THE RAFFLES BULLETIN OF ZOOLOGY 2002 **50**(1): 231-249

GUIDE TO THE AQUATIC HETEROPTERA OF SINGAPORE AND PENINSULAR MALAYSIA. - 2. VELIIDAE

Nils Møller Andersen
Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen, Denmark. Email: nmandersen@zmuc.ku.dk

Chang Man Yang
Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore, Singapore 119260
Email: dbsycm@nus.edu.sg

Herbert Zettel
Naturhistorisches Museum, 2. Zoologische Abteilung, Burgring 7, A-1014 Vienna, Austria
Email: herbert.zettel@nhm-wien.ac.at

ABSTRACT. – This is the second part of a series of guides to the aquatic Heteroptera of Singapore and Peninsular Malaysia published in the Raffles Bulletin of Zoology. The family Veliidae, with 15 genera and 33 recorded species, are the second commonest group of aquatic bugs in the region. We provide a list of known local species of Veliidae, a key to genera, and keys to species where applicable. We also include illustrations of representative members of each genus, some of the key characters used, and notes on biology and habitat.

KEY WORDS. – Veliidae, Singapore, Peninsular Malaysia, freshwater, marine, keys to genera, list of species.

INTRODUCTION

The family Veliidae (Heteroptera, Gerromorpha), commonly known as small water striders, water crickets, or riffle bugs are, after the Gerridae the second commonest group of semiaquatic bugs in Singapore and Peninsular Malaysia (in terms of known species). Fernando & Cheng (1974) listed 5 genera and 8 species in their review of the aquatic Hemiptera of the region. Since then 10 genera and 27 species have been added to the list (Andersen, 1981, 1983, 1989a; J. Polhemus & D. Polhemus, 1988; Murphy, 1990; Yang & D. Polhemus, 1994; Yang & Kovac, 1995; Yang et al., 1997; Andersen, 2000b; Kovac & Yang, 2000; Zettel, 2001).

FAMILY VELIIDAE

In this guide we provide a key to the genera of the family and keys to species where applicable. Most of the keys have been adapted from the literature, but a few have been constructed specifically for this paper. We have also illustrated representative members of each genus and key characters of each species to aid in their identifications. We have included only those species that have been collected or reported from Singapore and Peninsular Malaysia. As far as we are aware, only 12 species are endemic (Table 1); the remainder are found also in other parts of Malaysia, Indonesia, or Indochina.

Veliids live in a wide variety of aquatic habitats, but because of their small size and usually secretive habits they are generally not as well known as the true water striders, family Gerridae. Most species of *Microvelia* live on the nearshore, plant-covered surface of stagnant waters. Some species are frequently found in temporary habitats, such as pools and puddles filled with rainwater, and *Baptista* spp. occur even on moist soil close to the water's edge (Andersen, 1989a; Yang & Kovac, 1995). A few veliids are found only in water-filled bamboo internodes (e.g., *Lathriovelia* spp.; Kovac & Yang, 2000).

Received 15 Jun 2001 Accepted 2 Jan 2002

Table 1. Check-list and distribution of species of Veliidae (subgeneric names not given) recorded from Singapore and Peninsular Malaysia (Names in brackets are those given in Fernando & Cheng, 1974). (* = species expected to occur in the region).

Subfamily Haloveliinae Esaki, 1930
Entomovelia doveri Esaki, 1930
Halovelia abdominalis Andersen, 1989c
Halovelia lannae Andersen, 1989b
Halovelia malaya Esaki, 1930
Haloveloides sundaensis Andersen, 1992
Strongylovelia sp.
**Xenobates argentatus* Andersen, 2000b
Xenobates mandai Andersen, 2000b
Xenobates murphyi Andersen, 2000b
Xenobates pictus Andersen, 2000b
Xenobates singaporensis Andersen, 2000b

Subfamily Microveliinae China & Usinger, 1949 (1860)
Baptista collaris (Andersen, 1989a)
Baptista femoralis Andersen, 1989a)
Lathriovelia capitata Andersen, 1989a
Lathriovelia rickmersi Kovac & Yang , 2000
Microvelia albolineolata Bueno, 1927
Microvelia cameron Andersen, Yang & Zettel, 2002
Microvelia douglasi Scott, 1874
Microvelia genitalis Lundblad, 1933
Microvelia leveillei (Lethierry, 1877) (*M. diluta* Distant, 1909)
Microvelia petraeus Andersen, Yang & Zettel, 2002
**Microvelia plumbea* Lundblad, 1933
Neoalardus typicus (Distant, 1903)
Pseudovelia feuerborni (Lundblad, 1933)
Pseudovelia lundbladi Andersen, 1983
Pseudovelia sexualis (Paiva, 1917)
Xiphovelia sp.

Subfamily Perittopinae China & Usinger, 1949
Perittopus asiaticus Zettel, 2001 (*P. breddini* Kirkaldy, 1901; *P. vicarians* Breddin, 1905)
Perittopus webbi Zettel, 2001

Subfamily Rhagoveliinae China & Usinger, 1949
Rhagovelia femorata Dover, 1928
Rhagovelia rudischuhi Zettel, 1993
Rhagovelia singaporensis Yang & D. Polhemus, 1994
Rhagovelia sondaica J. Polhemus & D. Polhemus, 1988
Rhagovelia sumatrensis Lundblad, 1933
Tetraripis doveri Lundblad, 1936

Subfamily Veliinae Brullé, 1846
**Angilia* sp.
Angilovelia y-alba (Paiva, 1918)

Many veliids are naturally associated with surfaces of flowing or otherwise disturbed water. The brilliant red *Perittopus* spp. are found in numbers on quiet pools beside streams (Andersen, 1982; Zettel, 2001). *Pseudovelia* species are usually found among floating debris and foam on lentic bays of streams (Esaki & Miyamoto, 1955). *Pseudovelia sexualis* (Paiva), however, is found only in the narrow ripple zone on the shores of rivers, lakes, and water reservoirs (Andersen, 1983). *Xiphovelia* spp. which possess leaf-like, tarsal swimming fans live along the margins of streams and rivers (Lundblad, 1933; Esaki & Miyamoto, 1959). The riffle bugs, *Rhagovelia* spp., are found almost exclusively on running water, where they form loose schools (J. Polhemus & D. Polhemus, 1988; Zettel, 1993; Yang & D. Polhemus, 1974). When disturbed, these swarms tend to disperse, but reassociate later (Cheng & Fernando, 1971).

Three genera of veliids include only marine species. The coral bugs, *Halovelia* spp., live in the intertidal zone of coral reefs, where they are found in pools at low tide. At high tide they retreat to holes in coral rocks and stay submerged until the water recedes (Andersen, 1989b, 1989c). *Haloveloides* spp. and the mangrove bugs, *Xenobates* spp., live in tidal creeks in mangrove swamps (Murphy, 1990; Andersen, 1992, 2000b).

On the water surface, veliids either walk in the same way as on land, supported by alternating tripods of legs, or row by simultaneous strokes of their middle legs (Andersen, 1982). Several veliids have their claws and associated structures modified to form swimming fans, of which the plumose fans on the middle legs of *Rhagovelia* spp. are the most elaborate. The food of veliids is chiefly small arthropods that fall on the water surface, ostracods and cladocerans trapped on the surface film, and mosquitoes in various stages of development. Nakasuji & Dyck (1984) concluded that *Microvelia douglasi* Scott, is one of the most important predators of the brown planthopper (*Nilparvata lugens* Stål), one of the world's most important rice pests.

The life cycle of veliids involves the usual five nymphal instars, although only four instars have been reported for some *Microvelia* and *Rhagovelia* species (Cheng & Fernando, 1971; Andersen, 1982). Nymphs are similar to adults in external morphology but are usually paler, more soft-bodied, or have less elaborate color patterns. In addition the tarsal segmentation is absent or indistinct, wings are absent or not fully formed, and the genital segments are not differentiated. Most veliids are wing dimorphic, with apterous (wingless) and macropterous (winged) adult forms. Self mutilation (autotomy) of the distal wing parts is frequently observed in species of *Pseudovelia, Rhagovelia, Strongylovelia,* and *Xiphovelia* (Andersen, 1982). In a study of three species of *Microvelia* in Japan (including *M. douglasi*), Muraji & Nakasuji (1988) found higher frequencies of macropterous adults with increasing nymphal densities. The fertility was higher in the apterous form than in the macropterous form. During copulation, veliid males usually ride on the back of the females (Miyamoto, 1953). The combs commonly found on the distal part of the fore tibiae of most male veliids are probably adaptations to help the male grasp the female while riding.

There are 6 subfamilies in the Veliidae: Microveliinae, Haloveliinae, Rhagoveliinae, Perittopinae, Veliinae, and Ocelloveliinae (Andersen, 1982). All but the last one are represented in this region.

KEY TO GENERA OF VELIIDAE OF SINGAPORE AND PENINSULAR MALAYSIA

(modified from Andersen, 1982)

1. Last segment of middle tarsi deeply cleft, with leaf-like claws and plumose or setose swimming fan arising from base of cleft (Figs. 3, 11). (Rhagoveliinae) 2
- Last segment of middle tarsi not deeply cleft, without plumose or setose swimming fan 3
2. Last segment of middle and hind tarsi deeply cleft, each with setose swimming fan arising from base of cleft (Fig. 11). Apterous form with long pronotum (Fig. 10) ..... *Tetraripis*
- Only last segment of middle tarsi deeply cleft, with plumose swimming fan arising from base of cleft (Fig. 3). Apterous form with short pronotum (Fig. 1) ..... *Rhagovelia*
3. Middle tarsi with three segments (basal segment sometimes very small) 4
- Middle tarsi with two segments 6
4. Fore tarsi with two segments, basal segment very short. First segment of middle tarsi subequal in length to segment 2 and 3. Fore-wings divided into proximal coriaceus part and distal membranous part (without veins; Fig. 12). (Perittopinae) ..... *Perittopus*
- All tarsi with three segments (basal segments of fore and hind tarsi sometimes very short). Fore-wings structure not as above, with four closed cells. (Veliinae) 5
5. Both male and female with stridulatory devices on connexival margin of sterna 2 and 3 and on hind femora (Fig. 20). Head moderately deflected in front of eyes. Fore tibia of female without grasping comb ..... *Angilovelia*
- Without stridulatory devices. Head distinctly deflected in front of eyes. Fore tibia of female with long grasping comb ..... *Angilia*

6. All tarsi with two segments (basal segment of fore tarsi very short). Middle tarsi three times or more the length of hind tarsi. (Haloveliinae) 7
- Fore tarsi with only one segment, middle and hind tarsi with two segments. Middle tarsi rarely more then twice as long as hind tarsi. (Microveliinae) 11
7. Eyes large, wider than half width of interocular space (Fig. 22). Head strongly deflected in front of eyes (Fig. 21). Living in freshwater 8
- Eyes small, not wider than half width of interocular space (Fig. 23). Head moderately deflected in front of eyes (Fig. 24). Living in brackish or sea water 9
8. Second antennal segment shorter than first segment. First hind tarsal segment about half as long as second segment. Body with dense pilosity, but without pale markings (except on pronotum) ..... *Entomovelia*
- Second antennal segment longer than or subequal to first segment. Hind tarsal segments subequal in length. Body with pale markings (Fig. 22), but without dense pilosity ..... *Strongylovelia*
9. Pronotum completely dark. Eye width less than 0.3x interocular width. Fore tibia of male with grasping comb (Fig. 26). Male genital segments withdrawn into pregenital abdomen, only slightly protruding from abdominal end (Fig. 25) ..... *Halovelia*
- Pronotum with pale markings or spots. Eye width more than 0.3x interocular width. Fore tibia of male without grasping comb. Male genital segments distinctly protruding from pregenital abdomen 10
10. Usually dark and pale colored; thoracic dorsum with definite spots of silvery hairs. Fore trochanter of male without spine. Middle femur less than 0.9x body length; middle tarsus less than 0.8x length of middle tibia (Fig. 29) ..... *Xenobates*
- Chiefly dark colored; thoracic dorsum at most with scattered silvery hairs. Fore trochanter of male with a spine (Fig. 36). Middle femur more than 0.9x body length; middle tarsus about 0.8x length of middle tibia (Fig. 35) ..... *Haloveloides*
11. Head posteriorly produced, extending well behind hind margin of eyes; anterior margin of pronotum deeply emarginated (Fig. 37). Body usually elongate and relatively slender 12
- Head not produced as above; anterior margin of pronotum at most slightly concave. Body usually shorter and stouter (except in *Microvelia albolineolata*) 14
12. Fore tibia of male without grasping comb. Fore and middle femora of male simple (Fig. 37) ..... *Neoalardus*
- Fore tibia of male with grasping comb (Fig. 41). Fore and middle femora of male modified on posterior margin (except *Baptista collaris*) (Figs. 39, 45, 47) 13
13. Eyes distinctly removed from anterior margin of pronotum (Fig. 44) ..... *Lathriovelia*
- Eyes not removed from anterior margin of pronotum (Fig. 38) ..... *Baptista*
14. First antennal segment incrassate, extending more than two-thirds of its length beyond apex of head (Fig. 58). Distal cells of fore-wings reduced (Fig. 63) ..... *Pseudovelia*
- First antennal segment more slender and usually much shorter, extending less than two-thirds of its length beyond apex of head. Distal cells of fore-wings not reduced 15
15. Middle tarsi with three subapical leaf-like structures (claws and ventral arolium; Fig. 65). Pronotum of apterous form very short (Fig. 64) ..... *Xiphovelia*
- Middle tarsi not modified as above. Pronotum of apterous form long (except in *M. leveillei* and *M. petraeus* new species) ..... *Microvelia*

SUBFAMILY RHAGOVELIINAE

This subfamily contains only two genera in the region, *Rhagovelia* Mayr and *Tetraripis* Lundblad, both characterized by possessing elaborate, plumose or hairy swimming fans arising from the deeply cleft third segment of the middle tarsus (Fig. 3). Of the latter genus, only a single species, *T. doveri,* has been recorded from Peninsular Malaysia (Lundblad, 1936). It can be distinguished from *Rhagovelia* species by the presence of a grasping comb on the fore tibiae of both male and female, and especially by the presence of pretarsal swimming fans on both the middle and the hind tarsi (Fig. 11). A closely related genus and species, *Chenevelia stridulans* from northern Thailand, possess stridulatory devices in both sexes Zettel, 1996). As far as is known, *Tetraripis* species live in cryptic habitats, usually under stones and overhanging rocks in streams (Andersen, 1982, 2000a; Zettel, 1996; J. Polhemus & D. Polhemus, 1998).

Riffle bugs in the genus *Rhagovelia,* successful inhabitants of flowing freshwater throughout the world tropics, are commonly encountered in Singapore and Malaysia on both slow and fast flowing streams, especially on headwaters of forest streams, and on the very slow moving waters of forest swamps. Since all species present in the area are small, generally dark in color, and superficially similar, their correct identification has been problematic. Fernando & Cheng (1974) reported only *R. femorata* Dover from Peninsular Malaysia. J. Polhemus & D. Polhemus (1988) and D. Polhemus (1990) who revised the Southeast Asian fauna, recorded three species from the region: *R. femorata, sumatrensis,* and *sondaica.* These same three species were also reported from Ulu Kinchin, Pahang, in Peninsular Malaysia by Kovac & Yang (1989). Zettel (1993) subsequently described a fourth species, *R. rudischuhi* Zettel, from Perak, Peninsular Malaysia. Murphy (1990) reported *R. femorata* and *sumatrensis* from Singapore. Yang & D. Polhemus (1994) found that only *R. sumatrensis* and *rudischuhi* are common on the island, but also described a third species, *R. singaporensis.* Based on the current taxonomic interpretation, *R. femorata* is found from Trengganu to Johore, Peninsular Malaysia, but not in Singapore.

Key to the species of *Rhagovelia*
(after Yang & D. Polhemus, 1994)

1. Anterior margin of pronotum black, with a median orange brown transverse band, sourrounded by black margins, length of this band along midline less than 1/3 length of pronotum 2
- Anterior margin of pronotum with a broad orange band, extending laterally to propleura and prosternum, length of this band along midline about 2/3 length of pronotum. Armature of male hind femur with 2-6 basal, 1 middle, and 5-9 distal teeth (Fig. 5). Length 2.4-2.6 mm (male), 2.7 mm (female) ..... *rudischuhi* Zettel
2. Middle coxa entirely black. Posterior margin of pronotum concave. Hind femur of male with 10-12 basal teeth, followed by one large curved spine beyond middle, then 4-6 small distal teeth. Male paramere broad distally (Fig. 4). Hind femur of female with 1-2 basal, 1 middle, and 3-6 distal teeth ..... *femorata* Dover
- Middle coxa white or slightly brownish. Posterior margin of pronotum either concave or straight. Male paramere narrow distally (Fig. 8) 3
3. Middle femur of male with 3-4 slender, sharp ventral spine-like hairs on basal half (Fig. 1); middle coxa slightly brownish. Posterior margin of pronotum straight. Hind femur of male with 14-18 basal teeth extending from base of femur (Fig. 9); hind trochanter with 4-6 black denticles. Length 2.9 mm (male), 3.0 mm (female) ..... *sumatrensis* Lundblad
- Middle femur of male lacking sharp ventral spine-like hairs on basal half; middle coxa white. Posterior margin of pronotum straight or concave. Hind femur of male with less than 10 basal teeth, these teeth not reaching base of femur (Figs. 6, 7); hind trochanter with only 2-3 black denticles or none 4
4. Hind trochanter with 2-3 black denticles. Hind femur of male with two rows of teeth; anterior row beginning with 1-6 very small basal teeth, followed by 2-5 small distal teeth; posterior row without basal teeth, bearing one large curved spine at middle, followed by 6-10 smaller teeth decreasing in size distally (Fig. 6). Hind femur of female armed with only a single row of teeth, bearing 0-2 basal teeth, one middle, and 4-9 distal teeth. Posterior margin of pronotum straight. Length 2.6-2.8 mm (male), 2.8-3.0 mm (female) ..... *singaporensis* Yang & D. Polhemus
- Hind trochanter lacking black denticles. Hind femur of male with a single row of teeth, beginning with 4-7 small basal teeth, followed by one long and curved spine beyond middle, then 2-5 distal teeth (Fig. 7). Hind femur of female armed with 0-2 distal teeth. Posterior margin of pronotum concave. Length 2.6 mm (male), 3.0 mm (female) ..... *sondaica* J. Polhemus & D. Polhemus

SUBFAMILY PERITTOPINAE

Perittopus, the only genus of the subfamily Perittopinae, can be easily recognized by the orange to reddish coloration of the dorsum (in macropterous specimens with black wings), the tarsal formula 2-3-3, and the thickened basal part of the fore-wings ("corium") bearing two closed cells (Fig. 12). Andersen (1982) presents numerous morphological details of the genus and discusses its phylogenetic position. *Perittopus* was revised by Lundblad (1933), who treated all but one species known at that time. Since then no further species have been described until now. Zettel (2001) describes five new species from Southest Asia and keys out the 7 species known from this region, including *P. breddini* Kirkaldy and *P. vicarians* Breddin. Both species were previously recorded from Peninsular Malaysia (Fernando & Cheng, 1974; Yang & Kovac, 1995; Yang et al., 1999), but seem to have restricted distributions in Indonesia: *P. breddini* in Bali, Central and East Java, and *P. vicarians* in West Java (Zettel, 2001).

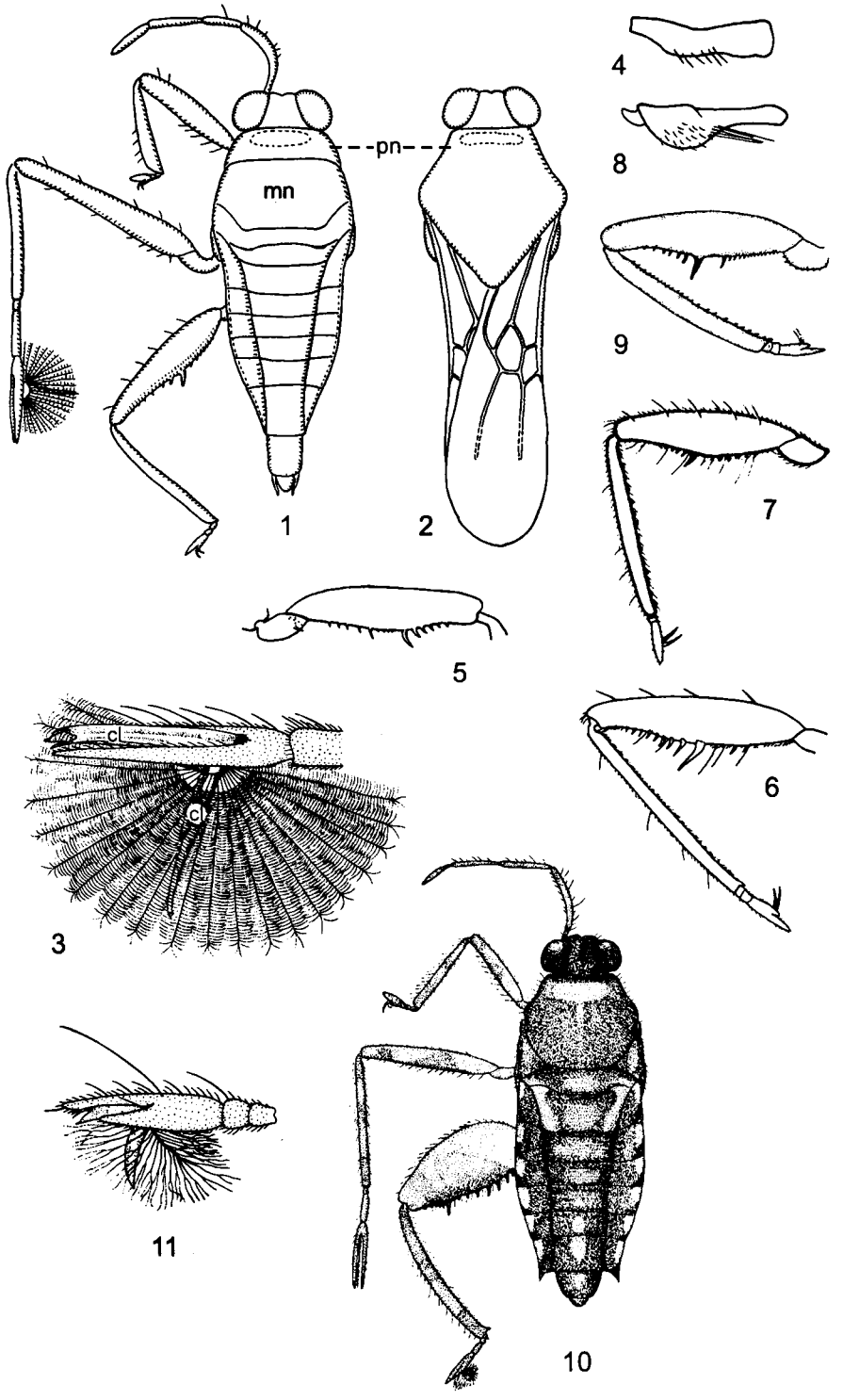
Identification of the species is complicated by the fact that diagnostic characters are usually confined to one sex or one wing morph. Distinction among species is mainly based on primary and secondary sexual characteristics, especially in apterous females. The following key is intended to assist in distinguishing the two species recorded from this region.

Key to the species of *Perittopus*
(modified from Zettel, 2001)

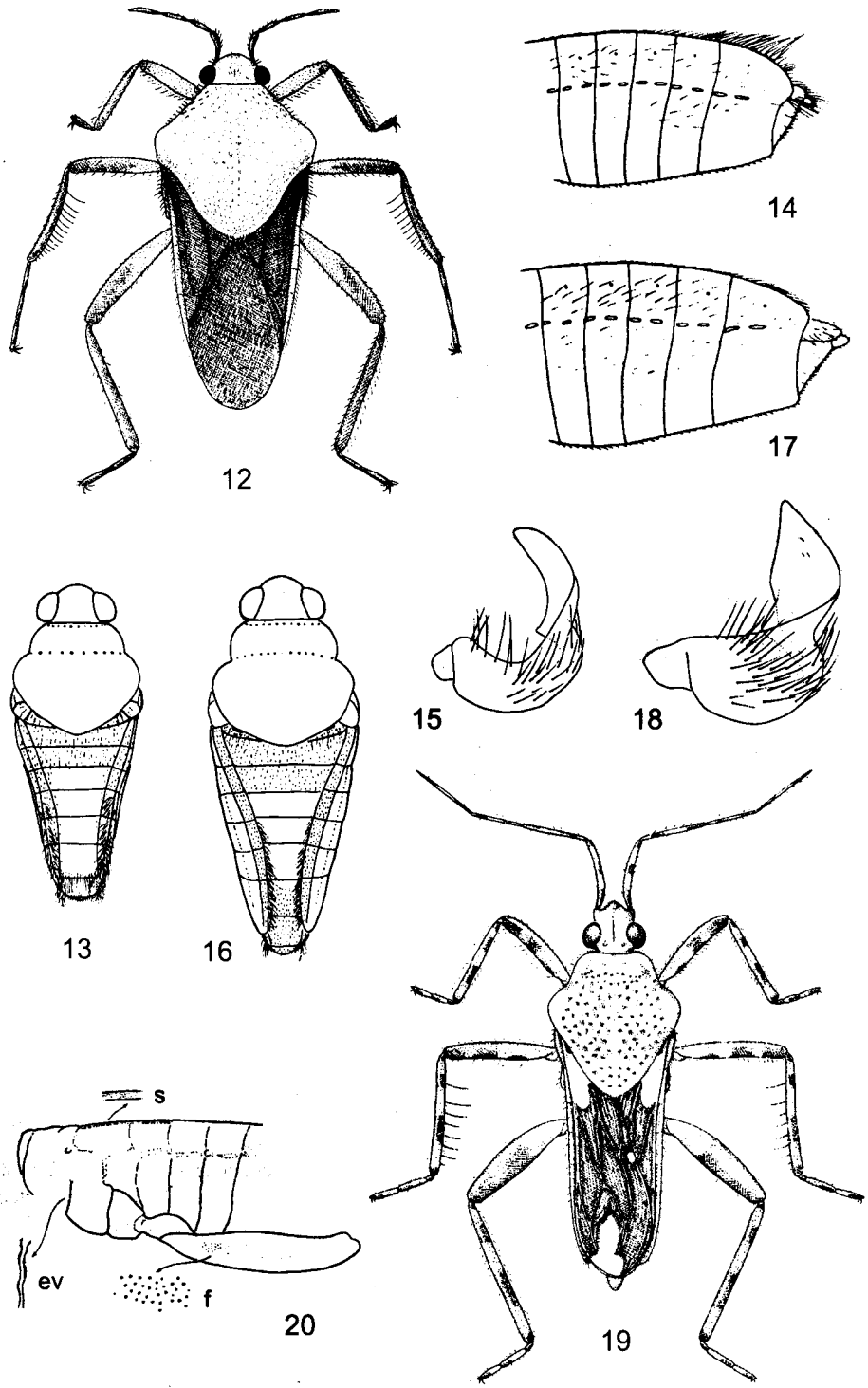
1. Hind tibiae strongly infuscated, at least dorsally. Male: paramere distally slender, elongate (Fig. 15). Apterous female: in lateral view, connexivum 7 with numerous long, postero-dorsad directed hairs (Fig. 14); hind margin of tergite 7 with long, black, backward directed hairs (Fig. 13). Macropterous female: tergite 8 posterolaterally with a distinct tuft of long dark bristles. Length 2.6-3.3 mm (male), 2.7-3.4 mm (female). ..... *asiaticus* Zettel
- Hind tibiae hardly infuscated. Male: paramere distally broad, triangular (Fig. 18). Apterous female: in lateral view, connexivum 7 with only short pubescence (Fig. 17); hind margin of tergite 7 without long hairs (Fig. 16). Macropterous female unknown. Length 2.7-3.3 mm (male), 3.0-3.6 mm (female) ..... *webbi* Zettel

SUBFAMILY VELIINAE

Two genera are known from Southeast Asia. *Angilovelia y-alba* (Paiva), however, is the only species recorded from Singapore and Peninsular Malaysia (Andersen, 1981; J. Polhemus & D. Polhemus, 1998). It is always long-winged (Fig. 19); length 5.0-5.1 mm, reddish-brown, with faintly banded legs, and fore-wings dark with white spots (the specific name refers to the shape of the whitish



Figs. 1-11. Rhagoveliinae (Veliidae). 1. *Rhagovelia sumatrensis*: apterous male, dorsal view; antennae and legs of right side omitted (mn, mesonotum; pn, pronotum). 2. *Rhagovelia sumatrensis*: macropterous male, dorsal view; antennae and legs omitted. 3. *Rhagovelia* sp.: middle tarsus with swimming fan and claws (cl) (from Andersen, 1982: Fig. 290). 4. *Rhagovelia femorata*: paramere (from J. Polhemus, 1990: Fig. 8). 5. *Rhagovelia rudischuhi*: hind femur of male (from Zettel, 1993: Fig. 3). 6. *Rhagovelia singaporensis*: hind leg of male (from Yang & D. Polhemus, 1994: Fig. 3). 7. *Rhagovelia sondaica*: hind leg of male (from J. Polhemus & D. Polhemus, 1988: Fig. 113). 8. *Rhagovelia sondaica*: paramere (from J. Polhemus & D. Polhemus, 1988: Fig. 110). 9: *Rhagovelia sumatrensis*: hind leg of male (Lundblad, 1936: Fig. 9B).10. *Tetraripis zetteli* Andersen (Thailand): apterous male, dorsal view; antennae and legs of right side omitted (from Andersen, 2000a: Fig. 1). 11. *Tetraripis* sp.: hind tarsus (from Andersen, 1982: Fig. 293)



Figs. 12-20. Perittopinae and Veliinae (Veliidae). 12. *Perittopus* sp.: macropterous female (from Andersen, 1982: Fig. 294). 13. *Perittopus asiaticus*: apterous female, dorsal view; antennae and legs omitted (from Zettel, 2001: Fig. 2).14. *Perittopus asiaticus*: abdomen of apterous female, lateral view (from Zettel, 2001: Fig. 6). 15. *Perittopus asiaticus*: left paramere of male, lateral view (from Zettel, 2001: Fig. 25).16. *Perittopus webbi*: apterous female, dorsal view; antennae and legs omitted (from Zettel, 2001: Fig. 3). 17. *Perittopus webbi*: abdomen of apterous female, lateral view (from Zettel, 2001: Fig. 9). 18. *Perittopus webbi*: left paramere of male, lateral view (from Zettel, 2001: Fig. 26). 19. *Angilovelia yalba*: macropterous female, dorsal view (from Andersen, 1981: Fig. 1). 20. *Angilovelia yalba*: male abdomen in lateral view and hind femur showing stridulatory devices (ev, scent evaporatorium; f, "file"; s, "strigil") (from Andersen, 1981: Fig. 2).

distal spot). Both male and female have stridulatory devices on upper part of abdominal pleura and on hind femora (Fig. 20). Throughout its distributional area, this species seems to be extremely rare. In this region it is only known from one female collected at a wayside pond in Perak Japah, and another female collected at Marang, Terrenganu, Peninsular Malaysia.

Three species of *Angilia* Stål (subgenus *Adriennella* Poisson) are found in adjacent areas. The type locality of *A. trispinosa* Andersen, once thought to be in Malaysia, is in reality in Sumatra (Andersen, 1981; J. Polhemus & D. Polhemus, 1998). *Angilia* species are almost always macropterous, length 5.5-7.2 mm, brownish, with distinctly banded legs, and fore-wings dark with whitish spots. The pronotum is very large, with elevated (sometimes pointed) humeral angles and posterior margin forming a median tubercle; both male and female have a grasping comb on the fore tibiae. They live in cryptic habitats such as dark secluded spots beneath stream banks with overhanging vegetation or in water-filled holes in the banks of streams, and could easily have been overlooked in the region.

D. Polhemus (1997) reclassified the genus *Tetraripis* (see above) in this subfamily, but following the argumentation presented by Andersen (2000a), the unique, complex structure of the middle tarsus of this genus clearly affiliates it with the subfamily Rhagoveliinae.

SUBFAMILY HALOVELIINAE

Water striders belonging to this subfamily are characterized by their small size, slender middle and hind legs of which the intermediate pair is the longest, a reduced pronotum in apterous forms (Fig. 21), and a unique tarsal formula of 2-2-2. Five genera belonging to this subfamily are recorded from Singapore and Peninsular Malaysia. Species belonging to the genera *Entomovelia* Esaki (Fig. 21) and *Strongylovelia* Esaki (Fig. 22) live in freshwater habitats (Andersen, 1982) and are usually apterous, although macropterous specimens do occur. They can be distinguished by the characters given in the key (see above). The first genus is represented by a single species, *Entomovelia doveri*, described from Gombak Valley (Malaysia: Selangor). Species of *Strongylovelia* (probably undescribed) have been recorded from Singapore (Murphy, 1990) and Peninsular Malaysia (Yang & Kovac, 1995; Yang et al., 1997).

The genera *Halovelia* Bergroth, *Haloveloides* Andersen, and *Xenobates* Esaki comprise only marine species and occur only in the apterous form (Andersen, 1989b, c, 1992, 2000b). They can be distinguished by the characters given in the key (see above). The first species of marine haloveliines recorded from Malaysia was *Halovelia malaya,* described by Esaki (1930) on the basis of specimens collected at Pulau Angsa, on the West coast of the Malayan Peninsula. Additional species of *Halovelia* and *Haloveloides* from Peninsular Malaysia and Singapore were described or recorded by Andersen (1989b, c, 1992, 2000b). Finally, Murphy (1990) recorded *Halovelia malaya* and a species of *Xenobates* from Singapore. Almost all *Halovelia* species inhabit the intertidal zone of coral reefs and are therefore called coral bugs. They are active on the surface of intertidal pools during low tide and retreat to holes in porous blocks of coral and stay submerged during high tide. The three species recorded from the region (Andersen, 2000b) can be separated by the key (see below). *Xenobates* species live on tidal streams in mangrove swamps and are therefore called mangrove bugs (Andersen & Weir, 1999). The four species recorded from the region (Andersen, 2000b) can be distinguished by the key characters (see below). Only one species of *Haloveloides, H. sundaensis,* is recorded from the region (Andersen, 1992). It is small, length 1.65-1.75 mm (male), 1.95-2.2 mm (female), with fusiform antennal segment 4 (Fig. 35), a long spine on the male fore trochanter (Fig. 36), and very long middle legs, usually more than 0.8x total length of insect.

Key to species of *Halovelia*
(modified from Andersen, 1989b, c)

1. Male grasping comb about 2/5 of fore tibial length. Female abdomen basally constricted, distinctly tapering towards abdominal end; connexiva erect and basally thickened (Figs. 23, 27) 2
- Male grasping comb less than 1/3 of fore tibial length. Female abdomen almost parallel-sided; connexiva suberect, not thickened basally (Fig. 28). Length 1.8-1.9 mm (male), 2.2-2.4 mm (female) ..... *lannae* Andersen
2. Female abdomen long and very narrow (Fig. 27); connexiva inflexed upon abdominal dorsum, meeting along the midline. Length 1.7-1.85 mm (male), 2.4-2.5 mm (female) ..... *abdominalis* Andersen
- Female abdomen shorter and broader (Fig. 23); connexiva inflexed upon abdominal dorsum, but not meeting along midline. Length 1.8-1.95 mm (male), 2.3-2.55 mm (female) ..... *malaya* Esaki

Key to species of *Xenobates*
(modified from Andersen, 2000b; *X. argentatus* from Phuket, Thailand, is included as it may occur in the region)

1. Middle femora with anterior row of long, bristle-like hairs (Fig. 29) 2
- Middle femora without anterior row of long, bristle-like hairs (or at most with short scattered hairs) 4
2. Male abdominal venter with basal tumescence which forms a steep angle towards depressed sternum 7 (Fig. 31); parameres very long, normally crossing each other above proctiger (Fig. 29). Female abdomen posteriorly narrowed; connexiva suberect, pilose (Fig. 30). Pale marking of pronotum distinctly interrupted in middle. Length 1.5-1.6 mm (male), 1.75-1.8 mm (female). ....*singaporensis* Andersen
- Male abdominal venter not modified as above; parameres long, but at most reaching or only slightly crossing each other above proctiger. Female abdomen more regularly tapering (Fig. 32); connexiva obliquely raised throughout. Pale marking of pronotum not interrupted in middle 3
3. Antennal segments 2 and 3 with long pilosity on anterior margin (Fig. 33). Basal part of male hind femur strongly incrassate (Fig. 33). Length 1.5 mm (male), 1.7 mm (female) ..... *mandai* Andersen
- Antennal segments 2 and 3 with short pilosity and at most with a few long hairs on anterior margin (Fig. 32). Basal part of male hind femur only slightly thickened. Length 1.55-1.6 mm (male), 1.7-1.8 mm (female) ....*murphyi* Andersen
4. Pronotum dark with transverse pale band or two transverse spots in posterior half; mesothorax without distinct pale markings. Male abdominal venter with basal tumescence which forms a steep angle towards depressed sternum 7 (as in Fig. 31). Length 1.5-1.6 mm (male), 1.7-1.8 mm (female). .....*argentatus* Andersen
- Pronotum chiefly pale; mesopleura (male) and lateral parts of mesonotum (female) with distinct pale markings (Fig. 34). Male abdominal venter not modified as above. Length 1.75-1.95 mm (male), 2.9-2.2 mm (female) ..... *pictus* Andersen

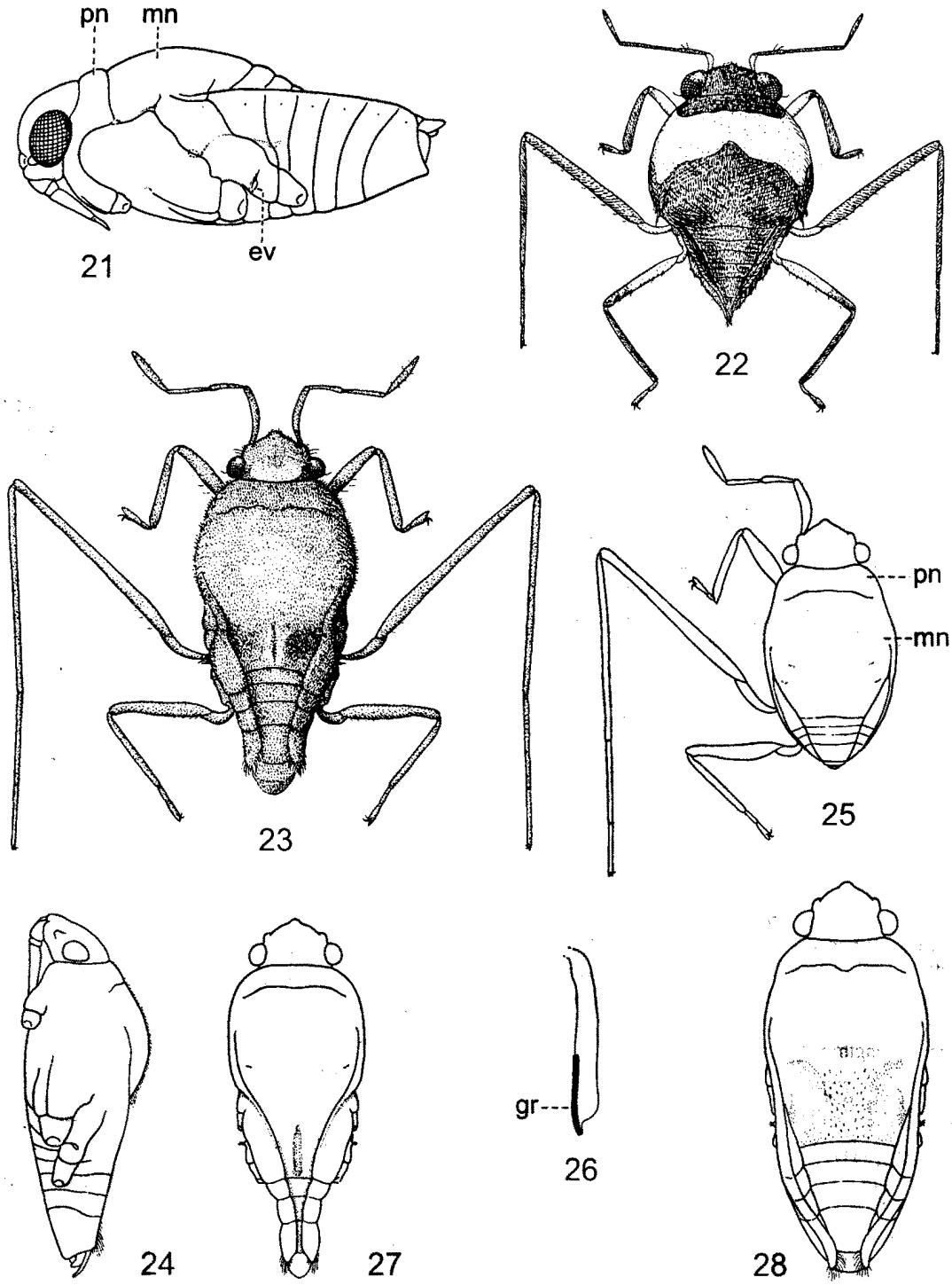
SUBFAMILY MICROVELIINAE

Species belonging to this subfamily are characterized by their small size, relatively short and stout middle and hind legs of which the hindmost pair are usually the longest, but chiefly by a unique tarsal formula of 1-2-2. Six genera belonging to this subfamily are recorded from Singapore and Peninsular Malaysia. *Neoalardus typicus* is relatively large, length 4.5-4.9 mm, with elongate body, dark brownish coloration, fore-wings with whitish stripes and spots (Fig. 37) (Yang et al., 1997; Zettel, 1998). In Thailand this species was found in living on moist sand and mud along a small forest stream, usually in deep shade from rocks (Andersen, 1982). *N. typicus* is usually macropterous and is attracted to light.

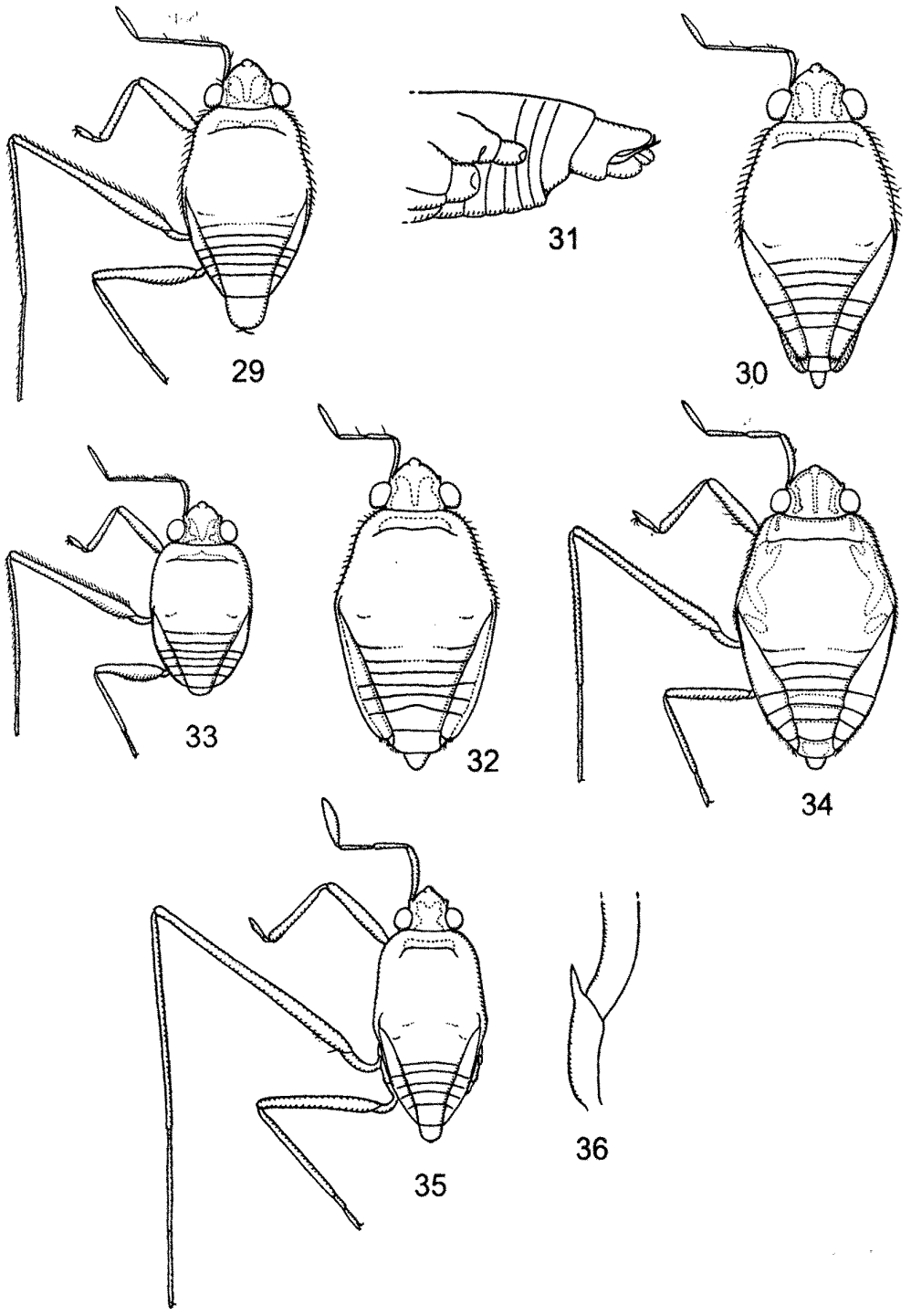
Some microveliines live in cryptic or secluded habitats and are easily overlooked by the inexperienced collector. *Baptista femoralis* (Fig. 38) was found among coarse litter (chiefly small pieces of wood, twigs, etc.) in seep areas on river banks. Another species was found in small water-filled cavities beneath turf at the foot of rock seeps, and in small holes in rocks on stream banks. In darkness, only the gleaming spots of silvery pubescence reveal the presence of these insects (Andersen, 1989a). The two species of *Baptista* recorded from the region can be distinguished by the characters given in the key (see below). *Baptista collaris* was originally assigned to the genus *Lathriovelia* by Andersen (1989a), but correctly reclassified by Kovac & Yang (2000). Since the original description is incomplete (based on only a single female), a redescription of this species is presented by Andersen et al. (2002).

A number of veliids are only found in so-called "phytotelmata", such as water-filled leaf axils of epiphytic plants, tree-holes, etc. (Andersen, 1982). Kovac & Yang (1992, 2000) report the exciting dicovery that the two known species of *Lathriovelia* are confined to the water-filled internodes of tall bamboos, e.g. *Gigantochloa* spp. These insects colonize their habitats through cracks or holes in the bamboo wall made by other animals (such as beetles, caterpillars, and woodpeckers) and feed on small arthropods floating on the water surface. Both *Lathriovelia* species are relatively large, length 3.5-5.6 mm, always macropterous, dark brownish to blackish, with whitish streaks and spots on the fore-wings (Fig. 44). The males have strongly modified legs and abdominal terminalia (Figs. 45-48). The two species can be distinguished by the characters given in the key (see below).

The genus *Microvelia* Westwood has about 180 species world wide, and more than 10 species in the region. Most of these are small or very small bugs, structurally quite uniform except for striking modifications of the male genital segments (e.g., *M. cameron* Andersen, Yang & Zettel; Fig. 54). Although some species are regularly found in flowing waters, most prefer the nearshore, usually plant-covered surface of stagnant waters, including temporary pools (Fernando, 1964). The Southeast Asian fauna of *Microvelia* has not been adequately revised since the excellent study by Lundblad (1933). Many undescribed species are known to occur in the region;



Figs. 21-28. Haloveliinae (Veliidae). 21. *Entomovelia doveri*: apterous female, lateral view; antennae and legs omitted (ev, scent evaporatorum; mn, mesonotum; pn, pronotum) (from Andersen, 1982: Fig. 265). 22. *Strongylovelia*: apterous female, dorsal view (from Andersen, 1982: Fig. 274). 23. *Halovelia malaya*, apterous female, dorsal view (from Andersen, 1989c: Fig. 1). 24. *Halovelia malaya*, apterous female, lateral view (from Andersen, 1989c: Fig. 13). 25. *Halovelia malaya*: apterous male, dorsal view (mn, mesonotum; pn, pronotum) (from Andersen, 1989c: Fig. 2). 26. *Halovelia malaya*: fore tibia of male with grasping comb (gr) (from Andersen, 1989c: Fig. 3). 27. *Halovelia abdominalis*, apterous female, dorsal view (from Andersen, 1989c: Fig. 19). 28. *Halovelia lannae*, apterous female, dorsal view (from Andersen, 1989b: Fig. 120).



Figs. 29-36. Haloveliinae (Veliidae). 29. *Xenobates singaporensis*: apterous male, dorsal view; antenna and legs of right side omitted (from Andersen, 2000b: Fig. 1). 30. *Xenobates singaporensis*: apterous female, dorsal view; antennae and legs omitted (from Andersen, 2000b: Fig. 2). 31. *Xenobates singaporensis*: male abdomen, lateral view (from Andersen, 2000b: Fig. 5). 32. *Xenobates murphyi*: apterous female, dorsal view; antennae and legs omitted (from Andersen, 2000b: Fig. 8). 33. *Xenobates mandai*: apterous male, dorsal view; antenna and legs of right side omitted (from Andersen, 2000b: Fig. 11). 34. *Xenobates pictus*: apterous female, dorsal view; antenna and legs of right side omitted (from Andersen, 2000b: Fig. 17). 35. *Haloveloides sundaensis*: apterous male, dorsal view; antenna and legs of right side omitted (from Andersen, 2000b: Fig. 22). 36. *Haloveloides sundaensis*: fore trochanter of male (from Andersen, 1992: Fig. 25).

two are described by Andersen et al. (2002). A preliminary key is presented below. The most common species in Singapore and Peninsular Malaysia are *M. cameron, douglasi,* and *leveillei* (Lethierry) (synonym *M. diluta* Distant; Zettel & Gapud, 1999) (Lundblad, 1933; Miyamoto, 1953; Andersen, 1967; Fernando & Cheng, 1974; Murphy, 1990; Yang et al., 1997, 1999).

The genus *Pseudovelia* Hoberlandt comprises several species previously classified in *Microvelia.* The Southeast Asian species were revised by Andersen (1983). They are chracterized by their relatively long first antennal segment (Fig. 58), reduced apical cells of the fore-wings (Fig. 63), usually modified male hind tibia and tarsus, and ventrally modified male segment 8 (Figs. 56, 57). They are usually found in lentic bays of streams with accumulated plant debris and foam. *Pseudovelia sexualis* (Paiva), however, lives in numbers in the narrow ripple zone of the sandy shore of rivers, lakes, and water reservoirs (Andersen, 1983). The three species recorded from the region can be separated by the key (see below).

Finally, an undescribed species of *Xiphovelia* Lundblad (1933) has been collected in Johor, Malaysia. This genus is characterized by the reduced pronotum of the apterous form (Fig. 64) and especially by having a swimming fan on the middle legs, composed of the leaf-like flattened claws and the ventral arolium (Fig. 65). *Xiphovelia* species live in mountain streams and along the shores of rivers (Esaki & Miyamoto, 1959).

Key to species of *Baptista*
(modified from Andersen, 1989a)

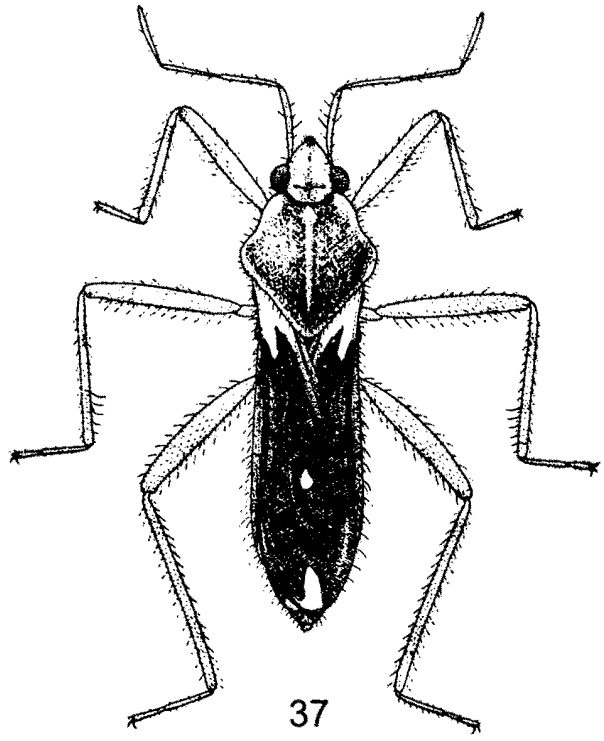
1. Male fore femora more or less arched, with a distal tumescence (Fig. 39). Male abdominal segments 6 and 7 strongly modified (Fig. 40), with a sharply demarcated, angular area in middle of sternum 7 and hairy lobes on each side of sterna 6 and 7. Length 2.8-3.5 mm (male), 2.8-3.2 mm (female) ..... *femoralis* Andersen
- Male fore femora not modified as above (Fig. 41). Male abdominal segments 6 and 7 simple, not modified as above (Fig. 42). Length 2.35-3.5 mm (male), 2.5-2.9 mm (female) ..... *collaris* (Andersen)

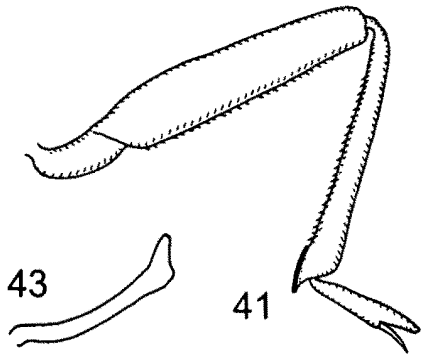
Key to species of *Lathriovelia*
(modified from Kovac & Yang, 2000)

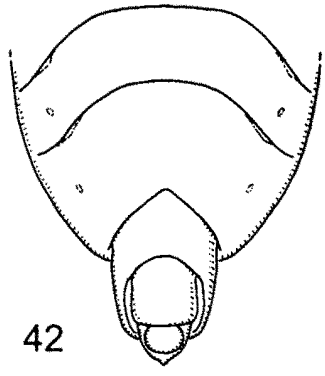
1. Male fore femora proximally thickened and furnished with a patch of dark, stiff hairs (Fig. 45); middle femora slightly constricted before apex, with ventral patch of short hairs. Male abdomen relatively broad, with a pair of slender, pilose projections arising from hind corners of mediotergites 6; posterior corners of laterotergites 7 (connexiva) distinctly widened (Fig. 46). Female proctiger pointed. Length 4.1-5.6 mm (male), 4.3-5.6 mm (female)..... *capitata* Andersen
- Male fore femora constricted in distal third and furnished with long ventral hairs in proximal two thirds (Fig. 47); middle femora slightly constricted before apex, with a ventral patch of short hairs. Male abdomen extremely long and slender, with a pair of broad, pilose projections arising from hind corners of mediotergites 6; posterior corners of laterotergites 7 rounded but not widened (Fig. 48). Female proctiger rounded. Length 5.5 mm (male), 3.45-4.6 mm (female) ..... *rickmersi* Kovac & Yang

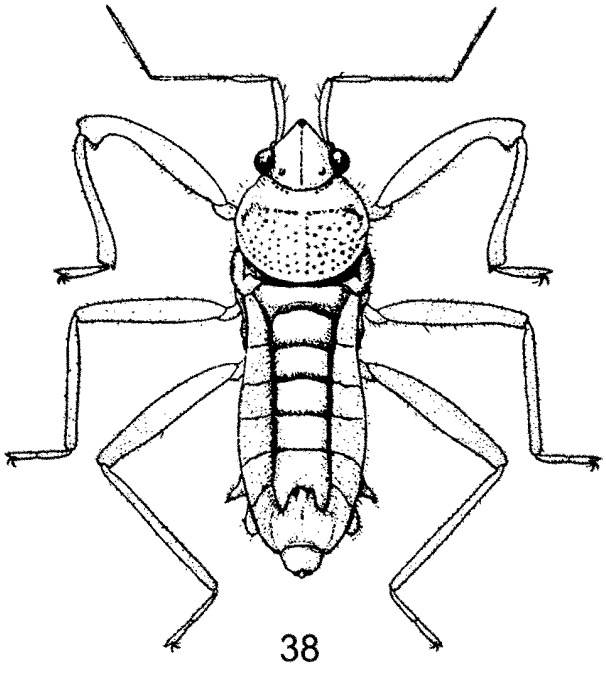
Key to species of *Microvelia*
(modified from Lundblad, 1933)

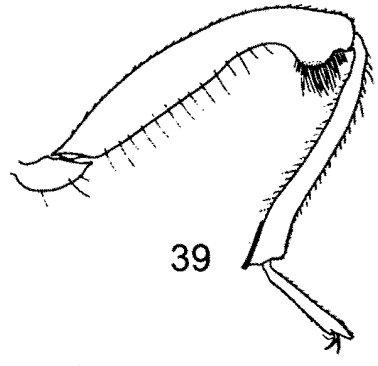
1. Third antennal segment longer than fourth segment. Large, elongate species, length 3.8-4.4 mm. Usually long-winged; forewings blackish with whitish streaks and spots (Fig. 49) ..... *albolineolata* Bueno
- Third antennal segment not longer than fourth segment 2
2. Only fore tibia of male with grasping comb 3
- Both fore and middle tibiae of male with grasping comb 4
3. Pronotum dark, hind margin yellowish. Head without dark punctures. Length 2.0-2.2 mm .... *plumbea* Lundblad
- Pronotum yellowish brown throughout. Head with dark punctures (Fig. 50). Length 1.2-1.3 mm .... *petraeus* Andersen, Yang & Zettel
4. Head with numerous long, erect hairs. Both parameres of male small. Antennal segments robust. Male (length 1.2-1.6 mm) much smaller than female (length 2.2-2.5 mm) (Fig. 55) .... *leveillei* (Lethierry) (syn. *diluta* Distant)
- Head with pilosity of short, depressed hairs. Right paramere of male well developed (Fig. 56), left paramere small. Antennal segments slender. 5
5. Abdominal venter of male tumose with large transverse pad of densely set, dark hairs in middle of sternum 6; genital segments strongly asymmetrical (Fig. 54). Fore tibia of male with slender distal process carrying a minute grasping comb (Fig. 52). Length 1.9-2.2 mm ..... *cameron* Andersen, Yang & Zettel
- Abdominal venter of male not modified as above; genital segments at most slightly asymmetrical. Fore tibia of male without distal process..... 6
6. Male genital segments very large, together extending about one fourth of male body length (Fig. 57). Length 1.4-1.8 mm ..... *genitalis* Lundblad
- Male genital segments not enlarged. Length 1.5-2.0 mm.... *douglasi* Scott (and undescribed, allied species)

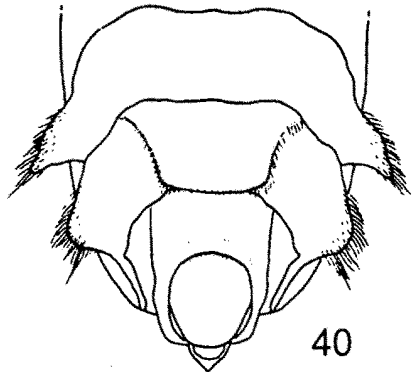




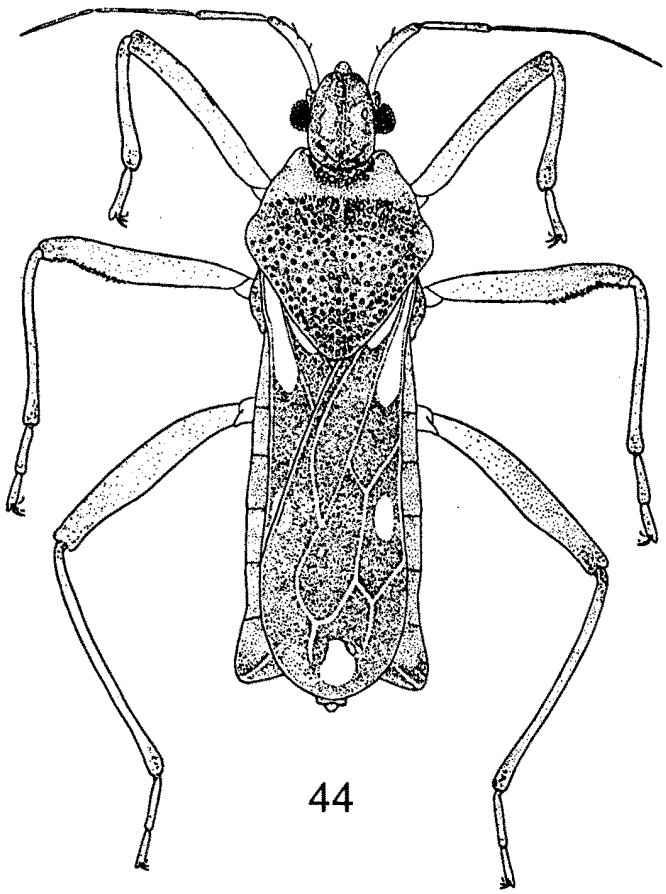


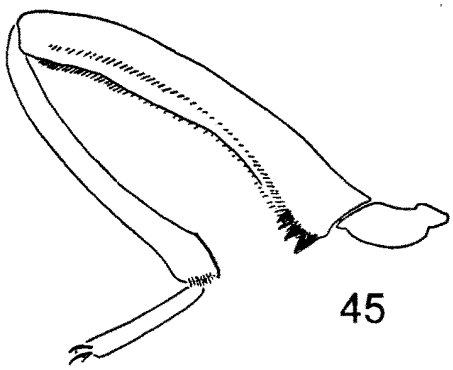


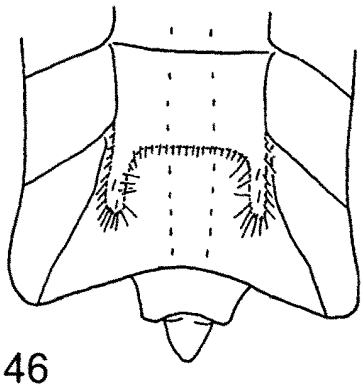


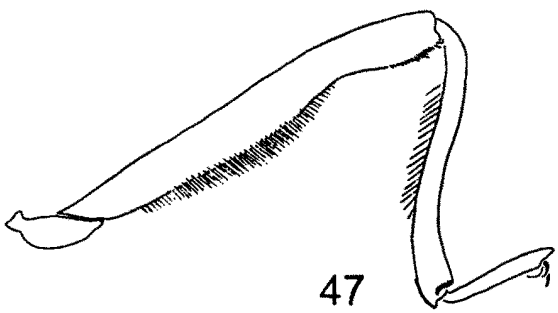


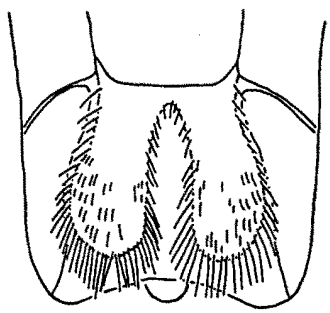
Figs. 37-43. Microveliinae (Veliidae). 37. *Neoalardus typicus*: macropterous male, dorsal view (from Andersen, 1982: Fig. 242). 38. *Baptista femoralis*: apterous male, dorsal view (from Andersen, 1989a: Fig. 7). 39. *Baptista femoralis*: male fore leg (from Andersen, 1989a: Fig. 10). 40. *Baptista femoralis*: male abdominal end, ventral view (from Andersen, 1989a: Fig. 12). 41. *Baptista collaris*: male fore leg. 42. *Baptista collaris*: male abdominal end, ventral view. 43. *Baptista collaris*: left paramere of male.



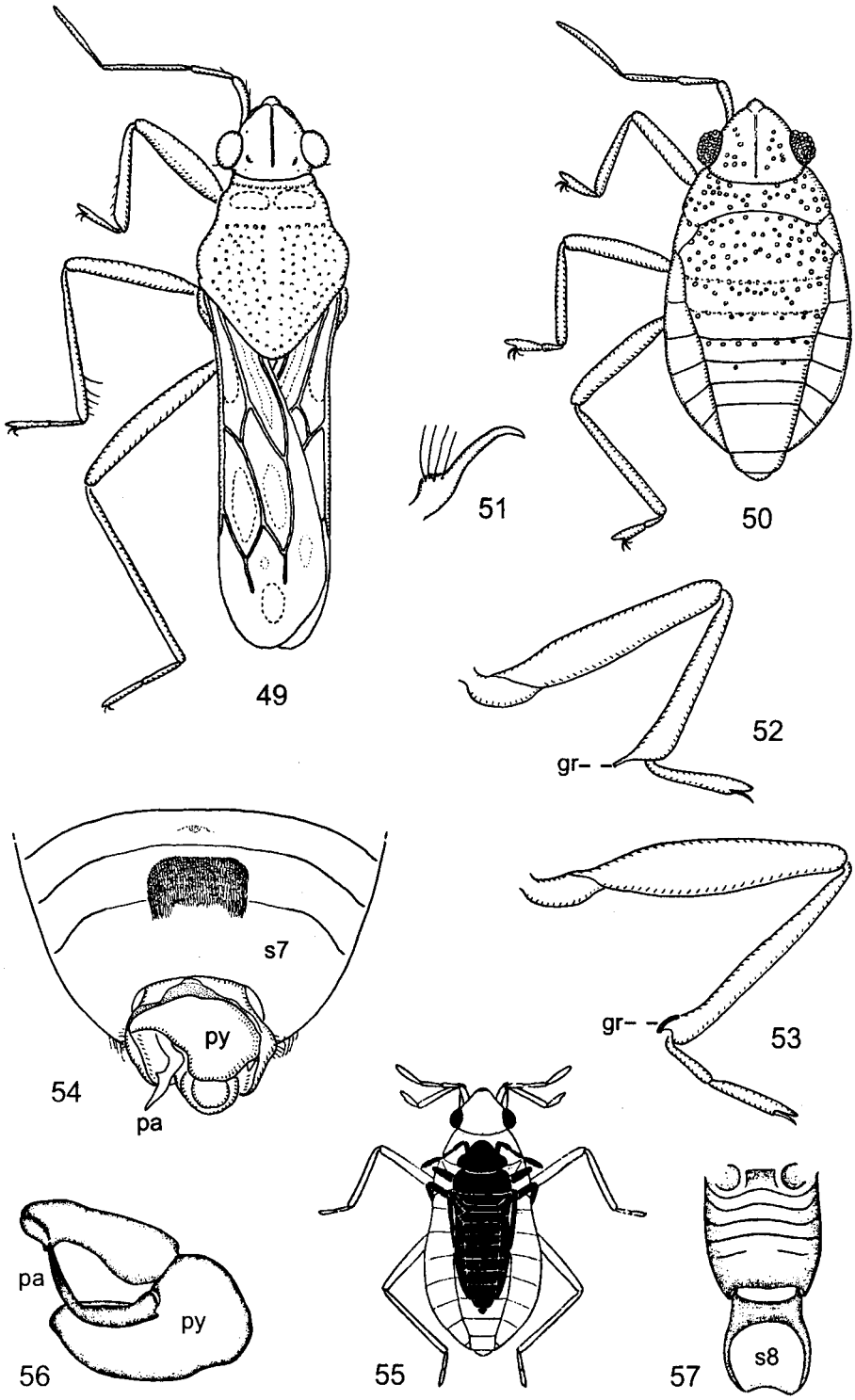




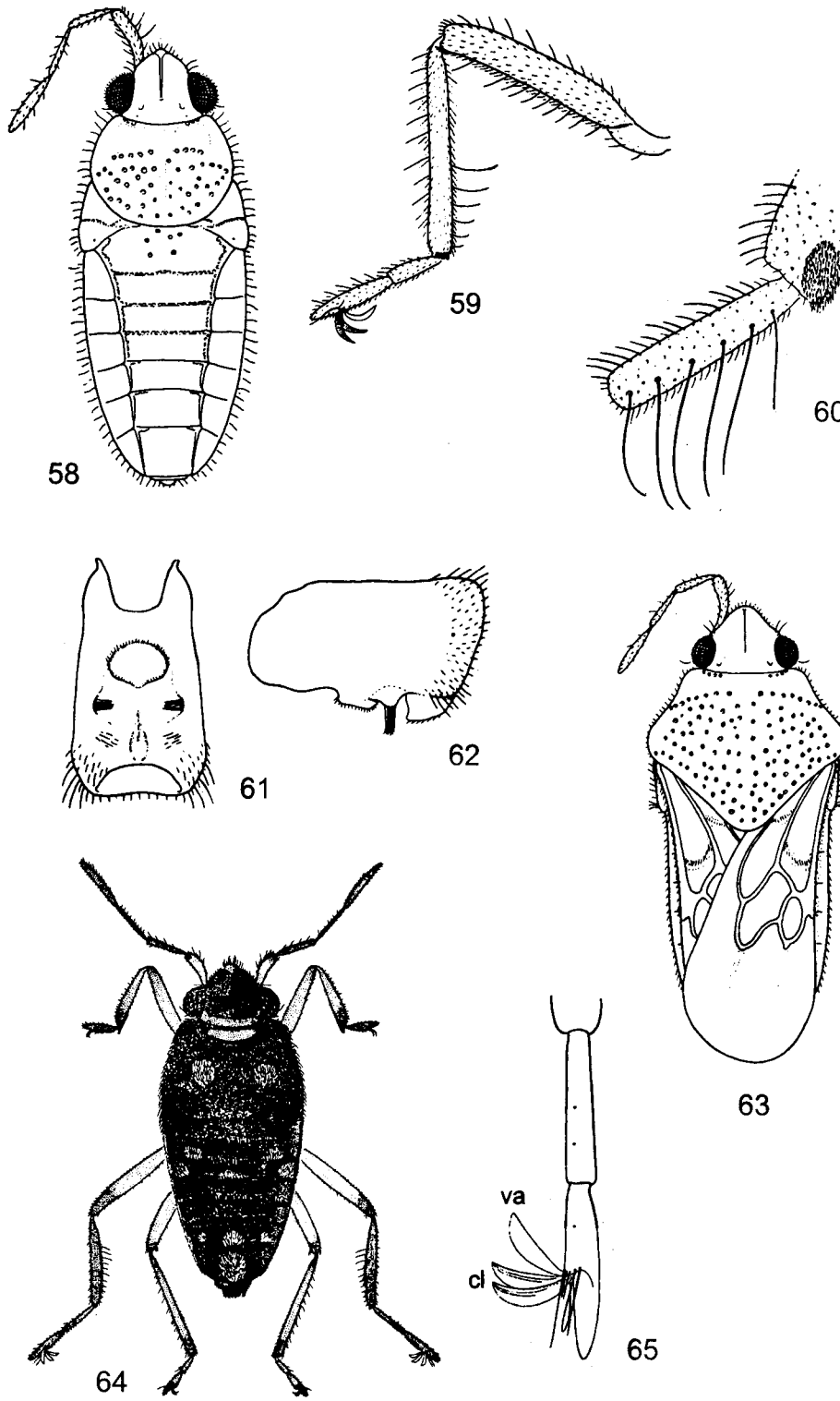




Figs. 44-48. Microveliinae (Veliidae). Fig. 44. *Lathriovelia capitata*: macropterous male, dorsal view (from Kovac & Yang, 2000: Fig. 1). 45. *Lathriovelia capitata*: male fore leg (from Kovac & Yang, 2000: Fig. 2). 46. *Lathriovelia capitata*: male abdominal end, dorsal view (from Kovac & Yang, 2000: Fig. 4). 47. *Lathriovelia rickmersi*: male fore leg (from Kovac & Yang, 2000: Fig. 12). 48. *Lathriovelia rickmersi*: male abdominal end, dorsal view (from Kovac & Yang, 2000: Fig. 17).



Figs. 49-57. Microveliinae (Veliidae). 49. *Microvelia albolineolata*: macropterous male, dorsal view; antenna and legs of right side omitted. 50. *Microvelia petraeus*: apterous male, dorsal view antenna and legs of right side omitted. 51. *Microvelia petraeus*: left paramere of male. 52. *Microvelia cameron*: male fore leg (gr, grasping comb). 53. *Microvelia cameron*: male middle leg (gr, grasping comb). 54. *Microvelia cameron*: male abdominal end, ventral view (pa, paramere; py, pygophore; s7, sternum 7). 55. *Microvelia leveillei*: apterous male and female in copula (from Miyamoto, 1953: plate 15B). 56. *Microvelia douglasi*: male genital segments, lateral view (pa, paramere; py, pygophore) (from Lundblad, 1933: Fig. 113G). 57. *Microvelia genitalis*: male abdominal end, ventral view (s8, segment 8) (from Lundblad, 1933: Fig. 117H).



Figs. 58-65. Microveliinae (Veliidae). Fig. 58. *Pseudovelia sexualis*: apterous male, dorsal view; antenna and legs omitted (from Andersen, 1983: Fig. 5). 59. *Pseudovelia sexualis*: middle tarsus (from Andersen, 1983: Fig. 2). 60. *Pseudovelia sexualis*: hind tarsus (from Andersen, 1983: Fig. 11). 61. *Pseudovelia lundbladi*: male segment 8, ventral view (from Andersen, 1983: Fig. 32). 62. *Pseudovelia lundbladi*: male segment 8, lateral view (from Andersen, 1983: Fig. 33). 63. *Pseudovelia feuerborni*: macropterous male, dorsal view; antenna and legs omitted (from Andersen, 1983: Fig. 39). 64. *Xiphovelia glauca* (Taiwan): apterous male, dorsal view (from Esaki & Miyamoto, 1959: plate 10A). 65. *Xiphovelia glauca*: middle tarsus with flattened claws (cl) and ventral arolium (va) (from Esaki & Miyamoto, 1959: Fig. 3E).

Table 2. Habitats of Veliidae in Singapore and Peninsular Malaysia (* = species expected to occur in the region).

Taxa / Habitats =	1	2	3	4	5	6	7	8	9	10	11
Subfamily Haloveliinae											
Entomovelia doveri		X									
Halovelia abdominalis											X
Halovelia lannae											X
Halovelia malaya											X
Haloveloides sundaensis										X	X
Strongylovelia sp.		X	X								
**Xenobates argentatus*										X	
Xenobates mandai										X	
Xenobates murphyi										X	
Xenobates pictus										X	
Xenobates singaporensis										X	
Subfamily Microveliinae											
Baptista collaris							X				
Baptista femoralis							X				
Lathriovelia capitata					X						
Lathriovelia rickmersi					X						
Microvelia albolineolata		X	X	X							
Microvelia cameron		X	X	X							
Microvelia douglasi		X	X	X				X	X		
Microvelia genitalis		X							X		
Microvelia leveillei				X				X	X		
Microvelia petraeus		X									
Microvelia plumbea								X	X		
Neoalardus typicus				X			X				
Pseudovelia feuerborni		X									
Pseudovelia lundbladi		X									
Pseudovelia sexualis								X			
Xiphovelia sp.		X									
Subfamily Perittopinae											
Perittopus asiaticus		X									
Perittopus webbi		X									
Subfamily Rhagoveliinae											
Rhagovelia femorata	X	X									
Rhagovelia rudischuhi	X	X	X								
Rhagovelia singaporensis	X	X	X								
Rhagovelia sondaica	X	X									
Rhagovelia sumatrensis	X	X	X								
Tetraripis doveri							X				
Subfamily Veliinae											
**Angilia* sp.		X					X				
Angilovelia y-alba								X			

Key to habitats:

1. Fast flowing forest stream
2. Slow flowing forest stream
3. Peaty stream (blackwater-acidic)
4. Lowland stream (non-acidic)
5. Container habitats
6. Rock pools
7. River banks or margins
8. Lakes, reservoirs or ponds
9. Temporary pools
10. Mangroves
11. Coral reefs

Key to species of *Pseudovelia*
(modified from Andersen, 1983)

1. Eyes densely haired. Ventral arolium leaf-like, flattened (Fig. 59). First segment of male hind tarsus with a row of long bristles (Fig. 60). Length 2.0-2.2 mm (male), 2.5-2.8 mm (female) ....*sexualis* (Paiva) (= *crassipes* Lundblad)
- Eyes naked except for two ocular setae. Ventral arolium bristle-like. First segment of male hind tarsus at most with a row of short bristles 2
2. Head with a median posterior patch of silvery hairs. First genital segment of male with 3 ventral tubercles (Figs. 61, 62). Only apterous forms known. Length 2.6 mm (male), 3.0 mm (female) .....*lundbladi* Andersen
- Head without a median patch of silvery hairs. First genital segment of male not as above. Only macropterous form known (Fig. 63). Length 2.2-2.4 mm (male), 2.7-2.8 mm (female)..... .....*feuerborni* (Lundblad)

ACKNOWLEDGEMENTS

We are most grateful to past and present students and various staff members of the Department of Biological Sciences, National University of Singapore for collecting many of the specimens for this study. We would like to thank Profs. D. H. Murphy and Peter Ng for helpful discussions, Dr D. Kovac for helpful comments on the manuscript, and Dr. R. Lewin for linguistic suggestions. NMA would like to acknowledge the hospitality offered by staff members during short-term visits to the Raffles Museum of Biodiversity Research, National University of Singapore.

LITERATURE CITED

Andersen, N. M., 1967. A contribution to the knowledge of Philippine semiaquatic Hemiptera-Heteroptera. *Entomologiske Meddelelser,* **35**: 260-282.

Andersen, N. M., 1981. A new genus of Veliidae and descriptions of new Oriental species of the subfamily (Hemiptera: Veliidae). *Entomological Scandinavica,* **12**: 339-356.

Andersen, N. M., 1982. The Semiaquatic Bugs (Hemiptera, Gerromorpha). Phylogeny, adaptations, biogeography, and classification. *Entomonograph,* **3**: 1-455.

Andersen, N. M., 1983. The Old World Microveliinae (Hemiptera: Veliidae). I. The status of *Pseudovelia* Hoberlandt and *Perivelia* Poisson, with a review of Oriental species. *Entomological Scandinavica,* **14**: 253-268.

Andersen, N. M., 1989a. The Old World Microveliinae (Hemiptera: Veliidae). II. Three new species of *Baptista* Distant and a new genus from the Oriental region. *Entomological Scandinavica,* **19** [1988]: 363-380.

Andersen, N. M., 1989b. The coral bugs, genus *Halovelia* Bergroth (Hemiptera, Veliidae). I. History, classification, and taxonomy of species except the *H. malaya*-group. *Entomological Scandinavica,* **20**: 75-120.

Andersen, N. M., 1989c. The coral bugs, genus *Halovelia* Bergroth (Hemiptera, Veliidae). II. Taxonomy of the *H. malaya*-group, cladistics, ecology, biology, and biogeography. *Entomological Scandinavica,* **20**: 179-227.

Andersen, N. M., 1992. A new genus of marine water striders (Hemiptera, Veliidae) with five new species from Malesia. *Entomological Scandinavica,* **22**: 389-404.

Andersen, N. M., 2000a. A new species of *Tetraripis* from Thailand, with a critical assessment of the generic classification of the subfamily Rhagoveliinae (Hemiptera, Veliidae). *Tijdsch voor Entomologie,* **142** [1999]: 185-194.

Andersen, N. M., 2000b. The marine Haloveliinae (Hemiptera, Gerromorpha, Veliidae) of Singapore, Peninsular Malaysia and Thailand, with five new species of *Xenobates* Esaki. *Raffles Bulletin Zoology,* **48**(2): 273-292.

Andersen, N. M. & T. A. Weir, 1999. The marine Haloveliinae (Hemiptera: Veliidae) of Australia, New Caledonia, and southern New Guinea. *Invertebrate Taxonomy,* **13**: 309-350.

Andersen, N. M., C. M. Yang & H. Zettel, 2002. Notes on the Microveliinae of Singapore and Peninsular Malaysia with the description of two new species of *Microvelia* Westwood (Hemiptera-Heteroptera, Veliidae). *Raffles Bulletin of Zoology,* **50**(1): 111-116.

Cheng, L. & C. H. Fernando, 1971. Life history and biology of the riffle bug *Rhagovelia obesa* Uhler in southern Ontario. *Canadian Journal of Zoology,* **49**: 435-442.

Esaki, T., 1930. New or little-known Gerridae from the Malay Peninsula. *Journal of Federated Malay States Museums,* **16**: 13-24.

Esaki, T. & S. Miyamoto, 1955. Veliidae of Japan and adjacent territory (Hemiptera-Heteroptera). I. *Microvelia* Westwood and *Pseudovelia* Hoberlandt of Japan. *Sieboldia,* **1**: 169-204, pls. 24-29.

Esaki, T. & S. Miyamoto, 1959. Veliidae of Japan and its adjacent territory (Hemiptera-Heteroptera). II. *Xiphovelia* Lundblad. *Sieboldia,* **2**: 91-108, pls. 10-13.

Fernando, C. H., 1961. Notes on aquatic insects caught at light in Malaya, with a discussion of to their distribution and dispersal. *Bulletin National Museum (Singapore),* **30**: 19-31.

Fernando, C. H., 1964. Notes on aquatic insects colonizing an isolated pond in Mawai, Johore. *Bulletin National Museum (Singapore),* **32**: 80-89.

Fernando, C. H. & L. Cheng, 1974. A preliminary study on the fauna and distribution of aquatic Hemiptera in Malaya and Singapore. *Federation Museums Journal,* **19**: 21-44.

Kovac, D. & C. M. Yang, 1990. A preliminary checklist of the semiaquatic and aquatic Hemiptera (Heteroptera: Gerromorpha and Nepomorpha) of Ulu Kinchin, Pahang, Malaysia. *Malayan Nature Journal,* **43** [1989]: 282-288.

Kovac, D. & C. M. Yang, 2000. Revision of the Oriental bamboo-inhabiting semiaquatic bugs genus *Lathriovelia* Andersen, 1989 (Heteroptera: Veliidae) with description of *L. rickmersi*, new species, and notes on the genus *Baptista* Distant, 1903. *Raffles Bulletin Zoology*, **48**(1): 153-165.

Lundblad, O. M., 1933. Zur Kenntniss der aquatilen und semiaquatilen Hemipteren von Sumatra, Java und Bali. *Archiv für Hydrobiologie, Supplement*, **12**: 1-195, 263-489.

Lundblad, O. M., 1936. Die Altweltlichen Arten der Veliidengattungen *Rhagovelia* und *Tetraripis*. *Archiv foer Zoologi*, **28A** (12): 1-63.

Miyamoto, S., 1953. Biology of *Microvelia diluta* Distant, with descriptions of its brachypterous form and larval stages. *Sieboldia*, **1**: 113-133, pls. 15-18.

Muraji, M. & F. Nakasuji, 1988. Comparative studies on life history traits of three wing dimorphic water bugs, *Microvelia* spp. Westwood (Heteroptera: Veliidae). *Researchers on Population Ecology*, **30**: 315-327.

Murphy, D. H., 1990. "Walkers on water" – An account of the pleuston of Singapore. In: Chou, L. M. & P. K. L. Ng (eds.), *Essays in Zoology. Papers Commemorating the 40th Anniversary of the Department of Zoology, National University of Singapore.* Department of Zoology, National University of Singapore. Pp. 153-175.

Nakasuji, F. & V. A. Dyck, 1984. Evaluation of the role of *Microvelia douglasi atrolineata* (Bergroth) as predator of the brown planthopper *Nilaparvata lugens* Stål. *Researchers on Population Ecology*, **26**: 134-149.

Polhemus, D. A., 1997. *Systematics, phylogeny, and zoogeography of the genus* Rhagovelia *(Heteroptera: Veliidae) in the western hemisphere (exclusive of the angustipes complex).* Thomas Say Monographs, Entomological Society of America. 410 pp.

Polhemus, J. T., 1990. Miscellaneous studies on the genus *Rhagovelia* Mayr (Heteroptera: Veliidae) in Southeast Asia and the Seychelles Islands, with keys and descriptions of new species. *Raffles Bulletin Zoology*, **38**: 65-75.

Polhemus, J. T. & D. A. Polhemus, 1988. Zoogeography, ecology, and systematics of the genus *Rhagovelia* Mayr (Heteroptera: Veliidae) in Borneo, Celebes, and the Moluccas. *Insecta Mundi*, **2**: 161-230.

Polhemus, J. T. & D. A. Polhemus, 1998. Notes on Asian Veliinae (Heteroptera: Veliidae) with descriptions of three new species. *Journal of New York Entomological Society*, **106**: 117-131.

Yang, C. M. & D. Kovac, 1995. A collection of aquatic and semi-aquatic bugs (Insecta: Hemiptera: Gerromorpha and Nepomorpha) from Temengor Forest Reserve, Hulu Perak, Malaysia. *Malayan Nature Journal*, **48**: 287-295.

Yang, C. M., H. K. Lua & K. L. Yeo, 1997. Semi-aquatic bug (Heteroptera: Gerromorpha) fauna in the Nature Reserves of Singapore. Proceedings of the Nature Reserves Survey Seminar. *Gardens Bulletin (Singapore)*, **49**: 313-319.

Yang, C. M. & D. A. Polhemus, 1994. Notes on *Rhagovelia* Mayr (Hemiptera: Veliidae) from Singapore, with description of a new species. *Raffles Bulletin Zoology*, **42**: 987-993.

Yang, C. M., T. C. M. Wong, H. K. Lua & L. M. Koh, 1999. A checklist of aquatic and semi-aquatic bugs (Insecta: Hemiptera: Heteroptera) from Pulau Tioman, Peninsular Malaysia. *Raffles Bulletin Zoology*, Supplement, **6**: 277-288.

Zettel, H., 1993. Eine neue *Rhagovelia* Mayr aus Westmalaysia (Heteroptera: Veliidae). *Entomologicke Problem*, **24**: 39-42.

Zettel, H., 1996. *Chenevelia stridulans* gen.n. et sp.n. from North Thailand (Insecta: Heteroptera: Veliidae). *Annalen des Naturhistorischen Museums in Wien*, **98B**: 353-359.

Zettel, H., 1998. On the Oriental genus *Neoalardus* Distant 1912 (Heteroptera: Veliidae). *Linzer Biologische Beitraege*, **30**: 595-599.

Zettel, H., 2001. Five new species of *Perittopus* Fieber, 1861 (Hemiptera: Veliidae) from Southeast Asia. *Raffles Bulletin Zoology*, **49**(1): 109-119.

Zettel, H. & V. P. Gapud, 1999. A new species group of Oriental *Microvelia* s.l. (Insecta: Heteroptera: Veliidae), with descriptions of three new species. *Annalen des Naturhistorischen Museums in Wien*, **101B**: 135-146.