

**AQUATIC BEETLES OF THE FAMILIES DRYOPIDAE AND
ELMIDAE (INSECTA: COLEOPTERA: BYRRHOIDEA)
OF THAILAND: ANNOTATED LIST AND
ILLUSTRATED KEY TO GENERA**

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ABSTRACT

Over the past two decades, Thailand has been surveyed extensively for its fauna of aquatic insects, including the beetle families Dryopidae and Elmidae, which are abundant in stream systems. Previously, nine genera were known from the country, all but one of which were re-collected: *Parahelichus*, *Stenomystax* (Dryopidae); *Ancyronyx*, *Aulacosolus*, *Dryopomorphus*, *Graphelmis*, *Macronevia*, *Macronychus*, *Pseudamophilus* (Elmidae). Here we add 13 genera not previously recorded from Thailand (*Dryops*, *Elmomorphus*, *Helichus*, *Pachyparnus*, [Dryopidae]; *Grouvellinus*, *Indosolus*, *Leptelmis*, *Ordobrevia*, *Potamophilinus*, *Stenelmis*, *Urumaelmis*, *Zaitzevia*, *Zaitzeviaria* [Elmidae]) and provide an annotated list and illustrated key to the genera. Additional information is provided to guide new work with Dryopidae and Elmidae in Thailand.

Keywords: Coleoptera, Dryopidae, Elmidae, Thailand, aquatic, taxonomic keys, checklist

INTRODUCTION

Thailand is a topographically and ecologically diverse country. Its many mountain ranges and high rainfall average of 240 cm/yr (ARBHABHIRAMA *ET AL.*, 1988) give rise to a multitude of streams and rivers. These streams and rivers support diverse lotic communities, especially of insects. Thai aquatic insects have been studied taxonomically across most orders including Ephemeroptera (UÉNO, 1961; GOSE, 1969; SITES *ET AL.*, 2001; BOONSOONG & BRAASCH, 2013), Odonata (FERRO & SITES, 2006; BOONSOONG & CHAINTHONG, 2014) Plecoptera (STARK & SIVEC, 2005; SIVEC & STARK, 2010), Heteroptera (SITES *ET AL.*, 1997; VITHEEPRADIT *ET AL.*, 2003; SITES 2005; SITES & ZETTEL, 2005; ZETTEL, 2005; VITHEEPRADIT & SITES, 2006), Coleoptera (SHEPARD 2003; SHORT & SWANSON, 2005), Diptera (PHASUK *ET AL.*, 2004; RATTANARITHIKUL *ET AL.*, 2005; ROZKOSNY & COURTNEY, 2005; JACOBSON *ET AL.*, 2006), and Trichoptera (MALICKY & CHANTARAMONGKOL, 2003; MALICKY *ET AL.*, 2004, THAPANYA *ET AL.*, 2004; MALICKY *ET AL.*, 2005, THAMSENANUPAP *ET AL.*, 2005; THAWARORIT *ET AL.*, 2013). Although a substantial amount of work on the aquatic insect fauna has been conducted, this rich fauna is far from being well understood. The growing knowledge of the aquatic insect fauna has begun to enable water quality assessments in Thai streams using aquatic insects (e.g. BATZER, 1995; MUSTOW, 1999,

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2002; MORSE *ET AL.*, 2007; BOONSOONG *ET AL.*, 2009, 2010; THANEE & PHALARAKSH, 2008, 2012; YOUPROM *ET AL.*, 2013). Aquatic insects have even been useful in understanding the impacts of the 2004 tsunami (CRANSTON, 2007; SITES & VITHEEPRAKIT, 2010).

Dryopidae and Elmidae are two closely related families in the Coleoptera superfamily Byrrhoidea. Both families are common in Thailand in shallow flowing water such as streams, rivers, and waterfalls. Dryopidae also includes some genera that are found in still waters such as ponds, pools, and rice paddies. Some genera of Dryopidae from countries other than Thailand (e.g. India and Malaysia) are terrestrial and found in forest leaf litter. The larvae of Elmidae are aquatic and often co-occur with adults, whereas the larvae of Dryopidae are terrestrial and found in the soil. Pupation in both families is on land. Elmid larvae crawl out of the water and pupate under moss, wood, rocks, etc., on the shore. Aquatic stages of both families consume organic matter such as algae, fungal hyphae, and rotting wood. Most elmids are collector/scrapers whereas a few elmids and dryopids are gougers and chew rotting wood. The few studies of life spans indicate that adults of both families may be long-lived and live for more than one year (BARR & SPANGLER, 1992). Larvae typically live one to two years. Pupae usually are present for only a few weeks before transforming to adults. Newly emerged adults have a brief terrestrial phase during which they may fly to new habitats during both day and night. At this time they are abundantly collected at lights at night. After returning to aquatic habitats, adults of both families begin mating and oviposition. Most adults do not leave the water once they have entered it. However, some adult dryopids, such as *Dryops* and *Pachyparnus*, and some adult Elmidae, such as *Potamophilinus*, can exit the water and fly to new habitats. Excellent reviews of the biology of dryopids and elmids were provided by BROWN (1987) and ELLIOT (2008).

Because the adults are long-lived, they can be collected throughout the year. Better collecting is usually during periods of dry weather when the flow of streams and rivers is low. This concentrates the specimens into preferred habitats, thereby making collecting more efficient and safer. Collecting mostly involves disturbing appropriate substrates immediately upstream of a net. Elmids and dryopids then drift with the current into the net. Specimens on larger pieces of wood require removing the wood from the water and manually picking specimens from the wood, or the wood can be brushed underwater with a stiff-bristle brush, which dislodges specimens that then drift into the net. Collecting adults can also be accomplished with lights at night for either newly transformed adult dryopids and elmids or for dryopids that live in still waters. More specimens and greater diversity of elmids and dryopids can be collected in streams with less anthropogenic disturbance and more microhabitats. The best collecting is where clean water flows swiftly over boulders and into riffles with gravel substrates, submerged wood and leaf packs (Fig. 1).

Identification of Thai dryopids and elmids generally is restricted to the generic level. Species level identifications are possible only in some cases because basic research is lacking. In Thailand very few elmid larvae have been associated with adults; thus, most larvae cannot be determined to genus. Some genera occurring in Thailand (e.g. *Ancyronyx*, *Macronychus*, *Ordobrevia*, *Stenelmis*, *Zaitzevia*) have larvae described from other zoogeographic areas, so their generic identities can be determined. Molecular techniques have enabled the identification of the larvae of *Hedyselmis* (ČIAMPOR & RIBERA, 2006).

Families of Byrrhoidea (Dryopidae, Elmidae, Psephenidae) have a history of being used in water quality assessment studies because of their long life in streams and their differing susceptibilities to various pollutants, such as surfactants, acids, and fine sediments, at both

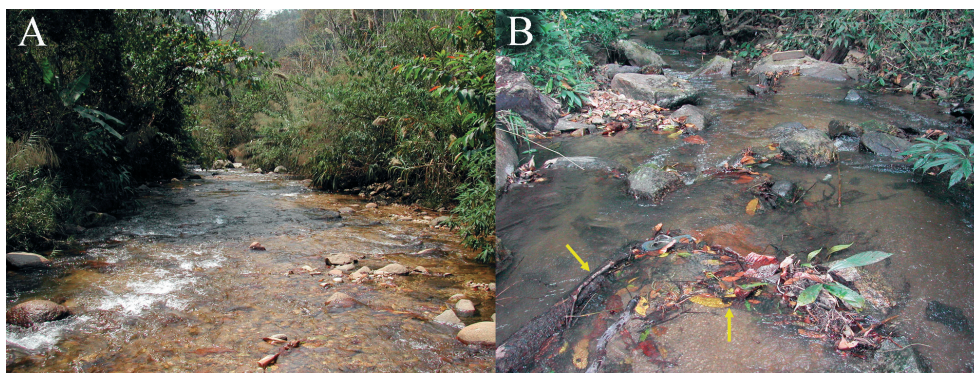


Figure 1. Habitats of adult Dryopidae and Elmidae in Thailand: (A) gravel riffles at the Fang Horticulture Station, (B) submerged wood and leaf packs (yellow arrows) in the stream at Namtok Monthathan, Doi Suthep.

the generic and specific level. Also detrimental to populations of dryopids and elmids are increasing water temperatures through both physiological influences and reduction of dissolved oxygen in the water. Dams on streams and rivers impound water, which increases depth and stillness and influences water chemistry both above and below the dam. Agricultural practices often extract water from streams or rivers, which invariably produces many negative effects. More specifically, extraction reduces flow, produces standing water in the form of flooded fields (which increases siltation, raises water temperature, lowers dissolved oxygen) and introduces agricultural chemicals including fertilizers, insecticides, herbicides, and acids. Logging opens the canopies that provide shade for streams and rivers, which increases temperatures, lowers dissolved oxygen, reduces organic matter input, and increases siltation. Mining activity increases siltation and introduces many different pollutants including acids and heavy metals. To the extent possible, conservation efforts should seek to minimize these anthropogenic activities to protect healthy lotic communities and Thailand's amazingly rich and largely undocumented aquatic insect fauna.

It is our hope that in beginning to describe the Thai aquatic Byrrhoidea fauna we will start to make this important group of insects more useful for future studies and to stimulate interest in developing student projects. This paper was designed to guide people with a growing interest in aquatic byrrhoid beetles and those beginning to use aquatic macroinvertebrates for water quality assessment. Herein we provide a checklist of all taxa of Dryopidae and Elmidae currently known from Thailand, illustrated dichotomous keys to genus, an annotated list of the Thai taxa with notes on aspects of their biology and distribution, and a list of additional taxa likely to occur in Thailand.

METHODS

Field Collections

Collections were conducted during February through April 1994 by WDS in the northern provinces. Extensive collecting by RWS since 1995 initially emphasized southern provinces

but has now covered many provinces throughout all regions of Thailand. Collecting has included sites in national parks, wildlife sanctuaries and wildlife management stations, all with permission. Additional collecting was conducted where roads crossed waterways and parking was available. Collecting emphasized lotic (stream) habitats and was usually by means of standard aquatic nets and manual inspection of substrates. In addition, some light-trap collections were made. In streams, the substrate was kick-sampled, allowing the current to carry organic debris, including insects, into the net. Along stream margins and in ponds, vegetation was vigorously swept with the net. Rocks and wood were lifted from the streams and manually examined. Insects were preserved in ethyl alcohol (70–95%) and transported to the laboratory for sorting and identification. In addition to collections by WDS and RWS, many specimens referenced here were collected by others while conducting various other projects.

Identifications

Our identifications generally were restricted to the generic level because many undescribed taxa exist and keys to species are either inadequate or lacking. Although specific identifications were not feasible, we could discern different and consistent “morphospecies.” All figures presented here are of specimens collected in Thailand.

Many genera such as *Elmomorphus*, *Helichus* (Dryopidae), *Stenelmis*, *Zaitzevia*, and *Zaitzeviaria* (Elmidae) are in need of revision and some are of uncertain phylogenetic status, making their generic identifications tenuous. Some are difficult to identify because of their small size (<1.5 mm) or slight morphological differences. Elmidae contains currently recognized subfamilies, tribes, and other suprageneric taxa; however, here we present only subfamilies. Dryopidae currently does not have any described subfamilies and tribes.

Very few elmid larvae can be identified to the generic level. This can be a problem because larvae are abundant in benthic collections. The inability to identify larvae to genus greatly reduces the information available to taxonomists, ecologists, and water quality assessors. A simple method to obtain generic identifications of larvae is to collect live last larval instars and rear them through pupation to adults (see WHITE & JENNINGS, 1973; GLAISTER, 1985). Live last larval instars are put in a small container with moist sand and a small rock or piece of wood. When ready, the larvae will crawl under the rock or wood, construct a pupal chamber and pupate. After approximately two weeks the adults will emerge from the pupae. The teneral adults require approximately one week for the cuticle to become fully sclerotized, after which they can be killed, prepared for the museum collection, and identified. Associating the identified adults with the unknown larval stage will enable the identification of larvae, and when enough of the adults have been reared in this way taxonomic keys to the larvae can be prepared. This would be a valuable advancement for our understanding of the Thai fauna.

In stream collections, most adult beetles are members of the families Dryopidae or Elmidae; however, they are seldom noticed because they can be exceedingly small. All adult Dryopidae have antennae in which the distal antennomeres form a loose club that is unilaterally pectinate. Adult Elmidae are more difficult to characterize morphologically; most have elongate filiform antennae, various body surfaces covered with a plastron (mat of fine setae holding a film of air), and large pretarsal claws. Viewing the habitus photographs in this paper will help build a “search image” of adult Dryopidae and Elmidae.

Collections were conducted over many years by many people and groups. In the Material examined sections of the Annotated List of the Genera, samples collected by CMU and UMC teams refer to Chiang Mai University and University of Missouri-Columbia students,

respectively. Elevation is given as meters (m) or feet (f) above sea level. Photographs of most collection sites identified as L-numbers are available in a Locality Image Database via a link from the internet site of the Enns Entomology Museum, University of Missouri. Specimen numbers and repositories are given for each sample. Voucher specimens for all genera will be deposited in each institutional collection below; extralimital representatives will be included for uncommonly collected genera. Voucher numbers for DNP and THNHM are given in the Material examined sections; the other museums do not assign numbers to vouchers.

Museum and Collection Abbreviations

- DNP: Department of National Parks, Wildlife and Plant Conservation (Bangkok, Thailand)
 EMEC: Essig Museum of Entomology, University of California (Berkeley, USA)
 KUEC: Faculty of Agriculture, Kasetsart University (Bangkok, Thailand)
 THNHM: Natural History Museum, National Science Museum (Pathum Thani, Thailand)
 UMC: University of Missouri (Columbia, USA)

RESULTS

We have examined numerous specimens representing many more taxa than would be expected based on the literature and anticipate additional genera and species will be collected with further studies. Based on our specimens and the literature, 6 genera of Dryopidae and 16 of Elmidae are now known from Thailand (Table 1). Of these, 4 dryopid and 9 elmid genera are recorded from Thailand for the first time. Distribution maps (Figs. 13, 39) were created from Google maps. Collections on multiple dates from the same locality are not indicated on the maps, although specific data for all collections are given in the Material examined sections of the Annotated List of the Genera.

Table 1. Checklist of taxa of Dryopidae and Elmidae known from Thailand.

Dryopidae

- Dryops* Oliver 1791*
Elmomorphus Sharp 1888*
 bryanti Hinton 1935*
 prosternalis Hinton 1935*
Helichus Erichson 1847*
Pachyparnus Fairmaire 1888*
 tonkineus Fairmaire 1888*
Parahelichus Bollow 1940
 pseudogranulosus Lujková, Degma & Kodada 2014
Stenomystax Kodada, Jäch & Čiampor 2003
 kubani Kodada, Jäch & Čiampor 2003

Elmidae

Elminae

- Ancyronyx* Erichson 1847

- acaroides* Grouvelle 1896*
malickyi Jäch 1994
Aulacosolus Jäch & Boukal 1997
carinatus Jäch & Boukal 1997
scida Jäch & Boukal 1997
spinosus Jäch & Boukal 1997
tenuior Jäch & Boukal 1997
Graphelmis Delève 1968
ambigua Delève 1970
boukali Čiampor 2004
clermonti (Pic 1923)
jaechi Čiampor 2001
jendeki Čiampor & Kodada 2004
picta (Reitter 1886)
sausi Čiampor 2004
Grouvellinus Champion 1923*
Indosolus Bollow 1940*
Leptelmis Sharp 1888*
 nr. *tawitawiensis* Delève 1973*
Macronevia Jäch & Boukal 1996
 simplex (Hinton 1936)
Macronychus Müller 1806
 indicus Hinton 1940
 ultimus Čiampor & Kodada 1998
Ordobrevia Sanderson 1953*
 constricta Delève 1968*
Pseudamophilus Bollow 1940
 davidi Kodada 1992
Stenelmis Dufour 1835*
 seres Hinton 1941*
Urumaelmis Satô 1963*
Zaitzevia Champion 1923*
Zaitzeviaria Nomura 1959*

Larainae

- Dryopomorphus* Hinton 1936
 bishopi Hinton 1971*
 siamensis Kodada 1993
Potamophilinus Grouvelle 1896*
 longipes (Grouvelle 1892)*

* New country records

Family **Dryopidae** Billberg 1820

Aquatic dryopids usually are associated with accumulations of organic matter, such as leaf packs and submerged wood, or the roots of riparian vegetation. Some occur in the stream substrate if organic matter is trapped below large rocks. Dryopids often are present in large numbers on or in suitable microhabitats. Larvae occur in terrestrial in riparian substrates; pupation also occurs in riparian substrates. Larvae live one to two years and adults live for an unknown number of years in the field, but have been maintained in the laboratory for more than a year (BARR & SPANGLER, 1992).

In many tropical areas of the world (e.g. Malaysia) are terrestrial genera that live in forest leaf litter. They can be collected by sifting leaf litter or by using light traps. We anticipate that some will be found in Thailand eventually.

Key to the Genera of Adult Dryopidae of Thailand

- | | | |
|-------|---|---------------------|
| 1 | Pronotum with a complete sublateral longitudinal sulcus on each side (Fig. 2) | <i>Dryops</i> |
| 1' | Pronotum without sublateral sulcus..... | 2 |
| 2(1') | Dorsal surface mostly shiny; elytra usually with sparse setation and lateral bands of plastron (Figs. 3, 7)..... | 3 |
| 2' | Dorsal surface mostly dull; elytra densely covered with setae and without plastron (Figs. 4–6)..... | 4 |
| 3(2) | Second antennomere strongly enlarged and triangular, covering remaining antennomeres (Fig. 9); eye with long, erect ocular setae | <i>Stenomystax</i> |
| 3' | Second antennomere small, not covering remaining antennomeres (Fig. 8); eye without long, erect ocular setae | <i>Elmomorphus</i> |
| 4(2') | Last abdominal sternite not as pubescent as anterior sternites (Fig. 10) | <i>Helichus</i> |
| 4' | Last abdominal sternite as pubescent as anterior sternites | 5 |
| 5(4') | Eyes with long, erect ocular setae (Fig. 11); dorsal surface of body covered with two types of setae, long erect setae and short recumbent setae (Fig. 5); last labial palpomere without lateral sensory area (Fig. 11) | <i>Pachyparnus</i> |
| 5' | Eyes without long erect ocular setae (Fig. 12); dorsal surface of body mainly bare, only scattered long erect setae present (Fig. 6); last labial palpomere with elongate tear-drop shaped lateral sensory area (Fig. 12) | <i>Parahelichus</i> |

Annotated list of the Genera of Adult Dryopidae of Thailand

Genus *Dryops* Oliver 1791

(Figs. 2, 13A)

Discussion: *Dryops* is cosmopolitan in distribution and currently comprises 79 species. It is in need of revisionary study and the species are externally monomorphic. Although no species have been reported specifically from Thailand, some of the species with a Palearctic distribution may occur in the country. We have examined one morphospecies from Mae Hong Son Province. *Dryops* can be recognized by a complete sublateral sulcus on each side of the pronotum (Fig. 2).

Material examined: Mae Hong Son Province: Amphoe Khun Yuam, Tambon Khun, Yuam, Huay Mae Surin at Ban Mae Surin, 18°54.588'N 97°56.695'E, 408 m, stream, 20 April 2009, Sites, Vitheepadit, & Prommi, L-1050 (3 EMEC, 3 UMC).

Genus *Elmomorphus* Sharp 1888

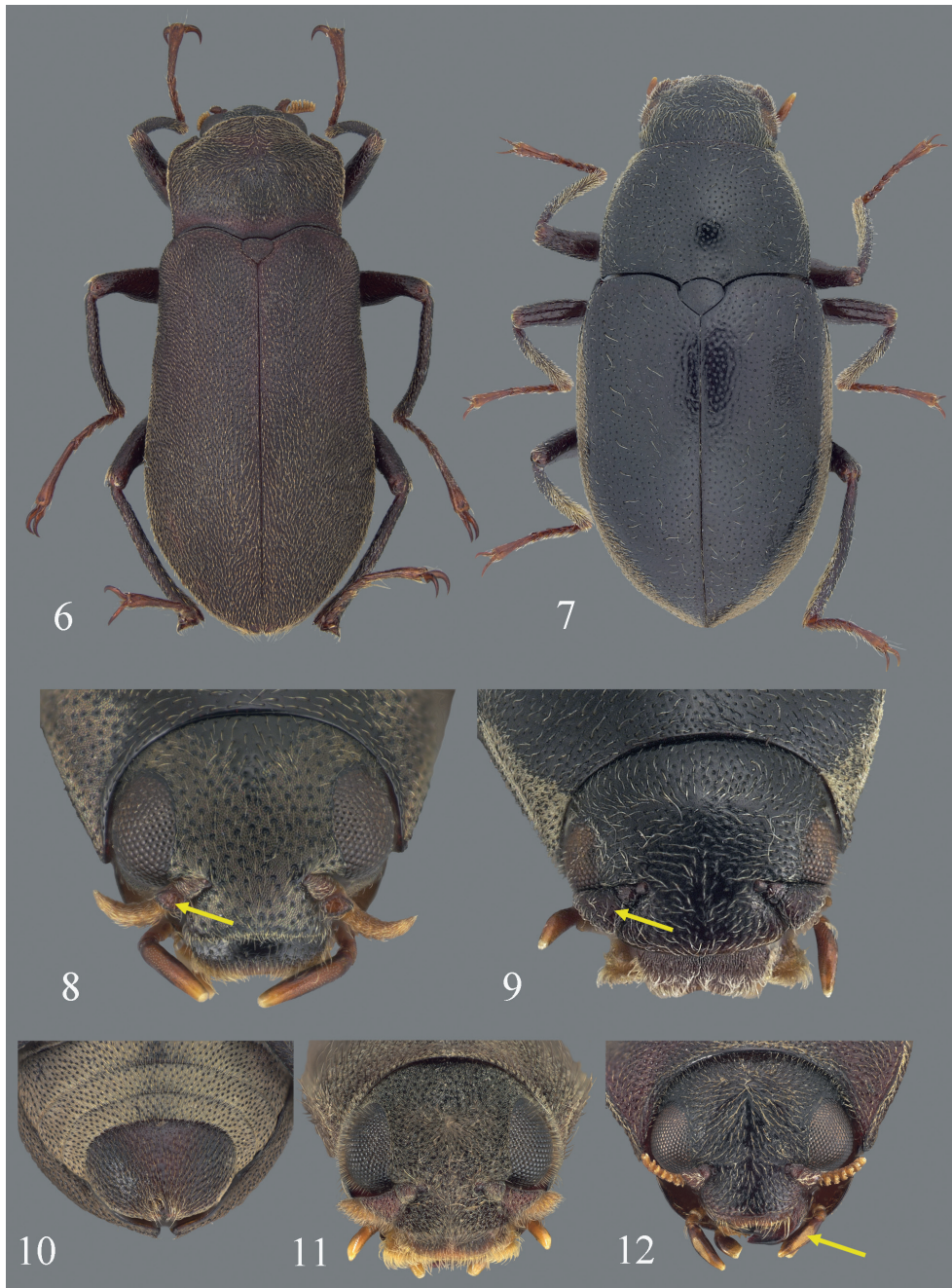
(Figs. 3, 8, 13B)

Discussion: *Elmomorphus* is a moderately-sized genus with 16 species and is distributed mainly in Malaysia; however, two species have been reported from Japan. The genus is currently being revised by Jan Kodada (Comenius University, Slovakia). No species have been reported from Thailand, although we have examined many morphospecies from 29 provinces. *Elmomorphus* is especially common in leaf packs and occurs throughout Thailand in suitable habitats. It can be recognized by a shiny dorsal surface and plastron laterally on the elytra, and the second antennomere is not enlarged (Fig. 8).

Material examined: Chaityaphum Province: Phu Kiew WS, Lam Nam Prom, 16°27.717'N 101°39.303'E, 589 m, 2 May 2004, A. Vitheepadit, L-656 (1 UMC). **Chanthaburi Province:** Khao Soi Dao Wildlife Sanctuary, stream from Namtok (waterfall or cascade) Khao Soi Dao, 13°5.810'N 102°10.332'E, 523 m, 17 January 2016, R.W. Sites, L-1911 (10 UMC). **Chiang Mai Province:** Amphoe Mae Chaem, Mae Pan, 18°31'N 98°23'E, 540 m, 3 April 2003, UMC and CMU teams, L-444 (5 KUEC, 5 DNP-13777, 5 THNHM-I-1250–1254, 8 EMEC, 32 UMC); Amphoe Doi Saket, Nam Kuang, 19°00.015'N 99°17.163'E, 554 m, 15 V 2004, Vitheepadit & Prommi, L-689 (2 UMC); Doi Inthanon National Park, Huay Sai, Luang Waterfall, 18°31'N 98°27'E, 1060 m, 4 April 2002, UMC & CMU teams, L-322, (1 UMC); same data except 3 April 2003, L-443 (1 UMC); Doi Inthanon National Park, stream from Huay Sai Luang Waterfall, 18°31'N 98°27'E, 1060 m, 3 March 2002, Vitheepadit, Kirawanich, L-254 (1 UMC); same data except 20 March 2002, R.W. Sites, L-312 (4 UMC); Doi Inthanon National Park, Mae Klang at Ban Khun Klang, 18°31.259'N 98°31.310'E, 1296 m, 18 May 2004, Vitheepadit, Prommi, Laudee, Thamsenanupap, L-694 (4 UMC); Doi Inthanon National Park, Namtok Mae Klang, 18°29'N 98°40'E, 415 m, 4 March 2002, Vitheepadit, Kirawanich, L-260 (1 UMC); same data except 3 April 2002, UMC and CMU teams, L-320 (1 UMC); Doi Inthanon National Park, Mae Pan Noi at Ban San Pathana, bedrock stream, 18°31'N 98°25'E, 750 m, 4 January 2003, CMU team (4 UMC); same data except 4 April 2003, UMC and CMU teams, L-446 (65 UMC); Doi Inthanon National Pk, 543 m, Mae Klang River at Sob Ab Waterfall, 18°31'N 98°36'E, 3 April 2002, UMC & CMU teams, L-318 (4 UMC); same data except 2 April 2003, L-435 (4 UMC); same data except 17 May 2004, Vitheepadit, Prommi, Laudee, Thamsenanupap, L-691 (1 UMC); Doi Inthanon National Park, Namtok Sob Ab, 18°31'N 98°36'E, 4 March 2002, Vitheepadit, Kirawanich, L-258 (53 UMC); same data except 3 April 2002, UMC and CMU teams, L-319 (8 UMC); same data except 8 May 2002, L-398 (5 UMC); same data except 2 April 2003, L-436 (5 KUEC, 5 DNP-13777, 5 THNHM-I-1255–1259, 48 UMC); same data except 2 May 2003, L-495 (76 UMC); same data except 17 May 2004, Vitheepadit



Figures 2–5. Dorsal habitus of genera of Dryopidae. (2) *Dryops*, (3) *Elmomorphus*, (4) *Helichus*, and (5) *Pachyparnus*. Arrow indicates sublateral sulcus.



Figures 6–12. Dryopidae. Dorsal habitus of (6) *Parahelichus* and (7) *Stenomystax*. Dorsal surface of head of (8) *Elmomorphus* and (9) *Stenomystax* (arrow indicates second antennomere). (10) Terminal abdominal sterna of *Helichus*. Dorsal surface of head of (11) *Pachyparnus* and (12) *Parahelichus* (arrow indicates lateral sensory area of labial palp).

& Prommi, L-690 (13 UMC); Doi Inthanon National Park, Nam Mae Aep above hwy 1009, 18°32'N 98°32'E, 630 m, 13 March 2002, P. Thamsenanupap (7 UMC); same data except 5 October 2002, (41 UMC); same data except 15 October 2002 (65 UMC); same data except 15 December 2002 (15 UMC); same data except 15 February 2003 (5 UMC); Doi Inthanon National Park, Siriphum Waterfall, 18°32'N 98°31'E, 1380 m, 26 June 2002, R.W. Sites, L-412 (11 UMC); same data except 2 March 2002, Vitheepradit, Kirawanich, L-251 (1 EMEC, 15 UMC); same data except (upper), L-249 (6 EMEC); Doi Inthanon National Park, Siriphum Waterfall, level 2, 1460 m, 18°32'N 98°31'E, 21 March 2002, Sites, Vitheepradit, Kirawanich, L-314 (17 UMC); same data except L-315 (1 UMC); same data except UMC & CMU teams, L-317 (2 UMC); same data except 3 April 2003, L-441 (33 UMC); same data except 2 March 2002, D. Tapanya (44 UMC); same data except Siriphum Waterfall at Ban Khun Klang, 15 November 2001, R.W. Sites, L-248 (1 EMEC); Doi Suthep National Park, Namtok Monthathan, 18°49'N 98°55'E, 700 m, 8 April 2002, UMC and CMU teams, L-330 (4 UMC); same data except 29 March 2003, L-427 (5 UMC); same data except 6 June 2002, P. Thamsenanupap (2 UMC); same data except immid. below Monthathan Falls, 690 m, 15 March 2002, R.W. Sites, L-296 (1 UMC); Doi Suthep Pui National Park, creek from Namtok Mohk Fah, 19°06'N 98°46'E, 600 m, 18 March 2002, CMU team (3 UMC); same data except 564 m, 18 March 2002, Sites, Vitheepradit, Kirawanich, L-304 (1 UMC); same data except 25 March 2003, Sites, Vitheepradit, Prommi, L-415 (6 UMC); Doi Suthep National Park, Pa Ngerb, stream, 18°48'N 98°56'E, 530 m, 5 April 2002, UMC and CMU teams, L-325 (6 UMC); same data except 29 March 2003, L-426 (1 UMC); same data except 29 April 2003, Vitheepradit, Thamsenanupap, Ferro, L-490 (2 UMC); Doi Suthep National Park, Sai Yoi Waterfall, 18°48'N 98°55'E, 1100 m, 4 April 2003, Sites, Vitheepradit, Prommi, Setaphan, L-447 (5 UMC); same data except Huay Kaew, 14 March 2003, Thamsenanupap (7 EMEC); Creek at Chiang Dao Wildlife Research Center, 19°21'N 98°55'E, 520 m, 24 July 2002, CMU Team (4 UMC); same data except, 26 August 2002 (6 UMC); same data except 25 March 2003, Sites, Vitheepradit, Prommi, L-416 (32 UMC); same data except 18 March 2002, Sites, Vitheepradit, Kirawanich, L-303 (3 UMC); Fang Horticulture Exp. Farm, Nam Mae Chai, 19°57'N 99°09'E, 600 m, 17 March 2002, Sites, Vitheepradit, Kirawanich, L-301 (28 UMC); same data except 26 March 2003, Sites, Vitheepradit, Prommi, L-419 (35 UMC). **Chiang Rai Province:** Doi Luang National Park, Namtok Poo Kaeng, 19°26'N 99°42'E, 540 m, 17 March 2002, Sites, Vitheepradit, Kirawanich, L-299 (3 UMC); stream from Khun Kon Waterfall, 19°51'N 99°39'E, 524 m, 19 April 2003, Vitheepradit, Prommi, Setaphan, L-466 (1 UMC). **Chumphon Province:** Amphoe Phato, Klong Tab Khon, 33.1 km NE int. Hwy 4 & 4006, 09°49'N 98°41'E, 47 m, 26 April 2002, Vitheepradit & Kirawanich, L-374 (1 UMC). **Kamphaeng Phet Province:** Mae Wong National Park, Kaeng Pa Nang Koi, 16°02'N 99°13'E, 7 April 2003, Sites, Vitheepradit, Prommi, Setaphan, L-451 (5 UMC); Khlong Klund, 20 October 2002, CMU team (1 EMEC); Khlong Lan National Park, Phetcha Khor Waterfall, 16°17'N 99°14'E, 7 April 2003, Sites, Vitheepradit, Prommi, Setaphan, L-452 (2 UMC); Khlong Lan National Park, stream at Namtok Klong Lan, 16°07'N 99°16'E, 8 March 2002, Vitheepradit, Kirawanich, Sites, L-272 (3 UMC); same data except Namtok Khlong Lan, 7 April 2003, Sites, Vitheepradit, Prommi, Setaphan, L-453 (4 UMC); same data except 6 April 2003, CMU team (1 UMC); same data except 19 July 2002 (1 UMC); same data except 21 August 2002 (2 UMC); same data except 7 March 2002, mercury vapor light, Vitheepradit, Kirawanich, Sites, L-271 (3 UMC). **Kanchanaburi Province:** Amphoe Sai Yok, Thong Pha Phum Forest Restoration Station, Mae Nam Noi, 14°31'N 98°37'E, 204 m, 12 April 2002, UMC and CMU teams, L-335 (16 UMC); same data except 10 April 2003, L-462 (5 KUEC, 5 DNP-13777, 5 THNHM-I-1260–1264, 82 UMC); Amphoe Thong Pha Phum, Huay Pak Kog, 14°39'N 98°32'E, 184 m, gravel stream, 12 April 2002, UMC and CMU teams, L-336 (2 UMC); same data except 8 April 2003, Sites, Vitheepradit, Prommi, Setaphan, L-455 (2 UMC); Amphoe Thong Pha Phum Huay Khayeng at Ban Padsadoo, Klang, 14°33'N 98°34'E, 296 m, stream, 9 April 2003, Sites, Vitheepradit, Prommi, Setaphan, L-457 (1 UMC); same data except CMU Team (1 UMC); same data except 26 May 2003, Vitheepradit & Prommi, L-717 (14 UMC); Amphoe Thong Pha Phum, Huay Ou Long, stream, 14°46'N 98°40'E, 139 m, 12 May 2003 Vitheepradit, Prommi, Ferro, L-525 (5 UMC); same data except 14°46.993'N 98°40.258'E, 123 m, Vitheepradit, L-919 (14 UMC);

Amphoe Sangkhla Buri, Huay Song Ka Lia, 15°13'N 98°26'E, gravel strrm, 13 IV 2002, 204 m, UMC and CMU teams, L-340 (2 UMC); Amphoe Sangkhla Buri, Huay Li Jia, gravel stream, 15°04'N 98°33'E, 169 m, 13 April 2002, UMC and CMU teams, L-338 (4 UMC); same data except 5 June 2006, Vitheepradit, L-917 (4 UMC); Gruengkravai Forest Garden, 14°35'N 98°35'E, 24-25 February 2002, black light trap (5 KUEC, 5 DNP-13777, 5 THNHM-I-1265-1269, 86 UMC). **Lampang Province:** Jae Sawn National Park, Namtok Jae Sawn, 18°50'N 99°28'E, 650 m, 16 March 2002, R.W. Sites, L-297 (2 EMEC, 4 UMC); same data except 27 March 2003, Sites, Vitheepradit, Prommi, L-421 (10 UMC). **Loei Province:** Phu Rua National Park, 10 June 1998, Sites, Simpson, Vitheepradit, black light at Park HQ, L-178 (1 EMEC); Na Haew National Park, Namtok Wahng Tahd, 750 m, 17°28'N 100°57'E, 9 March 2002, Vitheepradit, Kirawanich, Sites, rock face, L-277 (3 UMC); same data except 8 March 2002, CMU Team (18 UMC); Na Haew National Park, stream below Tahd Heuang Intl. Waterfall, 17°33'N 100°59'E, 500 m, 10 March 2002, Sites, Vitheepradit, Kirawanich, L-279 (4 UMC); Na Haew National Park, Tahd Heuang Intl. Waterfall, 17°33'N 100°59'E, rootmats above waterfall, 500m, 10 March 2002, R.W. Sites, L-282 (3 UMC); Phu Hin Rongkhla National Parak, Namtok Man Daeng, tier 3, 18°57'N 101°03'E, 1300 m, 11 March 2002, G.W. Courtney (1 EMEC). **Mae Hong Son Province:** Namtok Mae Surin National Park, Mae Nam Pai, 19°21'N 97°59'E, 310 m, 19 March 2002, R.W. Sites, L-307 (3 UMC); same data except mercury vapor light, Sites, Vitheepradit, Kirawanich, L-308 (6 EMEC, 23 UMC); Namtok Maw Pang 19°22'N 98°22'E, 850 m, 19 March 2002, Sites, Vitheepradit, Kirawanich, L-305 (12 UMC); same data except 31 March 2003, UMC and CMU teams, L-428 (1 UMC); Amphoe Pang Mapha, Nam Khong, 19°32'N 98°06'E, 349 m, 31 March 2003, UMC and CMU teams, L-429 (5 UMC); Amphoe Pang Mapha, Soppong River behind resort, 648 m, 19°31.159'N 98°14.844'E, 18 April 2009, Sites, Vitheepradit, Prommi, L-1046 (2 UMC); Huay Pha, 18 km N Mae Hong Son, 19°25'N 97°59'E, 340 m, 31 March 2003, UMC and CMU teams, L-430 (3 KUEC, 3 DNP-13777, 3 THNHM-I-1270-1272, 16 UMC); Tham Pla-Pha Seu National Park, Pha Seu Waterfall, 19°29'N 97°57'E, 415 m, 1 April 2003, UMC and CMU teams, L-432 (16 UMC). **Nakhon Si Thammarat Province:** Lan Sa Ka, Klong Wang Tai, stream, 08°21'N 99°44'E, 80 m, 27 May 2005, Sites, Vitheepradit, Prommi, L-803 (1 UMC); Tumbon Krung Ching, Klong Krai, 08°47.387'N 99°38.695'E, 80 m, 18 June 2004, Sites, Vitheepradit, & Prommi, L-779 (1 UMC); Nopphitam, Ban Pitam, gravel stream 10.7 km NW int. 4140 × 4186, 08°47'N 99°41'E, 127 m, 30 April 2002, Vitheepradit & Kirawanich, L-384 (1 UMC); Namtok Yong National Park, Yong Waterfall, 08°10.372'N 99°44.502'E, 117 m, 5 June 2004, Vitheepradit & Prommi, L-743 (3 UMC); Khao Luang National Park, Ka Rome Waterfall, 157 m, 6 June 2004, 08°22.428'N 99°44.155'E, Vitheepradit & Prommi, L-747 (1 UMC); same data except 26 May 2005, L-799 (1 UMC). **Nan Province:** Tak Man Waterfall, 19°17'N 100°47'E, 352 m, 21 April 2003, Vitheepradit, Prommi, Setaphan, L-471 (3 UMC); Amphoe Bo Kluea, Tambon Phufa Doi Phuka Park Ranger Station 6, Huay Korg, 19°01'N 101°11'E, 516 m, stream, 22 April 2003, Vitheepradit, Prommi, Setaphan, L-474 (8 UMC); Sa Pan Waterfall, 532 m, 19°11'N 101°11'E, 22 April 2003, Vitheepradit, Prommi, Setaphan, L-475 (8 UMC); Doi Phuka National Park, Namtok Ton Tong, 19°12'N 101°04'E, 900 m, 13 March 2002, R.W. Sites, L-291 (1 EMEC, 14 UMC); Doi Phuka National Park, Namtok Sila Phet, 19°05'N 100°56'E, 400 m, 13 March 2002, Sites, Vitheepradit, Kirawanich, L-292 (7 UMC); Doi Phuka National Park, Namtok Ton Thong, 19°12'N 101°04'E, 900 m, 21 April 2003, Vitheepradit, Prommi, Setaphan, L-472 (6 UMC); Mae Charim National Park, Nam Wa River, 18°36'N 100°59'E, 335 m, 13 March 2002, Sites, Vitheepradit, Kirawanich, L-293 (3 UMC). **Phatthalung Province:** Mom Jui Waterfall, 4 km W of Tamote Village, 11 July 1997, Sites & Permkam, rocky stream, L-134 (1 EMEC); Royal Thai Dept. Agric. Propagation Ctr, ca. 3 km E of Khao Chong Wild. Mgt. Stn., 11 July 1997, Sites & Permkam, stream w/ algae covered rocks, L-136 (1 UMC). **Phayao Province:** Doi Luang National Park, Namtok Cham Pa Thong, 19°13'N 99°44'E, 620 m, 17 March 2002, Sites, Vitheepradit, Kirawanich, L-300 (3 UMC); same data except 23 July 2002, CMU Team (1 UMC); Heuy Chom Poo W. Sanc. Stn., Huay Chom Poo Falls, 19°10'N 100°06'E, 526 m, 20 April 2003, Vitheepradit, Prommi, Setaphan, L-468 (3 UMC). **Phetchabun Province:** Amphoe Mueang, Klong Neung, stream, 16°21.145'N 101°15.952'E, 152 m, 30 April 2004, A. Vitheepradit, L-652 (1 UMC); Khao Khor National Park, stream

from Tarntip Waterfall, 16°39.594'N 101°07.901'E, 182 m, 11 May 2004, Vitheepradit & Prommi, L-678 (1 UMC); Nam Nao National Park, Huay Prom Laeng, 16°38'N 101°34'E, 800 m, 9 March 2002, R.W. Sites, L-276 (1 UMC). **Phetchaburi Province:** Kaeng Ka Chan National Park, Pranburi stream at Ban Krang, 12°48.037'N 99°26.557'E, 380 m, 28 May 2004, Vitheepradit & Prommi, L-721 (4 UMC). **Phitsanulok Province:** Chat Trakan Waterfall, 9 June 1998, Sites, Simpson, Vitheepradit, spillway over rock, L-170 (1 EMEC, 2 UMC); Phu Hin Rongkla National Park, Namtok Huay Kameun Noi, 17 March 2003, CMU Team (1 UMC). **Phrae Province:** Stream from Cheung Thong Waterfall, 18°03.020'N 100°14.927'E, 259 m, 14 May 2004, Vitheepradit & Prommi, L-688 (10 UMC); Wieng Ko Sai National Park, Namtok Mae Koeng Luang, 17°58'N 99°35'E, 350 m, 14 March 2002, R.W. Sites, L-295 (5 UMC); same data except 28 March 2003, Sites, Vitheepradit, Prommi, L-423 (2 UMC); Wieng Ko Sai National Park, Namtok Punjane, 17°56'N 99°34'E, 430 m, 28 March 2003, Sites, Vitheepradit, Prommi, L-424 (3 KUEC, 3 DNP-13777, 3 THNHM-I-1273-1275, 8 UMC); same data except 22 July 2002, CMU Team (2 UMC); same data except 27 May 2003, CMU Team (1 UMC); same data except 24 August 2002, CMU Team (1 UMC); Wieng Ko Sai National Park, Namtok Maekung, tier 7, N17°58' E99°35', 430 m, 22 March 2003, CMU Team (1 UMC); same data except upper Huay Panjane; 17°56'N 99°34'E (5 EMEC). **Prachuap Khiri Khan Province:** Amphoe Kui Buri, Forest Plantation Station, gravel & rock stream 12°04'N 99°43'E, 147 m, 22 April 2002, Vitheepradit & Kirawanich, L-360 (1 UMC); same data except 12°04'N 99°37'E, 117 m, 21 May 2005, Sites, Vitheepradit & Prommi, L-785a (1 UMC). **Ratchaburi Province:** Amphoe Suan Phueng, 50 km W of Amphoe Chom Bueng on Hwy 3087, 13°34'N 99°15'E, 192 m, 16 April 2002, Vitheepradit & Kirawanich, L-346 (1 UMC). **Sa Kaeo Province:** Pang Sida National Park, Kaeng Yai Mak, 15 April 2004, 42 m, 14°03.521'N 102°04.381'E, Sites & Vitheepradit, L-628 (1 UMC). **Satun Province:** Wangpachan District, Ton Bliw, 9 July 1997, Sites & Permkam, rocky & sandy stream, L-131 (1 EMEC, 6 UMC). **Songkhla Province:** Songkhla Province, Ton Nga Chang Wildl. Sanc., Ton Pliew Waterfall, 7° 00.038'N 100° 14.084'E, 120 m, 17 June 2006, Vitheepradit, L-957 (3 UMC); stream from Ton Nga Chang Waterfall at Buddhist Temple, 78 m, 06°56'N 100°15'E, 3 May 2002, Vitheepradit, Kirawanich, Suwonno, L-388 (4 UMC); same data except 8 January 1995, Sites & Nichols, L-65 (1 EMEC); same data except 6 July 1997, R.W. Sites, stream at Buddhist temple, L-127 (4 EMEC, 5 UMC); same data except 9 June 2001, L-243 (8 UMC); same data except 14 June 2002, R.W. Sites, L-408 (1 UMC); same data except Ton Nga Chang Wild. Sanc., 7 July 1997, R.W. Sites, level 6 of waterfall, L-128 (1 EMEC, 1 UMC); Ton Nga Chang Wildlife Sanc., 9 June 2001, R.W. Sites, bucket black light trap in stream, L-244 (11 UMC); same data except 14 June 2002 (3 UMC). **Surat Thani Province:** Amphoe Phanom, 20 km N of Amphoe Thap Put on Hwy 4118, 08°40'N 98°42'E, 49 m, 27 April 2002, Vitheepradit & Kirawanich, L-377 (5 UMC); Tai Rom Yen National Park, Dard Fah Waterfall, 08°51.728'N 99°28.850'E, 236 m, 17 June 2004, Sites, Vitheepradit, & Prommi, L-774 (1 UMC); Amphoe Ban Na San, Ban Plai Nam, stream, 08°52.680'N 99°28.621'E, 168 m, 17 June 2004, Sites, Vitheepradit, & Prommi, L-775 (5 UMC). **Tak Province:** Lan Sang National Park, creek below Namtok Lan Sang, 16°46'N 99°00'E, 380 m, 7 March 2002, Vitheepradit, Kirawanich, Sites, L-270 (15 UMC). **Udon Thani Province:** Phu Kao-Phu Pan Kham National Park, Koi Nang Waterfall, 17°07.294'N 102°43.469'E, 433 m, 6 May 2004, A. Vitheepradit, L-668 (3 KUEC, 3 DNP-13777, 3 THNHM-I-1276-1278, 10 UMC). **Uttaradit Province:** Phu Soi Dao National Park, Phu Soi Dao Waterfall, 17°47'N 100°57'E, 608 m, 24 April 2003, Vitheepradit, Prommi, Setaphan, L-482 (6 UMC). **Yala Province:** Than To, Banglang National Park, 14 January 1995, Sites & Nichols, riffles in stream, L-73 (5 KUEC, 5 DNP-13777, 5 NSM, 80 UMC); same data except mercury vapor light, Sites, Nichols & Permkam L-75 (4 UMC); 9 km N Than To, 15 January 1995, Sites & Nichols, L-76 (1 EMEC).

Genus *Helichus* Erichson 1847
(Figs. 4, 10, 13A)

Discussion: *Helichus* is cosmopolitan in distribution and comprises 36 species; however, it has never been revised. We have examined one morphospecies from seven provinces mostly in northern Thailand. *Helichus* is commonly found on submerged wood and in leaf packs. It

can be recognized by a dull dorsal surface densely covered with setae and the last abdominal sternite is less pubescent than anterior sternites.

Material examined: **Chiang Mai Province:** Doi Suthep National Park, Namtok Monthatharn, 700 m, 18°49'N 98°55'E, 9 August 2002, P. Thamsenanupap (1 EMEC). **Loei Province:** Na Haew National Park; Namtok Wang Tok, 750m, 9 March 2002, CMU team (2 EMEC). **Mukdahan Province:** Phu Pa Yon National Park, Keang Pho Waterfall, 16°45.368'N 104°14.736'E, 314 m, 23 April 2004, A. Vitheepadit, L-634 (1 UMC). **Nan Province:** Tak Man Waterfall, 19°17'N 100°47'E, 352 m, 21 April 2003, L-471, Vitheepadit, Prommi, Setaphan (2 UMC); Doi Phu Kha National Park, N Silapet, 19°05'N 100°56'E, 400 m, 13 March 2002 (1 EMEC). **Phayao Province:** Doi Luang National Park, Namtok Champatong, 19°13'N 99°44'E, 820 m, 24 April 2002 (1 EMEC). **Phitsanulok Province:** Phu Hin Rongkla National Park, Waterwheel Falls and stream, 16°59'N 101°00'E, 1280 m, 10 April 2003, CMU Team (1 UMC). **Phrae Province:** Wieng Ko Sai National Park, upper Huay Panjane, 17°56'N 99°34'E, 295 m, 22 April 2002, CMU team (1 EMEC).

Genus *Pachyparnus* Fairmaire 1888

(Figs. 5, 11, 13A)

Discussion: *Pachyparnus* occurs mainly in southeastern Asia, although two species have been reported from India [*P. indicus* (Waterhouse, 1876) and *P. waterhousei* (Grouvelle, 1892)]. Fourteen species currently are considered to be valid. Two species have been reported from Myanmar (*P. birmanicus* Bollow 1940, *P. opacus* [Grouvelle 1892]). The Thai fauna includes *P. tonkineus* Fairmaire 1888 and one undetermined species. *Pachyparnus* is commonly collected at night at lights, often in very large numbers. In Thailand, it occurs mainly in the northwestern part of the country. *Pachyparnus* can be recognized by a dull dorsal surface densely covered with both long, erect and short, recumbent setae; long ocular setae also are present.

Material examined: **Chiang Mai Province:** Fang Horticulture Exp. Farm, Nam Mae Chai, 19°57'N 99°09'E, 600 m, 17 March 2002, Sites, Vitheepadit, Kirawanich, L-301 (1 UMC); Chiang Dao env., 4.91, D. Kral (11 EMEC). **Loei Province:** Ma Nam Loei at Ban Huay Nam Une, 11 June 1998, Sites, Simpson, Vitheepadit, muddy river w/ gravel & veg., L-180 (4 EMEC, 1 UMC). **Mae Hong Son Province:** Amphoe Pang Mapha, Soppong River behind resort, 19°31.159'N 98°14.844'E, 648 m, 18 April 2009, Sites, Vitheepadit, Prommi, UV pan trap, L-1047 (15 DNP-13778, 15 KUEC, 15 THNHM-I-1284–1298, 32 EMEC, >100 UMC); Amphoe Khun Yuam, Tambon Khun, Yuam, Huay Mae Surin at Ban Mae Surin, 18°54.588'N 97°56.695'E, 408 m, stream, 20 April 2009, Sites, Vitheepadit, Prommi, L-1050 (1 EMEC); Namtok Mae Surin National Park, Mae Nam Pai, 19°21'N 97°59'E, 310 m, 19 March 2002, R.W. Sites, L-307 (53 UMC); same data except mercury vapor light, Sites, Vitheepadit, Kirawanich, L-308 (5 KUEC, 5 DNP-13778, 5 THNHM-I-1299–1303, 8 EMEC, 80 UMC); same data except pan UV lt. trap, 31 March 2003, UMC and CMU teams, L-431 (5 KUEC, 5 DNP-13778, 5 THNHM-I-1304–1308, 80 UMC). **Nan Province:** Mae Charim National Park, Nam Wa River, 18°36'N 100°59'E, 335 m, 13 March 2002, R.W. Sites, L-293 (1 UMC).

Genus *Parahelichus* Bollow 1940

(Figs. 6, 12, 13A)

Discussion: *Parahelichus* is distributed from Egypt to China and includes only five species. We have examined two morphospecies. In Thailand, *P. pseudogranulosus* Lujkova, Degma & Kodada 2014 was reported from Mae Hong Son Province (LOJKOVÁ ET AL. 2014) and our records are from three provinces also in the northern region. *Parahelichus* can be recognized by a dull dorsal surface with scattered setae and an elongate, teardrop-shaped lateral sensory area on the last labial palpomere (Fig. 12).

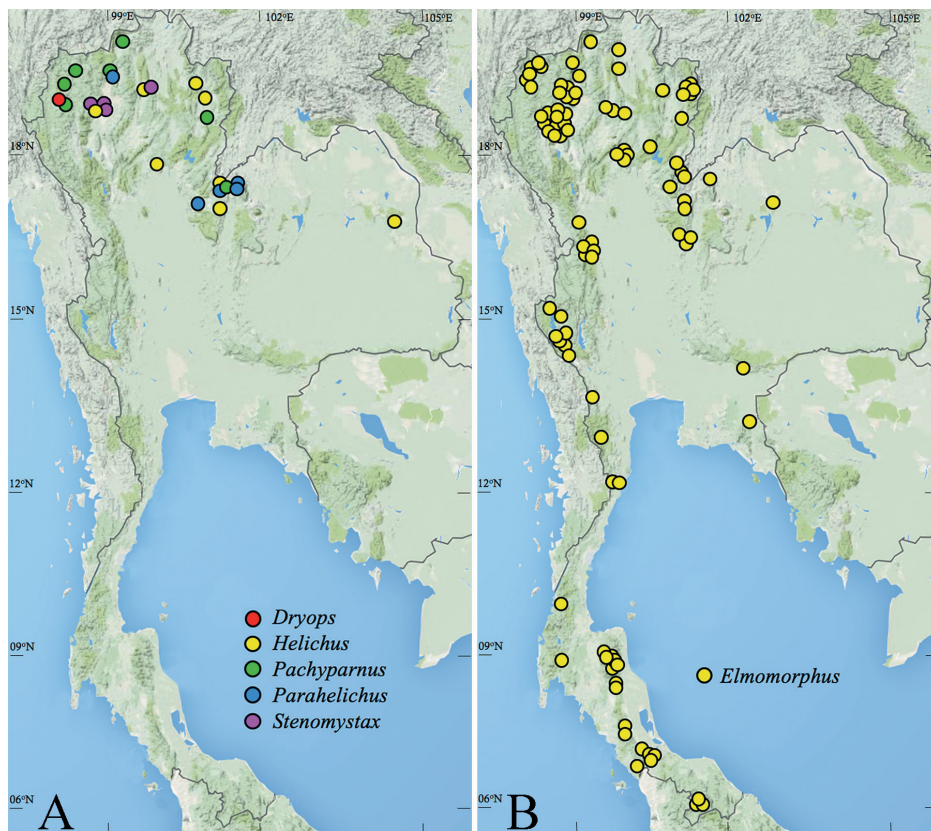


Figure 13. Distribution records of genera of Dryopidae. All records based on specimens examined. Multiple records from the same location not indicated here.

Material examined: **Chiang Mai Province:** 100 km N Chiang Mai, Chiang Dao Hill Resort, 650 m, 28.V-8.VI 2009, S. Murzin, leg. (3 KUEC, 3 DNP, 3 NSM, 53 EMEC). **Loei Province:** Ma Nam Loei at Ban Huay Nam Une, 11 VI 1998, Sites, Simpson, Vitheepradit, muddy riv. w/ gravel & veg, L-180 (6 EMEC, 2 UMC); Phu Rua National Park, 10 June 1998, Sites, Simpson, Vitheepradit, black light at Park HQ, L-178 (1 EMEC). **Phitsanulok Province:** Ban Coke Puk Hwuan, Amphoe Chartrakan, unnamed river, 9 June 1998, Sites, Simpson, Vitheepradit, L-172 (1 EMEC).

Genus *Stenomystax* Kodada, Jäch & Čiampor 2003
(Figs. 7, 9, 13A)

Discussion: *Stenomystax* comprises 12 species and has a Southeast Asian distribution extending from Thailand and Laos through Malaysia and into the Philippine Islands. Only *S. kubani* Kodada, Jäch & Čiampor 2003 is known from Thailand. *Stenomystax* usually co-occurs with *Elmomorphus* in the northwestern region. It can be recognized by a shiny dorsal surface and plastron laterally on the elytra, and the second antennomere is greatly enlarged, covering the remaining antennomeres (Fig. 9).

Material examined: Chiang Mai Province: Doi Suthep National Park, Namtok Monthathan, 18°49'N 98°55'E, 700 m, 6 June 2002, P. Thamsenanupap (1 UMC); Doi Suthep-Pui National Park, Pa Ngerb, stream, 18°48'N 98°56'E, 530 m, 29 April 2003, Vitheepradit, Thamsenanupap, Ferro, L-490 (1 EMEC); Amphoe Mae Chaem, Mae Pan, 18°31'N 98°23'E, 540 m, 3 April 2003, UMC and CMU teams, L-444 (2 EMEC). **Phayao Province:** Doi Luang National Park, Namtok Cham Pa Thong, 19°13'N 99°44'E, 620 m, 26 August 2002, CMU team (1 EMEC).

Family **Elmidae** Curtis 1830

Two subfamilies of Elmidae (Elminae and Larainae) occur in Thailand; they differ mainly in the structure and behavior of the adults. In both subfamilies the eggs, larvae, and adults are aquatic whereas the pupa is terrestrial. Larvae in their last instar have spiracles in addition to tracheal gills; all earlier instars lack spiracles and use tracheal gills to obtain dissolved oxygen from the water. The spiracles are seen as small sclerotized mounds on both sides of the mesothorax and abdominal segments 1–8. Spiracles allow the larvae to use atmospheric oxygen when they crawl out of the streams to find terrestrial pupation sites. Larvae in the last instar can be reared to adults (see the Identifications section of Methods).

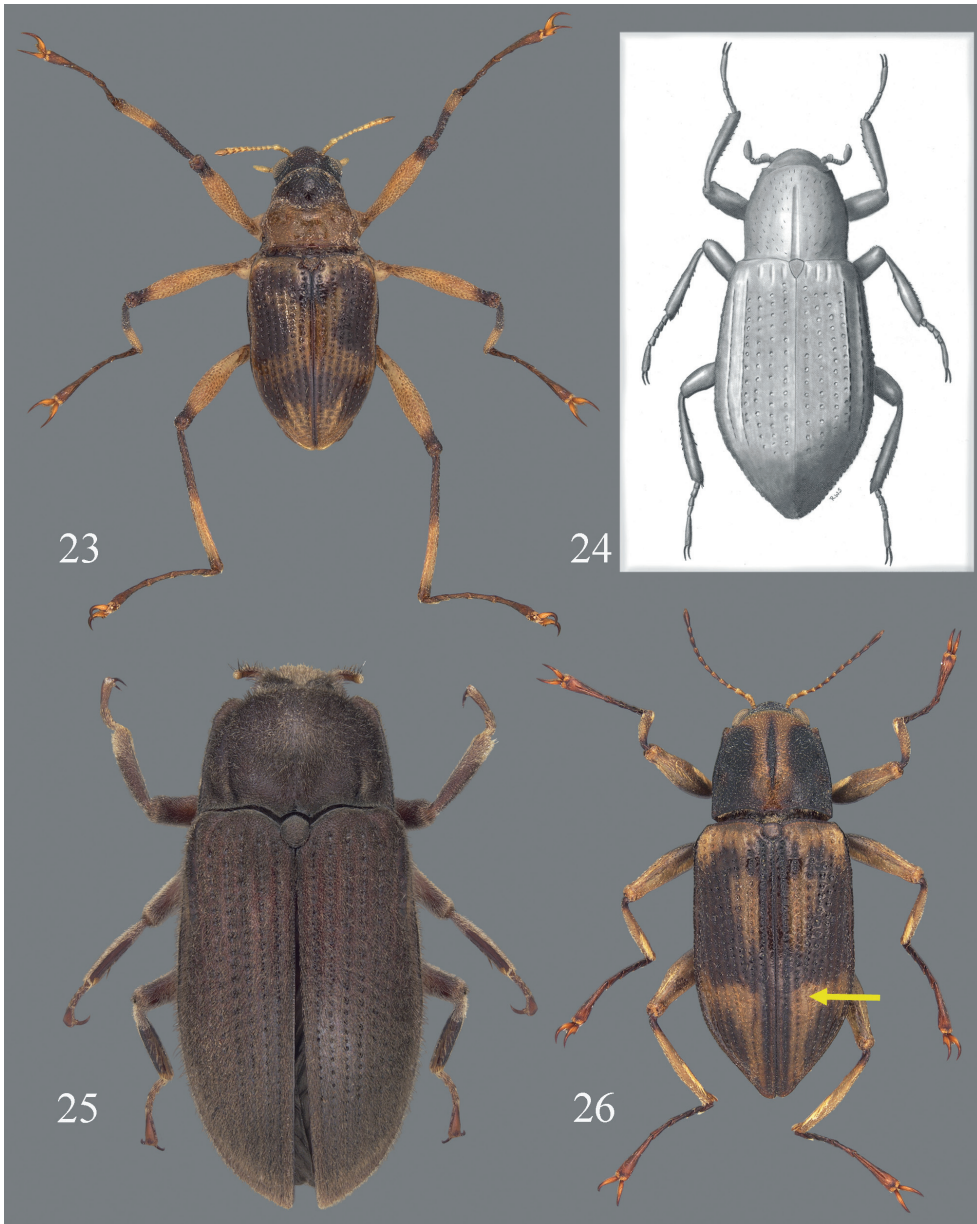
Key to the Genera of Adult Elmidae of Thailand

- | | | |
|-------|---|-----------------------|
| 1 | Procoxae transverse (Fig. 14) and with exposed trochantin; antennae with first antennomere elongate (Fig. 16) | Larainae 2 |
| 1' | Procoxae globular (Fig. 15) and with concealed trochantin; antennae with first antennomere not elongate (Fig. 17) | Elminae 3 |
| 2(1) | Elytra each with one short accessory basal stria between stria 1 and 2 (Fig. 33); pronotum without basal carinae or sulci; posterior prosternal process narrow, ≥ 3 times as long as wide (Fig. 18); abdominal sternites 1+2 conspicuously longer than 3–5 | <i>Potamophilinus</i> |
| 2' | Elytra without basal accessory stria (Fig. 25); pronotum on each side with a longitudinal carina or sulcus in basal third to half; posterior prosternal process wide, ≤ 2 times as long as wide (Fig. 19); abdominal sternites 1+2 not longer than 3–5 | <i>Dryopomorphus</i> |
| 3(1') | Antennae with 11 antennomeres (Figs. 17, 20, 21) | 4 |
| 3' | Antennae with 7 or 8 antennomeres | 10 |
| 4(3) | Coxae widely separated so that pro- and mesocoxae visible dorsally (Fig. 23); legs very long and pretarsal claws large | <i>Ancyronyx</i> |
| 4' | Coxae narrowly separated so that pro- and mesocoxae not visible dorsally; leg length and pretarsal claw size variable (Figs. 24–38) | 5 |
| 5(4') | Protibia without medio-apical fringe of setae (Fig. 20) | 6 |
| 5' | Protibia with medio-apical fringe of setae (Fig. 21) | 8 |

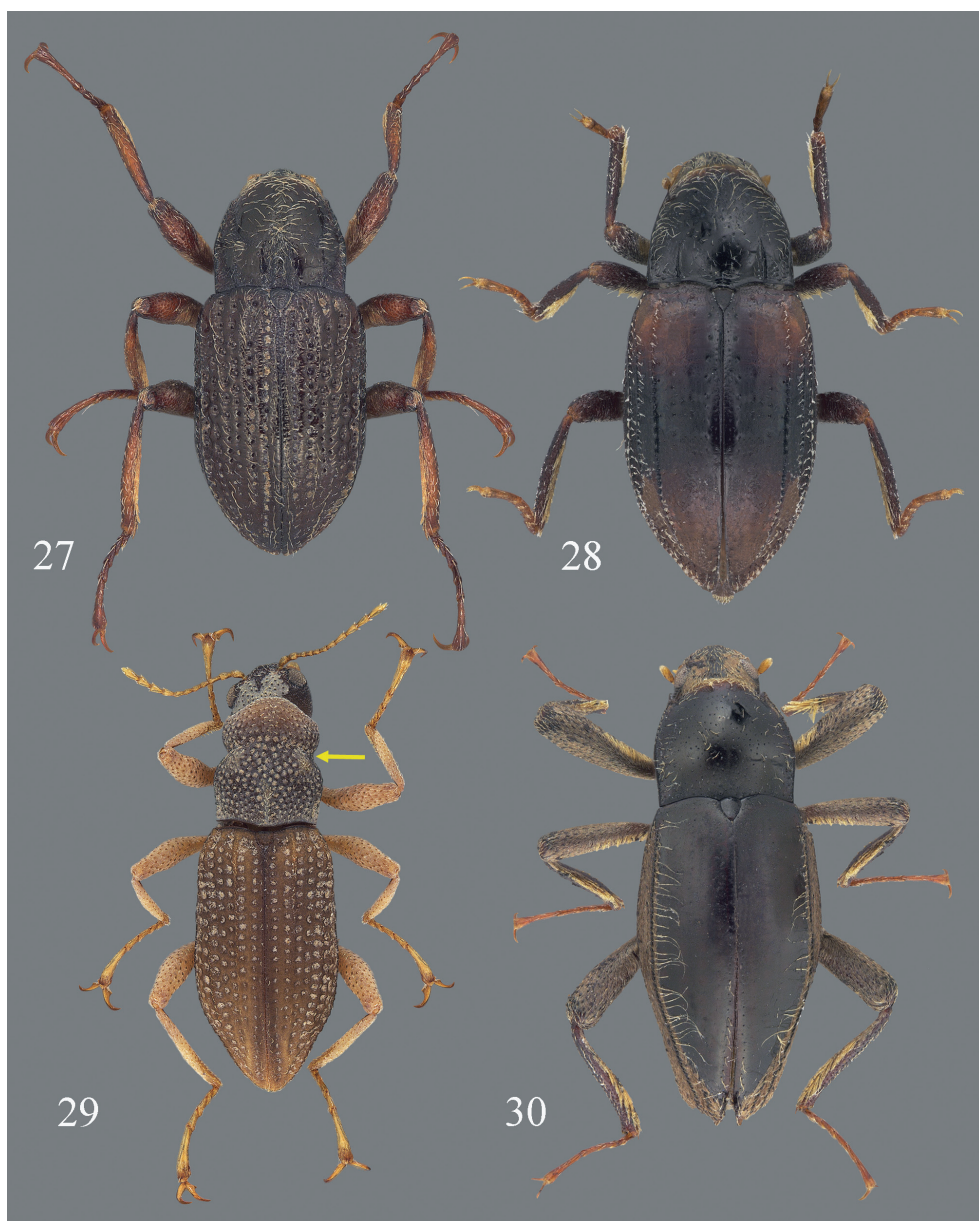
6(5)	Pronotum with a broad transverse impression (Fig. 29, yellow arrow); pretarsal claws with basal tooth	<i>Leptelmis</i>
6'	Pronotum without a broad transverse impression; pretarsal claws without basal tooth	7
7(6')	Elytra with a short basal accessory stria between stria 1 and 2 (Fig. 32, yellow arrow); granules on head and legs elongate	<i>Ordobrevia</i>
7'	Elytra without a short basal accessory stria; granules on head and legs rounded... ..	<i>Stenelmis</i>
8(5')	Antenna length subequal to or shorter than head width, last 3 antennomeres forming a loose club (Fig. 17)	<i>Grouvellinus</i>
8'	Antenna length approximately twice head width, filiform	9
9(8')	Elytra with third and fourth intervals between stria rows fused beyond middle (Fig. 26, yellow arrow); pretarsal claws with basal tooth (Fig. 22)	<i>Graphelmis</i>
9'	Elytra with third and fourth intervals not fused; pretarsal claws without basal tooth	<i>Pseudamophilus</i>
10(3')	Antennae with 7 antennomeres; pronotum with 2 large adbasal gibbositities (Fig. 31, yellow arrow)	<i>Macronychus</i>
10'	Antennae with 8 antennomeres; pronotum without gibbositities	11
11(10')	Elytra apically truncate or bispinose (Figs. 30, 36)	12
11'	Elytra apically conjointly rounded (Figs. 24, 28, 37)	13
12(11)	Elytra apically truncate (Fig. 36); pronotum with sublateral carinae; metafemur not clavate	<i>Urumaelmis</i>
12'	Elytra apically bispinose (Fig. 30); pronotum without sublateral carinae; metafemur clavate	<i>Macronevia</i>
13(11')	Labial palp with 2 palpomeres	14
13'	Labial palp with 3 palpomeres	15
14(13)	Distinct median longitudinal pronotal groove (Fig. 24); elytra unicolorous	<i>Aulacosolus</i>
14'	No median longitudinal pronotal groove; each elytron with a large red humeral spot and a large red apical spot (Fig. 28)	<i>Indosolus</i>
15(13')	Elytra with sublateral carinae only on stria intervals 7 and 8 (Fig. 38)	<i>Zaitzeviaria</i>
15'	Elytra with sublateral carinae on stria intervals 5 and 7, OR 5, 6 and 7 (Fig. 37) ..	<i>Zaitzevia</i>



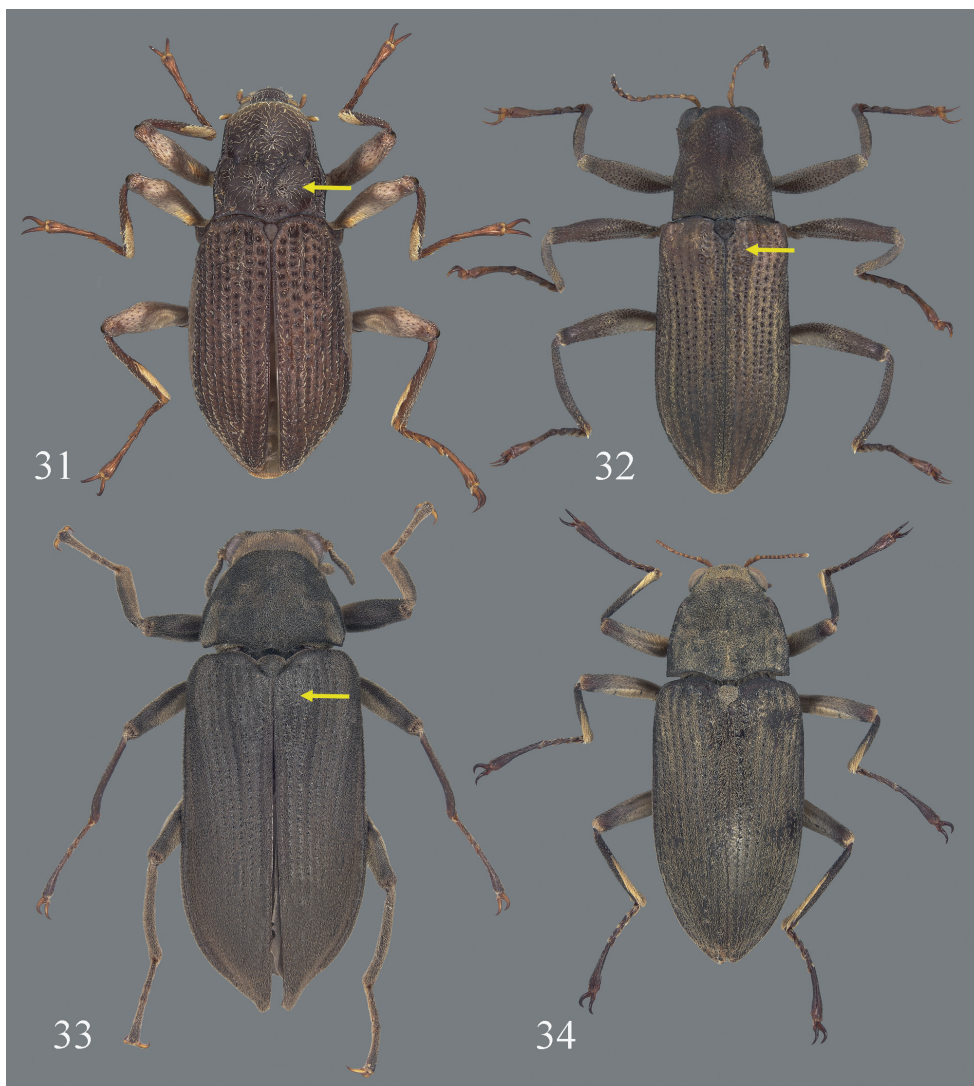
Figures 14–22. Elmidae. (14) Transverse procoxa of *Potamophilinus* (arrow indicates trochantin), (15) globular procoxa of *Ordobrevia*. Dorsal surface of head of (16) *Potamophilinus* and (17) *Grouvellinus*. Prosternum of (18) *Potamophilinus* and (19) *Dryopomorphus* (arrows indicate posterior process). Frontal view of (20) *Stenelmis* and (21) *Pseudamophilus*. (22) Pretarsal claw with basal tooth of *Graphelmis*.



Figures 23–26. Dorsal habitus of genera of Elmidae. (23) *Ancyronyx*, (24) *Aulacosolus*, (25) *Dryopomorphus*, (26) *Graphelmis* (arrow indicates fused stria rows).



Figures 27–30. Dorsal habitus of genera of Elmidae. (27) *Grouvellinus*, (28) *Indosolus*, (29) *Leptelmis* (arrow indicates transverse impression), (30) *Macronevia*.



Figures 31–34. Dorsal habitus of genera of Elmidae. (31) *Macronychus*, (32) *Ordobrevia*, (33) *Potamophilinus*, (34) *Pseudamophilus*. Arrows indicate pronotal gibbosities (31) and short accessory striae (32, 33).



Figures 35–38. Dorsal habitus of genera of Elmidae. (35) *Stenelmis*, (36) *Urumaelmis*, (37) *Zaitzevia*, (38) *Zaitzeviaria*.

Annotated list of the Elmidae of Thailand

Subfamily **Elminae** Curtis 1830

Adult elminae usually are found on or in inorganic substrates within a stream. They feed on fine organic particles collected or scraped from the substrate. Oxygen is extracted from the water by a plastron, thereby enabling elminae to remain in the water for years as adults. Because they die quickly if removed from the water, their presence is indication of the permanence of a stream. The larvae inhabit the finer substrates of streams; they are well-sclerotized and have a tubular shape which helps them avoid crushing by the substrate.

Genus ***Ancyronyx*** Erichson 1847

(Figs. 23, 39A)

Discussion: *Ancyronyx* is known as the “spider riffle beetle” due to its body shape and long legs (JÄCH, 1993) (Fig. 23). It has been reviewed recently (JÄCH, 1994) and a key to species is available (JÄCH 2003). Twenty-two species are considered to be valid, two of which are known from Thailand: *Ancyronyx acaroides* Grouvelle, 1896 and *A. malickyi* Jäch, 1994. Unlike many other elminae, adults are commonly encountered on submerged wood. Our records of *A. acaroides* are mainly from the central part of Thailand. *A. malickyi* has been reported from Songkhla and Yala provinces in southern Thailand (JÄCH, 1994).

Material examined: **Kamphaeng Phet Province:** Khlong Lan National Park, Namtok Khlong Lan, 16°07'N 99°16'E, 310 m, 21 August 2002, CMU team (1 UMC). **Kanchanaburi Province:** Amphoe Sai Yok, Thong Pha Phum Reforestation Station, Mae Nam Noi, 14°31'N 98°37'E, 204 m, 10 April 2003, UMC and CMU teams, L-462 (1 UMC). **Nakhon Nayok Province:** Khao Yai National Park, Huay Tadapoo above NT, 14°24'N 101°22'E 745 m, 18 May 2000, G.W. Courtney (1 KUEC, 1 DNP-13779, 1 THNHM-I-1309, 3 EMEC). **Nakhon Ratchasima Province:** Khao Yai National Park, E branch Huay Takrong at Wang Jampee, 11 August 97, 14°27'N 101°21'E, G.W. Courtney (1 EMEC).

Genus ***Aulacosolus*** Jäch & Boukal 1997

(Figs. 24, 39A)

Discussion: *Aulacosolus* is known mainly from Laos, Malaysia, and Thailand, although one species occurs in India. In Thailand, four species have been reported from Chiang Mai, Nakhon Ratchasima, and Phetchabun provinces: *A. carinatus* Jäch & Boukal 1997, *A. scida* Jäch & Boukal, 1997, *A. spinosus* Jäch & Boukal, 1997, and *A. tenuior* Jäch & Boukal, 1997. We have not examined specimens of this genus. *Aulacosolus* can be recognized by antennae with eight antennomeres and the characteristic carinae on the elytra (Fig. 24).

Genus ***Graphelmis*** Delève 1968

(Figs. 22, 26, 39A)

Discussion: *Graphelmis* is a large genus with 83 species that is currently being revised by Fedor Čiampor and Jan Kodada. It is mainly a Southeast Asian taxon, although species also are known from eastern Australia, India, Japan, and New Guinea. Seven species have been reported from Thailand: *G. ambigua* Delève, 1970; *G. boukali* Čiampor, 2003; *G. cleromonti* (Pic, 1923); *G. jaechi* Čiampor, 2001; *G. jendeki* Čiampor & Kodada, 2004; *G. sausai* Čiampor, 2004; and *G. spiralis* Čiampor, 2004. The occurrence of *Graphelmis picta* (Reitter, 1886) in Thailand is questionable (JÄCH ET AL., 2016). *Graphelmis* adults often are found on

submerged wood. We have examined three morphospecies from Thailand that were collected along the western border from Chiang Mai south to Narathiwat provinces. *Graphelmis* is best recognized by the yellow and brown color patterns (Fig. 26), fused elytral striae, and toothed pretarsal claws (Fig. 22).

Material examined: Chiang Mai Province: Doi Suthep National Park, Namtok Monthatthan, 18°49'N 98°55'E, 700 m, 6 June 2002, P. Thamsenanupap (1 UMC); Doi Suthep-Pui National Park, Pa Ngerb, stream, 18°48'N 98°56'E, 530 m, 29 April 2003, Vitheepradit, Thamasenanupap, Ferro, L-490 (3 UMC); Doi Inthanon National Park, Namtok Sob Ab, 18°31.775'N 98°36.488'E, 543 m, 17 May 2004, Vitheepradit & Prommi, L-690 (1 UMC); same data except 2 April 2003, UMC and CMU teams, L-436 (1 UMC); Doi Inthanon National Park, Mae Klang River at Sob Ab Waterfall, 543 m, 18°31'N 98°36'E, 17 May 2004, Vitheepradit, Prommi, Laudee, Thamsenanupap, L-691 (1 UMC). **Kamphaeng Phet Province:** Khlong Lan National Park, Namtok Khlong Lan, 16°07'N 99°16'E, 310 m, 12 August 2002, CMU team (2 UMC). **Kanchanaburi Province:** Amphoe Sai Yok, Thong Pha Phum Reforestation Station, Mae Nam Noi, 14°31'N 98°37'E, 204 m, 10 April 2003, UMC and CMU teams, L-462 (1 UMC); Huay Khayeng at Ban Pracham Mai, 428 m, 31 May 2011, R.W. Sites, veg. margins of stream, L-1298 (1 UMC); Ban Padsadoo Klang, 14°33.364'N 98°34.335'E, 296 m, Sites, Vitheepradit, Prommi, muddy tire rut pool, L-914 (4 UMC). **Lampang Province:** Jae Sawn National Park, Namtok Jae Sawn, 18°50'N 99°28'E, 650 m, 27 March 2003, Sites, Vitheepradit, Prommi, L-421 (1 UMC). **Mae Hong Son Province:** Namtok Mae Surin National Park, Mae Nam Pai, 19 March 2002, 19°21'N 97°59'E, 310 m, Sites, Vitheepradit, Kirawanich, mercury vapor light, L-308 (1 UMC). **Nakhon Nayok Province:** Khao Yai National Park, Huay Tadapoo above waterfall, 14°24'N 101°22'E, 745 m, 18 May 2000; G.W. Courtney (1 KUEC, 1 DNP-13780, 1 THNHM-I-1310, 3 EMEC). **Narathiwat Province:** stream 14 km W Srisakhon, 15 January 1995, Sites & Nichols, L-77 (1 EMEC); stream below Bacho Waterfall, 15 January 1995, Sites, Nichols, Permkam, L-78 (1 EMEC). **Nakhon Si Thammarat Province:** Tambon Krung Ching, Klong Nob, 16 June 2004, L-772, 08°44'N 99°39'E, 89 m, Sites, Vitheepradit, Prommi, L-772 (1 UMC). **Ranong Province:** Khun Mae Yam Oum Wldf. Sanc., Haew Lome Waterfall, 09°43.740'N 98°40.953'E, 122 m, 14 vi 2004, Sites, Vitheepradit, & Prommi, L-765 (1 UMC). **Suratthani Province:** Amphoe Phanom, 20 km N of Amphoe Thap Put on Hwy 4118, 08°40'N 98°42'E, 49 m, 27 April 2002, Vitheepradit & Kirawanich, L-377 (1 UMC).

Genus *Grouvellinus* Champion 1923

(Figs. 17, 27, 39B)

Discussion: *Grouvellinus* occurs from India throughout southeastern Asia and into Japan and China. Thirty-four species are considered to be valid, although none have been reported from Thailand. We have examined six morphospecies from Thailand. Our records of the genus are from 11 provinces throughout western and central Thailand from Mae Hong Son to Yala. *Grouvellinus* is best recognized by short antennae with the last three antennomeres forming a club (Fig. 17).

Material examined: Chanthaburi Province: Khao Soi Dao Wildlife Sanctuary, stream from Namtok Khao Soi Dao, 13°5.810'N 102°10.332'E, 523 m, 17 January 2016, R.W. Sites, L-1911 (1 UMC). **Chiang Mai Province:** Creek at Chiang Dao Wildlife Research Center, 19°21'N 98°55'E, 520 m, 14 July 2002, Sites, Vitheepradit, Kirawanich (10 UMC); Mae Fang National Park, creek behind dam, 19°58'N 99°09'E, 535 m, 26 March 2003, Sites, Vitheepradit, Prommi, L-418 (6 UMC); Suanrin, Nam Mae Sa, 18°54.09'N 98°53.08'E, 1600 ft, 25 March 1994, W.D. Shepard, WDS-A-1046 (8 EMEC); Doi Inthanon National Park, Nam Mae Aep above hwy 1009, 18°32'N 98°32'E, 630 m, 13 November 2002, P. Thamsenanupap (3 UMC); Doi Inthanon National Park, Huay Sai Luang Waterfall, 18°31'N 98°27'E, 1060 m, 3 March 2002, Vitheepradit, Kirawanich, L-255 (6 UMC); same data except 20 March 2002, R.W. Sites, L-311 (1 UMC); same data except 20 March 2002, L-312 (1 UMC); Doi Inthanon National Park, Mae Pan Noi at Ban San Pathana, bedrock stream, 18°31'N 98°25'E, 750 m, 4 April 2003, UMC

and CMU teams, L-446 (9 UMC); same data except Mae Klang River at Ecolodge, 18°32'N 98°32'E, 1000 m, 2 April 2003, L-437 (1 UMC); same data except Mae Klang at Ban Khun Klang, 18°31.259'N 98°31.310'E, 1296 m, 18 May 2004, Vitheepadit, Prommi, Laudee, Thamsenanupap, L-694 (7 UMC); Doi Inthanon National Park, Namtok Siriphum, 18°32'N 98°31'E, 1460 m, 2 March 2002, D. Tapanya (1 UMC); same data except 3 April 2003, UMC and CMU teams, L-441 (2 KUEC, 2 DNP-13781, 2 THNHM-I-1311–1312, 11 UMC); same data except 2 April 2002, L-317 (1 UMC); same data except 3 April 2003, L-441 (5 UMC); same data except 21 March 2002, R.W. Sites, L-316 (2 EMEC); same data except level 2, 21 March 2002, L-314 (1 EMEC, 11 UMC); same data except 1380 m, 2 March 2002, Vitheepadit, Kirawanich, L-250 (1 UMC); same data except 26 June 2002, R.W. Sites, L-412 (2 KUEC, 2 DNP-13781, 2 THNHM-I-1313–1314, 12 UMC); same data except 2 March 2002, Vitheepadit, Kirawanich, L-249 (1 UMC); Doi Suthep National Park, Sai Yoi Waterfall, 18°48'N 98°55'E, 1100 m, 4 April 2003, Sites, Vitheepadit, Prommi, Setaphan, L-447 (3 UMC); Doi Suthep National Park, Mae Sa Falls, 18°54.39'N 98°53.91'E, 1312 ft, 25 March 1994, WDS-A-1045 (5 KUEC, 5 DNP-13781, 5 THNHM-I-1315–1319, 25 EMEC); Doi Suthep-Pui National Park, 24 March 1994, Huay Sa Lad, 18°48.31'N 98°54.52'E, 3594 ft, W.D. Shepard, WDS-A-1043 (5 EMEC); Doi Suthep-Pui National Park, 24 March 1994, Monthatarn Falls, W. D. Shepard, WDS-A-1044 (5 EMEC); Doi Suthep National Park, immd. below Monthatarn Falls, 18°49'N 98°55'E, 690 m, 15 March 2002, Kirawanich, Sites, L-296 (1 UMC). **Kamphaeng Phet Province:** Province, Khlong Lan National Park, Khlong, Nam Lai Waterfall, 16°11'N 99°15'E, 6 April 2003, Sites, Vitheepadit, Prommi, Setaphan, L-448 (2 UMC). **Kanchanaburi Province:** Ou Long, stream, 14°46.993'N 98°40.258'E, 123 m, Vitheepadit, L-919 (1 UMC); Thong Pha Phum, Jok Kra Din Waterfall, 14°41'43"N, 98°23'18"E, 4 June 2006, Vitheepadit, Prommi, L-916 (1 EMEC); Amphoe Sai Yok, Thong Pha Phum Reforestation Station, Mae Nam Noi, 14°31'N 98°37'E, 204 m, 10 April 2003, UMC and CMU teams, L-462 (1 UMC); Thong Pha Phum National Park, Huay Pak Kog 14°47.183'N, 98°48.401'E, 139 m, 1 June 2011, R.W. Sites, gravel stream, L-1303 (1 EMEC). **Mae Hong Son Province:** Namtok Maw Pang, 19°22'N 98°22'E, 850 m, 19 March 2002, R.W. Sites, L-305 (1 UMC); Huay Pha, 18 km N Mae Hong Son, 19°25'N 97°59'E, 340 m, 31 March 2003, UMC and CMU team L-430 (1 UMC). **Nakhon Nayok Province:** Khao Yai, 18 May 2000 (3 EMEC). **Nan Province:** Doi Phu Kha National Park, Namtok Ton Tong, 19°12'N 101°04'E, 900 m, 13 March 2002, Vitheepadit & Kirawanich L-291 (6 UMC). **Phetchabun Province:** 2 km WNW Pha Biat, Tup Low, 16°32.65'N 101°51.07'E, 1478 ft, 5 April 1994, W.D. Shepard, WDS-A-1055 (12 EMEC). **Phitsanulok Province:** Phu Hin Rongkla National Park, Namtok Huay Kha Mheun Noi, 16°59'N 101°00'E, 1220 m, 22 May 2002, CMU Team (13 UMC); same data except 10 February 2002 (1 UMC); same data except Namtok Romglao, 16°59'N 101°00'E, 1190 m, 21 June 2002 (3 UMC); same data except Waterwheel Falls, 16°59'N 101°00'E, 1280 m, 21 June 2002 (8 UMC); same data except Mahn Dang Waterfall, 12 June 1998, R.W. Sites & K.B. Simpson, L-186 (1 EMEC). **Phrae Province:** Wieng Ko Sai National Park, Upper Namtok Maekung Luang, 17°58'N 99°35'E, 430 m, 26 October 2002, CMU Team (1 UMC). **Satun Province:** Wangpachan District, Ton Bliew, 9 July 1997, Sites & Permkam, rocky & sandy stream, L-131 (1 EMEC). **Yala Province:** Than To, Banglang National Park, 14 January 1995, Sites & Nichols, riffles in stream, L-73 (1 EMEC, 3 UMC).

Genus *Indosolus* Bollow 1940

(Figs. 28, 39A)

Discussion: *Indosolus* comprises only two species: *I. acutangulus* (Champion, 1923) from India and *I. nitidus* (Bollow, 1940) from Myanmar. The latter species is probably the identity of our specimen from Nan Province, which is the only known record of the genus from Thailand. *Indosolus* is recognized by antennae with eight antennomeres, labial palps with two palpomeres, and red elytral spots (Fig. 28).

Material examined: **Nan Province:** Doi Phu Kha National Park, Namtok Ton Tong, 19°12'N 101°04'E, 900 m, 13 March 2002, Vitheepadit & Kirawanich, L-291 (1 UMC).

Genus *Leptelmis* Sharp 1888
(Figs. 29, 39C)

Discussion: *Leptelmis* comprises 24 species and is distributed from Africa through India and Southeast Asia and into China, Korea and Japan. The genus has not been reported previously from Thailand, although we have examined three morphospecies from 13 provinces. *Leptelmis* is found on submerged wood throughout Thailand in appropriate habitats. This genus is easily recognized by the transverse impression on the pronotum (Fig. 29).

Material examined: **Chaiyaphum Province:** Phu Khieo Wld. Sanctuary, Nam Prom, 16°27.71'N 101°39.32'E, 1735 ft, 12 March 1994, WDS-A-1037 (1 EMEC); same data except 4 April 1994, WDS-A-1053 (4 EMEC). **Chiang Mai Province:** Creek at Chiang Dao Wildlife Research Center, 19°21'N 98°55'E, 520 m, 26 August 2002, CMU Team (1 UMC); 11 km N Chiang Mai, Chiang Dao Hill Resort, 640 m, 28.V-8.VI 2009, S. Murzin (1 KUEC, 1 DNP-13782, 1 THNHM-I-1320, 13 EMEC). **Kalasin Province:** Phu Phan National Park, 4 June 1998, Gang Mawt Dang, Sites, Simpson, Vitheepadit, L-150 (1 EMEC). **Kamphaeng Phet Province:** Khlong Lan National Park, Namtok Khlong Lan, 16°07'N 99°16'E, 310 m, 19 July 2002, CMU team (1 EMEC); Mae Wong National Park, Kaeng Pa Nang Koi, 16°02'N 99°13'E, 7 April 2003, Sites, Vitheepadit, Prommi, Setaphan, L-451 (1 UMC). **Kanchanaburi Province:** Huay Khayeng, 14°48.072'N, 98°40.379'E, 176 m, 2 June 2011, R.W. Sites, gravel stream, L-1306 (1 KUEC, 1 DNP-13782, 1 THNHM-I-1321, 1 EMEC); Amphoe Sai Yok, Thong Pha Phum Reforestation Station, Mae Nam Noi, 14°31'N 98°37'E, 204 m, 10 April 2003, UMC and CMU teams, L-462 (1 UMC). **Loei Province:** Ma Nam Loei at Ban Huay Nam Une, 11 June 1998, Sites, Simpson, Vitheepadit, muddy riv. w/ gravel & veg., L-180 (1 EMEC, 4 UMC). **Mae Hong Son Province:** Huay Pha, 18 km N Mae Hong Son, 19°25'N 97°59'E, 340 m, 31 March 2003, UMC and CMU teams, L-430 (2 UMC); same data except 14 October 2002 (1 EMEC). **Mukdahan Province:** Phu Pa Yon National Park, Keang Pho Waterfall, 16°45.368'N 104°14.736'E, 314 m, 23 April 2004, A. Vitheepadit, L-634 (1 UMC). **Nakhon Si Thammarat Province:** Khao Luang National Park, Ka Rome Waterfall, 08°22'N 99°44'E, 157 m, 26 May 2005, Sites, Vitheepadit & Prommi, L-799 (1 UMC). **Narathiwat Province:** 14 km W Srisakhon, 15 Januaray 1995, Sites & Nichols (1 UMC). **Phetchabun Province:** 5 km E Sila, Mae Nam Pa Sak, 17°00'N 101°21'E, 774 ft, 2 March 1994, W.D. Shepard, WDS-A-1025 (1 EMEC); Nam Nao National Park, Prom Laeng, 3 May 2004, 253 m, 16°38.424'N 101°34.984'E, A. Vitheepadit, L-659 (1 UMC). **Phetchaburi Province:** stream 16 km NE of Ban Yang Chum on Hwy 3410, 12°45'N 99°36'E, 140 m, 19 April 2002, Vitheepadit, Kirawanich, L-355 (1 UMC). **Phitsanulok Province:** Chat Trakan Waterfall, 9 June 1998, Sites, Simpson, Vitheepadit, spillway over rock, L-170 (1 EMEC); Kaeng Jet Kwaie National Park, Kaeng Jet Kwaie Waterfall, 17°08.545'N 100°26.462'E, 102 m, 13 May 2004, Vitheepadit & Prommi, L-684 (1 UMC); Thung Salaeng Luang National Park, Kaeng Sopa Waterfall, 30 June 1998, Vitheepadit & Sawangsak, L-218 (1 EMEC).

Genus *Macronevia* Jäch & Boukal 1996
(Figs. 30, 39A)

Discussion: *Macronevia* is monotypic and known by *M. simplex* (Hinton, 1936). This species occurs in southern Thailand and peninsular Malaysia; however, the previous record from Thailand was not specific to a province. We have collected it in four provinces from Phang Nga to the deep south. *Macronevia* is recognized by antennae with eight antennomeres and the elytra bispinose apically (Fig. 30).

Material examined: **Satun Province:** 100 m downstream from Boripat Waterfall, 60 km SW of Amphoe Hat Yai, 6°59'N, 100°9'E, 200 m, 10 June 2001, R.W. Sites, L-245 (1 EMEC). **Songkhla Province:** Ton Nga Chang Wild. Sanc., stream at Buddhist temple, 7 January 1995, Sites & Nichols, L-60 (1 EMEC). **Yala Province:** Than To, Banglang National Park, 14 January 1995, Sites & Nichols, riffles in stream, L-73 (1 UMC).

Genus *Macronychus* Müller 1806
(Figs. 31, 39B)

Discussion: *Macronychus* comprises 11 species distributed across the Holarctic region and was revised by ČIAMPOR & KODADA (1998). Two species are known from Thailand: *M. indicus* Hinton 1940 and *M. ultimus* Čiampor and Kodada 1998. Both species have been re-recorded from Chiang Mai Province and we add records of the genus from Loei and Phitsanulok provinces in north-central Thailand. *Macronychus* can be recognized by antennae with seven antennomeres and the pronotum with a pair of large gibbosities in the posterior half (Fig. 31).

Material examined: **Chiang Mai Province:** Doi Inthanon National Park, Siriphum Waterfall, 18°32'N 98°31'E, 1380 m, 26 June 2002, R.W. Sites, L-412 (1 EMEC, 1 UMC). **Loei Province:** Phu Hin Ronkla National Park, Namtok Man Daeng, Tier 5, 18°57'N 101°03'E, 1250 m, 11 March 2002, G.W. Courtney (1 EMEC). **Phitsanulok Province:** Phu Hin Rongkla National Park, Waterwheel Falls, 16°59'N 101°00'E, 1280 m, 15 November 2002, CMU Team (1 EMEC, 1 UMC); Phu Hin Rongkla, 2 September 2002, CMU team (1 EMEC).

Genus *Ordobrevia* Sanderson 1953
(Figs. 15, 32, 39B)

Discussion: *Ordobrevia* comprises 11 species that are currently considered to be valid; however, this genus is of uncertain phylogenetic status and might be synonymous with *Stenelmis*. Species are known mainly from Southeast Asia, although one species occurs in western North America. Our record of *O. constricta* Delève 1968 is the only species known from Thailand. *Ordobrevia* lacks protibial setal fringes and has a short accessory stria on each elytron (Fig. 32).

Material examined: **Chiang Mai Province:** Doi Inthanon National Park, Siriphum Waterfall, 18°32'N 98°31'E, 1460 m, 3 April 2003, UMC and CMU teams, L-441 (1 EMEC); Doi Suthep-Pui National Park, Monthatharn Falls, 24 March 1994, W. D. Shepard, WDS-A-1044 (3 EMEC); Doi Suthep-Pui National Park, Huay Sa Lad, 18°48.31'N 98°54.52'E, 3594 ft, 24 March 1994, WDS-A-1043 (2 EMEC).

Genus *Pseudamophilus* Bollow 1940
(Figs. 21, 34, 39B)

Discussion: *Pseudamophilus* comprises only four species and is known from China, Japan, Myanmar, and Thailand. Only *P. davidi* Kodada 1992 has been reported from Thailand. *Pseudamophilus* has long antennae with 11 antennomeres, protibiae with setal fringes (Fig. 21), and no teeth on the pretarsal claws.

Material examined: **Chiang Mai Province:** Doi Inthanon National Park, Nam Mae Aep above Rd 1009, 18°31'N 98°36'E, 630 m, 8 June 2002, Thamsenanupap (1 EMEC).

Genus *Stenelmis* Dufour 1835
(Figs. 20, 35, 39D)

Discussion: *Stenelmis* is a large genus that currently comprises 175 species and is nearly cosmopolitan, but is missing only from the Neotropics. The genus was not previously known from Thailand, and we have examined *S. seres* Hinton 1941 and many more undetermined species from 21 provinces. *Stenelmis* is common in gravel substrates but can also be found in other microhabitats. The genus occurs throughout Thailand in suitable habitats. *Stenelmis*

lacks both a protibial setal fringe (Fig. 20) and accessory striae on the elytra (Fig. 35). It is highly variable in color and size.

Material examined: Chaiphaphum Province: Phu Khieo Wld. Sanctuary, Nam Prom, 16°27.71'N 101°39.32'E, 1735 ft, 12 March 1994, WDS-A-1037 (3 KUEC, 3 DNP-13783, 3 THNHM-I-1322–1324, 33 EMEC); same data except 4 April 1994, WDS-A-1053 (8 EMEC). **Chanthaburi Province:** Khao Soi Dao Wildlife Sanctuary, stream from Namtok Khao Soi Dao, 13°5.810'N 102°10.332'E, 523 m, 17 January 2016, R.W. Sites, L-1911 (4 UMC). **Chiang Mai Province:** Amphoe Doi Saket, Nam Kuang, 19°00.015'N 99°17.163'E, 554 m, 15 May 2004, Vitheepadit & Prommi, L-689 (2 KUEC, 2 DNP-13783, 2 THNHM-I-1325–1326, 5 UMC); 100 km N Chiang Mai, Chiang Dao Hill Resort, 650 m, 28 May 2009, S. Murzin (10 KUEC, 10 DNP-13783, 10 THNHM-I-1327–1336, 27 EMEC); Suanrin, Nam Mae Sa, 18°54.09'N 98°53.08'E, 1600 ft, 25 March 1994, W.D. Shepard, WDS-A-1046 (1 EMEC); Mae Fang National Park, creek behind dam, 19°58'N 99°09'E, 535 m, 26 March 2003, Sites, Vitheepadit, Prommi, L-418 (4 UMC); Fang Horticulture Exp. Farm, Nam Mae Chai, 19°57'N 99°09'E, 600 m, 17 March 2002, R.W. Sites, L-301 (1 UMC); same data except 26 March 2003, Sites, Vitheepadit, Prommi, L-419 (2 UMC); Doi Inthanon National Park, Huay Sai Lueung Waterfall, 18°31'N 98°27'E, 1060 m, 4 April 2002; UMC & CMU teams, L-322 (1 UMC); same data except 3 IV 2003, L-443 (2 UMC); same data except stream 200 m W of Huay Sai Lueung Waterfall, 4 April 2002, L-323 (2 UMC); Doi Inthanon National Park, Nam Mae Aep above hwy 1009, 18°32'N 98°32'E, 630 m, 5 October 2002, P. Thamsenanupap (1 UMC); Doi Inthanon National Park, Mae Pan at Ban Mae Pan Noi, 750 m, 14 January 2003, P. Thamsenanupap (1 UMC); Doi Inthanon National Park, Mae Pan Noi, at Ban San Pathana, bedrock, stream, 18°31'N 98°25'E, 750 m, 4 April 2003, UMC and CMU teams, L-446 (1 UMC); Doi Inthanon National Park, Siriphum Waterfall, 18°32'N 98°31'E, 1380 m, 2 March 2002, Vitheepadit, Kirawanich, L-251 (1 UMC); same data except 26 June 2002, R.W. Sites, L-412 (2 UMC); same data except 1460 m, 21 March 2002, L-314 (7 UMC); same data except 3 April 2003, UMC and CMU teams, L-441 (2 UMC); Doi Inthanon National Park, Namtok Sop Ab, 4 March 2002, 18°31'N 98°36'E, 543 m, N. Changthong, L-258 (1 UMC), same locality, above Rd. 1009 (2 UMC); same data except Mae Klang River at Sob Ab Waterfall, 3 April 2002, UMC & CMU teams, L-318 (1 UMC); same data except 2 April 2003, L-435 (1 UMC); same data except 17 May 2004, Vitheepadit, Prommi, Laudee, Thamsenanupap, L-691 (1 UMC); Doi Inthanon National Park, Mae Klang at Ban Khun Klang, 18°31.259'N 98°31.310'E, 1296 m, 18 May 2004, Vitheepadit, Prommi, Laudee, Thamsenanupap, L-694 (2 UMC); Doi Inthanon National Park, Mae Klang River at Ecolodge, 18°32'N 98°32'E, 1000 m, 2 April 2003, UMC and CMU teams, L-437 (6 UMC); Doi Suthep-Pui National Park, 24 March 1994, Monthatarn Falls, W.D. Shepard, WDS-A-1044 (1 EMEC); Doi Suthep National Park, 1312 ft, 25 March 1994, Mae Sa Falls, 18°54.39'N 98°53.91'E, WDS-A-1045 (23 EMEC); Doi Suthep-Pui National Park, Namtok Monthathan, 18°49'N 98°55'E, 700 m, 19 May 2004, Vitheepadit, Prommi, Laudee, L-697 (1 UMC); Doi Suthep-Pui National Park, Namtok Mok Fah, 600 m, 19°06'N 98°46'E, 27 June 2002, Sites, Arnon, Thamsenanupap, Prommi, stream from waterfall, L-414 (4 UMC); Doi Suthep National Park, Sai Yoi Waterfall, 18°48'N 98°55'E, 1100 m, 4 April 2003, Sites, Vitheepadit, Prommi, Setaphan, L-447 (1 UMC); Doi Suthep-Pui National Park, Wang Bua Boon, 18°48.74'N 98°56.51'E, 1832 ft, 24 March 1994, W.D. Shepard (3 EMEC); Doi Suthep-Pui National Park, 24 March 1994, Huay Sa Lad, 18°48.31'E 98°54.52'E, 3594 ft, W.D. Shepard, WDS-A-1043 (2 EMEC). **Kamphaeng Phet Province:** Khlong Lan National Park, Khlong, Nam Lai Waterfall, 16°11'N 99°15'E, 6 April 2003, Sites, Vitheepadit, Prommi, Setaphan, L-448 (1 UMC). **Kanchanaburi Province:** Amphoe Thong Pha Phum, Huay Ou Long, stream, 14°46'N 98°40'E, 139 m, 11 April 2002, UMC and CMU teams, L-332 (1 UMC); Amphoe Sai Yok, Thong Pha Phum Reforestation Station, Mae Nam Noi, 14°31'N 98°37'E, 204 m, 10 April 2003, UMC and CMU teams, L-462 (4 UMC); Huay Khayeng at Pasa Klang, 14°33.364'N 98°34.335'E, 296 m, 4 June 2006, Vitheepadit & Prommi, L-915 (8 UMC); Amphoe Thong Pha Phum, Huay Khayeng at Ban Padsadoo Klang, stream, 14°33'N 98°34'E, 296 m, 26 May 2003, Vitheepadit & Prommi, L-717 (1 UMC). **Lampang Province:** Jae Sawn National Park, Namtok Jae Sawn, 18°50'N 99°28'E, 650 m, 16 March 2002, R.W. Sites, L-297 (1 UMC); Jae Sawn

National Park, Namtok Jae Sawn, 18°50'N 99°28'E, 650 m, 27 March 2003, Sites, Vitheepradit, Prommi, L-421 (1 UMC). **Loei Province:** Ma Nam Loei at Ban Huay Nam Une, 11 June 1998, Sites, Simpson, Vitheepradit, muddy riv. w/ gravel & veg., L-180 (1 EMEC); 5 km E of Loei, unnamed stream, 17°28'N 101°41'E, 9 March 1994, W.D. Shepard, WDS-A-1033 (3 EMEC). **Mae Hong Son Province:** Namtok Mae Surin National Park, Mae Nam Pai, 19 March 2002, 19°21'N 97°59'E, 310 m, R.W. Sites, L-307 (4 UMC); same data except CMU Team (1 EMEC); same data except Sites, Vitheepradit, Kirawanich, mercury vapor light, L-308 (1 UMC); Huay Pha, 18 km N Mae Hong Son, 19°25'N 97°59'E, 340 m, 19 March 2002, Sites, Vitheepradit, Kirawanich, L-306 (1 UMC); Namtok Maw Pang, 19°22'N 98°22'E, 850 m, 19 March 2002, R.W. Sites, L-305 (1 UMC); Huay Pha, <1 km N Ban Huay Pha, stream, 19°25.847'N 97°59.827'E, 360 m, 19 April 2009, Sites, Vitheepradit, Prommi, L-1049 (1 UMC); Tham Pla-Pha Seu National Park, Pha Seu Waterfall, 19°29'N 97°57'E, 415 m, 1 April 2003, UMC and CMU teams, L-432 (1 UMC). **Nan Province:** Amphoe Bo Kluea, Ban Bo Kluea Tai, Nam Mang, 19°09'N 101°09'E, 663 m, 22 April 2003, Vitheepradit, Prommi, Setaphan, L-476 (1 UMC). **Narathiwat Province:** stream 14 km W Srisakhon, 15 January 1995, Sites & Nichols, L-77 (1 EMEC). **Phatthalung Province:** ca. 3 km E Khao Chong Wild. Mgt. Stn. on Hwy 4, 12 January 1995, Sites & Nichols, L-69 (1 EMEC). **Phetchabun Province:** Nam Nao National Park, Huay Prom Laeng, 16°38'N 101°34'E, 800 m, 9 March 2002, R.W. Sites, L-276 (1 UMC); Phu Khieo National Park, Huay Ya Krua, 14 March 1994, W.D. Shepard, WDS-A-1039 (1 EMEC); 5 km E Sila, Mae Nam Pa Sak, 17°00.22'N 101°21.10'E, 774 ft, 3 April 1994, W.D. Shepard, WDS-A-1050 (1 EMEC); same data except 2 March 1994, WDS-A-1025 (1 EMEC); 2 km WNW Pha Biat, Tup Low, 16°32.65'N 101°51.07'E, 1478 ft, 5 April 1994, WDS-A-1055 (5 EMEC); Phu Hin Rongkla National Park, Waterwheel Falls, 27 March 1994, W.D. Shepard, WDS-A-1048 (1 EMEC). **Phitsanulok Province:** Ban Coke Puk Hwuan, Amphoe Chartrakan, unnamed river, 9 June 1998, Sites, Simpson, Vitheepradit, L-172 (1 EMEC); Phu Hin Rongkla National Park, Namtok Huay Khamuen Noi, 16°59'N 101°00'E, 1220 m, 22 May 2002 (1 UMC); Phu Hin Rongkla National Park, Waterwheel Falls, 16°59'N 101°00'E, 1280 m, 21 June 2002, CMU Team (1 UMC). **Phrae Province:** Wieng Ko Sai National Park, 28/29 October 2002, CMU Team (1 EMEC); Wieng Ko Sai National Park, Namtok Punjane (upper), 17°57'N 99°34'E, 285 m, 20 February 2002, CMU Team (1 UMC); same data except 22 July 2002 (1 UMC). **Prachin Buri Province:** Khao Yai National Park, Kaeng Wang Thong, 14°10.077'N 101°43.420'E, 12 m, 8 April 2004, Sites & Vitheepradit, L-608 (2 KUEC, 2 DNP-13783, 2 THNHM-I-1337–1338, 14 UMC); Khao Yai National Park, Ta Krow Waterfall, 14°11.099'N 101°35.632'E, 26 m, 8 April 2004, Sites & Vitheepradit, L-609 (1 UMC). **Prachuap Khiri Khan Province:** Amphoe Bang Saphan, stream from Kha On Waterfall, 11°26'N 99°26'E, 117 m, 18 May 2003, Vitheepradit & Ferro, L-544 (1 UMC). **Ratchaburi Province:** Amphoe Suan Phueng, 50 km W of Amphoe Chom Bueng on Hwy 3087, 13°34'N 99°15'E, 192 m, 16 April 2002, L-346, Vitheepradit & Kirawanich, L-346 (1 EMEC). **Surat Thani Province:** Amphoe Ban Na San, Ban Plai Nam, stream, 08°52.680'N 99°28.621'E, 168 m, 17 June 2004, Sites, Vitheepradit, & Prommi, L-775 (5 UMC); Tai Rom Yen National Park, Meung Toud Waterfall, 08°52.680'N 99°26.202'E, 98 m, 17 June 2004, Sites, Vitheepradit, & Prommi, L-776 (1 UMC). **Satun Province:** Kwandon District, Yaroy Waterfall, 9 July 1997, Sites & Permkam, stream w/ large rocks & sand, L-132 (1 EMEC). **Songkhla Province:** Khao Nam Khang, ca. 21 km SW Nathawi, 13 January 1995, Sites & Nichols, L-72 (1 EMEC); Ton Nga Chang Wild. Sanc., stream at Buddhist temple, 6 January 1995, Sites & Nichols, L-59 (1 EMEC); same data except 6 July 1997, R.W. Sites, L-127 (3 EMEC). **Yala Province:** Than To, Banglang National Park, 14 January 1995, Sites & Nichols, riffles in stream, L-73 (1 EMEC).

Genus *Urumaelmis* Satô 1963

(Figs. 36, 39C)

Discussion: *Urumaelmis* is monotypic and represented by *U. uenoi* Satô 1963, and was previously known only from the Ryukyu Islands of Japan (Satô, 1963). Thus, our records from three provinces in northern Thailand are a major range extension for the genus. We have

examined one morphospecies which probably represents an undescribed species. This genus is recognized by antennae with eight antennomeres, the pronotum with sublateral carinae, and the elytra apically truncate (Fig. 36).

Material examined: **Chiang Mai Province:** Doi Suthep Pui National Park, Monthatarn Falls, 24 March 1994 (1 EMEC); Doi Inthanon National Park, Nam Mae Aep above hwy 1009, 18°32'N 98°32'E, 630 m, 13 November 2002, P. Thamsenanupap (3 UMC). **Nan Province:** Doi Phu Kha National Park, Namtok Ton Tong, 19°12'N 101°04'E, 900 m, 13 March 2002, R.W. Sites, L-291 (1 EMEC, 1 UMC). **Phayao Province:** Doi Luang National Park, 23 June 2002, CMU Team (1 EMEC).

Genus *Zaitzevia* Champion 1923
(Figs. 37, 39C)

Discussion: *Zaitzevia* is a moderately-sized genus with 17 species. Fifteen of the species have distributions that include India through Southeast Asia, China, and Japan; the other two species occur in western North America. We have examined one undetermined species of *Zaitzevia* from disparate localities in southern and northern Thailand. *Zaitzevia* is recognized by antennae with eight antennomeres, labial palps with three palpomeres, and a unicolorous body.

Material examined: **Chaiyaphum Province:** Phu Khieo Wld. Sanct., Nam Prom, 16°27.71'N 101°39.32'E, 1735 ft, 4 April 1994, W. D. Shepard, WDS-A-1053 (9 EMEC); same data except 12 March 1994, WDS-A-1037 (6 EMEC). **Chiang Mai Province:** Fang Horticulture Exp. Farm, Nam Mae Chai, 19°57'N 99°09'E, 600 m, 17 March 2002, R.W. Sites, L-301 (1 UMC); Doi Inthanon National Park, Huay Sai Luang nr Pagoda, 18°33'N 98°29'E, 2100 m, 16 October 2002, G.W. Courtney (1 EMEC); Doi Inthanon National Park, Namtok Siriphum, 18°32'N 98°31'E, 1460 m, 2 March 2002, G.W. Courtney (1 EMEC); same data except level 2, 1460 m, 21 March 2002, R.W. Sites, L-314 (2 UMC); Doi Suthep National Park, Namtok Monthathan, 18°49'N 98°55'E, 700 m, 5 March 2002, Vitheepadit, Kirawanich, Sites, L-263 (1 UMC). **Nan Province:** Doi Phu Kha National Park, Namtok Ton Thong, 19°12'N 101°04'E, 900 m, 21 April 2003, Vitheepadit, Prommi, Setaphan, L-472 (2 UMC); Mae Charim National Park, Nam Wa River, 18°36'N 100°59'E, 335 m, 13 March 2002, R.W. Sites, L-293 (2 UMC). **Phetchabun Province:** 5 km E Sila, Mae Nam Pa Sak, 17°00.22'N 101°21.10'E, 774 ft, 3 April 1994, W.D. Shepard, WDS-A-1050 (6 EMEC); Phu Khieo National Park, Huay Ya Krua, 14 March 1994, W.D. Shepard, WDS-A-1039 (4 EMEC); Nam Nao National Park, Prom Laeng, 16°36.74'N 101°58.29'E, 22 March 1994, W.D. Shepard, WDS-A-1040 (4 EMEC). **Sakhon Nakhon Province:** 11 km NE Ban Kham Poem, Huay Ya, 17°01.24'N 103°59.57'E, 5 March 1994, W. D. Shepard, WDS-A-1027 (2 EMEC). **Songkhla Province:** Ton Nga Chang Wild. Sanc., 6 July 1997, R.W. Sites, stream at Buddhist temple, L-127 (1 UMC); same data except L-243 (1 UMC).

Genus *Zaitzeviaria* Nomura 1959
(Figs. 38, 39C)

Discussion: *Zaitzeviaria* is a moderately-sized genus with 13 species that occurs from Sri Lanka to Japan. It is remarkably similar to *Zaitzevia* from which it can be distinguished by the position of the sublateral carinae on the elytra; the two genera might be synonymous. We have examined one morphospecies from widely separated localities in Thailand.

Material examined: **Chaiyaphum Province:** Phu Kheio Wld. Sanctuary, Nam Prom, 16°27.71'N 101°39.32'E, 1735 ft, 4 April 1994, WDS-A-1053 (1 EMEC); same data except 12 March 1994, WDS-A-1037 (1 EMEC). **Chiang Mai Province:** Suanrin, Nam Mae Sa, 18°54.09'N 98°53.08'E, 1600 ft, 25 March 1994, W.D. Shepard, WDS-A-1046 (1 EMEC); Chiang Dao W. R., Res. Stn., 19.361°N 98.921°E, 500 m, 13 July 2002, G.W. Courtney; Doi Suthep-Pui National Park, 24 March 1994, Monthatarn Falls, W. D. Shepard, WDS-A-1044 (1 EMEC). **Narathiwat Province:** stream 14

km W Srisakhon, 15 January 1995, Sites & Nichols, L-77 (1 EMEC). **Phetchabun Province:** 5 km E Sila, Mae Nam Pa Sak, 17°00.22'N 101°21.10'E, 774 ft, 3 April 1994, W.D. Shepard, WDS-A-1050 (5 EMEC). **Yala Province:** Than To, Banglang National Park, 14 January 1995, Sites & Nichols, riffles in stream, L-73 (1 EMEC).

Subfamily **Larainae** LeConte 1861

Adult laraines, unlike adult elmines, are most often associated with large rocks and boulders in fast-flowing water. This water entrains air bubbles that are trapped against the surface structures on the insect. The bubbles on the surface of the beetles then function as a “physical gill” that extracts dissolved oxygen from the water. Thus, these beetles are invariably associated with substrates in fast-flowing, well-oxygenated water. The beetles have the ability to leave the water and fly into areas of faster water if they are dislodged or if the water flow decreases. They have the common name “cascade beetles” in reference to their preferred microhabitat. Larvae are found in the same microhabitat with adults or on submerged wood, and usually are dorsoventrally flattened to minimize their exposure to the current in fast water. Adult life spans are unknown because laraines do not accumulate encrustations, which typically indicates long periods of time under water.

Genus ***Dryopomorphus*** Hinton 1936 (Figs. 19, 25, 39D)

Discussion: *Dryopomorphus* is a moderately-sized genus with 14 species that occurs in Laos, Malaysia, Thailand, and Japan. Only *D. siamensis* Kodada 1993 previously has been reported from Thailand (KODADA, 1993). Herein, we add *D. bishopi* Hinton 1971 from Kanchanaburi Province. *Dryopomorphus* is common in leaf packs trapped by rocks in fast water. The genus can be distinguished from *Potamophilinus*, the only other laraine in Thailand, by the absence of a short accessory stria on the elytra and absence of carinae or sulci on the pronotum.

Material examined: **Chiang Mai Province:** Doi Suthep-Pui National Park, Huay Kaew at Namtok Sai Yoi, 18°48'N 98°55'E, 1100 m, 8 October 2002, Thamsenanupap (1 EMEC); Doi Suthep-Pui National Park, Namtok Monthatharn, 18°49'N 98°55'E, 700 m, 16 November 2002, Thamsenanupap (1 EMEC). **Kanchanaburi Province:** Amphoe Thong Pha Phum, Ban Padsadoo Klang, 6.3 km W of Border Police Station, 14°32.399'N 98°32.753'E, 568 m, 4 June 2006, Sites, Vitheepadit, Prommi, L-913 (1 EMEC).

Genus ***Potamophilinus*** Grouvelle 1896 (Figs. 14, 16, 18, 33, 39C)

Discussion: *Potamophilinus* comprises 13 species and is distributed from Sri Lanka through Southeast Asia and into China. Although the genus previously has not been reported from Thailand, we have collected *P. longipes* (Grouvelle, 1892) from throughout the country. This species is also known from Myanmar. *Potamophilinus* is commonly found on wood that is partially submerged and also can be collected at lights at night. *Potamophilinus* can be distinguished from *Dryopomorphus*, the only other laraine in Thailand, by the carinae or sulci on the pronotum and short accessory stria on the elytra (Fig. 33).

Material examined: **Chiang Mai Province:** Doi Inthanon National Park, Namtok Sob Ab, 18°31.775'N 98°36.488'E, 543 m, 17 May 2004, Vitheepadit & Prommi, L-690 (5 KUEC, 5 DNP-13785, 5 THNHM-I-1340–1344, 3 EMEC, 30 UMC); Doi Inthanon National Park, Mae Klang, River at Sob

Ab Waterfall, 18°31'N 98°36'E, 543 m, 17 May 2004, Vitheepradit, Prommi, Laudee, Thamsenanupap, L-691 (5 KUEC, 5 DNP-13785, 5 THNHM-I-1345–1349, 45 UMC). **Kalasin Province:** Phu Pan National Park, Huay Yai Namtok, 5 June 1998, Sites, Simpson, Vitheepradit, stream w/ waterfall & veg. L-154 (12 UMC); same data except 7 June 1998, sheeting water film on rock, L-164 (4 UMC). **Kamphaeng Phet Province:** Khlong Lan National Park, Namtok Khlong Lan, 16°07'N 99°16'E, 310 m, 21 August 2002, CMU team (1 UMC), same locality 19 July 2002 (1 UMC); Mae Wong National Park, 20 October 2002, G.W. Courtney (1 EMEC). **Loei Province:** Phu Rua National Park, Namtok Hin Sam Chan, 10 June 1998, Sites, Simpson, Vitheepradit, L-176 (1 EMEC). **Mae Hong Son Province:** Namtok Mae Surin (2 EMEC). **Phetchaburi Province:** Kaeng Ka Chan National Park, Pranburi stream at Ban Krang, 12°48.037'N 99°26.557'E, 380 m, 28 May 2004, Vitheepradit & Prommi, L-721 (1 UMC). **Phitsanulok Province:** Chat Trakan Waterfall, 9 June 1998, Sites, Simpson, Vitheepradit, spillway over rock, L-170 (15 KUEC, 15 DNP-13785, 15 THNHM-I-1350–1364, 70 UMC). **Phrae Province:** Mae Kham Waterfall, 18°07.635'N 100°17.741'E, 300 m, 14 May 2004, Vitheepradit & Prommi, L-686 (2 UMC); Wieng Ko Sai National Park, lower Namtok Mae Khueng Luang, 17°58'N 99°35'E, 400 m, 28–29 September 2002 (3 EMEC). **Prachuap Khiri Khan Province:** Amphoe Bang Saphan, Tambon Tong Mongkol, Moo Ban Tong Mongkol, 11°14'N 99°22'E, 73 m, 23 April 2002, Vitheepradit & Kirawanich, L-362 (1 EMEC); Namtok Huay Yang National Park, Kha On Waterfall, 11°27.047'N 99°25.040'E, 119 m, 29 May 2004, Vitheepradit & Prommi, L-727 (4 UMC). **Ranong Province:** Thung Raya-Nasak WS, Bok Krai Waterfall, 10°22.537'N 98°51.410'E, 79 m, 14 June 2004, Sites, Vitheepradit, & Prommi, L-766 (3 UMC). **Trang Province:** Namtok Tontae, 7°19'N 99°58'E, 17 October 1994, G.W.Courtney (1 EMEC).

Genera of possible occurrence in Thailand

Political instability has limited collecting in areas along some of Thailand's borders. These areas have higher likelihood of harboring genera not recorded from Thailand. Below are genera known from neighboring countries that might also occur in Thailand.

Dryopidae

Geoparnus Besuchet, 1978. This terrestrial genus is known from peninsular Malaysia

Spalacosostea Kodada, 1996. This terrestrial genus is known from Sumatra and East Malaysia.

Elmidae

Hedyselmis Hinton, 1976. This genus is known from West Malaysia (ČIAMPOR & ČIAMPOROVÁ-ZAŘOVIČOVÁ, 2008).

Okalia Kodada & Čiampor, 2003. This genus is known from Pahang, peninsular Malaysia (KODADA & ČIAMPOR, 2003).

Podelmis Hinton, 1941. This genus is known from India, Sri Lanka, and Malaysia (JACH ET AL., 2016).

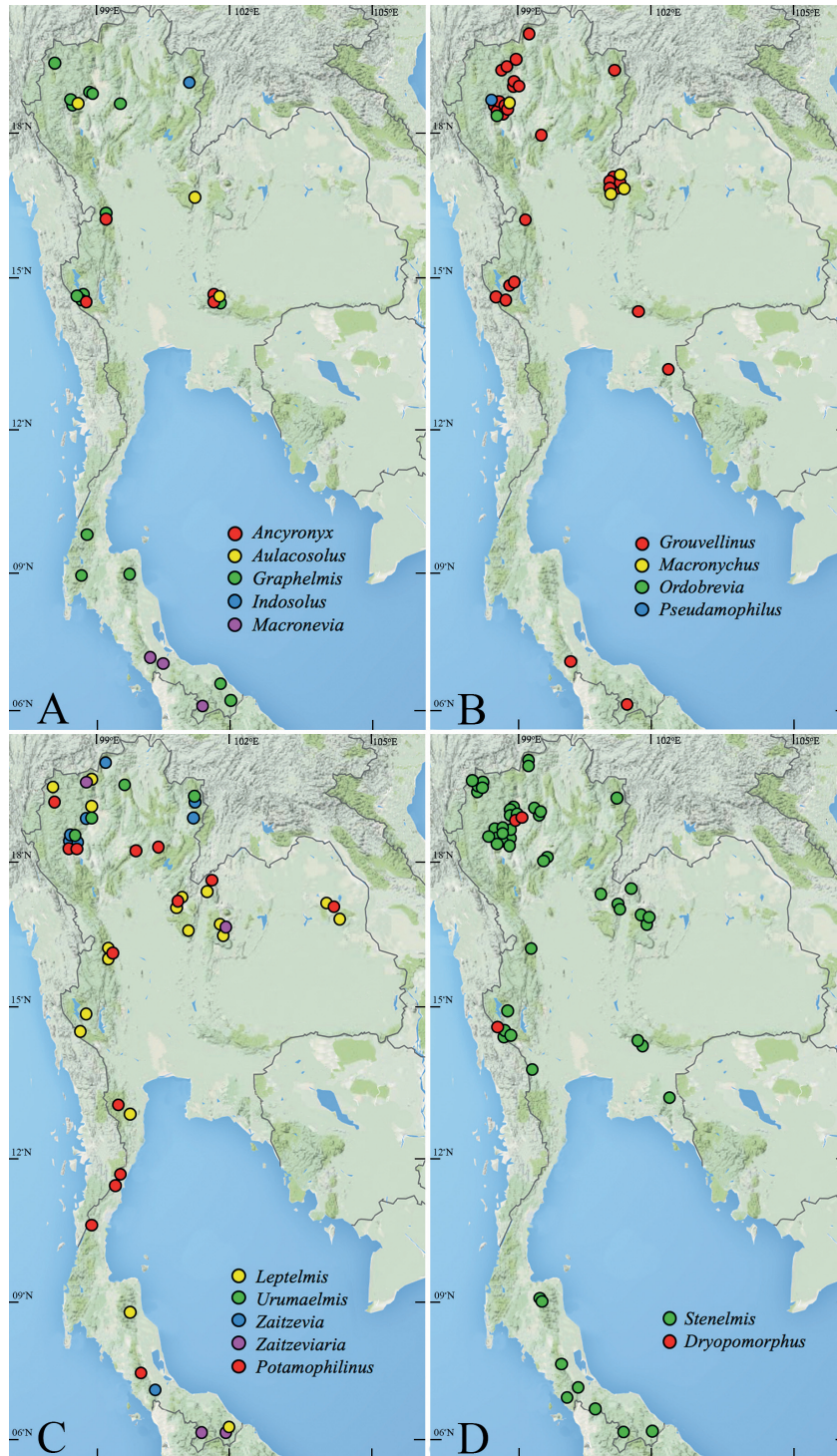


Figure 39. Distribution records of genera of Elmidae. All records based on specimens examined except *Aulacosolus* taken from original description. Multiple records from the same location not indicated here.

DISCUSSION

Thailand is situated within the Oriental Zoogeographic Realm, which is subdivided into smaller ecological regions. The Thai fauna is associated with two latitudinally distinct regions with a transition zone near the Isthmus of Kra. The Indochinese fauna is to the north and the Sundaic fauna to the south, with the position of the transition differing among the taxa being considered (see WOODRUFF, 2003). At the generic level, some of the dryopid and elmid taxa appear to be associated with one fauna or the other, whereas others are more widespread. For example, an Indochinese faunistic affinity is evident for *Parahelichus*, *Macronychus*, *Pseudamophilus* and *Urumaelmis*, whereas a Sundaic affinity is clear for *Macronevia*. Other genera such as *Elmomorphus* and *Potamophilinus* are more widespread in their distribution and not exclusively associated with either regional fauna.

Areas with high levels of diversity and endemism in Thailand are well known and most have been conserved as national parks or other designations that receive federal protection. Conservation of the vertebrates and other charismatic megabiota in Thailand has been enabled by the near-complete knowledge of the constituent fauna and flora. Although the less charismatic entomofauna is far more prevalent in diversity, biomass, and effects on ecosystem function, our knowledge of this fauna is grossly inadequate when compared with that of the vertebrates. That our work has more than doubled the known fauna at the level of genus in this small group of beetles is testament that faunistic research on Thai insects is in its infancy. As a result, conservation planning is necessarily being carried out in ignorance of this fauna. The clear way to resolve this knowledge disparity is by expeditiously allowing access and providing resources to qualified scientists with taxonomic expertise to conduct faunistic studies on insects and other biota with inherently less superficial appeal.

Collections of dryopid and elmid beetles as well as aquatic true bugs (Heteroptera: Nepomorpha) suggest that both Doi Inthanon (Chiang Mai Province) and Phu Hin Rongkla (Loei, Phetchabun, and Phitsanulok provinces) are areas with especially high levels of endemism for these groups. In particular, Doi Inthanon is a nexus of overlapping distribution patterns for various aquatic insects (SITES, 2005) and is a protected area of high importance (KITCHING, 1996). Further, every taxon that we collected from a small stream in Phu Hin Rongkla was undescribed and endemic (e.g. SITES & POLHEMUS, 2001). In addition to the array of areas under federal protection, other areas such as Khao Pok Yo (Yala and Narathiwat provinces) and Doi Pa Hom Pok (Chiang Mai Province) have been suggested as important for biodiversity conservation (KITCHING, 1996). Because Thailand has many areas of endemism and overlaps two major biotic regions, it stands to reason that the country's diversity across most major groups of biota is especially high. Further, given the incomplete collecting throughout Indochina, it is not surprising that our studies have more than doubled the number of genera of dryopids and elmids known from Thailand. We anticipate more genera will be discovered, especially along border areas and in areas of known high biodiversity and endemism.

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REFERENCES

- ARBHABHIRAMA, A., D. PHANTUMVANIT, J. ELKINGTON, AND P. INGKASUWAN. 1988. *Thailand: Natural Resources Profile*. Oxford University Press, Singapore. 431 pp.
- BARR, C. B., AND P. J. SPANGLER. 1992. A new genus and species of stygobiontic dryopid beetle, *Stygoparnus comalensis* (Coleoptera: Dryopidae), from Comal Springs, Texas. *Proc. Biol. Soc. Washington* 105(1): 40–54.
- BATZER, D. P. 1995. Aquatic macroinvertebrate response to short-term habitat loss in experimental pools in Thailand. *Pan-Pac. Entomol.* 71(1): 61–63.
- BESUCHT, C. 1978. Description d'un Dryopide terrestre nouveau de la Malaisie (Coleoptera). *Rev. Suisse Zool.* 85(4): 705–709.
- BILLBERG, G. J. 1820. *Enumeratio Insectorum in Musee Gust. Joh. Billberg*. Typus Gadelianis, Stockholm. 138 pp.
- BOONSOONG, B., AND D. BRAASCH. 2013. Heptageniidae (Insecta, Ephemeroptera) of Thailand. *ZooKeys* 272: 61–93.
- BOONSOONG, B., AND D. CHAINTHONG. 2014. Description of the last stadium larva and female of *Microgomphus thailandica* Asahina, 1981 (Odonata: Gomphidae). *Zootaxa* 3811: 271–279.
- BOONSOONG, B., N. SANGPRADUB, AND M. T. BARBOUR. 2009. Development of rapid bioassessment approaches using benthic macroinvertebrates for Thai streams. *Environ. Monit. and Assess.* 155: 129–147.
- BOONSOONG, B., N. SANGPRADUB, M. T. BARBOUR, AND W. SIMACHAYA. 2010. An implementation plan for using biological indicators to improve assessment of water quality in Thailand. *Environ. Monit. and Assess.* 165: 205–215.
- BOLLOW, H. 1940. Monographie der palaearktischen Dryopidae, mit Berücksichtigung der eventuell transgredierenden Arten. (Coleoptera). *Mitt. Münch. Entomol. Ges.* 30: 24–71.
- BROWN, H. P. 1987. Biology of riffle beetles. *Ann. Rev. Entomol.* 32: 253–273.
- CHAMPION, G. C. 1923. Some Indian Coleoptera (11). *Entomol. Mon. Mag. London* 59: 165–179.
- ČIAMPOR, F. 2001. Systematic revision of the genus *Graphelmis* (Coleoptera: Elmidae) I. Redescription of the genus and description of four new species. *Entomol. Prob.* 32: 17–32.
- ČIAMPOR, F. 2003. Systematic revision of the genus *Graphelmis* (Coleoptera: Elmidae) III. *Graphelmis labralis* species group. *Entomol. Prob.* 33:31–44.
- ČIAMPOR, F. 2004. Systematic revision of the genus *Graphelmis* (Coleoptera: Elmidae) IV. *Graphelmis scapularis* and *Graphelmis clermonti* species groups. *Entomol. Prob.* 34: 1–20.
- ČIAMPOR, F., AND I. RIBERA. 2006. *Hedyselmis opis*: description of the larva and its phylogenetic relations to *Graphelmis* (Coleoptera: Elmidae: Elminae). *Eur. J. Entomol.* 103: 627–636.
- ČIAMPOR, F., AND J. KODADA. 1998. Elmidae: I. Taxonomic revision of the genus *Macronychus* Müller (Coleoptera). *Water Beetles of China* 2: 219–287.
- ČIAMPOR, F., AND J. KODADA. 2004. Systematic revision of the genus *Graphelmis* (Coleoptera: Elmidae) V. *Graphelmis picta* species group. *Entomol. Prob.* 34: 55–102.
- ČIAMPOR, F., JR., AND Z. ČIAMPOROVÁ-ZAŤOVICOVÁ. 2008. A new species of *Hedyselmis* Hinton and notes on the phylogeny of the genus (Coleoptera: Elmidae). *Zootaxa* 1781: 55–62.
- CRANSTON, P. S. 2007. The Chironomidae larvae associated with the tsunami-impacted waterbodies of the coastal plain of southwestern Thailand. *Raffles Bull. Zool.* 55(2): 231–244.

- CURTIS, J. 1830. *British Entomology; being illustrations and descriptions of the genera of insects found in Great Britain and Ireland: containing coloured figures from nature of the most rare and beautiful species, and in many instances of the plants upon which they are found*. Volume 7, 290–338. J.H. Curtis, London.
- DELÈVE, J. 1968. Dryopidae et Elminthidae (Coleoptera) du Vietnam. *Ann. Hist.-Natur. Mus. Nat. Hungarici Zool.* 60: 149–181.
- DELÈVE, J. 1970. Contribution a l'Etude des Dryopoidea. XXI. Elminthidae (Coleoptera) peu ou mal connus de l'Indonésie et du Vietnam. *Bull. Ann. Soc. Royal Belge Entomol.* 106: 235–273.
- DELÈVE, J. 1973. Limnichidae, Dryopidae et Elminthidae des Iles Philippines et de l' Archipel Bismarck (Insecta, Coleoptera, Dryopoidea). *Steenstrupia* 3: 17–30.
- DUFOUR, M. L. 1835. Recherches anatomiques et considerations entomologiques sur les insectes des genres *Macronique* et *Elmis*. *Ann. Sci. Natur. Ser. 2*, 2: 151–174.
- ELLIOT, J. M. 2008. The ecology of riffle beetles (Coleoptera: Elmidae). *Freshwater Rev.* 1: 189–203.
- ERICHSON, W. H. 1847. Naturgeschichte der Insecten Deutschlands. *Abteilung I, Coleoptera* 3: 481–640.
- FAIRMAIRE, M. L. 1888. Descriptions de Coléoptères de l'Indo-Chine. *Ann. Soc. Entomol. France* 6: 333–378.
- FERRO, M. L., AND R. W. SITES. 2006. Description of the larva of *Gomphidictinus perakensis* (Laidlaw) (Odonata: Gomphidae), with distributional notes. *Proc. Entomol. Soc. Washington* 108(1): 76–81.
- GLAISTER, A. 1985. Laboratory rearing of Australian elm mid larvae (Elmidae: Coleoptera). *Aust. Soc. Limnol. Bull.* 10: 51–58.
- GOSE, K. 1969. Mayflies (Ephemeroptera) from Thailand. *Nat. Life Southeast Asia* 6: 125–138.
- GROUVELLE, M. A. 1892. Viaggio di Leonardo Fea in Birmania e regioni vicine. L. Nitidulides, Cucujides et parnides. 2me Partie. *Annali del Museo Civico di Storia Naturale de genova, Series 2*, 32: 831–868.
- GROUVELLE, M. A. 1896. Remarques synonymiques sur les Dryopides, Helmides, Heterocérides et spécialement sur les types de la collection Kuwert. *Bull. Soc. Entomol. France* 1896: 75–78.
- HINTON, H. E. 1935. Notes on the Dryopoidea (Col.). *Stylops* 4: 169–179.
- HINTON, H. E. 1936. New Dryopidae from the Japan Empire (Coleoptera). *Entomologist* 68: 164–168.
- HINTON, H. E. 1940. A synopsis of the genus *Macronychus* Müller (Coleoptera, Elmidae). *Proc. Royal Entomol. Soc. London* (B), 9(7): 113–119.
- HINTON, H. E. 1941. New genera and species of Elmidae (Coleoptera). *Trans. Royal Entomol. Soc. London*, 91: 65–104.
- HINTON, H. E. 1971. The species of *Dryopomorphus* (Coleoptera, Elmidae). *Entomologist* 104: 293–297.
- HINTON, H. E. 1976. *Hedyselmis*, a new genus of Elmidae (Coleoptera) from Malaysia. *Syst. Entomol.* 1: 259–261.
- JÄCH, M. A. 1993. *Ancyronyx* (Coleoptera: Elmidae) – The spider riffle beetle of the Malaysian forest rivers. *Nat. Malaysiana* 18: 86–89.
- JÄCH, M. A. 1994. A taxonomic review of the Oriental species of the genus *Ancyronyx* Erichson, 1847 (Coleoptera, Elmidae). *Rev. Suisse Zool.* 101: 601–622.
- JÄCH, M. A. 2003. *Ancyronyx*, Erichson: New faunistic records, and description of a new species from Sulawesi (Indonesia) (Coleoptera: Elmidae). *Koleopterol. Rundsch.* 73: 255–260.
- JÄCH, M. A., AND D. S. BOUKAL. 1996. Description of two new beetle genera from peninsular Malaysia (Elmidae). *Koleopterol. Rundsch.* 66: 170–189.
- JÄCH, M. A., AND D. S. BOUKAL. 1997. Description of two new genera of Macronychini: *Aulacosolus* and *Nesonychus* (Coleoptera: Elmidae). *Koleopterol. Rundsch.* 67: 207–224.
- JÄCH, M. A., J. KODADA, M. BROJER, W. D. SHEPARD, AND F. ČIAMPOR, JR. 2016. *World Catalogue of Insects. Vol. 14. Coleoptera: Elmidae and Protelmidae*. Brill, Leiden. 265 pp.
- JACOBSON, A. J., J. PHASUK, J. CHANPAISAENG, AND G. W. COURTNEY. 2006. The net-winged midges (Diptera: Blephariceridae) of Kao Yai National Park, Thailand, with description of a new species of *Blepharicera* Macquart. *Aquat. Insects* 28: 67–78.
- KITCHING, I. 1996. Identifying complementary areas for conservation in Thailand: an example using owls, hawkmoths and tiger beetles. *Biodivers. Conserv.* 5: 841–858.
- KODADA, J. 1992. *Pseudomaphilus davidi* sp. n. from Thailand (Coleoptera: Elmidae). *Linzer biol. Beiträge* 24: 359–365.
- KODADA, J. 1993. *Dryopomorphus siamensis* sp. nov., a new riffle beetle from Thailand (Coleoptera: Elmidae) and remarks on the morphology of the mouthparts and hind wing venation of *D. bishopi* Hinton. *Entomol. Probl.* 24: 51–58.
- KODADA, J. 1996. *Spalacosostea*, an anomalous new terrestrial dryopid from South-east Asia (Coleoptera: Dryopidae). *Rev. Suisse Zool.* 103(1): 581–605.

- KODADA, J., AND F. ČIAMPOR. 2003. *Okalia globosa*, a new genus and species of Macronychini from Malaysia (Insecta: Coleoptera: Elmidae). *Rev. Suisse Zool.* 110(4): 783–795.
- KODADA, J., M. A. JÄCH, AND F. ČIAMPOR. 2003. Dryopidae: *Stenomystax*, a new aquatic genus (Coleoptera). *Water Beetles of China* 3: 431–472.
- LECONTE, J. L. 1861. Classification of the Coleoptera of North America. *Smithson. Misc. Coll.* 136. 208 pages.
- LOJKOVÁ, S., P. DEGMA AND J. KODADA. 2014. Morphometry and redescription of *Parahelichus granulatus* (Delève, 1974) with description of *P. pseudogranulosus*, a new cryptic species of long-toed water beetles (Coleoptera: Dryopidae) from Indochinese peninsula, and proposal of a new synonym for *Præhelichus sericatus* (Waterhouse, 1881) from China. *Zootaxa* 3852(4): 475–488.
- MALICKY, H., AND P. CHANTARAMONGKOL. 2003. Vierzehn neue Kocherfliegen aus Thailand (Trichoptera). *Linzer biol. Beiträge* 35: 915–925.
- MALICKY, H., P. CHANTARAMONGKOL, N. CHANGTHONG, AND P. THAMSENANUPAP. 2005. Neun neue Kocherfliegen aus Thailand (Trichoptera). *Linzer biol. Beiträge* 37: 597–604.
- MALICKY, H., P. CHANTARAMONGKOL, P. BUNLUE, N. CHANGTHONG, J. NAWVONG, A. NUNTAKWANT, T. PROMMI, P. THAMSENANUPAP, AND D. THAPANYA. 2004. 27 neue Kocherfliegen aus Thailand (Insecta: Trichoptera) *Linzer biol. Beiträge* 36: 287–304.
- MORSE, J. C., Y. J. BAE, G. MUNKHJARGAL, N. SANGPRADUB, K. TANIDA, T. S. VSHIVKOVA, B. WANG, L. YANG, AND C. M. YULE. 2007. Freshwater biomonitoring with macroinvertebrates in East Asia. *Frontiers Ecol. Environ.* 5: 33–42.
- MÜLLER, Ph. 1806. *Macronychus*, Krallenkäfer. Eine neue Käfergattung. *Illiger's Mag. Insekten.* 5: 207–220.
- MUSTOW, S. E. 1999. Lotic macroinvertebrates assemblages in northern Thailand: altitudinal and longitudinal distributions and the effects of pollution. *Nat. Hist. Bull. Siam Soc.* 47: 225–252.
- MUSTOW, S. E. 2002. Biological monitoring of rivers in Thailand: use and adaptation of the BMWP score. *Hydrobiologia* 479: 191–229.
- NOMURA, S. 1959. Notes on the Japanese Dryopoidea (Coleoptera). II. *Tôhō-Gakuhô* 9: 33–38.
- OLIVER, G. A. 1791. Encyclopédie méthodique. *Hist. Natur. Insectes* 6: 1–368.
- PHASUK, J., J. CHANPAISAENG, AND G. W. COURTNEY. 2004 (2006). A preliminary report of black flies (Diptera: Simuliidae) of Khao Yai National Park, Thailand. *Thai J. Agric. Sci.* 37: 109–117.
- PIC, M. 1923. Nouveautés diverses. *Mélanges exotico-Entomologiques* 39: 1–32.
- RATTANARITHIKUL, R., B. A. HARRISON, P. RANTHUSIRI, AND R. E. COLEMAN. 2005. Illustrated keys to the mosquitoes of Thailand I. Background; Geographic distribution; lists of genera, subgenera, and species; and a key to the genera. *Southeast Asian J. Trop. Med. Public Health*, Vol. 36, Supplement 1: 1–80.
- REITTER, E. 1886. Drei neuen elmiden von Sumatra. *Notes Leyden Mus.* 8: 213–214.
- ROZKOSNY, R., AND G. W. COURTNEY. 2005. New records of *Plecticus* species from Thailand including description of a new species (Stratiomyidae, Diptera). *Acta Zool. Acad. Sci. Hungaricae* 51: 343–348.
- SANDERSON, M. W. 1953. A revision of the Nearctic genera of Elmidae. *J. Kansas Entomol. Soc.* 26: 148–163.
- SATÔ, M. 1963. New forms in the genus *Zaitzevia* Champion from the Ryukyu Islands (Col. Elmidae). *New Entomol.* 12: 1–3.
- SHARP, D. 1888. XXXI. Descriptions of some new Coleoptera from Japan. *Ann. Mag. Nat. Hist.* 2: 242–245.
- SHEPARD, W. D. 2003. The larva and pupa of *Nematopsephus* (Coleoptera: Psephenidae: Psephenoidinae). *Entomol. Prob.* 33: 1–4.
- SHORT, A. E. Z., AND A. P. SWANSON. 2005. A revision of the *Oocyclus* Sharp of Thailand with description of six new species (Coleoptera: Hydrophilidae). *Zootaxa* 1078: 1–24.
- SITES, R. W. 2005 (2006). New species of *Aphelocheirus* (Heteroptera: Aphelocheiridae) from Thailand. *Nat. Hist. Bull. Siam Soc.* 53: 215–235.
- SITES, R. W., AND A. VITHEEPADIT. 2010. Recovery of the freshwater lentic insect fauna in Thailand following the tsunami of 2004. *Raffles Bull. Zool.* 58(2): 329–348.
- SITES, R. W., AND H. ZETTEL. 2005. Three new species of *Aphelocheirus* (Heteroptera: Aphelocheiridae) from northern Thailand. *Aquat. Insects* 27: 99–112.
- SITES, R. W., AND J. T. POLHEMUS. 2001. A new species of *Telmatotrephes* (Heteroptera: Nepidae) from Thailand, with distributional notes on congeners. *Aquat. Insects* 23(4): 333–340.
- SITES, R. W., B. NICHOLS, AND S. PERMKAM. 1997. The Naucoridae (Heteroptera) of southern Thailand. *Pan-Pac. Entomol.* 73: 127–134.
- SITES, R. W., T. WANG, S. PERMKAM, AND M. C. HUBBARD. 2001. The mayfly genera (Ephemeroptera) of southern Thailand. *Nat. Hist. Bull. Siam Soc.* 49: 243–268.

- SIVEC, I., AND B. P. STARK. 2010. *Caroperla longiseta* (Plecoptera: Perlidae), a new stonefly species from Thailand. *Illiesia* 6: 58–61.
- STARK, B. P., AND I. SIVEC. 2005. New species of *Tyloperla* (Plecoptera: Perlidae) from Vietnam and Thailand. *Illiesia* 1: 1–7.
- THAMSENANUPAP, P., P. CHANTARAMONGKOL, AND H. MALICKY. 2005. Description of caddis larvae (Trichoptera) from northern Thailand of the genera *Himalopsyche* (Rhyacophilidae), *Arctopsyche* (Arctopsychidae), cf. *Eoneureclipsis* (Psychomyiidae) and *Inthanopsyche* (Odontoceridae). *Braueria* 32: 7–11.
- THANEE, I., AND C. PHALARAKSH. 2008. A preliminary study of the aquatic insect diversity and water quality of Mekong River, Thailand. *Khon Kaen Univ. Sci. J.* 36 (Supplement): 95–106.
- THANEE, I., AND C. PHALARAKSH. 2012. Diversity of aquatic insects and their functional feeding group from anthropogenically disturbed streams in Mae Sot District, Tak Province, Thailand. *Chiang Mai J. Sci.* 39: 399–409.
- THAPANYA, D., P. CHANTARAMONGKOL, AND H. MALICKY. 2004. An updated survey of caddisflies (Trichoptera, Insecta) from Doi Suthep-Pui and Doi Inthanon National Parks, Chiang Mai, Thailand. *Nat. Hist. J. Chulalongkorn Univ.* 4: 21–40.
- THAWARORIT, K., N. SANGPRADUB, AND J. C. MORSE. 2013. Five new species of the genus *Cheumatopsyche* (Trichoptera: Hydropsychidae) from the Phetchabun Mountains, Thailand. *Zootaxa* 3613: 445–454.
- UÉNO, M. 1961. Mayflies of Thailand. *Nat. Life Southeast Asia* 1: 207–208.
- VITHEEPADIT, A., AND R. W. SITES. 2006. A review of *Ptilomera* (Heteroptera: Gerridae) in Thailand, with descriptions of three new species. *Ann. Entomol. Soc. America* 100(2): 139–151.
- VITHEEPADIT, A., R. W. SITES, H. ZETTEL, AND Y. C. MAN. 2003. Review of the Hydrometridae (Heteroptera) of Thailand, with distribution records. *Nat. Hist. Bull. Siam Soc.* 51: 197–223.
- WATERHOUSE, C. O. 1876. On various new genera and species of Coleoptera. *Trans. Royal Entomol. Soc.* 1876: 11–25.
- WHITE, D. S., AND D. E. JENNINGS. 1973. A rearing technique for various aquatic Coleoptera. *Ann. Entomol. Soc. America* 66(5): 1174–1176.
- WOODRUFF, D. S. 2003. The location of the Indochinese-Sundaic biogeographic transition in plants and birds. *Nat. Hist. Bull. Siam Soc.* 51(1): 97–108.
- YOUPROM, P., T. PANICH-PAT AND T.-O. PROMMI. 2013. Aquatic insect communities and water quality in wetland, northern Thailand. *J. Appl. Sci. Environ. Sanit.* 8: 161–169.
- ZETTEL, H. 2005. Notes on the Helotrephini (Insects: Heteroptera: Helotrephidae) from Thailand and Vietnam, with description of three new species. *Ann. Naturhist. Mus. Wien* 106: 67–79.