Cah. Biol. Mar. (2005) 46 : 273-287

Upper littoral rhombognathines (Acari: Halacaridae) of Singapore: description of three new species

Ilse BARTSCH
Deutsches Zentrum für Marine Biodiversitätsforschung, Forschungsinstitut Senckenberg, Notkestr. 85, 22607 Hamburg, Germany, E-mail: bartsch@meeresforschung.de

Abstract: Abstract: Three rhombognathine species are described, species which predominate in the upper tidal area, in a zone not regularly submerged during every tidal cycle. The three species are *Isobactrus similis* sp. nov., *Rhombognathus bulbosus* sp. nov. and *R. major* sp. nov. *Isobactrus similis* inhabits barnacle colonies on rocks, *Rhombognathus bulbosus* patches of green algae on stems of mangroves and *R. major* algal turfs on rocky cliffs.

Résumé: *Rhombognathinae (Acari: Halacaridae) du littoral supérieur de Singapour : description de trois espèces nouvelles*. Trois espèces de Rhombognathinae, *Isobactrus similis* sp. nov., *Rhombognathus bulbosus* sp. nov. et *R. major* sp. nov. sont décrites. Les espèces ont été trouvées dans un étage médiolittoral supérieur qui n'est pas submergé entre chaque cycle des marées. *Isobactrus similis* est présente parmi des balanes, *Rhombognathus bulbosus* colonise des algues vertes sur les troncs des mangroves et *R. major* des touffes d'algues sur les rochers.

Keywords: Intertidal, Marine mites, *Rhombognathus, Isobactrus,* Descriptions, New species.

Introduction

Amongst the large group of mites only one family, the Halacaridae, is adapted to life in the sea in a depth range from the upper tidal edge to deep-sea trenches. The upper tidal zone is characterized by its long periods of emergence, with desiccation and large amplitudes in respect to salinity, temperature and oxygen supply. Only a few halacarid genera are regularly represented in the upper tidal zone, examples are *Isobactrus* and *Rhombognathus*. Three species of the Singaporean halacarid fauna, new to science and described below, seem to be restricted to this zone of long-term emergence.

Material and methods

Singapore lies in the tropics, at approximately 1°N. The island city-state is surrounded by the Johor Strait and Strait of Singapore which in turn are connecting the Strait of Malacca and the South China Sea. The tide is approximate-

Reçu le 26 janvier 2005 ; accepté après révision le 17 août 2005.
Received 26 January 2005; accepted in revised form 17 August 2005.

ly semi-diurnal with considerable differences in the tidal amplitude (Hopper, 1998/99). In September/October 2004, the tidal range varied from approximately 10 to 260 cm.

The samples were collected by the author. The mites were preserved and stored in ethanol and after clearing mounted in glycerine jelly. Holotypes and paratypes are deposited in 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; AE, anterior epimeral plate; AP, anal plate; ds-1 to ds-5, first to fifth pair of dorsal setae of idiosoma, numbered from anterior backward; GA, genitoanal plate; GO, genital opening; GP, genital plate; OC, ocular plate(s); P-2 to P-4, second to fourth palpal segment; pas, parambulacral seta(e); PD, posterior dorsal plate; PE, posterior epimeral plate(s); pgs, perigenital setae; sgs, subgenital setae. The legs, their segments and carpites are numbered I to IV, leg segments are trochanter, basifemur, telofemur, genu, tibia, and tarsus.

Drawings were prepared with a camera lucida. Adjunct and adanal setae are shown either in dorsal or in ventral aspect. Length of the idiosoma is that from the anterior margin of the AD to the end of the anal cone, the length of a leg segment that along the dorsal margin. The position of a seta is given in a decimal system, with reference to the length of a plate, from its anterior to posterior margin. The setation formula of the legs starts with the trochanter. Solenidia, famuli and parambulacral setae are excluded in the number of setae of tarsi I and II; similarly the parambulacral setae are omitted in the given number of setae of tarsi III and IV. In the setation formula are rare variants in parentheses. The descriptions are supplemented with notes on, often unilateral, variants; the number of cases is in parentheses.

Systematics

Isobactrus similis sp. nov.
Figures 1-14

Material examined

Holotype female, paratype male, ZRC.ARA.463, Singapore, West Coast Park (1°18'N, 103°46'E), barnacles (*Balanus* sp.) on boulders on a beach, just above mid-tide level, 8 October 2004.
Paratypes. One female, 1 male, ZRC.ARA.464, collecting data as above. One female, 1 male, ZRC.ARA.465, collecting data as above. One female, 1 male, ZRC.ARA.466, collecting data as above. One male, 2 tritonymphs, 1 deutonymph, ZRC.ARA.467, collecting data as above. One female, 1 male, SMF, collecting data as above. One male, SMF, collecting data as above. One female, 1 male, ZMH, collecting data as above. One female, 1 male, ZMH, collecting data as above.

Etymology

The species is similar, similis (L.), to congeners recorded from the adjacent South China Sea and eastern Indian Ocean.

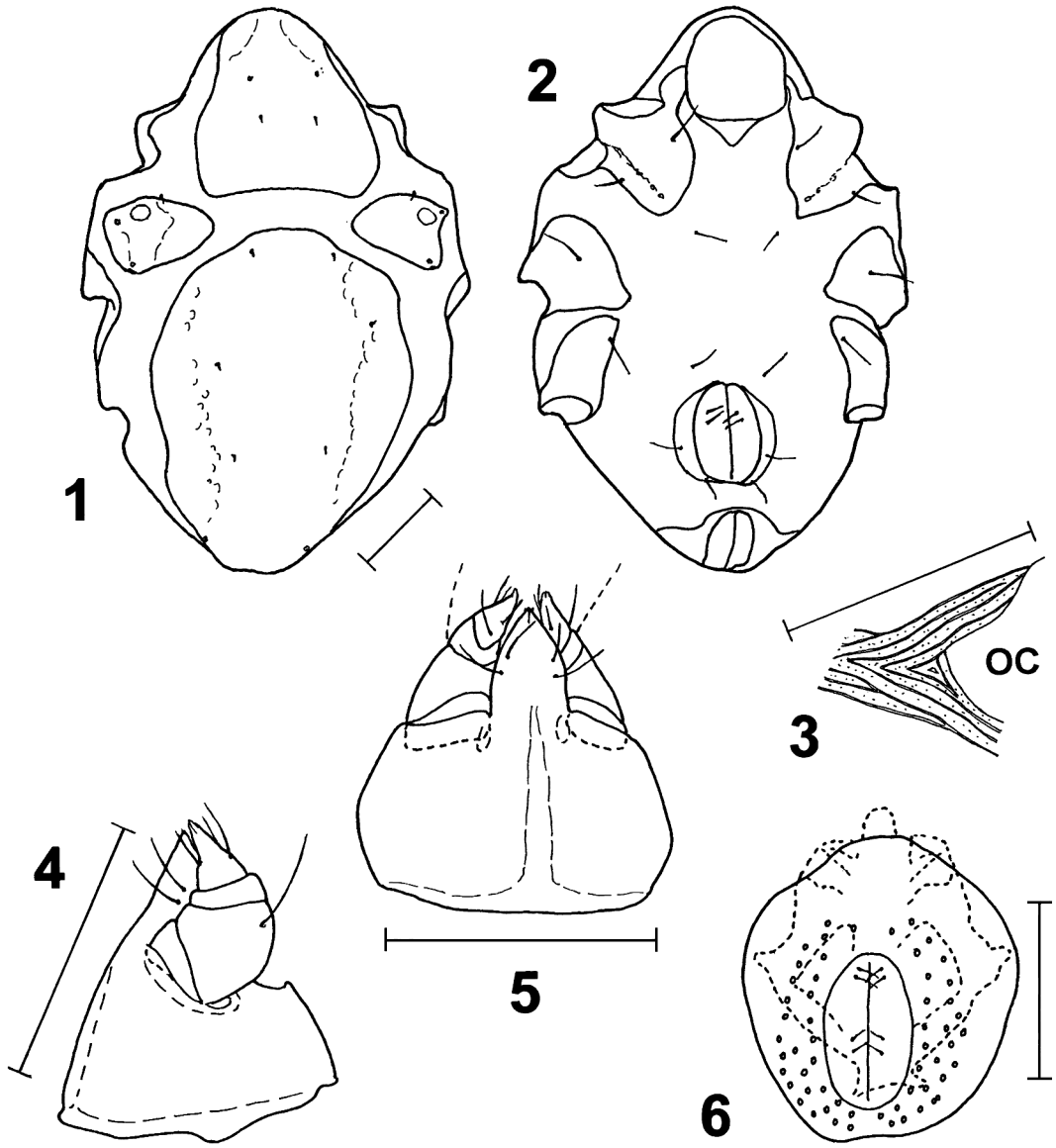
Diagnosis

Dorsum with four plates. PD foveate or pitted; with three pairs of setae. Epimeral plates I and II small, not fused in the median. Dorsal seta of epimeral plate III lacking. Female GO surrounded by genital plate. Female with three pairs of pgs, one pair of setae within striated integument, two pairs on genital plate. Genital sclerites with two pairs of sgs. Male with 53-60 pgs and 8 sgs. Plate around anus small. Gnathosoma wider than long. Length ratio gnathosoma to idiosoma 0.18-0.19. Tibiae I to IV with 5, 5, 4, 4 setae. Tarsi I to IV with 3, 3, 4, 3 dorsal setae. Claw with delicate accessory process; shaft smooth. Carpite almost solid, rod-like.

Description

Female. Idiosomal length of holotype 304 µm. Outline of dorsal plates as illustrated (Fig. 1). Integument between plates striated (Fig. 3), not distinctly villous but in general densely covered by debris. AD slightly wider than long; length 97 µm, width 102 µm; pair of gland pores just anterior to level of insertion of leg I and removed from lateral margin. OC conspicuously wide, length 40 µm, width 57 µm; anterior margin arched; integument posterior to single cornea smooth. OC with two gland pores, one lateral to cornea, the other in posterior edge; pore canaliculus immediately posterior to that gland pore. Distance between medial edge of OC and cornea about three times cornea diameter. Length of PD 187 µm, width 142 µm; at low magnification distinctly and uniformly pitted, each pit 5 µm in diameter. Anterior margin of PD slightly rounded; pair of gland pores near posterior margin. Dorsal setae very short, almost equal in length and apically pointed. Setae ds-1 on AD posterior to gland pores. Pair of ds-2 within striated integument adjacent to anterior margin of OC. Pairs of ds-3 to ds-5 on PD. Adanal setae lacking.

Epimera I and II of either side fused but in the median separated by striated integument (Fig. 2). One seta each on epimera I and II; pair of ventral setae within striated integument. Epimeral plate III with single ventral but no dorsal seta; epimeral plate IV with seta situated in the margin. GO surrounded by genital plate; anterior pair of pgs within stria-



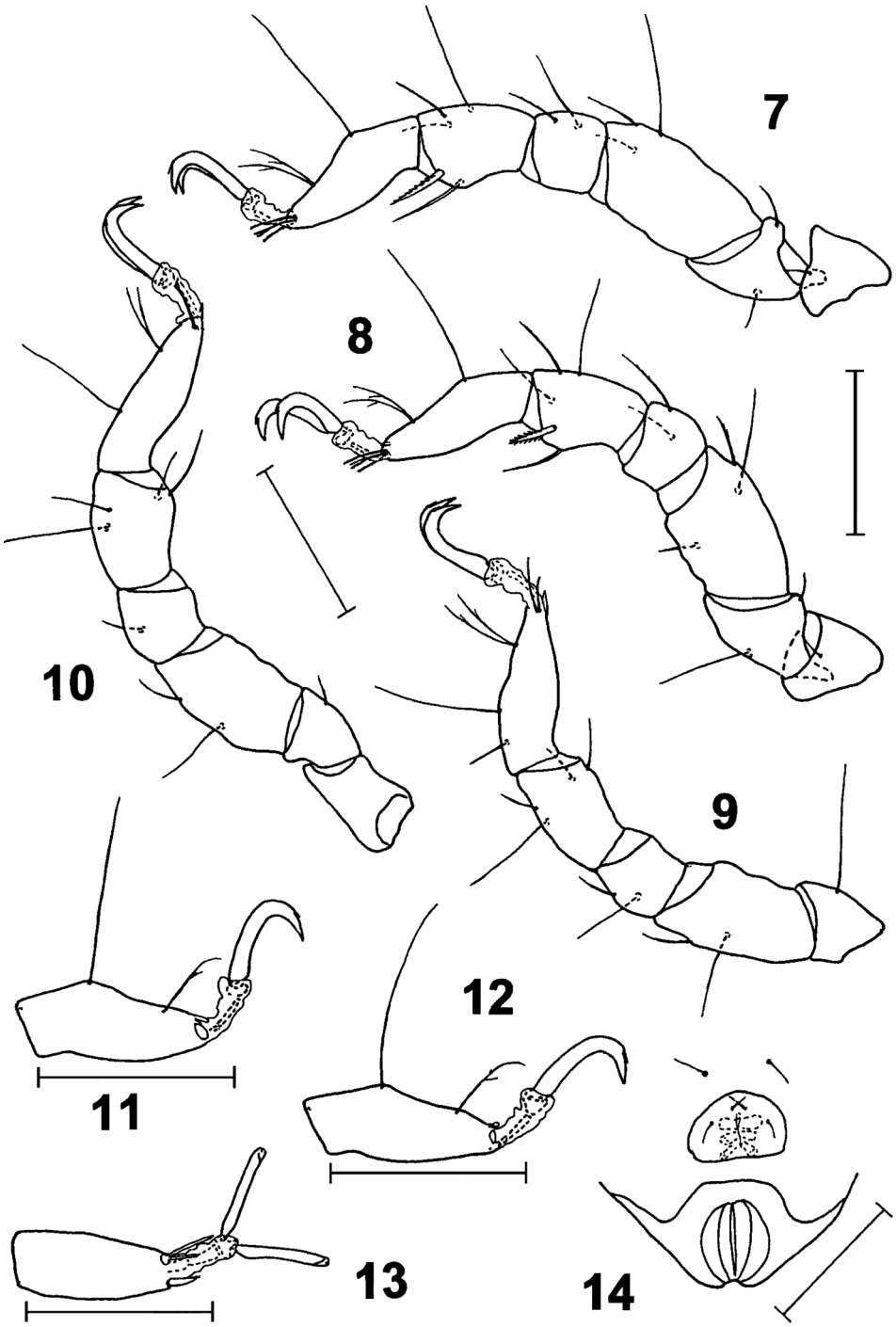
Figures 1-6. *Isobactrus similis* sp. nov. **1.** Idiosoma, dorsal, female. **2.** Idiosoma, ventral, female. **3.** Striated integument medial to OC, female. **4.** Gnathosoma, lateral, female. **5.** Gnathosoma, ventral, mâle (dorsal seta of P-2 in broken line). **6.** Genital plate, male. (OC, ocular plate). Scale bar = 50 µm.

Figures 1-6. *Isobactrus similis* sp. nov. **1.** Idiosome, vue dorsale, femelle. **2.** Idiosome, vue ventrale, femelle. **3.** Tégument plissé près de OC, femelle. **4.** Gnathosome, vue latérale, femelle. **5.** Gnathosome, vue ventrale, mâle (la soie de P-2 en ligne discontinue). **6.** Plaque genitale, mâle. (OC, plaque oculaire). Echelle = 50 µm.

ted integument, two following pairs of pgs inserted on the narrow genital plate. Genital sclerites with two pairs of sgs.

Gnathosoma short, length 57 µm, width 60 µm. Tectum truncate. Rostrum with two pairs of maxillary setae (Figs 4 and 5), inserted adjacent. Palps flattened, four-segmented. P-2 with long dorsal seta. P-4 with four setae.

Telofemora longer than tibiae. Ventral margins of telofemora slightly sinuate (Figs 7-10). Leg chaetotaxy: legs I and II, 1, 2, 3, 2, 5, 3; leg III, 1, 1, 2, 2, 4, 4; leg IV, 0, 1, 2, 1, 4, 3. Telofemora I and II with 3/0 and 2/1 dorsal/ventrolateral setae, respectively. Tibiae I and II each with one bipectinate seta in ventromedial position; tibiae III



Figures 7-14. *Isobactrus similis* sp. nov. **7.** Leg I, medial, female. **8.** Leg II, medial, female. **9.** Basifemur to tarsus III, medial, female. **10.** Leg IV, medial, female. **11.** Tarsus I, lateral, female (medial seta and pair of parambulacral setae omitted). **12.** Tarsus II, lateral, female (medial seta and pair of parambulacral setae omitted). **13.** Tarsus III, ventral, male (dorsal setae omitted). **14.** Posterior idiosoma, ventral, tritonymph. Scale bar = 50 µm.

Figures 7-14. *Isobactrus similis* sp. nov. **7.** Patte I, vue antérieure, femelle. **8.** Patte II, vue antérieure, femelle. **9.** Basifémur à tarse III, vue postérieure, femelle. **10.** Patte IV, vue postérieure, femelle. **11.** Tarse I, vue postérieure, femelle (sans la soie antérieure et la paire des parambulacrales). **12.** Tarse II, vue postérieure, femelle (sans la soie antérieure et la paire des parambulacrales). **13.** Tarse III, vue ventrale, mâle (sans les soies dorsales). **14.** Idiosome postérieure, vue ventrale, tritonymphe. Echelle = 50 µm.

and IV lack bipectinate setae. Paired fossary setae of all tarsi delicately divaricate. Tarsi I and II with small solenidia (Figs 11 and 12), their length 3 and 2 µm, respectively, apex with pair of doubled pas. Tarsus III with spiniform lateral pas and two eupathid medial pas (cf. Fig. 13), tarsus IV with similar spiniform lateral pas and one eupathid medial pas.

Claws with small accessory process. Carpite between tip of tarsus and central sclerite almost solid.

Male. Length 275-300 µm. In dorsal aspect similar to female. Genital plate larger than that of female, length 87 µm, width 77 µm. With 53-60 slender pgs, none of them distinctly outlying. Genital sclerites with four pairs of sgs (Fig. 6). Spermatopositor hardly extending beyond margins of genital plate. Setation of tarsus IV same as that of female.

Deutonymph. Length 184 µm. Dorsal aspect similar to that of adults. Genital plate small; with two pairs of internal genital acetabula. Pair of pgs within margin of GP.

Tritonymph. Length 250-254 µm. Genital plate with one pair of pgs and one pair of sgs, an anterior pair of pgs within striated integument (Fig. 14). Chaetotaxy of legs same as in adults.

Variations

Length of idiosoma, female: 269-307 µm (7).
Length of idiosoma, male: 275-300 µm (9).
Number of pgs around GO, male: 53(1), 54(1), 55(1), 57(2), 58(1), 59(1), 60(2).
Number of setae of leg segments 2 to 5:

segment	leg I	leg II	leg III	leg IV
2	2(20)	2(20)	1(20)	1(20)
3	2(1), 3(19)	3(19)	2(20)	2(20)
4	2(20)	2(19)	2(20)	1(19)
5	5(20)	1(1), 5(18)	4(19)	4(19)

Remarks

This is *Isobactrus* species number seven from the tropical and warm-temperate Indo-Pacific Ocean area. The other species are *Isobactrus asper* Bartsch, 1977, recorded from the Galapagos Islands, *I. australiensis* Bartsch, 2003 from northwestern Australia, *I. luxtoni* Bartsch, 1992 from southern China, *I. obesus* Bartsch, 1992 northwestern Australia and southern China, *I. pacificus* Bartsch, 1989 from the Hawaiian Islands, and *I. ponapensis* Abé, 1996 from the Ponape Island and northeastern Australia (Abé, 1996; Bartsch, 1977, 1989, 1992, 2000, 2003a, c). These species, *I. similis* included, share several characters, viz. absence of a dorsal (lateral) seta on epimeral plate III, presence of two pairs of sgs on female genital sclerites and no more than two setae on genua I and II. *Isobactrus* species from cold-temperate areas, from the northern Atlantic and Pacific Ocean and the southern Atlantic, Indian and Pacific Ocean, all have two setae on the epimeral plate III, a dorsal (lateral) and a ventral one, the female genital sclerites bears a single pair of sgs and the genua I and II three setae.

The seven Indo-Pacific species can be discriminated on the basis of the shape of the plates and position of setae. *Isobactrus obesus* has an elongate ventral plate between the pairs of epimera I and II; the AD of *I. asper* and *I. ponapensis* is much wider than long, the OC of *I. asper* are slightly longer than wide, the female genital plate is very large and the three anterior pairs of ventral setae insert within the epimeral plates; the OC of *I. luxtoni* are about as long as wide and the ds-2 close to their anteromedial margin, on the male GP of *I. luxtoni* there is a pair of outlying setae. *Isobactrus similis* strongly resembles *I. australiensis*; discriminating characters are: in *I. similis* the idiosomal length is less than in *I. australiensis* (269-307 vs. 322-347 µm), the OC are wider (length: width 1:1.43 vs. 1:1.04) and the number of male perigenital setae exceeding that of *I. australiensis* (53-60 vs. 44).

Biology

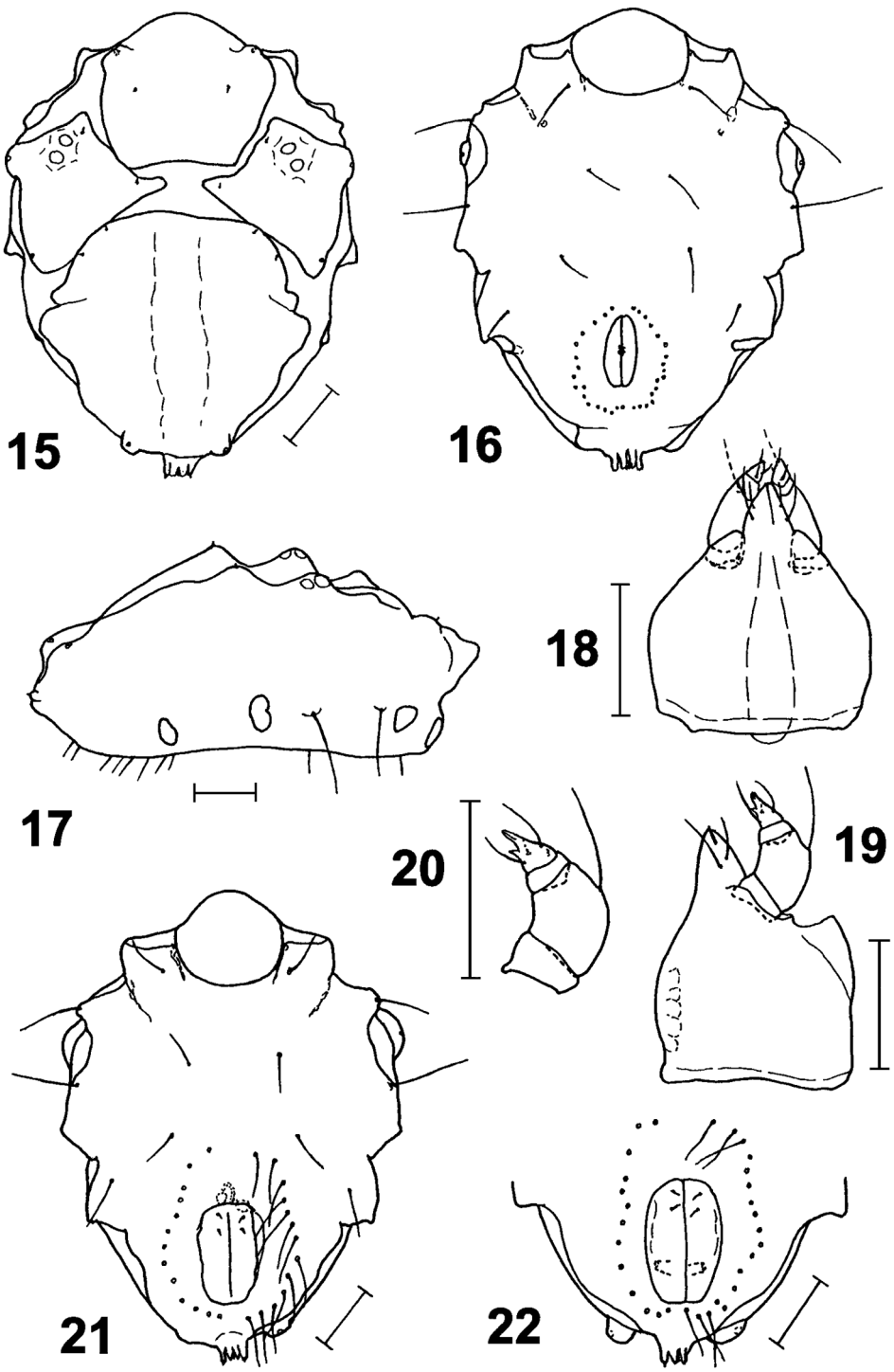
Isobactrus similis was very abundant on the shore of the West Coast Park, amongst barnacles densely covering rocks and boulders on a sandy beach. No halacarid mites were found on barnacles on a nearby wooden construction. Often this halacarid species was the only meiofaunal taxon amongst the barnacles, rarely, individuals of *Copidognathus* sp. and *Agauopsis* sp. were found. Other mites (oribatids, astigmatids) or arthropods (harpacticoids, ostracods) were lacking.

In contrast, similar extense barnacle colonies in other areas, e.g. on the stone packing of the bank of the river Serangoon, near its mouth, were inhabited by large numbers of hyadesiid mites (Astigmata), a few tardigrades but no halacarids.

Rhombognathus bulbosus sp. nov.
Figures 15-37

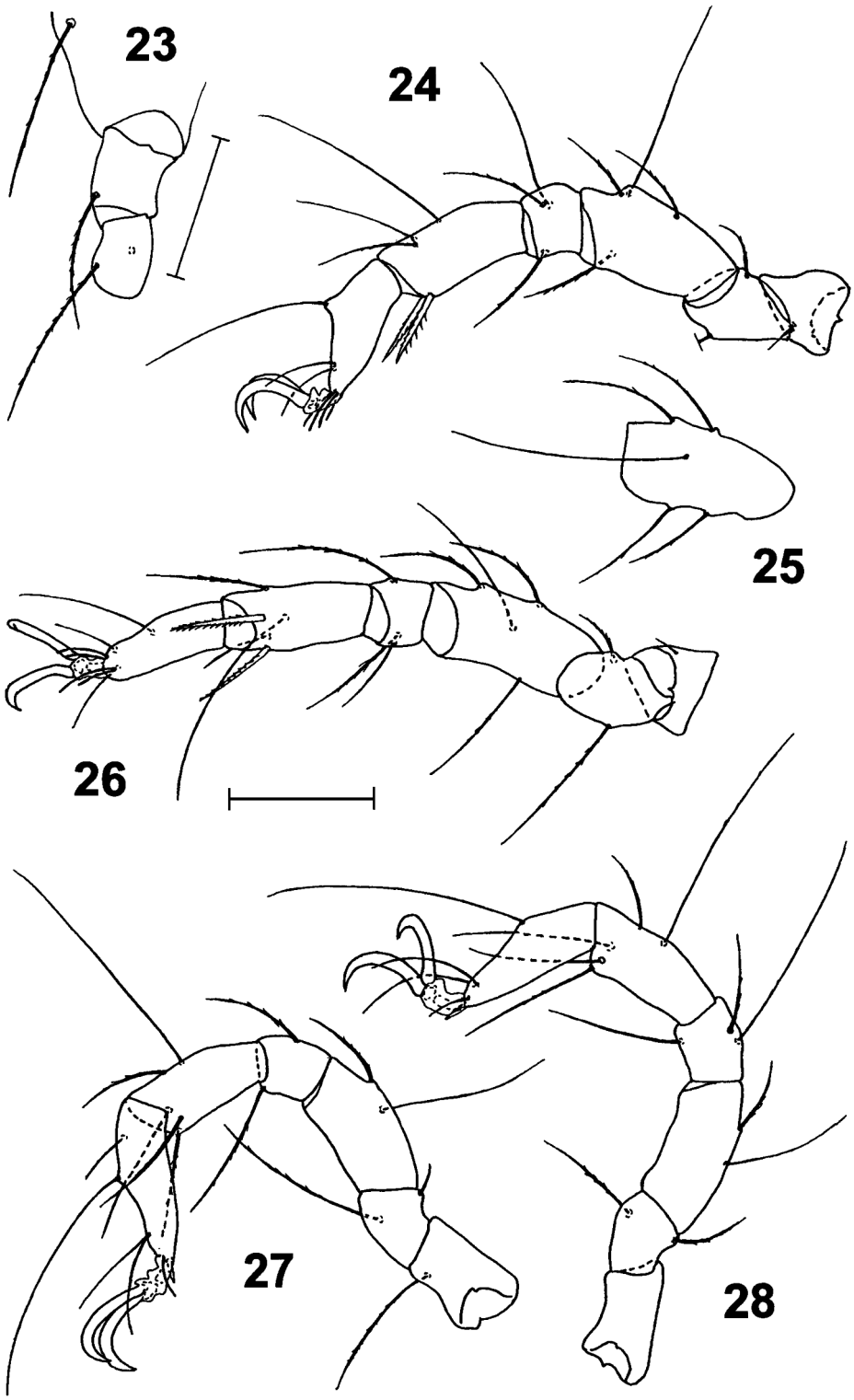
Material examined

Holotype male and paratype female, ZRC.ARA.468, Singapore, southwestern coast, small bay of the river Pandan (1°18'N, 103°45'E), unbranched thread-like green algae (Cladophorales, Chlorophyta) and debris from stem of mangrove *Rhizophora* sp., 11 October 2004.
Paratype female, ZRC.ARA.469, collecting data as above.
Other material. One female, ZRC.ARA.470, Singapore, southwestern coast, small bay of the river Pandan (1°18'N,



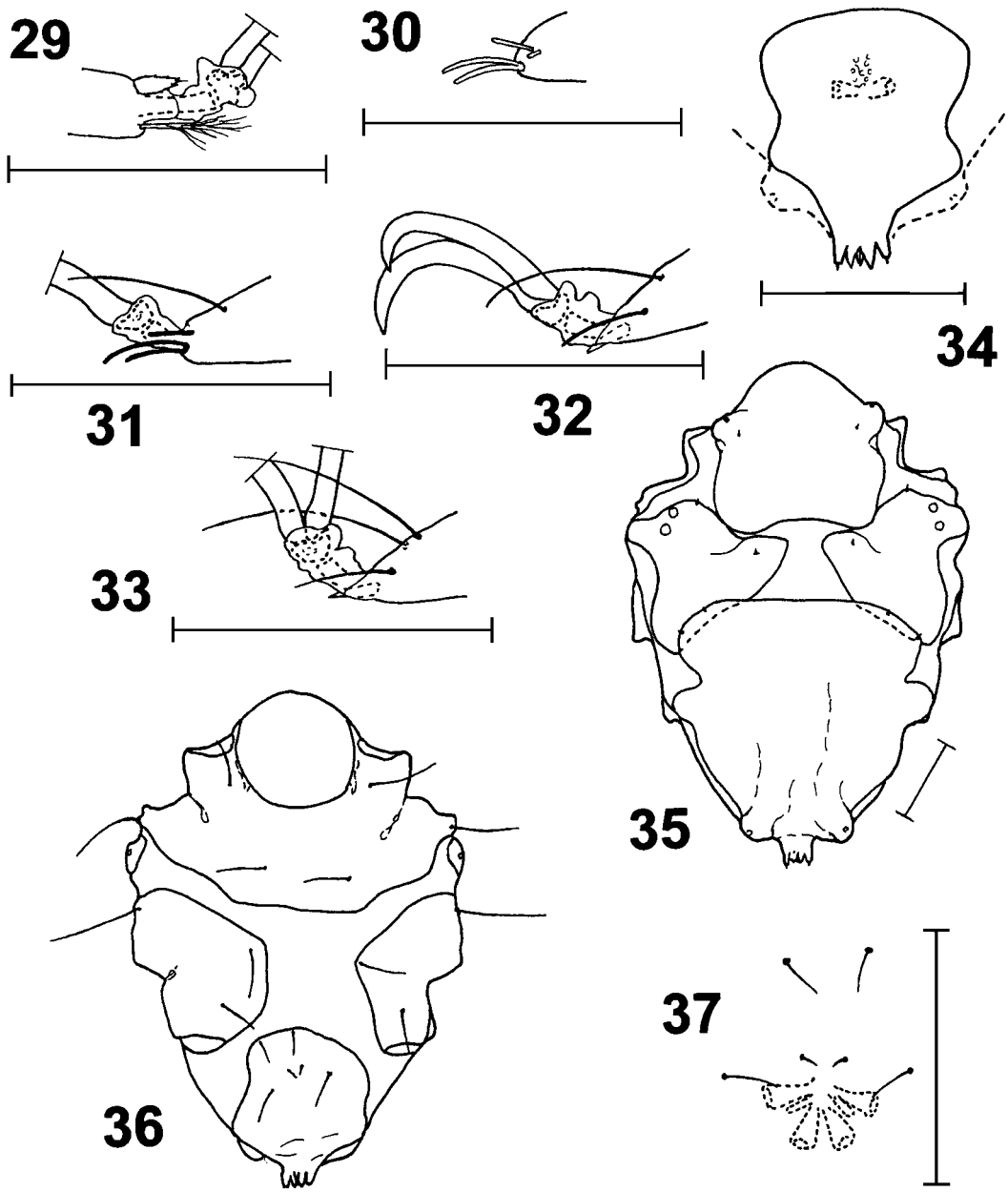
Figures 15-22. *Rhombognathus bulbosus* sp. nov. **15.** Idiosoma, dorsal, male. **16.** Idiosoma, ventral, male. **17.** Idiosoma, lateral, female. **18.** Gnathosoma, ventral, male (dorsal of P-2 in broken line). **19.** Gnathosoma, lateral, female. **20.** Palp, lateral, female. **21.** Idiosoma, ventral, female. **22.** Posterior idiosoma, ventral, female. Scale bar = 50 µm.

Figures 15-22. *Rhombognathus bulbosus* sp. nov. **15.** Idiosome, vue dorsale, mâle. **16.** Idiosome, vue ventrale, mâle. **17.** Idiosome, vue latérale, femelle. **18.** Gnathosome, vue ventrale, mâle (la soie de P-2 en ligne discontinue). **19.** Gnathosome, vue latérale, femelle. **20.** Palpe, vue latérale, femelle. **21.** Idiosome, vue ventrale, femelle. **22.** Idiosome postérieur, vue ventrale, femelle. Echelle = 50 µm.



Figures 23-28. *Rhombognathus bulbosus* sp. nov. **23.** Epimeral plate, trochanter and basifemur III, female. **24.** Leg I, medial, female. **25.** Telofemur I, lateral, female. **26.** Leg II, medial, female. **27.** Leg III, medial, female. **28.** Leg IV, medial, female. Scale bar = 50 µm.

Figures 23-28. *Rhombognathus bulbosus* sp. nov. **23.** Plaque épimérale, trochanter et basifémur III, femelle. **24.** Patte I, vue antérieure, femelle. **25.** Télofémur I, vue postérieure, femelle. **26.** Patte II, vue antérieure, femelle. **27.** Patte III, vue postérieure, femelle. **28.** Patte IV, vue postérieure, femelle. Echelle = 50 µm.



Figures 29-37. *Rhombognathus bulbosus* sp. nov. **29.** Tip of tarsus IV, ventral, male. **30.** Tip of tarsus I, lateral, female (medial setae omitted). **31.** Tip of tarsus II, lateral, female (medial setae omitted). **32.** Tip of tarsus III and claws, medial, female. **33.** Tip of tarsus IV, medial, female. **34.** Genitoanal plate, deutonymph. **35.** Idiosoma, dorsal, tritonymph. **36.** Idiosoma, ventral, tritonymph. **37.** Genital area, tritonymph. Scale bar = 50 µm

Figures 29-37. *Rhombognathus bulbosus* sp. nov. **29.** Extrémité du tarse IV, vue ventrale, mâle. **30.** Extrémité du tarse I, vue postérieure, femelle (sans les soies antérieures) **31.** Extrémité du tarse II, vue postérieure, femelle (sans les soies antérieures). **32.** Extrémité du tarse III et des griffes, vue postérieure, femelle. **33.** Extrémité du tarse IV, vue postérieure, femelle. **34.** Plaque génito-anale, deutonymphe. **35.** Idiosome, vue dorsale, tritonymphe. **36.** Idiosome, vue ventrale, tritonymphe. **37.** Région génitale, tritonymphe. Echelle = 50 µm

103°45'E), unbranched thread-like green algae (Cladophorales, Chlorophyta) and debris from stem of mangrove *Rhizophora* sp., 27 September 2004. One female, ZRC.ARA.471, collecting data as above. Two females, ZRC.ARA.472, collecting data as above. Two tritonymphs, 2 deutonymphs, ZRC.ARA.473, collecting data as above. Two females, SMF, collecting data as above. One female, 1 tritonymph, 1 protonymph, ZMH, collecting data as above. One female, ZMH, Singapore, northern coast, end of Lim Chu Kang Road (1°27'N, 103°44'E), green algae (Cladophorales) from *Rhizophora* stem, 7 October 2004.

Etymology

The dorsum is covered with bulbs, conspicuous already while sorting, hence the name bulbosus (L).

Diagnosis

Idiosomal length of female 334-370 µm, of male 349 µm. Dorsal plates separated. Surface of plates smooth. Dorsal idiosomatic setae peg-like. PD with two pairs of setae, situated in anterior fifth. Ventral plates fused in both female and male. PE lack dorsal seta. No adjunct setae, neither on AE nor on PE. Anal sclerites squeezed between anal valves. Female with 19-31 pgs. Male with 17 pairs of slender, almost smooth pgs. Gnathosoma 1.15 times longer than wide and about 0.28 of idiosomal length. Rostrum short. Telofemur I about 2.1 times longer than high. Leg chaetotaxy: leg I, 1, 2, 4-5, 3, 5, 3; leg II, 1, 2, 4, 3, 5, 3; leg III, 1, 2, 2, 2, 5, 4; leg IV, 0, 2, 2, 3, 5, 3. Ventral seta of genu I plumulose, not bipectinate. Telofemora I to IV with 3/1-2, 3/1, 2/0, 2/0 dorsal/ventral setae. Tibiae I to IV with 2, 2, 0, 0 bipectinate setae. Claws smooth.

Description

Male. Idiosoma wide, length of holotype 349 µm, width 267 µm. Dorsal plates without marked reticulation (Fig. 15) but with bulbously raised areas (cf. Fig. 17). Integument not markedly villous but intensely fouled with organic and inorganic material. Length of AD 112 µm, width 128 µm, anterior margin arched, posterior margin truncate. Gland pores I level with insertion of leg I, opening on cones; area posterior to cones raised as well. OC very wide, length 125 µm, width 119 µm, both length and width slightly more than length of AD. One pair of gland pores in marginal corner of OC, often opening ventrally, second pair near posterior corner. Area with two corneae and medial wedge of OC raised. PD wide, length 180 µm, width 205 µm; anterior margin almost truncate, two pairs of lateral protuberances. Anterolateral parts of PD bulbous. Pair of gland pores in posterior part of PD on distinctly raised cones. Dorsal setae very short, peg-like. Pair of ds-1 on AD posterior to gland pores. Setae ds-2 and ds-3 on OC, ds-2 near anteromedial margin and ds-3 in wedge-like medial portion of plate. Pair of ds-4 and ds-5 within anterolateral margin of PD, at about 0.07 and 0.18 relative to length of PD. Pair of adanal setae on small papillae flanking anal valves.

Ventral plates lack prominent ornamentation. All ventral plates fused to a shield (Fig. 16), its length 284 µm. Area of AE with three pairs of setae, marginal setae plumulose. Area representing PE with one marginal plumulose seta (cf. Fig. 23), two ventral setae but no dorsal seta. Adjunct setae lacking. Length of GO 52 µm. GO surrounded by a ring of 34 slender, smooth perigenital setae, no separate pair of basilar setae present. Genital sclerites with two pairs of sgs. Anal cone with small, narrow anal sclerites flanked by anal valves and papillae.

Gnathosoma slightly longer than wide, length 97 µm, width 85 µm. Rostrum short, its length 30 µm, with two pairs of maxillary setae (Figs 18 and 19) and setiform rostral setae. Tectum truncate.

Shape of legs and arrangement of setae as in female. Leg chaetotaxy: leg I, 1, 2, 4-5, 3, 5, 3; leg II, 1, 2, 4, 3, 5, 3; leg III, 1, 2, 2, 2, 5, 4; leg IV, 0, 2, 2, 3, 5, 3. Tarsus IV of male with serrate, spiniform lateral pas and plumose medial pas (Fig. 29).

Female. Length 334-370 µm. Dorsal aspect of idiosoma similar to that of male. Ventral plates fused to a shield (Fig. 21). GO large, extending anteriad beyond insertion of leg IV; 19-31 pgs arranged in a wide ring around GO. Genital sclerites with two pairs of sgs and single internal pair of genital acetabula (Fig. 22)

Gnathosoma as in male. Palps 4-segmented. P-2 with dorsal seta. P-4 with three basal setae and medial spur-like process (Fig. 20).

Legs slender (Figs 24, 26-28), all telofemora slightly longer than tibiae. Telofemora I and II 2.1-2.2 times longer than high. Telofemora III and IV 2.5-2.6 times longer than high. Majority of dorsal and lateral setae distinctly plumulose. Telofemur I with 3/1-2 dorsal/ventral setae (Figs 24 and 25), telofemora II to IV with 3/1, 2/0, 2/0 dorsal/ventral setae. Both ventral setae of tibiae I and II bristle-like and bipectinate; ventral setae of tibiae III and IV slender, plumulose but not bipectinate. Ventral seta of genu I delicately plumulose. Tarsus I with three dorsal setae, a dorsolateral solenidion, 7 µm long, and adjacent short famulus, 2 µm long (Fig. 30); tip of tarsus with pair of doubled pas. Tarsus II with three dorsal setae, a dorsolateral solenidion, 7 µm in length (Fig. 31), tip with pair of doubled pas. Tarsus III with four dorsal setae, distance between two basalmost setae almost same as height of tarsus; tip of tarsus III with spiniform lateral pas and eupathid medial pas (Fig. 32). Tarsus IV with three dorsal setae; lateral pas spiniform as on tarsus III, medial pas slender, tapering (Fig. 33).

All claws smooth. Central sclerite articulating with carpite which is fused with tip of tarsus.

Protonymph. Length 185 µm. Outline of dorsal and ventral plates similar to that of tritonymph. Genitoanal plate with a pair of genital acetabula. Leg IV five-segmented. Leg chaetotaxy: legs I and II, 1, 2, 3, 4, 5, 3; leg III, 1, 1, 2, 2, 5, 4; leg IV, 0, 0+2 (basi- + telofemur), 3, 5, 3. Genua I and II with four setae.

Deutonymph. Length 256 µm. Dorsal and ventral plates similar though smaller than those of tritonymph. Genitoanal plate with a single pair of genital acetabula (Fig. 34). Leg chaetotaxy: leg I, 1, 2, 3, 2-3, 5, 3; leg II, 1, 2, 3, 3, 5, 3; leg III, 1, 1, 2, 2, 5, 4; leg IV, 0, 1, 2-3, 3, 5, 3. Telofemora I and II with 2/1 dorsal/ventral setae, telofemora III and IV with 2/0 and 2-3/0 dorsal/ventral setae, respectively.

Tritonymph. Length 295-300 µm. Dorsal aspect as illustrated (Fig. 35); plates as in adults with bulbous areas. Ventral plates divided into AE, PE and GA (Fig. 36). Chaetotaxy of AE and PE same as in adults. GA with two pairs of pgs, one pair of sgs, two pairs of large internal genital acetabula and a third pair of narrow acetabula (Fig. 37). Primordial genital slit obscured. Leg chaetotaxy: leg I, 1, 2, 3, 3-4, 5, 3; leg II, 1, 2, 3, 3, 5, 3; leg III, 1, 2, 2, 2, 5, 4; leg IV, 0, 2, 2, 3, 5, 3. Telofemora I and II with 2/1 dorsal/ventral setae. In one specimen one of the genua I with four instead of three setae.

Variations

Length of idiosoma, female: 350-370 µm (9).
Length of idiosoma, male: 349 µm (1).
Number of adjunct setae of right or left half of AE: 0(20).
Number of adjunct setae of PE: 0(20).
Number of pgs right or left of GO, female: 9(1), 10(2), 11(3), 12(4), 13(5), 14(1), 15(1), 18(1).
Number of trapezoidally arranged pgs plus basilar setae right or left of GO, male: 17(2),
Number of setae of leg segments 2 to 5:

segment	leg I	leg II	leg III	leg IV
2	2(20)	2(20)	2(20)	2(20)
3	4(14), 5(6)	3(1), 4(19)	2(20)	1(1), 2(19)
4	3(20)	3(20)	2(20)	3(20)
5	1(1), 5(19)	5(20)	5(20)	5(19)

Remarks

Rhombognathus bulbosus is most similar to *R. verrucosus* Bartsch, 1992, a species described from Hong Kong (Bartsch, 1992). In both species the dorsal aspect is characterized by conspicuous cones, females have distinctly more than the usual number of five pairs of pgs, the claws are smooth, and both species have been collected in the upper tidal area.

Rhombognathus bulbosus can be distinguished from *R. verrucosus* on the basis of: absence of adjunct setae on AE and PE, absence of a dorsal seta on PE, and small number of setae on telofemora. In *R. verrucosus* the AE bears two pairs of adjunct setae, the PE one dorsal seta, the telofemora I and II five to six setae, and the telofemora III and IV three setae (Bartsch, 1992).

Species of *Rhombognathus*, like those of the majority of the other halacarid genera, have at least one pair of dorsal setae on the PE. This seta is lacking in *R. bulbosus*. In the rhombognathine genus *Isobactrus* presence of that seta is the most common character state but in the tropical and warm-temperate Indo-Pacific species, *I. asper*, *I. australiensis*, *I. luxtoni*, *I. obesus*, *I. pacificus*, *I. ponapensis,* and the above described *I. similis*, this pair of setae is lacking.

Unique within the genus *Rhombognathus* is that the adults have a single pair of internal acetabula; the other acetabula, if present, are obscured. The deutonymph of *R. bulbosus* has one pair of genital acetabula, in contrast to congeners which have two pairs of acetabula. A comparable reduction of the number of acetabula in deutonymphs is documented for *Isobactrus uniscutatus* (Viets, 1939) (Bartsch, 1972: Fig: 18D, 2003b: Fig. 3C).

In contrast to the adults, the single protonymph available bears four setae on genua I and II.

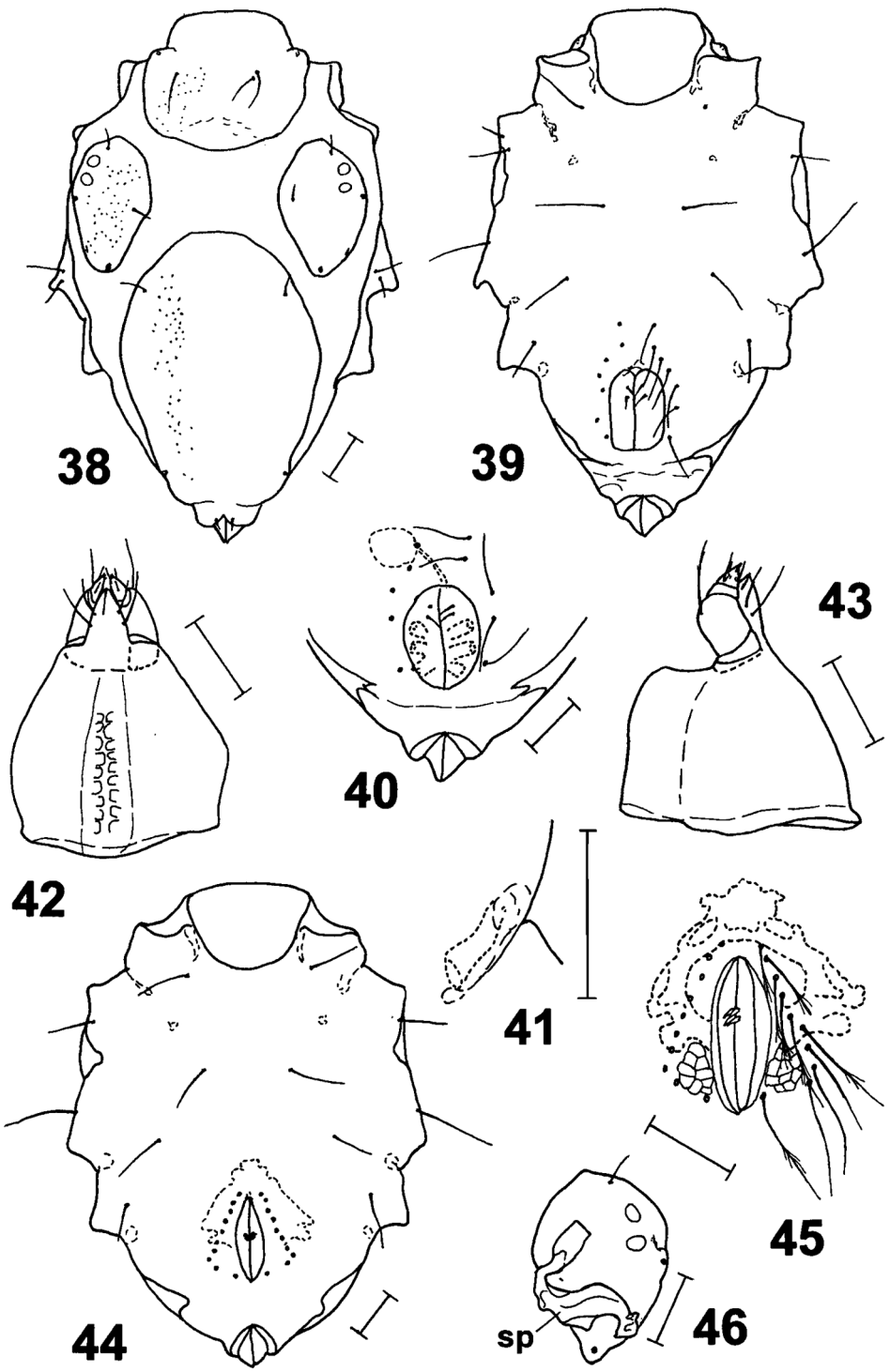
Biology

The species was present amongst patches of green algae (Cladophorales) on stems of *Rhizophora* sp.; a single specimen was extracted from algae (Chlorophyta) of *Avicennia* pneumatophores, growing in the adjacent tidal flat. The fauna within the green algal patches was sparse, apart from *R. bulbosus* just some few harpacticoids (one species) were found.

Rhombognathus major sp. nov.
Figures 38-57

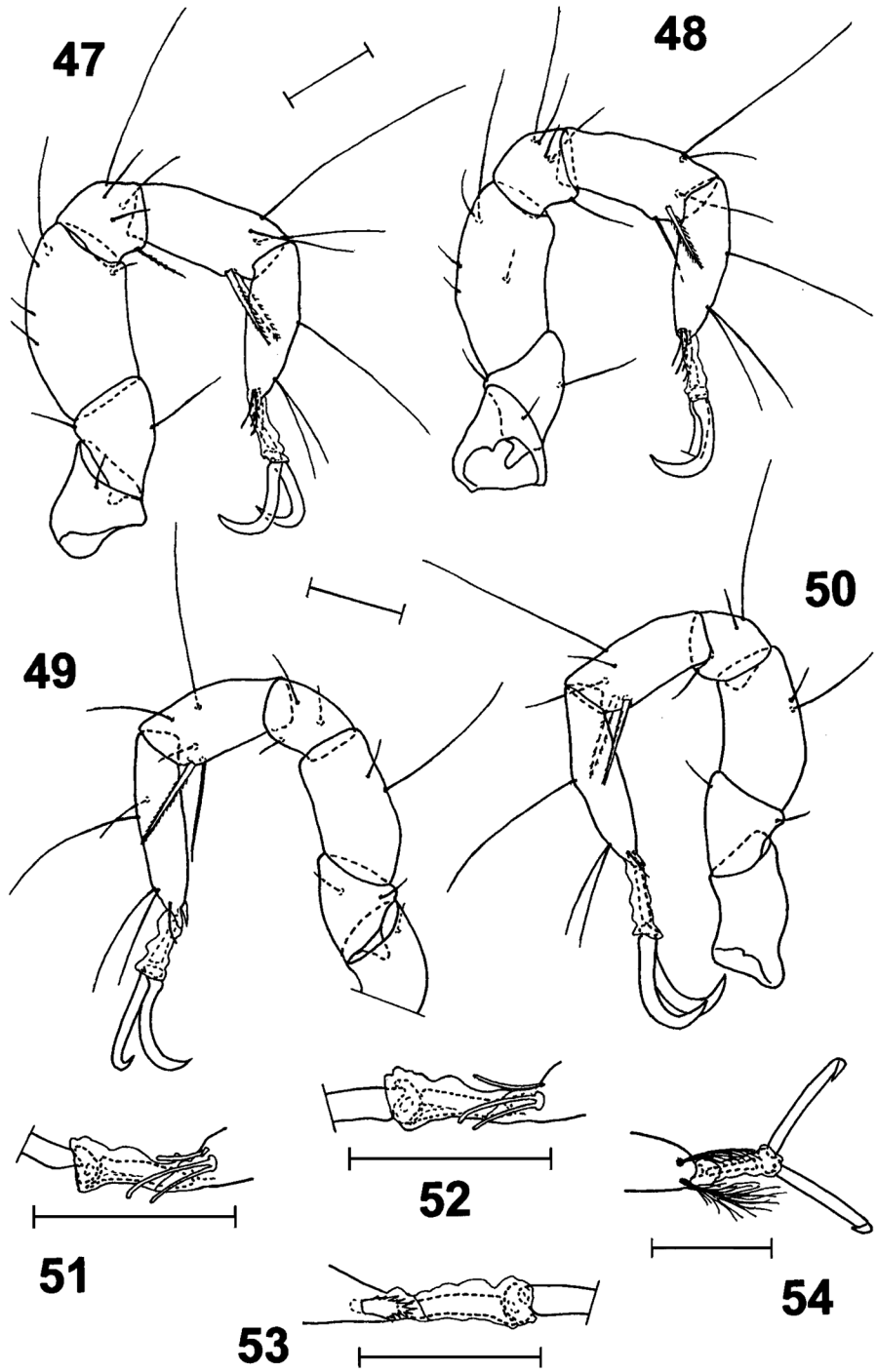
Material examined

Holotype female, ZRC.ARA.474, Singapore, south coast, Labrador Park (1°16'N, 103°48'E), from dense turf of *Bostrychia* sp. (Ceramiales, Rhodophyta) growing on upper tidal rocks at the foot of a steep hill, 28 September 2004.
Paratypes. One female, ZRC.ARA.475, collecting data as above. One female, ZRC.ARA.476, collecting data as above. One male, ZRC.ARA.477, collecting data as above. One male, 2 deutonymphs, ZRC.ARA.478, collecting data as above. One female, SMF, collecting data as above. One male, SMF, collecting data as above. One female, ZMH, collecting data as above. One male, ZMH, collecting data as above. One tritonymph, 1 larva, ZMH, collecting data as above.



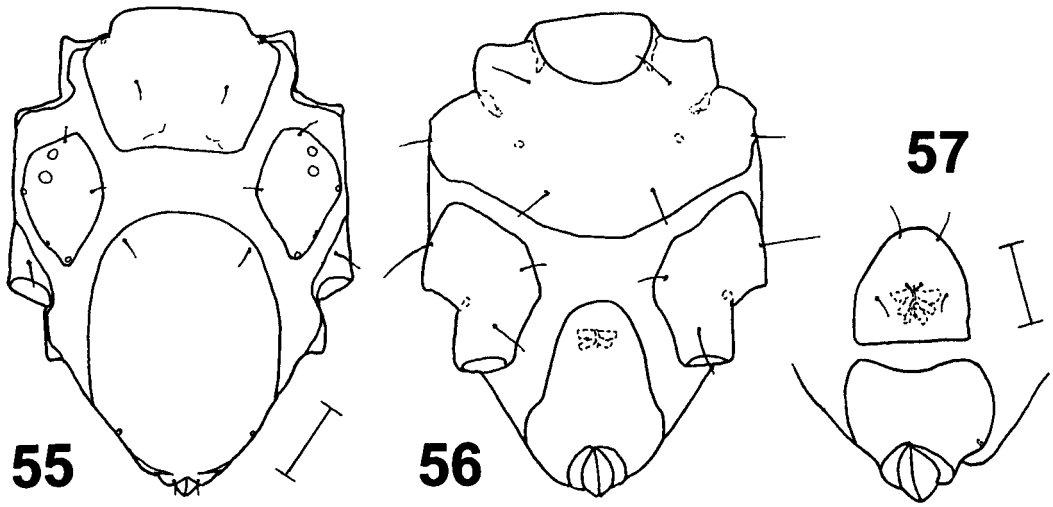
Figures 38-46. *Rhombognathus major* sp. nov. **38.** Idiosoma, dorsal, female; **39.** Idiosoma, ventral, female; **40.** Posterior idiosoma, ventral, female; **41.** Epimeral tube, female; **42.** Gnathosoma, ventral, female; **43.** Gnathosoma, lateral, male; **44.** Idiosoma, ventral, male; **45.** Genital opening, male; **46.** Ocular plate with spermatophor, male. (sp, spermatophor). Scale bar = 50 µm

Figures 38-46. *Rhombognathus major* sp. nov. **38.** Idiosome, vue dorsale, femelle; **39.** Idiosome, vue ventrale, femelle; **40.** Idiosome postérieure, vue ventrale, femelle; **41.** Acétabulum épiméral, femelle; **42.** Gnathosome, vue ventrale, femelle; **43.** Gnathosome, vue latérale, mâle; **44.** Idiosome, vue ventrale, mâle; **45.** Orifice génital, mâle; **46.** Plaque oculaire avec spermatophore, mâle. (sp, spermatophore). Echelle = 50 µm



Figures 47-54. *Rhombognathus major* sp. nov. **47.** Leg I, medial, female. **48.** Leg II, medial, female. **49.** Leg III, medial, female. **50.** Leg IV, medial, female. **51.** Tip of tarsus I, lateral, female (medial parambulacral setae omitted). **52.** Tip of tarsus II, lateral, female (medial parambulacral setae omitted). **53.** Tip of tarsus IV, lateral, female (medial parambulacral seta omitted). **54.** Tip of tarsus IV and claws, ventral, male. Scale bar = 50 µm.

Figures 47-54. *Rhombognathus major* sp. nov. **47.** Patte I, vue antérieure, femelle. **48.** Patte II, vue antérieure, femelle. **49.** Patte III, vue postérieure, femelle. **50.** Patte IV, vue postérieure, femelle. **51.** Extrémité du tarse I, vue postérieure, femelle (sans les soies parambulacrales antérieures). **52.** Extrémité du tarse II, vue postérieure, femelle (sans les soies parambulacrales antérieures). **53.** Extrémité du tarse IV, vue antérieure, femelle (sans la soie parambulacrale postérieure). **54.** Extrémité du tarse IV et des griffes, vue ventrale, mâle. Echelle = 50 µm.



Figures 55-57. *Rhombognathus major* sp. nov. **55.** Idiosoma, dorsal, deutonymph. **56.** Idiosoma, ventral, deutonymph. **57.** Posterior idiosoma, ventral, tritonymph. Scale bar = 50 µm.

Figures 55-57. *Rhombognathus major* sp. nov. **55.** Idiosome, vue dorsale, deutonymphe. **56.** Idiosome, vue ventrale, deutonymphe. **57.** Idiosome postérieur, vue ventrale, tritonymphe. Echelle = 50 µm.

Other material. One male, ZRC.ARA.479, Singapore, St John's Island, north coast (1°12'N, 103°51'E), from *Bostrychia* turf on upper tidal rocks, 30 September 2004.

Etymology

This is a large-sized species, it is distinctly larger, major (L.), than *Rhombognathus bulbosus* sp. nov. and other congeners in shallow water habitats of Singapore.

Diagnosis

Idiosomal length of female 500-560 µm, of male 452-510 µm. Dorsal plates separate. Ventral plates in both females and males fused; wedges of striated integument between GA and AP. Surface of plates almost smooth, pierced by canaliculi. PD with single pair of setae at 0.2. AE with none or one pair of adjunct setae, PE in general with one adjunct seta. Female with (5-)7 pairs of pgs and two pairs of sgs. Male generally with 10-12 pairs of delicately plumulose pgs. Gnathosoma 1.3 times longer than wide and about 0.3 of idiosomal length. Rostrum short. Leg chaetotaxy: legs I and II, 1, 2, 5, 5, 5, 3; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 2, 2, 3, 5, 3. Telofemur I about 2.0 times longer than high. Telofemora I to IV with 4/1, 4/1, 2/0, 2/0 dorsal/ventral setae. Tibiae I to IV with 2, 1, 1, 2 bipectinate setae. Ventral seta of genu I bristle-like, faintly pectinate. Claws smooth.

Description

Female. Idiosomal length of holotype 560 µm, width 370 µm. Dorsal plates superficially almost smooth but pierced by delicate canaliculi (Fig. 38). AD, OC and PD separate plates. Length of AD 145 µm, width 179 µm. Anterior margin truncate, posterior margin slightly arched. Triangular arrangement of internal muscle scars extending to margin of AD. Length of OC 145 µm, width 105 µm. Plate with two corneae; anterior gland pore just posterior to level of corneae, posterior gland pore in posterior edge. Length of PD 284 µm, width 213 µm, plate extending between OC. Pair of gland pores at 0.88, removed from posterior margin. Anal cone with large anal sclerites. Dorsal setae short, slender, ds-1 not longer than posterior pairs of setae. Setae on OC near medial margin, ds-3 at 0.43. PD with single pair of setae, inserted at 0.22. Adanal setae on anal cone.

AE, PE and GP fused, this ventral shield and anal plate fused in the median but separated laterally by pair of wedges of striated integument (Fig. 39). Length of ventral shield 452 µm. AE with three pairs of ventral setae, unilaterally with one adjunct seta. Pair of small internal tubes between epimeral plates I and II (Fig. 41). PE with one dorsal, one adjunct seta and three ventral setae. Length of GO 95 µm; with 7 (rarely five) pairs of pgs, two pairs of sgs and three pairs of internal genital acetabula (Fig. 40).

Gnathosoma large, length 157 µm, width 122 µm, ratio idiosoma:gnathosoma 1:0.28. Length of rostrum 40 µm, about one quarter of length of gnathosoma. Tectum truncate. Palps hardly extending beyond tip of rostrum (Figs 42 and 43). P-2 with dorsal plumulose seta; no seta on P-3; P-4 with three basal setae.

Legs. Length of telofemora I to IV almost twice their height. Leg chaetotaxy: legs I and II, 1, 2, 5, 5, 5, 3; leg III,

1, 2, 2, 3, 5, 4; leg IV, 0, 2, 2, 3, 5, 3. Genua I to IV with 1, 0, 0, 0 bipectinate setae; tibiae I to IV with 2, 1, 1, 2 bipectinate setae. Telofemora I, III and IV with 4/1, 2/0, 2/0 dorsal/ventral setae (Figs 47, 49 and 50), telofemur II with 4/1 dorsal/lateral setae (Fig. 48). Tarsus I with slender solenidion, 12 µm long, and adjacent minute famulus (Fig. 51); solenidion on tarsus II slightly longer (Fig. 52), 17 µm in length. Both tarsus I and II with pair of doubled pas; tarsus III with eupathid medial pas and flattened, spinose lateral pas; tarsus IV with slender medial and bipectinate, flattened lateral pas (Fig. 53).

Claws long and smooth. Carpite conspicuously long (Figs 51-53), length of carpites I and II 22 µm, of carpites III and IV 29 µm.

Male. Length 306-350 µm, in general more slender than illustrated in Fig. 44. In dorsal aspect similar to female. Pair of setae on PD at 0.18. Ventral plates fused to a shield (Fig. 44). With 8-11 pgs in line on either side of GO plus one pair of basilar setae. Perigenital setae delicately plumulose (Fig. 45). Length and width of spermatopositor 115 µm.

Deutonymph. Length 300-331 µm. Dorsal plates as illustrated (Fig. 55); gland pores of PD removed from posterior margin of plate. Ventral plates AE, PE and GA as illustrated (Fig. 56). GA with two pairs of internal genital acetabula; pgs and sgs lacking. Leg chaetotaxy: legs I and II, 1, 2, 3, 5, 5, 3; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 1, 2, 3, 5, 3. Telofemora I, III and IV with 2/1, 2/0, 2/0 dorsal/ventral setae, telofemur II with 2/1 dorsal/lateral setae.

Tritonymph. Length 435 µm. Venter with AE, PE, GP and AP separated. No adjunct setae on AE, none to one on PE. Genital plate with two pairs of pgs, one pair of sgs and three pairs of internal genital acetabula (Fig. 57). Leg chaetotaxy: legs I and II, 1, 2, 4, 5, 5, 3; leg III, 1, 2, 2, 3, 5, 4; leg IV, 0, 2, 2, 3, 5, 3. Telofemora I, III and IV with 3/1, 2/0, 2/0 dorsal/ventral setae and telofemur II with 3/1 dorsal/lateral setae. All tibiae with 3/2 dorsal/ventral setae.

Variations

Length of idiosoma, female: 500-560 µm (5).
Length of idiosoma, male: 452-510 µm (5).
Number of adjunct setae, either side of AE: 1(11), 0(9).
Number of adjunct setae of PE: 1(19), 0(1).
Number of pgs, either side of GO, female: 5(2), 6(1), 7(7).
Number of pgs, either side of GO, male: 9(2), 10(6), 11(1), 12(1).
Number of setae of leg segments 2 to 5:

segment	leg I	leg II	leg III	leg IV
2	2(20)	2(20)	2(20)	2(20)
3	4(4), 5(15)	4(4), 5(16)	3(1), 2(19)	2(20)
4	4(1), 5(19)	4(2), 5(18)	3(20)	3(20)
5	5(20)	5(20)	5(20)	5(20)

Remarks

The most obvious character combination of females is: PD with single pair of setae, ventral plates fused, female with 7 pairs of pgs, claws smooth. None of the approximately 100 *Rhombognathus* species demonstrates a similar combination. One of the five female *R. major* studied had no more than five pairs of perigenital setae. A combination of PD with single pair of setae, ventral plates fused, claws smooth and female with five pairs of pgs is present in half a dozen species but all of them have a larger number of setae on the telofemora than present in *R. major*.

Males of *R. major* can similarly be separated from congeners on the basis of the combination: PD with single pair of setae, ventral plates fused, 9-12 pairs of delicately plumulose pgs (with pair of basilar setae included), telofemora I-IV with (4-)5/(4-)5/2/2 setae, claws smooth.

One of the males has a spermatophore attached to the OC (Fig. 46).

Biology

Rhombognathus major seems to be dominant amongst turf of *Bostrychia* growing on upper tidal boulders and rocks. Other co-occurring mite taxa are mesostigmatids, oribatids and astigmatids, other meiofaunal components are gastropods, harpacticoids, small tanaidaceans and larvae of dipterans.

Ecological remarks

The three species described above, *Isobactrus similis*, *Rhombognathus bulbosus* and *R. major* are most abundant in the middle and upper tidal zone, in a zone not regularly flooded during a tidal cycle. The habitats of the three species are not exposed to severe desiccation. The turfs of *Bostrychia*, inhabited by *R. major*, are thick and dense, shaded by overhanging trees and thus protected from the sun, the substratum is still moist after a long-term tidal emersion. The green algae patches on the stems of *Rhizophora*, with *R. bulbosus*, are under the canopy of the trees. *Isobactrus similis*, very abundant amongst dense barnacle colonies on boulders on a sandy shore, are exposed to solar radiation, but the dense barnacle covering and capillary water are expected to prevent severe desiccation.

Littoral halacarid species are known to withstand long-term desiccation (Bartsch, 1974). In exposed substrata studied on the North Sea coast, Northern Atlantic, the water content within the algal cover on rocks could, during low tide, rapidly drop below 10 %, still the green and brown algae were inhabited by halacarid mites (Bartsch, 1972). In the tropical Singapore, with a persistently high relative humidity throughout the year, generally reduced insolation due to cloud-cover and not reaching excessive summer

temperatures as recorded at higher tropical latitudes, the conditions for an aquatic fauna in the upper littoral habitats may be less deteriorating than in similar habitats in the boreal region.

Several halacarid species living in the upper littoral have the integument covered by delicate villi and debris, which are expected to give shelter from desiccation. The dorsum and legs of *R. bulbosus* and *I. similis* were densely fouled with organic and inorganic material, whereas *R. major* was free from such a layer.

Acknowledgements

The studies on the halacarid fauna of Singapore were financed by a grant of the National University of Singapore which is gratefully acknowledged. A special thank is due to Dr. Darren C. J. Yeo, Raffles Museum of Biodiversity Research, and the staff of the Museum, who helped in many ways to make my stay a success.

References

Abé H. 1996. A new species of the genus *Isobactrus* (Acari: Halacaridae) from Ponape, Micronesia, with a special reference to infrageneric character state distribution. *Species Diversity,* **1:** 17-29.

Bartsch I. 1972. Ein Beitrag zur Systematik, Biologie und Ökologie der Halacaridae (Acari) aus dem Litoral der Nord- und Ostsee. I. Systematik und Biologie. *Abhandlungen und Verhandlungen des naturwissenschaftlichen Vereins in Hamburg*, (Neue Folge) **16:** 155-230.

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 in Hamburg*, (Neue Folge) **17:** 9-53.

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

Bartsch I. 1989. Rhombognathinae (Halacaridae, Acari) aus dem Pazifik. Beschreibung sieben neuer Arten. *Entomologische Mitteilungen aus dem Zoologischen Museum Hamburg*, **9:** 229-246.

Bartsch I. 1992. Hong Kong rhombognathine mites (Acari : Halacaridae). In *The Marine Flora and Fauna of Hong Kong and Southern China III* (B. Morton ed), 251-276. University Press: Hong Kong.

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

Bartsch I. 2003a. Mangrove halacarid fauna (Halacaridae, Acari) of the Dampier region, Western Australia, with description of five new species. *Journal of Natural History*, **37:** 1855-1877.

Bartsch I. 2003b. The subfamily Rhombognathinae: developmental pattern and re-evaluation of the phylogeny (Arachnida, Acari, Halacaridae). *Senckenbergiana biologica,* **82**: 15-57.

Bartsch I. 2003c. Rhombognathine mites (Halacaridae: Acari) from Dampier, Western Australia: taxonomy and biogeography. In *The Marine Flora and Fauna of Dampier, Western Australia* (F.E. Wells, D.I. Walker & D.S. Jones eds). 255-280. Western Australian Museum: Perth.

Hopper M. 1998/99. WXTide 32. (freeware).