Diversity, Life Cycle and Nutritional Values of Trichoptera at Montane Evergreen Forest of Nakhon Si Thammarat Ranges

Nannaphat Suwannarat

A Thesis Submittet in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy Program in Aquaculture and Fishery Resources (International Program)

Prince of Songkla University

2021

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Author	Miss Nannaphat Suwannarat
Major Program	Aquaculture and Fishery Resources (International Program)

Major Advisor:	**Examing Commitee:**
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	……..….Commitee (Asst.Prof.Dr. Kanda Kamchoo)

The Graduate School, Prince of Songkla University, has approved this thesis as partial fulfillment of the requirements for Doctor of Philosophy Degree in Aquaculture and Fishery Resources (International Program)

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(Prof. Dr. Damrongsak Faroongsarng)

Dean of Graduate School

This is to certify that the work here submitted is the result of the candidate's own investigations. Due acknowledgement has been made of any assistance received.

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(Assoc.Prof.Dr. Pongsak Laudee)

Major Advisor

……..……. Signature

(Miss Nannaphat Suwannarat)

Candidate

I hereby certify that this work has not been accepted in substance for any degree and is not being currently submitted in candidature for any degree.

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Candidate

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ปีการศึกษา 2564

บทคัดย่อ

การศึกษาครั้งนี้เป็นการศึกษาความหลากหลาย วงชีวิต และคุณค่าทางอาหารของแมลงหนอนปลอกน้ำ รวมถึงการศึกษาลักษณะของตัวอ่อน การเชื่อมโยงระหว่างระยะตัวอ่อนและตัวเต็มวัย ศึกษาวงชีวิตของแมลงหนอนปลอกน้ำชนิด *Lepidostoma abruptum* บริเวณเทือกเขานครศรีธรรมราช ซึ่งตั้งอยู่ในภาคใต้ของประเทศไทย จากการศึกษาพบแมลงหนอนปลอกน้ำ 3,949 ตัว โดยจำแนกจาก 21 วงศ์ 60 สกุล 173 ชนิด แมลงหนอนปลอกน้ำ วงศ์ Philopotamidae พบทั้งหมด 32 ชนิด เป็นกลุ่มที่มีความอุดมสมบูรณ์มากที่สุด รองลงมาวงศ์ Hydropsychidae 26 ชนิด วงศ์ Polycentropodidae 17 ชนิด และวงศ์ Psychomyiidae 14 ชนิด ตามลำดับ จากการนับจำนวนแมลงหนอนปลอกน้ำ พบว่า ชนิดที่มีจำนวนมากที่สุด คือ *Trichosetodes sisyphos* รองลงมา *Chimarra thienemanni Chrysotrichia pulmonaria* และ *Rhyacophila scissoidea* จากการศึกษาพบแมลงหนอนปลอกน้ำชนิดใหม่ 15 ชนิด ตัวอย่างเช่น *Rhyacophila aksornkoaei Plectrocnemia paras Helicopsyche artinc* และ *Oecetis rochcl* และชนิดเหล่านี้มีการปรากฏพบได้เฉพาะถิ่นที่เทือกเขานี้เท่านั้น

จากการศึกษาลักษณะของตัวอ่อน การเชื่อมโยงระหว่างระยะตัวอ่อนและตัวเต็มวัย ศึกษาวงชีวิต และคุณค่าทางอาหารของแมลงหนอนปลอกน้ำ ชนิด *Lepidostoma abruptum* โดยการเก็บตัวอย่างทุก 2 เดือน ตลอดทั้งปี เก็บโดยวิธีสุ่มเก็บตัวอย่าง บริเวณน้ำตกที่ความสูง 911 เมตร (พิกัด 8°50’35’’N 99°28’38’’E) ในเขตพื้นที่อุทยานแห่งชาติใต้ร่มเย็น ช่วงเดือนมีนาคม 2562 ถึง เดือนกุมภาพันธ์ 2563 จากการศึกษา พบว่า ตัวอ่อนแมลงหนอนปลอกน้ำชนิด *L. abruptum* อาศัยบริเวณแอ่งน้ำ ในลำธารขาดเล็ก ลักษณะแหล่งที่อยู่อาศัยเป็นทรายขนาดเล็ก ก้อนกรวดขนาดเล็ก วัสดุของพืชที่ตายแล้ว ใบไม้ทับถมบริเวณพื้นท้องน้ำ การศึกษาวงชีวิตของแมลงหนอนปลอกน้ำของตัวอย่างทั้งหมด 74 ตัว วงชีวิตมีทั้งหมด 5 ระยะ ได้แก่ (ระยะตัวอ่อน 1-4 ระยะดักแด้ และพัฒนาเป็นตัวเต็มวัย) การเจริญเติบโตตลอดวงชีวิตใช้ระยะเวลาประมาณ 1 ปี นอกจากนี้การวิเคราะห์คุณค่าทางอาหาร พบค่าโปรตีน เท่ากับ 49.08% ค่าไขมันรวมเท่ากับ 27.18% ค่าใยอาหารเท่ากับ 5.93% ค่าความชื้นเท่ากับ 68.87% ค่าโอเมก้า-3 เท่ากับ 0.19% ค่าโอเมก้า-6 เท่ากับ 6.42% และค่าโอเมก้า-9 เท่ากับ 11.75%.

สรุปผลการศึกษา บริเวณอุทยานแห่งชาติเขานันมีความหลากหลายมากที่สุด รองลงมาอุทยานแห่งชาติใต้ร่มเย็น และน้อยที่สุดที่อุทยานแห่งชาติเขาหลวง จากการศึกษาพบแมลงหนอนปลอกน้ำชนิดใหม่ของโลกทั้งหมด 15 ชนิด วงชีวิตของแมลงหนอนปลอกน้ำชนิด *L. abruptum* มี 5 ระยะ พบมีค่าโปรตีนสูงถึง 49.08%

Thesis Title	Diversity, Life cycle, and Nutritional Values of Trichoptera at Montane Evergreen Forest of Nakhon Si Thammarat Ranges
Author	Miss Nannaphat Suwannarat
Major Program	Aquaculture and Fishery Resources (International Program)
Academic Year	2021

Abstract

This study aimed to study the diversity, life cycle and nutritional values of Trichoptera and to study larval morphology, life cycle, and nutritional values of the *Lepidostoma abruptum* Banks, 1931 at Montane Evergreen Forest of Nakhon Si Thammarat Ranges. The result show that 3,949 adult Trichoptera specimens have been collected, belonging to 21 families, 60 genera, and 173 species. The most abundant Trichoptera families in the study sites were Philopotamidae (32 species), Hydropsychidae (26 species), Polycentropodidae (17 species), and Psychomyiidae (14 species), in rank order by species count. The Trichoptera species found in greatest numbers were *Trichosetodes sisyphos* Malicky&Prommi 2006, *Chimarra thienemanni* C&M 1989, *Chrysotrichia pulmonaria* Xue&Yang 1990, and *Rhyacophila scissoidea* Kimmins 1953. 15 new species of Trichoptera were described from this area, such as *Rhyacophila aksornkoaei* Laudee&Malicky 2019, *Plectrocnemia paras* Malicky&Suwannarat 2020, *Helicopsyche artinc* Malicky&Suwannarat 2020 and *Oecetis rochcl* Malicky&Suwannarat 2020, and these are apparently endemic to the mountain ranges.

The specimens were collected bimonthly in one year by pick sampling method from Tai Rom Yen National Park, in Southern Thailand (8°50’35’’N 99°28’38’’E), at 911 meters above the sea level during March 2019 and February 2020. The larvae of *L. abruptum* lived in a pool in a small stream, where the substrate was dominated by fine sand, fine gravel, dead plant materials, and leaves. For the life cycle, 74 specimens were measured for the head capsule width. The results indicate presence of 5th instar larvae (instar I-IV, pupae, and adult) this being a non-seasonal species. In addition, the specimens were determined for the nutritional values: protein (49.08%), total fat (27.18%), total dietary fiber (5.93%), moisture (68.87%), omega-3 (0.19%), omega-6 (6.42%), and omega-9 (11.75%).

Summary of the study the Trichoptera are the most diversity at Khao Nan, followed with Tai Rom Yen and the least at Khao Luang National Park. Montane Evergreen Forest of Nakhon Si Thammarat Ranges were found 15 new species of Trichoptera. The life cycle of *L. abruptum* was 5 stages, with protein values as high as 49.08%.

ACKNOWLEDGEMENTS

This thesis would not have been written without the help and support of my advisor Assoc.Prof.Dr. Pongsak Laudee, who was always at my side with help and support from start to finish.

I would also like to thank Assoc. Prof. Dr. Seppo Karrila and Dr. Khunchai Wongchana for their efforts to improve my English skills, who, in addition to the language training, were an essential support in creating the manuscript.

I am thankful to Prof. Dr. Hans Malicky for helping on insect identification, specimens confirmation and editing of the manuscript.

I am especially grateful to my examination committee: Assoc.Prof.Dr. Taeng on Prommi, Prof.Dr. Boonsirm Withyachumnarnkul, Assoc.Prof.Dr. Pattira Pongtippatee and Asst.Prof.Dr. Kanda Kamchoo for their comments and critics of my thesis.

I am grateful to Mr. Wolfgang Hofmaier who took a lot of time for teaching me the how-to's of IT, his ongoing support for the completion of this thesis book by setting up the layout and also providing the procedures how to move on into the state-of-the-art technologies of the Information Technology in future business life.

To add a very special "Thank You", on my trip to Austria in 2019, so literally to a quite cold and very much different part of the world, everything went surprisingly well, also and especially because of Dr. Gudrun Malicky and Mrs. Herta Hofmaier plus her family took their cordial and special care on me all over my entire stay.

I am extremely grateful to my parents and my family for their love and caring sacrifices to ensure the required education and preparation for my future life. I am very much thankful for understanding to complete this research work.

Besides, thanks to the Department of National Park, Wildlife and Plant Conservation for field trip to collect the specimens in the national parks.

Finally, I am thankful to be supported financially by the Prince of Songkla University, Surat Thani Campus Collaborative Research fund.

Nannaphat Suwannarat

CONTENTS

CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF ABBREVIATIONS AND SYMBOLS

M&C = Malicky&Chantaramonkol

C&M = Chantaramonkol&Malicky

TP = Decha Thapanya (2004)

BL = Pensri Bunlue (2013)

PM= Taeng-On Prommi (2007)

LD = Pongsak Laudee (2015)

* = New record in Thailand

\+ = present

– = absent

r = rare means that 1–2 specimens were found

p = partially found 3–20 specimens were found

c = common about 20–100 specimens were found

a = abundant more than 100 specimens were found

E = This species was only found in hill evergreen forest at Nakhon Si Thammarat range and is possibly endemic.

e =This species was found in either hill evergreen forest or moist evergreen forest, in Southern Thailand.

m = This species was also found in other areas and neighboring countries.

TR = Tai Rom Yen National Park

KN= Khao Nan National Park

KL = Khao Luang National Park

^{o}C = degree Celsius

cm = centimeter

LIST OF ABBREVIATIONS AND SYMBOLS (Continued)

EtOH =ethyl alcohol

km =kilometer

m =meter

mm =millimeter

NaOH =sodium hydroxide

Prov. = province

Ml = microliter

♂ = male

♀ = female

2. LIST OF PAPERS AND PROCEEDING

2.1 List of papers

The content of this thesis is based on the following papers and referred to their sequence of experimental design in the text. The publications are attached as chapter 3, and 5 of this thesis.

Paper 1 Suwannarat, N., Malicky, H., & Laudee, P. (2018). Two new species of Caddisflies (Trichoptera: Insecta) from Lower-Hill Evergreen Forests of Southern Thailand. *Zootaxa*, *4524*(4), 496–500.

Paper 2 Malicky, H., Suwannarat N., and Laudee P. (2018). Köcherfliegen (Trichoptera) aus dem Süden Thailand, mit der Beschreibung von vier neuen Arten. *Linzer biologische Beiträge,* 50/2, 1319–1328.

Paper 3 Suwannarat, N., Malicky, H., Morse, J. C., & Laudee, P. (2019). Four new species of Rhyacophila Pictet, 1834 (Trichoptera: Rhyacophilidae) from Southeast Asia. *Zootaxa*, *4657*(2), 369–376.

Paper 4 Suwannarat, N., Malicky, H., & Laudee, P. (2020). Four new species of caddisflies (Trichoptera: Polycentropodidae, Psychomyiidae, Hydropsychidae, Odontoceridae) from Khao Nan and Tai Rom Yen National Parks, Southern Thailand. *Zootaxa*, *4801*(3), 577–583.

Paper 5 Suwannarat, N., Malicky, H. (2020). Six new species of Trichoptera at Thailand. *Braueria*, 47, 48–51.

Paper 6 Suwannarat, N., Laudee, P., Malicky, H. (2022). Diversity of Caddisfly Species (Insecta: Trichoptera) at Lower Hill Evergreen Forest of Nakhon Si Thammarat Range in Southern Thailand. *Braueria.* (Accepted).

Paper 7 Suwannarat, N., Laudee, P. (2022). Larval morphology, Life cycle and Nutritional values of *Lepidostoma abruptum* Banks, 1931 (Trichoptera, Lepidostomatidae) from Lower-Hill Evergreen Forests of Southern Thailand. *Zootaxa*. (Submitted).

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Paper 1;3;4

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DOI: 10.11646/zootaxa.4524.4.7
ISSN: 1175-5334
Publication Type: Journal
Zootaxa 4524 (4): 496–500

*Second, Article Title: Four new species of Rhyacophila Pictet, 1834**(Trichoptera:Rhyacophilidae) from Southeast Asia *
Author (s): NANNAPHAT SUWANNARAT1, HANS MALICKY2, JOHN C. MORSE3 & PONGSAK LAUDEE1,4
DOI: 10.11646/zootaxa.4657.2.9
ISSN: 1175-5334
Publication Type: Journal
*Zootaxa *4657 (2): 369–376

*Third, Article Title: Four new species of caddisflies (Trichoptera: Polycentropodidae, Psychomyiidae, Hydropsychidae, Odontoceridae) from Khao Nan and Tai Rom Yen National Parks, southern Thailand *
Author (s): NANNAPHAT SUWANNARAT1,2, HANS MALICKY4,5 & PONGSAK LAUDEE1,3*
DOI: 10.11646/zootaxa.4801.3.10
ISSN: 1175-5334
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Nannaphat Suwannarat, MSc

-- Best regards --
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Paper 2 and 5

From: ZOBODAT@ooelkg.at
Date: 1 June BE 2564 22:23:48 GMT+7
To: nannaphat.psu@gmail.com
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Dear Nannaphat Suwannarat!
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As the article from Linzer biologische Beiträge is already freely online available you of course can use the paper in full text within your Thesis.
You may also use the paper published in Braueria for your Thesis.
sincerely yours
Michael Malicky

● DI Michael Malicky
Sammlungsleitung ZOBODAT, IT Betrieb
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UID.Nr. ATU75347714, FN 530246 z, Landesgericht Linz

Von: นันท์นภัส สุวรรณรัตน์ [mailto:nannaphat.psu@gmail.com]
Gesendet: Montag, 31. Mai 2021 08:20
An: LKG, ZOBODAT <ZOBODAT@ooelkg.at>
Betreff: Request for approval

Dear Mr. Malicky!
I am Nannaphat Suwannarat Ph.D. candidate of Prince of Songkla University in Thailand, and right now in the final procedures of my Thesis.

Regarding this request, I already published two journals to Zobodat:

1) Hans Malicky, Pongsak Laudee, Nannaphat Suwannarat (2018): Köcherfliegen (Trichoptera) aus dem Süden Thailands, mit der Beschreibung von vier neuen Arten – Linzer biologische Beiträge – 0050_2: 1319 - 1328.

2) Hans Malicky, Nannaphat Suwannarat (2020): Sechs neue Köcherfliegen (Trichoptera) aus Süd-Thailand – Braueria – 47: 48 - 51.

These articles are an integral part, used as full text 1:1 copy in my Thesis at Chapter 5, Papers. I would kindly like to ask for formal permission and sending me your approval statement shorthanded as it´s quite time critical now as you can imagine.

So Dear Sir, thank you very much in advance, in case of any questions please contact me directly.
Greetings from Prince of Songkla University and thank you very much again for your efforts, I appreciate that!
PS: Please find attached an example statement in the style which would be helpful for me for your information.

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Paper 6

BRAUERIA / Trichoptera Newsletter
ISSN 1011-6478

Dear: Mrs. Nannaphat Suwannarat

Herewith I confirm that your manuscript entitled **"Diversity of caddisfly species (Insecta, Trichoptera) at Lower Hill Evergreen Forest of Nakhon Si Thammarat Range in southern Thailand"** will be accepted to be published in BRAUERIA number 49.

(.....)
Univ.-Prof.Dr. Hans Malicky
Editor

Paper 7

From: PONGSAK LAUDEE <pongsak.l@psu.ac.th>
Sent: Wednesday, July 14, 2021 12:04 PM
To: John Morse
Subject: Manuscript for publishing in Zootaxa (Lepidostoma)

Dear Dr. John Mosre

My Ph.D. student, Nannaphat Suwannarat, would like to publish her article in the Journal of Zootaxa.
The article describes the larva of Lepidostoma abruptum with detail of life cycle and nutrition values. This is the first article that she tries to write by herself.

Please consider the article published in Zootaxa.

Sincerely,

Pongsak Laudee

Dear Pongsak,

Thank you for this manuscript submitted for consideration to be published in ZOOTAXA.

In future correspondence, please refer to Manuscript Number M20231-16.

I will attempt to get reviews for this manuscript as quickly as possible.

John

John C. Morse, Ph.D.
Editor for Trichoptera in ZOOTAXA

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Pronouns: he, him, his

3. Summary of Contents

3.1 Introduction

Thailand is in the oriental region of the zoogeographic region and has a high diversity of flora and fauna (Morse, 2016). It is in the tropical zone. Tropical evergreen forests are the most important ecosystems in the world, and they are found especially in the Southeast Asian countries Thailand, Laos, Myanmar, Malaysia, and Indonesia. They occupy about a tenth of the world's land area (Thomas&Baltzer, 2002) and include two main subtypes: deciduous forests and evergreen forests. Evergreen forest is characterized by trees not losing the leaves seasonally, but instead staying green throughout the year. However, the evergreen forests fall into three subtypes: tropical rain forests, dry tropical rain forests, and montane evergreen forests. These are located from the North to the South, throughout the latitudes. In Thailand, plentiful hill evergreen forests are found in the northern part, for example in Doi Inthanon National Park and Doi Suthep-Pui National Park, where the elevation is over 1,000 meters from the mean sea level (Ruangpanit, 1998). In the southern part of Thailand, this type of forest is found in the Nakhon Si Thammarat Ranges where it possesses a wide range of habitats and consists of tropical rain forest, dry tropical rain forest and montane evergreen forest. Four national parks are in the ranges, namely Namtok Si Khit, Tai Rom Yen, Khao Nan, and Khao Luang National Parks. The Trichoptera reported from this area include 75 species in 32 genera and 15 families. Also, one new species, *Rhyacophila suratthaniensis*, was discovered from the ranges at 164–436 meters above the mean sea level (Laudee&Malicky, 2015).

Trichoptera is in the kingdom Animalia, Phylum Arthropoda, and Class Insecta. Trichoptera are caddisflies (Williams&Feltmate, 1994). The Trichoptera insects go through a complete metamorphosis. They resemble moths but there are differences in hairs on the wings, long antennae, and a sucking mouthpart. Some species of adult Trichoptera show wonderful colors from yellow through grey or from brown to black. (Neboiss, 1997). Diversity of Trichoptera species is abundant and is most important for the freshwater ecology. There have been discovered 14,548 species, 616 genera, and 49 families worldwide, while Trichoptera species are found in the largest numbers in the Oriental Region (Morse, 2016). In Thailand, over 1,000 species of the Trichoptera order have been discovered in the past 40 years, with more than 70% being newly discovered (Malicky&Chantaramongkol, 1993; Thapanya et al., 2004; Malicky, 2010; Chantaramongkol et al., 2010; Esor et al., 2016; Laudee&Malicky, 2014; Laudee&Malicky, 2016; Laudee&Prommi, 2016; Laudee et al., 2017; Laudee&Malicky, 2018; Suwannarat et al., 2018; Suwannarat et al., 2019; Suwannarat et al., 2020; Malicky&Suwannarat, 2020; Malicky et al., 2020). The studied areas have mainly been in northern Thailand, such as Inthanon National Park and Suthep-Pui National Parks, where the forest types are upper hill evergreen forests, lower hill evergreen forests or moist evergreen forests (Malicky&Chantaramongkol, 1993; Thapanya et al,. 2014). In southern Thailand, studies of Trichoptera species have been conducted mainly in moist evergreen forest type. Prommi&Permkam (2010) reported on adult Trichoptera from Ko Hong hill, and thirty species, 20 genera and 10 families were recorded. The three new species *Chrysotrichia pallu* Prommi&Permkam 2010,

Adicella elon Prommi&Permkam 2010, and *Oecetis husam* Prommi&Permkam 2010 were described. Recently, Laudee&Malicky (2015) reported 75 species in 32 genera and 15 families, including a new species, *Rhyacophila suratthaniensis* Laudee&Malicky (2015) collected from streams in Nakhon Si Thammarat Range that is covered by moist evergreen forest.

The biology, habitat and life cycle of Trichoptera are distinguished into non-seasonal and seasonal cycles. The stages in the life cycle are holometabolous including eggs, larvae, and adults. Males and females copulate terrestrially, and the females generally lay 20 to 1,000 eggs. Most of the life is spent in the larval stage. Larvae have heads that are distinctively in a head capsule. Eyes and antennae are small and inconspicuous. They have thoracic legs, wing pads, anal prolegs, and filamentous gills (McCafferty, 1983). However, genus *Lepidostoma* was reported as a shredder and univoltine life cycle species (Grafius&Anderson 1980; Malicky 2021). Dinakaran et al. (2013) reported that the larvae live in slow-moving streams where leaf litter and woody debris are deposited. Also, Ito 2011 reported that the larvae of *Lepidostoma* spp. live in small streams in hygropetric habitats with wet semi-aquatic plants in mountain area. In addition, Karaouzas&Waringer (2016) and Terefe et al. (2018) reported that European Lepidostoma inhabits springs and cool slow streams at mountain areas. For the life cycle of the Lepidostoma, *L. nuburagangai* was reported from India. Five stages of instar larvae were shown with the first instar building their cases of sand, the second and third instars making their cases of sand and pieces of leaves, and the fourth and fifth instar cases are made of leaves (Dinakaran et al. 2013).

The nutritional values of insects are very diverse. More than 1,700 species of insects are reported to be edible for humans and animals that have been already used for this purpose for almost 10,000 years (Riggi et al. 2016). Insects have been long used as human food and animal feed (Riggi *et al*., 2014). The Trichoptera reportedly include 10 species providing healthy food with low fat, but high in calcium, iron, zinc and protein (Van Huis *et al*., 2003). An analysis of aquatic insect nutrition values reported that they have high protein contents as percentage of dry weight, as in Ephemeroptera (66.26%), Odonata (40–65%), Hemiptera (42–73%) and Coleoptera (23–66%) (Xiaoming et al. 2010). Trichoptera is important to aquatic ecosystems because it is a food source for fish and other aquatic life. Nutrition values of ten species of Trichoptera were reported as healthy food with low fat, but high calcium, iron, zine, and protein (Anankware et al. 2015). Reinecke&Owen (1980) reported that Trichoptera has high nutritional values: protein 45.7%, fiber 8.8 %, and ash 33.8 % by dry weight. In this study, the diversity and distribution of Trichoptera species from montane evergreen forests were surveyed. The species diversity data were used as primary data for ecological and life cycle study. Also, nutritional values of *Lepidostoma abruptum* Banks, 1931, are assessed. The results facilitate potential culturing of the insect for aquatic animal food.

3.2 Thesis objectives

3.2.1 To study the diversity and distribution of Trichoptera in montane evergreen forest streams of Nakhon Si Thammarat Ranges.

3.2.2 To study life cycle of some Trichoptera species found in Nakhon Si Thammarat Ranges.

3.2.3 To study the nutritional values of Trichoptera as regards protein, fat, fiber, moisture, omega–3 and omega-6.

3.3 Results and Discussion

3.3.1 Montane evergreen forest streams of Nakhon Si Thammarat Ranges

3.3.1.1 Study site

The samples of Trichoptera in this study were collected from 15 study sites covered by tropical evergreen forest at 1,000–1,800 meters above sea level in Nakhon Si Thammarat ranges (Figure 1), located in the three National Parks: Tai Rom Yen, Khao Nan, and Khao Luang. Five study sites were randomly chosen and placed along one major stream in each national park (Table 1). The forest cover was hill evergreen forest in each National Park. The forest cover at Tai Rom Yen National Park was mostly at 85%, while the forest cover at Khao Nan National Park at the first and fourth study sites was 95 %. The forest cover at Khao Luang National Park study sites was 80 % (Figure 1).

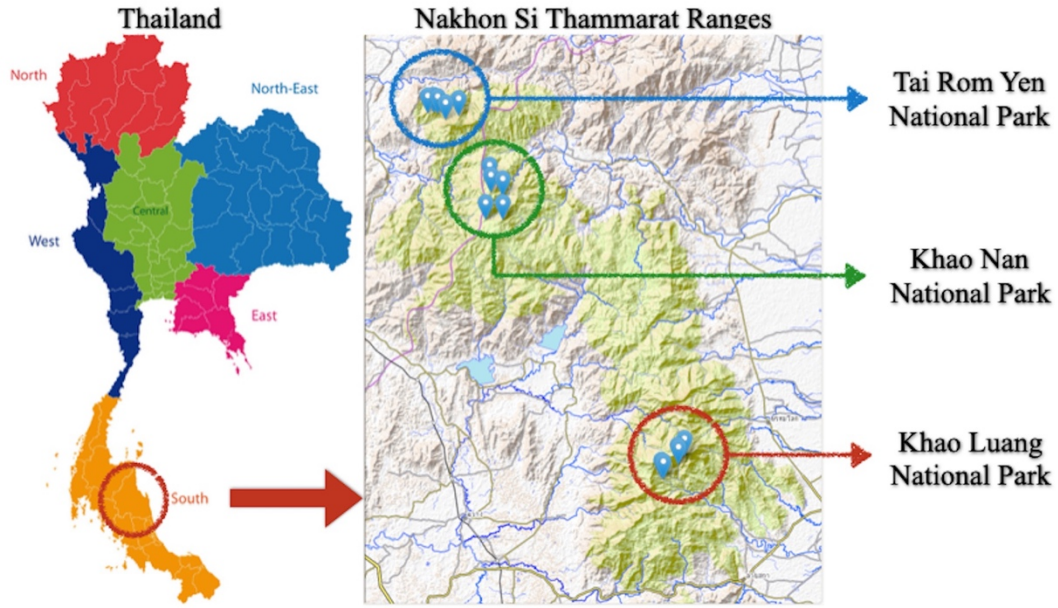


Figure 1. Map of study sites at Nakhon Si Thammarat Ranges, in Tai Rom Yen, Khao Nan and Khao Luang National Parks.

Table 1. Description of study sites in Tai Rom Yen National Park, Khao Nan National Park and Khao Luang National Park at Nakhon Si Thammarat Ranges

Area	Site Code	Stream Name	geographical locations	Height (meters)
Tai Rom Yen National Park, Surat Thani province	TR1	Klong Lamphun 1	8°50'26"N 99°29'56"E	1,100
	TR2	Klong Lamphun 2	8°50'11"N 99°29'07"E	960
	TR3	Klong Lamphun 3	8°50'35"N 99°28'38"E	911
	TR4	Klong Lamphun 4	8°50'39"N 99°28'21"E	875
	TR5	Klong Lamphun 5	8°50'36"N 99°28'01"E	854
Khao Nan National Park, Nakhon Si Thammarat province	KN1	Klong Gray 1	8°44'02"N 99°31'39"E	1,263
	KN2	Klong Gray 2	8°44'01"N 99°32'41"E	1,250
	KN3	Klong Gray 3	8°46'19"N 99°31'52"E	1,147
	KN4	Klong Gray 4	8°45'43"N 99°31'56''E	1,241
	KN5	Klong Gray 5	8°45'30"N 99°32'41"E	1,132
Khao Luang National Park, Nakhon Si Thammarat province	KL1	Klong Tha Di 1	8°29'24"N 99°44'40"E	1,366
	KL2	Klong Tha Di 2	8°28'59"N 99°43'40"E	903
	KL3	Klong Tha Di 3	8°28'02"N 99°43'37"E	823
	KL4	Klong Tha Di 4	8°28'51"N 99°43'42"E	802
	KL5	Klong Tha Di 5	8°27'58"N 99°42'45"E	793

3.3.1.2 Description of study sites at montane evergreen forest streams of Nakhon Si Thammarat Ranges

3.3.1.2.1 Description of study sites in Tai Rom Yen National Park

- The highest elevation study site (TR1) at this national park was 1,100 meters above sea level. The substrate was dominated by bedrock and boulders above water level, at a big pool, with cobble, gravel, and sand at the deepest level (Figure 2).

- The second highest study site (TR2) was 960 meters above sea level. The substrate was dominated by bedrock and boulders above water level, at a big pool, with cobble, gravel, and sand at the deepest level (Figure 3).

- The third highest study site (TR3) was 911 meters above sea level. The substrate was dominated by bedrock and boulders above water level, at the middle of pool covered with cobbles, and gravel and sand at deepest level (Figure 4).

- The fourth highest study site (TR4) was 875 meters above sea level. The substrate was dominated by bedrock and boulders with some sand at the deepest level (Figure 5).

- The lowest study site (TR5) was 854 meters above sea level. The substrate was dominated by bedrock and boulders above water level, with cobble, gravel, and sand at the deepest level (Figure 6).

- 95 percentage forest cover was dominant at Tai Rom Yen National Park at the first, fourth, and lowest study sites; but the third study site had 85 % and the second study site 80 % cover.

Figure 2. Study site (TR1) at Tai Rom Yen National Park.

Figure 3. Study site (TR2) at Tai Rom Yen National Park.

Figure 4. Study site (TR3) at Tai Rom Yen National Park.

Figure 5. Study site (TR4) at Tai Rom Yen National Park.

Figure 6. Study site (TR5) at Tai Rom Yen National Park.

3.3.1.2.2. Description of study sites at Khao Nan National Park

- The highest elevation study site (KN1) at this national park was 1,263 meters above sea level. The substrate was dominated by sand with gravel at the deepest level (Figure 7).

- The second highest study site (KN2) was 1,250 meters above sea level. The substrate was dominated by boulders, cobble, gravel, and sand (Figure 8).

- The third highest study site (KN3) was 1,147 meters above sea level. The substrate was dominated by bedrock and boulders above the water level, deep pool in the middle, cobble, gravel, and sand at the deepest location (Figure 9).

- The fourth highest study site (KN4) was 1,241 meters above sea level. The substrate was dominated by large boulders, cobble, gravel, and sand in the deepest area (Figure 10).

- The lowest study site (KN5) was 1,132 meters above sea level. The substrate was dominated by bedrock and boulders above water level, cobble, gravel, and sand at the deepest area (Figure 11).

- The forest cover at Khao Nan National Parks at the third and lowest locations was about 85 %, while the highest study site had 95 % cover. The other cases had 90 and 80 % covers, namely at the second and fourth study sites (Table 1).

Figure 7. Study site (KN1) at Khao Nan National Park.

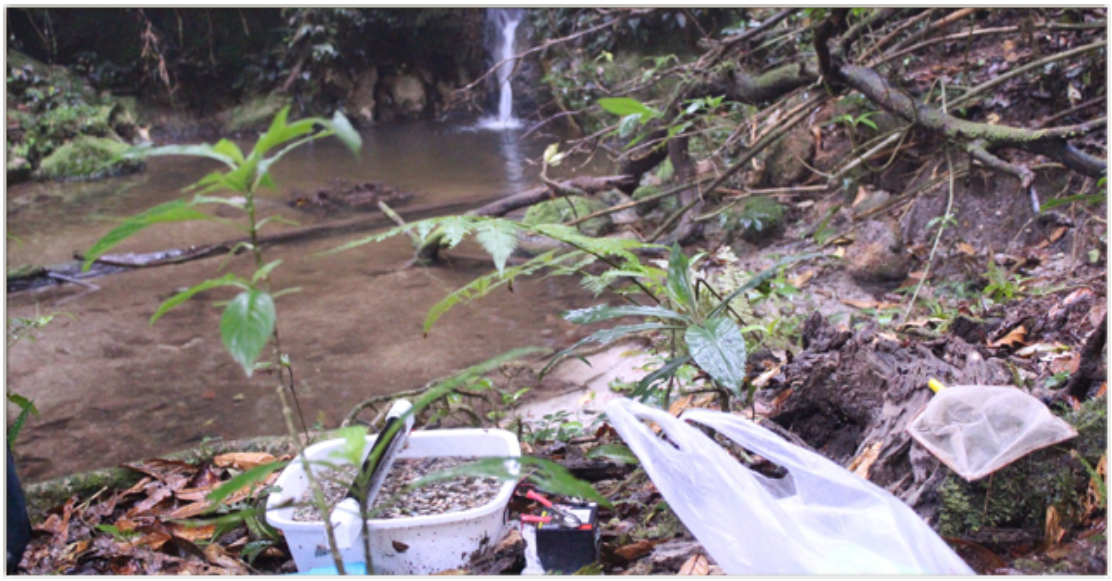


Figure 8. Study site (KN2) at Khao Nan National Park.

Figure 9. Study site (KN3) at Khao Nan National Park.

Figure 10. Study site (KN4) at Khao Nan National Park.

Figure 11. Study site (KN5) at Khao Nan National Park.

3.3.1.2.3. Description of study sites at Khao Luang National Park

- The highest study site (KL1) at this national park was 1,366 meters above sea level. The substrate was dominated bedrock above water level, the middle of the pool was covered with sand and silt, and there was cobble and gravel at the deepest level (Figure 12).

- The second highest study site (KL2) was 903 meters above the sea level. The substrate was dominated by large boulders, cobble, gravel, and sand (Figure 13).

- The third highest study site (KL3) was 823 meters above sea level. The substrate was dominated by bedrock above water level, while otherwise there was sand and silt, with cobble and gravel at the deepest level (Figure 14).

- The fourth highest study site (KL4) was 802 meters above sea level. The substrate was dominated by large boulders, cobble, gravel, and sand at the deepest level (Figure 15).

- The lowest study site (KL5) was 793 meters above sea level. The substrate was bedrock and boulders above water level, middle of the pool was covered with cobble, gravel, and sand was at the deepest level (Figure 16).

- To sum up, the highest and lowest study sites of this study were at Khao Luang National Park - KL1 and KL5 respectively. The substrate of all study sites was dominated by bedrock - predominant above water level, and middle of the pool was covered with sand and silt, cobble, and gravel at the deepest level with only small differences. The highest forest cover was 95 % and the lowest 80 %.

Figure 12. Study site (KL1) at Khao Luang National Park.

Figure 13. Study site (KL2) at Khao Luang National Park.

Figure 14. Study site (KL3) at Khao Luang National Park.

Figure 15. Study site (KL4) at Khao Luang National Park.

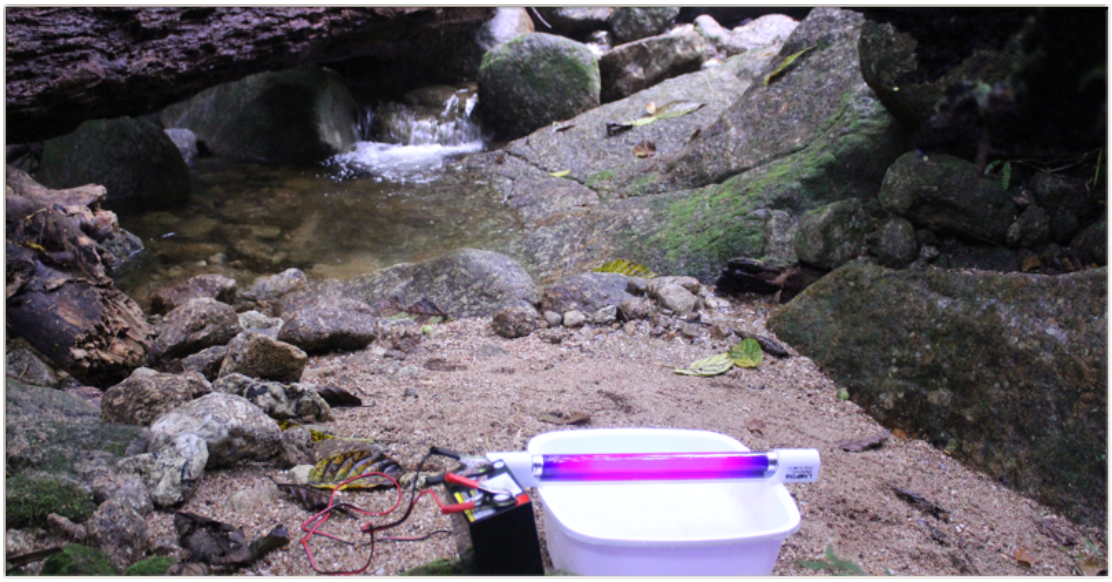


Figure 16. Study site (KL5) at Khao Luang National Park.

3.1.1.3 Physical and Chemical parameter of water quality at montane evergreen forest streams of Nakhon Si Thammarat Ranges

The determined water quality parameters for Nakhon Si Thammarat range are summarized in Table 2 showing the mean values. Water temperature greatly varied from 20.00±0.71 to 26±0.71 °C. Dudgeon (1999) reported the water temperature in tropical stream was on average about 20 °C. also Trichoptera species that live in high mountain steams where the temperature is under 25 °C are a cool adapted species group (Malicky and Chantaramongkol, 1993). That temperature is similar to the average in this current study. The mean dissolved oxygen ranged from 7.88±0.42 to 8.06±0.10 mg/l at Khao Nan National Parks with great species diversity. Moreover, the dissolved oxygen is most widely studied in aquatic environmental studies and is of high importance for aquatic animals (Hauer and Hill, 1996).

Table 2. Mean ± S.D. of water quality parameters in Tai Rom Yen, Khao Nan, and Khao Luang National Parks, shown with elevations.

Parameter	Mean ± SD		
	Tai Rom Yen 854–1,100	**Khao Nan 1,132–1,263**	**Khao Laung 793–1,336**
Water temperature (°C)	26±0.71	20.00±0.71	22.06±0.55
pH	7.56±0.24	7.91±0.20	7.93±0.36
Velocity (m/s)	0.27±0.21	0.27±0.22	0.56±0.18
Stream width (m.)	1.76±1.67	3±1.06	2.52±0.63
Stream depth (m.)	0.53±0.2	0.77±0.61	1.03±0.8
Alkalinity (mg/l)	65.19±11.75	79.39±6.45	68.37±2.24
Dissolved Oxygen (mg/l)	7.88±0.42	8.06±0.10	7.93±0.15
Electrical conductivity (µS/cm)	400.03±145.64	479.03±35.10	568.53±18.35
Total dissolved solid (mg/l)	204.87±37.21	214.59±23.26	248.43±19.53
Salinity (mg/l)	0.02±0.04	0.02±0.04	0.06±0.09
Nitrate-nitrogen, NO3-N (mg/l)	0.05±0.03	0.03±0.01	0.02±0.01
Phosphate, PO4 (mg/l)	0.17±0.01	0.15±0.01	0.15±0.01
Ammonia-nitrogen, NH4-N (mg/l)	0.20±0.27	0.45±0.35	0.48±0.36

3.3.2 Trichoptera diversity in montane evergreen forest streams of Nakhon Si Thammarat Ranges

Species diversity of Trichoptera in lower hill evergreen forests of Tai Rom Yen, Khao Nan, and Khao Luang National Parks, in Nakhon Si Thammarat Range of southern Thailand, was investigated. Adult Trichoptera specimens were collected representing 21 families, 60 genera, and 173 species (Table 3). From Tai Rom Yen National Park, which is in the western mountain range, 96 species of Trichoptera were identified. Khao Nan National Park in the eastern mountain range had 118 species found. In addition, Khao Luang National Park in the southern mountain range was represented by 81 recorded species of Trichoptera. The most abundant families of Trichoptera in this study were Philopotamidae (30 species), Hydropsychidae (26 species), Leptoceridae (21 species), and Polycentropodidae (17 species), in rank order of species count (Figure 17).

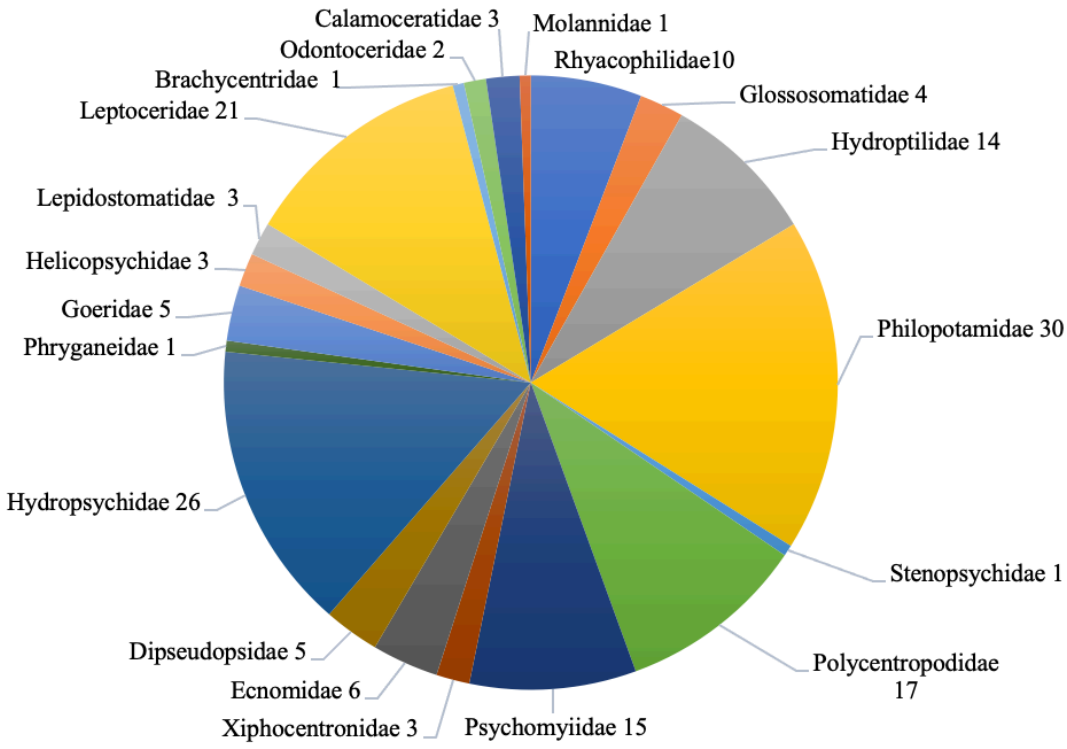


Figure 17. Numbers of Trichoptera species collected from Tai Rom Yen, Khao Nan and Khao Luang National Parks, shown by family.

The Trichoptera species found in greatest numbers are *Trichosetodes sisyphos, Chimarra thienemanni, Chrysotrichia pulmonaria,* and *Rhyacophila scissoidea.* The abundant Trichoptera species in these areas are *Rhyacophila scissoides, Chrysotrichia pulmonaria, Chimarra bimbltona, C. thienemanni, Pseudoneureclipsis uma, Psychomyia pinsuwanae, Diplectrona hermione, Cheumatopsyche charites, C. copia, C. dhanikari, Trichosetodes sisyphos, Paduniella hariel* and *Psychomyia hobrazym.*

Then there were rare Trichoptera species in these areas, such as *Rhyacophila olahi, Agapetus viricatus, Apsilochorema natibhinam, Glossosoma malayanum, Proxiphocentron arjinae, Psychomyia kerynitia, Tinodes sitto, Tinodes lebeli, Abaria iuma, Nyctiophylax tonngachang, Ecnomus vibenus, E. robustior, Diplectrona burha, Pseudoleptonema erawan, P. supalak* and *Eubasilissa maclachlani* (Table 3).

Trichoptera species from hill evergreen forests were compared and discussed, based on data of Trichoptera in Southern Thailand from moist evergreen forest (Laudee and Malicky, 2015; Prommi, 2007). The species of *Abaria iuma, Apsilochorema utchtchunam*, *A. natibhinam, Cheumatopsyche dhanikari, Chrysotrichia pulmonaria, C. talthybios, Drepanocentron jubal, Ecnomus robustior, E. thugarma, Eubasilissa maclachlani, Goera unica, G. fuscipenne, Hydroptila portunus, H. rumpun, H. sabit, Kisaura peleg, Lepidostoma moulmina, Leptocerus consus, Nyctiophylax tonngachang, Orthotrichia curvata, Polyplectropus nangajna, Psychomyia kerynitia, Pseudoneureclipsis baring, P. cheiron*, *Wormaldia lot*, *Eubasilissa maclachlani*, *Rhyacophila aksornkoaei*, *Plectrocnemia paras*, *Helicopsyche artinc*, *Oecetis rochcl*, and *Macrostemum nigralatum* were found only at lower hill evergreen forests. However, the species of Trichoptera from the two forest types are mostly similar, and the many species that occur in both forest types include *Rhyacophila suratthaniensis*, *R. tantichodoki*, *Ugandatrichia hairanga, Chimarra sita*, *C. spinifera*, *C. suthepensis*, *C. yskal*, *Gunungiella Sibylla*, *G. fimfafiazga*, *Polyplectropus matthatha*, *Pseudoneureclipsis baring*, *P. tramot*, *Paduniella hatyaiensis*, *Psychomyia adun*, *Tinodes lebeli*, *Abaria iuma*, *Ecnomus neri*, *E.puro*, *E. totiio*, *Diplectrona dulitensis*, *D. gombak*, *Amphipsyche gratiosa*, *Hydropsyche brontes*, *Goera anakpiatu*, *Helicopsyche boniata*, *Lepidostoma brevipennis*, *Oecetis lotis*, *Setodes kybele*, *S. thoneti*, and *Trichosetodes sisyphos* (Table 3).

For comparison with prior studies of Trichoptera species in northern Thailand, the caddisfly data from this study are discussed with the Trichoptera species from Doi Inthanon and Doi Suthep-Pui, in Northern Thailand (Malicky and Chantaramongkol, 1993; Thapanya *et al*., 2004; Suwannarat *et al*., 2020). The results show that many of Trichoptera species are ubiquitous and occur throughout the country, such as *Adicella evadne, A. koronis, Anisocentropus diana, Cheumatopsyche charites, C. copia, Chimarra monorum, C. bimbltona, C. Pipake, C. atnia, C. lannaensis, C. suthepensis, Goera uniformis, Hydromanicus abiud, H. inferior, Hydropsyche camillus, H. pallipenne, Micrasema fortiso, Macrostemum floridum, M. hestia, M. midas, Diplectrona hermione, Oecetis tripunctata, Rhyacophila scissoides, Stenopsyche siamensis, Potamyia flavata, P. phaidra, Ugandatrichia hairanga, U. kerdmuang,* and *Lype atnia* (Table 3). In addition, the Trichoptera species that occur in hill evergreen forests found in this study and also in Doi Inthanon and Suthep-Pui National Parks (where the elevation is higher than 900 meters from mean sea level) include *Agapetus viricatus, Apsilochorema utchtchunam, Chimarra devva, C. lannaensis, C. suthepensis, Cheumatopsyche dhanikari, C. trilari, Chrysotrichia pulmonaria, C. talthybios, Diplectrona hermione, D. burha, Dolophilodes adnamat, Eubasilissa maclachlani, Glossosoma malayanum, Goera mandana, Hydropsyche doctersi, Micrasema fortiso, Oecetis tripunctata, Orthotrichia deukalion, Paduniella semarangensis, Polyplectropus admin, P. menna, Potamyia flavata, P. phaidra, Pseudoneureclipsis usia, Rhyacophila murhu, R. xayide, R. malayana*, and *Tinodes ragu* (Table 3).

Trichoptera species that live in high mountain steams where the temperature is under 25 ^{o}C are a cool adapted species group (Malicky&Chantaramongkol 1993). The Oriental region of Zoogeographic region is divided into Indian subregion, Indo-chinese subregion, Sundaic subregion and Wallacea subregion. In this study, many species occurred only in southern Thailand, which is part of the Sundaic subregion, such as *Rhyacophila suratthaniensis*, *R. tantichodoki*, *Apsilochorema natibhinam*, *Pseudoneureclipsis zethos*, *Ecnomus thugarma*, *Tagalopsyche osiris*, and *Trichosetodes sisyphos,* and the 15 new species which were described from this study. This result shows that some species that live in lower hill evergreen forests of southern Thailand are Sundaic subregion species.

Table 3. Number counts of Trichoptera species found in Tai Rom Yen, Khao Nan and Khao Luang National Parks: distribution and abundance

Name of Trichoptera	Hill evergreen forests (the current study)			Northern Thailand		Southern Thailand		Abun-dance	Distri-bution
	TR	KN	KL	TP	BL	PM	LD		
Rhyacophilidae									
Rhyacophila aksornkoaei Laudee&Malicky 2019			14	-	-	-	-	p	E
Rhyacophila longicaudata Malicky&Suwannarat 2019		3	5	-	-	-	-	p	E
Rhyacophila olahi Aramitage&Arefina 2003			2	-	-	-	-	r	m
Rhyacophila suratthaniensis Laudee&Malicky 2016	2	8	6	-	-	-	+	p	e
Rhyacophila tantichodoki M&C 1993	10	7	8	-	-	+	+	c	e
Rhyacophila malayana Banks 1931	11		10	+	+	+	+	c	m
Rhyacophila scissoides Kimmins 1953	166	76	29	+	+	+	+	a	m
Rhyacophila tosagam M&C 1993		3	4	-	+	+	-	p	e
Rhyacophila murhu M&C 1931		2	1	+	+	-	-	p	m
Rhyacophila xayide M&C 1989		2	4	+	+	-	-	p	m
Glossosomatidae									
Agapetus viricatus M&C 1992	2			+	-	-	-	r	m
Apsilochorema natibhinam Schmid 1970		2		-	-	-	-	r	m
Apsilochorema utchtchunam Schmid 1970	2	2		-	-	-	-	p	m
Glossosoma malayanum Banks 1934		2		+	+	-	-	r	m

Table 3 Continued

Hydroptilidae									
Orthotrichia kaonan Malicky&Suwannarat 2018	12	2	108	-	-	-	-	a	E
Chrysotrichia pulmonaria Xue&Yang 1990		20	200	-	-	+	-	a	e
Chrysotrichia talthybios M&C 2007			2	-	-	-	-	r	m
Hydroptila sabit Wells&Huisman 1992	2	1		-	-	-	-	p	m
Hydroptila portunus M&C 2007		7		-	-	+	-	p	e
Hydroptila rumpun Wells&Huisman 1992		94		-	-	-	-	c	m
Hydroptila thuna Olah 1989		1		-	+	+	-	r	e
Macrostactobia runcing Wells&Huisman 1992	2			-	-	-	-	r	m
Orthotrichia terpsichore M&C 2007			2	-	-	-	+	r	e
Orthotrichia curvata Ulmer 1951		2		-	-	-	-	r	m
Orthotrichia deukalion Malicky&Prommi 2000		2	2	-	-	-	-	p	m
Scelotrichia temenos M&C 2007	10			-	-	-	-	p	m
Ugandatrichia honga Olah 1989		8	2	+	-	+	+	p	m
Ugandatrichia hairanga Olah 1989			2	+	-	+	-	r	e
Ugandatrichia kerdmuang M&C 1991			4	+	-	+	-	p	e

Table 3 Continued

Philopotamidae									
Chimarra atnia M&C 1993	8	1	2	+	+	+	+	p	e
Chimarra bimbltona Malicky 1979	42	24	>250	+	+	+	+	a	e
Chimarra chiangmaiensis C&M 1989	46		2	+	-	+	+	c	e
Chimarra devva M&C 1993	8	1		+	+	-	-	p	m
Chimarra fulmeki Ulmer 1951	8	4		-	-	-	-	p	m
Chimarra htinorum C&M 1989	5			+	+	-	+	p	e
Chimarra joliveti Jacquemart 1979		2	52	-	-	-	-	c	m
Chimarra khamuorum C&M 1989	12			+	+	-	+	p	e
Chimarra lannaensis C&M 1989	2			-	+	+	-	r	e
Chimarra meorum C&M 1989	9			+	+	+	-	p	e
Chimarra monorum C&M 1989	58	35		+	+	+	+	c	e
Chimarra okuihorum Mey 1998			2	+	-	-	-	r	m
Chimarra pipake M&C 1993			14	+	+	+	+	p	e
Chimarra rama M&C 1993	2		1	-	-	+	-	p	e
Chimarra ravanna M&C 1993	73	6		-	-	+	-	c	e
Chimarra reasilvia Malicky&Prommi 2006	2			-	-	+	-	r	e
Chimarra supanna Malicky 1993	50	24	2	-	-	+	-	c	e

Table 3 Continued

Chimarra scopulifera Kimmins 1957	5		8	+	+	+	-	p	e
Chimarra sita M&C 1993	42			-	-	+	-	c	e
Chimarra spinifera Kimmins 1957	8	1	20	+	+	+	+	c	e
Chimarra suthepensis C&M 1989	2			+	+	+	-	r	e
Chimarra thienemanni C&M 1989	>250	>250	>250	-	-	-	-	a	m
Chimarra uppita M&C 1993			2	+	+	-	-	r	m
Chimarra yskal Malicky 1989			2	-	-	+	+	r	e
Dolophilodes adnamat M&C 1993			8	+	+	-	-	p	m
Gunungiella sibylla Malicky&Prommi 2006	12	2	2	-	-	+	-	p	e
Gunungiella fimfafiazga M&C 1993	8	2		-	-	+	+	p	e
Kisaura peleg Malicky&Laudee 2009			4	-	-	-	-	p	m
Wormaldia lot M&C 2009	1			-	-	-	-	r	m
Wormaldia relicta Martynov 1935			2	+	-	-	-	r	m
Stenopsychidae									
Stenopsyche siamensis Martynov 1931	1	6	10	+	+	+	+	p	m
Polycentropodidae									
Plectrocnemia paras Malicky&Suwannarat 2020		2		-	-	-	-	r	E
Polyplectropus hofmaierae Malicky&Suwannarat 2019	1			-	-	-	-	r	E

Table 3 Continued

Polyplectropus josaphat Malicky 1993		2		-	-	-	-	r	m
Polyplectropus admin M&C 1993		1	6	+	+	.	.	p	m
Polyplectropus nangajna M&C 1993		2		-	+	-	-	r	m
Polyplectropus menna M&C 1993	2	2		+	+	-	-	p	m
Pseudoneureclipsis baring Malicky 1993		2		-	-	-	+	r	e
Pseudoneureclipsis cheiron Malicky&Sompong 2000	9	2		-	-	-	-	p	m
Pseudoneureclipsis zethos Malicky&Prommi 2006		8		-	-	-	-	p	m
Pseudoneureclipsis usia M&C 1993		1		+	+	-	-	r	m
Pseudoneureclipsis tramot M&C 1993	5			-	-	+	+	p	e
Pseudoneureclipsis thiras M&C 2009		2	74	-	-	-	-	c	m
Pseudoneureclipsis uma M&C 1993	2	3	126	-	+	+	+	a	m
Pseudoneureclipsis locutius M&C 1997			6	-	-	-	-	p	m
Psychomyia hobrazym Malicky&Suwannarat 2020	2	122		-	-	-	-	a	E
Psychomyiidae									
Amphipsyche gratiosa Navas 1922		2		+	+	+	-	r	m
Eoneureclipsis chinachotiae Malicky&Laudee 2019	5	12	2	-	-	-	-	p	E
Eoneureclipsis querquobad M&C 1989	1	2	1	+	-	+	-	p	m
Paduniella hatyaiensis M&C 1993		2	4	-	-	+	-	p	e

Table 3 Continued

Paduniella semarangensis Ulmer 1913		1		-	+	+	-	r	m
Proxiphocentron arjinae M&C 1993		2		-	-	-	-	r	m
Psychomyia adun M&C 1993			3	-	-	+	+	p	e
Psychomyia kerynitia Malicky&Nuntakwang 2006			2	-	+	-	-	r	m
Psychomyia kuni M&C 1993		10	11	-	-	-	-	c	m
Psychomyia reguel M&C 2009		2	1	-	-	-	-	p	m
Psychomyia pinsuwanae Laudee&Malicky 2018			110	-	-	-	-	a	m
Tinodes sitto M&C 1993			1	-	-	-	-	r	m
Tinodes ragu M&C 1993	6	1	2	-	+	+	-	p	m
Tinodes lebeli M&C 1993		2		-	-	+	-	r	e
Lype atnia M&C 1993	6	4	4	-	+	+	-	p	m
Xiphocentronidae									
Abaria iuma M&C 1992		1		-	-	+	-	r	e
Drepanocentron jubal M&C 2009	6			-	-	-	-	p	m
Nyctiophylax tonngachang M&C 1993			2	-	-	-	-	r	m
Ecnomidae									
Ecnomus neri M&C 1993	1	2		-	-	+	+	p	e
Ecnomus puro M&C 1993	2	13	1	-	-	+	-	p	e

Table 3 Continued

Ecnomus totiio M&C 1993	3	14	1	-	-	+	+	p	e
Ecnomus vibenus M&C 1993		2		-	-	-	-	r	m
Ecnomus robustior Ulmer 1929		2		-	+	+	-	r	m
Ecnomus thugarma M&C 2009	2	24	10	-	-	-	-	c	m
Dipseudopsidae									
Diplectrona burha Schmid 1961	1			+	-	-	-	r	m
Diplectrona dulitensis Kimmins 1955	62	17	19	-	-	+	-	c	e
Diplectrona gombak Olah 1993	2	1		-	-	+	-	p	e
Diplectrona hermione M&C 2002	111	19	31	-	-	+	-	a	e
Diplectrona joannisi Navas 1932		5	1	-	-	-	-	p	m
Hydropsychidae									
Amphipsyche gratiosa Navas 1997		2		-	-	-	+	r	e
Cheumatopsyche charites M&C 1997		61	>250	+	+	+	+	a	m
Cheumatopsyche copia M&C 1997	16	2	>250	+	+	+	+	a	m
Cheumatopsyche dhanikari Malicky 1979		23	>250	-	-	-	-	a	m
Cheumatopsyche trilari M&C 1997	2	1	1	-	+	-	+	p	m
Cheumatopsyche criseyde M&C 1997	1			+	+	-	+	r	m
Hydromanicus abiud M&C 1993	3	2	8	+	+	+	+	p	m

Table 3 Continued

Hydromanicus adonis M&C 1996	4	1	2	+	+	+	+	p	m
Hydromanicus klanklini M&C 1993	3	5	1	+	+	+	+	p	m
Hydromanicus inferior C&M 1995		84	4	+	+	+	-	c	m
Hydropsyche biton M&C 2000		12	1	+	-	+	-	p	m
Hydropsyche brontes M&C 2000	5	3	22	-	-	+	+	c	e
Hydropsyche camillus M&C 2000	14	14		+	+	+	+	c	m
Hydropsyche doctersi Ulmer 1951	2			+	+	+	-	r	m
Hydropsyche pallipenne Banks 1938	78	7		+	+	+	+	c	m
Hydropsyche kaonanensis Malicky&Suwannarat 2019	1	1		-	-	-	-	r	E
Macrostemum nigralatum Laudee&Malicky 2018	8	17	54	-	-	-	-	c	E
Macrostemum floridum Navas 1929		9		+	+	+	-	p	m
Macrostemum fenestratum Albarda 1887	2	2		+	-	+	-	p	m
Macrostemum hestia M&C 1998	60	27	4	+	+	+	+	c	m
Macrostemum midas M&C 1998	8	8	7	+	+	+	+	c	m
Potamyia phaidra M&C 1997	7	16	2	+	-	+	-	c	m
Potamyia flavata Banks 1934		1		+	-	+	-	r	m
Pseudoleptonema erawan M&C 2001		2		-	-	-	-	r	m
Pseudoleptonema supalak M&C 1998		1		-	-	-	-	r	m

Table 3 Continued

Trichomacronema vietnamemsis Malicky&Bae 2018 *		4		-	-	-	-	p	m
Phryganeidae									
Eubasilissa maclachlani White 1862		1		+	+	-	-	r	m
Goeridae									
Goera unica Ulmer 1951	5	11		-	-	-	-	p	m
Goera uniformis Banks 1931	67	2	2	+	+	+	+	c	m
Goera anakpiatu Malicky 1995	1	2		-	-	-	+	p	e
Goera mandana Mosely 1938	1			+	+	-	-	r	m
Goera fuscipenne Albarda 1881	3		1	-	-	-	-	p	m
Helicopsychidae									
Helicopsyche chairum Malicky&Suwannarat 2020	2		10	-	-	-	-	p	E
Helicopsyche artinc Malicky&Suwannarat 2020	1			-	-	-	-	p	E
Helicopsyche boniata M&C 1992		8		-	-	+	+	p	e
Lepidostomatidae									
Lepidostoma abruptum Banks 1931	40	20	29	+	+	+	+	c	m
Lepidostoma brevipennis Olah 1993	11	19	4	+	-	-	+	c	e
Lepidostoma moulmina Mosely 1949	18	26	5	+	+	-	-	c	m
Leptoceridae									
Adicella evadne Schmid 1994		3	1	-	-	-	-	p	m

Table 3 Continued

Adicella koronis Malicky&Thani 2002			1	-	-	-	-	r	m
Adicella pulcherrima Ulmer 1906	2			-	-	-	-	r	m
Leptocerus consus Malicky&Sompong 2000			1	-	-	-	-	r	m
Leptocerus tursiops Malicky 1979		4	1	-	-	-	-	p	m
Oecetis lehachiah Malicky&Suwannarat 2020	2		2	-	-	-	-	p	E
Oecetis rochcl Malicky&Suwannarat 2020	1			-	-	-	-	p	E
Oecetis miletos Malicky&Naewvong 2005			4	-	-	-	-	p	m
Oecetis lotis Malicky&Thapanya 2004		2		-	-	+	+	r	e
Oecetis tripunctata Fabricius 1793	3	8		-	+	+	-	p	m
Parasetodes respersellus Rambur 1842		2		-	-	-	-	p	m
Setodes sarapis M&C 2006	1	1		-	-	-	-	r	m
Setodes kybele M&C 2006			10	-	-	+	-	p	e
Setodes thoneti M&C 2006		53		-	-	+	-	c	e
Setodes akrura Gordon&Schmid 1987		8		+	-	+	-	p	m
Setodes alampata Schmid 1987	45	2		-	-	-	-	c	m
Setodes isis Malicky&Naewvong 2006		78		-	+	+	-	c	m
Tagalopsyche brunnea Ulmer 1905	2			-	-	-	-	r	m
Tagalopsyche osiris Malicky&Prommi 2006	8	2		-	-	-	-	p	m

Table 3 Continued

Trichosetodes sisyphos Malicky&Prommi 2006	>250	19	68	-	-	+	+	a	e
Triaenodes dusra Schmid 1965	1			-	-	-	-	r	m
Brachycentridae									
Micrasema fortiso M&C 1992	4	2	1	+	+	-	-	p	m
Odontoceridae									
Lannapsyche tairomyenensis Malicky&Suwannarat 2019	10	2	2	-	-	-	-	p	E
Psilotreta assur M&C 2009		3		-	-	-	-	p	m
Calamoceratidae									
Anisocentropus tairomyenensis Malicky&Suwannarat 2018	29	23	3	-	-	-	-	c	E
Anisocentropus diana M&C 1994	9	6		+	+	+	+	p	m
Ganonema fuscipenne Albarda 1881	5	4	4	+	+	+	+	p	m
Molannidae									
Molanna oglamar M&C 1989	1	2		+	+	-	-	p	m

3.3.3 New species in montane evergreen forest streams of Nakhon Si Thammarat Ranges

This research added 16 species to Thailand's Trichoptera checklist, with 15 new species and 1 new record. Totally, 1053 species of Trichoptera are recorded from Thailand (Chantaramongkol et al. 2010; Laudee&Malicky 2015; Suwannarat et al. 2018; Suwannarat et al. 2019; Malicky&Suwannarat 2020; Malicky et al. 2020; Suwannarat et al. 2020). In a caddisfly diversity survey, there were 15 species that have been reported for the first time and were described as new species from this study, including *Macrostemum nigralatum* (Figure 18), *Anisocentropus tairomyenensis* (Figure 19), *Rhyacophila aksornkoaei* (Figure 20), *Rhyacophila longicaudata* (Figure 21), *Lannapsyche tairomyenensis* (Figure 22), *Eoneureclipsis chinachotiae* (Figure 23), *Hydropsyche kaonanensis* (Figure 24), *Plectrocnemia paras* (Figure 25), *Psychomyia hobrazym* (Figure 26), *Polyplectropus hofmaierae* (Figure 27), *Orthotrichia kaonan* (Figure 28), *Helicopsyche chairum* (Figure 29), *Helicopsyche artinc* (Figure 30),

Oecetis lehachiah (Figure 31), and *Oecetis rochcl* (Figure 32). In addition, *Trichomacronema vietnamemsis* is new record for Thailand.

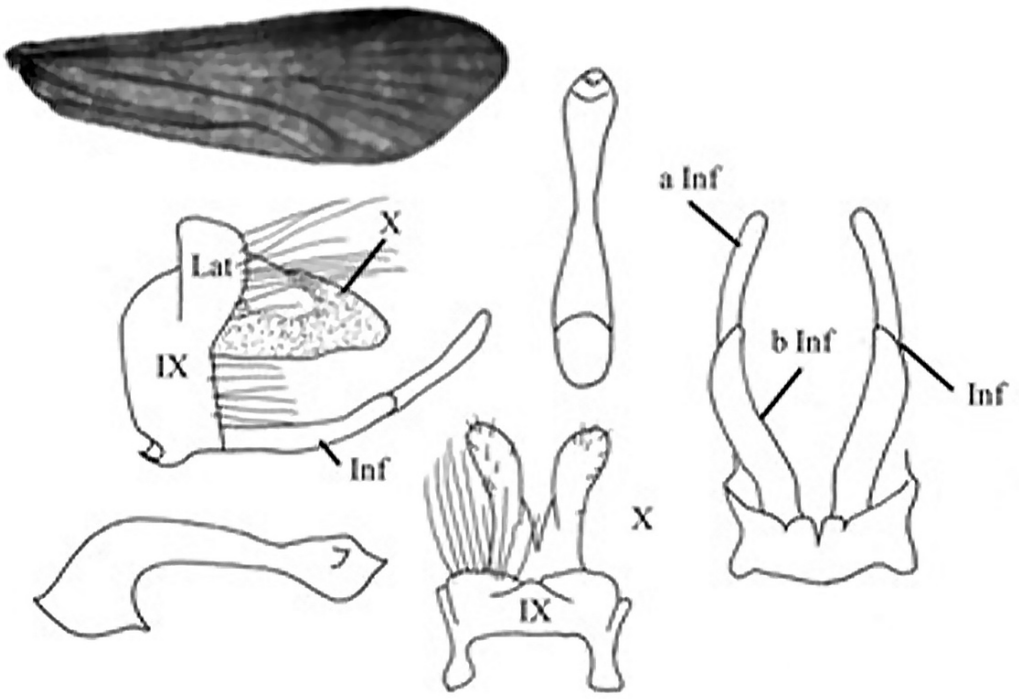


Figure 18. Male genitalia of *Macrostemum nigralatum* **n. sp.**

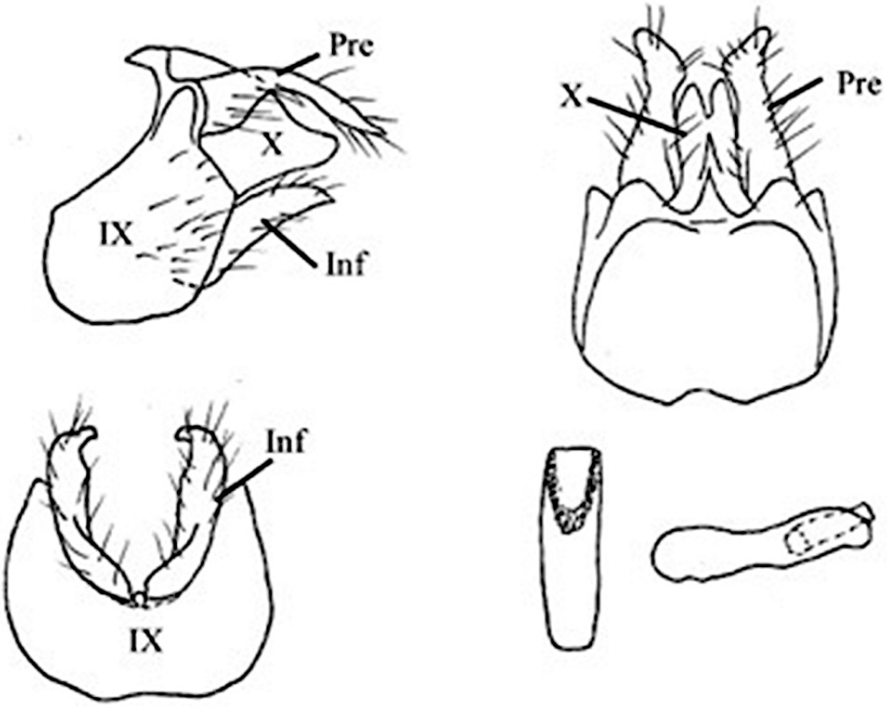


Figure 19. Male genitalia of *Anisocentropus tairomyenensis* **n. sp.**

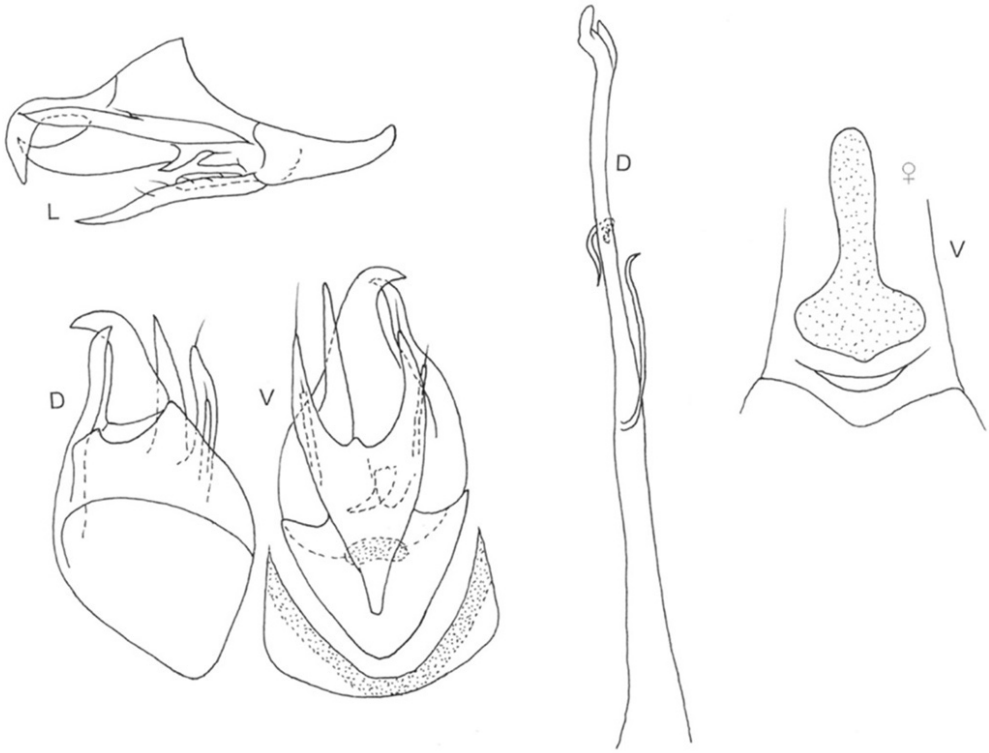


Figure 20. Male genitalia of *Orthotrichia kaonan* **n. sp**

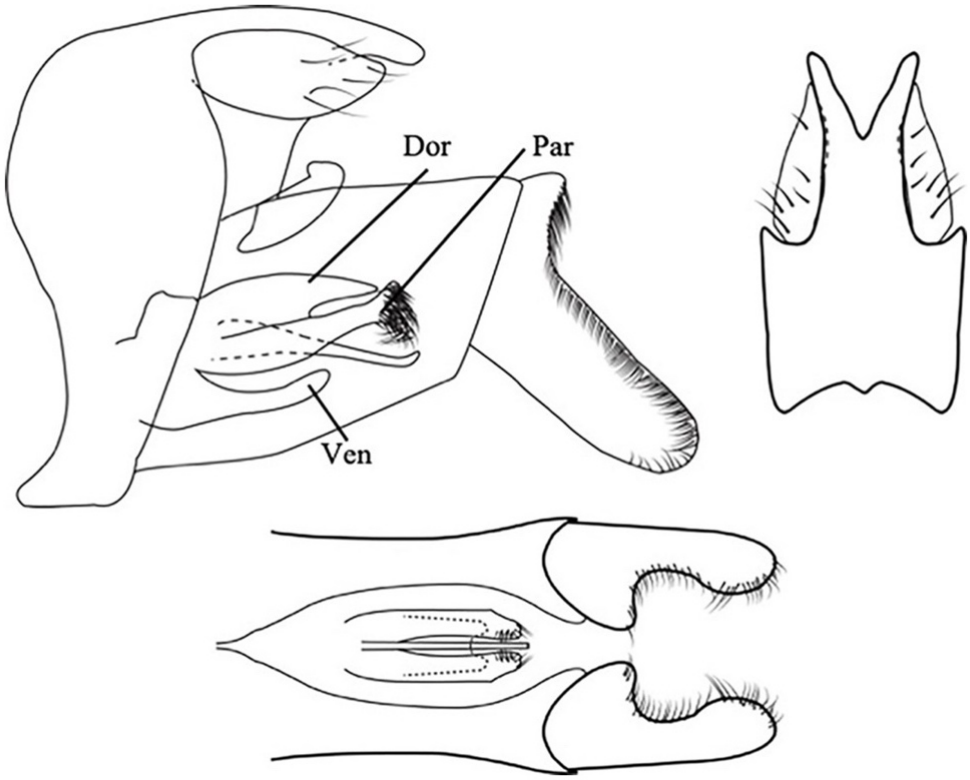


Figure 21. Male genitalia of *Rhyacophila aksornkoaei* **n. sp.**

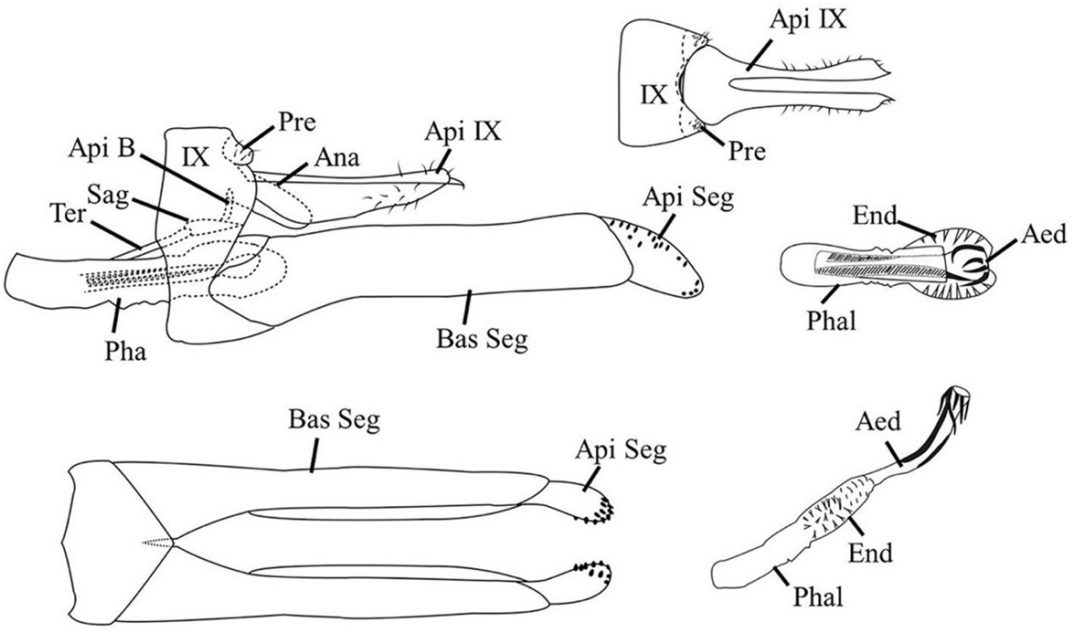


Figure 22. Male genitalia of *Rhyacophila longicaudata* **n. sp.**

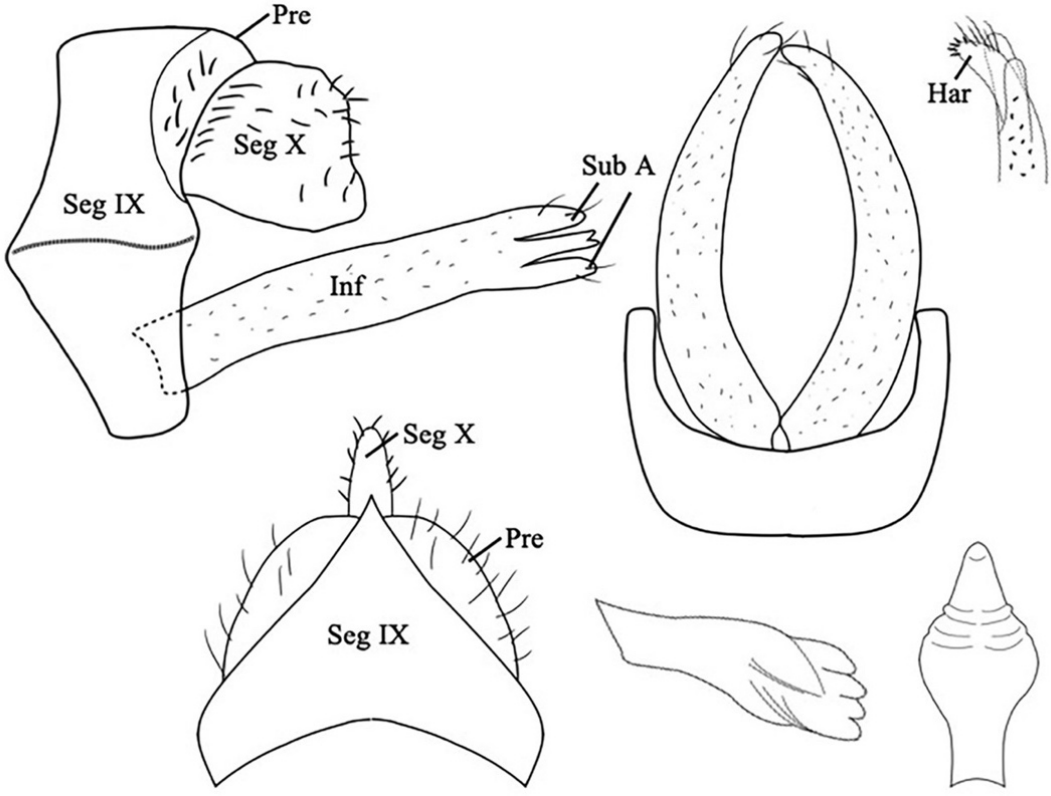


Figure 23. Male genitalia of *Lannapsyche tairomyenensis* **n. sp.**

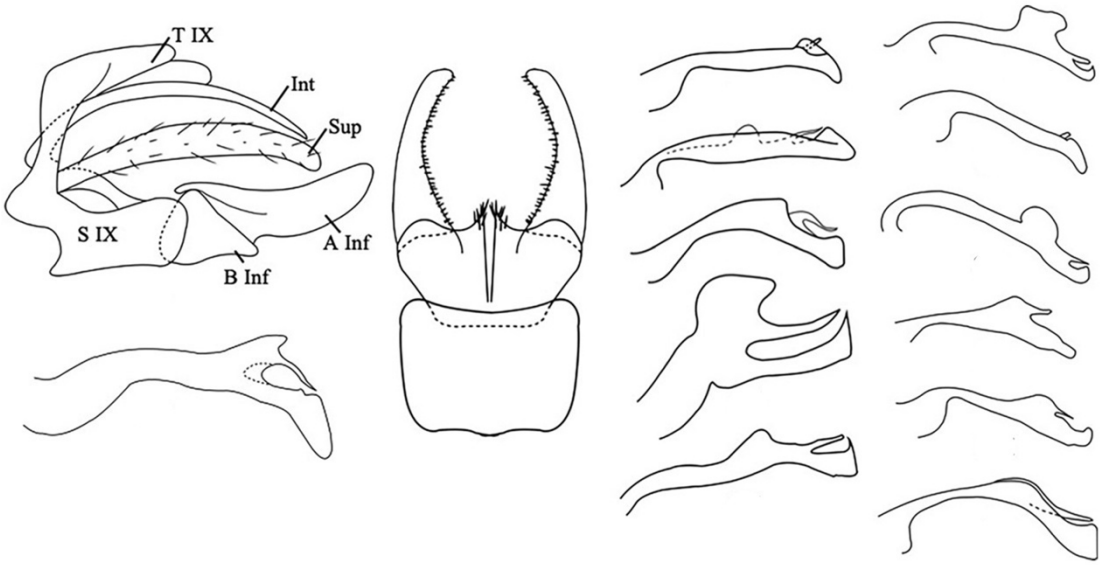


Figure 24. Male genitalia of *Eoneureclipsis chinachotiae* **n. sp.**

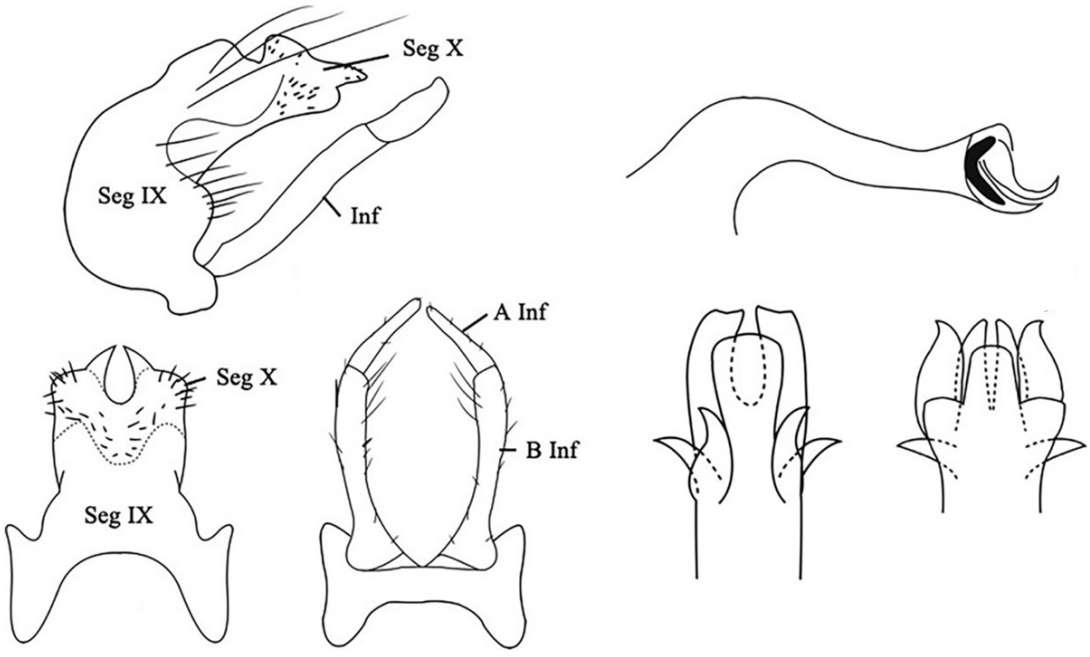


Figure 25. Male genitalia of *Hydropsyche khaonanensis* **n. sp.**

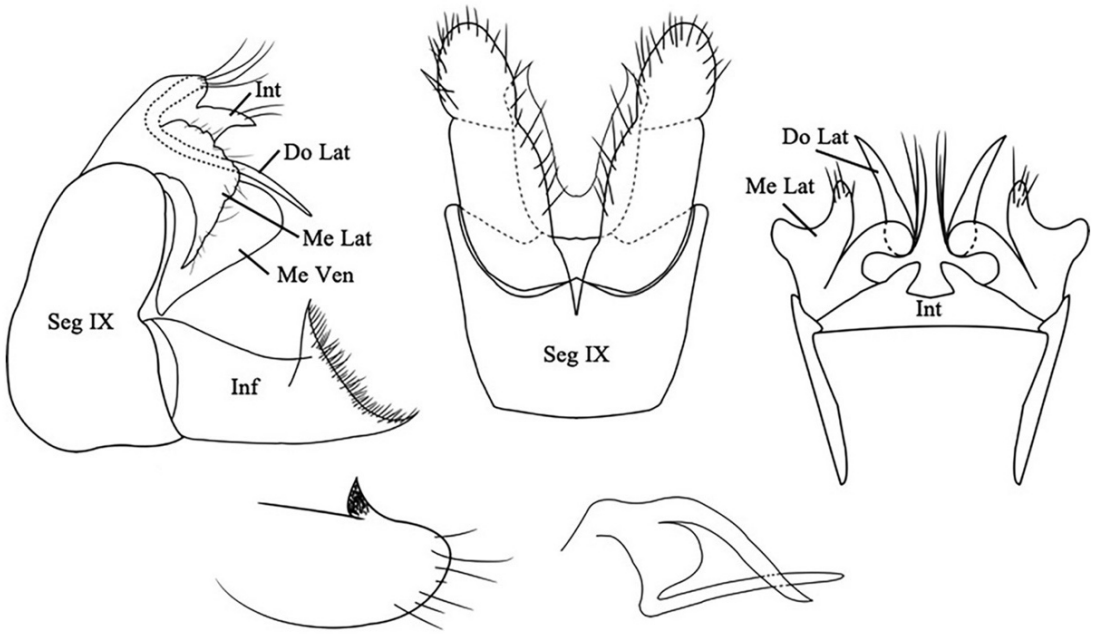


Figure 26. Male genitalia of *Polyplectopus hofmaierae* **n. sp.**

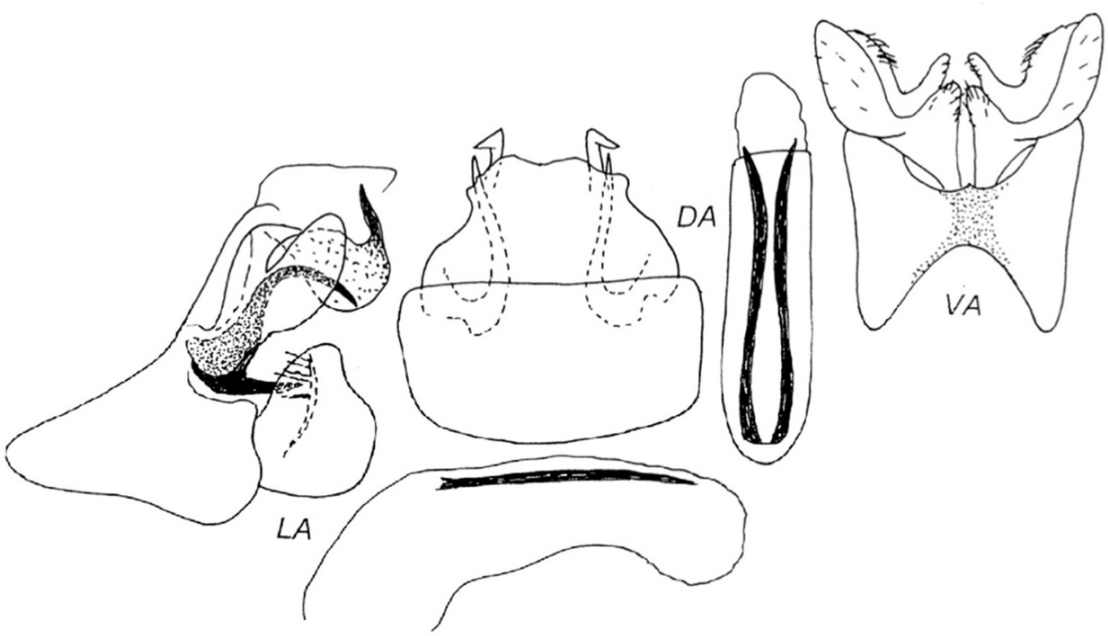


Figure 27. Male genitalia of *Plectrocnemia paras* **n. sp.**

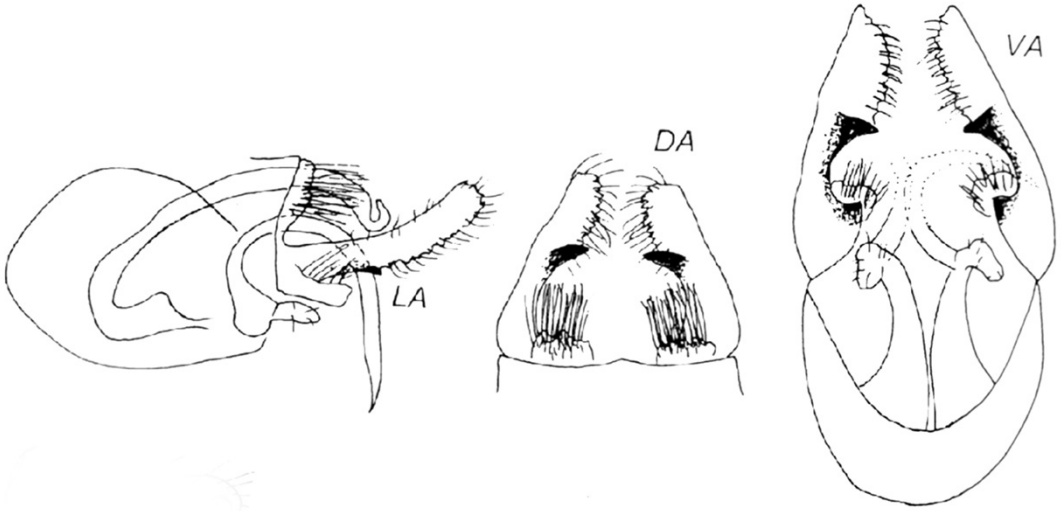


Figure 28. Male genitalia of *Psychomyia hobrazym* **n. sp.**

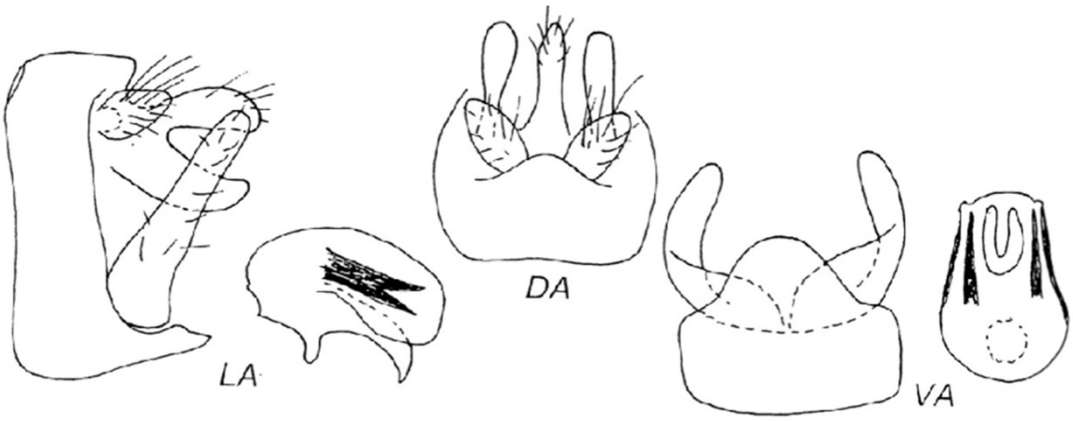


Figure 29. Male genitalia of *Oecetis rochel* **n. sp.**

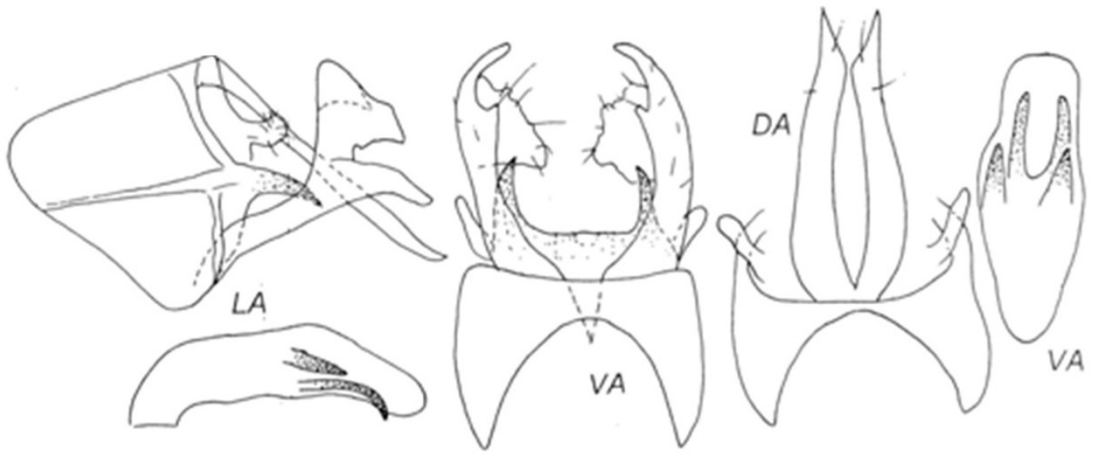


Figure 30. Male genitalia of *Helicopsyche chairum* **n. sp.**

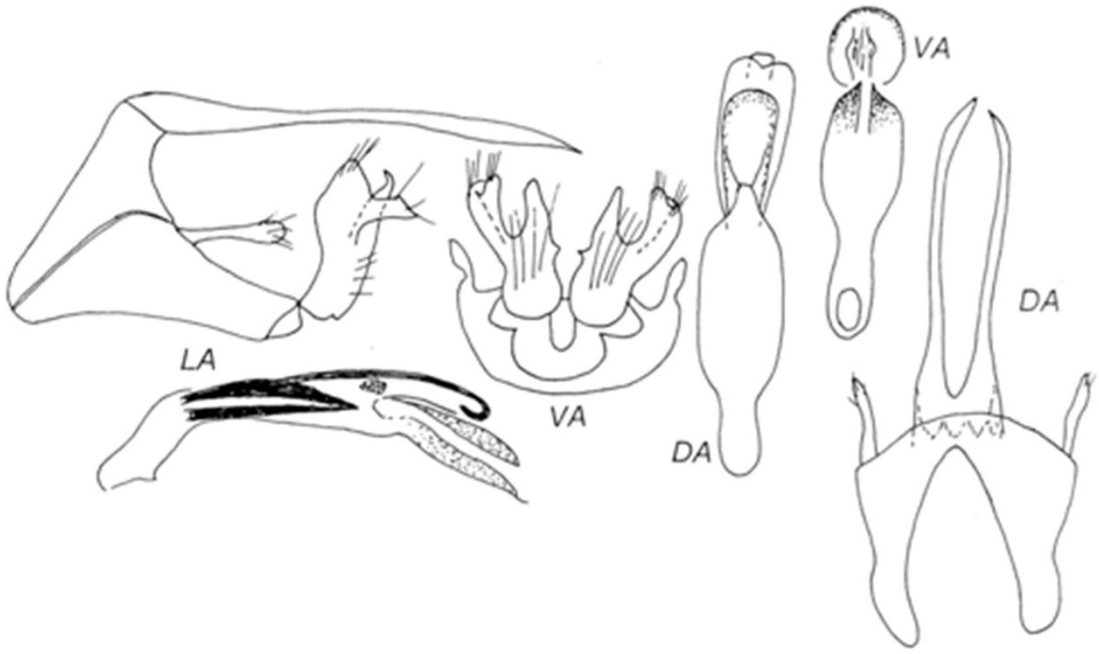


Figure 31. Male genitalia of *Helicopsyche artinc* **n. sp.**

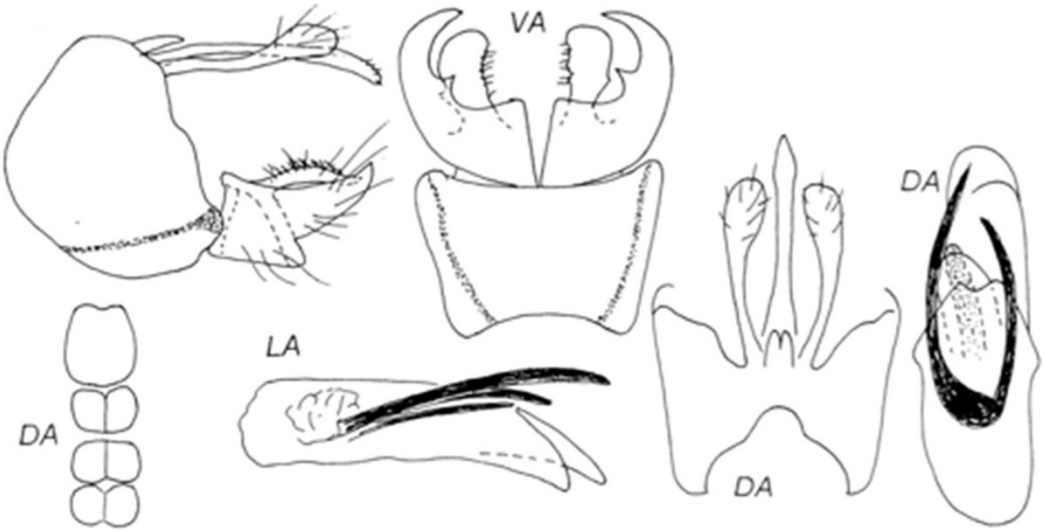


Figure 32. Male genitalia *of Oecetis lehachiah* **n. sp.**

3.3.4 Morphology, Ecology, and Nutritional values of Trichoptera Larvae in Tai Rom Yen National Park of Nakhon Si Thammarat Ranges

3.3.4.1 Morphology of final instar Trichoptera Larvae, description of the final instar Larvae: *Lepidostoma abruptum* Banks, 1931

3.3.4.1.1 General aspects, Total length 8.0–12.0 mm (n=12). Head and other sclerotized parts dark brown to yellow brown. Soft part of thorax and abdominal segment white. Abdominal segments II–VII with single gills dorsally and ventrally, bifurcated.

3.3.4.1.2 Larval case, Case length 9.5–12.5 mm (n=12). Case rectangular, cylindrical, made of rectangular pieces of leaf (Figure 33).

3.3.4.1.3 Final instar larva, Head slightly circular, granulated surface; head capsule length 1.25–1.30 mm (n=12); head capsule width 1.50–1.58 mm (n=12). Dorsal of head dark brown to yellow brown with numerous somewhat circular yellow muscle scars from mid-posterior of head. Eyes black, round with semicircle yellow muscle scar posteriorly. Frontoclypeus with anterior margin concave, anterior part somewhat trapezoid and dark brown, subposterior end with yellow marks. Labium light brown, elliptical with setae anteriorly. Ventral of head light brown. Submentum small, short, rectangular. Ventral apotome isosceles triangle that is broad anteriorly and narrowest posteriorly. Medial ecdysial line shorter than ventral apotome. Ventral apotome yellow brown, triangular (Figure 34).

3.3.4.1.4 Thorax three-segmented, yellow brown, and with moderate numerous long black setae. Pronotum dark brown sclerite, eleven black setae anteriorly, four setae medially, curved row of muscle marks subposteriorly (Figure 35; a-c).

Mesonotum yellow brown sclerite, one anteromedial seta (*Sa1*), three posteromedial setae (*Sa2*), two lateral setae (*Sa3*). Metanotum light yellow membranous, non-anteromedial setae (*Sa1*), two posteromedial setae (*Sa2*), four lateral setae (*Sa3*); see (Figure 35; d-e).

3.3.4.1.5 Forelegs shortest with coxa trapezoid, somewhat rectangular trochanter, stout femur, short tibia, and bifid tarsal claws. Midlegs and hindlegs somewhat similar with coxa, trochanter, femur, tibia slender and long, and with bifid tarsal claws (Figures 35; f-h). Abdominal segments membranous, light red brown.

3.3.4.1.6 Abdominal segments cylindrical, creamy white, with dorsal and ventral single gills. Abdominal segment I with lateral humps on each side (Figure 12), dorsal setal area 1 and 3 absent, dorsal setal area 2 with single seta, ventral setal area 2 and 3 with single seta, ventral setal area 1 absent (Figures 36; a-b). Abdominal segment II–VII with single seta on dorsal setal area 2 and dorsal setal area 3, dorsal setal area 1 with no seta, ventral setal areas 2 and 3 with single seta, ventral setal area 1 with no seta (Figure 36; b and Figure 37). Abdominal segment with single dorsal and ventral gills, with lateral line, number and positioning of gills and the extent of lateral line show as in (Figures 36; b-e). Abdominal segment IX dark brown, with semicircle dorsal sclerite and four of long seta on its sclerite (Figure 36; c), with 4 pairs of ventral setae (Figure 36; d). Anal prolegs short with anal sclerite. Anal claws dark brown, each with accessory hook (Figure 36; e).

Figure 33. General appearance of final instar larva and its case for *Lepidostoma abruptum* Banks, 1931.

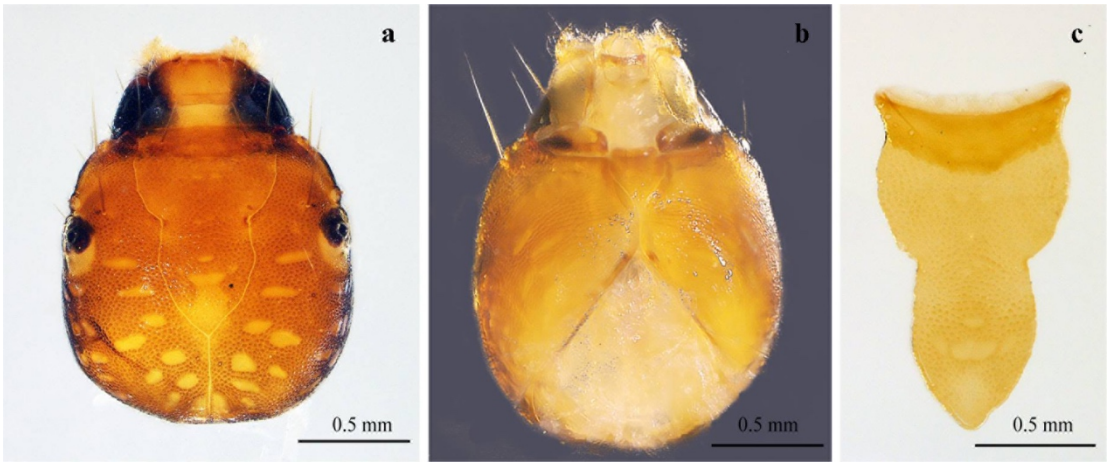
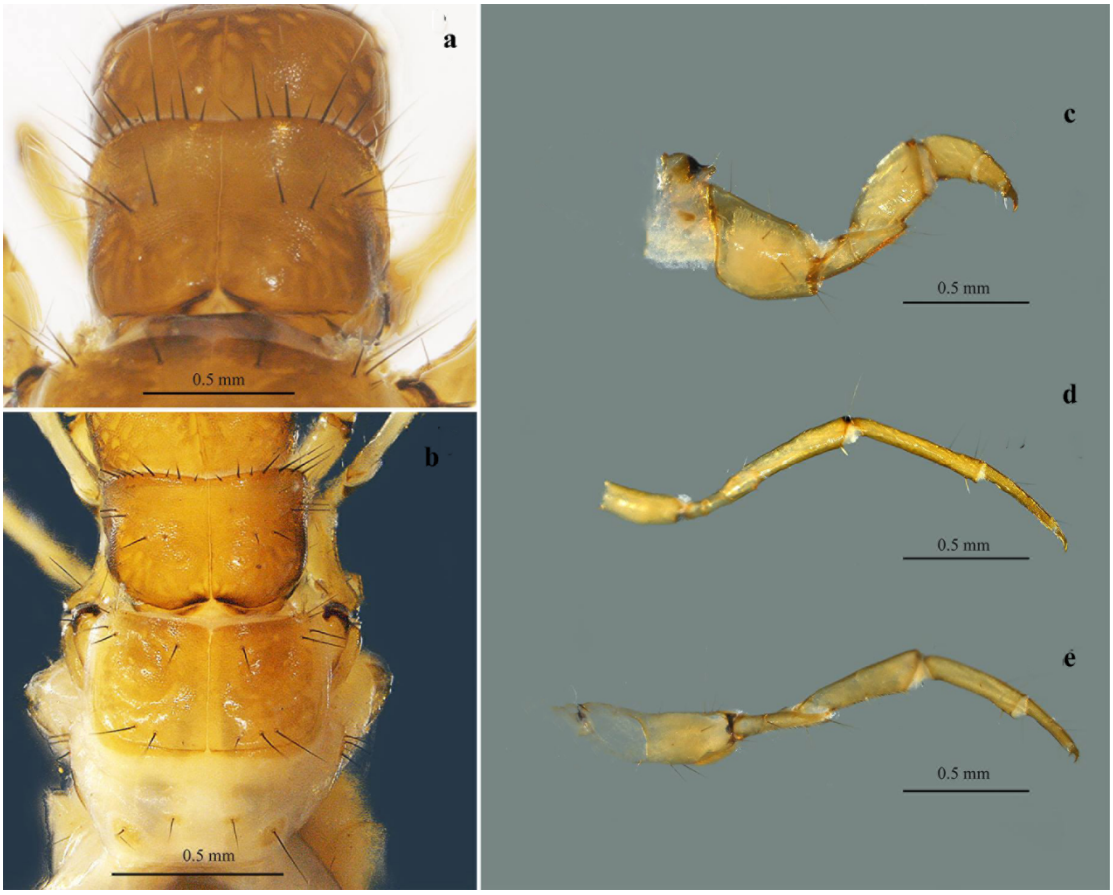


Figure 34. a Head dorsal, **b** Head ventral, **c** Frontoclypeus.



Figures 35. **a** and **b** Thorax (pronotum, mesonotum, and metanotum), setae on pronotum, **c** Left front leg, **d** Left middle leg, **e** Left hind leg.

Figures 36. **a** Abdomen segment I (arrow indicates abdominal segment I lateral humps), **b** Abdomen gills segment I–VII, lateral view, **c** Abdomen segment VIII–IX dorsal, **d** Abdomen segment IX, **e** Anal claw and accessory hook ventral.

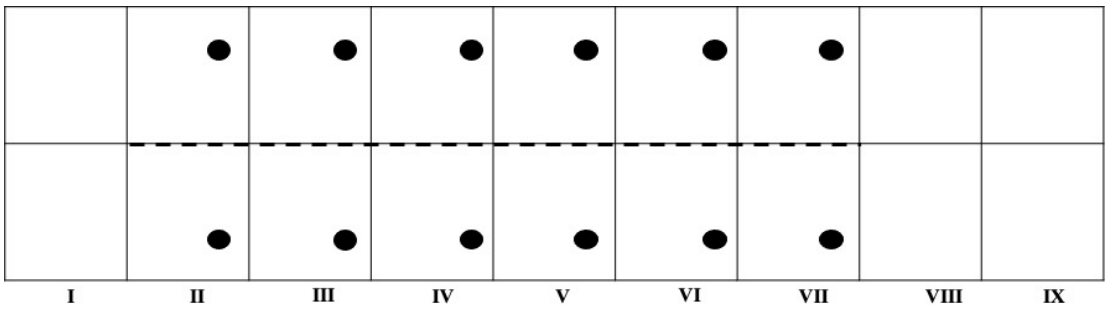


Figure 37. Lepidostoma abruptum, 5th instar larva. Gill diagram of dorsal and ventral gills and extent of lateral line (dashed bold line along the middle).

3.3.4.2 Ecology and Life cycle study

3.3.4.2.1 Ecology of study site, The *Lepidostoma abruptum* larvae were collected bimonthly from a small stream at the Tai Rom Yen National Park, Southern Thailand (8º50'35''N 99º28'38''E) at 911meter elevation from average mean sea level during March 2019–February 2020. The larvae were taken from a pool in a small stream. The substrate was dominated by fine sand, fine gravel, dead plant materials and leaves. Physical and chemical parameters of environment and water quality were as follows: air temperature 19±0.84°C, water temperature 23±1.41 °C, pH 7.85±0.36, velocity 0.18±0.25 m/s, stream width 4±0.63 m, stream depth 0.5±0.8m, alkalinity 55.78±2.24 mg/l, dissolved oxygen 6.03±0.20 mg/l, electrical conductivity 506.84±18.35µS/cm, total dissolved solids 211.56±19.53

3.3.4.2.2 Life cycle study, The seasonal light trapping for hot season (March–May) and rainy season (September–October) for the adults of *L. abruptum* showed that the *L. abruptum* has a non-seasonal life cycle. A total of 74 *L. abruptum* larvae were measured for head capsule width, then analyzed for frequency distribution. The results indicate the presence of 5 instars of larvae. The ranges and mean ± SD of head capsule width of each instar were: Instar I, HCW = 0.50–0.63 mm, 0.56±0.05 mm (n=11); Instar II, HCW = 0.75–0.90 mm, 0.83±0.05 mm (n= 17); Instar III, HCW =1.00–1.06 mm, 1.06±0.05 mm (n=27); Instar IV, HCW = 1.25–1.38 mm, 1.31±0.05 mm (n=7); and Instar V, HCW= 1.5–1.63 mm 1.58±0.05 mm (n=12) (see Figure 48).

Larval rearing of 1st–5th instars at the laboratory showed that development time of Instar I was 2 weeks, Instar II 5 weeks, Instar III 8 weeks, Instar IV about 10 weeks, Instar V about 21 weeks. The last instar became pupae for about 3–4 weeks, and the adults after emerging lived for about 1–2 weeks (Table 4).

Table 4. Mean and range of head capsule width (mm) for larval instars along with time spent at each stage

Larval instar	Range of head capsule width (mm)	Development time
Instar I	0.50–0.63	2 weeks
Instar II	0.75–0.90	5 weeks
Instar III	1.00–1.06	8 weeks
Instar IV	1.25–1.38	about 10 weeks
Instar V	1.50–1.63	about 21 weeks
Pupae	-	3–4 weeks (n=5)
Adult	-	1–2 weeks (n=5)

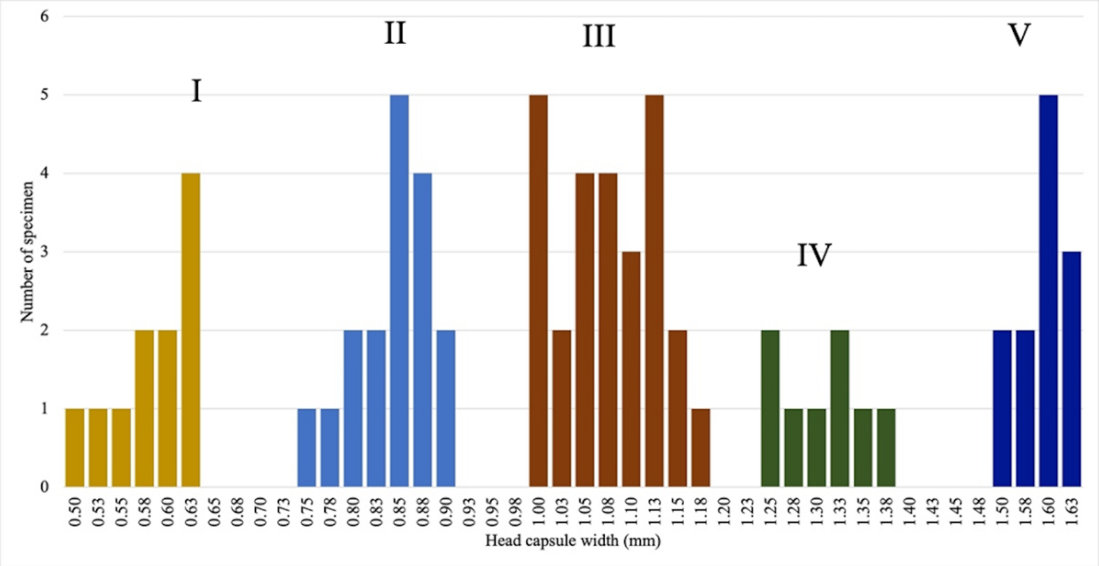


Figure 38. The frequency distributions of head capsule widths (mm) by larval instar stage of *Lepidostoma abruptum*

3.3.4.3 Nutritional Values of *Lepidostoma abruptum* larvae

The nutrient composition determined from in total 70g of pooled *L. abruptum* larval stages, in dry matter, is presented in (Table 5). The proximate analysis determined protein, fat, fiber, moisture, omega 3, omega 6 and omega 9 based on dry weight of the larval stage.

Table 5. Nutritional values of the *L. abruptum* larvae in the current study

Component	% Mass dry basis	Unit
1) Protein	49.08	g/100 g dry weight
2) Total Fat	27.18	g/100 g dry weight
3) Total dietary fiber	5.93	g/100 g dry weight
4) Moisture	68.87	g/100 g dry weight
5) Omega-3	0.19	g/100 g dry weight
6) Omega-6	6.42	g/100 g dry weight
7) Omega-9	11.75	g/100 g dry weight

3.4 Concluding remarks

Species diversity of Trichoptera in lower hill evergreen forests of Tai Rom Yen, Khao Nan, and Khao Luang National Parks, in Nakhon Si Thammarat Range of southern Thailand, was investigated. Adult Trichoptera specimens were collected representing 21 families, 60 genera and 173 species. This research added 16 species to Thailand's Trichoptera checklist, with 15 new species and 1 new record. The species were *Macrostemum nigralatum, Anisocentropus tairomyenensis, Rhyacophila aksornkoaei, Rhyacophila longicaudata, Lannapsyche tairomyenensis, Eoneureclipsis chinachotiae, Hydropsyche kaonanensis, Plectrocnemia paras, Psychomyia hobrazym, Polyplectropus hofmaierae, Orthotrichia kaonan, Helicopsyche chairum, Helicopsyche artinc, Oecetis lehachiah, Oecetis rochcl,* and *Trichomacronema vietnamemsis*. Totally, 1053 species of Trichoptera are recorded from Thailand.

Lepidostoma abruptum Bank 1993 is a common species that has been recorded nationwide in Thailand for the adult stage, but the larval stages have not been described (Thapanya *et al*., 2004; Malicky, 2010; Bunlue *et al*., 2012; Laudee and Malicky, 2015). The larvae of *L. abruptum* share the characteristics of *Lepidostoma* spp. found in Southeastern USA (*L. griseum*), Japan (*L. pseudemarginatum*, *L. mennokiense, L. yosakoiense*), India (*L. nuburagangai*), Greece (*L. doehleri*), and Central Ethiopia (*L. scotti*). The characteristics of those species were: frontoclypeus narrow and elongated, anterior margin concave, ventral apotome is longer than median ecdysial line, the cases are rectangular tubes made or leaf or/and sand, protorax and mesothorax were sclerites, dorsal hump is on abdomen segment I (Morse *et al*., 2017; Ito, 2011; Dinakaran *et al*.,

2013; Karaouzas and Waringer 2016; Terefe *at al*., 2018). However, Ito *et al*. (2011) diagnosed the difference of three species of final instar larvae from Japan including *L. pseudemarginatum*, *L. mennokiense, L. yosakoiense* by the presence and position of abdominal gills. *L. pseudemarginatum* bears both dorsal and ventral abdominal gills on posterior rows of segments III–VI, *L. mennokiense* presents the dorsal abdominal gills on segments III–VII and ventral abdominal gills on segments III–VI, and *L. yosakoiense* presents both dorsal and ventral abdominal gills on posterior rows of segments II–VI. In addition, Terafe et al. (2018) reported that *L. scotti* bears single abdominal gills on posterior of dorsal and ventral on segments II and VII, but presents a pair of gills on segments III–VI. In this study, *L. abruptum* can be separated from those species by the rows of single gills on dorsal and ventral abdominal segments II–VII. Then, we suggest that the presence and absence of abdominal gills on each abdominal segment and the position of anterior and posterior abdominal gills on each abdominal segment can be used as one of the diagnostic characters to identify *Lepidostoma* to species level.

Furthermore, Karaouzas and Waringer (2016) established the diagnostic key for final instar larvae of three *Lepidostoma* species in Greece. The setae on mesonotum and metanotum were the main characteristics identifying the insects to species level. Anterior margins of each mesonotal sclerite in *Lepidostomum hirtum* is with only one median seta. Nevertheless, *L. basale* and *L. doeleri* have more than 20 setae on anterior margins of mesonotal sclerites but they can be differentiated by the number of setae on posteromedial of each mesonotum sclerite. Moreover, *L. basale* builds the case with sand, but *L. hirtum* makes the case with sand and grains, and *L. doehleri* builds a case with the detrital plant fragments. In this current study, the cases are rectangular, cylindrical and made of rectangular pieces of leaf.

Malicky (2021) reported that *Lepidostoma* spp. in northern Thailand, including *L. moulmina* and *L. doligung*, have non-seasonal life cycle with the adults observed year-round. In this study, the adults of *L. abruptum* were collected both in the hot season (March–May 2019) and in the rainy season (September–October 2019) and larvae at every stage were found at each collecting time, year-round. We then report that the *L. abruptum* has a non-seasonal life cycle. The life cycle of *L. abruptum* has 5 instars, which is similar to *Lepidostoma* spp. in Japan, India, Greece, and Central Ethiopia. All of the *Lepidostoma* spp. have 5 instars. The first instar builds their case with sand, the second and third instars make their cases with sand and pieces of leaves, and the fourth and fifth instars have cases made of leaves (Ito, 2011; Dinakaran *et al*., 2013; Karaouzas and Waringer, 2016; and Terefe *et al*., 2018).

The *Lepidostoma* spp. in Thailand are inhabitants at the first and second order streams, with substrates dominated by bedrock, boulders, cobbles, pebbles, and sand, but they have not yet been found in big rivers (Laudee and Prommi, 2011; Laudee, 2015; and Malicky, 2021). Besides, Dinakaran *et al*. (2013) found that the *L. nuburagangai* lived in slow-moving streams at pool and riffle areas, where the woody debris and leaf litter accumulate. Moreover, Terafe *et al*. (2018) reported that, in general, larvae of the genus *Lepidostoma* are shredders living in forested streams. Also, this current study found the habitat of *L. abruptum* in a pool at a small stream where the substrates are dominated by fine sand, fine gravel, dead plant materials and leaves.

Trichoptera is one of the largest groups of aquatic life exhibiting primary and secondary consumers in streams and rivers (McCafferty, 1981; Holzenthal *et al*., 2007). Trichoptera (*Macrostemum indistictum* larvae) were reported for their gut contents, showing seven foods including arthropod fragments, blue green algae, diatoms, gastropods, green algae, protozoa, and rotifers (Khamrak and Prommi, 2020). Because of their high crude protein contents, aquatic insects have been used as human food in addition to being natural aquatic animal food (Williams and Williams, 2017). Reinecke and Owen (1980) reported that Trichoptera have high nutritional values with 45% of protein, 8.8 % of fiber, and 33.8 % of ash by dry weight. In addition, Xiaoming *et al*., (2010) have reported on high protein in aquatic insects, with Ephemeroptera having 66.26%, Odonata 40–65%, Hemiptera 42–73%, and Coleoptera 23–66%. In this study *L. abruptum* had about 49.08% of protein. Therefore, the high nutrients could be developed for food and aquatic animal feed, to support sustainable development in freshwater aquatic animal cultures.

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Two new species of Caddisflies (Trichoptera: Insecta) from Lower-Hill Evergreen Forests of Southern Thailand

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Abstract

Two new species of caddisflies, *Macrostemum nigralatum* **n. sp.** and *Anisocentropus tairomyenensis* **n. sp.**, are described and figured from lower-hill evergreen forests in southern Thailand. Wings of *M. nigralatum* are black, which distinguishes the new species from other related species. *Anisocentropus tairomyenensis* **n. sp.** is a member of the subgenus *Anisomontropus* and is characterized by the obvious basal expansion of the preanal appendages.

Key words: Southeast Asia, Tropical forest, Hydropsychidae, Calamoceratidae

Introduction

Southern Thailand is covered by different types of forest, such as tropical rain forest, dry evergreen forest, hill evergreen forest, coniferous forest, and swamp forest. Many new caddisfly species have been described from southern Thailand (Malicky & Prommi 2006; Laudee & Malicky 2014). However, all of these species were collected from lowland areas, meaning tropical rain forests or dry evergreen forests. Hill evergreen forest or cloud forest occurs at a high elevation (1,000 meters above sea level), and has comparatively high humidity and low temperatures. This kind of forest is common in northern Thailand. For example, Malicky and Chantaramongkol (1993) reported species diversity of Trichoptera from lower and high hill evergreen forests at Doi Inthanon National Park, northern Thailand. In the southern Thailand, this forest type is found in Khao Nong Mountain of Tai Rom Yen National Park and also in Khao Luang Mountain of Khao Luang National Park. The biodiversity of caddisflies has not been studied before in these areas.

Trichoptera diversity in Thailand has been surveyed for more than 30 years. Chantaramongkol *et al*. (2010) reported 12 species of the genus *Macrostemum* have been found in Thailand, of which 7 species occur in southern Thailand, including *M. albardanum* Banks 1931, *M. dohrni* Ulmer 1905, *M. fenestratum* Albarda 1881, *M. floridum* Navás 1929, *M. hestia* Malicky and Chantaramongkol 1998 (in Malicky 1998), *M. midas* Malicky and Chantaramongkol 1998 (in Malicky 1998), and *M. seba* Malicky and Prommi 2009 (in Malicky 2009) (Prommi 2007; Malicky 2010; Laudee & Malicky 2014). For the genus *Anisocentropus*, 10 species have been recorded from Thailand, of which 5 species have been reported from southern Thailand (Prommi 2007; Laudee & Malicky 2014).

In this article, we are presenting the preliminary results of our study of Trichoptera from lower hill evergreen forests in southern Thailand. Two new species from families Hydropsychidae, and Calamoceratidae are introduced to science.

Materials and methods

Caddisfly specimens were collected with a UV pan light trap (12V, 10W) near the river overnight. The Trichoptera

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specimens were captured and preserved in 70% ethanol. Adult male genitalia of the new species were excised and macerated by heating in 10% KOH at 60ºC for 30–60 minutes. The male genitalia of the new species were drawn by compound microscopy with a drawing tube, first with pencil and then with ink. Their holotypes and paratypes are stored in 70% ethanol and are deposited at Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Hat Yai Campus, Hat Yai District, Songkhla Province, Thailand (PSUNHM).

Terminology used in the description of *Macrostemum* male genitalia follows Flint *et al*. (1987); morphological terms of *Anisocentropus* mainly follow Neboiss (1980) and Oláh and Johanson (2010).

Taxonomy

Hydropsychidae

***Macrostemum nigralatum* n. sp. Laudee and Malicky**
Figs. 1–6

Type material. Holotype male (PSUNHM). Thailand: Surat Thani Province, Tai Rom Yen National Park, Khao Nong, Lam Phun stream 8°50′33″N, 99°30′27″E, ca. 960 m a.s.l., 20 March 2017, leg. Pongsak Laudee.

Paratypes: Same data as holotype, 2 males (PSUNHM); Thailand: Surat Thani Province, Tai Rom Yen National Park, Pha San Yen stream, 12°04′52″N, 99°37′43″E, ca. 1,100 m a.s.l., 12 February 2017, leg. Pongsak Laudee, 2 males (PSUNHM).

Etymology. The species epithet comes from the Latin adjectives *niger*, *-ra*, *-rum*, and *alatus*, *-a*, *-um*, meaning "black" and "winged," in reference to the black forewings of this species.

Description. Length of each male forewing 12.0 mm (n = 5); specimens in alcohol with head, thorax, and forewings black (Fig. 6).

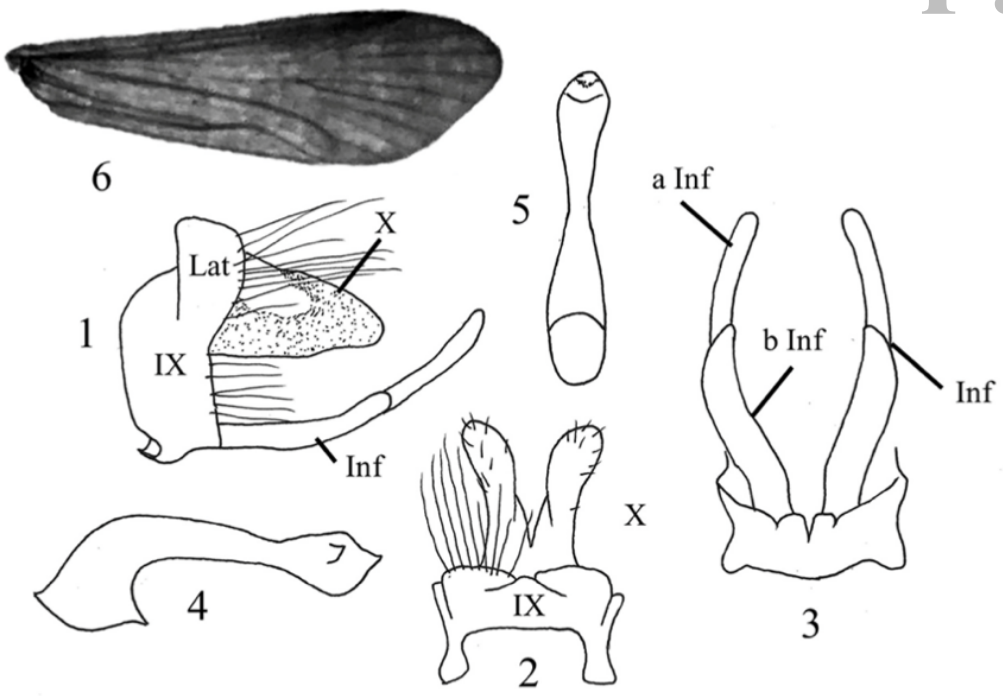
Male genitalia (Figures 1–5). In dorsal view (Fig. 2), segment IX rectangular with subrectangular incision for half of its length anteriorly; lateral lobes of segment IX subrectangular, truncate apically with long setae; in lateral view (Fig. 1), segment IX short with truncated lateral lobes, convex basodorsally, truncated apicoventrally, apicolateral margins with numerous setae; in ventral view (Fig. 3), segment IX subrectangular with anterolateral lobes and V-shaped incision posteromesally. Segment X in dorsal view (Fig. 2), long, with deep V-shaped incision apically forming 2 oval lobes; in lateral view (Fig. 1) with somewhat triangular, round apically. Inferior appendages slender, long; each with basal segment slender, about 1.5 times as long as apical segment; apical segment slender with short setae apically, rounded apex; curving slightly mesad in ventral view (Fig. 3). Phallus axe-shaped, expanded basally, bulb-like subapically, pointed apically in lateral view (Fig. 4); long, hourglass-shaped in ventral view (Fig. 5).

Diagnosis. The genitalia of the new species are similar to those of the well-known and widespread *M. fastosum* (Walker 1852) found in Southeast Asia: Bali, Java, Sumatra, Laos, Thailand, and Vietnam (Malicky 2010). They can separate by characteristics of the dorsal view of segment X. In *Macrostemum nigralatum* **n. sp.**, segment X is rectangular with a deep V-shaped incision apically forming 2 oval lobes, rounded apically. The dorsal view of *M. fastosum* segment X has a V-shaped incision for 1/2 of its length, with apical lobes bent outward apically. They can be separated very easily by the color of the forewings, M. *fastosum* has yellow wings with dark markings, but the wings are black without marking in the new species (Fig. 6). The Brazilian species *M. nigrum* Franca *et al*. 2013 also has the forewings entirely black, but the male genitalia are different.

Calamoceratidae

***Anisocentropus tairomyenensis* n. sp. Suwannarat and Malicky**
Figs. 7–11

Type material. Holotype male (PSUNHM). Thailand: Surat Thani Province, Tai Rom Yen National Park, Khao Nong, Lam Phun stream, 8°50′33″N, 99°30′27″E, ca. 960 m a.s.l., 20 March 2017, leg. Pongsak Laudee.



FIGURES 1–6. Male genitalia and forewing of *Macrostemum nigralatum* **n. sp.** 6, left lateral. 7, dorsal. 8, ventral. 9, phallus, left lateral. 10, phallus, ventral. 11, right forewing, dorsal. IX = segment IX, X = segment X, Inf = inferior appendage (paired), Lat = lateral lobe (paired), a Inf = apical segment of an inferior appendage (paired), b Inf = basal segment of an inferior appendage (paired).

Paratypes: Same data as holotype, 2 males (PSUNHM); Thailand: Surat Thani Province, Tai Rom Yen National Park, Pha San Yen stream, 12°04′52″N, 99°37′43″E, ca. 1,100 m a.s.l., 12 February 2017, leg. Pongsak Laudee, 1 male (PSUNHM).

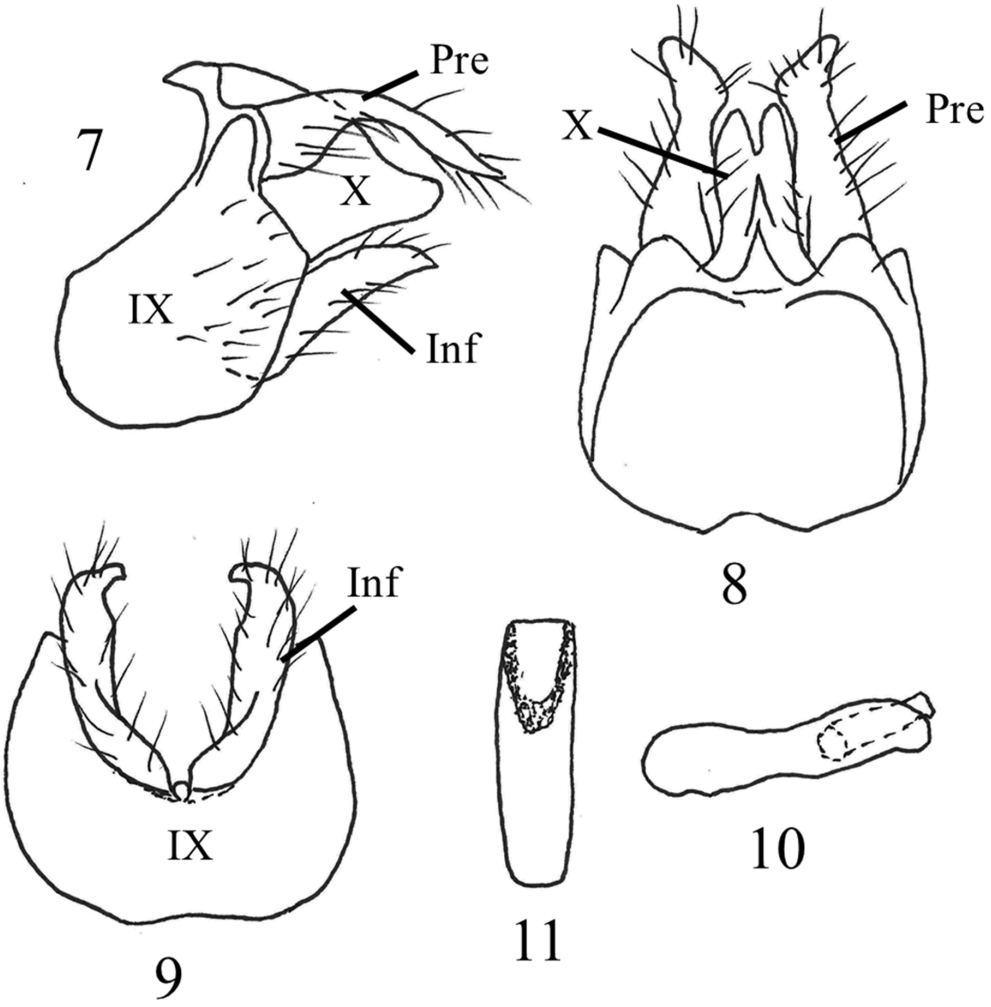
Etymology. The species is named for the type locality, Tai Rom Yen National Park.

Description. Length of each male forewing 13.0–14.0 mm (n = 4); specimens in alcohol with head, thorax, abdomen light yellowish brown and forewings dark brown.

Male genitalia (Figures 7–11). Segment IX in dorsal view longitudinally short, broad, with pair of rounded posterolateral projections and acute mesal projection (Fig. 8); in lateral view (Fig. 7), trapezoidal with round incision anterodorsally; in ventral view (Fig. 9), segment IX somewhat semicircular, with U-shaped excavation apically for half of its length. Preanal appendages in dorsal view (Fig. 8) long and stoutly tubular basally, short and triangular and projecting caudolaterad apically, covered by long setae; in lateral view (Fig. 7) long, slender, wide basally, curved ventrad, and tapering to acute apices. Segment X in dorsal view (Fig. 8) rectangular with shallow V-shaped excision and rounded ends apically; somewhat triangular, rounded apically in lateral view (Fig. 7). Inferior appendages tubular, apicoventrally pointed in lateral view (Fig. 7); tubular, hooked mesad apically in ventral view (Fig. 9). Phallus tubular with conspicuous phallotremal sclerite, rounded apically in lateral view (Fig. 10); truncate apically in ventral view (Fig. 11).

Diagnosis. *Anisocentropus tairomyenensis* **n. sp.** is a member of the subgenus *Anisomontropus* (Malicky 1994). Some of these species are very similar to each other and may be separated by minor differences only, such as the dorsal aspect of the tips of the preanal appendages, as in *A. insularis* Matynov 1930, *A. janus* Malicky & Chantaramongkol (in Malicky 1994), and *A. maculatus* Ulmer 1926, but these differences were seen to be constant in many specimens studied. The new species is similar to *A. janus*. Both of the species have very similar lateral

aspects of genitalia and are characterised by tubular inferior appendages with clawed-like apices. *Anisocentropus* (*Anisomontropus*) *tairomyenensis* **n. sp.** is well characterized by the striking, basally wider and apically pointed preanal appendages, distinguished from *A. janus* with its cylindrical, straight, apically rounded preanal appendages.



FIGURES 7–11. Male genitalia of *Anisocentropus tairomyenensis* **n. sp.** 7, left lateral. 8, dorsal. 9, ventral. 10, phallus, left lateral. 11, phallus, ventral. IX = segment IX, X = segment X, Inf = inferior appendage (paired), Pre = preanal appendage (paired).

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Köcherfliegen (Trichoptera) aus dem Süden Thailands, mit der Beschreibung von vier neuen Arten

Hans MALICKY, Nannaphat SUWANNARAT & Pongsak LAUDEE

A b s t r a c t : The Trichoptera collected during a research trip in six sites in the provinces of Surat Thani and Nakon Si Thammarat are listed, and four new species of the genera *Hydroptila*, *Orthotrichia*, *Stactobia* (Hydroptilidae) and *Chimarra* (Philopotamidae) are described and figured.

K e y w o r d s : Trichoptera, Thailand, new species

Einleitung

Auf einer gemeinsamen Sammelfahrt im Süden Thailands in den Provinzen Surat Thani und Nakon Si Thammarat wurden an sechs Stellen mit Hilfe von transportablen kleinen Lichtfallen Köcherfliegen gesammelt. In der Region ist wiederholt von verschiedenen Autoren gesammelt worden, aber eine zusammenfassende Darstellung der Ergebisse ist im Werden. Die letzte faunistische Übersicht über die Trichopteren Thailands stammt von CHANTARAMONGKOL & al. (2010). Die Determination erfolgte mit Hilfe des Buches von MALICKY (2010). In den Listen verzichten wir auf die durchgehende Anführung der Autorennamen, weil sie leicht mit Hilfe dieses Buches ausfindig gemacht werden können. Die Typen sind in der Sammlung des Erstautors. Häufige Abkürzungen: LA: Lateralansicht, DA: Dorsalansicht, VA: Ventralansicht, UA: Untere Anhänge, KA: Kopulationsarmaturen.

Beschreibung neuer Arten

Hydroptila huaivat nov.sp. (Hydroptilidae)

H o l o t y p u s ♂: Thailand, Huai Vat (Nebenbach des Klong Kay) bei Ban Pak Lang, nahe der Grenze zum Kao Nan Nationalpark, 8°47'N, 99°35'E, 140m, 14.6.2018, leg. Malicky & Suwannarat.

Habitus wie in der Verwandtschaft üblich, braun. VFL 2,5 mm. ♂ KA (Tafel 1): 9. Segment in LA niedrig und annähernd flach eiförmig, mit einem dreieckigen stumpfen Vorsprung im Dorsalteil seiner Kaudalkante. Dorsal gibt es ein Paar sehr langer, dünner Stäbe, die distal in einen runden Kopf erweitert sind, der eine nach unten gerichtete kurze Spitze hat. In DA sind sie distal spitz nach außen gewendet. Dazwischen gibt es einen ebenfalls langen, dünnen unpaaren Stab, der distal nach oben verbreitert ist. Die UA sind überaus lang, in LA über den größten Teil ihrer Länge annähernd gleich breit, in der Mitte leicht geknickt. und erst gegen das Ende zu lang und scharf zugespitzt; die Ventralkante

hat subbasal eine kleinen Zahn. In VA erscheinen die UA als sehr lange, dünne, spitze Stäbe. Der Phallus ist lang und dünn, nach dem ersten Drittel, wo die kurze Paramere entspringt, stark erweitert und von dort an kontinuierlich konisch verschmälert. – Nach der Form der Anhänge ist diese Art unverkennbar. Ich (Malicky) kenne keine auch nur annähernd ähnliche *Hydroptila*-Art.

***Orthotrichia kaonan* nov.sp. (Hydroptilidae)**

H o l o t y p u s ♂: Thailand, Huai Vat (Nebenbach des Klong Kay) bei Ban Pak Lang, nahe dem Kao Nan Nationalpark, 8°47‘N, 99°35‘E, 140m, 14.6.2018, leg. Malicky & Suwannarat.

Habitus wie üblich, braun. VFL 1,5 - 1,8 mm. Vorderflügel beim ♂ mit dunklen Schuppen in der Costalfalte, wie in der Gattung üblich. ♂ KA (Tafel 1): Die Strukturen sind extrem asymmetrisch und die einzelnen Teile kaum zu homologisieren, es muss daher vor allem auf die Abbildung verwiesen werden. In LA verläuft die Vorderkante des 9. Segments flach und schräg von der Ventralspitze allmählich zu dem schmalen Dorsalteil; in VA erscheint der Rand des 9. Segments dreieckig mit geraden Seitenkanten und breit abgerundeter medianer Ecke. In DA gibt es eine große, relativ breite vorspringende Platte mit nach links gewendeter Spitze, neben ihr zwei schlanke, fast ebenso lange Spitzen. In VA gibt es eine große Struktur, die vermutlich den miteinander verwachsenen UA entspricht, mit zwei schlanken, geraden Fingern mit je einer Distalborste. In LA ist die erstgenannte Platte spitz nach unten gebogen. Der Kaudalrand des 8. Segments hat eine breite dunkle Zone. Es ist anscheinend kein freier Innendorn vorhanden, dessen Form bei vielen *Orthotrichia*-Arten ein gutes Merkmal zu sein pflegt. – Bei ♀ fällt in VA ein großer pilzförmiger Sklerit auf.

***Stactobia klongpod* nov.sp. (Hydroptilidae)**

H o l o t y p u s ♂: Thailand, Klong Pod an der Grenze des Kao Nan Nationalparks, 180m, 8°48‘N, 99°34‘E, 15.6.2018, leg. Malicky & Suwannarat.

Habitus wie üblich, braun. VFL 1,5 mm. 7. Sternit mit einer großen Ventralschuppe. Spornformel 024. ♂ KA (Tafel 2): 9. Tergit mit einem Paar sehr langer, gerader, dünner, nach vorne gerichteter Stäbe. Ihr Ventralrand verläuft in den Ventralrand des Tergits in einem Bogen nach unten, wo er in einen Finger ausläuft, an dessen Ventralende die UA ansitzen. Diese sind in VA kurz fingerförmig und nach innen gebogen. Der Kaudalrand des 9. Segments ist in LA leicht konvex, ihm entspringt ein Paar großer, abgerundeter Lappen. Der Phallus ist lang und schlank und läuft in vier lange, dünne Stäbe aus: einen sehr dünnen mit einem distalen runden Verbreiterung, einem ebenso langen, aber etwas breiteren, einem noch breiteren, aber deutlich kürzeren und distal abgestutzten, und einem ebenfalls kürzeren, spitzen, der etwas breiter als der erste ist. – Es gibt viele ähnliche Arten, die aber anders gestaltete Phalli haben; diese Art ist gut durch seinen vierteiligen Endteil charakterisiert.

***Chimarra banpaklang* nov.sp. (Philopotamidae)**

H o l o t y p u s ♂: Thailand, Huai Vat (Nebenbach des Klong Kay) bei Ban Pak Lang, nahe dem Kao Nan Nationalpark, 8°47‘N, 99°35‘E, 140m, 14.6.2018, leg. Malicky & Suwannarat.

Ventralseite des Abdomens, Femora und Tibien weißlich, sonst Körper, Mundwerkzeuge, Antennen und Tarsen braun. Flügel hellbraun mit dunkleren Adern. Vorderflügellänge 4,5 mm. ♂ KA (Tafel 2): 8. Tergit und Sternit sehr schmal, letzteres ventrokaudal in der Mitte

spitz vorspringend. 9. Segment in LA ventral breiter als dorsal, Vorderkante gerade mit einem dorsalen kurzen, runden Lappen, seine Ventralkante gerade, ventrokaudal mit einem rundlichen, deutlich abgesetzten Sporn. OA klein und rund. 10. Segment in LA rundlich, relativ breit, mit einem dorsalen flachen Höcker. Es erinnert in der LA an *C. terramater* MALICKY, 2008, *C. oikuhorum* MEY, 1998 oder *C. xumappa* MALICKY, IVANOV & MELNITSKY, 2011. UA in LA mit geradem Dorsalrand und einem in der Basalhälfte bauchigen, in der Distalhälfte stark verschmälerten Ventralrand; Ende leicht abgerundet. VA der UA lang dreieckig, mit einem geraden Außenrand und einem schräg zur Spitze verlaufenden Innenrand, der stark gezähnt ist, Ende spitz. Phallus größtenteils häutig, mit drei leicht gekrümmten Dornen innen. Diese Art ist vor allem durch den stark gezähnten und spitzen Innenrand der UA in VA gut charakterisiert. Ich kenne keine andere *Chimarra* mit dieser Form.

Die Fanglisten

In den Listen sind die Arten in der Reihenfolge der Familien und Gattungen wie bei MALICKY (2010) angeordnet, die Arten in alphabetischer Reihenfolge.

Thailand, Eingang zum Tairomyen Nationalpark, 240m, 8°51‘N, 99°28‘E, 5.6.2018:

Chrysotrichia pulmonaria viele ♂, ♀
Psychomyia kuni 1♂
Cheumatopsyche copia 4♂♂
Diplectrona gombak 2♂♂
Hydropsyche pallipenne 3♂♂
Macrostemum midas 1♀
Goera unica 1♂
Oecetis hyperion 1♂
Trichosetodes sisyphos 6♂♂

Thailand, Ban Kiriwong, Nebenbach des Klong Tapi, 100m, 8°26‘N, 99°46‘E, 11.6.2018:

Rhyacophila tantichodoki 1♂
Chrysotrichia pulmonaria viele ♂, ♀
Hydroptila portunus 10♂♂
Chimarra bimbltona 6♂♂, 9♀♀
Stenopsyche siamensis 1♀
Psychomyia adun 4♂♂
Psychomyia indra 3♂♂
Psychomyia kuni 1♂
Ecnomus vibenus 1♂
Diplectrona gombak 1♂
Hydropsyche brontes 6♂♂
Macrostemum midas 1♀
Oecetis tripunctata 1♂

Triaenodes menestheus 2♀♀
Trichosetodes sisyphos 6♂♂, 5♀♀

Thailand, Klong Pong beim Kloster Kao Kun Nam Kiriwong, oberhalb des Wasserfalls Wang Mai Pak, 230m, 8°27‘N, 99°46‘E, 12.6.2018:

Rhyacophila tantichodoki 1♂
Agapetus dangorum 1♂
Chimarra spinifera 3♂♂, 1♀
Chimarra thienemanni / monorum 2♂♂, 2♀♀
Stenopsyche siamensis 3♀♀
Polyplectropus matthatha 1♂
Pseudoneureclipsis chrysippus 1♂
Pseudoneureclipsis tramot 1♂
Psychomyia indra 1♂
Psychomyia kuni 1♂
Ecnomus neri 1♂
Cheumatopsyche copia 8♂♂
Cheumatopsyche trilari 15♂♂
Diplectrona gombak 19♂♂
Hydromanicus abiud 3♂♂
Hydropsyche brontes 1♂
Hydropsyche camillus 1♂
Macrostemum dohrni 1♂
Macrostemum midas 2♀♀
Lepidostoma abruptum 1♂
Adicella evadne 1♂, 1♀
Oecetis maron 2♂♂
Oecetis tripunctata 2♀♀
Triaenodes menestheus 2♀♀

Thailand, Huai Vat bei Ban Pak Lang (Nebenbach des Klong Kai) nahe beim Kao Nan Nationalpark, 140m, 8°47‘N, 99°35‘E, 14.6.2018:

Chrysotrichia pulmonaria viele ♂, ♀
Hellyethira bulat 1♂
Hydroptila portunus 32♂♂, 12♀♀
Hydroptila rumpun 2♂♂
Hydroptila sabit 12♂♂
Hydroptila venus 1♂
Hydroptila verticordia 1♂
Hydroptila huaivat nov.sp. 1♂
Orthotrichia terpsichore 2♂♂
Orthotrichia kaonan nov.sp. 3♂♂, 1♀
Chimarra bimbltona 1♂, 2♀♀

Chimarra (*chiangmaiensis*) 43♂♂, 27♀♀
Chimarra yskal 1♂
Chimarra banpaklang nov.sp. 1♂
Stenopsyche siamensis 1♀
Pseudoneureclipsis cheiron 1♂
Paduniella hatyaiensis 4♂♂
Ecnomus puro 3♂♂
Ecnomus totiio 5♂♂
Cheumatopsyche tramota 1♂
Hydropsyche camillus 14♂♂
Macrostemum midas 2♂♂ 4♀♀
Potamyia phaidra 1♂
Goera unica 1♂, 2♀♀
Goera uniformis 10♂♂, 5♀♀
Oecetis lotis 2♂♂
Oecetis tripunctata 6♂♂, 1♀
Setodes sarapis 3♂♂, 5♀
Setodes isis 2♂♂
Setodes thoneti 21♂♂, 16♀♀
Tagalopsyche brunnea 1♂
Triaenodes dusra 1♂, 3♀♀
Marilia (*sumatrana*) 1♂

Thailand, Klong Pod an der Grenze zum Kao Nan Nationalpark, 180m, 8°48‘N, 99°34‘E, 15.6.2018:

Chrysotrichia pulmonaria viele ♂, ♀
Chrysotrichia quirinus 2♂♂
Chrysotrichia volcanus 1♂
Hellyethira bulat 1♂
Hydroptila keres 1♂
Hydroptila rumpun 4♂♂
Hydroptila portunus 4♂♂
Hydroptila verticordia 9♂♂
Plethus ulixes 6♂♂
Ugandatrichia honga 12♂♂, 4♀♀
Stactobia klongpod nov.sp. 2♂♂
Glossosoma elvisso 1♂
Chimarra bimbltona 27♂♂, 23♀♀
Chimarra (*chiangmaiensis*) 3♂♂
Stenopsyche siamensis 1♂, 4♀♀
Polyplectropus matthatha 1♂
Hyalopsyche (*winkleri*?) 7♀♀
Paduniella semarangensis 2♂♂

Paduniella suwannamali 1♂
Psychomyia adun 1♂
Psychiomyia indra 33♂♂
Psychomyia kuni 2♂♂
Tinodes sitto 1♂
Ecnomus totiio 1♂
Cheumatopsyche chinensis 1♂
Cheumatopsyche tramota 19♂♂
Hydropsyche brontes 27♂♂
Hydropsyche camillus 8♂♂
Hydropsyche doctersi 1♂
Macrostemum fenestratum 2♂♂
Macrostemum midas 11♀♀
Goera unica 2♂♂
Goera uniformis 2♂♂
Oecetis purusamedha 4♂♂
Oecetis tripunctata 1♂, 1♀
Setodes akrura 3♂♂
Setodes isis 2♂♂, 4♀♀
Triaenodes dusra 2♂♂, 1♀
Triaenodes menestheus 1♂

Thailand, Nebenbach des Klong Sok beim Eingang zum Kao Sok Nationalpark, 70m, 8°54‘N, 98°31‘E, 17.-18.6.2018:

Chrysotrichia pulmonaria 1♂
Chimarra bimbltona 15♂♂, 16♀♀
Chimarra monorum 3♂♂
Chimarra okuihorum 5♂♂
Chimarra spinifera 1♂
Chimarra yskal 4♂♂
Stenopsyche siamensis 1♀
Cheumatopsyche lucida 2♂♂
Macrostemum midas 1♀
Diplectrona gombak 3♂♂
Goera matuilla 1♂
Leptocerus rutulus 1♂
Leptocerus wangtakraiensis 1♂
Oecetis kyanippus 1♂
Oecetis lotis 1♂
Oecetis purusamedha 1♂
Oecetis tripunctata 1♂, 2♀♀
Setodes thoneti 2♂♂
Marilia (*sumatrana*) 2♂♂, 2♀♀

Kommentare

Bei den besammelten Bächen handelt es sich um kleine und mittelgroße Bäche in bewaldeter Umgebung. Sie sind als weitgehend naturbelassen zu charakterisieren. In den Listen sieht man viele Arten, von denen aber die meisten nur in wenigen Exemplaren auftraten. Das ist für tropische Verhältnisse typisch: hohe Diversität, aber geringe Abundanz. Man vergleiche dafür andere Beispiele aus Thailand und Europa bei MALICKY (2014).

Viele Weibchen der Ausbeute konnten nach dem derzeitigen Stand unseres Wissens nicht bestimmt werden. Ihre kenntliche Beschreibung ist eine Aufgabe der Zukunft.

Chimarra thienemanni ULMER, 1951 und *C. monorum* CHANTARAMONGKOL & MALICKY, 1989 haben miteinander eine breite Übergangszone im Bereich von Süd-Thailand und Nord-Sumatra (MALICKY 2017). Die hier angeführten Tiere zeigen Übergangsmerkmale zwischen diesen beiden Arten.

Chimarra chiangmaiensis CHANTARAMONGKOL & MALICKY, 1989: Wie neues Material zeigt, gibt es mehrere sehr ähnliche Arten und darüber hinaus viele Belegstücke, die keiner dieser Arten eindeutig zugeordnet werden können (MALICKY 2017). Es handelt sich also um einen Komplex von Arten, deren Klärung eine Aufgabe der Zukunft ist. Man wird dafür molekulargenetische Methoden anwenden müssen.

Marilia sumatrana: Die Bestimmung erfolgte mit dem genannten Buch. Inzwischen hat sich aber herausgestellt (eigene unpublizierte Befunde), dass es sich bei den thailändischen *Marilia*-Arten um eine größere Zahl von molekulargenetisch unterscheidbaren Arten handelt, deren Klärung noch aussteht.

Hyalopsyche winkleri ULMER, 1930: Die Unterscheidung der Männchen von *H. winkleri* und *H. parsula* MARTYNOV, 1935 ist an Hand der vorhandenen oder fehlenden Gabel 1 im Vorderflügel leicht, aber bei den Weibchen scheint sie immer zu fehlen.

Acknowledgement

This research was financially supported by Prince of Songkla University, Surat Thani Campus Collaborative Research Fund.

Zusammenfassung

Die auf einer Reise an sechs Plätzen in den Provinzen Surat Thani und Nakon Si Thammarat gefundenen Arten werden aufgezählt, und vier neue Arten aus den Gattungen *Hydroptila*, *Orthotrichia*, *Stactobia* (Hydroptilidae) und *Chimarra* (Philopotamidae) werden beschrieben und abgebildet.

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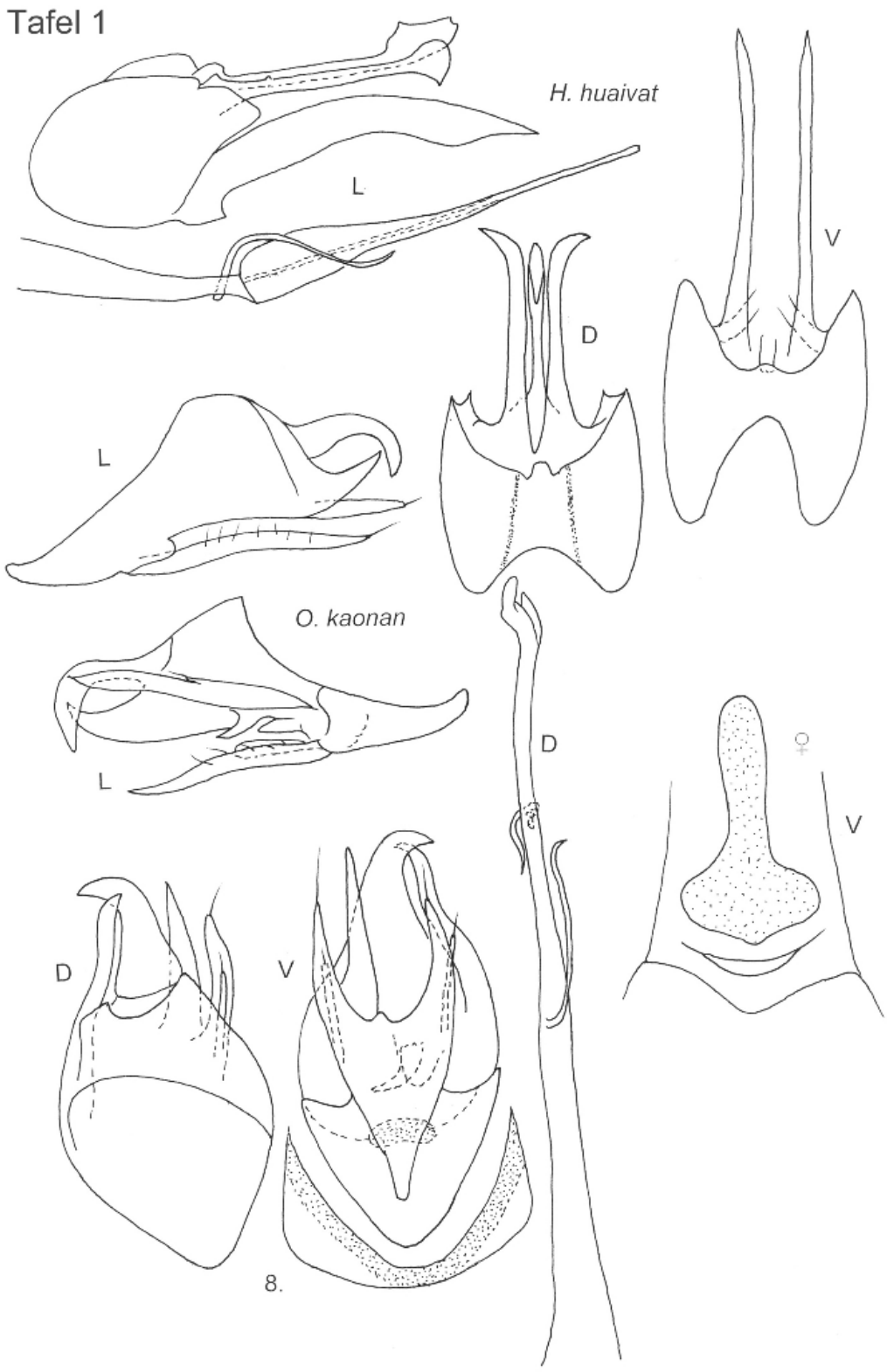
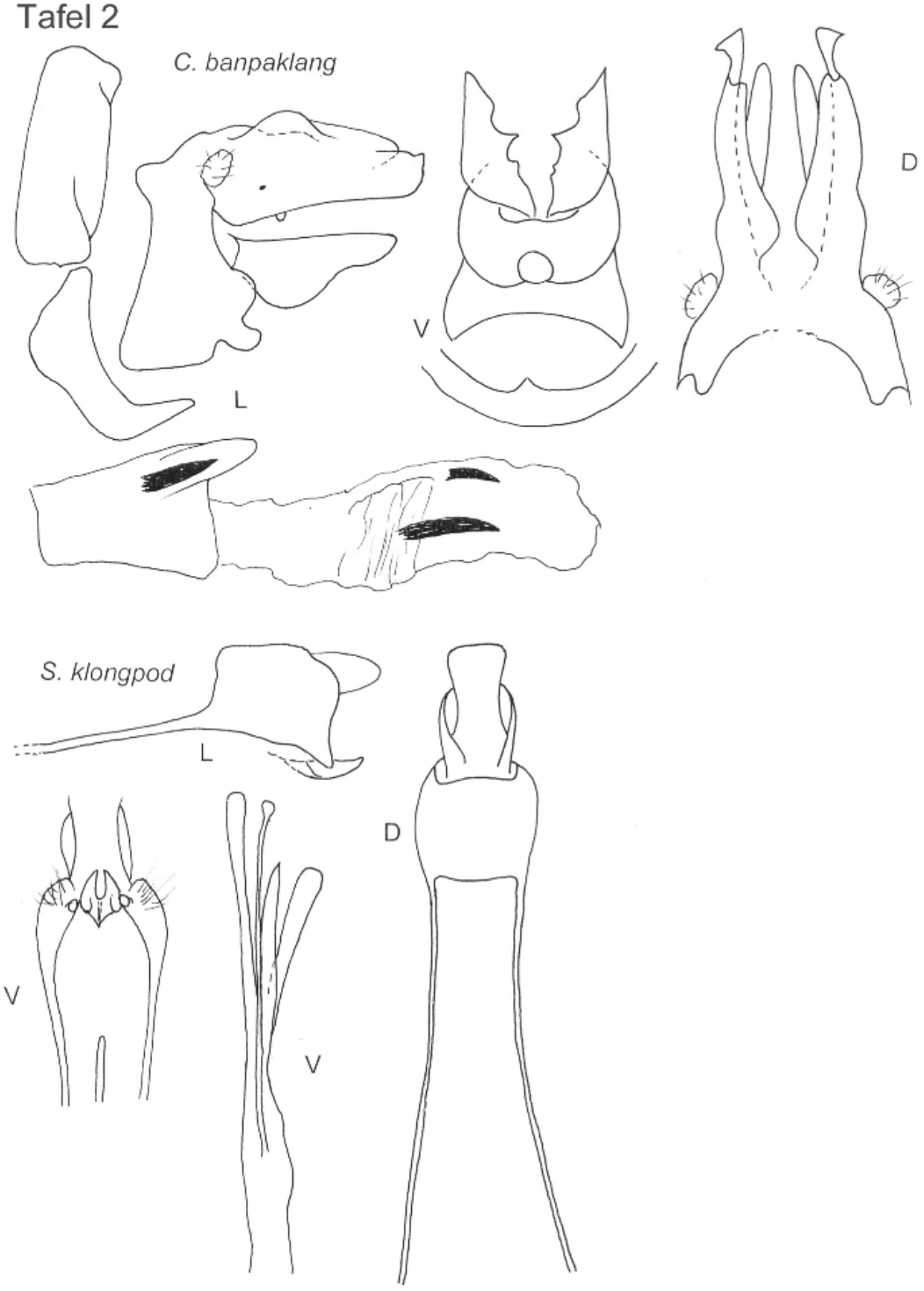


Tafel 1: ♂ Kopulationsarmaturen von *Hydroptila huaivat* nov.sp. und *Orthotrichia kaonan* nov.sp. – L: lateral, D: dorsal, V: ventral.

Tafel 2



Tafel 2: ♂ Kopulationsarmaturen von *Chimarra banpaklang* nov.sp. und *Stactobia klongpod* nov.sp. – L: lateral, D: dorsal, V: ventral.

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Four new species of *Rhyacophila* Pictet, 1834 (Trichoptera: Rhyacophilidae) from Southeast Asia

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Abstract

Four new species of genus *Rhyacophila* are described and illustrated from Thailand and Myanmar, Southeast Asia. *Rhyacophila longicaudata* sp. n. is in the *R. nigrocephala* Group; the very long basal segment of each inferior appendage distinguishes it from other related species. *Rhyacophila aksornkoaei* sp. n. and *R. limsakuli* sp. n. are in the *R. anatina* Group: they can be differentiated from other species of the group by the brush-like parameres and presence of a ventral process of the aedeagus in R. *aksornkoaei* sp. n., and by the rectangular apical segment of each inferior appendage and the hooked parameres in *R. limsakuli* sp. n.. *Rhyacophila kengtungensis* is in the *R. yishepa* Group and is characterized by the subtriangular shape of the preanal appendages in dorsal view and by the very large dorsal appendages of the phallic apparatus.

Key words: caddisfly, Thailand, Myanmar

Introduction

Rhyacophila (Trichoptera: Rhyacophilidae) is one of the most diverse genera of Trichoptera, with 780 extant species recorded worldwide (Morse 2018). Malicky (2010) reported 88 species of *Rhyacophila* from Southeast Asia (Andaman Islands to Vietnam to Borneo and Indonesia-Java). Among these, 37 species were recorded from Thailand alone by Chantaramongkol *et al.* (2010). In Myanmar, 20 species of *Rhyacophila* have been reported, mostly described by Kimmins in 1953 (Wityi *et al.* 2015). In Southeast Asia, in the Oriental Region, where Trichoptera biodiversity is high (Morse 2016), there are undoubtedly still many species unknown to science (Malicky 2010).

Schmid (1970) established diagnostic Branches, Twigs, and Groups of *Rhyacophila* by characters of male genitalia, including the *R. anatina*, *R. nigrocephala*, and *R. yishepa* Groups. Sun (2016) described 2 new species of the *R. anatina* Group from China and listed the species of the *R. anatina* Species Group worldwide, including 36 species from the Oriental Region (33 species) and the East Palearctic Region (3 species). Laudee & Malicky 2014 subsequently described a new species in the *R. antina* Group from southern Thailand and Kiss (2017) described one new species of the *R. yishepa* Group from Nepal.

This study describes 4 new species of *Rhyacophila* from the lower hill evergreen forest and lowland evergreen forest of Thailand and Myanmar.

Materials and Methods

The caddisfly specimens were collected by an UV pan light trap (12 V, 10 W) placed near a stream overnight at locations and times indicated below. The Trichoptera specimens were preserved in 70% ethanol and manually sorted afterwards. Adult male genitalia of the new species were removed and muscle tissue was macerated by heating in

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10% KOH at 60°C for 30–60 minutes or in lactic acid (Blahnik *et al*. 2007). The male genitalia of the new species were drawn using compound microscopy and a drawing tube, first as a pencil template and then with vector-graphic Adobe Illustrator© software. Holotypes and paratypes are stored in 70% ethanol and are deposited in the Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Hat Yai Campus, Hat Yai District, Songkhla Province, Thailand (PSUNHM). Additional paratypes are deposited in the Clemson University Arthropod Collection, Clemson University, Clemson, South Carolina, USA (CUAC), as indicated in the species descriptions. Terminology for genitalic structures is that of Schmid (1970).

Taxonomy

Rhyacophilidae

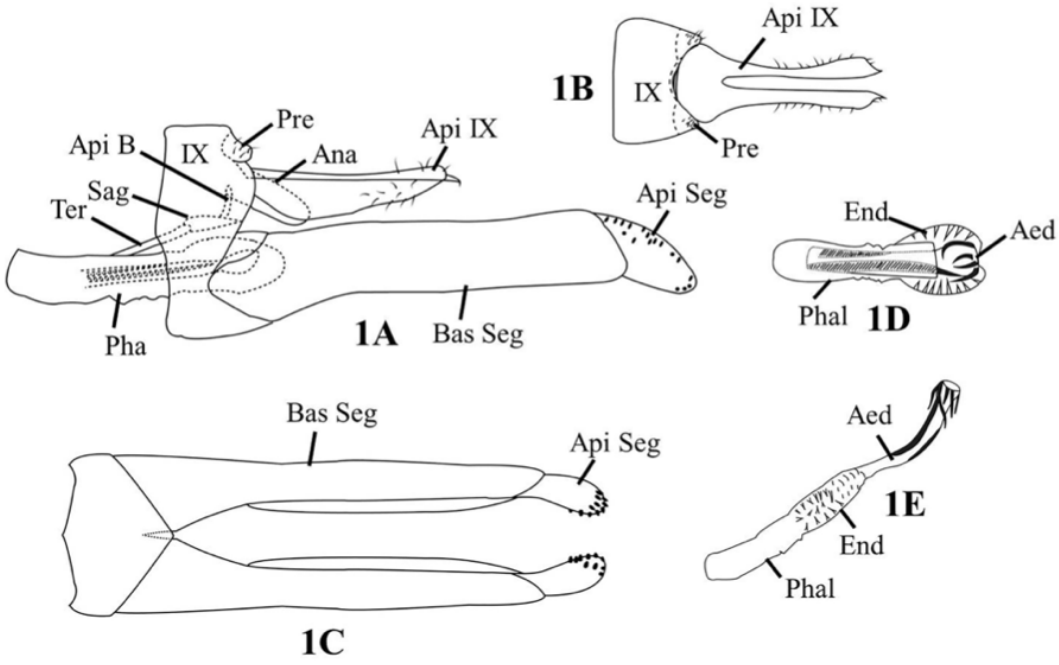
Rhyacophila longicaudata **n. sp. Suwannarat & Malicky**
Figs. 1A–1E

Type material. Holotype male (PSUNHM). THAILAND: Surat Thani Province, Tai Rom Yen National Park, Pha San Yen stream, 8°42′43″N, 99°30′36″E, ca. 1100 m a.s.l., 12 February 2017, leg. Pongsak Laudee.

Paratypes: Same data as holotype, 1 male (PSUNHM).

Etymology. The species epithet comes from Latin adjectives longus, -a, -um and caudatus, -a, -um, meaning "long tailed," in reference to the long inferior appendages.

Description. Length of each male forewing 7.0 mm (n = 2); specimens in alcohol with head, thorax, and forewings dark brown.



FIGURES 1A–1E. Male genitalia of *Rhyacophila longicaudata* n. sp. 1A, left lateral, with left inferior appendage omitted. 1B, dorsal. 1C, ventral. 1D, phallus, ventral. 1E, phallus, left lateral. IX = segment IX, Pre = preanal appendages, Api IX = apicodorsal lobe of segment IX, Ana = anal sclerites, Api B = apical band, Sag = sagittal appendage, Ter = tergal band, Pha = phallus, Bas Seg = basal segment of an inferior appendage (paired), Api Seg = apical segment of an inferior appendage (paired), Aed = aedeagus, Phal= phallotheca, End = endotheca.

Male genitalia (Figures 1A–1E5). In lateral view (Fig. 1A), segment IX subrectangular with broad posterolateral excision below midline, its apicodorsal lobe very long, lancet-like with short setae subapicodorsally, acute apically; in dorsal view (Fig. 1B), annular portion of segment IX transversely straight anteriorly, appearing separated by concave suture from its apicodorsal lobe (Schmid 1970), apicodorsal lobe of segment IX very long, hourglass-like with very deep incision in apical 3/4 of posterior margin, apices acute. Preanal appendages located at posterodorsal margin of annular portion of segment IX, very short, black, wart-like. Segment X reduced, obscure, except anal sclerites, the latter oval in lateral view, rounded posteriorly, positioned underneath anterior portion of apicodorsal lobe of segment IX. Inferior appendages very long, more than twice as long as apicodorsal lobe of segment IX, cylindrical; each with basal segment about six times as long as apical segment, dorsal and ventral margins parallel in lateral view (Fig. 1A), broader basally in ventral view (Fig. 1C), with longitudinal ridge dorsomesally; apical segment short and ovoid in lateral and ventral views, with numerous stout subapicomesal setae. Tergal band from dorsal base of phallotheca terminating in sagittal appendage articulating with apical band connected with root of anal sclerite. In dorsal and ventral views (Figs. 1A, 1D), retracted phallus clavate, with phallotheca rectangular, endotheca thicker and oval with numerous spines, and aedeagus long and spoon-like with two long internal spines and five curved hooks apically (only four visible ventrally); in lateral view (Fig. 1E) protracted phallus long, phallotheca cylindrical, endotheca with numerous spines basally and membranous apically; aedeagus slender and cylindrical with two long internal spines of which dorsal spine about twice as long as ventral spine and with five long hooks apically.

Diagnosis. *Rhyacophila longicaudata* n. sp. is a member of *R. nigrocephala* Group (Schmid 1970) in which there is a long apicodorsal lobe of segment IX extending caudad from the annular portion of that segment, the fused anal sclerites are reduced, apical and tergal bands are present and sclerotized, and in most species (including this new species) the phallic parameres are absent and the basal segments of the inferior appendages are fused with each other at their extreme bases. This species is similar to R. *drosampa* Schmid 1970, R. *laocai* Armitage & Arefina 2003, *R. lhabu* Schmid 1970, *R. paratecta* Mey 1996, and *R. mayestril* Malicky 1991. However, R. *longicaudata* n. sp. differs from those by the unusually long inferior appendages and by the presence of long hooks at the apex of the aedeagus.

Rhyacophila aksornkoaei **sp. n. Laudee & Malicky**
Figs. 2A–2C

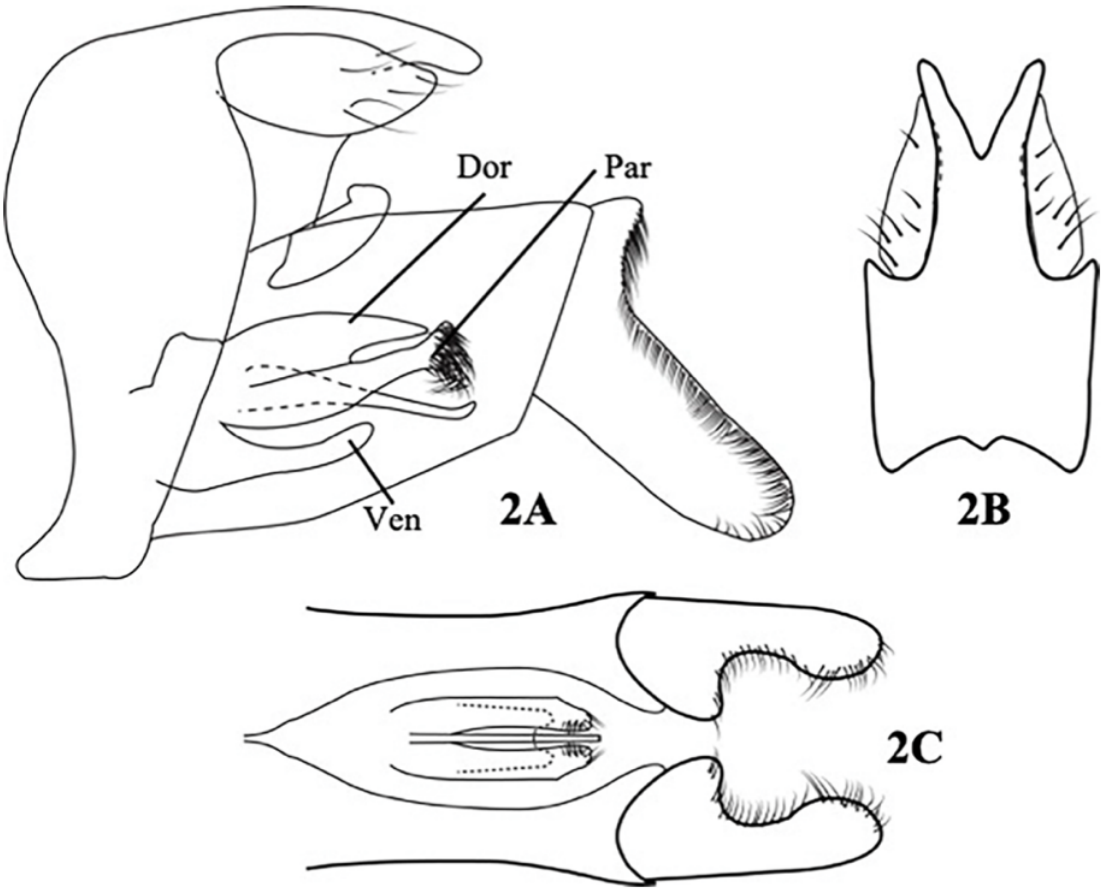
Type material. Holotype male (PSUNHM). THAILAND: Surat Thani Province, Khao Luang National Park, Tha Di stream, 8°28′46″N, 99°45′07″E, ca. 802 m a.s.l., 31 March 2018, leg. Nannaphat Suwannarat.

Paratypes: Same data as holotype, 5 male (PSUNHM).

Etymology. The species is dedicated to Prof. Dr. Sanit Aksornkoae, who is a prominent Thai ecologist.

Description. Length of each male forewing 11.0 mm (n = 2); specimens in alcohol with head, thorax, and forewings dark brown.

Male genitalia (Figures 2A–2C). Segment IX anterior margins convex dorsally and concave ventrally, posterior margins convex below its apicodorsal lobe, longitudinally longest at 2/3 height, anterodorsal margin concave except for small triangular mesal projection, its apicodorsal lobe about as long as annular portion of segment, divided by deep V-shaped apical incision nearly half its length mesally, slightly concave laterally, dark brown apically and subapically. Preanal appendages drop-like, shorter than apicodorsal lobe of segment IX. Segment X trapezoid, hidden below apicodorsal lobe of segment IX and between preanal appendages. Anal sclerite flat oval, oblique in lateral view. Inferior appendages each with basal segment shaped as pararellogram in lateral view, in ventral view slender in middle; apical segment mitten-shaped in mesal and ventral views, with short triangular “thumb” and with stout marginal and submarginal setae along subapicomesal and apicomesal margins. Phallus complex; phallobase short, tubular, its dorsal process somewhat triangular, convex dorsally, acute apically; ventral process tubular with expanded base and blunt apex; parameres long, tubular, expanded and bent slightly upward, each with tuft of bristles subapicomesally and apically, slightly expanded and truncate in lateral view and slightly convergent and blunt in ventral view; aedeagus as long as parameres, needle-like, expanded basally and upturned apically in lateral view (Fig. 2A), uniformly slender and straight in ventral view (Fig. 2C).



FIGURES 2A–2C. Male genitalia of *Rhyacophila aksornkoaei* n. sp. 2A, left lateral, with left inferior appendage omitted. 2B, dorsal. 2C, ventral. Par = parameres, Dor = dorsal process of the phallic apparatus, Ven = ventral plate of the aedeagus.

Diagnosis. This new species is a member of *Rhyacophila anatina* Group (Schmid 1970) and is similar to other species of this Group found in Asia. According to Sun (2016), the males of this Group can be diagnosed as follows: "segment IX is short ventrally; the apicodorsal lobe of segment IX is strong and bilobed; the preanal appendages are large and closely joined to the apicodorsal lobe, segment X is vertical; the anal sclerites are usually paired, without roots; the apical band is strongly sclerotized and with its two lateral arms not joined to each other at the base; the tergal band is short and membranous; the basal segment of the inferior appendages are usually long, and the apical segments are short, the phallotheca is cylindrical and the endotheca well developed; the aedeagus is slender, tubular; parameres are slender, with the distal ends heavily bristled." *Rhyacophila aksornkoaei* sp. n. is very similar to R. *suratthaniensis* Laudee & Malicky 2014 and *R. petersorum* Schmid & Denning 1971 (in Denning & Schmid 1971), but can be distinguished in that (1) the phallus of the new species is armed with a ventral plate that is absent in *R. suratthaniensis* Laudee & Malicky 2014 and *R. petersorum* Schmid & Denning 1971 (in Denning & Schmid 1971), (2) the distal ends of the parameres of *Rhyacophila aksornkoaei* sp. n. are bent upward and bristled apically, but bristles are arranged like a toothbrush in *R. suratthaniensis* and the paramere apices bear several thin and long spines directed distad in *R. petersorum*.

Rhyacophila limsakuli **sp. n. Laudee & Malicky**
Figs. 3A–3D

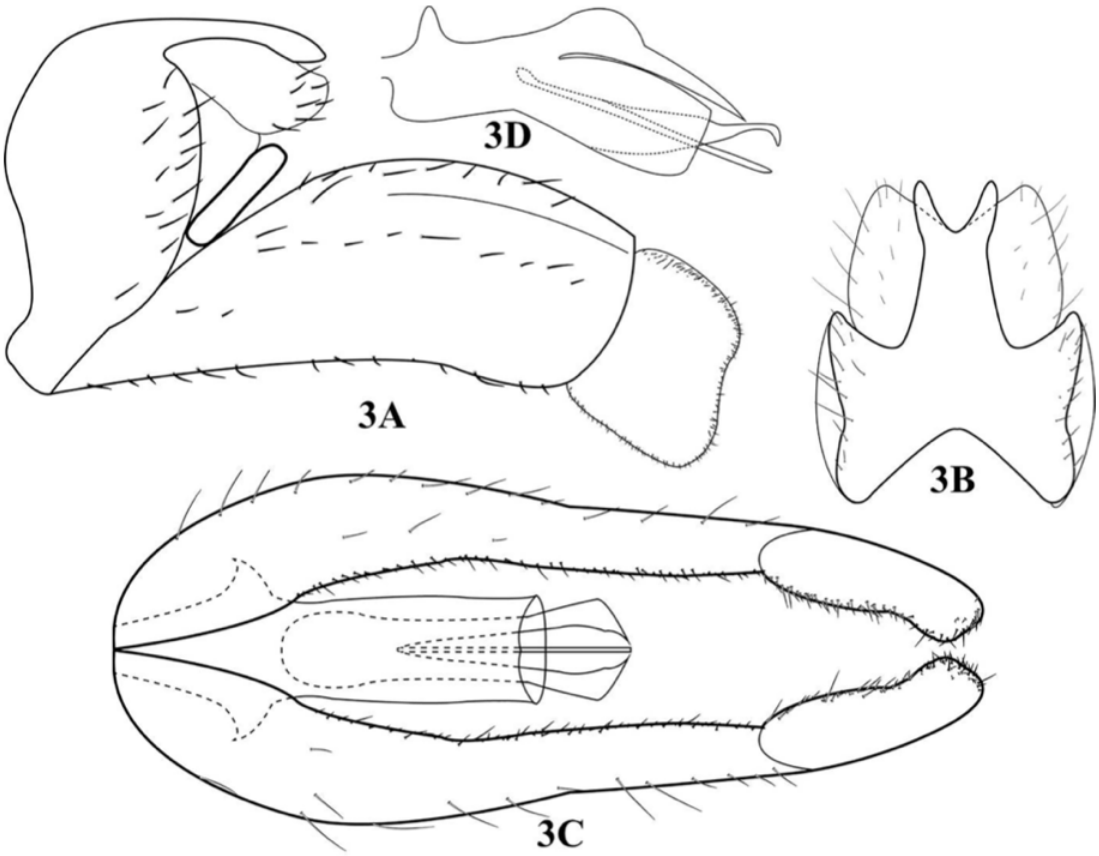
Type material. Holotype male (PSUNHM). THAILAND: Phetchaburi Province, Kaeng Krachan National Park, Ban Klang stream, 12°47′54″N, 99°27′09″E, ca. 352 m a.s.l., 1 June 2017, leg. Pongsak Laudee.

Paratypes: Same data as holotype, 1 male (PSUNHM).

Etymology. The species is dedicated to Assoc. Prof. Dr. Chusak Limsakul, who was the President of Prince of Songkla University during 2013–2018.

Description. Length of each male forewing 7.0 mm (n = 2); specimens in alcohol with head, thorax, and forewings dark brown.

Male genitalia (Figures 3A–3D). Anterolateral margins of segment IX convex subdorsally and concave subventrally, posterolateral margins convex; apicodorsal lobe of segment IX about as long as preanal appendages, convex dorsally and apically blunt in lateral view; in dorsal view slightly concave laterally and with V-shaped incision in apicomesal 1/3. Preanal appendages as long as apicodorsal lobe of segment IX, oval in lateral view, blunt in dorsal view. Anal sclerite flat, oval in lateral view, oriented obliquely dorsad from root. Basal segment of each inferior appendage tubular, tapered anteriorly, rounded posteriorly, and with longitudinal ridge subdorsally in apical half, apical segment nearly rectangular with broad and shallow invagination apically; in ventral view basal segment of each inferior appendage cylindrical and apical segment peanut-like with subapicomesal setae. Phallus complex; phallotheca tubular with lateral tenons; in lateral view dorsal process somewhat bird-head-like with round "crown" dorsally and long "beak" apically; aedeagus as long as parameres, needle-like; parameres fused basally, thick especially basally, their apices horizontally flattened and hooked ventromesad and caudad.



FIGURES 3A–3D. Male genitalia of *Rhyacophila limsakuli* n. sp. 3A, left lateral, with left inferior appendage and phallus omitted. 3B, dorsal. 3C, ventral. 3D, phallus, left lateral. Ana = anal sclerites.

Diagnosis. This new species is a member of *R. anatina* Group (Schmid 1970). It is similar to other species from Asia and can be diagnosed by the characters mentioned by Sun (2016). *Rhyacophila limsakuli* sp. n. closely resembles *R. noeibia* Malicky & Chantaramongkol 1993, but the two species can be distinguished in that (1) the basal segment of each inferior appendage of *R. limsakuli* sp. n. is 4.5 times as long as the apical segment, but only 2.5 times as long in *R. noeibia*, (2) the apical segment of each inferior appendage of *R. noeibia* is boot-shaped and projected dorsad, but that of *R. limsakuli* sp. n. is rectangular and lacks a dorsal projection, and (3) the apices of the parameres of *R. noeibia* are bent upward, but in *R. limsakuli* sp. n. they are bent downward.

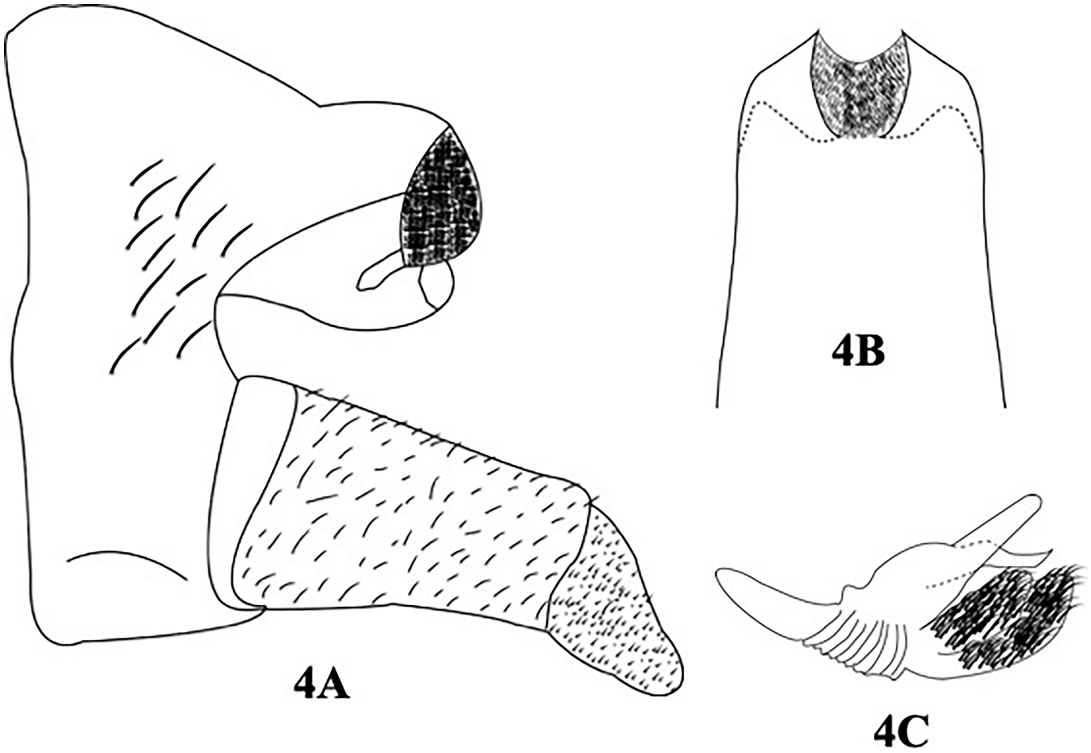
Rhyacophila kengtungensis **sp. n. Morse & Malicky**
Figs. 4A–4C

Type material. Holotype male (PSUNHM). MYANMAR: Shan State, Keng Tung Province, Pin Tao Waterfall, 21°26′37″N, 99°34′42″E, ca. 977 m a.s.l., 13 January 2015, leg. Pongsak Laudee.

Paratypes: Same data as holotype, 1 male (CUAC).

Etymology. The species epithet refers to the province where the new species was found.

Description. Length of each male forewing 5.0 mm (n = 2); specimens in alcohol with head, thorax, and forewings light yellow.



FIGURES 4A–4C. Male genitalia of *Rhyacophila kengtungensis* n. sp. 4A, left lateral, with left inferior appendage and phallus omitted. 4B, dorsal. 4C, phallus, left lateral. Pre = preanal appendages, Api IX = apicodorsal lobe of segment IX, Ana = anal sclerites.

Male genitalia (Figures 4A–4C). Segment IX anterolateral margins nearly straight, posterolateral margins sinuous below apicodorsal lobe, apicodorsal lobe short, half as long as inferior appendages, and nearly as wide as annular portion of segment, tubular. Preanal appendages strongly sclerotized, extending beyond apicodorsal lobe of segment IX, their mesal surfaces covered with short dark brown setae, oval in lateral view, subtriangular in dorsal view. Anal sclerites small, beneath preanal appendages. Inferior appendages long, cylindrical, each with basal seg-

ment twice as long as apical segment; apical segment subtriangular, its dorsal margin forming 50° angle with dorsal margin of basal segment, blunt apically, mesal surface covered with numerous setae. Phallus (Fig. 4C) small, dorsal appendage of phallic apparatus cylindrical, aedeagus short, apically acute; pair of ventral appendages of phallic apparatus very large, curved upward, covered with strong setae.

Diagnosis. *Rhyacophila kengtungensis* sp. n. is a member of the *R. yishepa* Group, in which males each have a short and broad apicodorsal lobe of segment IX, a reduced anal sclerite, and no parameres (Schmid 1970). This species is close to *R. ligulata* Malicky & Sun 2002 and *R. suah* Malicky & Chantaramongkol 2009 (in Malicky 2009). However, *R. kengtungensis* sp. n. differs from those species by (1) the subtriangular shape of the preanal appendages in dorsal view in *R. kengtungensis* sp. n., but hooked in *R. ligulata* and bilobed in *R. suah*; (2) the right-angled triangular shape of the apical segment of each inferior appendage in *R. kengtungensis* sp. n., contrasting with the oval apical segment of each inferior appendage in *R. ligulata* and *R. suah*; and (3) the ventral plate of the aedeagus of *R. kentungensis* is obscured by the setose dorsal appendages of the phallic apparatus, but is conspicuous, slender, tubular, and acute in *R. ligulata* and *R. suah*..

Acknowledgements

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Four new species of caddisflies (Trichoptera: Polycentropodidae, Psychomyiidae, Hydropsychidae, Odontoceridae) from Khao Nan and Tai Rom Yen National Parks, southern Thailand

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Abstract

Males of four new species of caddisflies, *Polyplectropus hofmaierae* **n. sp.** (Polycentropodidae), *Eoneureclipsis chinachotiae* **n. sp.** (Psychomyiidae), *Hydropsyche khaonanensis* **n. sp.** (Hydropsychidae), and *Lannapsyche tairomyenensis* **n. sp.** (Odontoceridae) are described and illustrated. *Polyplectropus hofmaierae* **n. sp.** is distinguished from other species by the shape of the apical end of its inferior appendages and its sharp intermediate appendages. The posterior edges of their inferior appendages run slanting to the ventrodistal point and are densely covered by short and stiff bristles. *Eoneureclipsis chinachotiae* **n. sp.** is differentiated by characters of its phallus, as the first two thirds of its length are slender and slightly curved. The distal part has a dorsal hump with a very slender thread on its caudal edge and is slightly bent downward and dilated. *Hydropsyche khaonanensis* **n. sp.** can be differentiated from the other species by its phallus, in which the two apicolateral lobes in ventral view have rounded outer edges. *Lannapsyche tairomyenensis* **n. sp.** can be separated from the others by characteristics of the dorsal view of segment IX and the harpago of its inferior appendages. Segment IX is triangular with distinctly convex preanal appendages along the posterior edge of this segment, and the harpago and subapical lobes are relatively similar in shape and length.

Key words: Southeast Asia, taxonomy, aquatic insects, caddisfly

Introduction

As more than 1,000 species of Trichoptera have been recorded in Thailand, both the taxonomy and distribution of this aquatic insect group are now very well known (Chantaramongkol *et al*. 2010). However, there are still many locations, such as small streams close to mountain tops, that are protected from human activities and have not been surveyed. The montane evergreen forests at Khao Nan and Tai Rom Yen National Parks located in southern Thailand have not been surveyed for Trichoptera. This kind of forest is found only at high elevations, with high humidity and low temperature selecting the species living in such an ecosystem. Previous studies concerning caddisflies of southern Thailand focused on tropical rain forest and dry evergreen forest (Malicky & Prommi 2006; Laudee & Malicky 2014). For this reason, there are probably many undiscovered species of caddisflies in the montane evergreen forests in Khao Nan and Tai Rom Yen National Parks.

The Trichoptera genus *Polyplectropus* has been recorded in Thailand for 18 species. These currently include 3 species from southern Thailand, namely *P. matthatha* Malicky & Chantaramongkol 1993, *P. maiyarap* Malicky & Chantaramongkol 1993, and *P. saturnus* Malicky & Prommi 2006. Regarding the genus *Eoneureclipsis*, three species have been found in Thailand and none in southern Thailand. The genus *Hydropsyche* has been recorded for 30 species in Thailand, with 9 species in southern Thailand: *H. assarakos* Malicky & Chantaramongkol 2000, *H. atropos* Malicky & Chantaramongkol 2000, *H. biton* Malicky & Chantaramongkol 2000, *H. briareus* Malicky

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& Chantaramongkol 2000, *H. brontes* Malicky & Chantaramongkol 2000, *H. butes* Malicky & Chantaramongkol 2000, *H. camillus* Malicky & Chantaramongkol 2000, *H. clitumnus* Malicky & Chantaramongkol 2000, *H. doctersi* Malicky & Chantaramongkol 2000, *H. dolosa* Banks 1939, *H. formosana* Ulmer 1911, and *H. pallipenne* Banks 1938. In the genus *Lannapsyche*, the species *L. chantaramongkolae* Malicky 1989 has been found only in northern Thailand (Prommi 2007; Malicky 2010; Laudee & Malicky 2014)

In this article, we present new species of Trichoptera from montane evergreen forests in southern Thailand, representing the families Polycentropodidae, Psychomyiidae, Hydropsychidae, and Odontoceridae.

Materials and methods

The collecting sites are in Khao Nan National Park and Tai Rom Yen National Park which are in the Nakhon Si Thammarat Range. The forest type is lower mountain evergreen forest, dominated by *Lithocarpus encleisacarpus, L. curtisii, Quercus myrsinifolia, Caryota obtusa, Ficus attissima, and F. microcarpa*. The study sites are 1st and 2nd order streams with substrate dominated by bedrock, boulders, and cobble.

The caddisfly specimens were collected with a UV pan light trap (12 V, 10 W) operated along the streams overnight at the locations and the times indicated below. The Trichoptera specimens were preserved in 70% ethanol, then manually sorted from other insects. Adult male genitalia of the new species were excised and muscle tissue was macerated by heating in 10% KOH at 60°C for 30–60 minutes. Pencil templates of the male genitalia of the new species were drawn using a compound microscope equipped with a drawing tube, then final vector-graphics were prepared from the templates with Adobe Illustrator© software.

Holotypes and paratypes are stored in 70% ethanol and are deposited in the Princess Maha Chakri Sirindhorn Natural History Museum, Prince of Songkla University, Hat Yai Campus, Hat Yai District, Songkhla Province, Thailand (PSUNHM). Terminology for genitalic structures is that of Chamorro and Holzenthal (2011), Kimmins (1955), Flint *et al.* (1987), and Yang *et al.* (2017).

Taxonomy

Polycentropodidae

***Polyplectropus hofmaierae* sp. n. Malicky and Suwannarat**
Figs. 1A–1D

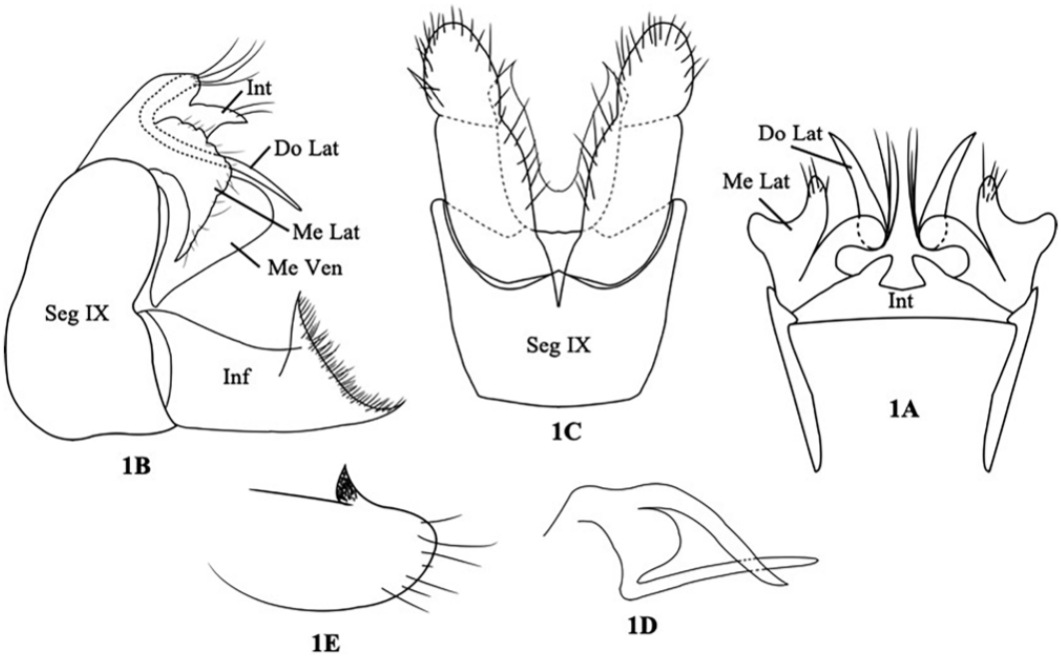
Type material. Holotype male (PSUNHM). Thailand, Surat Thani Province, Huai Khamin, Ban Song, Wiang Sa district, 8°42'N, 99°28'E, altitude 820 m, 30.x.2018, leg Nannaphat Suwannarat.

Etymology. The species is dedicated to Mrs. Herta Hofmaier, who has supported us during our research visits to Austria.

Description. Body and appendages yellowish. Forewings greyish brown and hind wings hyaline. Length of each forewing 4 mm.

Male genitalia (Figures 1A–1D). Segment IX kidney-bean-like with pointed ventroposterior edge in lateral view (Fig. 1B); subrectangular with 1/3 of its length having pair of U-shaped incisions posteriorly in ventral view (Fig. 1C). Intermediate appendages each triangular with flask-bottle-like incision posteromesally in dorsal view (Fig. 1A), beak-like in lateral view (Fig. 1B). In dorsal view, dorsolateral processes of preanal appendages curved inward basally and curved outward and needle-like subapically, in lateral view (Fig. 1B) needle-like, first turned downward and then abruptly turned caudad, pointed apically; mesolateral processes curved outward, thumb-like in dorsal view (Fig. 1A), long, curved downward, beak-like with setae in lateral view (Fig. 1B); mesoventral process of each preanal appendage beak-like with moderate protrusion posteromesally in lateral view (Fig. 1B). In lateral view, inferior appendages straight, relatively broad, each divided into dorsal branch and ventral branch; dorsal branch very small, triangular with numerous bristles posteriorly, pointed dorsally; ventral branch short, pointed posteroventrally, with numerous setae (Fig. 1B). In ventral view, inferior appendages long oval; ventral branch of each inferior appendage parallel-sided with numerous long setae along posteromesal edge; dorsal branch cylindrical, bent inward, beak-like posteriorly (Fig. 1C). Phallus plough-handle-like with two long tube-like processes crossing subapically (Fig. 1D).

Diagnosis. The new species is very similar to *P. akrisios* Malicky 1997 with which it shares the unusual shape of the phallus; which may raise the question of the proper generic position. We leave both species in *Polyplectropus* until a new revision of Polycentropodidae is available. The characters that can differentiate the new species from *P. akrisios* are the shapes of the apical ends of the inferior appendages and the sharp intermediate appendages. *Polyplectropus hofmaierae* **n. sp.** has the posterior edge of each inferior appendage running diagonally to the posteroventral point and is densely covered by short, stiff bristles on that edge (Fig. 1E). In *P. akrisios* the posterior end of each inferior appendage is rounded with a prominent dorsal point and is covered with only sparse fine hairs. The intermediate appendages of the new species are beak-like in lateral view (Fig. 1B) but rounded in *P. akrisios*.



FIGURES 1A–1E. Male genitalia of *Polyplectropus* spp. 1A–1D, *Polyplectopus hofmaierae* **n. sp.**: 1A, dorsal; 1B, left lateral; 1C, ventral; 1D, phallus, left lateral. 1E, *P. akrisios* Malicky 1997, apical end of left inferior appendage, left lateral. Do Lat = dorsolateral process of preanal appendage (paired), Int = intermediate appendage (paired), Me Lat = mesolateral process of preanal appendage (paired), Me Ven = Mesoventral process of preanal appendage (paired), Seg IX = abdominal segment IX.

Psychomyiidae

***Eoneureclipsis chinachotiae* n. sp. Malicky & Laudee**
Figs. 2A–2C

Type Material. Holotype male (PSUNHM). Thailand, Tai Rom Yen National, Dad Fah waterfall 2, 8°50'N, 99°30'E, altitude 960 m, 22.iv.2018, leg. Nannaphat Suwannarat.

Paratypes: 3 males from the same site or from sites nearby, altitudes 911–1100 m, collected on 22.iv.2018; 6 males from Kao Nan National Park, altitude 1147–1263 m, collected on 7.iv.2018 and 19.x.2018; all leg. Nannaphat Suwannarat (PSUNHM).

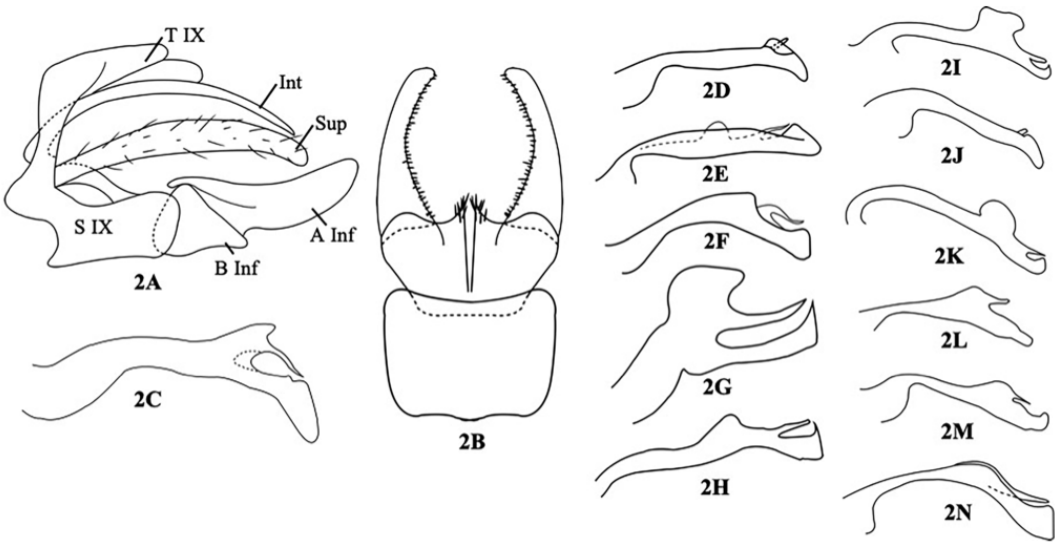
Etymology. The species is dedicated to Prof. Dr. Pavinee Chinachotiae, who was Dean of Faculty of Agroindustry, Prince of Songkla University, Hat Yai Campus.

Description. Body and wings unicolorous yellowish brown, eyes and genital structure dark yellowish brown. Length of each forewing 7–9 mm (n = 10).

Male genitalia (Figures 2A–2C). Tergum IX in lateral view produced posteriorly into broad triangle, rounded

posteriorly; sternum IX rectangular with prominent triangular projection on each side anteriorly, posterior end of sternum IX rounded in lateral view (Fig. 2A); sternum IX in ventral view somewhat rectangular with broad and shallow incision posteriorly (Fig. 2B). Superior appendages club-shaped, slightly bent downward in lateral view (Fig. 2A). Intermediate appendages needle-like, long, pointed apically in dorsal view; in lateral view, intermediate appendages long, slender, curved downward, pointed apically (Fig. 2A). Inferior appendages each divided into two parts, basal segment somewhat triangular, apical segment banana-like and about twice as long as basal segment in lateral view; in ventral view, basal segments of inferior appendages trapezoidal and separated by deep incision mesoposteriorly, each with setose acute angle mesoposteriorly; apical segments each curved inward with stout black teeth on mesal edge, rounded posteriorly (Fig. 2B). Phallus hammer-like, curved downward with needle-like process apicodorsally (Fig 2C).

Diagnosis. Male genitalia structures of this species are very similar to those of its congeners, which are constructed in the same pattern, but differences are seen in the details and form of the phallus and can easily be seen in by comparison with figures of the phalli of other species (Figs. 2D–2N). The new species is similar to *E. akrichalakchmi* Schmid 1972 from the state of Manipur, in that the distal part of the phallus is shorter than in most species (Fig. 2L), and the inner edge of each inferior appendage has a sub-basal hump. However, in *E. chinachotiae* **n. sp.**, the basal two-thirds of the phallus is slender and sinuate; the distal part has a dorsal hump with a very slender spine on its caudal edge and is bent downward and dilated more than for *E. akrichalakchmi.*



FIGURES 2A–2N. Male genitalia of *Eoneureclipsis* spp., 2A–2C, *E. chinachotiae* **n. sp.**: 2A, left lateral; 2B, ventral; 2C, phallus, left lateral. 2D–2N, phalli of *Eoneureclipsis* spp., left lateral: 2D, *E. pravrisija*; 2E, *E. quangi*; 2F, *E. tieni*; 2G, *E. nykteus*; 2H, *E. varsikiyja*; 2I, *E. alekto*; 2J, *E. sebulon*; 2K, *E. limax*; 2L, *E. akrichalakchmi*; 2M, *E. querquobad*; 2N, *E. afonini*. A Inf = apical segment of an inferior appendage (paired), B Inf = basal segment of an inferior appendage (paired), Int = intermediate appendages (paired), Sup = Superior appendage (paired), T IX = abdominal tergum IX, S IX = abdominal sternum IX.

Hydropsychidae

Hydropsyche khaonanensis n. sp. Malicky & Suwannarat

Figs. 3A–3E

Type material. Holotype male (PSUNHM). Thailand, Tai Rom Yen National Park, Dad Fah waterfall 3, 8°50'N, 99°19'E, 911 m, 22.iv.2018, leg. Nannaphat Suwannarat.

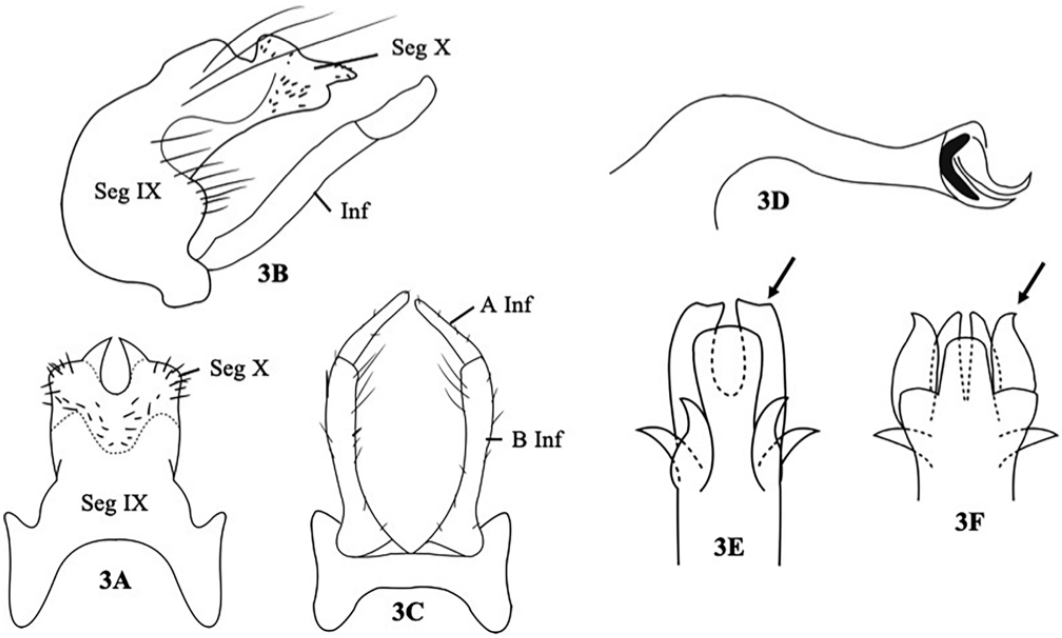
Paratype: 1 male, Thailand, Kao Nan National Park, Klong Gray river 5, 8°45'N, 99°32'E, 1132 m, 6.iv.2018, leg. Nannaphat Suwannarat (PSUNHM).

Etymology. The species is named for the type locality, Khao Nan National Park.

Description. The whole insect is yellowish grey with comparatively dark eyes. Length of each forewing 8–10 mm (n = 2).

Male genitalia (Figures 3A–3E). In dorsal view (Fig. 3A), segment IX forming isosceles trapezoid with U-shaped incision for one-third of its length anteriorly; posterior part of segment IX fused with segment X at shallow M-shaped line of fusion; lateral lobes of segment IX triangular and acute apically; in lateral view (Fig. 3B), segment IX C-shaped with anterolateral margins convex; posterior margins of segment IX setose; in ventral view (Fig. 3C), segment IX subrectangular with anterolateral lobes. Segment X in dorsal view (Fig. 3A) short with numerous of setae, posteromesal margin with 2 pointed processes; in lateral view (Fig. 3B), segment X somewhat triangular, beak-like posteriorly. Inferior appendages slender and long, each with basal segment slender and more than twice as long as apical segment; apical segment slender and short, apex rounded and slightly upturned in lateral view; in ventral view, inferior appendages tubular, slightly curved inward (Fig. 3C). Phallus axe-shaped, expanded and downcurved basally, apicodorsal end abruptly truncate and apicoventral portion curved caudad and pointed in lateral view (Fig. 3D).

Diagnosis. The phallus of *H. khaonanensis* **n. sp.** is similar to that of *H. arcturus* Malicky & Chantaramongkol 2000, but a clear difference is seen in the ventral view of the phallus (Figs. 3E, 3F); the two distal lateral lobes have rounded outer edges in *H. khaonanensis* **n. sp.** (3E), but in *H. arcturus* these lobes have short distal points which are directed outward (Fig. 3F).



FIGURES 3A–3F. Male genitalia of *Hydropsyche* spp. 3A–3E, *H. khaonanensis* **n. sp.**: 3A, dorsal; 3B, left lateral; 3C, ventral; 3D, phallus, left lateral; 3E, phallus apex, ventral. 3F, *H. arcturus*, phallus apex, ventral. A Inf = apical segment of inferior appendage (paired), B Inf = basal segment of inferior appendage (paired), Inf = inferior appendage (paired), Seg IX = abdominal segment IX, Seg X = abdominal segment X.

Odontoceridae

***Lannapsyche tairomyenensis* n. sp. Malicky & Suwannarat**
Figs. 4A–4F

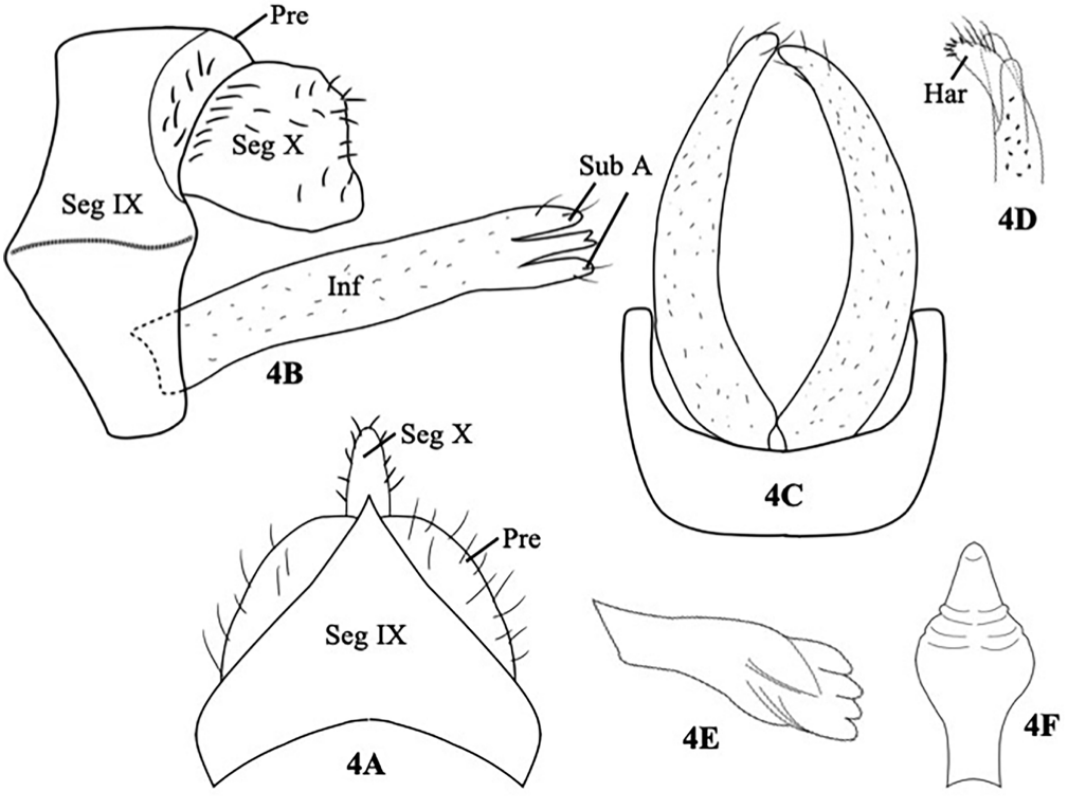
Type Material. Holotype male (PSUNHM). Thailand, Tai Rom Yen National Park, Dad Fah waterfall 3, 8°50'N, 99°19'E, 911 m, 31.x.2018, leg. Nannaphat Suwannarat.

Paratypes: 5 males from the same site and from nearby sites, altitudes 854–960 m, collected on 22.iv.2018 and 30.x.2018, leg. Nannaphat Suwannarat; one male: Tai Rom Yen National Park, Pha San Yen stream, 1100 m, 30.x.2018, leg. Nannaphat Suwannarat; 3 males: Huai Khamin, Ban Song, Wiang Sa district, 8°42'N, 99°29'E, 820 m, 30.x.2018, leg. Nannaphat Suwannarat; one male: Khao Nan National Park, Klong Gray river 3, 8°45'N, 99°32'E, 1147 m, 6.iv.2018, leg. Nannaphat Suwannarat (PSUNHM).

Etymology. The species is named for the type locality, Tai Rom Yen National Park.

Description. Unicolorous brown with darker eyes. Length of each forewing 7–8 mm.

Male genitalia (Figs. 4A–4F). In dorsal view (Fig. 4A), segment IX somewhat triangular and with shallow U-shaped excision anteriorly; in lateral view (Fig. 4B), segment IX hexagonal, lateral margins slightly concave anterodorsally and posterodorsally; segment IX divided by lateral horizontal grooves into two parts, dorsal part slightly taller than ventral part. Preanal appendages semicircular along posterior edges of segment IX in dorsal view (Fig. 4A); in lateral view, preanal appendages transversely crescent-shaped and with setae; segment X small, tubular, rounded posteriorly with setae in dorsal view (Fig. 4A); in lateral view, segment X scale-like with setae present mostly parallel with posterior edge of preanal appendages (Fig. 4B). Inferior appendages each with coxopodite straight, long and cylindrical with two subapical lobes nearly identical in shape and size in lateral view, separated by harpago (Fig. 4B); harpago slender, setose, inserted between subapical lobes (Fig. 4B) in lateral view. In ventral view, inferior appendages long, bent inward and tapered apically (Fig. 4C), with harpago scarcely visible (Fig. 4D). Phallus short and stout, hand-shaped in lateral view, and bulb-shaped in ventral view (Figs. 4E, 4F)



FIGURES 4A–4F. Male genitalia of *Lannapsyche tairomyenensis* **n. sp.** 4A, dorsal. 4B left lateral. 4C, ventral. 4D, right inferior appendage apex, ventral. 4E, phallus, left lateral. 4F, phallus, ventral. Har = harpago (paired), Inf = inferior appendage (paired), Pre = preanal appendage (paired), Seg IX = abdominal segment IX, Seg X = abdominal segment IX, Sub A = dorsal and ventral subapical lobes of basal segment of inferior appendage (paired).

Diagnosis. The genitalia of the new species are similar to those of *L. chantaramongkolae* found in northern Thailand (Malicky 1989) and in southern China (Yang *et al* 2017). They can be distinguished by characteristics of the dorsal view of segment IX. In *L. chantaramongkolae*, segment IX is rectangular with relatively small, concave preanal appendages along posterior edge of segment IX, but in *L. tairomyenensis* n sp. segment IX in dorsal view is triangular with distinctly convex preanal appendages along posterior edges of this segment. In dorsal view, segment X of *L. chantaramongkolae* is long and triangular, but short and tubular in the new species. Moreover, the harpago of *L. chantaramongkolae* appears distinctly longer than the subapical lobes of inferior appendages, but in the new species the harpago and subapical lobes are relatively similar in shape and length.

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Sechs neue Köcherfliegen (Trichoptera) aus Süd-Thailand

Hans MALICKY & Nannaphat SUWANNARAT

Abstract. New species of Trichoptera from the National Parks Tai Rom Yen, Klong Gray and Kao Luang in peninsular Thailand are described and figured: *Plectrocnemia paras* (Polycentropodidae), *Psychomyia hobrazym* (Psychomyiidae), *Helicopsyche artinc* (Helicopsychidae), *Helicopsyche chairum*, *Oecetis rochel* (Leptoceridae), *Oecetis lehachiah*. – *Rhyacophila* cf. *olahi* (Rhyacophilidae) is figured for comparison.

Aus neuen Ausbeuten der Zweitautorin werden hier einige neue Arten beschrieben. Die Arbeit ist Teil einer umfangreichen Untersuchung über die Trichopterendiversität der höheren Gebirgslagen in drei Nationalparks im Süden Thailands (SUWANNARAT in Vorbereitung). Die Funddaten sind (um sie nicht bei jeder Art wiederholen zu müssen):

Thailand, Provinz Surat Thani, Tai Rom Yen Nationalpark, Dad Fah Wasserfall, 8°50'N, 99°16-30'E, 850-1100m, 22.4.-31.10.2018, leg. Nannaphat Suwannarat.

Thailand, Provinz Nakon Si Thamarat, Kao Nan Nationalpark, Klong Gray [oder Kay geschrieben], 8°45'N, 99°31'E, 1130-1260m, 6.4.-19.10.2018, leg. Nannaphat Suwannarat.

Thailand, Provinz Nakon Si Thamarat, Kao Luang Nationalpark, Bach Kiriwong, 8°28'N, 99°45'E, 800-1360m, 30.3.-10.11.2018, leg. Nannaphat Suwannarat.

Die Arbeit von Nannaphat Suwannarat wird finanziell unterstützt von der Prince of Songkla University, Surat Thani Campus Collaborative Research Fund. Aus diesen Ausbeuten sind bereits mehrere neue Arten beschrieben worden (Suwannarat in Druck). Die Holotypen der neuen Arten befinden sich in der Sammlung des Erstautors, Paratypen auch in der Sammlung des Princess Maha Chakri Sirindhorn Natural History Museum, Hat Yai, Thailand. Die Namen der neuen Arten kommen von der Liste der Engel nach Umberto Eco. Häufige Abkürzungen: LA: Lateralansicht, DA: Dorsalansicht, VA: Ventralansicht, OA: obere Anhänge, UA: untere Anhänge, PA: phallischer Apparat, VFL: Vorderflügellänge.

Rhyacophila cf. *olahi* ARMITAGE & AREFINA 2003 (Rhyacophilidae)

Das Belegstück aus dem Kao Luang NP ähnelt weitgehend *Rhyacophila olahi* aus Vietnam aus der *R. castanea*-Gruppe (SCHMID 1970), weshalb wir keine Neubenennung vornehmen. Weiteres Material wird abgewartet, um zu einer Entscheidung zu kommen, aber wir bilden das Stück hier ab. Nach der Abbildung (ARMITAGE & AREFINA 2003:113, MALICKY 2010:9) zu schließen, ist das 2.Gied der UA etwas anders geformt, und der dorsale Ast des PA ist vor seinem schmalen Endteil dorsal rundlich erweitert; bei *olahi* ist er eckig. Auch die DA des 10. Segments scheint etwas anders zu sein, was aber möglicherweise an einem leicht verschiedenen Betrachtungswinkel liegt.

Plectrocnemia paras n.sp. (Polycentropodidae)

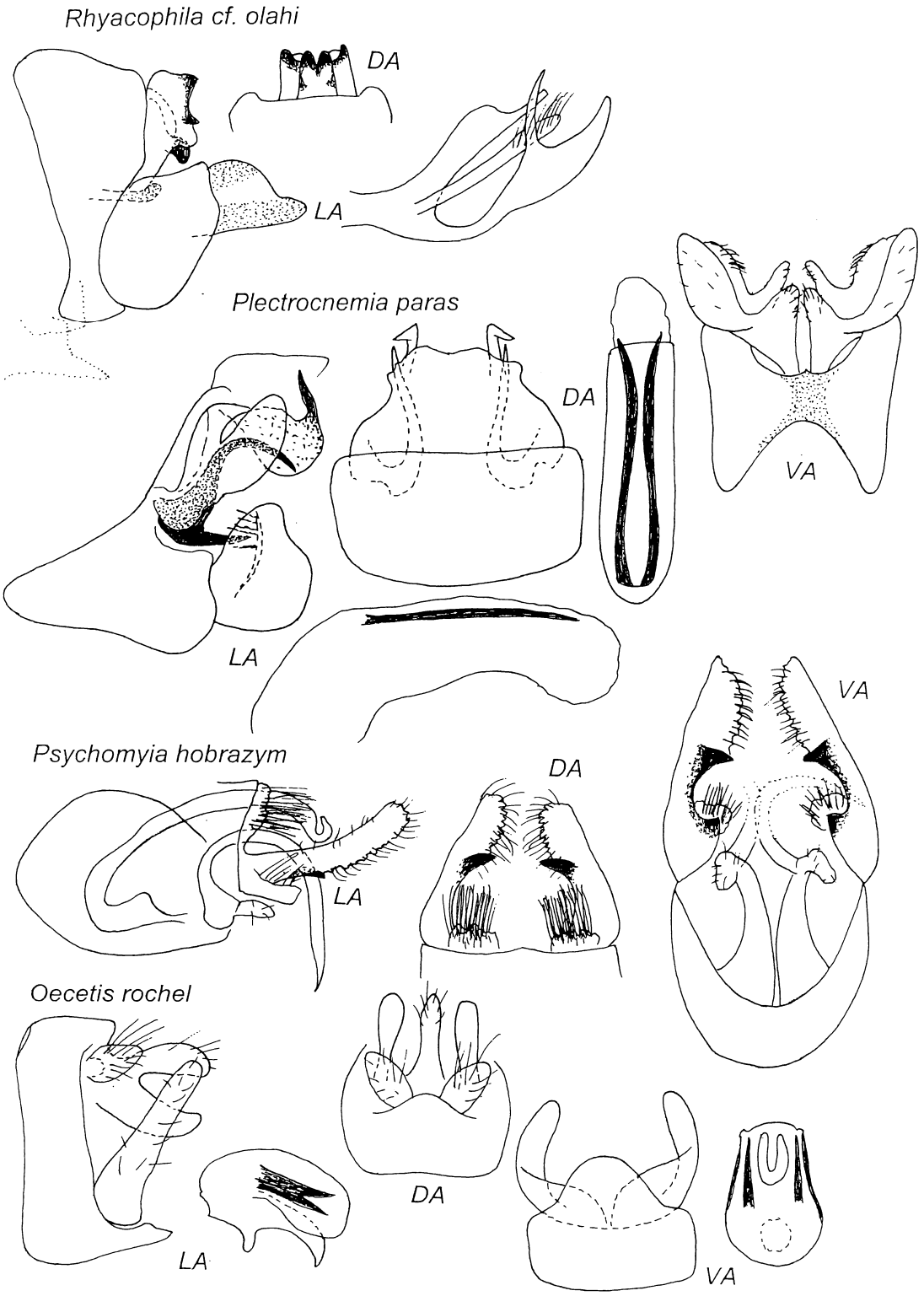
Habitus wie in der Verwandtschaft üblich. Körper und Anhänge gelblich, Körper dorsal braun gesprenkelt, Flügel gelblichgrau. VFL 6 mm. ♂KA: Ventralteil des 9. Segments in LA weit nach zephal vorspringend. Zwischen den großen ovalen OA liegt ein Paar rundlicher Platten, die distal einen langen, dünnen, nach oben gebogenen Finger tragen. UA in LA fast kreisrund, innen ist eine bestachelte Leiste erkennbar; in VA mit einem großen äußeren Lappen und zwei inneren vorstehenden Fingern. Aus dem Innern des 9. Segments entspringt ein Paar stark sklerotisierter Platten mit je zwei langen, spitzen Fingern; der eine weist geradeaus nach hinten und der andere größere, s-förmig gebogene, weist nach dorsal und ist dann nach hinten gebogen. Mehrere Arten aus Südostasien sind dieser ähnlich: *P. babel* MALICKY & MEY 2008, *P. apsyrtos* MALICKY 1999, *P. resa* MALICKY & CHANTARAMONGKOL 1993, *P. sinyajevi* MEY 1996, *P. alheniel* MALICKY 2012, *P. dalat* OLÁH & JOHANSON 2010, *P. thai* OLÁH & JOHANSON 2010. Von allen diesen unterscheidet sind *P. paras* n.sp. durch die charakteristische Form der inneren zweispitzigen Platte sowie durch weitere Details (MALICKY 2010, p.104).
Holotypus ♂: Kao Nan Nationalpark.

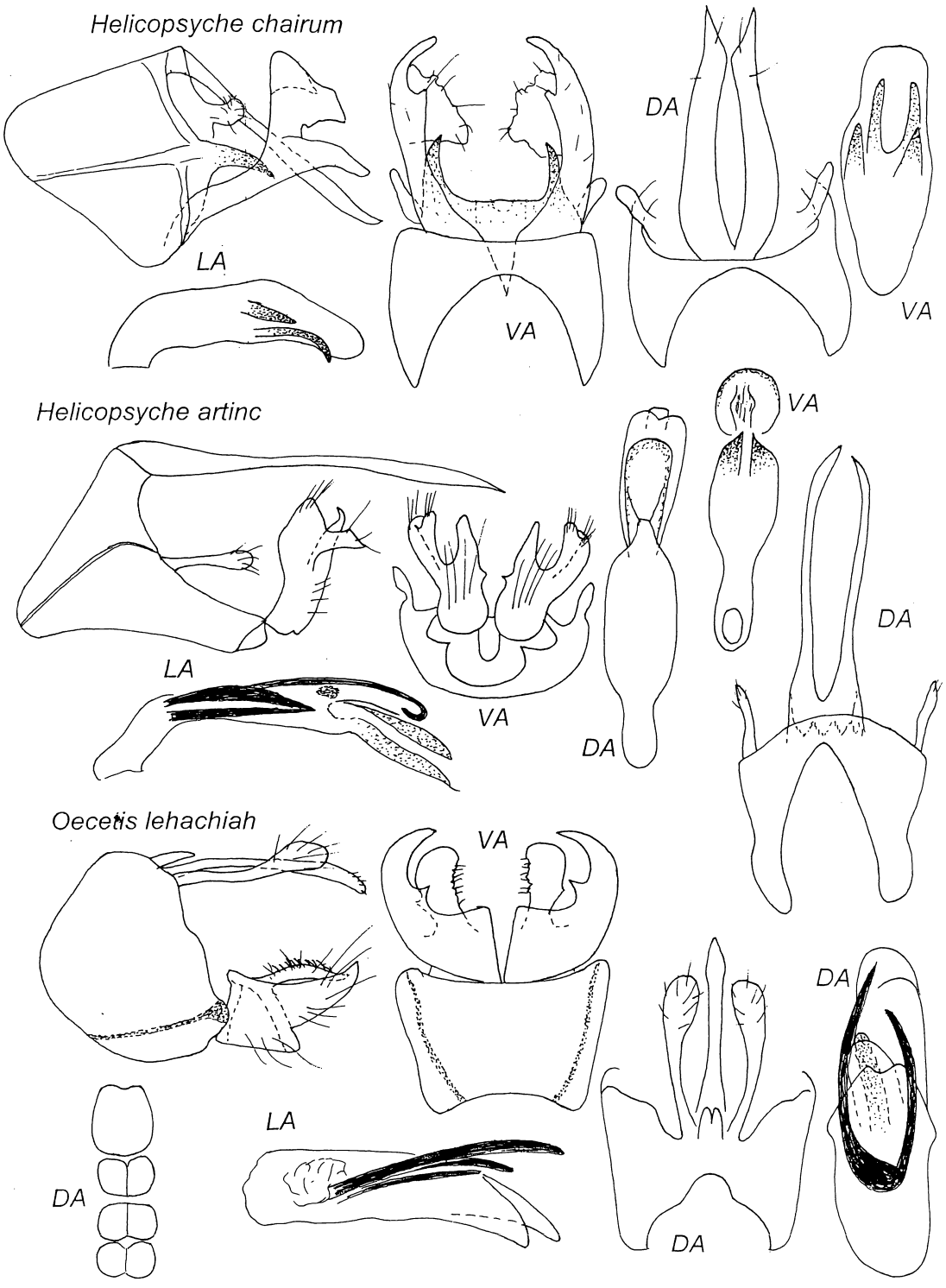
Psychomyia hobrazym n.sp. (Psychomyiidae)

Habitus wie üblich, gelbbraun, VFL 3 mm. ♂KA: 9. Segment in LA fast kreisrund. OA sehr groß, in LA schmal, parallelrandig, leicht nach oben gekrümmt; in DA mit einem nach innen vorspringenden schwarzen Zahn in der Mitte des Innenrandes, basal davon rund ausgehöhlt und am basalen Ende der Höhlung ebenfalls leicht vorspringend und schwarz. Außenteil der UA kurz und gedrungen, Innenteil in Form einer sehr großen, langen, spitzen, im Bogen nach unten gekrümmten Kralle. PA lang, basal stark nach hinten gebogen und dann mäßig stark nach unten gekrümmt, Ende mit einem nach oben gerichteten kleinen Haken. – Drei Arten aus der Region sind sehr ähnlich: *P. habibuah* MALICKY 2012, *P. indra* MALICKY & CHANTARAMONGKOL 1993 und *P. intorachit* MALICKY & CHANTARAMONGKOL 1993. Sie unterscheiden sich aber deutlich durch die andere Anordnung der schwarzen Zähne an der Innenkante der OA, was aus den Abbildungen (MALICKY 2010:136-137, 2012) zu entnehmen ist.
Holotypus ♂ und viele ♂ Paratypen: Kao Nan Nationalpark. – 1♂ Paratypus: Tai Rom Yen Nationalpark.

Helicopsyche artinc n.sp. (Helicopsychidae)

Habitus wie üblich, graubraun. Maxillarpalpen zweigliedrig. VFL 4 mm. ♂KA: 9.Segment in LA dreieckig, Vorderkante weit nach zephal vorspringend, Kaudalkante tief konkav. Die OA sind schlank und löffelförmig und entspringen aus der Mitte des Kaudalrandes. Das 10. Segment besteht aus einem Paar sehr langer, dünner, spitzen Stäbe, die geradeaus nach hinten gerichtet sind. UA kurz und gedrungen und kompliziert gebaut (siehe Abbildung): in LA mit einem nach hinten gerichteten spitzen Finger und einem inneren, nach oben gerichteten Häkchen, in VA gegabelt, mit breitem Außenfinger und schmälerem Innenfinger. PA kompliziert gebaut und Details schlecht erkennbar: siehe die Abbildung. Uns sind keine auch nur annähernd ähnliche Arten bekannt.
Holotypus 1♂: Tai Rom Yen Nationalpark.


Rhyacophila cf. olahi
DA
LA
Plectrocnemia paras
DA
VA
LA
Psychomyia hobrazym
VA
DA
LA
Oecetis rochel
DA
LA
VA


Helicopsyche chairum
LA
VA
DA
VA
Helicopsyche artinc
LA
VA
VA
DA
DA
Oecetis lehachiah
VA
DA
LA
DA
DA

***Helicopsyche chairum* n.sp.**

Gelbbraun, VFL 3 – 3,5 mm. Maxillarpalpen viergliedrig. ♂KA: 9.Segment in LA dreieckig, Vorderkante nach vorne vorspringend und dort abgerundet. Aus der Mitte der Kaudalkante entspringt ein großer, leicht nach unten gekrümmter Zahn. OA klein und knopfförmig. Das 10. Segment besteht aus einem Paar langer Stäbe; sie sind in LA gerade, schmal und distal leicht nach oben gekrümmt, in DA etwas breiter, parallelrandig, basal leicht gebogen, dann gerade und distal spitz, wobei die Spitze in Fortsetzung der Außenkante liegt. UA in LA mit einem basalen Stiel und in der Distalhälfte zweiteilig: der ventrale Teil ist schmal und spitz, leicht nach unten gekrümmt; der Dorsalteil ist hoch dreieckig. UA in VA mit nach innen gebogener Außenkante, die in eine Spitze ausläuft; aus der Innenkante entspringt ein großer, rundlicher Lappen. PA gedrungen, mit zwei Paar kurzer Stäbe. Es gibt mehrere ähnliche Arten in der Region (MALICKY 2010, p.242-245), die man vor allem an der LA der UA unterscheiden kann.
Holotypus ♂ und 4♂, 1♀ Paratypen: Kao Luang Nationalpark.

***Oecetis rochel* n.sp. (Leptoceridae)**

Gelblich, Flügel gelbbraun. VFL 4 mm. ♂KA: 9.Segment schmal, Vorder- und Kaudalkanten gerade, parallel verlaufend, in VA mit einem großen halbrunden Vorsprung. Das 10. Segment besteht aus einem unpaaren mittleren Finger und ventral davon zwei weiteren Fingern, alle distal abgerundet und ziemlich gerade nach hinten verlaufend. OA kurz, oval. UA in LA schmal und gerade, in VA basal breit und dann fingerförmig verschmälert, nach innen gebogen. PA kurz und gebogen, mit einem Paar gerader Dornen innen und mit einem kurzen ventralen Haken. – Wir kennen keine sehr ähnliche Arten.
Holotypus 1♂: Tai Rom Yen Nationalpark.

***Oecetis lehachiah* n.sp.**

Gelblich, Antennen schmal dunkel geringelt. Hinterrand der Hinterflügel mit langen, schwarzen Haaren. VFL 5 mm. Eine Art der *testacea*-Gruppe (MALICKY 2005) mit Maschenplatten auf den Abdominaltergiten 5 – 8, wobei die Platte 8 oval und einheitlich ohne Mittelkiel ist, die Platten auf den Segmenten 5 – 7 einheitlich sind, aber einem Mittelkiel haben. ♂KA: 9. Segment in LA fast kreisrund, aber Kaudalkante leicht eckig. 10. Segment lang und dünn, fast gerade nach hinten gerichtet. OA fast ebenso lang, löffelförmig mit dünnem Stiel. UA in LA unregelmäßig geformt (siehe Abbildung), in VA basal breit, Außenrand nach innen gebogen und distal spitz, Innenrand in der Hälfte der Länge plötzlich und eckig verschmälert; dort entspringt ein in LA dünner, in VA breit runder Finger. Aus der so entstehenden Höhlung entspringt ein kurzer, spitzer Zahn. PA länglich, mit einem Paar asymmetrischer, langen, nach innen und unten gekrümmten großen Dornen und einem kürzeren sklerotisierten Platte. – Von den ähnlichen Arten, die ebenfalls Maschenplatten auf vier Tergiten haben (MALICKY 2010, pp. 279, 282-283) unterscheidet sich diese Art sehr deutlich durch die Form der UA
Holotypus 1♂: Kao Luang Nationalpark.

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Diversity of caddisfly species (Insecta: Trichoptera) at Lower Hill Evergreen Forest of Nakhon Si Thammarat Range in southern Thailand

Nannaphat SUWANNARAT, Hans MALICKY, Pongsak LAUDEE

Abstract. Nakhon Si Thammarat range in southern Thailand is dominated by evergreen rainforest, with lower hill type evergreen forest at the peak. The species richness of Trichoptera of the study sites in the Tai Rom Yen (Surat Thani province), Khao Nan and Khao Luang (both Nakon Si Thammarat province) National Parks is described and discussed along with previous studies in several regions of Thailand. In the present study, 3949 adult Trichoptera specimens were collected, belonging to 21 families, 60 genera, and 173 species. 15 of the recorded species turned out to be new for science.

Keywords: Trichoptera, Tai Rom Yen, Khao Nan, Khao Luang, distribution, diversity, lower hill evergreen forest.

Introduction

In Thailand, over 1000 species of Trichoptera have been discovered in the past 40 years of which more than 70% were new species described from the country in over 70 publications. A summary is given by CHANTARAMONGKOL & al. (2010). Most field studies were made in northern Thailand, particularly at Doi Inthanon and Doi Suthep-Pui National Parks where the forest types are dry dipterocarp, moist evergreen, evergreen deciduous, hill evergreen and moist hill evergreen forests (GARDNER & al. 2000). Studies in these areas are e.g. by MALICKY & CHANTARAMONGKOL 1993, THAPANYA & al. 2004, and BUNLUE & al. 2012. Examples of sites are to be found in MALICKY (2014).

In southern Thailand, studies of Trichoptera have been made mainly in moist evergreen forests. By the year 2007, PROMMI (2007) had recorded 275 species from southern Thailand. PROMMI & PERMKAM (2010) have recorded 30 species from Ko Hong Hill. LAUDEE & MALICKY (2015) and SUWANNARAT & al. (2020) have collected 75 species from streams in Nakhon Si Thammarat Range which is covered by moist evergreen forest.

The hill evergreen forest type is dominating in the southern part of Thailand at Nakhon Si Thammarat Range where Nam Tok Si Khit, Tai Rom Yen, Khao Luang and Khao Nan National Parks are located. Streams of first and second orders dominate in this area. No prior study or survey of Trichoptera was made in hill evergreen forests at 1000 to 1600 metres until now, and many caddis species had not yet been found from this kind of forest. The present study aimed to find out the species richness, and to detect new species in Tai Rom Yen, Khao Nan and Khao Luang National parks (Figure), and to compare the species richness with previous studies.

Material and methods

Adult Trichoptera were collected using a UV pan light trap (10 W fluorescent tube lamp, 12 Volt DC battery) near streams and waterfalls overnight (Figure). In each of the three National parks, five sites were chosen for the collection, and at each site was collected two times to cover the hot and the rainy season of the year (Table 1). The specimens were preserved in 70% ethanol. In the laboratory at Surat Thani, the terminal part of the abdomen of the males was cut and macerated in hot 10% KOH at 60°C for 0,5 – 2 hours. The structures

were studied under a light microscope to identify the species with the help of literature (Malicky 2010).

Study sites

The study sites are in three protected areas (see table 1) where the vegetation is dominated by *Styrax betongensis*, *Lithocarpus garrettianus*, *L. polystachus*, *Podocarpus neriifolius*, *P. wallichianus*, *Cedrela toona*, *Betula alnoides*, *Cephalotaxus griffithii*, *Shorea gratissima*, *Hopea odorata*, *Cotylelobium lanceolatum*, *Intsia palembanica*, *Ailanthus triphysa*, and *Caryota obtusa*. Most of the trees are covered with fern, moss and lichen such as *Aneura indica*, *Colure conica*, *Frullania apiculata*, *Marsupidium knightii*, *Schistochila montricola*, *Adiantum latifolium*, *Angiopteris evecta*, *Antrophyum callifolium*, and *Cyathea contaminans* (JAROENSUTASINEE & al. 2010). There are two seasons: the hot and dry season in January-May and the rainy season in June-December. Air temperatures vary within 18,9 ± 2,8°C, and the average humidity is 87,9 ± 12,2 %. Thoroughout the year, are about 169 days with rainfall, and the average annual precipitation is about 2400 mm.

Table 1. The study sites

Area	site code	name of stream	Coordinate North	Coordinate East	elevation metres
Tai Rom Yen	TR1	Klong Lamphun 1	8°50'26"	99°29'56"	1100
	TR2	Klong Lamphun 2	8°50'11"	99°29'07"	960
	TR3	Klong Lamphun 3	8°50'35"	99°28'38"	911
	TR4	Klong Lamphun 4	8°50'39"	99°28'21"	875
	TR5	Klong Lamphun 5	8°50'36"	99°28°01"	854
Khao Nan	KN1	Klong Gray 1	8°44'02"	99°31'39"	1263
	KN2	Klong Gray 2	8°44'01"	99°32'41"	1250
	KN3	Klong Gray 3	8°46'19"	99°31'52"	1147
	KN4	Klong Gray 4	8°45'43"	99°31'56"	1241
	KN5	Klong Gray 5	8°45'30"	99°32'41"	1132
Khao Luang	KL1	Klong Tha Di 1	8°29'24"	99°44'40"	1366
	KL2	Klong Tha Di 2	8°28'59"	99°43'40"	903
	KL3	Klong Tha Di 3	8°28'02"	99°43'37"	823
	KL4	Klong Tha Di 4	8°28'51"	99°43'42"	802
	KL5	Klong Tha Di 5	8°27'58"	99°42'45"	793

Stream characteristics

The three streams Klong Lamphun, Klong Gray and Klong Tha Di are first or second order streams, with substrates dominated by bedrock, boulders, cobbles, pebbles and sand. Some physiochemical parameters of water quality were measured by thermometer, flow meter, and dissolved oxygen meters Aqua-probe AP-700 and AP-800, here shown as Mean ± DS: air temperature 19,5 ± 2,56°C, water temperature 17,6 ± 2,31 °C, velocity 0,37 ± 0,05 m/s, and dissolved oxygen 5,43 ± 0.74 mg/l. The canopy coverage over the streams exceeded 80%.

Results and discussion

The results are given in Tables 2 and 3, including a comparison with the other mentioned earlier studies. In Tai Rom Yen NP we found 96 species, in Khao Nan NP 118 species, and in Khao Luang NP 81 species. *Trichomacronema vietnamensis* was a new record for Thailand, and the following 15 species were new for science:

Table 2: New species detected during the present study

Name	authors	Reference
Rhyacophila aksornkoaei	LAUDEE & MALICKY 2019	SUWANNARAT & al. 2019
Rhyacophila longicaudata	SUWANNARAT & MALICKY 2019	SUWANNARAT & al. 2019
Orthotrichia kaonan	MALICKY, SUWANNARAT & LAUDEE 2018	MALICKY & al. 2018
Plectrocnemia paras	MALICKY & SUWANNARAT 2020	MALICKY & SUWANNARAT 2020
Polyplectropus hofmaierae	MALICKY & SUWANNARAT 2020	SUWANNARAT & al 2020
Eoneureclipsis chinachotiae	MALICKY & LAUDEE 2020	SUWANNARAT & al 2020
Psychomyia hobrazym	MALICKY & SUWANNARAT 2020	MALICKY & SUWANNARAT 2020
Hydropsyche khaonanensis	MALICKY & SUWANNARAT 2020	SUWANNARAT & al 2020
Macrostemum nigralatum	LAUDEE & MALICKY 2018	SUWANNARAT & al. 2018
Helicopsyche artinc	MALICKY & SUWANNARAT 2020	MALICKY & SUWANNARAT 2020
Helicopsyche chairum	MALICKY & SUWANNARAT 2020	MALICKY & SUWANNARAT 2020
Oecetis lehachiah	MALICKY & SUWANNARAT 2020	MALICKY & SUWANNARAT 2020
Oecetis rochel	MALICKY & SUWANNARAT 2020	MALICKY & SUWANNARAT 2020
Lannapsyche tairomyenensis	MALICKY & SUWANNARAT 2020	SUWANNARAT & al 2020
Anisocentropus tairomyenensis	SUWANNARAT & MALICKY 2018	SUWANNARAT & al. 2018

It is difficult to state anything about endemism, although local or regional endemics may be present. The density of records in Thailand is still too low; as compared e.g. with Europe (NEU & al. 2018). However, it may be suspected that striking species such as *Macrostemum nigralatum* which were never found elsewhere could be regional endemics.

Table 3: Numbers of specimens found during the present study in the three National Parks, and comparison of the species which were in common with other sites:

Abbreviations: LA – LAUDEE, MA – MALICKY, SU – SUWANNARAT, M&C – MALICKY & CHANTARAMONGKOL, C&M – CHANTARAMONGKOL & MALICKY, ■ - present, - absent

Southern Thailand:

TR Tai Rom Yen NP
KL Khao Luang NP
KN Khao Nan NP
PM several sites in southern Thailand (Prommi 2007)
LD 8 waterfalls in Tai Rom Yen andKhao Luang NP+ (Laudee & Malicky 2015)
HY Tramot, Boripat and Ton Nga Chang near Hat Yai (Malicky 2014)

Northern Thailand:

TP Doi Suthep-Pui NP and Doi Inthanon NP: Thapanya & al. 2004
BL Doi Suthep-Pui NP and Doi Inthanon NP: Bunlue & al. 2012

Name	Authors	TR	KN	KL	PM	LD	HY	TP	BL
Rhyacophilidae									
Rhyacophila aksornkoaei	LA & MA 2019	-	-	14	-	-	-	-	-
R. longicaudata	MA & SU 2019	-	3	5	-	-	-	-	-

R. olahi	ARMITAGE & AREFINA 2003	-	-	2	-	-	-	-	-
R. suratthaniensis	LA & MA 2016	2	8	6	-	■	-	-	-
R. tantichodoki	M&C 1993	10	7	8	■	■	■	-	-
R. malayana	BANKS 1931	11	-	10	■	■	-	-	■
R. scissoides	KIMMINS 1953	166	76	29	■	■	■	■	■
R. tosagan	M&C 1993	-	3	4	■	-	-	-	-
R. murhu	M&C 1989	-	2	1	-	-	-	■	■
R. xayide	M&C 1989	-	2	4	-	-	-	■	■
Hydrobiosidae									
Apsilochorema natibinham	SCHMID 1970	-	2	-	-	-	-	-	-
A. utchtchunam	SCHMID 1970	2	2	-	-	-	-	-	-
Glossosomatidae									
Agapetus viricatus	M&C 1992	2	-	-	-	-	-	■	-
Glossosoma malayanum	BANKS 1934	-	2	-	-	-	-	■	■
Hydroptilidae									
Chrysotrichia pulmonaria	XUE & YANG 1990	-	20	200	-	-	■	-	-
Chrysotrichia talthybios	M&C 2007	-	-	2	-	-	-	-	-
Hydroptila sabit	WELLS & HUISMAN 1992	2	1	-	-	-	-	-	-
H. portunus	M&C 2007	-	7	-	-	-	■	-	-
H. rumpun	WELLS & HUISMAN 1992	-	94	-	-	-	-	-	-
H. thuna	OLÁH 1989	-	1	-	-	-	■	-	■
Macrostactobia runcing	WELLS & HUISMAN 1992	2	-	-	-	-	-	-	-
Orthotrichia curvata	ULMER 1951	-	2	-	-	-	-	-	-
O. deukalion	MA & PROMMI 2000	-	2	2	-	-	-	■	-
O. kaonan	MA & SU 2018	12	2	108	-	-	-	-	-
O. terpsichore	M&C 2007	-	-	2	-	■	-	-	-
Scelotrichia temenos	M&C 2007	10	-	-	-	-	-	-	-
Ugandatrichia honga	OLÁH 1989	-	8	2	■	■	■	■	-
U. hairanga	OLÁH 1989	-	-	2	■	-	-	■	-
U. kerdmuang	M&C 1991	-	-	4	■	■	■	■	-
Philopotamidae									
Chimarra atnia	M&C 1993	8	1	2	■	-	■	■	■
C. bimbltona	MALICKY 1979	42	24	>250	■	■	■	■	-
C. chiangmaiensis	C&M 1989	46	-	2	-	■	-	■	■
C. devva	M&C 1993	8	1	-	-	-	-	■	■
C. fulmeki	ULMER 1951	8	4	-	-	-	-	-	-
C. htinorum	C&M 1989	5	-	-	-	■	-	■	■
C. joliveti	JACQUEMART 1979	-	2	52	-	-	-	■	-
C. khamuorum	C&M 1989	12	-	-	■	■	-	-	■
C. lannaensis	C&M 1989	2	-	-	■	-	-	■	■
C. meorum	C&M 1989	9	-	-	-	-	-	-	■
C. monorum	C&M 1989	58	35	-	■	■	■	■	■
C. okuihorum	MEY 1998	-	-	2	-	-	-	■	■
C. pipake	M&C 1993	-	-	14	■	■	■	■	■
C. rama	M&C 1993	2	-	1	■	-	■	-	-
C. ravanna	M&C 1993	73	6	-	■	-	■	-	-
C. reasilvia	MA & PROMMI 2006	2	-	-	■	-	-	-	-
C. supanna	MALICKY 1993	50	24	2	-	-	-	-	-
C. scopulifera	KIMMINS 1957	5	-	8	-	-	-	■	-
C. sita	M&C 1993	42	-	-	■	-	-	-	-
C. spinifera	KIMMINS 1957	8	1	20	■	■	■	■	■
C. suthepensis	C&M 1989	2	-	-	■	-	■	■	■
C. thienemanni	Ulmer 1951	>250	>250	>250	-	-	-	-	-
C. uppita	M&C 1993	-	-	2	-	-	-	■	■
C. yskal	MALICKY 1989	-	-	2	■	■	■	-	-
Dolophilodes adnamat	M&C 1993	-	-	8	-	-	-	■	■
Gunungiella sibylla	MA & PROMMI 2006	12	2	2	■	-	-	-	-
G. fimfafiazga	M&C 1993	8	2	-	■	-	■	-	-
Kisaura peleg	MA & LA 2009	-	-	4	-	-	-	-	-

Wormaldia lot	M&C 2009	1	-	-	-	-	-	-	-
W. relicta	MARTYNOV 1935	-	-	2	-	-	-	■	■
Stenopsychidae									
Stenopsyche siamensis	MARTYNOV 1931	1	6	10	■	■	■	■	-
Polycentropodidae									
Nyctiophylax tonngachang	M&C 1993	-	-	2	■	-	■	-	-
Plectrocnemia paras	MA & SU 2020	-	2	-	-	-	-	-	-
Polyplectropus hofmaierae	MA & SU 2019	1	-	-	-	-	-	-	-
P. josaphat	MALICKY 1993	-	2	-	-	-	-	-	-
P. admin	M&C 1993	-	1	6	-	-	-	■	■
P. nangajna	M&C 1993	-	2	-	-	-	-	-	■
P. matthatha	M&C 1993	-	2	-	■	■	■	-	-
P. menna	M&C 1993	2	2	-	-	-	-	■	■
Pseudoneureclipsis baring	MALICKY 1993	-	2	-	-	-	-	-	-
P. cheiron	MA & SOMPONG 2000	9	2	-	■	■	-	-	-
P. zethos	MA & PROMMI 2006	-	8	-	■	-	-	-	-
P. usia	M&C 1993	-	1	-	-	-	-	■	■
P. tramot	M&C 1993	5	-	-	■	■	■	-	-
P. thiras	M&C 2009	-	2	74	-	-	-	-	-
P. uma	M&C 1993	2	3	126	■	■	■	-	■
P. locutius	M&C 1997	-	-	6	-	-	-	-	-
Psychomyiidae									
Eoneureclipsis chinachotiae	MA & LA 2019	5	12	2	-	-	-	-	-
E. querquopad	M&C1989	1	2	1	-	-	-	■	-
Paduniella hatyaiensis	M&C 1993	-	2	4	-	-	-	-	-
P. semarangensis	ULMER 1913	-	1	-	■	-	■	■	■
Psychomyia adun	M&C 1993	-	-	3	■	■	■	-	-
P. hobrazym	MA & SU 2020	2	122	-	-	-	-	-	-
P. kerynitia	MA & NUNTAK-WANG 2006	-	-	2	-	-	-	-	■
P. kuni	M&C 1993	-	10	11	■	-	-	-	-
P. reguel	M&C 2009	-	2	1	-	-	-	-	-
P. pinsuwanae	LA & MA 2018	-	-	110	-	-	-	-	-
Tinodes sitto	M&C 1993	-	-	1	■	■	-	-	-
T. ragu	M&C 1993	6	1	2	■	-	■	-	■
T. lebeli	M&C 1993	-	2	-	■	-	■	-	-
Lype atnia	M&C 1993	6	4	4	■	-	■	■	■
Xiphocentronidae									
Abaria iuma	M&C 1992	-	1	-	-	-	-	-	-
Drepanocentron jubal	M&C 2009	6	-	-	-	-	-	-	-
Proxiphocentron arjmae	M&C 1993	-	2	-	-	-	-	-	-
Ecnomidae									
Ecnomus neri	M&C 1993	1	2	-	■	■	■	-	-
E. puro	M&C 1993	2	13	1	■	-	■	■	-
E. totiio	M&C 1993	3	14	1	■	■	-	-	-
E. vibenus	M&C 1993	-	2	-	■	■	-	-	-
E. robustior	ULMER 1929	-	2	-	■	-	■	-	■
E. thugarma	M&C 2009	2	24	10	-	-	-	-	-
Hydropsychidae									
Diplectrona burha	SCHMID 1961	1	-	-	-	-	-	■	-
D. dulitensis	KIMMINS 1955	62	17	19	■	■	■	-	-
D. gombak	OLÁH 1993	2	1	-	■	-	■	-	-
D. hermione	M&C 2002	111	19	31	■	-	-	■	■
D. joannisi	NAVÁS 1932	-	5	1	-	-	-	■	■
Amphipsyche gratiosa	NAVÁS 1922	-	2	-	-	■	-	-	-
Cheumatopsyche charites	M&C 1997	-	61	>250	■	■	-	■	■
C. copia	M&C 1997	16	2	>250	■	■	■	■	■
C. dhanikari	MALICKY 1979	-	23	>250	-	-	-	-	-
C. trilari	M&C 1997	2	1	1	■	■	-	-	■
C. criseyde	M&C 1997	1	-	-	-	■	-	■	■
Hydromanicus abiud	M&C 1993	3	2	8	■	■	■	■	■
H. adonis	M&C 1996	4	1	2	■	■	-	■	■
H. klanklini	M&C 1993	3	5	1	■	■	■	■	■

H. inferior	C&M 1995	-	84	4	■	-	-	■	■
Hydropsyche biton	M&C 2000	-	12	1	■	-	-	-	-
H. brontes	M&C 2000	5	3	22	■	■	■	-	-
H. camillus	M&C 2000	14	14	-	■	■	-	■	■
H. doctersi	ULMER 1951	2	-	-	■	■	-	■	■
H. pallipenne	BANKS 1938	78	7	-	■	■	■	■	■
H. kaonanensis	MA & SU 2019	1	1	-	-	-	-	-	-
Macrostemum nigralatum	LA & MA 2018	8	17	54	-	-	-	-	-
M. floridum	NAVAS 1929	-	9	-	■	-	-	■	■
M. fenestratum	ALBARDA 1887	2	2	-	■	■	■	-	-
M. hestia	M&C 1998	60	27	4	■	■	-	■	■
M. midas	M&C 1998	8	8	7	■	■	■	■	■
Potamyia phaidra	M&C 1997	7	16	2	■	-	-	■	■
P. flavata	BANKS 1934	-	1	-	■	-	-	■	■
Pseudoleptonema erawan	M&C 2001	-	2	-	-	-	-	-	-
P. supalak	M&C 1998	-	1	-	■	-	-	-	-
Trichomacronema vietnamensis	UY,MA & BAE 2018	-	4	-	-	-	-	-	-
Phryganeidae									
Eubasilissa maclachlani	WHITE 1862	-	1	-	-	-	-	■	■
Goeridae									
Goera unica	ULMER 1951	5	11	-	-	-	-	-	■
G. uniformis	BANKS 1931	67	2	2	■	■	■	■	■
G. anakpiatu	MALICKY 1995	1	2	-	-	■	-	-	-
G. mandana	MOSELY 1938	1	-	-	-	-	-	■	■
Helicopsychidae									
Helicopsyche chairum	MA & SU 2020	2	-	10	-	-	-	-	-
H. artinc	MA & SU 2020	1	-	-	-	-	-	-	-
H. boniata	M&C 1992	-	8	-	■	■	■	-	-
Lepidostomatidae									
Lepidostoma abruptum	BANKS 1931	40	20	29	■	■	■	■	■
L. brevipennis	OLÄH 1993	11	19	4	■	■	-	-	-
L. moulmina	MOSELY 1949	18	26	5	-	-	-	■	■
Leptoceridae									
Adicella evadne	SCHMID 1994	-	3	1	■	■	■	■	■
A. koronis	MA & THANI 2002	-	-	1	■	■	-	■	■
A. pulcherrima	ULMER 1906	2	-	-	■	-	-	-	-
Leptocerus consus	MA & SOMPONG 2000	-	-	1	-	-	-	-	-
L. tursiops	MALICKY 1979	-	4	1	■	-	-	-	-
Oecetis lehachiah	MA & SU 2020	2	-	2	-	-	-	-	-
O. rochel	MA & SU 2020	1	-	-	-	-	-	-	-
O. miletos	MA & NAEWVONG 2005	-	-	4	-	-	-	-	■
O. lotis	MA & THAPANYA 2004	-	2	-	■	■	■	-	-
O. tripunctata	FABRICIUS 1793	3	8	-	■	-	■	■	■
Parasetodes respersellus	RAMBUR 1842	-	2	-	-	-	■	-	-
Setodes sarapis	M&C 2006	1	1	-	■	-	■	-	-
S. kybele	M&C 2006	-	-	10	-	-	-	-	-
S. thoneti	M&C 2006	-	53	-	-	-	■	-	-
S. akrura	GORDON & SCHMID 1987	-	8	-	-	-	■	■	-
S. alampata	SCHMID 1987	45	2	-	-	-	-	-	-
S. isis	MA & NAEWVONG 2006	-	78	-	■	-	■	-	■
Tagalopsyche brunnea	ULMER 1905	2	-	-	■	-	-	-	-
T. osiris	MA & PROMMI 2006	8	2	-	■	-	-	-	-
Trichosetodes sisyphos	MA & PROMMI 2006	>250	19	68	■	■	-	-	-
Triaenodes dusra	SCHMID 1965	1	-	-	■	-	-	-	-
Brachycentridae									
Micrasema fortiso	M&C 1992	4	2	1	■	-	-	■	■
Odontoceridae									
Lannapsyche	MA & SU 2019	10	2	2	-	-	-	-	-

tairomyenensis									
Psilotreta assur	M&C 2009	-	3	-	-	-	-	-	-
Calamoceratidae									
Anisocentropus diana	M&C 1994	9	6	-	■	■	-	■	■
A. tairomyenensis	MA & SU 2018	29	23	3	-	-	-	-	-
Ganonema fuscipenne	ALBARDA 1881	5	4	4	■	■	■	-	■
Molannidae									
Molanna oglamar	M&C 1989	1	2	-	-	-	-	-	■

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Larval morphology, Life cycle and Nutritional values of *Lepidostoma abruptum* Banks, 1931 (Trichoptera, Lepidostomatidae) from Lower-Hill Evergreen Forests of Southern Thailand

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Abstract

This study aimed to study larval morphology, life cycle, and nutritional values of the *Lepidostoma abruptum* Banks, 1931. The specimens were collected bimonthly in one year by pick sampling method from Tai Rom Yen National Park, in Southern Thailand (8°50'35''N 99°28'38''E), at 911 meters above the sea level during March 2019 and February 2020. The larvae of *L. abruptum* lived in a pool in a small stream, where the substrate was dominated by fine sand, fine gravel, dead plant materials, and leaves. For the life cycle, 74 specimens were measured for the head capsule width. The results indicate presence of 5th instar larvae and this being a non-seasonal species. In addition, the specimens were determined for the nutritional values: protein (49.08%), total fat (27.18%), total dietary fiber (5.93%), moisture (68.87%), omega-3 (0.19%), omega-6 (6.42%), and omega-9 (11.75%).

Keywords: larval morphology, life cycle, nutritional values, and *Lepidostoma abruptum*.

Introduction

The Lepidostomatidae is a common family that occurs worldwide in all zoogeographic regions, including the Nearctic areas, Palearctic, Oriental, and Afrotropical regions, and the northern areas of the Neotropical and Australian Regions (Holzenthal et al. 2017; Weaver et al. 2010). Three genera, *Paraphlegopteryx, Zephyropsyche,* and *Lepidostoma* have been recorded from Thailand, where forty-three species are found (Malicky 2010). The genus *Lepidostoma* is the biggest genus of the family, and is distributed over the whole country (Thapanya et al. 2004; Malicky 2010; Laudee & Prommi 2011; Bunlue et al. 2012; Laudee & Malicky 2014). Three species of the genus *Lepidostoma,* namely *L. abruptum* Banks 1931, *L. brevipennis* Oläh 1993, and *L. moulmina* Mosely 1949, were recorded from the Nakhon Si Thammarat ranges. *L. abruptum* is common and dominant at the Tai Rom Yen National Park, and a great number

of samples has been recorded (Laudee & Malicky 2014).

The description of the larvae of Lepidostomatidae within the genus *Lepidostoma* sp. in Asia has been studied. Ito et al. (2011) described the characteristics of the final instar larvae from Japan for three species, *Lepidosatoma pseudemarginatum*, *L. mennokiense,* and *L. yosakoiense*. The cases of the larvae are cylindrical and made from sand for early instars, but the second to fifth instar cases are 4-sided and made of leaves. The head is subequal to length and dark brown. Frontoclypeus was small in width and light brown. Abdominal segments II–VI are with single tracheal gills. Dinakaran et al. (2013) reported that the case of *L. nuburagangai* was made of sand for early instar and was 4-sided of leaf pieces for the second to fifth instars. The case of the larvae is cylindrical. Head is brown with many round light spots at posterior, triangular in dorsal view with three teeth at apex. Frontoclypeus is dark brown. Thoracic legs, light brown, foreleg is shortest, middle leg is longest, and hind legs consist of of numerous comb-like setae. Abdominal segments II–XII are with single tracheal gills on their subventral and subdorsal parts. Anal legs with anal claw and accessory hook.

The biology and habitat of genus *Lepidostoma* was reported as a shredder and univoltine life cycle species (Grafius & Anderson 1980; Malicky 2021). Dinakaran et al. (2013) reported that the larvae live in slow-moving streams where leaf litter and woody debris are deposited. Also, Ito 2011 reported that the larvae of *Lepidostoma* spp. live in small streams in hygropetric habitats with wet semi-aquatic plants in mountain area. In addition, Karaouzas & Waringer (2016) and Terefe et al. (2018) reported that European Lepidostoma inhabits springs and cool slow streams at mountain areas. For the life cycle of the Lepidostoma, *L. nuburagangai* was reported from India. Five stages of instar larvae were shown with the first instar building their cases of sand, the second and third instars making their cases of sand and pieces of leaves, and the fourth and fifth instar cases are made of leaves (Dinakaran et al. 2013).

More than 1,700 species of insects are reported to be edible for humans and animals, and have been already used for this purpose for almost 10,000 years (Riggi et al. 2016). An analysis of aquatic insect nutrition values reported that they have high protein contents as percentage of dry weight, as in Ephemeroptera (66.26%), Odonata (40–65%), Hemiptera (42–73%) and Coleoptera (23–66%) (Xiaoming et al. 2010). Trichoptera is important to aquatic ecosystems because it is a food source for fish and other aquatic life. Nutrition values of ten species of Trichoptera were reported as healthy food with low fat, but high calcium, iron, zine, and protein (Anankware et al. 2015). Reinecke & Owen (1980) reported that Trichoptera has high nutritional values: protein 45.7%, fiber 8.8 %, and ash 33.8 % by dry weight.

The current study aimed to investigate the life cycle, some aspects of biology, larval morphology, and nutritional values of *Lepidostoma abruptum* Banks, 1931. The results facilitate potential culturing of the insect for aquatic animal food.

Materials and Methods

Larval morphology study

The final instar larvae and mature pupae of *L. abruptum* were collected at Lumphum stream, Tai Rom Yen National Park, Southern Thailand (8°50'35''N 99°28'38''E) during March 2019 and February 2020 (Fig. 1). The final instar larvae and male matured pupae of *L. abruptum* were associated with larval sclerites in the pupal case (metamorphotype method, Wiggins 1996). Features of the identified larvae were photographed by stereomicroscopy (Leica Stereo S series). An ocular micrometer was used to measure larval dimensions.

Figure 1. Pool zone characteristics at the study site, Tai Rom Yen National Park

Life cycle studies

Seventy-four larval specimens of *L. abruptum* were collected bimonthly in one year by pick sampling method from the study site. The head capsule widths of the larvae were measured with an ocular micrometer. The distribution of head capsule widths was plotted to determine the larval instars of the insect.

To determine the development time of *L. abruptum*, live larvae at different stages were collected and cultured in an aquarium (40x60x20cm) covered with a

net. The illumination in the aquarium was managed by using a timed light, with 12 hours daylight and 12 hours darkness. The temperature was controlled within the range 22–25°C. The rearing water was changed every week. The head capsule widths of the larvae were observed and measured every week until the larvae developed to adult stage.

Nutritional values analysis

To analyze the nutritional values, the larvae were collected during January to June 2020. The specimens were dried in a vacuum freeze-dryer at -40°C for 24 hours and were thoroughly ground with mortar and pestle in liquid nitrogen. The ground samples were analyzed at the Laboratory of food and beverage testing, Institute of Food Research and Product Development, Kasetsart University. The methods applied were as follows. Protein: In-house method based on AOAC (2016) 991.20. Fat: In-house method based on AOAC (2016) 2003.05. Fiber: In-house method based on AOAC (2016) 985.29. Moisture: In-house method based on AOAC (2016) 925.45. Omega-3, Omega-6, and Omega-9: In-house method based on Compendium of Methods for food analysis, Thailand (1st Edition, 2003).

Results

Description of the final instar Larvae: *Lepidostoma abruptum* Banks, 1931

General aspects. Total length 8.0–12.0 mm (n=12). Head and other sclerotized parts dark brown to yellow brown. Soft part of thorax and abdominal segment white. Abdominal segments II–VII with single gills dorsally and ventrally, bifurcated.

Larval case. Case length 9.5–12.5 mm (n=12). Case rectangular, cylindrical, made of rectangular pieces of leaf (Fig. 2–3).

Final instar larva. Head slightly circular, granulated surface; head capsule length 1.25–1.30 mm (n=12); head capsule width 1.50–1.58 mm (n=12). Dorsal of head dark brown to yellow brown with numerous somewhat circular yellow muscle scars from mid-posterior of head (Fig. 4). Eyes black, round with semicircle yellow muscle scar posteriorly. Frontoclypeus with anterior margin concave (Fig. 6), anterior part somewhat trapezoid and dark brown, subposterior end with yellow marks. Labium light brown, elliptical with setae anteriorly. Ventral of head light brown. Submentum small, short, rectangular. Ventral apotome isosceles triangle that is broad anteriorly and narrowest posteriorly. Medial ecdysial line shorter than ventral apotome. Ventral apotome yellow brown, triangular (Fig. 5).

Thorax three-segmented, yellow brown, and with moderate numerous long black setae. Pronotum dark brown sclerite, eleven black setae anteriorly, four setae medially, curved row of muscle marks subposteriorly (Fig. 7). Mesonotum yellow brown sclerite, one anteromedial setae (*Sa1*), three posteromedial setae (*Sa2*), two lateral setae (*Sa3*). Metanotum light yellow membranous, non-anteromedial setae

(*Sa1*), two posteromedial setae (*Sa2*), four lateral setae (*Sa3*); see Fig. 8.

Forelegs shortest with coxa trapezoid, somewhat rectangular trochanter, stout femur, short tibia, and bifid tarsal claws. Midlegs and hindlegs somewhat similar with coxa, trochanter, femur, tibia slender and long, and with bifid tarsal claws (Figs. 9–11). Abdominal segments membranous, light red brown.

Abdominal segments cylindrical, creamy white, with dorsal and ventral single gills. Abdominal segment I with lateral humps on each side (Fig. 12), dorsal setal area 1 and 3 absent, dorsal setal area 2 with single seta, ventral setal area 2 and 3 with single seta, ventral setal area 1 absent (Figs. 12–13). Abdominal segment II–VII with single seta on dorsal setal area 2 and dorsal setal area 3, dorsal setal area 1 with no seta, ventral setal areas 2 and 3 with single seta, ventral setal area 1 with no seta (Fig. 13). Abdominal segment with single dorsal and ventral gills, with lateral line, number and positioning of gills and the extent of lateral line show as in (Figs. 13–17). Abdominal segment IX dark brown, with semicircle dorsal sclerite and four of long seta on its sclerite (Fig. 14), with 4 pairs of ventral setae (Fig. 15). Anal prolegs short with anal sclerite. Anal claws dark brown, each with accessory hook (Fig. 16).

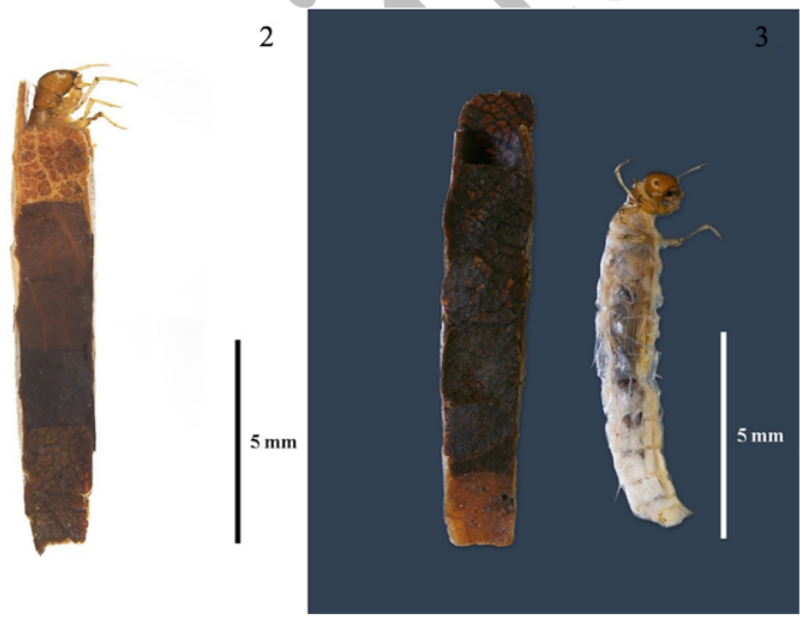


Figure 2–3. General appearance of final instar larva and its case for *Lepidostoma abruptum* Banks, 1931.

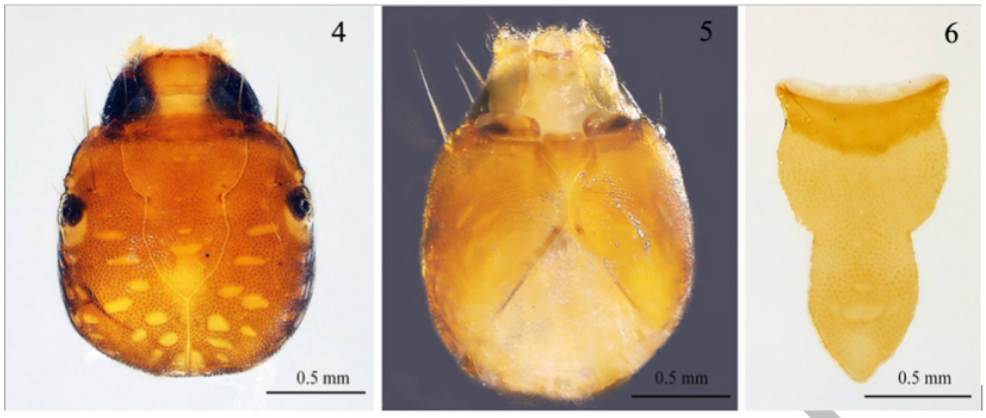
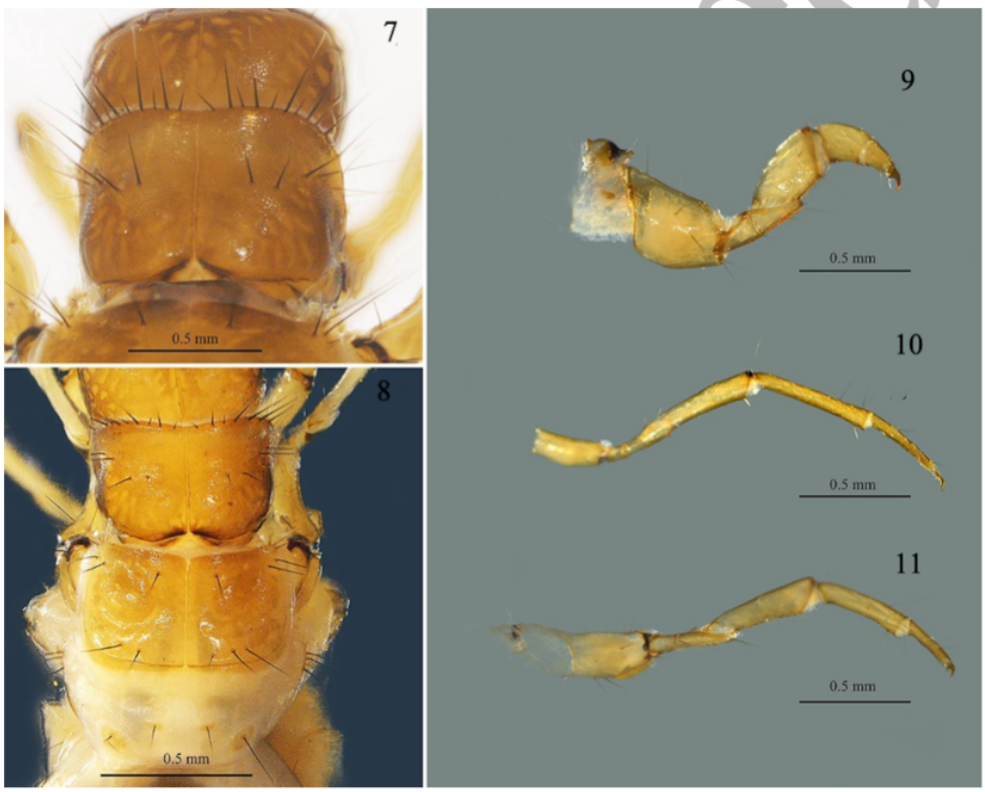


Figure 4–6. **4** Head dorsal, **5** Head ventral, **6** Frontoclypeus.



Figures 7–11. **7** and **8** Thorax (pronotum, mesonotum, and metanotum), setae on pronotum, **9** Left front leg, **10** Left middle leg, **11** Left hind leg

Figures 12–16. **12** Abdomen segment I (arrow indicates abdominal segment I lateral humps), **13** Abdomen gills segment I–VII, lateral view, **14** Abdomen segment VIII–IX dorsal, **15** Abdomen segment IX, **16** Anal claw and accessory hook ventral.

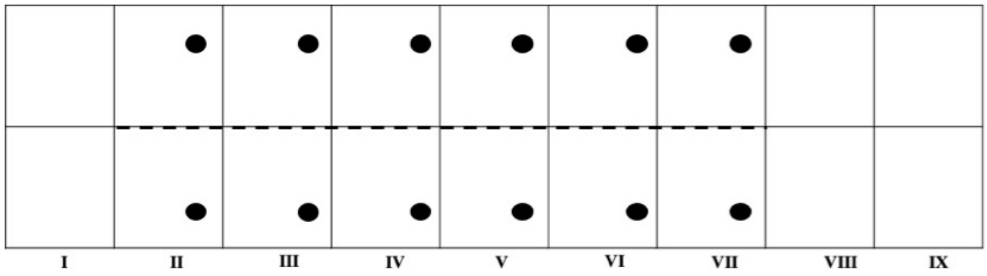


Figure 17. *Lepidostoma abruptum,* 5th instar larva. Gill diagram of dorsal and ventral gills and extent of lateral line (dashed bold line along the middle).

Life cycle study

The *Lepidostoma abruptum* larvae were collected bimonthly from a small stream at the Tai Rom Yen National Park, Southern Thailand (8°50'35''N 99°28'38''E) at 911-meter elevation from average mean sea level during March 2019 – February 2020. The larvae were taken from a pool in a small stream. The substrate was dominated by fine sand, fine gravel, dead plant materials and leaves. Physical and chemical parameters of environment and water quality were as follows: air temperature 19±0.84°C, water temperature 23±1.41 °C, pH 7.85±0.36, velocity 0.18±0.25 m/s, stream width 4±0.63 m, stream depth 0.5±0.8m, alkalinity 55.78±2.24 mg/l, dissolved oxygen 6.03±0.20 mg/l, electrical conductivity 506.84±18.35µS/cm., total dissolved solids 211.56±19.53

The seasonal light trapping for hot season (March–May) and rainy season (September–October) for the adults of *L. abruptum* showed that the *L. abruptum* has a non-seasonal life cycle. A total of 74 *L. abruptum* larvae were measured for head capsule width, then analyzed for frequency distribution. The results indicate the presence of 5 instars of larvae. The ranges and mean ± SD of head capsule width of each instar were: Instar I, HCW = 0.50–0.63 mm, 0.56±0.05 mm (n=11); Instar II, HCW = 0.75–0.90 mm, 0.83±0.05 mm (n= 17); Instar III, HCW =1.00–1.06 mm, 1.06±0.05 mm (n=27); Instar IV, HCW = 1.25–1.38 mm, 1.31±0.05 mm (n=7); and Instar V, HCW= 1.5–1.63 mm 1.58±0.05 mm (n=12) (see Fig. 18).

Larval rearing of 1st–5th instars at the laboratory showed that development time of Instar I was 2 weeks, Instar II 5 weeks, Instar III 8 weeks. The last instar became pupae for about 3–4 weeks, and the adults after emerging lived for about 1–2 weeks (Table 1).

Table 1. Mean and range of head capsule width (mm) for larval instars along with times spent at each stage

Larval instar	Range of head capsule width (mm)	Development times
Instar I	0.50–0.63	2 weeks
Instar II	0.75–0.90	5 weeks
Instar III	1.00–1.06	8 weeks
Instar IV	1.25–1.38	-
Instar V	1.50–1.63	-
Pupae	-	3–4 weeks (n=5)
Adult	-	1–2 weeks (n=5)

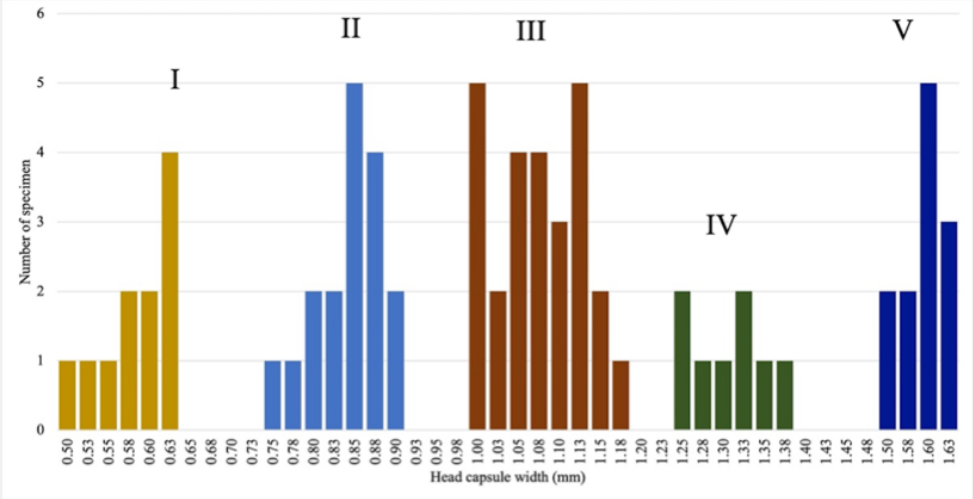


Figure 18. The frequency distributions of head capsule widths (mm) by larval instar stage of *Lepidostoma abruptum*

Nutritional values

The nutrient composition determined from in total 70g of pooled *L. abruptum* larval stages, in dry matter, is presented in (Table 2). The proximate analysis determined protein, fat, fiber, moisture, omega 3, omega 6 and omega 9 based on dry weight of the larval stage.

Table 2. Nutritional values of the *L. abruptum* larvae in the current study

Component	% Mass dry basis	Unit
1) Protein	49.08	g/100 g dry weight
2) Total Fat	27.18	g/100 g dry weight
3) Total dietary fiber	5.93	g/100 g dry weight
4) Moisture	68.87	g/100 g dry weight
5) Omega-3	0.19	g/100 g dry weight
6) Omega-6	6.42	g/100 g dry weight
7) Omega-9	11.75	g/100 g dry weight

Discussion and Conclusions

Lepidostoma abruptum Bank 1993 is a common species that has been recorded nationwide in Thailand for the adult stage, but the larval stages have not been described (Thapanya et al. 2004; Malicky 2010; Bunlue et al. 2012; Laudee &Malicky 2015). The larvae of *L. abruptum* share the characteristics of *Lepidostoma* spp. found in Southeastern USA (*L. griseum*), Japan (*L. pseudemarginatum, L. mennokiense, L. yosakoiense*), India (*L. nuburagangai*), Grece (*L. doehleri*), and Central Ethiopia (*L. scotti*). The characteristics of those species were frontoclypeus narrow and elongated by anterior margin concave, ventral apotome is longer than median ecdysial line, the cases are rectangular tubes made or leaf or/and sand, protorax and mesothorax were sclerites, dorsal hump is on abdomen segment I (Morse et al. 2017; Ito 2011; Dinakaran et al. 2013; Karaouzas & Waringer 2016; Terefe at al. 2018). However, Ito et al. (2011) diagnosed the difference of three species of final instar larvae from Japan including *L. pseudemarginatum*, *L. mennokiense, L. yosakoiense* by the presence and position of abdominal gills. *L. pseudemarginatum* bears both dorsal and ventral abdominal gills on posterior rows of segments III–VI, *L. mennokiense* presents the dorsal abdominal gills on segments III–VII and ventral abdominal gills on segments III–VI, and *L. yosakoiense* presents both dorsal and ventral abdominal gills on posterior rows of segments II–VI. In addition, Terafe et al. (2018) reported that *L. scotti* bears single abdominal gills on posterior of dorsal and ventral on segments II and VII, but presents a pair of gills on segments III–VI. In this study, *L. abruptum* can be separated from those species by the rows of single gills on dorsal and ventral abdominal segments II–VII. Then, we suggest that the presence and absence of abdominal gills on each abdominal segment and the position of anterior and posterior abdominal gills on each abdominal segment can be used as one of the diagnostic characters to identify *Lepidostoma* to species level.

Furthermore, Karaouzas & Waringer (2016) established the diagnostic key for final instar larvae of three *Lepidostoma* species in Greece. The setae on mesonotum and metanotum were the main characteristics identifying the insects to species level. Anterior margins of each mesonotal sclerite in *Lepidostomum hirtum* is with only one median seta. Nevertheless, *L. basale* and *L. doeleri* have more than 20 setae on anterior margins of mesonotal sclerites but they can be differentiated by the number of setae on posteromedial of each mesonotum sclerite. Moreover, *L. basale* builds the case with sand, but *L. hirtum* makes the case with sand and grains, and *L. doehleri* builds a case with the detrital plant fragments. In this current study, the cases are rectangular, cylindrical and made of rectangular pieces of leaf.

Malicky (2021) reported that *Lepidostoma* spp. in northern Thailand, including *L. moulmina* and *L. doligung*, have non-seasonal life cycle with the adults observed year-round. In this study, the adults of *L. abruptum* were collected both in the hot season (March–May 2019) and in the rainy season (September–October 2019) and larvae at every stage were found at each collecting time, year-round. We then report that the *L. abruptum* has a non-seasonal life cycle. The life cycle of *L. abruptum* has 5 instars, which is similar to *Lepidostoma* spp. in Japan, India, Greece, and Central Ethiopia. All of the *Lepidostoma* spp. have 5 instars. The first instar builds their case with sand, the second and third instars make their cases with sand and pieces of leaves, and the fourth and fifth instars have cases made of leaves (Ito 2011; Dinakaran et al. 2013; Karaouzas & Waringer 2016; and Terefe et al. 2018).

The *Lepidostoma* spp. in Thailand are inhabitants at the first and second order streams, with substrates dominated by bedrock, boulders, cobbles, pebbles, and sand, but they have not yet been found in big rivers (Laudee & Prommi 2011; Laudee 2015; and Malicky 2021). Besides, Dinakaran et al. (2013) found that the *L. nuburagangai* lived in slow-moving streams at pool and riffle areas, where the woody debris and leaf litter accumulate. Moreover, Terafe et al. (2018) reported that, in general, larvae of the genus *Lepidostoma* are shredders living in forested streams. Also, this current study found the habitat of *L. abruptum* in a pool at a small stream where the substrates are dominated by fine sand, fine gravel, dead plant materials and leaves.

Trichoptera is one of the largest groups of aquatic life exhibiting secondary and tertiary consumers in streams and rivers (McCafferty 1981; Holzenthal et al. 2007). Because of their high crude protein contents, aquatic insects have been used as human food in addition to being natural aquatic animal food (Williams & Williams 2017). Reinecke & Owen (1980) reported that Trichoptera have high nutritional values with 45% of protein, 8.8 % of fiber, and 33.8 % of ash by dry weight. In addition, Xiaoming et al. (2010) have reported on high protein in aquatic insects, with Ephemeroptera having 66.26%, Odonata 40–65%, Hemiptera 42–73%, and Coleoptera 23–66%. In this study *L. abruptum* had about 49.08% of protein. Therefore, the high nutrients could be developed for food and aquatic animal feed, to support sustainable developments in freshwater aquatic animal cultures.

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List of Publication and Proceeding

1. **Suwannarat, N**., Laudee, P., Malicky, H. (2022). Diversity of Caddisfly Species (Insecta: Trichoptera) at Lower Hill Evergreen Forest of Nakhon Si Thammarat Range in Southern Thailand. *Braueria*. 49 (accepted).

2. **Suwannarat, N**., Malicky, H., & Laudee, P. (2018). Two new species of Caddisflies (Trichoptera: Insecta) from Lower-Hill Evergreen Forests of Southern Thailand. *Zootaxa*, *4524*(4), 496–500.

3. **Suwannarat, N**., Malicky, H., Morse, J. C., & Laudee, P. (2019). Four new species of Rhyacophila Pictet, 1834 (Trichoptera: Rhyacophilidae) from Southeast Asia. *Zootaxa*, *4657*(2), 369–376.

4. **Suwannarat, N**., Malicky, H., & Laudee, P. (2020). Four new species of caddisflies (Trichoptera: Polycentropodidae, Psychomyiidae, Hydropsychidae, Odontoceridae) from Khao Nan and Tai Rom Yen National Parks, southern Thailand. *Zootaxa*, *4801*(3), 577–583.

5. Malicky, H., **Suwannarat N**., and Laudee P. (2018). Köcherfliegen (Trichoptera) aus dem Süden Thailand, mit der Beschreibung von vier neuen Arten. *Braueria*. Biologiezentrum Linz. Austria.

6. **Suwannarat, N**., Malicky, H. (2020). Six new species of Trichoptera at Thailand. *Braueria*. Biologiezentrum Linz. Austria.

7. Laudee, P., **Suwannarat, N**., (2021). Larval morphology, Life cycle and Nutritional values of *Lepidostoma abruptum* Banks, 1931 (Trichoptera, Lepidostomatidae) from Lower-Hill Evergreen Forests of Southern Thailand. *Zootaxa*.