Aquatic Larvae Of Eulichadidae and Ptilodactylidae (Coleoptera: Byrrhoidea) from Thailand, with Description of the Larva of Pseudocladotoma Pic

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AQUATIC LARVAE OF EULICHADIDAE AND PTILODACTYLIDAE (COLEOPTERA: BYRRHOIDEA) FROM THAILAND, WITH DESCRIPTION OF THE LARVA OF \textit{PSEUDOCLADOTOMA} PIC

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ABSTRACT

Over the last two decades, Thailand has been surveyed extensively for its fauna of aquatic insects. During this work, we collected the first specimens of the larvae of Eulichadidae and Ptilodactylidae reported from Thailand. We provide new locality data for these families and discuss their general natural history. The larva of \textit{Pseudocladotoma} Pic (Ptilodactylidae: Cladotominae) is described and illustrated. New country records include \textit{Eulichas birmanica} Hájek and \textit{Pseudocladotoma} Pic.

Key Words: morphology, Cladotominae, distribution, biodiversity

The aquatic insect fauna of Thailand is becoming increasingly well-known across all insect orders. For an in-depth listing of appropriate papers, see Shepard and Sites (2016). This aquatic insect fauna is quite diverse, even though many orders need further study.

Eulichadidae and Ptilodactylidae are aquatic beetles in the superfamilies Byrrhoidea in the series Elateriformia. Phylogenies based on molecular data from this group of beetles recently have been given (Kundrata \textit{et al.} 2014, 2016). In addition to Eulichadidae and Ptilodactylidae, the superfamilies Byrrhoidea includes the families Byrrhidae, Callirhipidae, Chelonariidae, Cneoglossidae, Dryopidae, Elmidae, Heteroceridae, Limnichidae, Lutrochidae, and Psephenidae. Most of these families are aquatic or semiaquatic, but the others are often in damp organic matter. The Thai members of Dryopidae and Elmidae were recently reviewed by Shepard and Sites (2016). Cneoglossidae and Lutrochidae do not occur in Thailand and are restricted to the New World. The larvae of Thai Psephenidae, the last untreated aquatic member of Byrrhoidea known from Thailand, are currently being studied.

In this paper, we report the first Thai records of aquatic larvae for the beetle families Eulichadidae and Ptilodactylidae and provide a discussion of their general natural history. The larva of \textit{Pseudocladotoma} Pic (Ptilodactylidae: Cladotominae) is described and illustrated.

MATERIAL AND METHODS

Collections were made at various localities across Thailand, all with permission. Samples were collected into 80% etOH and brought to the laboratory for processing and identification. Specimens are deposited in the Enns Entomology Museum, University of Missouri-Columbia, the Essig Museum of Entomology, University of California, and the Iowa State Insect Collection, Iowa State University (ISU). Most localities with “L- numbers” have site photographs available in the Locality Image Database of the Enns Entomology Museum website (museum.insecta.missouri.edu/database.cfm). Some specimens are reported from collections made by G. W. Courtney (Iowa State University).

Rearing. Our identifications were restricted to the generic level due to the general lack of knowledge at the species level. The inability to identify larvae to species reduces the information
available to ecologists and water quality assessors. A simple method to obtain species identifications used by the first author for North American eulichadids is to collect last instars and retain them in sealable plastic containers with moist sand and a small rock or piece of wood. When ready, the larvae will burrow into the damp sand or under the rock or wood and pupate. Pupation takes about two weeks followed by a week for the exoskeleton of the new adult to fully sclerotize. After this the adult can be killed, prepared for the museum collection, and identified. The process is described more fully in Richards and Shepard (2017). The larval exuvium may retain characters necessary to recognize the larval morph in the future. After larvae of multiple species have been reared and identified to the species level, characters used to separate species can be identified and an identification key can be constructed.

Alternatively, larvae and adults of other aquatic beetles have been successfully associated using DNA sequencing (Ciampor and Ribera 2006).

**RESULTS**

**Eulichadidae**

The family Eulichadidae comprises two genera: *Eulichas* Jacobson and *Stenoculus* LeConte. *Stenoculus* is monotypic and occurs only in the western USA (Shepard 2002; Richards and Shepard 2017). *Eulichas* contains more than 40 species distributed from India, throughout the Orient, and in the Philippine Islands, Borneo, and Sumatra (Jách 1995; Ivie and Jách 2002; Hálek 2007, 2008, 2009). Adults usually are collected at lights at night, whereas larvae are found in streams under rocks. Most descriptions of *Eulichas* species have been based on adults taken at lights; thus, little life history information is available. Larvae are described for both *Eulichas* (Costa and Vanin 1998) and *Stenoculus* (Lawrence 1991; Shepard 2002). Because of their large size, *Eulichas* larvae likely are semivoltine (multi-year lifespan). Thus, they should be found in streams year-round. They are easily recognized by their large, gill-shaped osmobbanchiae (Richards and Shepard 2017). Some *Eulichas* larvae have vestigial metathoracic spiracles (see Discussion in Richards and Shepard 2017). The life history of *Stenoculus scutellaris* LeConte was described by Richards and Shepard (2017). It is likely that the life cycle of *Eulichas* will be found to be similar, since they are in the same family and occupy the same habitats and microhabitats. A small amount of life history information is available for *Eulichas* dudgeon Jách (Costa and Vanin 1998).

Two species of *Eulichas* were previously known as adults from Thailand, *Eulichas haucki* Hálek (Loei Province, Phu Kradung National Park) and *Eulichas kubani* Hálek (Isthmus of Kra) (Hálek 2007, 2008). Here we report a third species, *Eulichas birmanica* Hálek, from Thailand (THAILAND: Chiang Mai Province; Doi Inthanon Natl. Park, Namtok Wachiratan, 18°32′N, 98°35′E, 650 m, 24 V 2004, MVL, G. W. Courtnrey - 1♂, 2♀). An image of an adult female of *Eulichas* is provided to enable recognition of the genus (Fig. 1A). Females are not identifiable to species. This female has the following collection data: THAILAND: Phatthalung Province, Khao Ban Tad Wildlife Sanctuary, Namtok Mohm Juey, UV pan trap, 3 June 2004, L-735, 95 m, 07°15.232′N 100°02.265′E, Vitheepradit & Prommi. The adult collection sites are shown in Fig. 5. Larval *Eulichas* are easily recognized by their large size and gill-like shape of the osmobbanchiae (Fig. 2). Here we report larval *Eulichas* spp. from many localities.

**CHECKLIST OF THE KNOWN SPECIES OF EULICHADIDAE FROM THAILAND**

*Eulichas* Jacobson, 1913

*Eulichas birmanica* Hálek 2007 (new country record)

*Eulichas haucki* Hálek 2007

*Eulichas kubani* Hálek 2007

**Localities of Larval *Eulichas* spp.** The following localities are mapped in Fig. 5. All localities are in mountain streams.

**CHIANG MAI Province:** Chiang Dao Wildlife Research Center, 24 July 2002, 520 m, 19°21′N 98°55′E, coll. CMU team (1 larva); Doi Inthanon National Park, Mae Klang River at Sob Ab Waterfall, 2 May 2003, 543m, L-496, 18°31′N 98°36′E, UMC & CMU teams (1 larva); Doi Inthanon National Park, Nam Mae Aep above Rd 1009, 5 October 2002, 630 m, ISU-0018058, 18°32.78′N 98°36.49′E, coll. P. Thamsenanupap (1 larva); Doi Inthanon National Park, Mae Pan @ Ban Mae Pan Noi, 7 July 2002, 750 m, ISU-0018055, 18°31′N 98°25′E, coll. P. Thamsenanupap (1 larva); Doi Inthanon National Park, Nam Mae Klaeng @ Ecolodge, 13 January 2003, 1000 m, ISU-0018060, 18°32′N 98°34′E, coll. P. Thamsenanupap (1 larva); Doi Inthanon National Park, Nam Mae Klaeng @ Ecolodge, 13 January 2003, 1000 m, ISU-0018060, 18°32′N 98°34′E, coll. P. Thamsenanupap (1 larva); Doi Inthanon National Park, Namtok Huai Sai Lueng, 6 October 2002, 1060 m, ISU-0018061, 18°31.42′N 98°27.32′E, coll. P. Thamsenanupap (1 larva); Doi Inthanon National Park, Siriphum Waterfall, level 2, 21 March 2002, 1460 m, L-314, 18°32′N 98°31′E, R. W. Sites (2 larvae); Fang Horticultural Exp. Farm, Nam Mae Chai, 17 Mar 2002, 600 m, 19°57′N 99°09′E, R. W. Sites (1 larva); same data except ISU-0018063, coll. G. W. Courtnrey (1 larva); same locality, 26 March 2003, L-419, Sites, Vitheepradit, Prommi (2 larvae); Mae Pan, 14 Jan 2003 (2 larvae); Suanrim, Nam Mai
Fig. 1. A) *Eulichas* female (27 mm long), B) *Pseudocladotoma maculata* (9 mm long).

Sa (WDS-A-1046 on reverse), 25 III 1994, 1600 ft, 18°54.09'N 98°53.08'E, W. D. Shepard (1 larva).

**CHIANG RAI Province**: Doi Luang National Park, Namtok Pukaeng, 17 March 2002, 540 m, ISU-0018064, 19°26'N 99°41'E, coll. G. W. Courtney (1 larva); Doi Luang National Park, Namtok Pulaeng, 24 June 2002, 540 m, ISU-0018059, 19°26'N 99°41'E, coll. CMU team (1 larva).

**KANCHANBURI Province**: Huay Ou Long at Hwy 323 bridge, 1 June 2011, 261 m, L-1304, 14°38.453'N 98°31.321'E, R. W. Sites (1 larva); Thong Pha Phum National Park, Huay Pak Kog, 1 June 2011, 139 m, L-1303, 14°47.183'N 98°48.401'E, R. W. Sites (1 larva).

**MAE HONG SON Province**: Huai Pha, 18 km N of Mae Hong Son, 14 October 2002, 340 m, ISU-0018065, 19°25'N 97°59'E, coll. G. W. Courtney (1 larva); Namtok Mawpang, 19 March 2002, 850 m, ISU-0018054, 19°22.73N 98°22.53'E, G. W. Courtney (1 larva).

**NAKHON SI THAMMARAT Province**: Klong Krai, 18 June 2004, 80 m, L-779, 08°47.387'N 99°38.695'E, Sites & Vitheepradit (1 larva); Khao Luang National Park, Ka Rome Waterfall, 6 June 2004, 157 m, L-747, 08°22'N 99°44'E, Vitheepradit & Prommi (1 larva).

**PHANGNGA Province**: Amphur Khura Buri, Tumbon Bang Won, 27 April 2002, 45 m, L-375, 08°59'N 98°26'E, Vitheepradit and Kirawanich (1 larva).

**PHRAE Province**: Wieng Ko Sai National Park, Mae Koeng Luang, 28 March 2003, 350 m, L-423, 17°58'N 99°35'E, Sites, Vitheepradit, Prommi (1 larva); Wieng Ko Sai National Park, Nam Tok

SURATTHANI Province: Amphur Ban Na San, Ban Plai Nam, 17 June 2004, 168 m, L-775, 08°52.680'N 99°28.621'E, Sites, Vitheepradit & Prommi (1 larva).

TAK Province: Lansang National Park, Namtok Lansang, 19 October 2002, 380 m, ISU-0018057, 16°46'N 99°00'E, coll. G. W. Courtney (1 larva).

TRANG Province: Kao Ban Tad Wildlife Sanctuary, Tone Tae Waterfall, 8 June 2004, 116 m, L-753, 07°17'N 99°53'E, Vitheepradit & Prommi (1 larva).

Ptilodactylidae

Ptilodactylidae comprises approximately 35 genera (Lawrence 2008) and 500–600 species (Stebbing 1986a) placed in five extant subfamilies: Anchytarsinae, Aploglossinae, Araeopidiinae, Cladotominae, and Ptilodactylinae (Costa et al. 1999; Chatzimanolis et al. 2012; Kundrata et al. 2018). Ptilodactylidae are particularly diverse in the tropics and subtropics (Lawrence 2008). Two species, Aphebodactyla rhetine Chatzimanolis, Cashion, Engel, and Falin (Chatzimanolis et al. 2012) and Ptilodactylidores stipulicornis Motschulsky (Motschulsky 1856), are known from fossils. Most species are terrestrial, although several genera have aquatic larvae. Adults are usually swept from stream-side vegetation or found at lights at night. Aquatic larvae are associated with organic matter (leaf packs and rotting wood) or rocks in streams. Life history information is available for Paralichas trivittis (Germar) (Funk and Fenstermacher 2002), Anchytarsus bicolor (Melsheimer) (LeSage and Harper 1976), Anchytarsus papalis (Champion) (Spangler 1983), Austrolichas monteithi Lawrence and Striling (Lawrence and Striling 1992), Drupeus hygropetricus Lee, Lawrence, and Satô (Lee et al. 2005) and Anchyteis brunneicornis (Lewis) (Hayashi and Nakamura 2008).

All described larvae from the subfamily Cladotominae are unique in that they possess a spiracular siphon on the eighth abdominal segment (Lawrence and Striling 1992; Funk and Fenstermacher 2002; Lee et al. 2005; Lawrence 2008; R. Kundrata, in litt.). Our new larva possesses that spiracular siphon. Additionally, Cladotominae is the only subfamily with genera having aquatic larvae and that is geographically close to Thailand. The six extant cladotomine genera and their known distributions are: Austrolichas Lawrence and Striling (Australia); Cladotoma Westwood (South America); Drupeus Lewis (Japan, Russia, Taiwan); Hovactyla Fairmaire (Afrotropical); Paralichas White (North
America, Japan, China, Madagascar); and *Pseudocladotoma* Pic (China, Malaysia, Java). Larvae are described for *Australichas* (Lawrence and Stribling 1992), *Drupeus* (Lee et al. 2005), and *Paralichas* (Funk and Fenstermacher 2002). None of those larvae match the morphology of the Thai specimen we examined, although the larva of *Drupeus* bears some resemblance (see below). *Cladotoma* and *Hovactyla* are geographically extralimital as candidate genera for the Thai specimen. Thus, we conclude that the larva we describe, diagnose and illustrate herein is *?Pseudocladotoma*; we include the "?" because it could represent an undescribed genus. Ventral thoracic sclerite terminology follows Lee et al. (2005).

*Pseudocladotoma* has four species: *P. maculata* Pic, 1918; *P. piceiceps* Pic, 1930; *P. rufonotatus* (Pic, 1931), and *P. vitaticollis* Pic, 1930. All four species are considered to have an Oriental distribution. *Pseudocladotoma maculata* was described from Java. *Pseudocladotoma piceiceps* was described from China. *Pseudocladotoma rufonotatus* was described from Borneo. *Pseudocladotoma vitaticollis* was described from China (Stribling 1986b). An image of the holotype of *Pseudocladotoma maculata* (deposited in the Muséum national d’Histoire naturelle, Paris) is provided to enable recognition of adults of the genus (Fig. 1B).

**?Pseudocladotoma** sp. larva

**Description.** **Body:** Length 7.80 mm, well-sclerotized, covered with round tubercles, elongate, parallel-sided, cylindrical in cross-section (Figs. 3, 4); Color brown; patches of long white setae laterally on all thoracic and abdominal segments; light-colored middorsal line from prothorax to abdominal segment 5; posterior borders of prothorax to abdominal segment 7 dentate, with dense row of stiff, white setae, setae angled toward midline; abdominal segment 8 triangular in cross-section, middorsal ridge stout, armed with short setae, lateral ridges parallel-sided in basal third, then pinched toward middle until drawn out into a siphon with apical patch of long white setae. **Head:** Anterior border with 6 projecting lobes, middle 2 lobes on labrum; dorsum covered with round tubercles; stemmata grouped into eyespots, eyespot areas not well sclerotized, gena with stout ridges. Labrum very short and wide, with median anterior cleft. Clypeus short and wide, with 2 flat, apically truncate lateral lobes; clypeofrontal suture indistinct. Frons shorter than broad; laterally with 2 anteriorly directed, rectangular lobes overlaying antenna; coronal suture distinct, anteriorly directed and reaching lateral edges of lateral lobes. Labium a single large flat plate covering entire venter of head. Labial palps projecting from under plate; 3 palpomeres – antepenultima palpomere barely visible, penultimate palpomere approximately 5X longer than wide, ultimate palpomere 2X longer than wide and much shorter than previous palpomere. **Thorax:** Pro- and mesonota with short, linear areas devoid of tubercles and situated halfway between midline and lateral margin. Venter with lightly sclerotized cervical...
sclerite, sclerite broadly triangular. Prosternal area with 4 sclerites on each side—precoxale wide anteriorly and extending posteriorly between coxae, 3 laterotergites; procoxal cavities open. Meso- and metasternal areas with median basisternum; with lateral precoxale and 4 laterotergites; mesothorax without spiracles; meso- and metacoxal cavities open. All legs heavily tuberculate; coxae conical; trochanters elongate triangular; femora and tibiae elongate, with numerous white setae; tarsunguli stout.

Abdomen: Segments 1–3 with rectangular sternite and 2 lateral pleurites, pleurites on segment 3 elongate-triangular. Segments 4–8 lacking pleurites and longitudinal sutures; segment 8 drawn out dorsally into a truncate spiracular siphon and ventrally with ring-like segment 9 partially visible around circular operculum which covers tracheal gills. Spiracles on segments 2–7 and apically on spiracular siphon; small tubercle-free spot on abdominal segment 1 where spiracle might be but no sclerotized ring present as on following segments.

Discussion. This larva of ?Pseudocladotoma differs from that of Austrocladotoma by the plate-like labium, metathorax with a diamond-shaped basisternum, lack of separate sternal sclerites on abdominal segments 4–7 (all sclerites fused to yield a sclerotized ring), and a narrower siphon on abdominal segment 8. It differs from that of Drupeus (see fig. 48 in Lee et al. 2008) by the lack of a probasisternum, lack of intertergites on the meso- and metathoraces, lack of a postcoxale on the pro-, meso-, and metathoraces, presence of pleurites on abdominal segment 3, and having undivided abdominal pleurites. It differs from the larva of Paralichas by the plate-like labium, mesothoracic basisternum in one piece, lack of pleurites on abdominal segments 4–7, and the middorsal line extending only to abdominal segment 5.

Locality. The locality is a mountain stream.

PHRAE Province: Wieng Ko Sai National Park, Namtok Maekung, Tier 1, 2 September 2002, 400 m, 17°58’N 99°35’E, CMU team (1 larva) (Fig. 5) This is a new country record for the genus.

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