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AQUATIC HETEROPTERA (INSECTA: GERROMORPHA AND NEPOMORPHA) FROM XISHUANGBANNA, YUNNAN, CHINA

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ABSTRACT. **–** Eighty five species of aquatic and semi-aquatic Heteroptera belonging to 14 families are reported from Xishuangbanna and nearby counties in Yunnan. Collecting locations and habitats are given. Ten species (*Hydrometra jaczewskii, H. longicapitis, H. orientalis, Amemboa (Amemboa) sexualis, A. (A.) lyra, Metrocoris ciliatus, Pleciobates pacholatkoi, Ptilomera burmana, Rhyacobates anderseni, Ventidus pulai*) are new records for China. In addition, Nine new species (*Timasius yunanensis, Ranatra lansburyi, R. sterea, Micronecta (Micronecta) erythra, M. (M.) janssoni, M. (M.) lobata, M. (M.) ornitheia, M. (Unguinecta) melanochroa, Anisops pseudostali)* based on material collected during this study have been described and published elsewhere.

KEY WORDS. **–** Aquatic Heteroptera, Gerromorpha, Nepomorpha, Yunnan, Xishuangbanna, China.

INTRODUCTION

One of the missions of the Raffles Museum of Biodiversity Research (RMBR) is to study the fauna and flora of Southeast Asia and to develop joint projects with other research institutions. Following an exploratory survey carried out in 2000 a joint research project was set up between the RMBR and the Xishuangbanna Tropical Botanic Garden (XTBG). In this paper we present a list of aquatic Heteroptera collected during several expeditions to Xishuangbanna and surrounding counties.

Xishuangbanna is a Dai minority autonomous region in the southwestern corner of Yunnan Province, China (Fig. 1). It shares common borders with Myanmar and Laos to the south. It is rather remote and has rarely been explored until the late 1950s when relics of an ancient tropical forest were discovered. The XTBG was set up in Mengla county by the Academia Sinica in 1959. One of its chief functions was to promote scientific research on the diversity and exploitation of tropical plants in Yunnan province. In recognition of the unique biological nature of the area, Xishuangbanna became recognized as an UNESCO Biosphere Reserve in 1993. The geographical, physical and cultural features of the biosphere and some of its management problems have been reported by Wu & Ou (1995).

The XTBG is situated on a high plateau about 570 m above sea level. Although it lies within the tropical zone (at latitude 21°N), because of its high altitude it enjoys an average annual temperature of 21°C and some 150 cm of rainfall per year. The garden occupies an area of about 900 hectares on Huoluodao, a gourd-shaped peninsula surrounded on three sides by the Luosuo River, a tributary of the Mekong River or Lanchangjiang. It has a well-preserved natural tropical forest with a collection of more than 3,000 plant species from

various regions of China. It is well maintained and is a major tourist attraction for the region.

Early literature on aquatic insects of China is rather sparse and widely scattered. Although various groups of aquatic insects have caught the attention of entomologists in China and elsewhere, many groups remained unstudied. Certain aquatic insect species are useful indicators of water quality. Morse et al. (1994) took the lead by producing "Aquatic Insects of China useful for Monitoring Water Quality". Most orders and families of Chinese aquatic insects were included. Keys to genera were provided and there were excellent illustrations of many species. However, no detailed distribution data were given for any of the species. The aquatic and semi-aquatic Heteroptera were reviewed by Zheng et al. (1994) in this book but relatively few records from Xishuangbanna can be found in the published literature. We present this study to document some of the aquatic Gerromorpha and Nepomorpha from the area.

MATERIAL AND METHODS

The material used in compiling Appendix 1 was collected by various scientists at different times between 1999 and 2002. The area surveyed covered mainly the Lanchangjiang (or Mekong) Basin, more or less the entire Xishuangbanna County. In addition, some samples were collected from several neighboring counties: Simao, Baoshan, Lijiang, Dali, Nujiang and Dehong of the Yangtze and Salween Basin (Figs. 1 & 2, Appendix 2 & 3). Sampling sites visited ranged from small, temporary roadside pools to fast-flowing mountain streams and rivers. At each site we tried to collect insects from as many ecological habitats as possible. Collections from all the sites were grouped into 26 locations according to the river system they belong to (Appendix 2). Reference numbers for each sampling site with habitat notes by different collectors are listed in Appendix 3.

We used two types of nets for collecting aquatic insects: a long-handled (50-cm) aquatic "D"net (15-cm in diameter with 1-mm mesh), and a shallow bottom-sampling net (30-cm square with 2-mm mesh). Insects were collected by sweeping the net over the water surface, or by kicking bottom and side substrates, around rock surfaces and among aquatic vegetation. The sample data are only qualitative. We tried to identify insects to family, genus and species and many of the specific identifications were authenticated later by various experts. Nevertheless, some species remain unidentified. Descriptions of new species are published separately (Nieser et al., 2005; Tran & Yang, 2006; Zettel, 2004b). Most specimens were preserved in 75% alcohol but some were mounted dry. Specimens have been deposited in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research and in the Institute of Zoology, Academy of Sciences, Beijing, China (CASB).

RESULTS

Seven orders of aquatic insects were represented in our survey: - Heteroptera, Coleoptera, Ephemeroptera, Odonata, Diptera, Trichoptera and Plecoptera. Only aquatic insects belonging to Gerromorpha and Nepomorpha will be discussed in some detail. A list of aquatic Coleoptera is presented in Appendix 4.

Eighty five species of insects in 42 genera belonging to 14 families (Aphelocheiridae (1), Belostomatidae (1), Gerridae (27), Hebridae (4), Helotrephidae (6), Hydrometridae (5), Mesoveliidae (1), Micronectidae (9), Naucoridae (3), Nepidae (6), Notonectidae (8), Ochteridae (1), Pleidae (1), and Veliidae (12)) were collected, as listed in Appendix 1. The following is a brief summary of species found in this study, grouped according to different habitats:

Flowing water.-

1. Torrential rivers:- Only a few species of semi-aquatic bugs, all belonging to the Gerridae, were collected. *Pleciobates pacholatkoi* can be found skating rapidly against fast currents in the middle of the river or resting on quiet sides of exposed rocks just above water level. Some *Ptilomera hemmingseni*, *P. hylactor* and *Rhyacobates anderseni* were occasionally encountered on moderately flowing water.

2. Slow to fast flowing streams (forest hill streams and tributaries of Lanchangjiang):- Most species of aquatic bugs were collected from these streams. They can be subdivided into the following groups:
   (i). Common and widespread species:- *Ptilomera hylactor, P. hemmingseni, P. tigrina, Metrocoris ciliatus, M. acutus* (Gerridae); *Rhagovelia sumatrensis, Rhagovelia* sp. 1 (Veliidae).
   (ii). Less common and always found at quiet sides of flowing waters:- *Amemboa* spp., *Rhagadotarsus kraepelini, Rheumatogonus* sp., *Ventidius pulai, Limnometra matsudai* (Gerridae); *Pseudovelia* spp., *Perittopus* spp., *Strongylovelia* sp. (Veliidae).
   (iii). Rather uncommon and found among submerged roots or edges of slow flowing streams:- *Distotrephes pavelstysi, Helotrephes australis, H. incisus, H. nieserianus, H. papaceki, Trephotomas compactus* (Helotrephidae), and Hebridae.
   (iv). Common or rather uncommon and found on rocky bottoms of fast flowing streams:- *Aphelocheirus* sp. (Aphelocheiridae); *Gestroiella limnocoroides*, *Cheirochela* sp., *Heleocoris* sp. (Naucoridae).
   (v). Uncommon and found on stream margins with vegetation:- *Cercotmetus asiaticus*, *Ranatra* spp. (Nepidae); *Hydrometra* spp. (Hydrometridae); *Mesovelia vittigera* (Mesoveliidae).
   (vi). Rare and found only on hygropetric boulders along streams or water falls:- *Onychotrechus* spp. (Gerridae).

Fig. 1. Map of Yunnan Province, China, showing geographical area of Xishungbanna and sampling locations (24-26) in nearby counties.

(vii). Rare and found in creeks:- Hebridae.
(viii). Rare and found on sand banks:- *Ochterus marginatus* (Ochteridae).
(ix). Rare and found in rock pools by waterfalls at high altitude:- *Velia sinensis* (Veliidae).

Standing water (pools, puddles, ponds, rock pools).- *Aquarius paludum, Gerris latiabdominis, G. lobatus, Limnogonus fossarum, Neogerris parvulus* (Gerridae); *Microvelia* spp. (Veliidae); *Laccotrephes* spp. (Nepidae); *Micronecta* spp. (Micronectidae); *Anisops* spp., *Enithares* spp., *Nychia sappho* (Notonectidae).

DISCUSSION

All three infra-orders of aquatic Heteroptera were represented in our samples. The Nepomorpha and Leptopodomorpha, normally found in stagnant pools and shorelines, were poorly represented because we encountered few such habitats in the area. The majority of our samples were collected from flowing waters, along rocky rivers and streams. Among the Leptopodomorpha, we collected only one sample of Saldidae (*Saldula* sp.). The Nepomorpha, which are truly aquatic and usually submerged, are represented by the following eight families: Aphelocheiridae, Belostomatidae, Helotrephidae, Micronectidae, Naucoridae, Nepidae, Ochteridae and Pleidae. Except for the Micronectidae and Nepidae we collected only a few samples of each family (see Appendix 1). Members of Gerromorpha, which are semi-aquatic and usually found at the water surface, are represented by five families: Gerridae, Hebridae, Hydrometridae, Mesoveliidae and Veliidae. Gerridae and Veliidae, the commonest and most abundant members in our collections, are represented by 14 and seven genera respectively. Some species were common and found in almost all the locations sampled. Others were rare and represented by only a few specimens or found in only one or two sites (e.g. *Onychotrechus* spp., *Ptilomera assamensis, P. burmana, Rhyacobates anderseni, Helotrephes* spp., *Hydrometra* spp., *Velia sinensis*).

Zheng et al. (1994) listed five families of Gerromorpha, 10 families of Nepomorpha and two families of Leptopodomorpha from various regions in China. In the

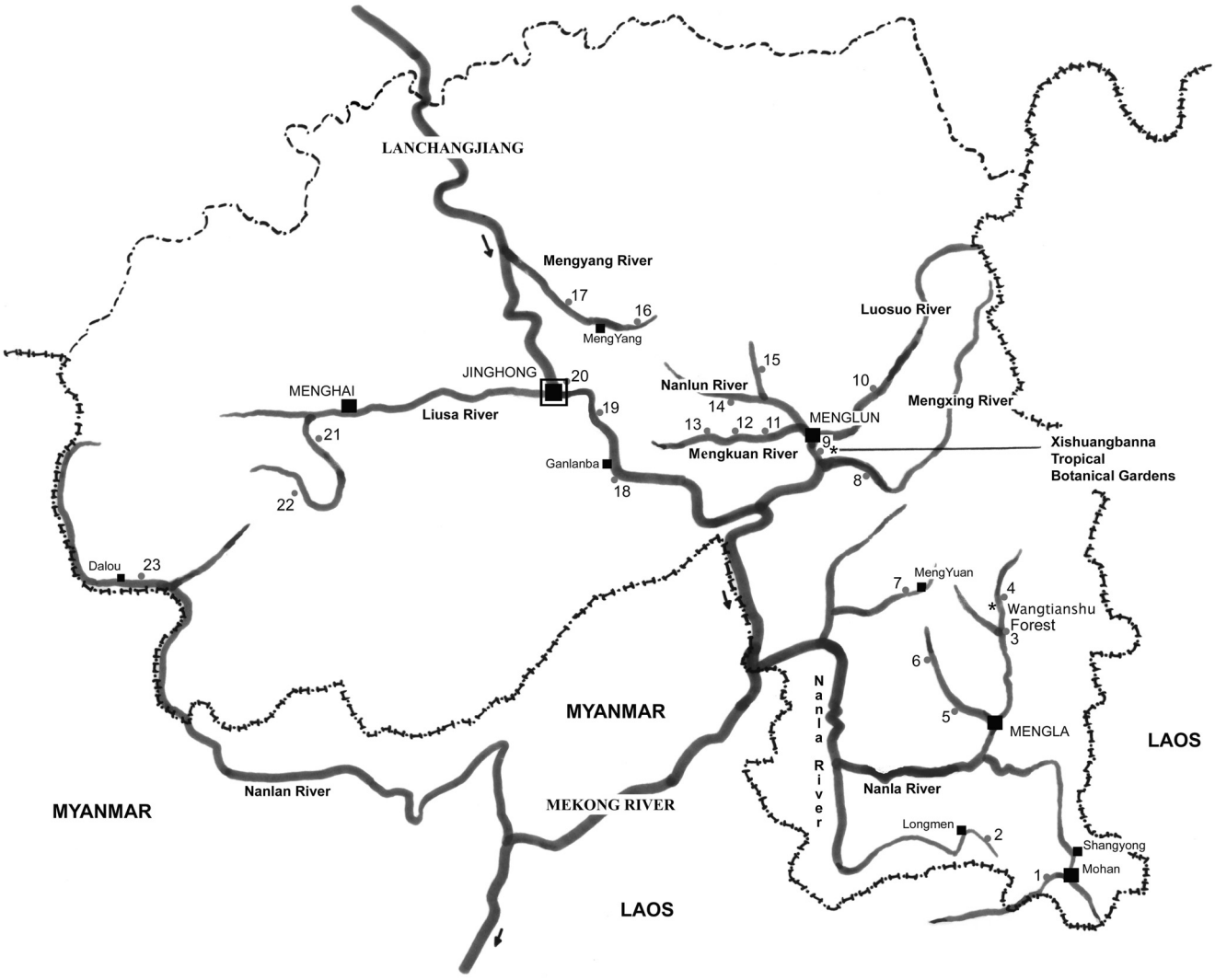

Fig. 2. Map of Xishuangbanna showing locations of major sampling sites 1-23 (See Appendix 2 for further details).

checklist of Gerromorpha of China by Chen and Andersen (1993), five families (Gerridae, Hebridae, Hydrometridae, Mesoveliidae and Veliidae) with 31 genera and 93 species were listed. This is probably the most complete published record of Gerromorpha for China. In their list of Leptopodomorpha from China, Chen and Lindskog (1994) reported six species of Saldidae and one species of Leptopodidae from Yunnan Province. Besides these checklists there are very few other publications on the aquatic insects of China in the English language (Liu & Zheng, 1994; Zettel, 2001a, b, 2004a, b). Most of the publications in Chinese were either descriptions of new species or new regional records (e.g. Liu & Ren, 1997). In the recently published "List of Chinese Insects" (Hua, 2000), 16 families of aquatic Heteroptera were reported from China but only eight families with 15 genera and 29 species were listed for Yunnan. Our study recorded 15 families, 43 genera and 86 species. Based on the species list given by Hua (2000) and others (Andersen & Chen, 1993; Chen, 1994, 1995; Chen & Nieser, 1993a, 1993b; Chen et al., 2004; Nieser et al., 2005; Polhemus, 2001; Ren, 1992; Tran & Yang, 2006; Zettel, 1995, 1998, 2004a), 10 species (*Hydrometra jaczewskii, H. longicapitis, H. orientalis, Amemboa (Amemboa) sexualis, A. (A.) lyra, Metrocoris ciliatus, Pleciobates pacholatkoi, Ptilomera burmana, Rhyacobates anderseni*, *Ventidus pulai*) found in this study are new records for China. In addition, nine species (*Timasius yunanensis*, *Ranatra lansburyi, R. sterea, Micronecta (Micronecta) erythra, M. (M.) janssoni, M. (M.) lobata, M. (M.) ornitheia, M. (Unguinecta) melanochroa, Anisops pseudostali*) from our collection were new to science and had been described elsewhere (Nieser et al., 2005; Zettel, 2004b). Although the following species (*Hyrcanus chenae, Hydrometra albolineata, H. greeni, H. procera, Microvelia horvathi, Gerris gracilicornis, G. tigrinus, Metrocoris obscurus, M. genitalis, Tenagogonus kuiterti, Ranatra chinensis, Sigara esakii, Aphelocheirus maculosus, Anisops exigua, A. ogasawarensis, Notonecta kirkaldy, N. violacea, Distotrephes laoticus, Helotrephes sausai*) have been reported from Yunnan in the literature given above, we have not collected them in Xishuangbann. Nevertheless, our report represents the first comprehensive survey of aquatic Heteroptera from Xishuangbanna, an area with a very rich and diverse aquatic insect fauna seldom visited by aquatic biologists. Undoubtedly, as more surveys are carried out many more taxa will be added to the list and many new species remain to be discovered.

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LITERATURE CITED

Andersen, N. M. & P. P. Chen, 1993. Taxonomic review of the pondskater genus *Gerris* Fabricius in China, with two new species (Hemiptera: Gerridae). *Entomologica Scandinavica*, **24**:147-166.

Chen, P. P., 1994. An overview of Chinese *Metrocoris* Mayr, with description of three new species (Hemiptera: Gerridae). *Entomologica Sinica*, **1**: 121-131.

Chen, P. P., 1995. A new species of *Metrocoris* Mayr from Yunnan, China. (Insecta: Heteroptera: Gerridae). *Annalen Naturhistorie Museum Wien*, **97B**: 155-158.

Chen, P. P. & N. M. Andersen, 1993. A checklist of Gerromorpha from China (Hemiptera). *Chinese Journal of Entomology*, **13**: 69-75.

Chen, P. P. & P. Lindskog, 1994. A namelist of Leptopodomorpha from China (Hemiptera). *Chinese Journal of Entomology*, **14**: 405-409.

Chen, P. P. & N. Nieser, 1993a. A taxonomic review of the oriental water strider genus *Metrocoris* Mayr (Hemiptera. Gerridae). Part I. *Streenstrupia*, **19**(1): 1-43

Chen, P. P. & N. Nieser, 1993b. A taxonomic review of the oriental water strider genus *Metrocoris* Mayr (Hemiptera. Gerridae). Part II. *Streenstrupia,* **19**(2): 45-82

Chen P. P., N. Nieser & J-Z. Ho, 2004. Review of Chinese Ranatrinae (Hemiptera: Nepidae), with descriptions of four new species of *Ranatra* Fabricius. *Tijdschrift voor Entomologie*. **147**: 81-102.

Hua, L-Z., 2000. *List of Chinese Insects, Vol. 1*. Zhongshan University Press, Guangzhou. Pp. 212-216.

Liu, G. Q. & L. Y. Zheng, 1994. Two new species of genus *Aphelocheirus* Westwood from China (Insecta: Heteroptera: Aphelocheiridae). *Reichenbachia Museum furTierkunde Dresden*, **30**: 113-117.

Liu, G. Q. & S. Z. Ren, 1997. Hemiptera : Corixidae and Nepidae. In: Yang X. (ed.) *Insects of the Three Gorge Reservoir Area of Yangtze River.* Chongqing Publishing House. Pp.184-186.

Morse, J. C., L. F. Yang & L. X. Tian, (eds) 1994. *Aquatic Insects of China Useful for Monitoring Water Quality.* Hohai University Press, Nanjing, P. R. China. 570 pp.

Nieser, N., P. P. Chen & C. M. Yang, 2005. A new subgenus and six new species of Nepomorpha (Insecta: Heteroptera) from Yunnan, China. *Raffles Bulletin of Zoology*, **53**(2): 189-209.

Polhemus, D., 2001. A review of the genus *Ptilomera* (Heteroptera: Gerridae) in Indochina, with descriptions of two new species. *Journal of New York Entomological Society*, **109**(2): 214-234

Ren, S. Z., 1992. Corixidae. C*ontributions from Tianjin Natural History Museum*, **9**: 60-61.

Tran, D. A. & C. M. Yang, 2006. New species of the water strider Genera *Eotrechus* Kirkaldy and *Rhyacobates* Esaki (Heteroptera: Gerridae) From Vietnam. *Raffles Bulletin of Zoology,* **54**(1): 11-20.

Wu, Z. L. & X. K. Ou, 1995. *The Xishuangbanna Biosphere Reserve (China). A tropical land of natural and cultural diversity*. Working paper no. 2 (1995), UNESCO Publications, Paris, France. 52 pp.

Zettel, H., 1995. Zwei neue Arten der Gattung *Helotrephes* Stll aus China (Helotroptera: Helotrephidae). *Tijdschrift voor Entomologie*, **138**: 291-295.

Zettel, H., 1998. Eine taxonomische Revision der Gattung *Hyrcanus* Distant 1910 (Heteroptera: Hebridae) mit Neubeschrei bungen von vier Arten aus Indien, Thailand, Laos und China. *Stapfia*, **55**: 585-606.

Zettel, H., 2001a. Few new species of *Perittopus* Fieber, 1861 (Hemiptera: Velidae) from Southeast Asia. *Raffles Bulletin of Zoology*, **49**(1): 109-120.

Zettel, H., 2001b. *Helotrephes papaceki* sp. n. und Erstnachweise von vier weiteren *Helotrephes* Arten aus Yunnan, China (Heteroptera: Helotrephidae). *Linzer biologische Beitraege*, **33**: 97-102.

Zettel, H., 2004a. Helotrephidae (Insecta: Heteroptera) aus den chinesischen Provinzen Guangdong, Yunnan und Guizhou, mit Beschreibungen neuer Arten der Gattungen *Helotrephes* und *Distotrephes*. *Annalen Naturhistorie Museum Wien*, **105B**: 397-410.

Zettel, H. 2004b. Revision of the *Timasius chinai* species group (Insects: Heteroptera: Hebridae), with descriptions of ten new species. *Insect Systematics and Evolution*, **35**: 241-260.

Zheng, L. Y., P. P. Chen, G. P. Liu & S. Z. Ren, 1994. Aquatic and semiaquatic Hemiptera. In: Morse, J. C., L. F. Yang & L. X. Tian (eds.), *Aquatic Insects of China for Monitoring Water Quality*. Hohai University Press, Nanjing, P. R. China. Pp. 210-249.

Appendix 1. Genera and species of aquatic Heteroptera collected from Xishuangbanna and nearby counties in Yunnan, China (Numbers refer to sampling sites listed in Appendix 2. **Bold print** indicates new species described elsewhere based on material collected during this project; * = first record from China).

INFRAORDER GERROMORPHA

FAMILY MESOVELIIDAE
Mesovelia vittigera Horvath 9

FAMILY HEBRIDAE
Timasius miyamotoi Andersen 11, 12, 15
Timasius yunnanensis Zettel 13
Hyrcanus draculus Zettel 1, 5, 11, 15
Hebrus sp. 15

FAMILY HYDROMETRIDAE
Hydrometra annamana Hungerford & Evans 23
H. greeni Kirkaldy 5
**H. jaczewskii* Lundblad 4
**H. longicapitis* Torre-Bueno 5, 9, 15, 16, 17
**H. orientalis* Lundblad 13

FAMILY VELIIDAE
Microvelia douglasi Scott 13
M. leveillei (Lethierry) (= *diluta* Distant) 13
Perittopus asiaticus Zettel 15, 16
Perittopus sp. 11-15, 20
Pseudovelia sp. 1 2
Pseudovelia sp. 2 10
Rhagovelia sumatrensis Lundblad 1, 2, 5, 6, 8, 9, 12, 15, 16, 22, 25
Rhagovelia sp. 1. ..... 2, 4, 5, 7, 9, 12-17, 20, 21
Rhagovelia sp. 2. 17
Strongylovelia sp. 2, 9, 15
Velia sinensis Andersen 24
Xiphovelia sp. 23
Microvelinae (unidentified) 4, 15

FAMILY GERRIDAE
**Amemboa (Amemboa) sexualis* Polhemus & Andersen 12, 17
**Amemboa (Amemboa) lyra* (Paiva) 1, 2, 5, 6, 11, 13-16, 20
Amemboa (Amemboides) sp. 1 16
Amemboa (Amemboides) sp. 2 ..... 3-7, 12, 16, 15, 20, 24
Aquarius paludum (Fabricius) 10, 11, 15, 19, 22, 23, 26
Gerris latiabdominis Miyamoto 26
Gerris lobatus Andersen & Chen 24, 25, 26
Limnogonus fossarum (Fabricius) 9, 13, 17, 19, 20
Limnometra matsudai (Miyamoto) 9, 15
Metrocoris bilobatus Den Boer 6, 15
**Metrocoris ciliatus* Den Boer 2, 3, 12-16, 20
Metrocoris acutus Chen & Nieser 3-7, 11, 14, 15, 20, 21, 24
Metrocoris sp. (*M. bilobatus* group) 15, 17, 24, 25
Neogerris parvulus (Stål) 11
Onychotrechus esakii Andersen 12, 24
Onychotrechus sp. 1 7
Onychotrechus sp. 2 ..... 5, 20
**Pleciobates pacholatkoi* Zettel & Chen 3, 8, 10, 14, 16
Ptilomera assamensis Hunderford & Matsuda 21
**Ptilomera burmana* D Polhemus 1
Ptilomera hylactor Breddin 1-8, 10, 11, 13-15, 21, 22
Ptilomera hemmingseni Andersen 2-4, 6, 7, 11-15, 20, 21
Ptilomera tigrina Uhler 1, 2, 5, 11-13, 15
**Rhyacobates anderseni* Tran & Yang 24
Rhagadotarsus kraepelini Breddin 9, 23
Rheumatogonus sp. 8, 14
**Ventidius pulai* Cheng 1, 8

INFRAORDER NEPOMORPHA

Appendix 2. Major sampling sites listed by township and river system. Numbers 1-23 refer to locations in Xishangbanna given in Fig. 2. Numbers 24-26 refer to other locations given in Fig. 1. Data on collection numbers in brackets are given in Appendix 3.

1. Mohan, Nanla River tributaries: ditch by rice field (LC 021), muddy stream (LC 022), mountain stream (LC 023), slow flowing water
2. Shangyong/Longmen, Nanla River tributaries: tiny creek (LC 024), river by roadside (LC 025), forest stream (LC 026).
3. Mengla, Nanla River and tributary: torrential river (YCM 312), rocky forest stream (YCM 313)
4. Mengla, Nanla River, Wantianshu Nature Reserves: slow to moderate flowing forest streams and side pools (DL001/1999, LC 001, THH 0059, YCM 314)
5. Mengla, Nanla River tributary: rocky streams (LC 002, 003, 027, 028; THH 0060, 0061; YCM 311), side pool (LC 029).
6. Mengla, Nanla River tributary: slow to moderate flowing rocky stream (YCM 310), pools (LC 030), waterfall (LC 031).
7. Mengyuan, Nanla River tributary: slow flowing stream (LC 032, 033), forested stream (LC 034), hygropetric boulders near waterfalls (YCM 309).
8. Menglun, Mengxing River: Chui Ping Fan Tropical Forest Park, fast flowing water (LC 035, YCM 308).
9. Menglun, Xishuangbanna Tropical Botanic Garden: slow flowing stream (LC 007, 008), pools and ponds (LC 009, 036, 037, YCM 322, 324), by light (YCM 316, 317).
10. Menglun, Luoso River: torrential river (YCM 321, 307).
11. Menglun, Mengkuan River, Man-Er Stream: moderate flowing stream (YCM 299), down-stream by padi field, (YCM 318), down-stream (YCM 319), mid-stream (YCM 320), mid-stream surface samples (ME001-006)
12. Menglun, Man-le stream: surface samples (ML001 – 006)
13. Menglun, Man-zhang stream: small flowing stream (YCM 300), puddle (YCM 301), surface samples (MZ 001-006).
14. Menglun, Nanlun River tributary: slow flowing forest stream near Manpao Village (LC 013, YCM 302).
15. Menglun, Baka, Nanlun River: moderate flowing forest stream (YCM 303, 305, LC 015, 016), irrigation canal (LC 014, 038, YCM 304), small creek with waterfall (YCM 306)
16. Mengyang, Mengang River: small milky roadside creek (LC 017), forest stream (LC 018).
17. Mengyang, Mengang River: forest stream (LC 019), ditch by paddy field (LC 020).
18. Ganlanba, Lanchangjang: fast flowing river with sandy bank (YCM 325).
19. Jinghong, Lanchangjang: exposed rock pools on huge boulders, 5 meters above river surface (YCM 326a); standing pools beside the river (YCM 326b)
20. Jinghong: streams in Banna Nature Reserves (DL002/1999, YCM 327, 329), hygropetric boulders in forest (YCM 328).
21. Menghai, Liusa River tributary: fast flowing hill stream by paddy field (LC 004, THH 0064).
22. Menghai, Liusa River tributary: moderate flow (LC 006, THH 0066)
23. Dalou, Nanlan River: moderate flow (LC 005, THH 0065).
24. Lanchangjing, tributaries : Simao (THH0068, 0073, 0078, 0080, 0081); Bashan (THH0085); Dali (THH0098, 0100); Cangshan (YCM330-332).
25. Jianshajiang (Yangtze River), tributaries: Lijinag (THH 0092, 0094-0095).
26. Nujiang (Salween River), tributaries: Laowo (THH0102); Baoshan, Gaoling Mountain (THH0108); Dehong (THH 0114).

Appendix 3. List of collection numbers with habitat notes. All locations in Xishuangbanna unless otherwise mentioned. XTBG = Xishuangbanna Tropical Botanic Garden. Altitudes given in meters above sea level. Name of collector and dates of collection:- LC (Lanna Cheng, 18-31 May 2000); DL (Daiqing Lee, December 1999 and June to July 2001); ME (Hongmao Liu, 29 June -15 July 2001); MZ (Hongmao Liu, May-June 2001); ML (Hongmao Liu, 09-12 April 2001); THH (Tan Heok Hui and Cai Yi Xion, 18-31 May 2000); YCM (Yang Chang Man and P. Chew, 28 May-12 June 2002).

DL 001/1999. Wantianshu Nature Reserve, 700m, stream
DL 002/1999. Jinghong Banna Nature Reserve, stream
DL 001/2001. Baka, 53km from Jinghong, stream
DL 002/2001. Mengkuan, 51km from Jinghong, stream
DL 003/2001. Manmo Village, stream
DL 004/2001. Between Manmo and Manzhang, stream
DL 006/2001. Manzhang, Menglun, stream
LC 001. Clear moutain stream by waterfall, Wantianshu Nature Reserve
LC 002. Slow flowing roadside stream, km5, Mengla to Menglun
LC 003. Shaded forest stream, moderateflow, km9, Mengla to Menglun
LC 004. Fast-flowing stream by padi field, km29 Menghai to Dalou
LC 005. Nanlan River at border between China and Myanmar, moderate flow
LC 006. Mangkuan River, km57, Dalou to Menghai, clear water, moderate flow
LC 007. Muddy river within XTBG
LC 008. Small creek, 1 km upstream from LC 007
LC 009. Lily pond within XTBG
LC 010. Clear flowing creek near Yulingku Nature Reserve
LC 011. Pool at waterfall near Yulingku Nature Reserve
LC 012. Rocks at splash zone by waterfall near Yulingku Nature Reserve
LC 013. Slow-flowing stream near Manpao Village, km57, Menglun to Jinhong
LC 014. Roadside canal, No.55 power station, km10, Menglun to Mengyang
LC 015. Small waterfall near No.55 power station
LC 016. Quiet pool near waterfall above
LC 017. Milky roadside creek, km12 Menglun to Mengyang
LC 018. Clear forest stream, km13, Menglun to Mengyang
LC 019. Clear forest stream, km20, Menglun to Mengyang
LC 020. Ditch by paddy field near Mengyang town
LC 021. Muddy ditch by paddy field near army base, Morhan, 2 km from Laotian boarder
LC 022. Reddish muddy stream near grazing field, Morhan, 3 km from Laotian boarder
LC 023. Clear mountain stream at Shangang, 8 km from Morhan
LC 024. Tiny creek at Dalongha village, road to Longmen
LC 025. River by roadside, slightly muddy, Dalongha village
LC 026. Clear forest stream, fast-flowing, Dalongha village
LC 027. Clear forest stream near small dam, km7, Mengla to Mengyang
LC 028. Stream by small waterfall, km10, Mengla to Mengyang
LC 029. Roadside pool, still water, 18 km Menglato Mengyang, near Longling
LC 030. Small roadside pool, km26, Mengla to Mengyang
LC 031. Small waterfall, km28 Mengla to Mengyang
LC 032. Ditch leading to paddy field, 6 km from Mengyuan
LC 033. River by Jingmengyuan village near Mengyuan
LC 035. Fastflowing river near Chuipingfan Tropical Forest entrance, Mengxing
LC 036. Small muddy pond, still water, XTBG
LC 037. Lily pond near entrance to XTBG, still water
LC 038. Forest stream across road from No.55 Power Station (Coll. Yang Xiaodong)
ME1. Man-Er stream, tributary of Mengkuan River, clear, shaded forest stream, in nature reserve, 707m
ME2. As above, upstream, 930m
ME3. As above, downstream, 583m
ME4. As above, downstream, 613m
ME5. As above, downstream, 740m
ME6. As above, downstream, 870m
ML1- ML2. Man-Le stream, tributary of Mengkuan River, downstream by paddy field.
ML3- ML4. As above, midstream
ML5- ML6. As above, upstream, forested
MZ1- MZ2. Man-Zhang stream, tributary of Mengkuan River, downstream
MZ3- MZ4. As above, midstream
MZ5- MZ6. As above, upstream
QD1- QD6. Qian Di Stream, XTBG grounds
THH0059. Mengla Nature Reserve, Wangtianshulin, 560m
THH0060. Rocky hill stream, km12, Mengla to Menglun, 560m
THH0061. Hill stream at Longlin, Mengla, 900m
THH0064. Hill stream next to paddy fields, km29, Menghai to Dalo, 1170m

THH0065. Nanlan river, Dalou town, China-Myanmar border
THH0066. Mengkuan river, ca. km56.5, Menghai to Dalou, 650m
THH0068. Hill stream, km90, Jinghong to Simao, 1070m
THH0070. SIMAO. Hill stream km20, Simao to Pu'er, near border, 1380m
THH0073. SIMAO. Mekong basin, hill stream km2, Ning'er to Yuanjiang, 1500m
THH0078. SIMAO. Mekong basin, upstream of Xiaoheijiang, km46, Jinggu to Ming'er, 980m
THH0080. SIMAO. Mekong basin, hill stream at km38, Jinggu to Linchang, 1500m
THH0081. SIMAO. Mekong basin, hill creek km110, Jinggu to Linchang, 1000m
THH0085. BAOSHAN. Mekong basin, creek near Tabing village (Changning), on road Fengqing to Baoshan, 1600m
THH0092. LIJIANG. Yangtze basin: Qingxi reservoir near Lijiang town, 2380m
THH0094. LIJIANG. Yangtze basin. Lashi Hai, 2420m
THH0095. LIJIANG. Yangtze basin, Jinshajiang, 70 km from Lijiang to Shigu, 1850m
THH0098. DALI. Mekong basin, Jian Hu, ca. 3 km from Jianchuan to Dali, 2200m
THH0100. DALI. Mekong basin, Chebi Hu, reservoir ca. 100 km north of Dali, 2030m
THH0102. NUJIANG. Salween basin, streams and pools in peat bog along road from Yongping to Liuku, near Laowo, 2400m
THH0108. BAOSHAN. Irawaddy basin, Gaoligong Mountain, creek and pools along road from Baoshan to Tengchong (114 km), 1630m
THH0114. DEHONG. Irawaddy basin, Luxi (Mangshi), Banguo river running through town, 950m
YCM0299. Mengle stream, near Menglun, moderate flow through paddy field; clear, granite/stone bottom
YCM0300. Manchang stream, 63 km Jinghong to Menglun, moderate to fast flowing with vegetation on edges, from primary forest through paddy fields, 647m
YCM0301. Puddle, next to YCM0300
YCM0302. Mengmoe stream near Aini village, km56 Jinghong to Menglun, slow to moderate flow, rocky bottom.
YCM0303. Baka, moderate to fast flowing stream, from primary forest near 55 power station 630m.
YCM0304. Baka, Canal at No.55 power station as above
YCM0305. Baka, fast flowing stream before dam at 55 power station as above
YCM0306. Baka, creek, sandy bottom, off YCM 0305
YCM0307. Luosuo River, fast flowing muddy water, near XTBG
YCM0308. Mengxing River, fast flowing, under bridge
YCM0309. Waterfalls near Mengyuan, 1000m
YCM0310. Rocky stream, km119 Jinghong to Mengla
YCM0311. Rocky stream 67 km from Mengla
YCM0312. Nanla River, rocky, fast flowing
YCM0313. Small forest stream off Nanla River near YCM0312
YCM0314. Upstream of Nanla River, Wangtianshulin, rocky with low cascades
YCM0315. Fast flowing stream near village, Mengyuan
YCM0319. Mengyuan, stream near YCM 0315
YCM0320. Man-er stream, small rocky stream next to rubber plantation
YCM0321. Luosuo River, fast flowing
YCM0322. Pond (island for gibbons, *Hylobates leucogenys*), XTBG
YCM0324. Pool near power station, XTBG
YCM0325. Ganlanba, Lanchangjiang, fast flowing, sandy bank
YCM0326a. Lanchangjiang, 24 km from Jinghong, exposed rock pools on huge boulders, 5 meters above river surface
YCM0326b. Standing pools beside Lanchangjiang, near to YCM0326a
YCM0327. Jinghong, Banna National Park, 850m, small forest stream
YCM0328. Jinghong, Banna National Park, wet boulders near stream
YCM0329. Jinghong, small sandy stream on road to Banna National Park, 777m
YCM0332. DALI. Cangshan, Seven Dragon Daughter Waterfall, pool below the fall. 2400 m

Appendix 4. List of aquatic Coleoptera collected from Xishuangbanna (Identifications kindly provided by Drs. M. Balke, M. A. Jäch, , A. Komarek, P. Mazzoldi, S. Schödl, H. V. Shaverdo).

Family Dryopidae: *Elmomorphus dentipes* Kodada & Jäch*, E. paramontanus* Kodada & Jäch, *Elmomorphus* sp.

Family Dytiscidae: *Cybister posticus* Aube, *Eretes sticticus* (Linnaeus)*, Hydaticus sp., Hydroglyphus flammulatus* (Sharp)*, Hyphydrus* spp.*, Ilybius* sp.*, Laccophilus* sp.*, Microdytes* sp., *Nebrioporus cf melanogrammus* (Régimbart)*, Neptosternus cf. hydaticoides* Régimbart, *Platambus lineatus* Schwendtner, *Platambus* sp., *Platynectes* sp., *Rhantus suturalis* (MacLeay).

Family Elmidae: *Grouvellinus* sp., *Graphelmis clermonti* (Pic), *Indosolus* sp., *Leptelmis* sp., *Laorina* sp., *Stenelmis* sp., *Zaitzevia* sp., species in Macronychini

Family Gyrinidae: *Orectochilus helferi* Ochs, *O. apicalis subapicalis* Ochs, *O. oblongiusculus hoabinhensis* Ochs, *O. cribratellus cribratellus* Régimbart, *O. landaisi* Régimbart.

Family Hydroscaphidae: *Hydroscaphia* sp.

Family Hydrophilidae: *Amphiops* sp.*, Coelostoma* sp.*, Crenitis shaanxiensis* Ji & Komarek, *Enochrus* sp.*, Helochares* sp.*, Hydrocassis baoshanensis* Schöld & Ji*, H. uncinata* Ji & Schödl *, Hydrophilomima jaechi* Hansen & Schödl*, Hydrophilus* sp.*, Pelthydrus incognitus* Schönmann*, P. madli* Schönmann, *P. nepalensis* Schönmann*, P. vitalisi* d'Orchympnt, *P.* cf *vitalisi, P. dudgeoni* Schönmann*, P. minutus* d'Orchymont*, Pelthydrus* sp.*, Sphaerius* sp.*, Sternolophus* sp.

Family Hydraenidae: *Hydraena* spp.

Family Limnichidae: *Bryrrhinus* spp.*, Limnichus* spp.

Family Noteridae: *Canthydrus* sp.*, Neohydrocoptus subvittulus* (Motschulsky)

Family Psephenidae: larvae

Family Ptilodactylidae: larvae