

Water Beetles (Insecta: Coleoptera) in the Nature Reserves of Singapore

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Abstract

Of the 36 species of aquatic beetles recognised here, 17 are rated threatened. Two rare species of *Microdytes* (Dytiscidae) were only found in a small springlet in the Bukit Timah Nature Reserve. Nee Soon Swamp Forest has the highest diversity as well as the highest number of locally threatened water beetle species in the Nature Reserves.

Introduction

Conservationists and systematists nowadays agree that most species can only be saved when habitats of adequate size can be protected (Polhemus, 1993; Samways, 1994). However, conservation action with clear management strategies on a rather limited geographical scale is also frequently needed. This is especially true in areas that have already experienced considerable disturbance for a long period of time. To facilitate such action, biomonitoring groups are needed to determine the state of a given habitat. In wetland management, water beetles prove to be one such group, especially when microhabitats such as springs, low order streams or small waterholes require evaluation (Balke & Hendrich, 1991; Foster, 1991; Hendrich & Balke, 1993). The theoretical background characterising water beetle communities in terms of their conservation value, too, has been well worked out (e.g., Eyre & Rushton, 1989; Foster *et al.*, 1990; Richoux, 1994; Larson, 1997).

Balke and Hendrich (Hendrich & Balke, 1995; Balke *et al.*, 1997a, 1997b) have successfully utilised water beetles in the course of numerous environmental impact assessments in Germany, Malaysia and Indonesia. Several species of water beetle are to date not only included in regional red lists in Europe but also in the latest IUCN Red List of Threatened Animals (IUCN, 1996). Moreover, detailed conservation plans are in hand for two European species of diving beetles (Foster, 1996a, 1996b). These

are target species by the law in the European Community (EC), where every suitable aquatic habitat within their respective ranges must be monitored for the two beetle species before the land can be used for purposes other than conservation. As adequate observations on the distribution and biology of Southeast Asian water beetles have now become available, we believe that several factors could make them a useful biomonitoring group here as well: 1) the group is species rich; 2) they are present in virtually every type of fresh and brackish water habitat; 3) the group has numerous species confined to particular microhabitats; 4) knowledge of the group's taxonomic status is improving rapidly; 5) there is a good general knowledge of most groups; and 6) the group is represented by some large or especially colourful or enigmatic species, which may attract public interest (Hendrich, 1995).

The term 'water beetle' as used here, does not represent a phylogenetic unit, such as a family or superfamily. Rather, this is an arbitrary umbrella term for several beetle groups. For convenience, we refer to beetles spending most of their adult stage in the water as 'water beetles'. Of these, Dytiscidae (diving beetles) and Hydrophilidae (true water beetles) are the most species-rich groups in Singapore.

As early as the 1870s, Singapore was the type locality for numerous water beetles, such as the highly threatened *Copelatus minutissimus* Balfour-Browne, 1939. The holotypes of *Hydrovatus pisiformis* Biström, 1996 and *Hydrovatus stridulus* Biström, 1996 are the Saunders's material collected from Singapore in 1920s (Biström, 1996). Among the collections made by H.N. Ridley at the beginning of the century, *Lacconectus corayi* Brancucci, 1986, is a species no longer found in Singapore.

Yang (1992) listed 28 species of aquatic beetles from the Lower Peirce forest but her list is incomplete. Our aim is to evaluate the water beetle fauna based on recent surveys of the nature reserves in Singapore and identify the species that appear to be most threatened in Singapore and to discuss possible conservation action.

Methods

The survey area of this study included all water drainages in the Central Catchment Nature Reserve and Bukit Timah Nature Reserve (Figure 1) carried out during the period 1992 to 1997. Every type of water body was investigated. Those that appeared to be of particular interest according to our field experience were most intensively sampled. Interesting sites were revisited for observations on population dynamics and habitat succession.

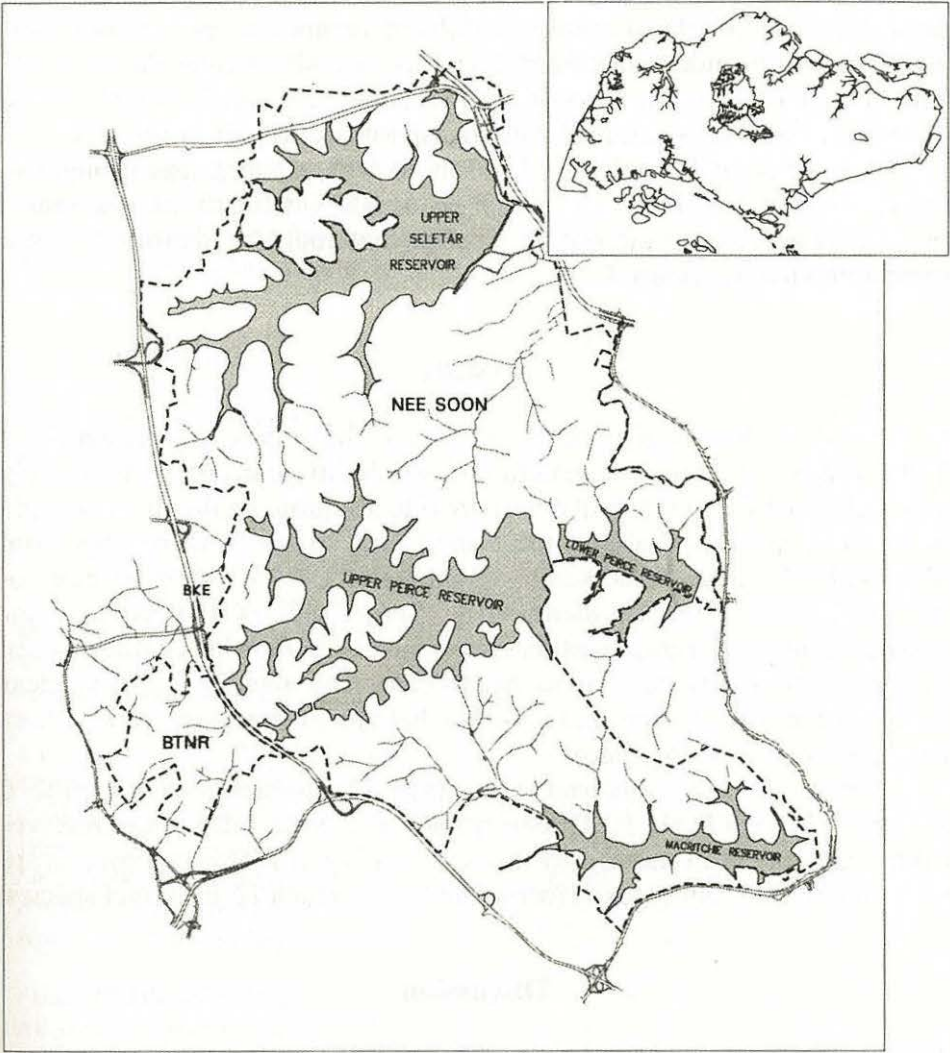


Figure 1. Map of Nature Reserves with an inset showing its location in Singapore. Central Catchment Nature Reserve (CCNR) and Bukit Timah Nature Reserve (BTNR) are separated by the Bukit Timah Expressway (BKE). Dotted lines = boundaries of Nature Reserves.

Larger water bodies were sampled with an aquatic dip net and a set of kitchen sieves of different diameters. The substrate obtained by strongly sweeping the net through mats of submerged grasses, aquatic plants, or open water, was placed on a 1 m x 1 m nylon panel for drainage. The substrate was then examined for the presence of the insects that, in most cases, within a couple of minutes exhibited themselves by running. Less active species or individuals were traced by carefully sorting the substrate with a pair of forceps. Beetles from springs and small streams could frequently be directly sampled with an aspirator or a pair of forceps.

Specimens collected were fixed in 70–90% alcohol, and brought to the Zoological Reference Collection (National University of Singapore) for further processing and setting. Species that could be identified on site were immediately released.

Results

A total of 36 species of water beetles from the survey are presented in Table 1. Several additional genera and species are currently under study and additional fieldwork is likely to provide additions to the list. A couple of species, most probably undescribed, are so far known only from Singapore. We have made some comments on ecological preferences of the species. Some species identified as 'target species' that deserve our special attention and conservation efforts have the following characteristics: 1) they are presently rare due to threats caused by man, 2) they have clear taxonomic status, 3) they have known habitat preferences, and 4) they have low ecological tolerance.

Of the 36 species surveyed in this study, 17 are threatened or identified as target species (Table 1). Fifteen species also occur outside the reserves ('other areas') but of these, only three are threatened. Thirteen species are restricted to different types of forest habitats of which 12 are target species.

Discussion

Though rather isolated from potential source areas that might contribute to a re-colonisation of wetlands in Singapore, our results suggest that the Nature Reserves contain communities of water beetles typical of lowland sites in Southeast Asia. However, the sites in Singapore are either relict sites (Bukit Timah Nature Reserve, Nee Soon Swamp Forest) or in many cases secondary (many parts of the Central Catchment Nature Reserve). Thus, their water beetle fauna deserve special attention. Two important areas are briefly discussed here:

Table 1. Preliminary checklist of water beetles from nature reserves in Singapore, with data on their ecology and conservation status. (t - temporary habitats; p - permanent habitats; lo - lotic species; ln - lentic species; R - restricted in distribution to forest sites; bold species names and numbers - target species.)

Species	Bukit Timah Nature Reserve	Nee Soon Swamp Forest	Mac Ritchie	Other areas	Ecology	Forest Species
Family NOTERIDAE						
<i>Neohydrocoptus bivittis</i> (Motschulsky, 1859)	-	+	+	+	p/ ln/ lo	-
<i>Neohydrocoptus distinctus</i> (Wehncke, 1883)	-	+	-	-	p/ ln/ lo	-
<i>Neohydrocoptus frontalis</i> (Régimbart, 1899)	-	+	-	-	p/ ln	-
<i>Hydrocanthus indicus</i> Wehncke, 1876	-	-	+	-	p/ ln	R
Family DYTISCIDAE						
<i>Hydrovatus maai</i> Biström, 1996	-	+	-	-	p/ ln	-
<i>Hydrovatus pisiformis</i> Biström, 1996	-	+	-	-	p/ ln	R
<i>Hydrovatus pudicus</i> (Clark, 1863)	-	+	-	-	p/ ln	-
<i>Hydrovatus rufoniger</i> (Clark, 1863)	-	+	-	+	p/ ln	-
<i>Hydrovatus saundersi</i> Biström, 1996	-	+	-	-	p/ ln	-
<i>Hydrovatus sinister</i> Sharp, 1882	-	+	-	+	p/ ln	-
<i>Hydrovatus stridulus</i> Biström, 1996	-	+	-	+	p/ ln	-
<i>Hydrovatus sumatrensis</i> Sharp, 1882	-	+	-	-	p/ ln	-
<i>Microdytes elgae</i> Hendrich, Balke & Wewalka, 1995	+	-	-	-	p/ lo	R
<i>Microdytes pasiricus</i> (Csiki, 1937)	+	-	-	-	p/ lo	R
<i>Laccophilus pulicarius</i> Sharp, 1882	-	+	-	+	p/ ln/ lo	-
<i>Laccophilus ritsemae</i> Régimbart, 1880	-	+	-	+	p/ t/ ln	-
<i>Copelatus andamanicus</i> Régimbart, 1899	+	+	+	+	t/ ln	R
<i>Copelatus minutissimus</i> Balfour-Browne, 1939	-	+	-	-	t/ ln	R
<i>Lacconectus krikkeni</i> Brancucci, 1986	+	+	-	-	p/ ln/ lo	R
<i>Hydaticus bipunctatus</i> Régimbart, 1899	+	+	-	+	p/ ln	-
<i>Hydaticus sexguttatus</i> Régimbart, 1899	-	-	+	-	p/ ln	R
Family HYDROPHILIDAE						
<i>Allocotocerus muelleri</i> (Kirsch, 1875)	-	-	+	+	p/ ln	-
<i>Amphiops mater</i> (Sharp, 1873)	-	+	+	+	p/ ln/ lo	-
<i>Helochaeres lentus</i> Sharp, 1890	-	+	-	+	p/ ln	-
<i>Enochrus esuriens</i> (Walker, 1858)	+	-	+	+	p/ ln/ lo	-
<i>Enochrus gaggermeieri</i> Hebauer, 1995	+	+	+	-	p/ ln/ lo	R
<i>Paracymus evanescens</i> Sharp, 1890	+	-	-	+	p/ ln	-
<i>Coelostoma subditum</i> d'Orchymont, 1936	+	-	-	+	P/ ln	-

Species	Bukit Timah Nature Reserve	Nee Soon Swamp Forest	Mac Ritchie	Other areas	Ecology	Forest Species
Family HYDRAENIDAE						
<i>Hydraena</i> sp. 1	+	-	-	-	p/ lo	R
<i>Hydraena</i> sp. 2	+	-	-	-	p/ ln	-
<i>Hydraena</i> sp. 3	-	+	-	-	p/ lo	R
Family GYRINIDAE						
<i>Dineutus spinosus</i> (Fabricius, 1781)	-	-	+	-	p/ lo	-
<i>Orectochilus productus</i> Regimbart, 1883	-	+	+	+	p/ lo/ ln	-
<i>Orectochilus oxygonus</i> Regimbart, 1907	-	+	+	-	p/ lo/ ln	-
<i>Orectochilus andamanicus</i> Regimbart, 1883	-	+	-	-	p/ lo	R
<i>Orectochilus corniger</i> Zaitzev, 1910	-	+	-	-	p/ lo	R
36/ 17	11/ 8	25/ 11	11/ 4	15/ 3		13/ 12

Bukit Timah Nature Reserve

One of the most interesting sites we sampled is the small forest springlet in Taban Valley (Plate 1a) - a true relict site. It was found to contain viable populations of three target species, *Microdytes elgae* (Plate 1b), *Lacconectus krikkeni* and *Hydraena* sp. 1, while a fourth target species is represented by a relict population only, i.e., *Microdytes pasiricus*. For three of these species, this is the only known locality in Singapore (Table 1). *Microdytes* species are rare and rather localised in distribution not only in Singapore but also elsewhere (Hendrich, 1995; Hendrich & Balke, 1995). Thus, for the water beetles, the Bukit Timah site has conservation implications at the global level (Balke *et al.*, 1997a). At the local level, the site should be considered a potential source from which other suitable Singapore sites could be re-colonised, assuming viable populations could be maintained at Bukit Timah over longer periods of time.

Briffett (1990) listed the following threats to the Bukit Timah Nature Reserve: a) construction of the Bukit Timah Expressway has cut off the forest from the larger water catchment forest area, reducing the migratory interflow of flora and fauna (Fig. 1); b) the general drying-up of the forest threatens freshwater life that is now in danger of extinction; and c) heavy quarrying has resulted in many landslides over the years, causing several streams to be diverted or disrupted and endangering rare freshwater life.

With regards to management of the area, strategies to prevent further draining of the sites must be found. In fact, the above-mentioned water beetles could be used as an umbrella group here, and their protection will save many other rare animals, too. Further draining will, inevitably, make them disappear from the local scene.

Nee Soon Swamp Forest

Of the expected streamfauna, only one species, *Hydraena* sp. 3, was detected. The primary swamp nearby with a rich vegetation structure (Plate 1c) fully contained what should be there, i.e., a species-rich community of *Hydrovatus* species. Species of this genus are typical inhabitants of semi-exposed to exposed swampy sites and can thus be found in a wide variety of water bodies, such as Kent Ridge Park. However, a species-rich community, like Nee Soon Swamp Forest with at least six species, can only be found in primary environments for reasons not yet fully understood. Moreover, five of these *Hydrovatus* species have not been collected from localities other than Nee Soon Swamp Forest in Singapore (Table 1), and two of them are threatened fauna. It is notable that the populations of most species appear viable. However, a single specimen of the rare *Copelatus minutissimus* was collected here as well (Balke, 1994). This species is an inhabitant of small waterholes in forested areas and is among the rarest of the Southeast Asian water beetles (Balke, 1994). It probably faces extinction now, and we will include it in the next edition of the IUCN Red List of Threatened Animals. More sites deeper in the forest will have to be surveyed to attempt to detect a population of this species.

The whirligig beetles, *Orectochilus andamanicus* and *O. corniger*, were both found in well-shaded streams in the Central Catchment Nature Reserve swamp forest, mainly located in the Nee Soon area. *O. andamanicus* is a very rare and threatened species in Singapore as only one to two specimens per site were collected from the bigger streams. Although distributed from India to Peninsular Malaysia, it appears to be a very rare species (Mazzoldi, *pers. comm.*).

Without doubt Nee Soon Swamp Forest is the most important site for water beetles that warrants full conservation attention. Additional fieldwork will undoubtedly reveal many more species of interest. However, any lowering of the groundwater level would be disastrous to the swamp forest species. Management strategies should take into consideration the creation of small water holes in the forest that may serve as new breeding habitats for the rare *Copelatus* species and a range of other rare species not discussed here.

Conclusion

Preliminary surveys show that Singapore is home to a relatively rich water beetle fauna. It still offers the opportunity to discover either new or rare and little known species. However, those species adapted to primary habitats can be extremely vulnerable, some even on the verge of (local) extinction. To maintain the diversity presently observed, more proactive conservation actions need to be taken.

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References

- Balke, M. 1994. Regenwald in der Stadt. *Ökowerkmagazin, Berlin*. **8**: 32–34.
- Balke, M. & L. Hendrich. 1991. Rote Liste der Wasserkäfergruppen Hydradeephaga und Hydrophiloidea von Berlin (West). In: A. Auhagen, R. Platen & H. Sukopp (eds). *Rote Listen der gefährdeten Pflanzen und Tiere in Berlin*. Landschaftsentwicklung und Umweltschutz S **6**: 359–372.
- Balke, M., L. Hendrich. & G. Foster. 1997a. Water beetle specialist group report: water beetles and EIAs: Southeast Asian projects/ Action plans for water beetles. *Species*. **29**: 54.
- Balke, M., L. Hendrich & C.M. Yang. 1997b. Updating the Southeast Asian *Neptosternus* Sharp fauna (Coleoptera: Dytiscidae). *Raffles Bulletin of Zoology*. **45**: 369–374.
- Biström, O. 1996. Taxonomic revision of the genus *Hydrovatus* Motschulsky (Coleoptera, Dytiscidae). *Entomologica Basiliensia*. **19**: 57–584.

- Briffett, C. (ed.). 1990. *Master Plan for the Conservation of Nature in Singapore*. Malayan Nature Society, Singapore Branch.
- Eyre, M.D. & S.P. Rushton. 1989. Quantification of conservation criteria using invertebrates. *Journal of Applied Entomology*. **26**: 159–171.
- Foster, G.N. 1991. Conserving insects of aquatic and wetland habitats, with special reference to beetles. In: N.M. Collins & J.A. Thomas. *The Conservation of Insects and Their Habitats*. Academic Press, London. pp. 237–262.
- Foster, G.N. 1996a. *Dytiscus latissimus* Linnaeus, 1758. In: P.S. Helsdingen, L. van Willemse & M.C.D. Speight. *Background information on invertebrates of the Habitats Directive and the Bern Convention, Part 1*. European Invertebrate Survey. pp. 31–39.
- Foster, G.N. 1996b. *Graphoderus bilineatus* (DeGeer, 1774). In: P.S. Helsdingen, L. van Willemse & M.C.D. Speight. *Background information on invertebrates of the Habitats Directive and the Bern Convention, Part 1*. European Invertebrate Survey. pp. 40–48.
- Foster, G.N., A.P. Foster, M.D. Eyre & D.T. Bilton. 1990. Classification of water beetle assemblages in arable fenland and ranking of sites in relation to conservation value. *Freshwater Biology*. **22**: 343–354.
- Hendrich, L. 1995. Malaysia's predaceous water beetles. *Nature Malaysiana*. **20**: 46–49.
- Hendrich, L. & M. Balke. 1993. Bewertungschema zur Eignung einer Insektengruppe ("Wasserkäfer") als Bioindikator (Indikator, Zielgruppe) für Landschaftsplanung und UVP in Deutschland. *Insecta*. **1**: 147–154.
- Hendrich, L. & M. Balke. 1995. Die Schwimmkäfer der Sundainsel Bali: Faunistik, Taxonomie, Ökologie, Besiedlungsgeschichte und Beschreibung von vier neuen Arten (Coleoptera: Dytiscidae). *Faunistische Abhandlungen*. **20**: 29–56.
- Larson, D.J. 1997. Habitat and community patterns of tropical Australian hydradephagan water beetles (Coleoptera: Dytiscidae, Gyrinidae, Noteridae). *Australian Journal of Entomology*. **36**: 269–285.
- IUCN. 1996. *1996 IUCN Red List of threatened animals*. IUCN, Gland. pp. 368.
- Polhemus, D.A. 1993. Conservation of aquatic insects: Worldwide crisis or localized threats? *American Zoologist*. **33**: 588–598.

- Richoux, P. 1994. Theoretical habitat templets, species traits, and species richness: aquatic *Coleoptera* in the upper Rhone River and its floodplain. *Freshwater biology*. **31**: 377–395.
- Samways, M.J. 1994. *Insect conservation biology*. Chapman & Hall, London. pp. 358.
- Yang, C.M. 1992. Aquatic Beetles. In: Y.C. Wee (ed.). *Proposed golf course at Lower Peirce Reservoir*. Nature Society (Singapore). pp. 17.



Plate 1a. Michael Balke



Plate 1b. Michael Balke



Plate 1c. Lars Hendrich



Plate 1d. Michael Balke

Plate 1. a. A small springlet in Bukit Timah Nature Reserve. b. *Microdytes elgae*, a rare dytiscid from Bukit Timah Nature Reserve. c. A species rich habitat for *Hydrovatus* in Nee Soon Swamp Forest. d. *Hydaticus bipunctatus*, a forest pool species.