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GUIDE TO AQUATIC HETEROPTERA OF SINGAPORE AND PENINSULAR MALAYSIA. INTRODUCTION AND KEY TO FAMILIES

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ABSTRACT. – This is the first of a series of publications planned as guides to aquatic Heteroptera of Singapore and Peninsular Malaysia to be published in the Raffles Bulletin of Zoology. A key to families and a list of known genera with number of described species for each genus are given.

KEY WORDS. – Heteroptera, aquatic, marine, freshwater, Singapore, Peninsular Malaysia, Key to families, list of genera

INTRODUCTION

Insects are the most successful and widely distributed of all animals on land. Many species have also successfully invaded a variety of aquatic habitats, including the open sea (Cheng, 1985). Although aquatic insects comprise less than 3% of all insects known (Cheng, 1976a), they may represent over 95% of all macro-invertebrate species in some freshwater habitats (Ward, 1992). Some of the commonest and most widespread insects found in the fresh and marine waters of Singapore and Peninsula Malaysia are the aquatic bugs, yet many of the species remain poorly known or undescribed. They are found in a wide range of habitats such as intertidal rocks, torrential streams, temporary pools, and even water trapped in internodes of bamboo plants (Kovac & Streit, 1996; Kovac & Yang, 2000). The first guide to the genera of Malayan water bugs, produced by Fernando & Cheng (1963), was intended for students of the University of Singapore. It was, and still is, used for the identification of aquatic bugs of the region, but was never formally published. Since then our collections and knowledge of aquatic insects have been greatly expanded. There is thus an urgent need for an up-to-date guide.

Fernando & Cheng (1963) listed 12 families of aquatic bugs from Singapore and Peninsular Malaysia. They included bugs which are totally submerged (aquatic) as well as those living on the water surface (semi-aquatic), but not those living at shorelines. Since then at least six families of shore-

living bugs have been recognized, and there is no doubt that more species and perhaps even genera will continue to be added to the existing list. In addition, several new genera and species have been or are being described (Andersen, pers. comm.; J. T. Polhemus, unpublished data). Thus the production of a single guide to include all known families could prove to be a daunting task, involving many authors and years of work. We have therefore decided to invite specialists who work on specific families to contribute separate papers and to publish them as a series of individual guides. We envisage that each guide will include an introduction to the family, a key to genera, an up-to-date list of species, and some general information on biology, habitats, and distributions. The guides are not meant to be comprehensive but to serve as introductions and working tools for each family.

We would like to dedicate this series to Dr. Herbert C. Fernando who almost single-handedly started the study of aquatic insects in the Department of Zoology at the then University of Singapore. Dr. Fernando is now Professor Emeritus, Department of Biology, University of Waterloo, Ontario, Canada.

The literature on aquatic Heteroptera in our region is very scattered. Much of the earlier literature can be found in Fernando and Cheng (1974). Some of the more recent general reference books or publications relating to aquatic bugs of our region include Andersen (1982), Cheng (1976b),

Table 1. List of families and genera of aquatic Hemiptera of Singapore and Peninsular Malaysia (number of known species in brackets)

GERROMORPHA	Family VELIIDAE	Family NAUCORIDAE
Family GERRIDAE	<i>Angilovelina</i> (1)	<i>Ctenipocoris</i> (1)
<i>Amemboa</i> (6)	<i>Aphrovelia</i> (1)	<i>Heleocoris</i> (1)
<i>Aquarius</i> (1)	<i>Baptista</i> (2)	<i>Laccocoris</i> (1)
<i>Asclepios</i> (1)	<i>Entomovelina</i> (1)	<i>Naucoris</i> (2)
<i>Cryptobates</i> (2)	<i>Halovelina</i> (3)	Family NEPIDAE
<i>Cylindrostethus</i> (2)	<i>Haloveloides</i> (1)	<i>Cercometus</i> (3)
<i>Esakia</i> (3)	<i>Lathriovelina</i> (2)	<i>Laccotrephes</i> (5)
<i>Gnomobates</i> (1)	<i>Microvelia</i> (6)	<i>Ranatra</i> (4)
<i>Halobates</i> (8)	<i>Nealardus</i> (1)	Family NOTONECTIDAE
<i>Limnogonus</i> (3)	<i>Perittopus</i> (2)	<i>Anisops</i> (8)
<i>Limnometra</i> (5)	<i>Pseudovelina</i> (3)	<i>Aphelonecta</i> (1)
<i>Metrocoris</i> (4)	<i>Rhagovelina</i> (5)	<i>Enithares</i> (5)
<i>Naboandelus</i> (1)	<i>Strongylovelina</i> (1)	<i>Nychia</i> (1)
<i>Neogerris</i> (2)	<i>Tetraripis</i> (1)	Family OCHTERIDAE
<i>Onychotrechus</i> (3)	<i>Xenobates</i> (5)	<i>Ochterus</i> (3)
<i>Pleciobates</i> (1)	NEPOMORPHA	Family PLEIDAE
<i>Ptilomera</i> (1)	Family APHELOCHEIRIDAE	<i>Paraplea</i> (2)
<i>Rhagadotarsus</i> (1)	<i>Aphelocheirus</i> (3)	LEPTOPODOMORPHA
<i>Rheumatogonus</i> (1)	Family BELASTOMATIDAE	Family LEPTOPODIDAE
<i>Rheumatometroides</i> (1)	<i>Diplonychus</i> (1)	<i>Leotichius</i> (1)
<i>Stenobates</i> (1)	<i>Lethocerus</i> (1)	<i>Valleriola</i> (1)
<i>Tenagogonus</i> (2)	Family CORIXIDAE	Family OMANIIDAE
<i>Ventidius</i> (5)	<i>Agraptocorixa</i> (1)	<i>Corallocoris</i> (1)
Family HEBRIDAE	<i>Micronecta</i> (8)	Family SALDIDAE
<i>Hyrceanus</i> (1)	<i>Sigara</i> (1)	<i>Pentacora</i> (1)
<i>Hebrus</i> (4)	<i>Synaptonecta</i> (1)	<i>Saldoida</i> (1)
<i>Limasius</i> (3)	Family GELASTOCORIDAE	<i>Saldula</i> (3)
Family HERMATOBATIDAE	<i>Nerthra</i> (1)	<i>Salduncula</i> (1)
<i>Hermatobates</i> (2)	Family HELOTREPHIDAE	
Family HYDROMETRIDAE	<i>Helotrephes</i> (1)	
<i>Hydrometra</i> (12)	<i>Hydrotrephes</i> (2)	
Family MESOVELIIDAE	<i>Idiotrephes</i> (1)	
<i>Mesovelina</i> (2)	<i>Tiphotrephes</i> (1)	
<i>Nereivelina</i> (1)		

CSIRO (1991), Murphy (1990), Polhemus & Polhemus (1990), Shuh & Slater (1995), Spence & Andersen (1994) and Yang et al. (1997a, 1997b).

The families of aquatic Heteroptera can be broadly divided into three infra-orders by habitat:-

1. Those generally found living on the surface of the water, or along the margins, including marine environments (Gerromorpha).
2. Truly aquatic forms generally found fully submerged in water (Nepomorpha).
3. Those generally associated with the shore (Leptopodomorpha).

A list of families and genera of aquatic Heteroptera known to occur in Singapore and Peninsular Malaysia, with number of species described for each genus is given in Table 1. We have tried to provide illustrations of representative members of each family showing general morphology and some of the specific characters used for identification. The following key can be used to identify adults to families. Nymphs are difficult to identify in most cases.

KEY TO FAMILIES OF AQUATIC HETEROPTERA (ADULTS ONLY)

1. Antennae exposed and longer than head (Mostly living on water surface, hygropetric zones, intertidal rocks, or along water margins) 2
- Antennae shorter than head, inserted beneath eyes, with at most the tips visible from above (Living under water surface, except for two littoral families, Ochteridae and Gelastocoridae) NEPOMORPHA 10
2. Long-winged, short-winged and apterous forms may be present. Hind-coxae small, cylindrical or conical; coxal cavity socket-like (Living on water surface, along water margins, in springs, hygropetric zones, or waterfall splash zones) GERROMORPHA 3
- Always long-winged. Hind-coxae large, transverse; coxal cavity broad (Living on shores, hygropetric zones, among intertidal rocks or large stones) LEPTOPODOMORPHA 8
3. Head distinctly prolonged; eyes situated halfway along the head (On quiet water surfaces or adjacent shores) HYDROMETRIDAE (Fig. 1)
- Head not distinctly prolonged; eyes situated at base of head 4
4. Head and pronotum extremely short. Head at least three times as broad as long; meso- and metanota completely fused

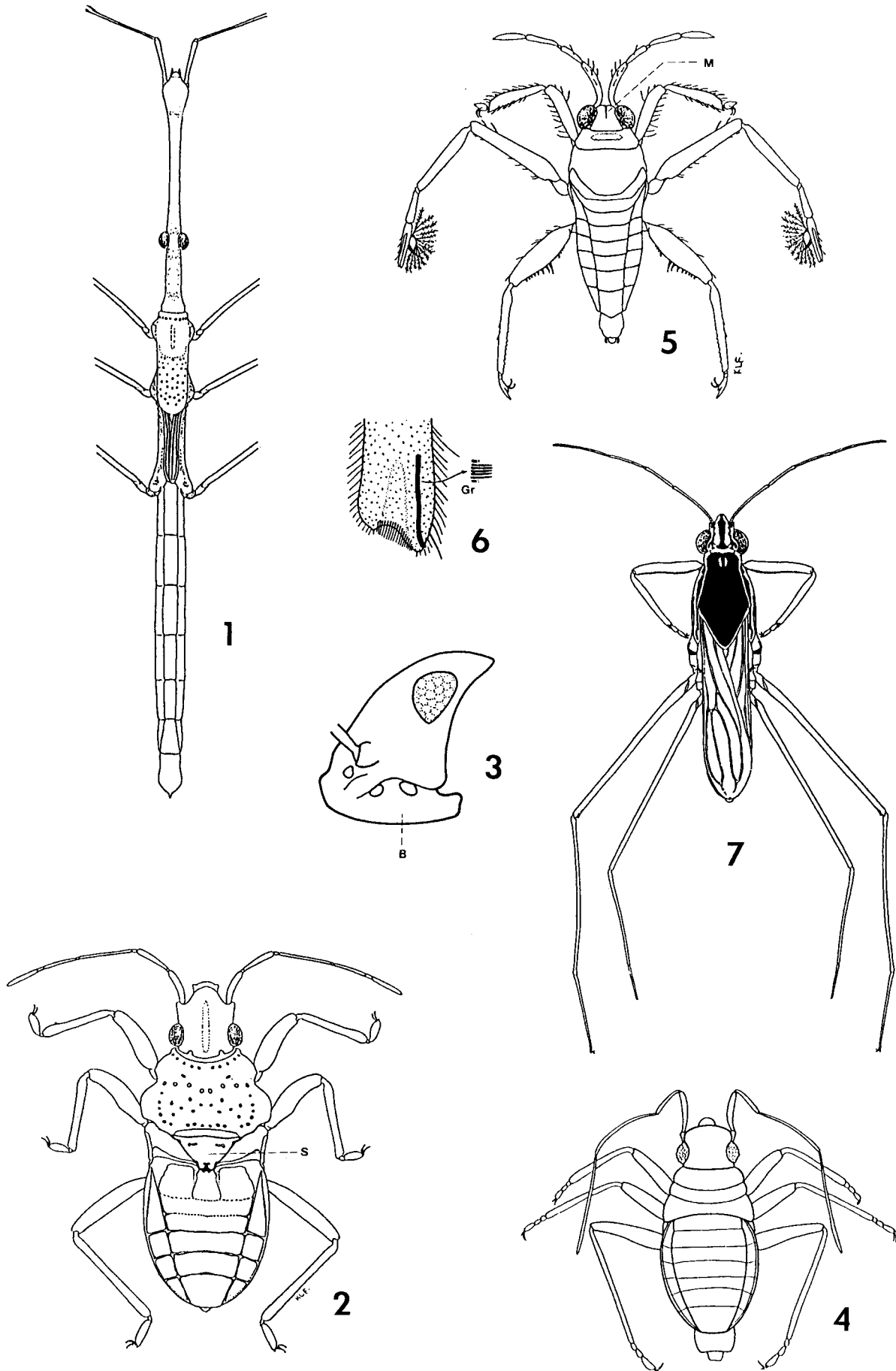
- except laterally; always apterous; front-claws subapical (Exclusively marine) HERMATOBATIDAE (Fig. 17)
- Head longer than broad; meso- and metanota not completely fused; apterous, short-winged or long-winged; front-claws apical or subapical (Marine or freshwater) 5
 - 5. Long-winged forms with scutellum (Fig. 2) exposed, forming subtriangular, rounded or transverse plate behind pronotal lobe; apterous or short-winged forms with abdominal scent gland on tergum four 6
 - Long-winged forms with scutellum not visible, hidden by pronotal lobe (Fig. 7); apterous or short-winged forms lacking abdominal scent gland 7
 - 6. Antenna four-jointed (may appear five-jointed due to membranous zone on fourth segment); bucculae (Fig. 3) well developed, reaching base of head; tarsi two-segmented (Margins of ponds and streams, some species amphibious or even permanently submerged) HEBRIDAE (Fig. 2)
 - Antenna clearly four-jointed; bucculae absent or poorly developed; tarsi three-segmented (Margins of ponds and streams, also intertidal) MESOVELIIDAE (Fig. 4)
 - 7. Head with median longitudinal groove (Fig. 5) on dorsal surface; male fore-tibiae usually with a comb of short spines along inner margin; mid-femora scarcely if at all extending beyond abdomen; hind-femora usually stouter than mid-femora (Standing water, streams, phytotelmata, freshwater or marine) VELIIDAE (Fig. 18)
 - Head without median groove on dorsal surface; male fore-tibiae without comb; mid-femora usually extending well beyond abdomen; hind-femora usually more slender than mid-femora (Standing or running waters, freshwater or marine) GERRIDAE (Fig. 7)
 - 8. Forewings coleopteroid, hardened. Eyes very large, reaching to about one-third length of pronotum; body less than 2mm long (Intertidal rocks at low tide) OMANIIDAE (Fig. 8)
 - Forewings never coleopteroid or completely hardened. Eyes smaller, reaching only to pronotal collar or slightly beyond; body more than 2.2 mm long 9
 - 9. Antennae shorter than body. Rostrum long, tapering, reaching base of hind-coxae or beyond (Margins of ponds and streams, also intertidal habitats) SALDIDAE (Fig. 9)
 - Antennae as long as or longer than body. Rostrum much shorter, reaching at most to apex of fore-coxae, often only to base of fore-coxae (On large stones, either above stream surface or on land) LEPTOPODIDAE (Fig. 11)
 - 10. Apex of abdomen with paired respiratory processes 11
 - Apex of abdomen without paired respiratory processes .. 12
 - 11. Respiratory processes cylindrical and non-retractable, usually long and filiform; body either cylindrical or ovoid and flat (Quiet waters, ponds or streams) NEPIDAE (Figs. 21, 22)
 - Respiratory processes cylindrical, straplike and retractable; body never cylindrical, always ovoid and flat (Standing water or slow-flowing streams) BELOSTOMATIDAE (Fig. 23)
 - 12. Ocelli present (Littoral) 13
 - Ocelli absent (Living under water) 14
 - 13. Head strongly transverse. Tarsal formula 2:2:2; antennae concealed in pits beneath eyes; fore-femora incrassate (Stream bank, riparian) GELASTOCORIDAE (Fig. 16)
 - Head normal and rounded. Tarsal formula 2:2:3; antennae not concealed in pits; fore-femora not incrassate (Pond or stream shore) OCHTERIDAE (Fig. 24)
 - 14. Body and forewings with transverse dark lines. Rostrum broadly triangular (Fig. 13), non-segmented, transversely striate, appearing as apex of head. Front-tarsi with a single segment, spoon- or scoop-like (Fig. 14), fringed with long stiff setae ventrally (Standing or slow-flowing streams, freshwater and saline) CORIXIDAE (Fig. 12)
 - Body coloration never as above. Rostrum cylindrical, short to long, obviously segmented, not transversely striate. Front-tarsi segmented or not, not scoop-like or fringed with long stiff setae 15
 - 15. Forelegs not raptorial. Dorsum usually strongly convex or inversely boat-shaped; cephalonotal sulcus (head-pronotal boundary) (Fig. 10) sometimes incomplete. (Swim on their backs) 16
 - Forelegs raptorial. Dorsum usually flat; head and prothorax never fused. (Swim with dorsal surface uppermost) 18
 - 16. Body elongate, wedge-shaped, usually over 4mm long; hind-legs elongate, oar-shaped, with two reduced and inconspicuous claws (Standing water or slow-flowing streams) NOTONECTIDAE (Fig. 19)
 - Body oval, robust, less than 3.5 mm long; hind-legs not oar-shaped, usually with two distinct claws 17
 - 17. Antenna three-jointed; head and pronotum separate, cephalonotal sulcus (Fig. 10) straight, complete, and distinct (Standing water) PLEIDAE (Fig. 10)
 - Antenna one- or two-jointed; head and pronotum fused, cephalonotal sulcus not straight, incomplete, often indistinct (Standing water as well as fast-flowing streams) HELOTREPHIDAE (Fig. 20)
 - 18. Head much wider than long, only slightly produced in front of eyes. Rostrum cylindrical, short and thick, not surpassing prosternum (Standing water as well as fast-flowing streams) NAUCORIDAE (Fig. 25)
 - Head usually longer than wide and produced in front of eyes. Rostrum long, slender, extending at least to middle of mesosternum (Among gravel or stones in fast-flowing streams) APHELOCHEIRIDAE (Fig. 15)

CONCLUDING REMARKS

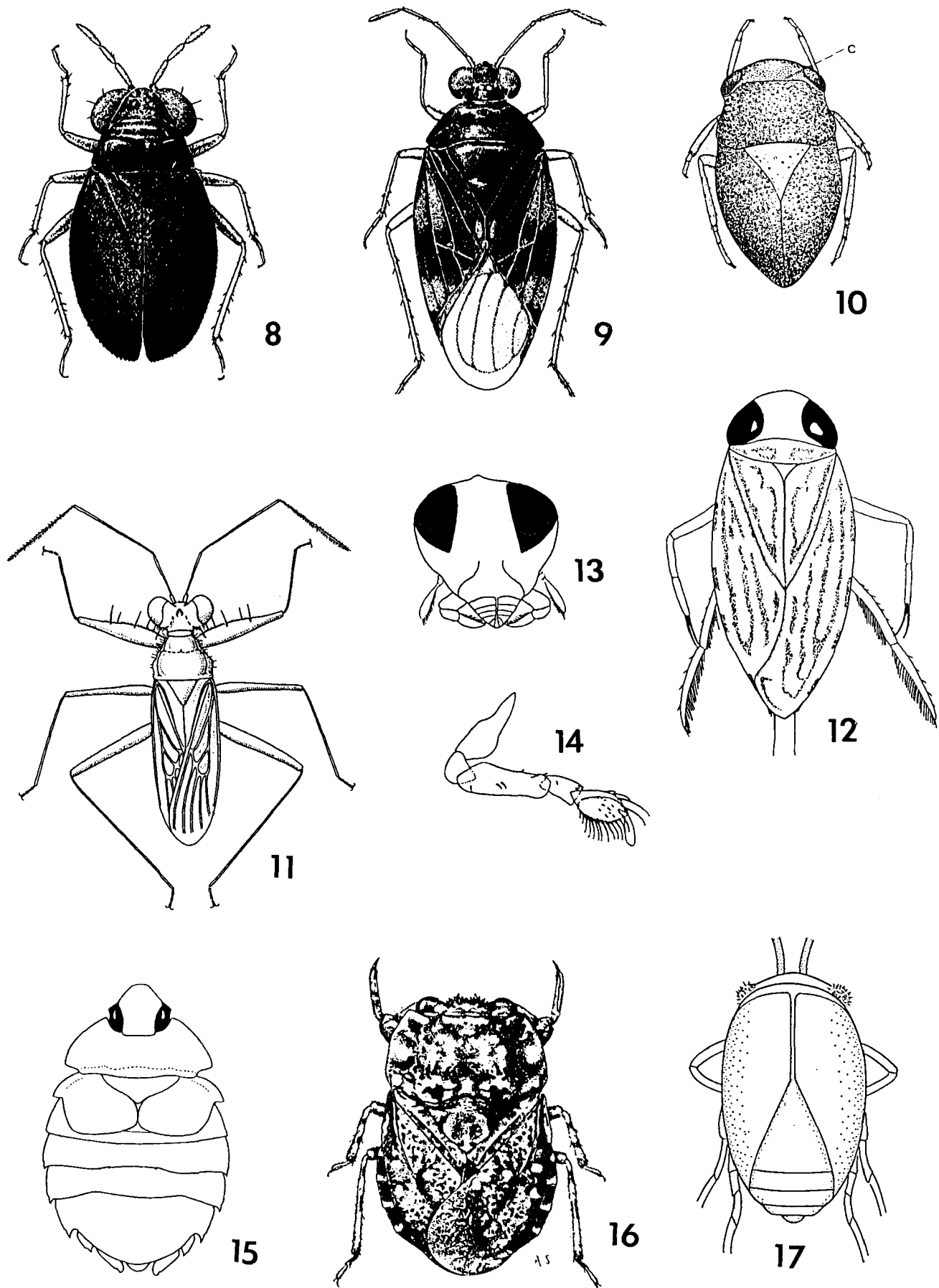
Singapore and Peninsula Malaysia, generally considered hotspots of biodiversity in the World (Ng, 2000), are undergoing rapid changes. Many of the freshwater habitats are quickly disappearing due to dam building, road construction, or urban development in general. We recognize that most of these developments are unavoidable and some of our aquatic insects may become extinct or endangered with the loss of habitats. It is hoped that this series of guides will help us identify what species we have, and encourage us to preserve areas which may contain rare or unusual species.

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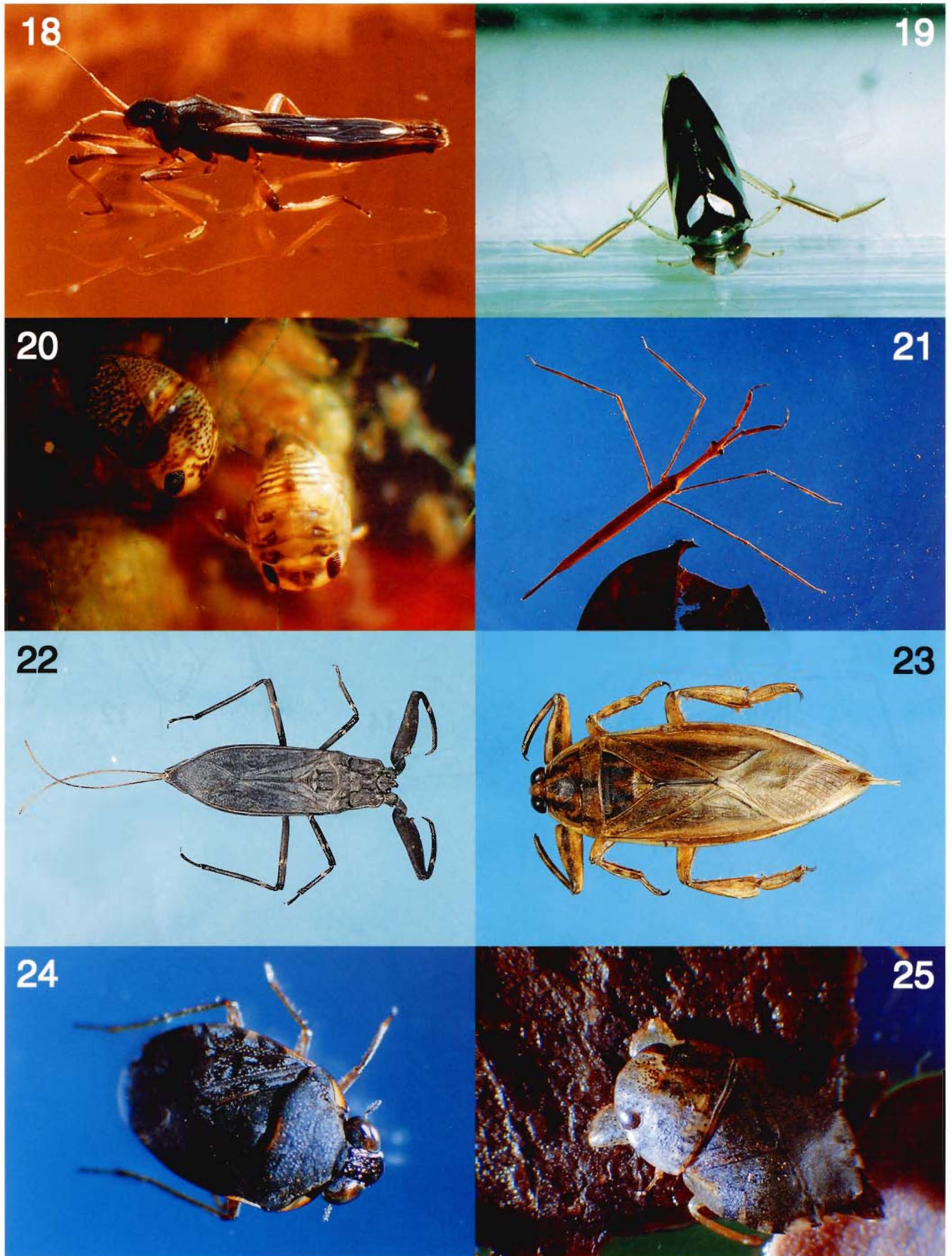
We are most grateful to various colleagues around the World as well as past and present members of the staff and students of the Department of Biological Sciences, National University of Singapore for collecting and/or sending us



Figs. 1-7. 1. *Hydrometra*, Hydrometridae (15.0 mm), 2. *Hebrus*, Hebridae (S =scutellum) (2.0 mm), 3. Buccula of Hebridae (B = buccula), 4. *Nereivelia*, Mesoveliidae (1.6 mm), 5. *Rhagovelia*, Veliidae (M = medium groove) (2.7 mm), 6. *Angilia* showing grasping comb (Gr) of fore-tibia (from Andersen, 1982), 7. *Limnogonus*, Gerridae (7.0 mm).



Figs. 8-17. 8. *Corallocoris*, Omaniidae (1.4 mm), 9. *Saldula*, Saldidae (3.5 mm), 10. Pleidae (C = cephalonotal sulcus) (2.0 mm), 11. *Valleriola*, Leptopodidae (5.0 mm), 12. *Micronecta*, Corixidae (from Leong, 1961) (1.8 mm), 13. Front view of head showing rostrum of Corixidae (from Leong, 1961), 14. First leg of *Micronecta* (from Leong, 1961), 15. *Aphelocheirus*, Aphelocheiridae (9.0 mm), 16. *Nerthra*, Gelastocoridae (from Usinger, 1956) (7.0 mm), 17. *Hermatobates*, Hermatobatidae (from Cheng, 1976c) (3.5 mm).



Figs. 18-25. 18. *Lathriovelina*, Veliidae (D. Kovac) (5.5 mm). 19. *Enithares*, Notonectidae (D. Kovac) (9.0 mm). 20. Helotrephidae (B.H. Tan) (1.8 mm). 21. *Cercometus*, Nepidae (B.H. Tan) (45.0 mm). 22. *Laccotrephes*, Nepidae (H.H. Tan) (43.0 mm). 23. *Lethocerus*, Belostomatidae (H. H. Tan) (70.0mm). 24. *Ochterus*, Ochteridae (B.H. Tan) (4.5 mm). 25. Naucoridae (B.H. Tan) (7.0 mm).

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