singapore, from the Tioman and Phangan Islands (Malaysia and Vietnam), Gulf of Thailand, six species are recorded, *C. bavayi*, *C. dictyotus* Bartsch, 1993, *C. euryalus* Bartsch, 1997, *C. malaysius* Bartsch, 1993, *C. orarius* Otto, 2001, and *C. thailandicus* Chatterjee & Chang, 2002 (Bartsch, 1993a; Chatterjee & Chang, 2002).

Halacarus Gosse, 1855

Diagnosis. – Dorsal plates smooth or faintly reticulated, without prominent costae or conspicuous porose areolae. Dorsal plates may be obscured by layers of striated or



Figs. 49–58. *Copidognathus viridulus*, new species: 49, idiosoma, dorsal, male; 50, idiosoma, ventral, male; 51, gnathosoma, ventral, male; 52, P-2 to P-4, ventromedial, female; 53, posterior part of idiosoma with genitoanal plate, female; 54, basifemur to tarsus I, medial, male; 55, basifemur to tarsus II, medial, male; 56, leg III, medial, male; 57, basifemur to tarsus IV, medial, male; 58, tarsus I, lateral, male (medial setae and claw in broken line). Scale bars = 50 μm.

maze-like ornamented cerotegument. AD mostly with frontal process. OC and/or PD often lacking. If present, PD in males often larger than in females. Five pairs of large gland pores, first pair arising on or close to AD, second pair marginally, within membraneous integument (rarely on PE). Dorsum with 6 pairs of idiosomatic setae; adanal setae adjacent to posterior pair of gland pores. PE with 1(–2) dorsal seta(e) and 3 ventral setae. Female GA with 2–15 pairs of pgs; in species with 2 pairs of pgs on GA a 3rd pair (rarely a 4th pair) present within membraneous integument anterior to GA. Females often with pair of crescent areas on either side of GO. Female genital sclerites with 3–5 pairs of sgs. Male GA rounded or oval in outline; number of pgs surrounding GO ranging from about 30 to more than 150; a pair of outlying pgs may be present within membraneous integument. Male genital sclerites with 3–5 pairs of sgs. Gnathosoma longer than wide. Gnathosomal base subquadrangular. Rostrum ending bluntly. Both pairs of maxillary setae on rostrum. Palps 4-segmented, lateral to gnathosoma and extending beyond rostrum. P-2 with 2 dorsal setae, generally both in apical half. P-3 short, with a medial spine. P-4 with 3 basal setae, a seta in the middle and a minute seta and 2 spurs at the tip. Leg I generally longer and wider than following legs. Genu I about as long as both telofemur and tibia I. Similarly, genua of the following legs almost as long as adjoining segments. Telofemur I with 1–5 ventral spines; spines tapering or blunt. Genu I with 1 pair of spiniform or bristle-like setae. Tibia I with 4 often spiniform ventral setae; tibiae II, III and IV with 2–7 ventral bristle-like setae. Tarsus I with 3 dorsal setae, baculiform dorsolateral solenidion, 2–4 ventral bristle-shaped setae, and 2–5 pairs of eupathidia (pas included). Tarsus II with 3 dorsal setae, dorsomedial solenidion, 0–4 ventral setae, and pair of doubled or tripled pas. Tarsi III and IV with 3–4 and 3 dorsal setae, respectively, 0–6 ventral setae, and pair of pas. Parambulacral setae of male tarsus IV often plumose. Paired claws either smooth or with accessory process and pecten. Median claw present, usually small.

Type species. **–** *Halacarus ctenopus* Gosse, 1855.

Halacarus discophorus Bartsch, 1993
(Figs. 59–64)

Halacarus discophorus Bartsch, 1993d: 50–53, Figs. 3A–G, 4A–D; Otto, 2001a: 695–696, Fig. 6.

Material examined. **–** One male, ZRC.ARA.717, Singapore, Lazarus Island, coarse surface sediment, just above low water edge, 3 Oct.2004. One deutonymph, SMF, Singapore, Lazarus Island, coarse surface sediment, just above low water edge, 2 Oct.2004.

Supplementary description. **–** Length of male 550 µm. Epicuticula on plates, gnathosoma and legs minutely reticulate. AD with short frontal spine (Fig. 59). Gland pores on AD; ds-1 slightly anterior to the level of gland pores. OC small, with 1 large cornea; pore canaliculus in membraneous integument. Posterior part of idiosoma with pair of small plates. Pairs of glp-4 and glp-5 on minute platelets which also include ds-5 and ds-6. Apodemes between epimera III and IV reaching to medial margin of PE (Fig. 60). One pair of pgs within membraneous integument; GA with almost 60 pgs close around GO, 4 pairs outlying (Fig. 61) and 3 pairs of large internal genital acetabula. P-2 with 2 setae, both in posterior half of segment (Fig. 62); P-3 with blunt dorsomedial spur. Legs I and II almost as long as idiosoma. Telofemur to tibia I with 2, 2, 4 tapering spines (Fig. 64). Two ventromedial setae on tibia II with unilateral pectination, 2 ventrolateral setae slender, apical one much more slender than basal one (Fig. 63). Tarsi II to IV with 2, 3, 3 ventral setae.

Remarks. **–** One deutonymph, collected at the same locality, is similar to the male in its shape, has the same arrangement of the setae ds-1 and ds-4 relative to the gland pores, and the shape of the ventral setae on leg I and tibia II is the same. In contrast to the male, the deutonymph lacks the pair of posterior dorsal plates in the membraneous integument.

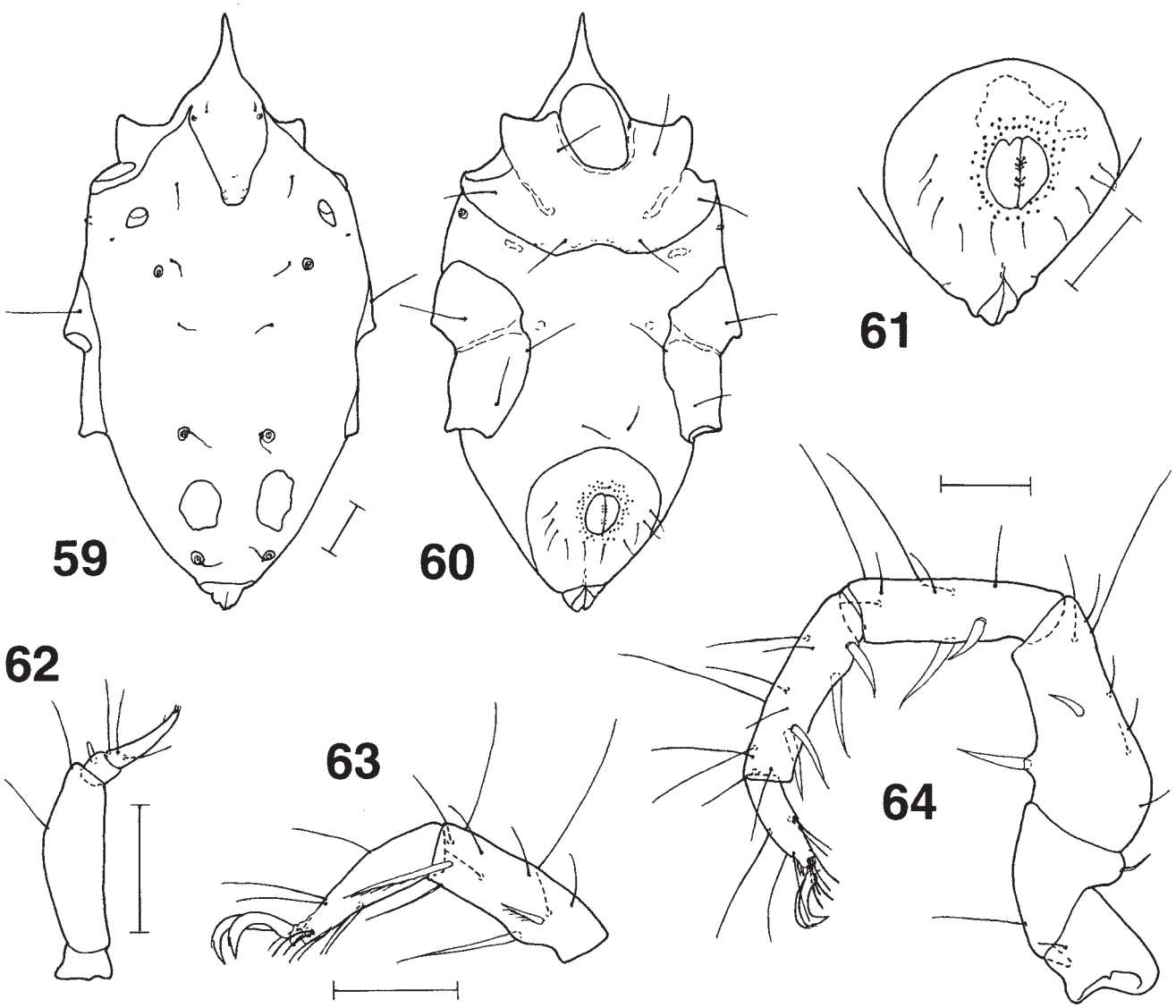
Two species are now known from the Malay Peninsula, *H. discophorus* and *H. malaysius* Bartsch, 1993, the latter is from north of Singapore, from Malaysia (Bartsch, 1993b). *Halacarus malaysius* has a PD which includes the two posterior pairs of gland pores (no PD in *H. discophorus*), the OC are larger than in *H. discophorus* and the epicuticula is arranged in parallel striae (delicately reticulate in *H. discophorus*).

Distribution and ecology. **–** Western Australia (Rottnest and Montebello Islands), Queensland (Great Barrier Reef and Queensland Plateau) (Bartsch, 1993d; Otto, 2001a), and Singapore. The records are from tidal and shallow subtidal depth (0–17 m), from sandy and gravely deposits.

Halacarus *species in Singapore.* **–** No other representative of this genus was found in the samples taken on the shores of Singapore. A species from Malaysia, Gulf of Thailand, Tioman Archipelago, is *Halacarus malaysius* (Bartsch, 1993b).

Rhombognathus Trouessart, 1888

Diagnosis. **–** Dorsal plates AD, OC and PD present, 2 or more plates may be fused. Dorsum with 5–6 pairs of idiosomatic setae; ads on anal plate. OC with 2 dorsal setae, 2 gland pores and often 2 corneae. PD with 1 or 2 pairs of dorsal setae. Ventral plates often fused, rarely separated. AE (or area of AE) with 3 ventral plus 0–6 adjunct setae posterior to insertion of leg II. PE with (0–)1 dorsal and 3 ventral setae, and 0–3 adjunct marginal setae anterior to insertion of leg III. Female with 1–45 pairs of pgs and 2 pairs of sgs. Majority of males with 7–25 pairs of pgs and 2 pairs of sgs; pgs often plumose and in trapezoidal arrangement. Gnathosoma generally longer than wide. Rostrum short and conical or parallel-sided and about as long as gnathosomal base. Both pairs of maxillary setae on rostrum. Palps 4-segmented, extending just beyond rostral tip. P-2 with 1 distal seta; no seta on P-3; 3 setae in basal whorl of P-4.



Figs. 59–64. *Halacarus discophorus* Bartsch, 1993, male: 59, idiosoma, dorsal; 60, idiosoma, ventral; 61, genitoanal plate; 62, palp; 63, tibia and tarsus II, medial; 64, leg I, medial. Scale bars = 50 µm.

Genua shorter than adjoining segments. Tibiae I to IV with (1–)2 ventral setae. Ventral setae of tibia I bipectinate. Tarsi I, II and IV with 3 dorsal and 0 ventral setae, tarsus III with (3–)4 dorsal and 0 ventral setae. Dorsolateral solenidion of tarsi I and II generally setiform. Parambulacral setae on tarsus IV often pectinate or divaricate, in males medial pas long and plumose. Tarsi with rod-like carpite between tip of tarsus and median sclerite. Paired claws either smooth, with a J-shaped pecten or with an accessory process, the latter may be widened and armed with more than 20 tines. Central sclerite never with a large claw-like hook.

***Type species.* –** *Rhombognathus notops* (Gosse, 1855).

Rhombognathus lathridius Bartsch, 2000
(Figs. 65–69)

Rhombognathus lathridius Bartsch, 2000: 174–179, Figs. 7A–J, 8A–H.

***Material examined.* –** One female, one male, ZRC.ARA.718, Singapore, Lazarus Island, coarse surface sediment, just above low water edge, 3 Oct.2004; one female, SMF, same collection data; one male, one female, ZMH, same collection data.

***Supplementary description*. –** Length of female 246–267 µm, of male 238–252 µm. Dorsal plates evenly and delicately punctate. Shape of dorsal plates as outlined (Fig. 65). OC with single cornea. Pair of setae of PD at 0.27–0.31. Adanal setae on pedestals. All ventral plates fused. Area of AE with 1–2 pairs of adjunct setae. PE with 2 adjunct setae. Female GO surrounded by 5(–4) pairs of pgs (Fig. 66); distance between anterior margin of GO and margin of camerostome 2.3–2.4 times length of GO. In male distance between small GO and margin of camerostome 4.8 times length of GO. Perigenital setae plumose, in triangular

arrangement; basilar setae posterior to level of end of GO (Fig. 67). Gnathosoma 80–82 µm long, 1.6 times longer than wide (Fig. 68). Tectum arched. Legs distinctly shorter than idiosoma. Telofemora flattened, 1.1–1.2 times longer than high. Dorsal seta on basifemora plumulose (Fig. 69). From leg I to IV basifemora with 2 setae; telofemora with (4–)5/2, 5/2, 3/1, 3/1 dorsal/ventral setae and tibiae with 2, 1, 1, 2 bipectinate setae; bipectinate setae wide. Claws smooth.

***Remarks*. –** *Rhombognathus lathridius* is very similar to *R. caudiculus* Bartsch, 1983 and *R. latibulus* Bartsch, 1993, the former is known from the Philippines, the latter from Rottnest Island, off Perth, Western Australia (Bartsch, 1983b, 1993c). In the three species the anterior margin of the idiosoma is slightly hood-like, the adanal setae are on small pedestals, the legs are short, the telofemora flattened, hardly longer than wide, the claws smooth and the gnathosoma is slender.

Rhombognathus lathridius and *R. latibulus* differ in presence (*R. lathridius*) versus absence (*R. latibulus*) of a cornea on the OC and the number of setae on the telofemora and genua (telofemora with 5/2, 5/2, 3/1, 3/1 dorsal/ventral and genua with 3, 3, 4, 5 setae in *R. lathridius* versus 3–4/2, 4/2, 2/1, 2/1 and 3–4, 3, 3, 2 in *R. latibulus*). *Rhombognathus lathridius* and *R. caudiculus* both have a cornea on the OC and share the number of setae on telofemora and genua; differences are in the length and shape of the PD (anterior part slender, triangular in *R. lathridius* versus anterior margin of PD arched in *R. caudiculus*), the number of adjunct setae on the PE (two, rarely one, in *R. lathridius* versus one seta in *R. caudiculus*), and the position of the basilar setae (distinctly posterior to the level of end of GO in *R. lathridius* versus almost level with end of GO in *R. caudiculus*).

***Distribution and ecology*. –** Records are from the tropical Australia (Great Barrier Reef, Queensland, Dampier Archipelago, Western Australia) (Bartsch, 2000, 2005c) and Singapore. Because of its shape (anterior idiosoma with small hood, integument of plates uniformly smooth, leg segments wide and flattened) and the collecting data (sandy deposits) the species is classified as psammophilous.

Rhombognathus *species in Singapore*. – Five species are now known from the Singapore area, *Rhombognathus aspidotus* Bartsch, 2006, *R. bulbosus* Bartsch, 2005, *R. major* Bartsch, 2005, and *R. scutulatus* Bartsch, 1983, and the above mentioned *R. lathridius*. Another three species were found amongst low tide algae. The four first-mentioned species are larger than *R. lathridius*. *Rhombognathus scutulatus* and *R. aspidotus* are common on middle and lower tidal and subtidal algae, sporadically they are also found in sediment samples. *Rhombognathus bulbosus* is a species of the upper littoral, most likely restricted to the delicate cover of green algae under the canopy of mangroves (Bartsch, 2005b). The present records of *R. major* are from Singapore (Bartsch, 2005b) and Moreton Island (Queensland, Australia) (Bartsch, 2009), the species seems to be restricted to *Bostrychia* turf (Rhodophyta) growing in the middle and upper half of the tidal area.

Scaptognathides Monniot, 1972

***Diagnosis*. –** AD and PD large, OC much smaller. AD rectangular to hexagonal; first pair of gland pores in truncate anterior margin. OC with 1 or 2 gland pores, rarely with a minute seta. PD with (1–)2 pairs of gland pores. Dorsum with 6 pairs of setae; ads on anal plate. AE with 3 pairs of setae and minute pair of epimeral tubes. PE with a dorsal and 3 ventral setae. Females with 2 pairs of pgs and 0–1 pairs of sgs. Males with 7–16 pairs of pgs, included the pair of outlying setae. Male genital sclerites with 3 pairs of sgs. Length of gnathosoma about half that of idiosoma. Gnathosomal base quadrangular. Rostrum slender, parallel-sided, as long as or somewhat longer than gnathosomal base. One pair of maxillary setae inserted on gnathosomal base near rostral base, 1 pair near apex of rostrum. Palps 2-segmented, P-2, P-3 and P-4 fused. Palps inserted laterally, separated from each other by more than width of P-1, and extending to end of rostrum. Second palpal segment with 1 ventral seta in basal half and 3 setae plus 4 spines at end of segment. Spines level with apex of rostrum. Leg I distinctly larger than following legs. Telofemur I long, tibia I longer than genu but less than half length of telofemur and often shorter than tarsus I. Genua of all legs shorter than tibiae. Tibiae I to IV each with pair of short bristle-like ventral setae. Tarsi I and II each with 3 dorsal setae, 1 dorsolateral solenidion and 0 ventral setae; tarsi III and IV with 3–4 and 3 dorsal setae, respectively, both tarsi lack ventral setae. Tarsus I with pair of large claws; their pectines with umbrella-like arranged tines. On following legs tines of claw pecten arranged along ventral flank of claw.

***Type species*. –** *Scaptognathides planus* Monniot, 1972.

Scaptognathides hawaiiensis Bartsch, 1988
(Figs. 70–74)

Scaptognathides hawaiiensis Bartsch, 1988: 221, 222, Figs. 27–30; Bartsch, 1991: 59, Fig. 1A–H; Bartsch, 2003: 32–34, Fig. 7A–D.

***Material examined*. –** One female, ZRC.ARA.719, Singapore, Lazarus Island, subsurface unsorted sediment, low water edge, 3 Oct.2004; one female, one protonymph, ZMH, same collection data.

One female, SMF, St John's Island, southwestern part, surface sediment, low water edge, 2 Oct.2004.

***Supplementary description*. –** Length of female 153–157 µm. Dorsal plates delicately and scatteredly punctate. AD with 3 pairs of minute dorsal setae (ds-1, ds-2 and ds-3). OC triangular, with single gland pore (Fig. 70). PD with single pair of gland pores. In female anterior margin of GA arched. Interval between anterior margin of GO and that of GA 1.3 times length of GO (Fig. 71). With 2 pairs of internal genital acetabula. Gnathosoma somewhat less than half length of idiosoma, its length 72–77 µm, width 41–45 µm, outline as illustrated (Fig. 74). Chelicera with minute claw (Fig. 73). Telofemur I 2.3 times longer than tibia I (Fig. 72).

Integument of telofemur I reticulated with narrow, oblong polygons. Claws on tarsi II to IV with 1–2 basal tines.
One of females with large egg, 55–57 µm in diameter. Surface of egg densely papillose.

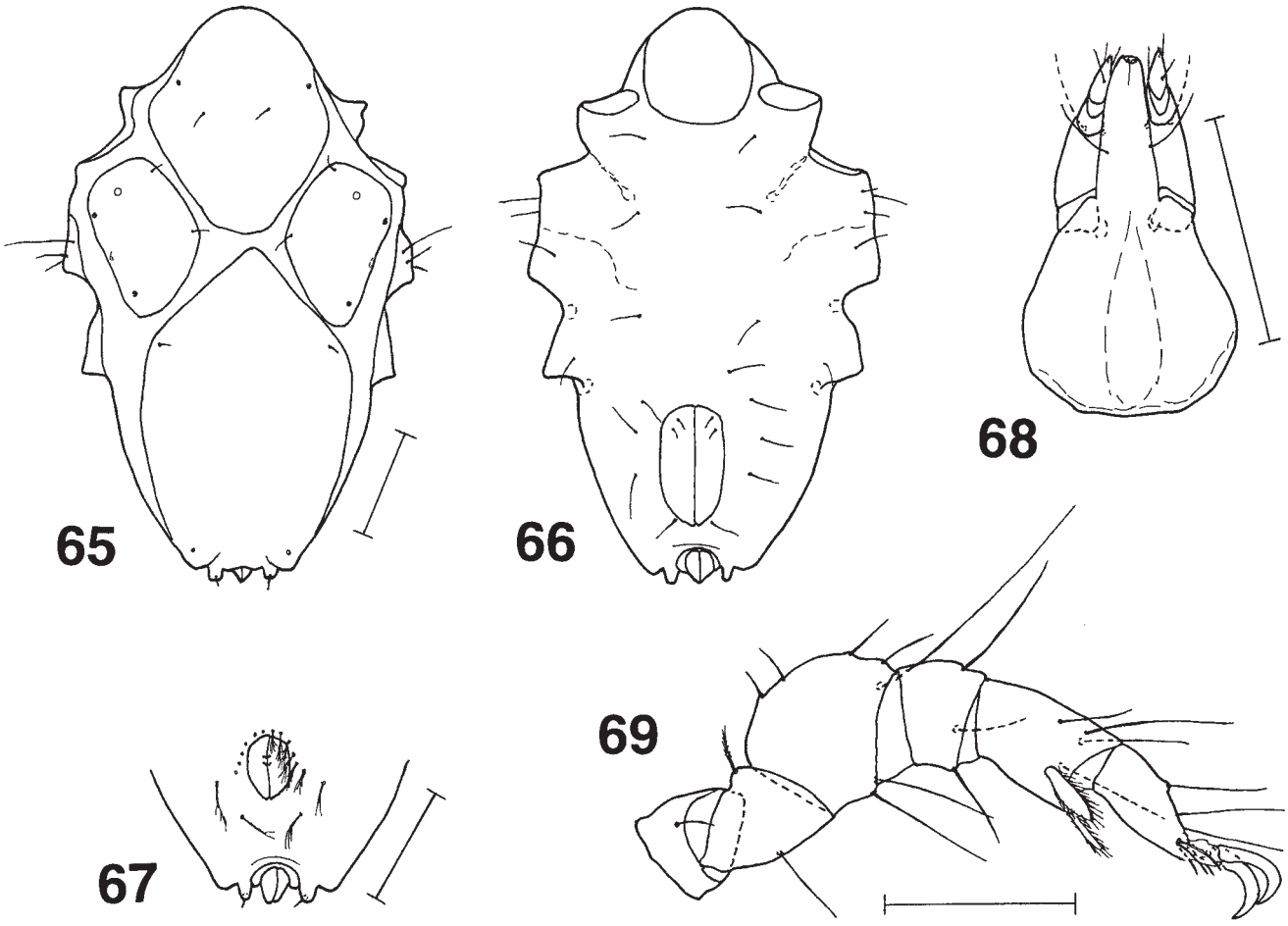
***Remarks*. –** Beside the shape and ornamentation of the dorsal and ventral plates *Scaptognathides* species are separated with help of the number of gland pores on the OC and PD. A single gland pore on the OC, as in the specimens from St John's and Lazarus Islands, is present in *S. australis* Bartsch, 1993, *S. hawaiiensis*, *S. heraldensis* Otto, 2000, and *S. tomkinsae* Otto, 2000. *Scaptognathides australis*, with records from Western Australia (Bartsch, 1993e), is characterized by its very slender OC which are at least four times longer than wide. In most (not all) of the other described species, the OC are about twice as long as wide. *S. tomkinsae*, from the Great Barrier Reef, eastern Australia (Otto, 2000b), can be discriminated from the other species on the basis of the minute seta in the posterior part of the OC. *Scaptognathides heraldensis* has two pairs on gland pores in the lateral margins of the PD, *S. hawaiiensis* a single pair of pores.

***Distribution and ecology*. –** *Scaptognathides hawaiiensis* was first described from the Hawaiian Islands (Bartsch, 1988). It proved to be abundant in tidal beaches of the Tolo Channel, Hong Kong, Southern China and was also found in Dampier, tropical Western Australia (Bartsch, 1991, 2003). All records are from coarse sediment of tidal beaches.

Scaptognathides *species in Singapore*. – No other representative of this genus was found.

Scaptognathus Trouessart, 1889

***Diagnosis*. –** Idiosoma flattened, with large AD and PD and small OC. AD and PD panelled or porose. AD, OC and PD each with pair of gland pores. Dorsum with 7, rarely 6 pairs of small dorsal setae; no setae close to anal cone. Ventral plates large. AE with epimeral pores. Female GA bipartite or tripartite (divided into 2 or 3 differently ornamented areas), rarely uniform. Posterior portion of female GA with 2–4 pairs of pgs; majority of species with (0–)2 pairs of sgs. Male GA either uni- or bipartite, rarely coarsely striated



Figs. 65–69. *Rhombognathus lathridius* Bartsch, 2000: 65, idiosoma, dorsal, female; 66, idiosoma, ventral, female; 67, genital area, male; 68, gnathosoma, ventral, male (setae on P-2 in broken line); 69, leg I, medial, female. Scale bars = 50 µm.

areola separated. Male GA with 12–40 pgs and 2–3 pairs of sgs. Length of gnathosoma half to almost same length of idiosoma. Rostrum spatula-shaped or wide and lamellar, apex truncate. Both pairs of maxillary setae inserted in posterior half of rostrum; 2 pairs of rostral setae in lateral and medial margin of apex. Palps inserted dorsally; interval between P-1 less than their width. Palps extending to end of rostrum, 2-segmented (P-2, P-3 and P-4 fused), rarely seemingly 3-segmented. Palpal shaft (corresponding to P-2) with 1 basal and 1 distal seta; apex of palp (corresponding to P-3 and P-4) with 2 large spines, 2 long setae, its tip with 1 setula and 2 spinelets. Legs slender. Genua shorter than adjoining segment. Telofemora I to IV with 0–3, 0–2, 0, 0 bipectinate setae, dorsal or dorsomedial in position. Genua I to IV with 0–2, 0–1, 0, 0 bipectinate ventral setae. Tibia I with 3–6 bristle-like bipectinate ventral setae. Tibiae II to IV with 2–4 ventral setae, 1–4 of setae bipectinate. Tarsus I with 3 dorsal setae, dorsolateral solenidion and famulus, 0–1 bipectinate ventral setae plus 0–1 short ventral setae. Tarsus II with 3 dorsal setae, a dorsomedial solenidion and 0–1 bipectinate ventral setae. Tarsi III and IV with 3–4 and 3 dorsal setae, respectively, and 0 ventral setae. All tarsi with pair of pas. Paired claws large; claw-like process of central sclerite minute or almost half length of paired claws.

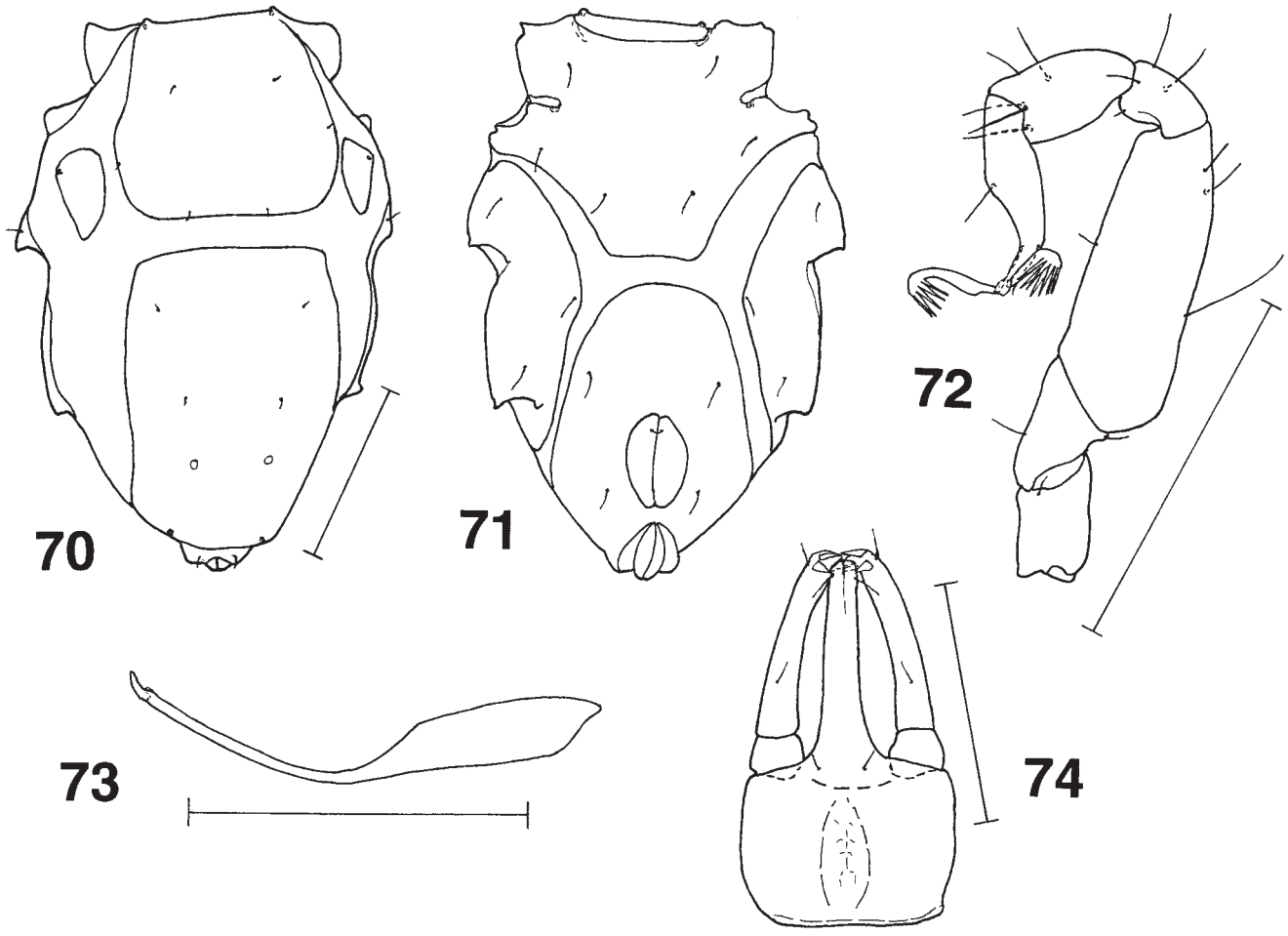
***Type species.* –** *Scaptognathus tridens* Trouessart, 1889.

Scaptognathus exquisitus Otto, 2000
(Figs. 75–79)

Scaptognathus exquisitus Otto, 2000b: 539–543, Fig. 4A–I; Bartsch, 2003: 35, 36, Fig. 8A–E.

***Material examined*. –** One female, ZRC.ARA.720, Singapore, Lazarus Island, subsurface unsorted sediment, low water edge, 3 Oct.2004.

***Supplementary description*. –** Length of female 220 µm. AD and PD pitted, pits faintly arranged in polygons (Fig. 79). Posterior margin of AD wide, truncate to arched; integument almost smooth around glp-1 and ds-1 (Fig. 75). OC about as long as wide. Pairs of ds-1 and glp-1 at almost same level. Pairs of ds-2 to ds-5 in membraneous integument. Ornamentation of ventral plates same as that of dorsal plates. Female GA bipartite (Fig. 76), both parts almost equal in length. Posterior part of GA with 2 pairs of pgs; genital sclerites with single pair of sgs. Length of gnathosoma 170 µm or 0.77 of that of gnathosoma. Rostrum



Figs. 70–74. *Scaptognathides hawaiiensis* Bartsch, 1988, female: 70, idiosoma, dorsal; 71, idiosoma, ventral; 72, leg I, medial; 73, chelicera; 74, gnathosoma, ventral. Scale bars = 50 µm.

shorter than gnathosomal base. Lateral flank of basi- and telofemora with small, deep foveae (Fig. 77). Telofemur I 2.6 times longer than high. Telofemur to tarsus I with 2, 2, 5, 1 bipectinate setae (Fig. 78), genu to tarsus II with 1, 2, 1 bipectinate setae, tibiae III and IV both with 3 bipectinate setae. Bipectinate setae on telofemur I at 0.4 and 0.6. Claws with accessory process.

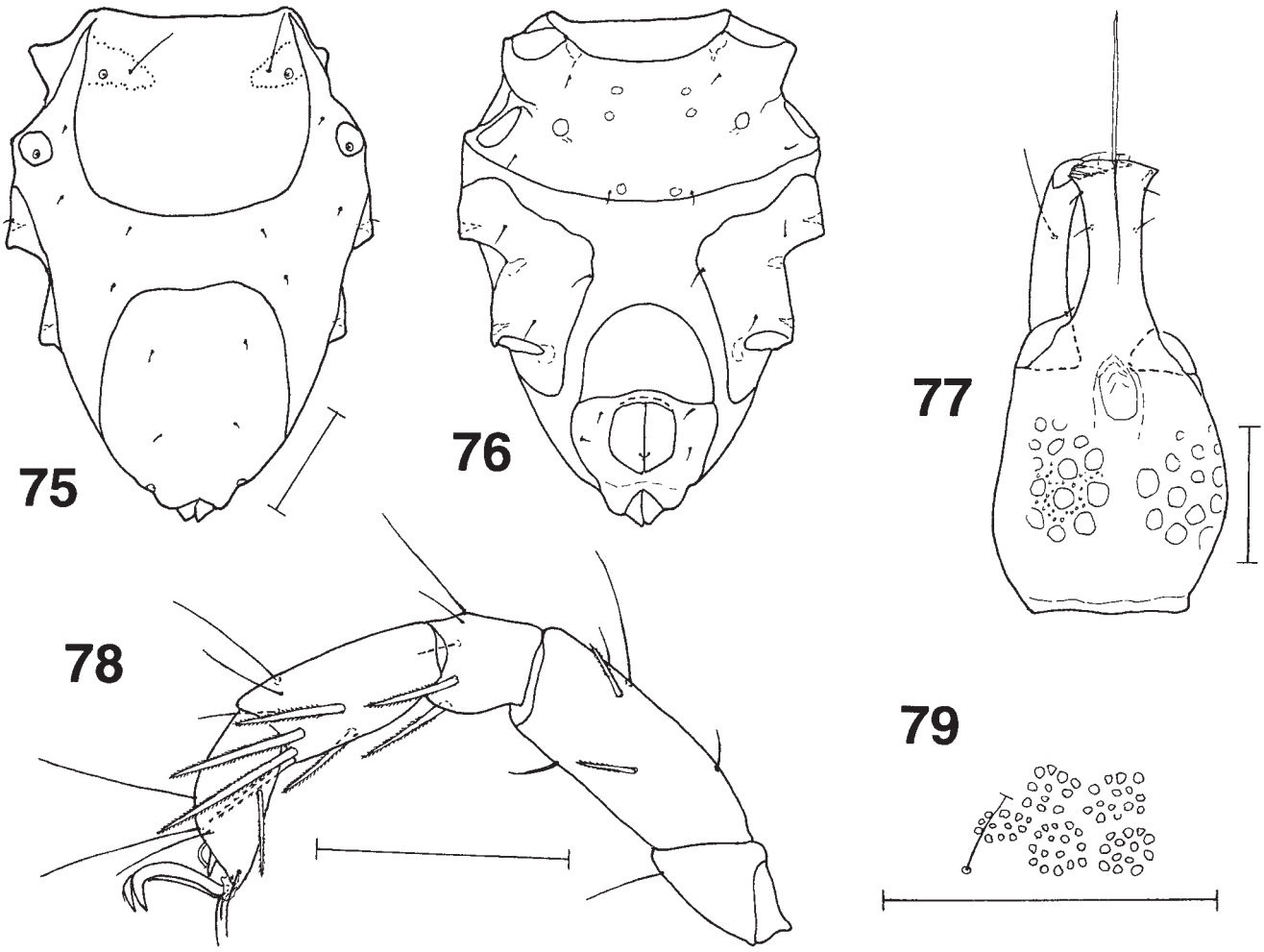
***Remarks*. –** *Scaptognathus exquisitus* and *S. australis* Bartsch, 1993 share the size of idiosoma and gnathosoma, the shape and ornamentation of dorsal and ventral plates, and the number and arrangement of bipectinate setae on telofemur I and on the genua, tibiae and tarsi of legs I to IV. Both species are known from Australia, from the north-eastern and south-western coastline, respectively (Bartsch, 1993e; Otto, 2000b). The differences are small, namely in the number and arrangement of the dorsal setae, female perigenital setae and subgenital setae and the shape the dorsal seta on telofemur II.

***Distribution and ecology.* –** Previous records are from the tropical Australia, from the Dampier Archipelago, Western Australia and Great Barrier Reef, Queensland (Otto, 2000b; Bartsch, 2003). In samples from the Great Barrier Reef this was the most widespread and abundant *Scaptognathus* species. All records are from sandy deposits, mostly from shallow sublittoral, from the low water edge to 13 m depth.

Scaptognathus *species in Singapore.* – No other representative of this genus was found.

Simognathus Trouessart, 1889

***Diagnosis.* –** Dorsal and ventral plates strongly sclerotized; parts of plates may have a dark-brown pigmentation. Integument of large AD and PD often foveate or porose. OC smaller than AD and PD, either distinct, rounded or subtriangular in shape, or largely reduced, elongate. Gland pores minute or vestigial. Pairs of ds-1 and ds-3 usually on AD, ds-4 and ds-5 on PD; ds-6 on anal cone, either in dorsal or ventral position. AE with 3 pairs of ventral setae and a pair of epimeral vesicles. PE with a dorsal and 3 ventral setae. Female GA with 4–5 pairs of pgs, no sgs. Males with approximately 10–25 pairs of pgs arranged around GO and 0–3 pairs of outlying pgs; genital sclerites with 3 pairs of sgs.



Figs. 75–79. *Scaptognathus exquisitus* Otto, 2000, female: 75, idiosoma, dorsal; 76, idiosoma, ventral; 77, gnathosoma, ventral; 78, basifemur to tarsus I, medial; 79, part of AD with ds-1. Scale bars = 50 µm.

Perigenital setae filiform or plumose. Gnathosoma broadly attached to idiosoma. Gnathosomal base almost spherical, rostrum short, conical. Rostrum shorter than gnathosomal base. One pair of maxillary setae near base of rostrum, 1 pair close to tip of rostrum. Palps attached to gnathosoma dorsally. Palps 3-segmented. Second palpal segment with 1 ventral seta, and often with quadrangular ventral apophysis. Telofemora and tibiae large; genua short, almost spherical. Tibia I clavate and larger than tibiae of following legs. Tarsus I short, length:height ratio 1.2–3.1:1; tarsi II to IV at least 3 times longer than high. Tibia I with large, wide ventral spine. Ventromedial seta of tibia I slender, rarely spiniform or bipectinate. Tibiae II, III and IV with 2 pectinate ventral setae. Tarsus I with 3 dorsal setae, dorsolateral solenidion, and a strong, often spiniform ventral seta; apically with pair of pas. Median claw of tarsus I large, smooth, in general flanked by scythe-shaped or setiform paired claws. Tarsi II to IV with large paired claws; minute central sclerite without or with small claw-like process.

Type species. – *Simognathus minutus* (Hodge, 1863).

Simognathus actius Otto, 2000
(Figs. 80–90)

Simognathus actius Otto, 2000a: 511–513, Fig. 5A–E, 6A–D.

Material examined. – One female, ZRC.ARA.721, Singapore, Lazarus Island, sediment between gravel, just above low water edge, 3 Oct.2004; one deutonymph, ZMH, same collection data. One male, ZRC.ARA.722, Singapore, Lazarus Island, subsurface unsorted sediment, low water edge, 3 Oct.2004; one female, SMF, same collection data; one male, author's collection, same collection data.

Supplementary description. – **Adults**: Length of female 234–250 µm, of male 227–242 µm. OC absent (Fig. 80). AD and PD with delicate foveae, 2–3 µm in diameter and separated from each other by slightly more than their diameter. Opposing margins of AD and PD arched. Dorsal setae delicate, ds-2 in membraneous integument. Ventral plates marginally with delicate foveae, ca 4 µm in diameter; large median portions surficially almost smooth. Female with 4 pairs of pgs (Fig. 81), males with 10 pairs, none outlying (Fig. 82). Perigenital setae slender, smooth. Base of gnathosoma foveate (Fig. 83). P-2 with ventral seta and narrow ventral lamella but without apophysis (Fig. 84). Tectum triangular. Integument of telofemora almost smooth. Tibia I about twice as long as high; with a narrow base, then abruptly increasing in height (Fig. 88); posterior two-third almost equal in height; ventral spine apically blunt. Ventromedial seta on tibia I flattened, plumose, almost 25 µm in length (Fig. 85). Tarsus I short; length hardly more than twice the height; with tapering ventral spine and pair of pas, dorsally with solenidion, famulus and 3 fossary setae, all in apical half of tarsus (Fig. 87); paired fossary setae very close to claw. Median claw with ventral notch (Fig. 86). Two ventral setae on tibiae II to IV spiniform and bipectinate. Tarsi II to IV longer than tarsus I; each tarsus with 3 dorsal setae and 1 ventral seta. Median claw of tarsi II to IV minute; paired claws slender, without accessory process, claws of tarsi II and III with tines along arc of claw but none on shaft; pectines with delicate tines.

Deutonymph: Length of idiosoma 239 µm. Dorsal plates delicately foveate. PD much smaller than in adults. Pair of ds-2, ds-3 and ds-4 in membraneous integument (Fig. 89), ds-5 in anterior margin of PD. Parts representing epimera III and IV connected (Fig. 90).

Remarks. – Species of the genus *Simognathus* can roughly be divided into those species which bear distinct, round or triangular OC and those with narrow, elongate or reduced OC which are more or less obscured by the rough striae of membraneous integument. In *S. actius* the OC are reduced, the small internal spots are obviously attachment spots of muscle strings. Tarsus I of *S. actius* is short, it bears a tapering ventral seta, a pair of pas singlets, the three dorsal fossary setae, the solenidion, and the median claw. Lateral claws were not recognized and none are illustrated in Otto (2000a: fig. 6A). In general, tarsus I of *Simognathus* ends with a stout, long median claw which is flanked by the paired claws which are about as long as the median claw but much more slender, sometimes as slender as the dorsal fossary setae. *Simognathus actius* differs from other *Simognathus* species because of the absence of paired claws on tarsus I, the very reduced OC and the plumose seta on tibia I.

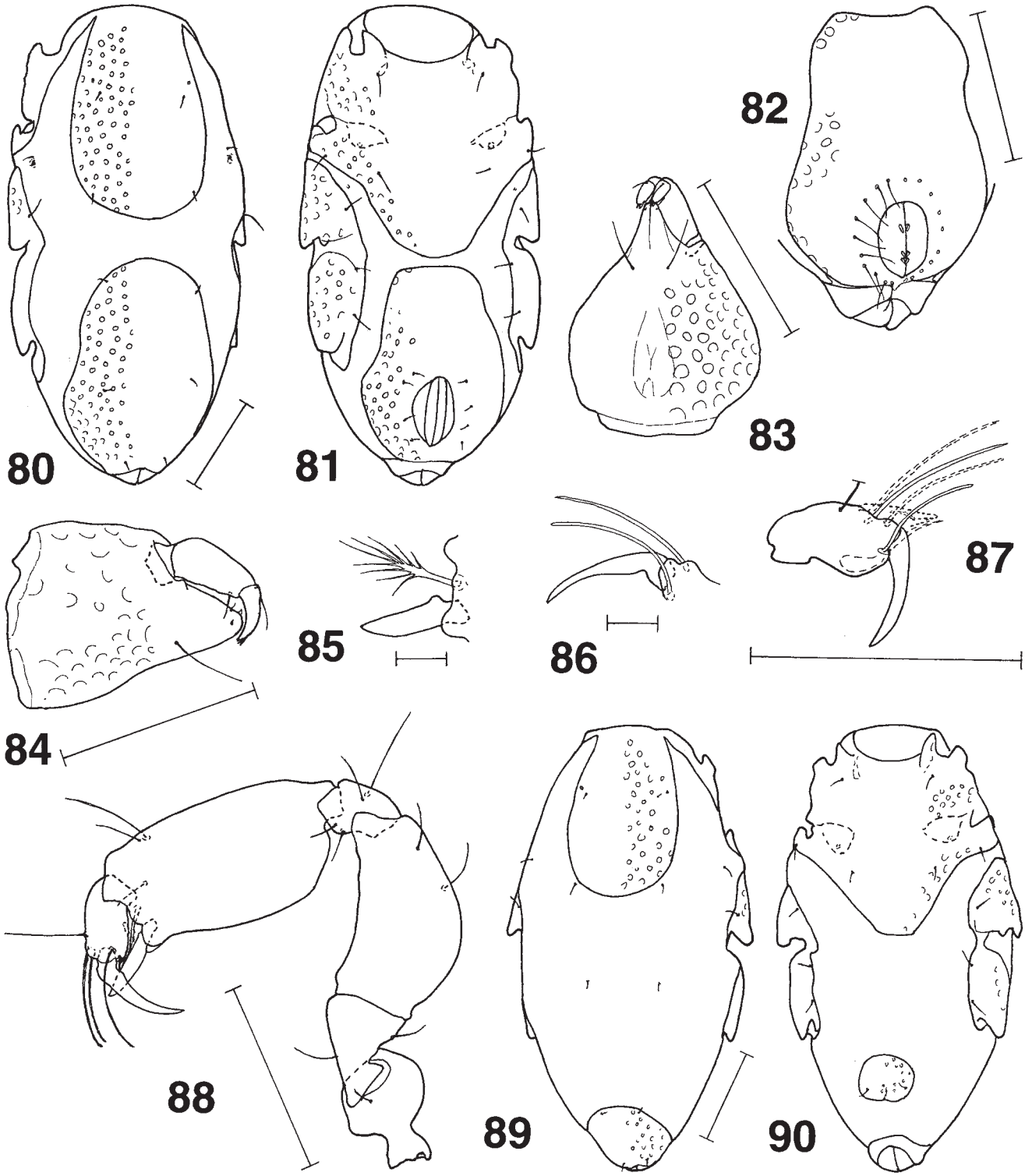
Acaromantis is a genus most similar to *Simognathus*, but its tarsus I is short and ends with a single median claw, the OC are always reduced to minute, elongate sclerites within the coarsely striated membraneous integument, and the palps are two-segmented, their second segment bears a stout ventral and a mid-segmental dorsal seta. *Simognathus actius* shares with *Acaromantis* the character that tarsus I bears a single median claw but differs in that its palps are three-segmented and have a dorsal seta on the third segment.

The epimera III and IV often are distinctly raised, obscuring the remainder of plate. In *S. tropicalis* Chatterjee & De Troch, 2000 the epimera are said to be separated by membraneous integument (Chatterjee & De Troch, 2000: 189). Adult *S. actius* have epimera III and IV broadly fused, whereas in the deutonymph the connecting part is narrowed by wedges of membraneous integument.

Distribution and ecology. – *Simognathus actius* was first described from the Great Barrier Reef where it had been extracted from intertidal sandy beaches (Otto, 2000a). The specimens from Singapore also are from tidal beach areas. Locally they may be abundant and dominate the halacarid fauna.

Simognathus fuscus Viets, 1936
(Figs. 91–97)

Simognathus fuscus Viets, 1936: 421–423, Figs. 50–54; Pepato & Tiago, 2004: 11–15, Figs. 6A–J, 7A–K



Figs. 80–90. *Simognathus actius* Otto, 2000: 80, idiosoma, dorsal, female; 81, idiosoma, ventral, female; 82, genitoanal plate, male; 83, gnathosoma, ventral, female; 84, gnathosoma, lateral, deutonymph; 85, ventromedial seta of tibia I, male; 86, tip of tarsus I with claw, medial pas and dorsomedial fossary seta, female; 87, tip of tarsus I, dorsomedial, female (lateral pas, dorsolateral fossary seta, fossa membrane with solenidion, and ventral seta in broken line); 88, leg I, medial; 89, idiosoma, dorsal, deutonymph; 90, idiosoma, ventral, deutonymph. Scale bars: 80–84, 87–90 = 50 µm; 85, 86 = 10 µm.

Simognathus platyaspis Otto, 2000a: 519–521, Figs. 14A–D, 15 A–D; Bartsch, 2003: 36, 37, Figs. 9A–F. (new synonymy).

***Material examined*. –** One female, ZRC.ARA.723, Singapore, Lazarus Island, coarse surface sediment, just above low water edge, 3 Oct.2004. One female, SMF, Singapore, St John's Island, southwestern shore, algal hapteres, low water edge, 1 Oct.2004. One female, ZMH, same collection data.

***Supplementary description*. –** Length of female 311–349 µm. Dorsal plates foveate. Integument in posterior part of AD brown. OC ovate or almost round in outline (Figs 91, 93). Pair of ds-2 in membraneous integument, ds-1, ds-3, ds-4 and ds-5 on dorsal plates; ds-6 on GA in ventral position. Central part of AE evenly foveate (Fig. 92); integument in anterior part of GA lack foveae. Second palpal segment with a ventral protuberance and separate seta (Figs 94, 95). Tectum triangular (Fig. 96). Ventral seta on tibia I tapering (Fig. 97); ventromedial seta smooth. Tarsus II with 1 ventral seta and pair of pas, tarsi III and IV each with 1 ventral seta and single pas. Tarsus I with large median claw, scythe-shaped, slender paired claws and pair of long pas. Paired claws of tarsi II to IV each with accessory process; no pecten on shaft; central sclerite with minute claw-like process.

***Remarks*. –** *Simognathus fuscus* has rather large OC, the second palpal segment bears a ventral protuberance, the seta is distal to that protuberance, the ventral spine on tibia I is tapering, the ventromedial seta slender, and the tarsi III and IV bear a single pas and a ventral seta. Nineteen out of the 45 species known (Bartsch, 2005a; Rivas, 2006) have a similar combination (in some of these species no information is given on the number of setae of tarsi III and IV). The integument in the posterior part of the AD is brown. A similar coloration is commonly present in *Simognathus* species which live in tropical and warm-temperate waters. It is not known whether the colour is a permanent character, dependent on environment, age of the adults or preservative agens. Hence the colour is not used for species discrimination.

Specimens collected on the Great Barrier Reef, Australia, and described as *S. platyaspis* (Otto, 2000a) shares the above mentioned characters as well as the almost uniform foveation of the AE. Otto (2000a) used the length:width ratio of the AD to discriminate between *S. fuscus* and *S. platyaspis*, but that ratio is dependent on the mounting. The idiosoma of *Simognathus* species is rather cylindrical, though the venter flattened. The mounted specimens studied by Otto in general are strongly pressed, hence much wider than in life. The shape of the OC proved to vary from oblong to round and cannot be used for discrimination. All specimens from Singapore have the ds-2 in the membraneous integument anterior to the OC whereas in specimen from Australia (Great Barrier Reef) the ds-2 either insert in the corner of the OC or anterior to the OC (Otto, 2000a: 521, fig. 14A; Bartsch, 2003: Fig. 9A).

***Distribution and ecology*. –** According to present data, *S. fuscus* inhabits the warm-temperate and tropical Atlantic (Brazil and Caribbean Sea) (Viets, 1936; Pepato & Tiago, 2004a), the Pacific (Great Barrier Reef) (Otto, 2000a) and the adjacent South China Sea (the Philippines, NW Australia, Singapore) (Bartsch, 2005a). The species is commonly found in coarse sandy surface deposits, but also amongst algal turf.

Simognathus *species in Singapore*. – A third *Simognathus* species was found amongst algae.

BIOGEOGRAPHICAL REMARKS

Singapore is a part of the Indo-West Pacific region, a biogeographical region that includes the shelves of the tropical and subtropical portion of the Indian Ocean and the western and central part of the Pacific. Its marine fauna is characterized by a remarkable species diversity and a wide geographical range of many of these species (Ekman, 1953, Briggs, 1995). The centre of the Indo-West Pacific region, corresponding to an area from the Malay Peninsula to the Philippines and New Guinea, is said to be a hotspot with a species richness that exceeds that known from other areas, at least according to analyses of molluscs, echinoderms, reef corals and fishes (Ekman, 1953; Briggs, 1999, 2000, 2003, 2005; Hughes et al., 2002). But as demonstrated by Bouchet et al. (2002), intense sampling may considerably increase the number of species known from a given region and change the dominance in species richness. After a massive collecting and sorting effort, the number of mollusc species on the west coast of New Caledonia (which lies outside the centre of the Indo-West Pacific) proved to be far beyond that recorded from other areas (Bouchet et al., 2002).

The halacarid fauna of the shores of Singapore was sampled in a period of about 15 days. The result is summarised in Table 1. In the table listed are the above described species from St John's and Lazarus Island, previously published records from Singapore and also unnamed and unidentified species. In all 39 species are listed, 23 identified and 16 still unidentified species. The list is of course not complete but gives a basis for a faunal comparison with other geographical regions. The number of almost 40 halacarid species is not strikingly high. In the course of a collecting program similar to that in Singapore (same collecting effort, time and extracting methods), more than 80 halacarid species were found on Rottnest Island, warm-temperate Western Australia (Bartsch, 2007) and more than 70 species in the Roscoff area, France, coast of English Channel, temperate North Atlantic (Bartsch, 2004). Almost 100 published species was the result of about two years sampling on the Great Barrier Reef, Queensland done by J. C. Otto, and many more still unpublished species and records are in the material collected by him (pers. obs.). The halacarid fauna of Singapore is by far not as rich in species as in the nearby tropical north-eastern and warm-temperate south-western Australia, and not as diverse as in the temperate north-eastern Atlantic.

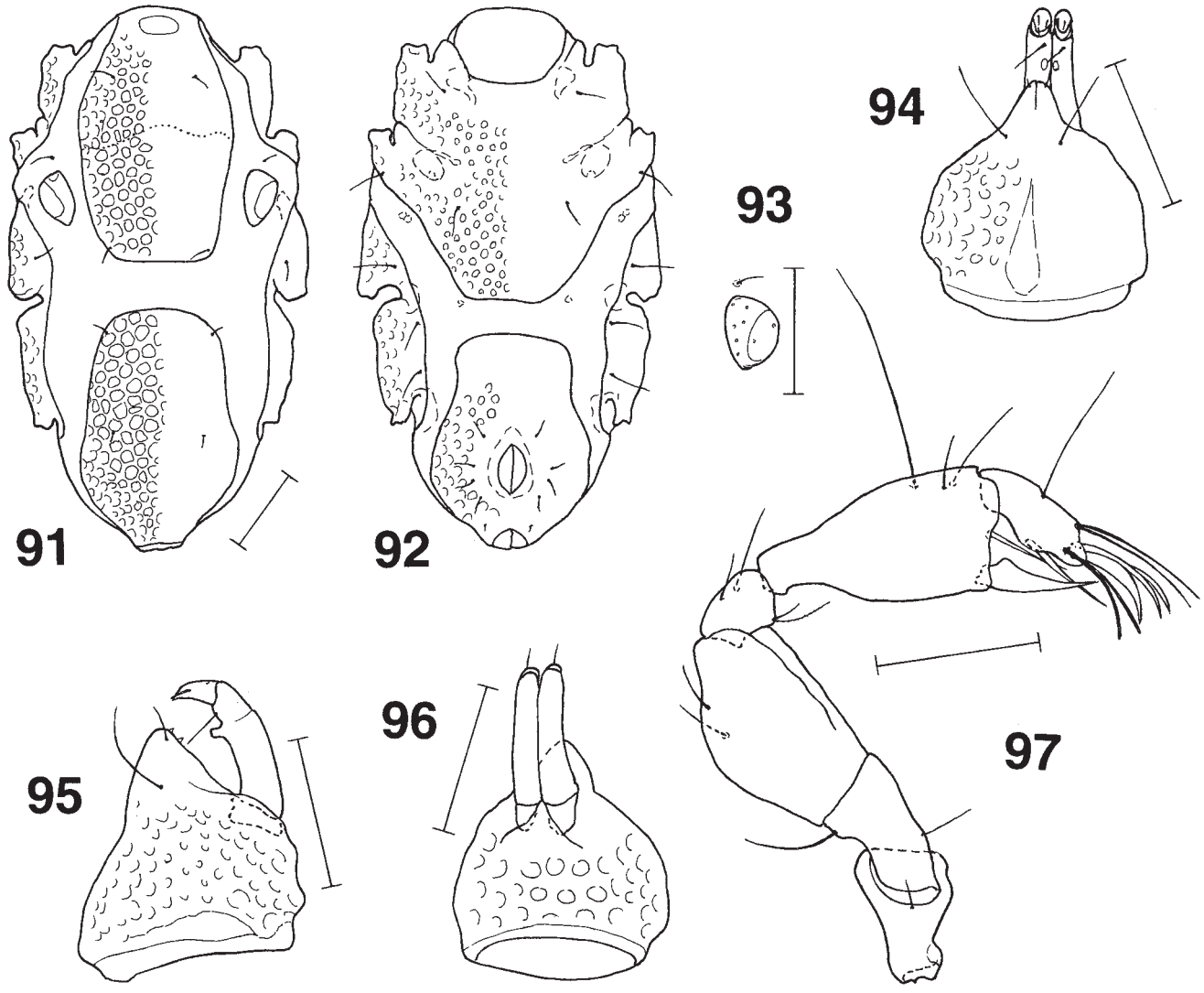
The fauna of Singapore is within a magnitude commonly

found, the diversity is similar to the slightly more than 40 halacarid species mentioned from Esperance, southern coast of Western Australia (Bartsch, 2007) and the 40 species from Hong Kong (Bartsch, 2004; 35 identified species and about 5 unpublished species in the author's slide collection). The collecting and extracting time and methods were about the same in Singapore, Esperance and Hong Kong. In a biogeographical aspect, the waters around Singapore are no part of a halacarid hotspot area. Further investigations will of course raise the number of species known from Singapore, but more collections in other areas will add species to their faunas, too.

Singapore is one of the most densely populated countries in the world with intense industrial and shipping activities, the biota of the shores is inevitably exposed to pollution (despite strict legislation). It is unknown if the halacarid fauna is reduced due to human impact. The visible pollution, e.g. oil spills, seemed to be in an order of magnitude commonly found on shores. Halacarids in general are known to withstand environmental challenges (Bartsch, 1974). There was no evidence (high percentage of morphological anomalies or intense fouling) that the halacarid fauna was seriously affected by pollution. Accordingly, the given number of species from Singapore seems to present reliable data on species diversity in this geographical region.

The Indo-West Pacific region is characterized by a faunal homogeneity as many of the species have an enormous range in their distribution, on the other hand there is a high number of endemisms (Ekman, 1953, Briggs, 1995). The knowledge of the halacarid fauna of the Indo-West Pacific region is far from complete, given records are often the result of only short-term sampling activities and large parts of the coastlines have never been studied in respect to their marine mite fauna.

Amongst the Singapore halacarid fauna wide-ranging species seem to dominate. The nine species not known from outside Singapore, out of the identified species (22



Figs. 91–97. *Simognathus fuscus* Viets, 1936, female: 91, idiosoma, dorsal (dotted line represents border between differently tinged areas); 92, idiosoma, ventral; 93, right ocular plate; 94, gnathosoma, ventral; 95, gnathosoma, lateral; 96, gnathosoma, dorsal; 97, leg I, medial. Scale bars = 50 µm.

named, one unnamed), are from poorly sampled habitats. *Acarothrix ampliumeris*, *Copidognathus rhombognathoides* and *Rhombognathus bulbosus* are expected to be restricted to mangroves, *R. bulbosus* to the sparse green algal cover in the upper tidal zone, *A. ampliumeris* and *C. rhombognathoides* to the tidal flat. The absence of records from outside Singapore is most likely due to a lack of adequate sampling in mangroves. *Agauopsis* sp. A, *Arhodeoporus nanus*, *Copidognathus macropus* and *C. viridulus* are psammobionts, and this habitat is under-represented in many collections; the species certainly will be found outside the Malay Peninsula. The present lack of records from outside Singapore is accordingly no evidence that these species are endemics, but due to a scarcity or absence of collections from relevant habitats.

Fourteen of the species taken on the coast of Singapore are also recorded from localities in and outside the centre of the Indo-West Pacific, and two species from outside the Indian and Pacific region. The two latter species, *Arhodeoporus bonairensis* and *Simognathus fuscus*, are spread from 76°E to 70°W and 104°E to 45°W, respectively. As the halacarid fauna of the tropical eastern Atlantic Ocean and western Indian Ocean is not or poorly known, it is impossible to say whether these two species are circum-tropical in their distribution or Indo-Pacific species which crossed the barrier between North and South America, either via small steps through a passage or via vectors. Of course, as in many other species once thought to be widespread, further investigations may show that there are several cryptic species.

Most of the fourteen species with records from outside Singapore are not restricted to the West Indies triangle. Records of eight species are from the Great Barrier Reef and seven species from the Dampier Archipelago and adjacent Montebello Islands, these are tropical environments as that of Singapore, records of three species are from the temperate Western Australia (Rottnest Island and Esperance). The Singapore halacarid fauna supports the idea of a basic homogeneity in the Indo West-Pacific fauna.

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LITERATURE CITED

André, M., 1937. Description de trois halacariens de Conchinchine. *Bulletin du Muséum histoire naturelle Paris, Série 2*, **9**: 206–211.

André, M., 1959. Acari I. Contribution a l'étude des halacariens de la Mer Rouge. In: *Mission Robert Ph. Dollfus en Égypte*, **XXVI**: 93–119.

Bartsch, I., 1974. Ein Beitrag zur Systematik, Biologie und Ökologie der Halacaridae (Acari) aus dem Litoral der Nord- und Ostsee. II. Ökologische Analyse der Halacaridenfauna. *Abhandlungen und Verhandlungen des naturwissenschaftlichen Vereins zu Hamburg, (Neue Folge)*, **17**: 9–53.

Bartsch, I., 1977. Interstitielle Fauna von Galapagos. XX. Halacaridae (Acari). *Mikrofauna des Meeresbodens*, **65**: 1–108.

Bartsch, I., 1983a. Zur Systematik und Verbreitung der Gattung *Arhodeoporus* (Halacaridae, Acari) und Beschreibung zweier neuer Arten. *Zoologische Beiträge*, **28**: 1–16.

Bartsch, I., 1983b. Zur Halacaridenfauna der Philippinen. Beschreibung von fünf Arten der Gattung *Rhombognathus* (Acari, Halacaridae). *Entomologische Mitteilungen aus dem Zoologischen Museum Hamburg*, **7**: 399–416.

Bartsch, I., 1985. Zur Halacaridenfauna (Halacaridae, Acari) der Philippinen. Beschreibung von drei neuen Arten. *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut*, **82**: 269–277.

Bartsch, I., 1988. Arenicolous Halacaridae (Acari) in Hawaiian waters. *Proceedings, Hawaiian Entomological Society*, **28**: 213–228.

Bartsch, I., 1990. *Acarothrix palustris* gen. et spec. nov. (Halacaroidea, Acari), ein Bewohner der Salzwiesen Südchinas. *Zoologischer Anzeiger*, **224**: 204–210.

Bartsch, I., 1991. Arenicolous Halacaridae (Acari) from Hong Kong. *Asian Marine Biology*, **8**: 57–75.

Bartsch, I., 1992. Two new species of arenicolous *Agauopsis* (Acari Halacaridae) from Hoi Ha Wan. In: Morton, B. (ed.), *The Marine Flora and Fauna of Hong Kong and Southern China, III*. University Press, Hong Kong. Pp. 891–897.

Bartsch, I., 1993a. Halacaridae (Acari) von Malaysia. Beschreibung von drei Arten der Gattung *Copidognathus*. *Entomologische Mitteilungen aus dem Zoologischen Museum Hamburg*, **11**: 45–58.

Bartsch, I., 1993b. *Halacarus malaysius*, a new halacarid mite (Halacariden: Acari) from the island of Babi Besar, Peninsular Malaysia. *The Raffles Bulletin of Zoology*, **41**: 297–302.

Bartsch, I., 1993c. Rhombognathine mites (Halacaridae, Acari) from Rottnest Island, Western Australia. In: Wells, F.E., D.I. Walker, H. Kirkman & R. Lethbridge (eds.), *The Marine Flora and Fauna of Rottnest Island, Western Australia*. Western Australian Museum, Perth. Pp. 19–43.

Bartsch, I., 1993d. *Halacarus* (Halacaridae, Acari) from south-western Australia. In: Wells, F.E., D.I. Walker, H. Kirkman & R. Lethbridge (eds.), *The Marine Flora and Fauna of Rottnest Island, Western Australia*. Western Australian Museum, Perth. Pp. 45–71.

Bartsch, I., 1993e. Arenicolous Halacaridae (Acari) from Rottnest Island, Western Australia. In: Wells, F.E., D.I. Walker, H. Kirkman & R. Lethbridge (eds.), *The Marine Flora and Fauna of Rottnest Island, Western Australia*. Western Australian Museum, Perth. Pp. 73–103.

Bartsch, I., 1996. New records of *Actacarus* from the Caribbean area, and notes on the subfamily Actacarinae and its species (Arachnida: Acari: Halacaridae). *Senckenbergiana Biologica*, **75**: 229–241.

Bartsch, I., 1997a. Copidognathinae (Halacaridae, Acari) from Northern Australia; description of four new species. In: Hanley, J. R., G. Caswell, D. Megirian & H. K. Larson (eds.), *Proceeding of the Sixth International Marine Biological Workshop. The marine flora and fauna of Darwin Harbour, Northern Territory, Australia*. Western Australian Museum, Perth. Pp. 231–243.

Bartsch, I., 1997b. *Arhodeoporus* (Acari: Halacaridae) from Rottnest Island, description of three new species. *Acarologia*, **38**: 265–274.

Bartsch, I., 2000. Rhombognathinae (Acari: Halacaridae) from the Great Barrier Reef, Australia. *Memoirs of the Queensland Museum*, **45**: 165–203.

Bartsch, I., 2002. Halacarids from the Great Meteor Seamount (Northeastern Atlantic). Description of new species of the genera *Agauopsis*, *Atelopsalis* and *Halacarus* and redescription of *H. spiniger* Bartsch (Arachnida: Acari: Halacaridae). *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut*, **99**: 29–45.

Bartsch, I., 2003. Psammophilous halacarids (Halacaridae, Acari) from Dampier, Western Australia. Description of species and faunal comparison of the mesopsammal halacarid fauna of western and eastern Australia. *Records of the Western Australian Museum*, **22**: 23–45.

Bartsch, I., 2004. Geographical and ecological distribution of marine genera and species (Acari: Halacaridae). *Experimental and Applied Acarology*, **34**: 37–58.

Bartsch, I., 2005a. *Lohmannella* and *Simognathus* (Halacaridae: Acari) from Western Australia: description of two new species and reflections on the distribution of these genera. *Records of the Western Australian Museum*, **22**: 293–307.

Bartsch, I., 2005b. Upper littoral rhombognathines (Acari: Halacaridae: Rhombognathinae) of Singapore: description of three new species. *Cahiers de Biologie marine*, **30**: 1–18.

Bartsch, I., 2005c. The rhombognathine fauna of Australia (Rhombognathinae: Halacaridae: Acari) with notes on the fauna of Esperance Western Australia. In: Wells, F. E., D. I. Walker & G. A. Kendrick (eds.), *The Marine Flora and Fauna of Esperance, Western Australia, Australia*. Western Australian Museum, Perth. Pp. 375–397.

Bartsch, I., 2006a. A new species and new record of *Rhombognathus* from Singapore (Acari: Halacaridae). *Zootaxa*, **1120**: 41–49.

Bartsch, I., 2006b. Copidognathines (Acari: Halacaridae) in mangroves of Singapore. I. Description of three species. *The Raffles Bulletin of Zoology*, **54**(1): 83–92.

Bartsch, I., 2006c. *Agauopsis narinosa* Otto, 1999 (Acari: Halacaridae), a new record from Sri Lanka: complementary description. *Entomologische Mitteilungen aus dem Zoologischen Museum Hamburg*, **14**: 293–297.

Bartsch, I., 2007. Halacarid mites (Acari: Halacaridae) from Esperance, Western Australia: Notes on taxonomy and faunal distribution of non-Copidognathinae. *Records of the Western Australian Museum*, **23**: 359–392.

Bartsch, I., 2009. Six upper littoral halacarid mites (Acari: Halacaridae) from Moreton Bay, Queensland. Description of three new species and three new records. *Meiofauna Marina*, 17: 103–120.

Bouchet, P., Lozouet, P., Maestrati, P. & V. Heros, 2002. Assessing the magnitude of species in tropical marine environments: exceptionally high numbers of molluscs at a New Caledonia site. *Biological Journal of the Linnean Society*, **75**: 421–436.

Briggs, J. C., 1995. *Global Biogeography*. Elsevier, Amsterdam, 452 pp.

Briggs, J. C., 1999. Coincident biogeographic patterns: Indo-West Pacific Ocean. *Evolution*, **53**: 326–335.

Briggs, J. C., 2000. Centrifugal speciation and centres of origin. *Journal of Biogeography*, **27**: 1183–1188.

Briggs, J. C., 2003. Marine centres of origin as evolutionary engines. *Journal of Biogeography*, **30**: 1–18.

Briggs, J. C., 2005. The marine East Indies: diversity and speciation. *Journal of Biogeography*, **32**: 1517–1522.

Chatterjee, T. & C. Y. Chang, 2003. Halacaridae (Acari) from Thailand: One new and two known species of the genus *Copidognathus* Trouessart. *Korean Journal of Biological Sciences*, **6**: 201–206.

Chatterjee, T. & M. DeTroch, 2000. Halacaridae (Acari) from Gazi Bay (Kenya): description and biogeography of three new and two known species. *Hydrobiologia*, **427**: 177–194.

Ekman, S., 1953. *Zoogeography of the sea*. Sidgwick & Jackson, London, 417 pp.

Gosse, P. H., 1855a. Notes on some new or little-known marine animals (II.) Class Arachnida. *Annals and Magazine of Natural History*, **16**(91): 27–30.

Gosse, P. H., 1855b. Notes on some new or little-known marine animals (III.) Class Arachnida. *Annals and Magazine of Natural History*, **16**(91): 305–306.

Hodge, G., 1863. Contributions to the marine zoology of Seaham Harbour. On some undescribed marine Acari. *Transactions of the Tyneside Naturalists' Field Club*, **5**(4): 298–303.

Hopper, M. (1998): WXTide 32. (freeware).

Hughes, T. P., Bellwood D. R. & S. R. Connolly, 2002. Biodiversity hotspots, centres of endemicity, and the conservation of coral reefs. *Ecology Letters*, **5**: 775–784.

Lohmann, H., 1893. Die Halacarinen der Plankton-Expedition. *Ergebnisse der Plankton-Expedition der Humboldt Stiftung*, **2**: 11–95.

Lohmann, H., 1909. Marine Hydrachnidae und Halacaridae. In: Michaelsen W. & R. Hartmeyer (eds), *Die Fauna Südwestaustraliens. Ergebnisse der Hamburger südwest-australischen Forschungsreise 1905*, **2**: 149–154.

Monniot, F., 1972. *Scaptognathides*, un nouveau genre d'acariens marins (Halacaridae) dans l'Atlantique ouest. *Acarologia*, **13**: 361–366.

Newell, I. M., 1947. A systematic and ecological study of the Halacaridae of eastern North America. *Bulletin of the Bingham Oceanographic Collection*, **10**: 1–232.

Newell, I. M., 1984. Antarctic Halacaroidea. *Antarctic Research Series*, **40**: 1–284.

Otto, J. C., 1994. New species of Halacaridae from Australia (Acarina : Prostigmata). *Acarologia*, **35**: 31–48.

Otto, J. C., 1999. Halacarid fauna of the Great Barrier Reef and Coral Sea: the genera *Agauopsis* and *Halacaropsis* (Acarina: Halacaridae). *Memoirs of the Queensland Museum*, **43**: 797–817.

Otto, J. C., 2000a. Simognathinae (Acarina: Halacaridae) from the Great Barrier Reef and Coral Sea, description of thirteen new species. *Memoirs of the Queensland Museum*, **45**: 505–534.

Otto, J.C., 2000b. Halacaridae from the Great Barrier Reef and Coral Sea: the genera *Lohmannella*, *Scaptognathides* and *Scaptognathus* (Acarina: Halacaridae: Lohmannellinae). *Memoirs of the Queensland Museum*, **45**: 535–555.

Otto, J. C., 2000c. *Acarochelopodia* and *Actacarus* (Acari: Halacaridae) from northern Australia, with remarks on *A. pacificus* and *A. orthotectus*. *Species Diversity*, **5**: 111–127.

Otto, J. C., 2000d. Seven new species of *Arhodeoporus* (Acarina: Halacaridae) from the Great Barrier Reef and Coral Sea. *Hydrobiologia*, **436**: 1–16.

Otto, J. C., 2001a. Halacaridae of the Great Barrier Reef Lagoon and Coral Sea: *Halacarellus* and *Halacarus.* (Acarina: Halacaroidea). *Memoirs of the Queensland Museum*, **46**: 691–716.

Otto, J. C., 2001b. Halacaridae of the Great Barrier Reef Lagoon and Coral Sea: The *Copidognathus ornatus* group (Acarina: Prostigmata: Halacaroidea). *Memoirs of the Queensland Museum*, **46**: 717–731.

Pepato, A. R. & C. G. Tiago, 2004a. The genera *Acaromantis* and *Simognathus* (Simognathinae, Halacaridae) on the north coast of Sao Paulo State, Brazil. *Zootaxa*, **615**: 1–16.

Pepato, A. R. & C. G. Tiago, 2004b. *Atelopsalis atlantica* sp.n., a new species of halacarid mites from the south-eastern Brazilian coast (Acari, Halacaridae). *Revista Ibérica de Aracnologia*, **10**: 145–148.

Pepato, A.R. & C.G. Tiago, 2005. New species and new occurence of *Copidognathus* (Acari, Halacaridae) from the northern littoral zone of Sao Paulo State (Brazil). *Zootaxa*, **1083**: 1–35.

Rivas, G., 2006. First record of *Simognathus* (Acari: Halacaridae) from Mexico, including the description of a new species. *Zootaxa*, **1259**: 61–68.

Sarma, A. L. N. & T. Chatterjee, 1993a. Record of *Atelopsalis pacifica* Bartsch 1985 (Halacaridae: Acari) from eastern Indian Ocean. *Journal of the Bombay Natural History Society*, **90**: 117–119.

Sarma, A. L. N. & T. Chatterjee, 1993b. Occurence of *Arhodeoporus bonairensis* (Viets, 1936) (Halacaridae: Acari) from Indian Ocean with zoogeographical remarks on the genus *Arhodeoporus* Newell. *Journal of the Bombay Natural History Society*, **90**: 417–422.

Schulz, E. 1937. *Actacarus pygmaeus* n.g. n. sp., eine merkwürdige Meeresmilbe aus der Otoplanen-Zone der Nordsee. *Kieler Meeresforschungen*, **1**: 327–331.

Trouessart, E., 1888. Note sur les acariens marins recueillis par M. Giard au laboratoire maritime de Wimereux. *Compte rendu de l'Académie des Sciences, Paris*, **107**: 753–755.

Trouessart, E., 1889a. Sur les acariens marins des côtes de France. *Compte rendu de l'Académie des Sciences, Paris*, **108**: 1178–1181.

Trouessart, E., 1889b. Revue synoptique de la famille des *Halacaridae*. *Bulletin scientifiques de la France et de la Belgique*, *Série 3*, **20**: 225–251.

Trouessart, E., 1896a. Description d'espèces nouvelles d'Acariens marins. *Bulletin de la Société Entomologique de France*, **65**: 250–253.

Trouessart, E., 1896b. Halacariens. Résultats scientifiques de la Campagne du 'Caudan' dans le Golfe de Gascogne. *Annales de l'Université de Lyon*, **26**: 325–353.

Viets, K., 1927: Die Halacaridae der Nordsee. *Zeitschrift für wissenschaftliche Zoologie*, **130**: 83–173.

Viets, K., 1936. Zoologische Ergebnisse einer Reise nach Bonaire, Curaçao und Aruba im Jahre 1930. No. 18. Halacariden aus Westindien. *Zoologische Jahrbücher, Abteilung für Systematik, Ökologie und Geographie der Tiere*, **67**: 389–424.

Table 1. Halacarid mites from Singapore with notes on records from other areas (number of unidentified species in parentheses). Abbreviations used: AuD, Dampier Archipelago and Montebello Islands, Western Australia; AuE, Esperance, Western Australia; AuM, Moreton Island, Queensland; AuR, Rottnest Island, Western Australia; Bra, Brazil; Car, Caribbean area (Bonaire, Florida); FPo, Moorea, French Polynesia; Gal, Galapagos Islands; GBR, Great Barrier Reef and Coral Sea; Haw, Hawaiian Islands; HKC, Hong Kong, China; InE, India, east coast, Andaman and Nicobar Islands; Ins, Indonesia; InW, India, west coast; Ken, Kenya; Mal, Malaysia; Phi, the Philippines; SrL, Sri Lanka; Vie, Vietnam; – , no record. In the References column only those not already mentioned are listed.

Species	Additional Records	References
Acarothrix		
ampliumeris Bartsch, 2006	–	
palustris Bartsch, 1990	HKC	Bartsch, 1990
Actacarus		
chelonis Otto, 2000	FPo, GBR, Ins	
sp. (1)		
Agaue		
sp. (1)		
Agauopsis		
narinosa Otto, 1999	GBR, SrL	Bartsch, 2006c
sp. A	–	
spp. (2)		
Arhodeoporus		
bonairensis (Viets, 1936)	AuD, Car, Gal, GBR, Haw, HKC, InE, InW, Phi	
nanus, new species	–	
Atelopsalis		
pacifica Bartsch, 1985	AuE, AuR, Haw, HKC, InE, Phi	
Copidognathus		
bavayi (Trouessart, 1896)	Mal, Vie	
macropus, new species	–	
rhombognathoides Bartsch, 2006	–	
viridulus, new species	–	
spp. (ca 8)		
Halacarus		
discophorus Bartsch, 1993	AuD, AuR, GBR	
Isobactrus		
similis Bartsch, 2005	–	
Rhombognathus		
aspidotus Bartsch, 2006	–	
bulbosus Bartsch, 2005	–	
lathridius Bartsch, 2000	AuD, GBR	
major Bartsch, 2005	AuM	
scutulatus Bartsch, 1983	AuD, AuR, InE, InW, Ken, Phi, SrL	
spp. (3)		
Scaptognathides		
hawaiiensis Bartsch, 1988	AuD, Haw, HKC	
Scaptognathus		
exquisitus Otto, 2000	AuD, GBR	
Simognathus		
actius Otto, 2000	GBR	
fuscus Viets, 1936	AuD, Bra, Car, GBR, Phi	
sp. (1)		