รายงานวิจัยฉบับสมบูรณ์

โครงการ แมลงหางดีดถ้ำ (Hexapoda: Collembola) ของคาบสมุทรไทย

Cave-dwelling springtails (Hexapoda: Collembola) of Thai peninsula

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แห่งคาบสมุทรไทย คณะวิทยาศาสตร์
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ด้วยทำเลที่ตั้งอันเป็นศูนย์กลางของเอเชียตะวันออกเฉียงใต้และความหลากหลายทางชีวภาพ พื้นที่ของคาบสมุทรไทยจึงถือเป็นหนึ่งในพื้นที่ที่มีความหลากหลายทางชีวภาพมากที่สุดในโลก และยังเป็นพื้นที่ที่ประกอบไปเทือกเขาหินปูนและถ้ำมากมาย อย่างไรก็ตามถ้ำและเทือกเขาหินปูนของคาบสมุทรไทยอยู่ในสภาวะถูกคุกคามจากการรบกวนของกิจกรรมมนุษย์ ซึ่งเสมือนว่าจะไม่เป็นปัญหามากนักสำหรับนักอนุกรมวิธานแต่ถือว่าเป็นปัญหาที่กระทบต่อความหลากหลายทางชีวภาพอย่างมาก

แมลงหางดีดเป็นแมลงที่พบได้ทั่วไปและมีความหลากหลายในถ้ำ แต่อย่างไรก็ตามกลับเป็นกลุ่มแมลงที่มีข้อมูลน้อยมาก ซึ่งกระทบต่อการศึกษารวบรวมความหลากหลายทางชีวภาพของแมลงหางดีดในถ้ำ ดังนั้นวัตถุประสงค์ของการศึกษาในครั้งนี้ คือ 1) เพื่อที่จะสำรวจเก็บตัวอย่าง และจัดจำแนกแมลงหางดีดที่อยู่ในถ้ำของคาบสมุทรไทย 2) เพื่อศึกษาองค์ประกอบของชนิด อนุกรมวิธาน และรูปแบบการแพร่กระจายของแมลงหางดีดถ้ำ 3) เพื่อสร้างคู่มือจัดจำแนกแมลงหางดีดถ้ำของคาบสมุทรไทย 4) เพื่อเผยแพร่ความรู้เกี่ยวกับแมลงหางดีดถ้ำในคาบสมุทรไทยสู่สาธารณะรวมทั้งการเผยแพร่บทความทางวิชาการ และ 5) เพื่อให้ตระหนักถึงความสำคัญของระบบนิเวศถ้ำ อันนำไปสู่การจัดการและอนุรักษ์ที่ยั่งยืนต่อไป ซึ่งในการศึกษาครั้งนี้ เก็บตัวอย่างแมลงหางดีดจากถ้ำทั่วทั้งคาบสมุทรไทยทั้งหมดจำนวน 76 ถ้ำ จาก 65 เทือกเขาหินปูน ใน 11 จังหวัดภาคใต้ (จากทั้งหมด 14 จังหวัด)เก็บตัวอย่างโดยใช้พู่กันและเครื่องดูดแมลง (aspirator), กับดักหลุม และ Berlese extraction.

ผลการศึกษา พบแมลงหางดีดถ้ำในคาบสมุทรไทยทั้งหมด 24,855 ตัว ใน 4 อันดับ 9 วงศ์ 23 สกุล อย่างน้อย 90 ชนิด (MOTUs) และแมลงหางดีดถือเป็นกลุ่มสัตว์ขาข้อที่มีความหลากหลายและพบมากสุดในถ้ำของประเทศไทย ในแต่ละถ้ำ จะพบแมลงหางดีดอย่างน้อยหนึ่งถึงสูงสุดสิบชนิด ซึ่งการศึกษาครั้งนี้พบว่าน้อยมาก (18%) ที่ถ้ำจะไม่มีแมลงหางดีดอาศัยอยู่ โดยชนิดที่ได้รับการตรวจสอบส่วนใหญ่มีความใกล้ชิดกับสายพันธ์ที่อยู่นอกถ้ำ ซึ่งในแต่ละเทือกเขา ชนิดที่อยู่ในสกุลเดียวกันจะมีสัณฐานวิทยาที่แตกต่างกันเล็กน้อยกับถ้ำในเทือกเขาใกล้เคียงกัน ซึ่งมากกว่า 30 ชนิดเป็นแมลงหางดีดชนิดใหม่ของโลกซึ่งอยู่ในขั้นตอนการตรวจสอบและเผยแพร่ผลงานทางวิชาการต่อไป

หลักฐานจากอนูชีววิทยาและสัณฐานวิทยาพบว่า ในแต่ละถ้ำจะมีแมลงหางดีดเฉพาะถ้ำนั้น ๆ โดยเฉพาะอย่างยิ่ง แมลงหางดีดในวงศ์ Paronellidae, Entomobryidaeและ Cyphoderidae แมลงหางดีดในสกุล*Cyphoderopsis*, *Lepidonella*และ*Coecobrya* ส่วนใหญ่มีความจำเพาะสูงกับถ้ำนั้นๆ และยังเป็นสิ่งมีชีวิตชนิดใหม่ของโลก แม้ว่าพื้นที่ถ้ำจะอยู่ไม่ไกลกันมากก็ตาม การปรากฏลักษณะของสิ่งมีชิวิตถ้ำอย่างแท้จริง (troglomorphic species) ในป่าเขตร้อน โดยเฉพาะอย่างยิ่งแมลงหางดีดในสกุล *Coecobrya*และ*Lepidonella* สร้างความประหลาดใจ และเป็นหลักฐานสำคัญในการสนับสนุนความคิดที่ว่า การแสดงออกของสิ่งมีชิวิตถ้ำที่แท้จริงอาจจะเกิดในถ้ำของป่าฝนเขตร้อน

การแสดงความจำเพาะสูงของแมลงหางดีดกับถ้ำในคาบสมุทรไทย ทำให้ตระหนักถึงความสำคัญของการอนุรักษ์พื้นที่ถ้ำ และควรมีการจัดการอย่างเร่งด่วน ทั้งนี้เนื่องจากถ้ำส่วนใหญ่ในคาบสมุทรไทยอยู่ในสภาวะสุ่มเสี่ยงต่อการถูกคุกคามจากกิจกรรมของมนุษย์และการเปลี่ยนแปลงของพื้นที่อาศัย ขณะที่มาตรการกำหนดเกี่ยวกับการอนุรักษ์แมลงหางดีดในถ้ำยังไม่ได้มีการจัดสร้าง

คำหลัก : guano, limestone, extinction

Abstract

Project Code :TRG5880189

Project Title : Cave-dwelling springtails (Hexapoda: Collembola) of Thai peninsula

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Project Period :2 years

Located in the heart of the ASEAN region and the biodiversity hub, the area along the Thai peninsular is one of the world's richest biodiversity and hot spot on earth. It also has extensive cave-containing karsts throughout the region. However, most of caves and karstic hills in this area are threatened by various human activities, which may in a way result in less problem for the taxonomists, but is ethically increasingly worrying.

The Collembola are among the most common and diverse group in cave, however, they are also among the least known organism in this region. This handicap significantly affected the inventory of cave Collembola fauna. Filling taxonomic gaps is therefore the first objective of this research. Hence, The objectives of the research are 1) to survey, collect, classify and identity the cave dwelling Collembola in Thai peninsula 2) to examine the species composition, taxonomic study and distribution patterns of cave dwelling Collembola in this region, 3) to construct a key for cave dwelling Collembola, 4) to disseminate knowledge to community concerning the species composition, taxonomic study and distribution patterns of cave dwelling Collembola in Thai peninsula as well as publications and 5) to raise environmental awareness and considerable ecological value to cave conservation strategies and sustainable use of biological resources. In this research, 76 caves in 65 limestone outcrops, located in 11 provinces (from 14 provinces) were sampled throughout the region. Methods used to capture Collembola include visual searching using brush and aspirator, pitfall trap, and modified Berlese extraction.

The result showed that a total of 24,855 individuals belonging to 4 orders, 9 families, 24 genera and at least 90 species or MOTUs were recognized and they are among the most common and diverse group in caves, and by far the most diverse of terrestrial Hexapod of Thai caves.In each cave, one to maximum ten species was reported, with small number of caves (18%) without any Collembola. Most species belong to lineages present in the soil. In each karstic unit, species of a same genus or lineage is morphologically slightly different from that of the nearest karstic hill. More than 30 species are being described as new to science.

Molecular and morphological evidences reveal that each karstic unit has its own, well differentiated species of Collembola in particular in the family Paronellidae, Entomobryidae and Cyphoderidae. Most collected species of *Cyphoderopsis*, *Lepidonella*and *Coecobrya*were in particular unknown to science and are endemic to karst units of limited extent. All of them appear to be different species and narrow cave-restricted endemics, in spite of their close locations. The presence of several highly troglomorphic species in *Coecobrya* and *Lepidonella* come like a surprise for a tropical karst,and a further support to the idea that troglomorphy may develop in tropical subterranean habitats

This very high level of endemicity of Thai caves emphasize a need higher than expected for conservation and management, because of cave vulnerability in the face of growing anthropic disturbance and habitat degradation in the area. However, no critical conservation issue has been detected so far regarding the genus and species given here.

Keywords: guano, limestone, extinction, troglomorphy

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Any errors contained herein are mine.

Sopark Jantarit

CONTENTS

CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1) Introduction to the research problem and its significance

It is evident beyond reasonable doubt that global biodiversity is being lost at an unprecedented rate as a result of certain human activities. Hence, the effective conservation and management of biodiversity must be put into action, however, these schemes depend in large part on our understanding of taxonomy. However, the lack of taxonomic information and expertise available in many parts of the world and every groups of organism in particular insect are widely acknowledged. It is certain that there are more unknown species than known ones on earth and many is expected to be discovered. The Global Taxonomic Initiative (GTI) is then developed to reduce the taxonomic impediment and thereby to improve decision-making in conservation, sustainable use of biological resources under the supported from the governments through the Convention on Biological Diversity (CBD) (The Convention on Biological Diversity, 2014). Thailand is one of the hotspot areas and most ecosystems have been threatened greatly. In consequence, the National Research Council of Thailand (NRCT) has enjoyed this policy in formulating the national research policy and strategy (2012-2016), highlighting the strategy 3, in order for conservation, promotion and development of natural resources and environmental capital. It aims to promote the body of knowledge and database for efficient and systemic management and development of natural resource and environmental capital through local and community participation (National Research Council of Thailand, 2014). Realizing the need of taxonomy, improving the conservation strategy and the sustainable use of biological resources as well as to support the CBD and NRCT, this proposal has been established using cave-dwelling springtails as an agent.

Thai peninsula is fascinating region in South East Asia to examine the biodiversity and distribution pattern of organisms according to the fact that it is a biogeographic boundary between the two major biogeographical sub-regions, the Indochinese and the Sundaic sub-regions (Southern of Kra Isthmus) (Woodruff, 2009, 2010). This large area is also affected by both Andaman Sea (Indian Ocean) and Gulf of Thailand (Pacific Ocean) monsoons throughout the region. In consequence, there is diverse topography, Thai peninsula is then one of the hot-spot areas and has the most remarkable biodiversity and abundance of terrestrial habitats for plants, animals and micro-organisms in the world (Jacobs, 1988; Whitmore, 1984). Moreover, there are three major mountain ranges lying along the peninsula; 1) Phuket Mountain range; 2) Nakhon Si Thammarat Mountain range and 3) Sankarakhiri or Titiwangsa Mountain range which play a crucial role in supporting the diversity of organism both in terms of species and biomass. Thai peninsula has also extensive cave-containing karst areas in carbonate rock mostly all region. Hence, cave is commonly found in karst area like a limestone mountain both from main mountain ranges and isolated mountains. Unfortunately, diversity in Thai-cave is poorly known and seldom scientific observed. Therefore, cave is an interesting habitat which challenges a detailed investigation.

Light is the origin of all life, and primary production is the source of biodiversity, however, life also exists in darkness especially cave. Cave has long been of human interest since prehistoric times for 22,000 years before the present (in Upper Paleolithic) and has been considered to be a unique ecosystem (Romero, 2009). Most sources identify more than 30 orders and nearly 700 families of hexapods found in caves (Romero, 2009). Hexapods represent more than half of all the described biodiversity of living organism on earth and they are also well-represented in cave ecosystem. One of the most important hexapods represented in cave environment is the Collembola. The Collembola, also known as springtails, are small wingless hexapods measuring 0.2-10.0 mm in length, of elongated to globular shape. Collembola are the oldest group of hexapods, and are represented in the fossil record approximately 400 million years ago. About 8,000 species have been described worldwide. They are ubiquitous and can be found from seashore to the highest altitudes, from deep caves to the forest canopy, and can live both wet and dry ecosystems from arctic and alpine tundra to sub-deserts and tropical rainforest (Hopkin, 1997). Formerly, they were typically classified as an order of insect. Recent morphological and molecular evidence, however, has changed interpretations of hexapod phylogeny and evolution, the springtails are then no longer considered insects and are classified as being within the class Collembola (Nardi, *et al.* 2003; Deharveng, 2004; Regier *et al.,* 2010; Bellinger *et al*., 2017). The functional role that Collembola play in ecosystems is well-documented in particular the temperate region. They are predominantly associated with the soil fauna, particularly abundant in the litter, humus, deep soil layers and even in cave environment. They are primarily consumer group in decomposer systems (detritivores and microbivores) and have significant influences on nutrient cycling, soil fertility, contributing to the formation of soil microstructure and, controlling the population dynamics of soil microorganisms (Hopkin, 1997; Rusek, 1998; Scheu and Simmerling, 2004). Collembola occupy different biotopes in caves for example material detritus, soil and guano. They have a vital role in decomposition and energy flow in subterranean trophic webs and serving as prey of several groups of insect, spiders and mites (Castaño-Meneses and Palacios-Vargas, 2011). Among a total of 769 genera worldwide, only 72 genera are cave species. More than 1,500 species have been reported from caves worldwide and 278 of them are considered troglomorphic species (Thibaud and Deharveng, 1994, Castaño-Meneses and Palacios-Vargas, 2011). Cave springtails then are also a very useful model for taxonomic, biogeographic and evolutionary studies (Christiansen, 1961, 1965; Christiansen and Culver, 1987, Culver and Pipan, 2009; Gunn, 2004; Romero, 2009).

As aforementioned above, cave has been recognized as a habitat reservoir for genetically diverse organism. However, most of Thai cave is being destroyed significantly both direct and indirect manners. Human activities have brought death and destruction to cave ecosystems. For example, limestone mountain is threatening as demand for cement growth, an increasing of temples and cave occupation for religion ritual, increasing frequent human visitations as growing of tourism industry, the building of concrete walkways and introduction of light energy inside the cave, bat guano mining, the utilization of cave by indigenous people and so forth (Day and Urich, 2000; Clements *et al*., 2006; Vermeulen and Whitten, 1999; personal observation). Cave is considered to be an island of biodiversity and is recognized as a biodiversity hotspot of high biological importance (Deharveng & Bedos, 2000; 2012 Clements *et al*., 2006; Latine *et al*., 2011, Romero, 2009). Then those human activities are somehow causing organisms living inside cave to become extinct. It is also evident by that fact that the species richness of Thai cave faunal community is also poorly known. Most studies in Thailand have focused on low-energy cave habitats, and large regions of the country have seldom been sampled. Consequently, the species composition, taxonomy, evolution, and biogeography of Thai cave Collembola are ambiguous. Although Collembola are among the most abundance in cave, unfortunately, relatively little research on Collembola have been carried out in Thailand. Hence, the species richness, taxonomic and biogeographic study is poorly known. Collembola have been paid very less attention and the knowledge domain is fragmented. Most intensive studies have been conducted over the past two decades (Bedos and Deharveng, 1990, 1991, 1994; Deharveng, 1987a, 1987b, 1988a, 1988b, 1989, 1990, 1991; Deharveng and Bedos, 1991, 1992, 1993; Deharveng and Brougeois, 1991; Deharveng and Gers, 1993; Deharveng *et al*., 1989; Kim *et al*., 1999a, 1999b; Mari-Mutt, 1988; Nayrolles, 1990, Yosii, 1961) and these existing publications were made primarily on groups from the northern part of Thailand. A few studies were focused on cave habitats and Jantarit *et al*. (2013, 2014) have described 5 new species of cave springtails in different localities in Southern Thailand. It is highly probable to state that each karstic unit has its own species of Collembola and they are considered to be endemic species as gene flow cannot easily move the limits of the limestone (Deharveng, 1987a; Jantarit *et al*. 2013). Many more species are expected to be discovered as new to science. Therefore the gap of knowledge opens up an avenue for the study of cave dwelling springtails of Thai peninsula.

Taking everything into consideration, this research establishes to give the answers to the problems described above. In particular it begins to redress the lack of information on the cave dwelling springtails of Thai peninsula. An understanding of the species composition, taxonomic study and distribution patterns of cave dwelling Collembola in Thai peninsula not only address the body of knowledge and important database but also has implications of environmental awareness and considerable ecological value to cave managers and conservation strategies with respect to local and regional diversity.

2) Research question

1) What is the species composition and distribution pattern of cave dwelling Collembola in Thai peninsula?

3). Objectives of the research

1) To survey, collect, classify and identity the cave dwelling Collembola in Thai peninsula

2) To examine the species composition, taxonomic study and distribution patterns of cave dwelling Collembola in Thai peninsula.

3) To construct a key for cave dwelling Collembola of Thai peninsula.

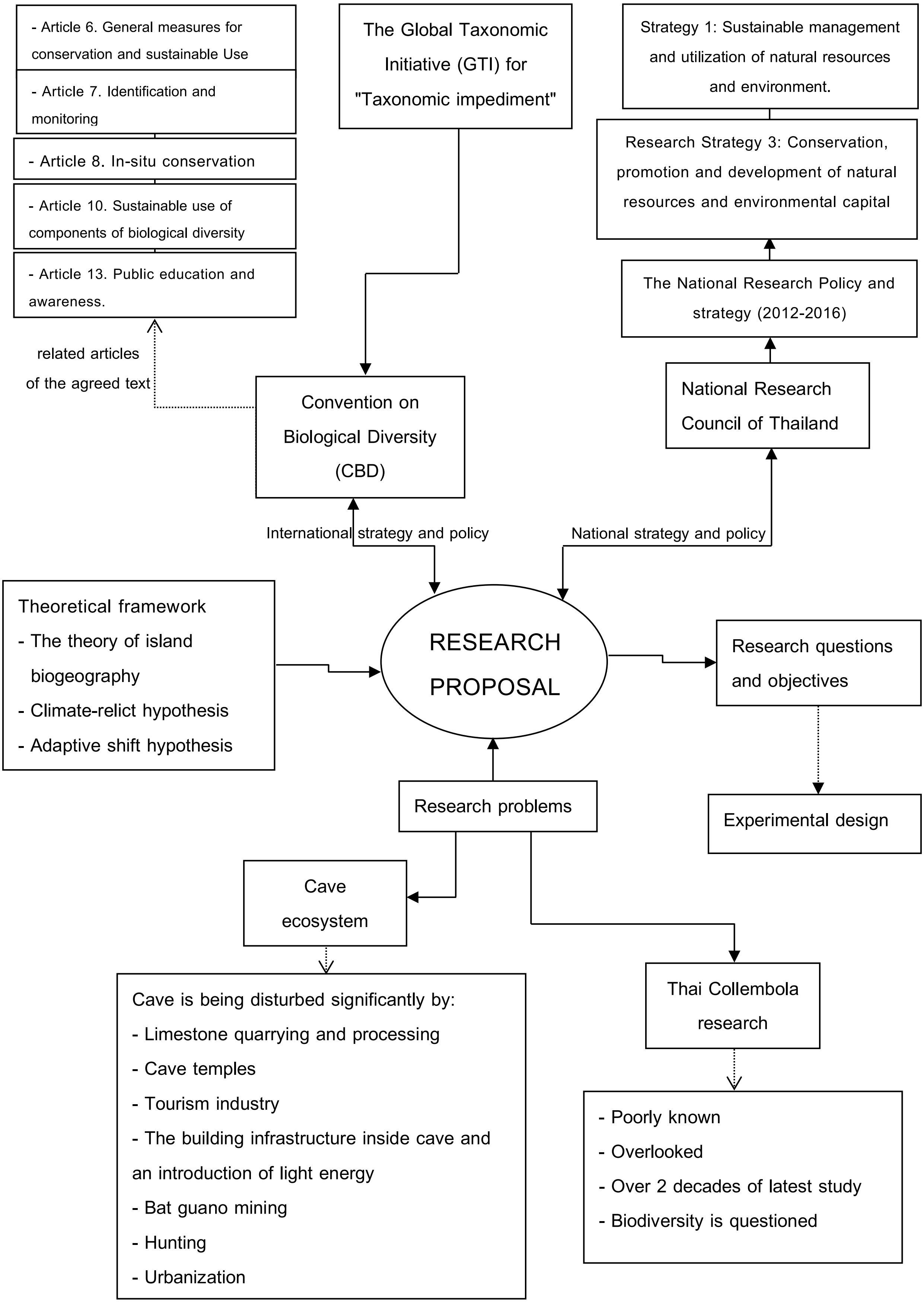
4) To disseminate knowledge to community concerning the species composition, taxonomic study and distribution patterns of cave dwelling Collembola in Thai peninsula as well as publications.

5) To raise environmental awareness and considerable ecological value to cave conservation strategies and sustainable use of biological resources, as well as to support the Convention on Biological Diversity (CBD) and the National Research Council of Thailand (NRCT).

CHAPTER 2

METHODOLOGY

1) Conceptual framewor



2) **Study Sites**

This study is focused on cave dwelling springtails (Collembola) of Thai peninsula (it starts downward the Isthmus of Kra in Chumphon province). Thailand has extensive cave-containing karst areas in carbonate rock mostly all country. As a consequence, the study sites of this research were selected based on the location of main limestone outcrops according to the mineral resource map from the Economic Geology Division, Department of Mineral Resources, Ministry of Natural Resources and Environment (http://www.dmr.go.th/download/web map/Ls.pdf) in figure.

According to the limestone distribution map, they are 11 provinces where limestone is distributed. So, the study sites were located in Chumphon, Ranong, Surat Thaini, Nakhon Si Thammarat, Phang Nga, Krabi, Trang, Phatthalung, Satun, Songkhla and Yala province (figure 2). In contrast, Phuket, Pattani and Narathiwat province were ignored to capture the specimen as there do not have limestone available in this area, implying that there is no cave in these localities (figure 2).

3) Sampling locations

Caves were arbitrary surveyed to collect the Collembola based on the mineral resource map described above (figure 1 and 2). The most favorable characters of sampling cave were large enough for human to admit. Three zones of cave must be presented such as the entrance zone, the twilight zone and the dark zone in order to appreciate the distribution pattern. In particular the dark zone, where the troglobite species live, was subject to be found as it contains various bizarre morphological characters (troglomorphy) of caved welling organisms. Cave without a true dark zone were refused to study. Cave with small streams were also carried out. If there is a large stream in the cave (water cave), the lateral passages that are not submerged during flooding were selected to capture the Collembola individuals. Caves with a large stream inside and without lateral passages for organism to live/or can fully deluge in wet season were denied to conduct the experiment to minimize any contamination (as flooding will get rid of all organisms and at the same time will take small arthropods outside the cave into the cave). Natural cave were centered to study, however, caves under frequent human activities (limestone mining, bat guano mining, tourism, cave temples, etc.) and destruction were also conducted the research. Caves in National Parks were ignored to study in order to avoid any bureaucratic procedure. A total of 76 caves in 65 limestone outcrops, located in 11 provinces (from 14 provinces in Thai peninsula) were sampled throughout the region, as presented in Fig. 2. Details of sampled caves were recorded in database (see appendix A).

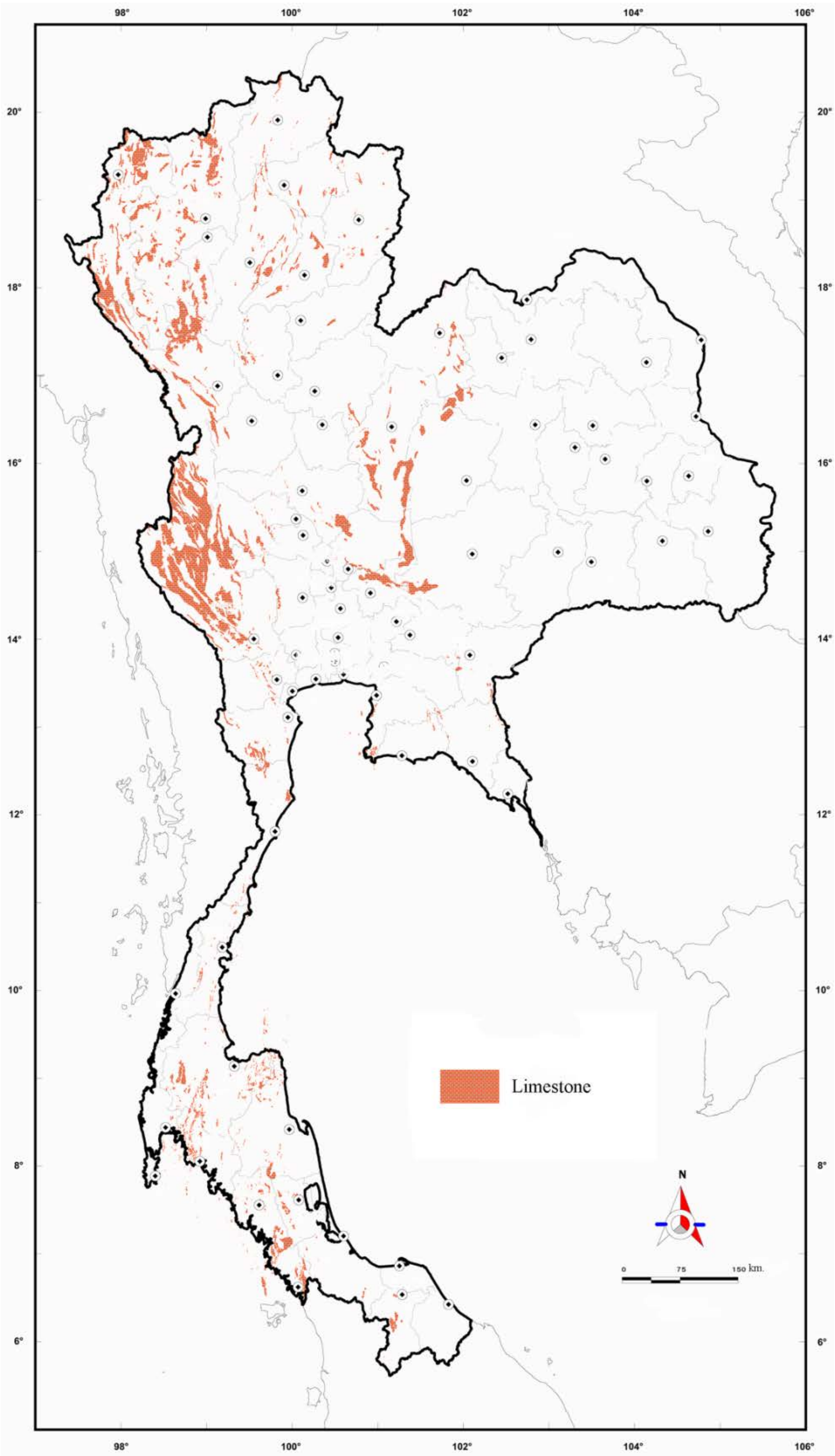


Figure 1: Mineral map of distributed limestone (orange color) in Thailand (scale 1:250,000) (Source: modified from the Economic Geology Division, Department of Mineral Resources, Ministry of Natural Resources and Environment)

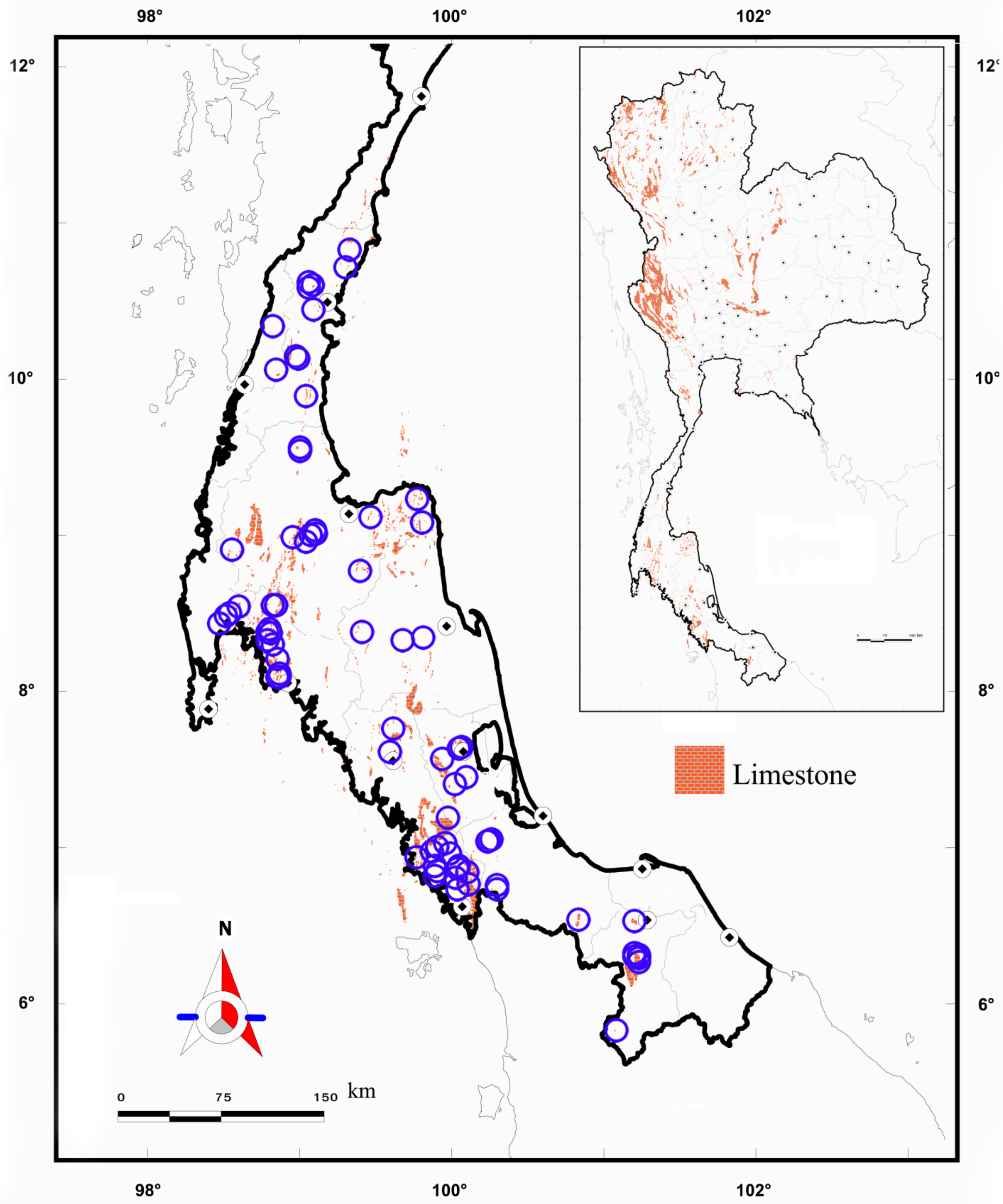


Figure 2: An enlargement of distributed limestone (orange color) in Southern Thailand (scale 1:250,000). Blue circles indicate 76 sampled caves in 65 limestone outcrops, located in 11 provinces (Chumphon, Surat Thaini, Nakhon Si Thammarat, Phang Nga, Krabi, Trang, Phatthalung, Satun, Songkhla and Yala provinces).

4) Sampling procedure

Detailed caves were recorded, they are GPS co-ordinate, location, character of habitat, utilization of cave (for instance, natural cave, tourism cave, temple cave, guano mining cave). Cave photographs were taken. In this study, the simple sampling design combining standardized and *ad hoc* sampling were performed. Ecological standardized sampling consisted of ten sample points in each cave were applied. At each point, a quadrat sampling of 1×1 meter was used to sample guano and soil surface. However, the distribution of cave animal is very uneven so the standardized sampling is often difficult to explain or compare between caves. Then, intensive non-standardized methods were also carried out in order to create an inventory of Collembola living in cave, and to characterize their community structure in connection with life in this very unique habitat. They were three effective sampling methods as follows:

4.1 Berlese funnel extractions:

A modified Berlese funnel extractions were applied to collect the surface-active springtails from guano, material detritus, top soil and leaf litter from the standardized sampling quadrat. Guano and surface-active Collembola assemblage were collected to zip plastic bag (25 cm × 38 cm). All materials in zip plastic bags were placed in the modified Berlese funnel extractions (plastic funnel) with a sieve of 2 mm on the screen. This method was used to extract Collembola from material particles with a collecting vessel containing 95% ethanol below (fig. 3). This method was checked every two days and was carried out for a week or till it reached a critical point (a time where a large number of Collembola immediately fell down to the collecting vessel at the same time). All specimens from Berlese funnels were kept in 95% ethanol until the material were sorted.

Figure 3. A modified Berlese funnel extractions in the laboratory.

4.2 Pitfall traps:

Pitfall traps were used to collect surface-active Collembola buried in the ground with its rim at surface level. A total of 10-15 pitfall traps (the dimension is 10 cm x 10 cm x 10 cm) containing 95% ethanol were applied to capture the individual of Collembola. The traps were placed arbitrary and left for a few days. The opening will be covered by the roof (white plastic dish) in order to protect the trap against bat drops, water drops, or any unexpected incident. Importantly, white plastic dish was noticeable to monitor when the traps were placed in the darkness (fig.4). All specimens in the pitfall traps were fixed in 95% ethanol until sourced in laboratory.


Figure 4. Pitfall traps with the roof in the field.

4.3 Visual searching:

The individuals of Collembola were searched carefully on any kind of organic matters for example, leaf litter, rotten wood, bat drops (guano), on clay, and the surface of pool of standing water (if there is water). Rock walls, stalagmites and other surface of cave habitat were also searched by vision monitoring using a brush and an aspirator (fig. 5). This procedure was carried out for 2-3 hours each cave. All specimens were kept in 95% ethanol.


Figure 5. Author and visual searching by using aspirator in the field.

5) Duration of fieldwork

Individual of cave Collembola were collected between June 2015 and April 2016 throughout Thai peninsula. Most of each cave was extensive sampled one time, however, some caves for example in Satun province was sampled more often as it contained very interesting fauna.

6) Specimen preparation

Specimens were counted, sourced and mounted on microscope slides in Marc Andre II medium after clearing in lactic acid. The method for slide preparation is summarized here.

1) Target specimens were chosen and placed in 90% lactic acid, then specimen was heated for 1-2 minute(s) at 200-220 ^{0}C, or until the specimen became transparent (it depended on how long specimen have been preserved, 1-2 minute(s) worked well for fresh specimen, and it took longer for the old specimen).

2) Specimen was immediately transferred into 10% Potassium Hydroxide (KOH) solution for 2-3 minutes in order to cleanse the specimen.

3) The position of specimen was arranged in convenience order (dorsal side, ventral side, lateral side) using permanent slide. In order to make some specific target organ(s) of animal for instance antennal segment, head, mouthparts, leg, furca, ventral tube and so on, these kinds of organs were dissected carefully under the microscopy before arranging the position.

4) A drop of Marc Andre II medium was applied to drown the specimen and a cover slide was used to cover up, then it was heated for a short time or until the bubbles disappear (in case of having bubble air), and dried in the room temperature.

5) The cover slide and permanent slide was sealed by Nitrocellulose or Gisin liquid in order to make it long-term preservation and any contamination.

7) Figure examination

Image of specimens was taken by Canon EOS 6D with Canon EF 100mm f/2.8 Macro lens enhancing by Helicon Remote software. All photos were combined by Helicon Focus 6. Drawings were made by a drawing tube and figures were improved with Photoshop CS5/PC (Adobe Inc.). For the taxonomic description, almost every parts of the Collembola in the slide were examined, they were antennal chaetae; an arrangement of chaetae on all antenna segments both dorsal and ventral side; outer maxillary lobe; maxilla head and ventral complex of the labrium; mandible; labial palp; labrum; chaetotaxy of labial basis; frontal chaetae and pseudopore of head; dorsal head chaetotaxy; morphological chaetae of tergites; dorsal tergites chaetotaxy; trichobothrial complex of Abd.II, III, IV; chaetae of furca; morphological scale of furca; trochanteral organ; claw and distal part of tibiotarsus; tenaculum; anterior face of the ventral tube; posterior face of the ventral tube; furca; mucro and genital plate both male and female. The morphological analyses used a light microscope and a scanning electron microscope (SEM).

8) Morphology identification

Both stereo and compound light microscopy methods were used for external morphological identification. The Janssen's key on the Collembola’s website (http://www.collembola.org/) was initially an avenue for classifying and identifying the specimen into family and genus level. For species diagnosis, various sources of publication were gathered to identify the specimen. Most identified species were confirmed by Collembola authority Dr. Louis Deharveng from the Muséum National d'Histoire Naturelle (MNHN), France and the genus *Coecobrya* were confirmed by Dr. Feng Zhang, Department of Entomology, College of Plant Protection, Nanjing Agricultural University, China as well as the describing of the three new species (see detail in Appendix E “three new species of *Coecobrya* (Collembola: Entomobryidae) from caves in the Thai Peninsula”).

9) Type/Material deposition

All of materials in this research are deposited at the collection of the Princess Maha Chakri Sirindhorn Natural History Museum, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, Thailand. Type specimens of the described species for example *Coecobrya polychaeta, C. chumphonensis* and *C. cavicta* (Holotype including paratypes) are also deposited at the Princess Maha Chakri Sirindhorn Natural History Museum, PSU and some paratypes (12 paratypes both slide and wet specimens) are deposited at the Department of Entomology, College of Plant Protection, Nanjing Agricultural University, China.

10) Genetic analyzes

The population of *Coecobrya*, *Cyphoderopsis* and *Cyphoderus* were selected to examine the molecular approach according to their extremely abundance in cave of Thai peninsula both in terms of number of species and individuals. DNA barcoding using Cytochrome Oxidase Subunit I (*COI*) was used to identify unknown species or assess whether species should be combined or separated when the taxa lack conspicuous morphological features or are difficult to distinguish. In order to keep a link between morphological specimen and molecular data for soft small body invertebrates, a rapid non-destructive DNA extraction method (Porco *et al*., 2010) were performed which allowed the specimen to be identified using DNA analysis without any obvious alterations to the morphological characters. The voucher specimens (whole to part of cuticle) of the Collembola were retrieved after DNA extraction for the preparation of slide mounting. All protocols (DNA extraction, amplification and sequencing) were performed at the Canadian Center for DNA Barcoding, University of Guelph under BOLDsystem campaign. BOLDsystem is the main engine for the generation and application of DAN barcode data of various groups of organism (see detail http://www.boldsystems.org/). Collembola play a part in this database and BOLDsystem, at the moment, is the most reliable sources for Collembola barcode data (see detail http://www.barcodinglife.org/index.php/Taxbrowser_Taxonpage?taxid=372).The author is involved in Collembola DNA barcoding project with Dr. Louis Dehaveng (MNHN, Paris) and Dr. David Porco (University of Guelph, Canada) under the project COLSO (Collembola Sopark) (http://www.boldsystems.org/index.php/MAS_Management_OpenProject?code=COLSO). All sequences are published in Barcode of Life Database (Ratnasingham and Hebert, 2007; BOLD, www.boldsystem.org).

Sequences were aligned by eye using BIOEDIT version 7.0.5.3 (Hall, 1999); final sequences were aligned using ClustalX version 2.0 (Larkin *et al*., 2007). A total of 159 nucleotide sequences of *Coecobrya* (658 bp of 69 *COI* sequences), *Cyphoderopsis* (586 bp of 50 *COI* sequences) and *Cyphoderus* (587 bp of 40 *COI* sequences) were analyzed. The tree was conducted by MEGA6 using a Neighbor-Joining (Saitou and Nei, 1987) algorithm and distances corrected with the Kimura-2 parameter (Kimura, 1980). The robustness of nodes was evaluated through bootstrap re-analysis of 1000 pseudoreplicates.

CHAPTER 3
RESULTS AND DISCUSSION

1. Cave Collembola species composition

In this study, 76 caves were sampled to collect cave dwelling Collembola throughout Thai peninsula. A total of 24,855 individuals belonging to 4 orders, 9 families, 24 genera and at least 90 species or MOTUs were recognized. A summary of cave Collembola fauna as well as species inventory are summarized in table 1 and table 2. Order Entomobryomorpha were the largest order found in Thai peninsula caves which included 5 families, 17 genera 71 species and 21,143 individuals. It followed by order Poduromorpha which contained 2 families, 4 genera, 6 species and 3,450 individuals, order Neelipleona comprised 1 families, 2 genera, 9 species and 123 individuals and order Symphypleona with a single family and genus, 4 species and 139 individuals. According to the Bellinger *et al*., (1996-2017) website "checklist of the Collembola of the world", ca 8,714 species of Collembola have been described globally, the majority is the order Entomobryomorpha (4,070 species) followed by order Poduromorpha (3,355 species), order Symphypleona (1,240 species) and order Neelipleona (49 species) respectively. So, it is not surprise if the population of Entomobryomorpha is the dominant group in cave of South East Asia (SEA) and Thai peninsula.

With regard to the nine identified families, Paronellidae is the largest group in having 4 genera, 28 species and 4,967 individuals followed by Entomobryidae with 8 genera, 27 species and 9,227 individuals, Cyphoderidae with 1 genus, 10 species and 6,479 individuals. Family Hypogastruridae and Isotomidae had the same number of 3 genera and 5 species with 3,446 and 402 individuals respectively. The rests contained one or two genera with a few species (Table 1 and 2). In fact, the family Paronellidae, Entomobryidae, Cyphoderidae, Hypogastruridae and Isotomidae are very common in cave in SEA and Thailand as reported in Deharveng (1987), Deharveng and Bedos (2000), Jantarit et al. (2016).

With reference to species level, the *Cyphoderopsis* was very common in caves of Thai peninsula which can be divided at least 17 species by DNA barcoding (*COI*), followed by *Coecobrya* with 12 species, *Cyphoderus* and *Lepidonella* with 10 and 6 species respectively. The rest had a few species as presented in table 1 and 2. This is the first time to report the presence of high number of species of these genera in tropics illustrating that cave is a favorable habitat for these Collembola and they have an ability to cope with the subterranean environment. The genus *Lepidonella* has never been reported from caves in Thailand before and preliminary investigations indicate that they are closely related to *Lepidonella lecongkieti* from southern Vietnam caves (Deharveng and Bedos, 1995)

In each cave, one to maximum ten species was observed. For example Tham Yee Lun in Kong Ra district, Phatthalung province and Tham Wang Kram in La Ngu district, Satun province support a very high number of species of Collembola maximum to ten different taxa even though those caves are not large much comparing to the largest cave like Tham Phu Pha Phet in Satun Province. However, the factors that drive species richness in cave is not clearly explained in tropic but from the observation these caves are also partly disturbed by indigenous people but many parts are in good condition with wet and humid environment and guano patches which is a favorable habitat for Collembola to live. Interestingly, most caves in Satun province have rather high number of Collembola species. This is because this area was collected many times owing to the fact that 12 caves is under the thesis study of master student. In contrast, among the 76 sampled caves, 14 caves (18%) are without any Collembola (Table 2). There is no strong evidence to support the absence of Collembola in some caves, even their habitat meets the requirement of Collembola fauna (for instance wet and humid with some guano patch and debris). Overall, the average of Collembola is at least 3 species per cave.

Regarding the abundance in terms of number of individual, the result showed that the genus *Cyphoderus* was a common cave dwelling Collembola with a largest population of 6,479 individuals followed by the genus *Lepidocyrtus* with a total of 5,031 individuals, genus *Cyphoderopsis* with a total of 4,435 individuals, the genus *Xenylla* with a total of 3,182 individuals and the genus *Coecobrya* with a total of 2,592 individuals were captured. The rest had a population in total less than a thousand while the rarest genus of cave Collembola in Thai peninsula was the genus *Onychiurus* (4 individuals) and the genus *Salina* (4 individuals). In fact, the genera *Cyphoderus, Cyphoderopsis*, *Xenylla* and *Coecobrya* are very common in cave throughout South East Asia with a large population (Deharveng 1987, Deharveng and Bedos, 2000, Jantarit *et al*., 2016). The knowledge of life cycle behavioural and evolutionary strategy of these genera remains poorly-known and it is not easy to draw a conclusion why they are so diverse in terms of number of individual. From the observation, they are associated with bat guano which is a main food source in cave. However, some species of *Cyphoderopsis* and *Coecobrya* prefer the oligotrophic environment with a small population and they exhibit strong troglomorphic characters by having elongate appendages, larger body size and reduced eyes and pigmentation. The genus *Onychiurus* and *Salina* was reported for the first time in Thai cave and were found near guano patches, it is likely to consider that both genera may be brought or accidentally enter to the cave as they are found only two caves.

According to Jantarit *et al* (2016), the overall recorded cave Collembola of Thailand is only 29 species belonging to the 11 genera: *Acherontiella* (2 species), *Arrhopalites* (2 species), *Coecobrya* (2 species), *Cyphoderopsis* (3 species), *Cyphoderus* (2 species), *Folsomides* (1 species), *Folsomina* (1 species), *Paralobella* (1 species), *Pseudosinella* (1 species), *Salina* (1 species), *Troglopedetes* (12 species) and *Willemia* (1 species). In this study, 24 genera were identified, *Acherontiella, Acrocyrtus, Ascocyrtus, Alloscopus, Coecobrya, Cyphoderopsis, Cyphoderus, Folsomides, Folsomina, Isotomiella, Lepidocyrtus, Lepidonella, Neelus,Oncopodura, Onychiurus*, *Pararrhopalites, Pseudosinella, Rambutsinella, Salina, Seira, Spinaethorax, Troglopedetes, Willemia* and *Xenyllan* which is higher more than a half of the overall richness of the country. This is because the extensive study of this research for 76 caves throughout the Thai peninsular and the combination of sampling methods used in this study (Berless extraction, pitfall trap, and visual searching). The results obviously reflect the importance of Collembola in subterranean ecosystems as the dominant invertebrates in terms of abundance and diversity (after mites) in guano micro-habitats (Deharveng *et al*. 2011). Thailand has extensive cave-containing karst areas across almost the whole country. About 3,850 caves have been reported throughout the country so far (Ellis 2016). Among these, very few have been zoologically sampled. Thai karst is also extremely fragmented (fig. 1 and 2), and surveys have been limited to few karstic units at the scale of the country. It is truly to state that the higher number of sampled caves, the higher number of species alpha diversity. Moreover, the genus *Spinaethorax* is a new record in Thailand and Afro-Eurasia region. In fact, this genus has just erected by Papác and Palacios-Vargas in 2016 and only known from cave in Mexico.

Table 1. Summary of cave Collembola fauna in Thai peninsula.

Order	Family	Genus	No. of species (taxa)	No. of individual
Poduromorpha	Hypogastruridae	*Acherontiella*	3	229
		Willemia	1	35
		Xenylla	1	3,182
	Onychiuridae	*Onychiurus*?	1	4
Entomobryomorpha	Isotomidae	*Folsomides*	1	6
		Folsomina	1	199
		Isotomiella	3	197
	Entomobryidae	*Acrocyrtus*	4	800
		Ascocyrtus	2	279
		Alloscopus	3	395
		Coecobrya	13*	2,592
		Lepidocyrtus	2	5,031
		Pseudosinella	1	56
		Rambutsinella	1	60
		Seira	1	14
	Paronellidae	*Cyphoderopsis*	18*	4,435
		Lepidonella	7*	483
		Salina	1	4
		Troglopedetes	2	45
	Cyphoderidae	*Cyphoderus*	7*	6,479
	Oncopoduridae	*Oncopodura*	4	68
Symphypleona	Sminthuridae	*Pararrhopalites*	4	139
Neelipleona	Neelidae	*Spinaethorax*	5	91
		Neelus	4	32
Total	9	24	90	24,855

* Number of species may increase based on DNA barcoding (*COI*).

? Uncertain identification genus

Table 2. Species list of cave Collembola in Thai Peninsula

Order	Family	Genus	No.	Species	Distribution
Poduromorpha Börner, 1913					
	Hypogastruridae Börner, 1906				
		Acherontiella Absolon, 1913			
			1.	*Acherontiella* sp.1	SNI01, PNA04, NRT01
			2.	*Acherontiella* sp.2	NRT02, NRT03
			3.	*Acherontiella* sp.3	PLG01, PLG02
		Willemia Börner, 1901			
			4.	*Willemia nadchatrami* Yoshii, 1959	CPN07, SNI01, SNI06, PLG02, SKA02
		Xenylla Tullberg, 1869			
			5.	*Xenylla yucatana* Mills, 1938	RNG02, PLG01, PLG02, PLG04, SKA01, STN01, STN02, STN03, STN05, STN09, STN12, STN15
	Onychiuridae Lubbock, 1867				
		Onychiurus Gervais, 1841			
			6.	*Onychiurus* ?	PLG01, STN06
Entomobryomorpha Börner, 1913					
	Isotomidae Schäffer, 1896				
		Folsomides Stach, 1922			
			7.	*Folsomides centralis* Denis, 1931	PLG01

Table 2. Species list of cave Collembola in Thai Peninsula (cont.)

Order	Family	Genus	No.	Species	Distribution
		Folsomina Denis, 1931			
			8.	*Folsomina onychiurina* Denis, 1931	NRT01, STN01, STN02, STN03, STN04, STN07, STN08, STN09, STN10, STN15 YLA07
		Isotomiella Bagnall, 1939			
			9.	*Isotomiella* sp.1	CPN08, RNG01, RNG02
			10.	*Isotomiella* sp.2	SNI01, SNI02, NRT04, PNA03
			11.	*Isotomiella* sp.3	PLG01, PLG02, PLG05
	Entomobryidae Schäffer, 1896				
		Acrocyrtus Yosii, 1959			
			12.	*Acrocyrtus* cf. *malayanus* Yoshii and Suhardjono, 1989	STN03, STN08, STN10, STN05
			13	*Acrocyrtus* cf. *carosus gentingensis* Yoshii, 1982	STN01, STN04, STN15, STN07, STN12
			14.	*Acrocyrtus* sp.1	CPN08, RNG01, SNI06, TRG01, PLG01, PLG02,
			15.	*Acrocyrtus* sp.2	STN02, STN09, SNT13, STN14, YLA03
Entomobryomorpha Börner, 1913					
	Entomobryidae Schäffer, 1896				
		Ascocyrtus Yosii, 1963			
			16.	*Ascocyrtus* sp.1	RNG02, SNI09
			17.	*Ascocyrtus* sp.2	STN07
		Alloscopus Börner, 1906			

Table 2. Species list of cave Collembola in Thai Peninsula (cont.)

Order	Family	Genus	No.	Species	Distribution
			18.	*Alloscopus* sp.1	SNI06, SNI09,
			19.	*Alloscopus* sp.2	PNA03
			20.	*Alloscopus* sp.3	KBI11
		Coecobrya Yoshii, 1956			
			21.	*Coecobrya cavicta* Nilsai and Zhang, 2017	STN08
			22.	*Coecobrya chumphonensis* Zhang and Nilsai, 2017	CPN08
			23.	*Coecobrya polychaeta* Zhang and Nilsai, 2017	STN015
			24.	*Coecobrya* cf. *polychaeta* Zhang and Nilsai	STN08
			25.	*Coecobrya* sp.1	NRT01*
			26.	*Coecobrya* sp.2	SNI02*
			27.	*Coecobrya* sp.3	NRT03*
			28.	*Coecobrya* sp.4	RNG01*
			29.	*Coecobrya* sp.5	CPN01*
			30.	*Coecobrya* sp.6	SNI08*
			31.	*Coecobrya* sp.7	STN02*
			32.	*Coecobrya* sp.8	SNI01*
			33.	*Coecobrya* spp.	RNG02, NRT04, NRT05, PNA03, KBI11, STN05, STN10
		Lepidocyrtus Bourlet, 1839			
			34.	*Lepidocyrtus (Lanocyrtus)* sp.1	CPN04, CPA07, SNI01, PNA01, PNA04, KBI01, KBI06, PLG01, PLG02, PLG04, PLG05,

Table 2. Species list of cave Collembola in Thai Peninsula (cont.)

Order	Family	Genus	No.	Species	Distribution
			35.	*Lepidocyrtus (Lanocyrtus)* sp.2	SKA01, STN01, STN02, STN03, STN04, STN05, STN06, STN07, STN08, STN09, STN10, STN12, STN15, YLA07
	Entomobryidae Schäffer, 1896				
		Pseudosinella Schäffer, 1897			
			36.	*Pseudosinella* sp.1	SNI05, YLA03
		Rambutsinella Deharveng and Bedos, 1996			
			37.	*Rambutsinella* sp.1	STN05, YLA02
		Seira Lubbock, 1870			
			38.	*Seira* sp.1	PNA01, STN01, STN07
	Paronellidae Börner, 1913				
		Cyphoderopsis Carpenter, 1917			
			39.	*Cyphoderopsis* sp.1	STN12*
			40.	*Cyphoderopsis* sp.2	STN07*
			41.	*Cyphoderopsis* sp.3	STN06*
			42.	*Cyphoderopsis* sp.4	STN15*
			43.	*Cyphoderopsis* sp.5	SNI04*
			44.	*Cyphoderopsis* sp.6	STN02*
			45.	*Cyphoderopsis* sp.7	STN01*
			46.	*Cyphoderopsis* sp.8	PLG05*
			47.	*Cyphoderopsis* sp.9	CPN06*

Table 2. Species list of cave Collembola in Thai Peninsula (cont.)

Order	Family	Genus	No.	Species	Distribution
			48.	*Cyphoderopsis* sp.10	SNI01*
			49.	*Cyphoderopsis* sp.11	PNA02*
			50.	*Cyphoderopsis* sp.12	STN05*
			51.	*Cyphoderopsis* sp.13	STN03*, STN04*
			52.	*Cyphoderopsis* sp.14	NRT03*
			53.	*Cyphoderopsis* sp.15	STN09*
			54.	*Cyphoderopsis* sp.16	STN06*
			55.	*Cyphoderopsis* sp.17	KBI02*
			56.	*Cyphoderopsis* spp.	CPN01, CPN03, CPN04, RNG02, SNI06, SNI07, SNI08, NRT02, PNA03, PNA04, KBI03, KBI06, KBI10, KBI11, TRG01, PLG03, SKA02, STN08, STN10, SNT11, STN13, YLA07
		Lepidonella Yosii, 1960			
			57.	*Lepidonella* sp.1	STN05
			58.	*Lepidonella* sp.2	STN07
			59.	*Lepidonella* sp.3	NRT02
			60.	*Lepidonella* sp.4	NRT02
			61.	*Lepidonella* sp.5	YLA02
			62.	*Lepidonella* sp.6	SKA04
			63.	*Lepidonella* spp.	CPN05, PLG01, SKA02, STN02, STN04, STN08, SNT09, STN10, STN11, STN14, STN15

Table 2. Species list of cave Collembola in Thai Peninsula (cont.)

Order	Family	Genus	No.	Species	Distribution
		Salina Gillivray, 1894			
			64.	*Salina* sp.1	PNA03, STN04
		Troglopedetes Absolon, 1907			
			65.	*Troglopedetes* sp.1	CPN01
			66.	*Troglopedetes* sp.2	STN04
		Cyphoderus Nicolet, 1842			
			67.	*Cyphoderus songkhlaensis*	SKA02*, SKA03*
			68.	*Cyphoderus* sp.1	SNI01*, STN01*
			69.	*Cyphoderus* sp.2	PLG01*, STN07*, NRT02*
			70.	*Cyphoderus* sp.3	PNA01*
			71.	*Cyphoderus* sp.4	CPN05*
			72.	*Cyphoderus* sp.5	STN03*, STN04*, STN05*, STN06*, STN09*, STN13*
			73.	*Cyphoderus* spp.	CPN02, CPN07, RNG01, RNG02, SNI03, SNI06, PLG02, PLG03, PLG04, STN02, STN10, STN11, STN12, STN15
	Oncopoduridae Carl and Lebedinsky, 1905				
		Oncopodura Carl and Lebedinsky, 1905			
			74.	*Oncopodura* sp.1	CPN05, CPN08
			75.	*Oncopodura* sp.2	SNI01, NRT04, KBI10
			76.	*Oncopodura* sp.3	STN06, STN08
			77.	*Oncopodura* sp.4	YLA07

Table 2. Species list of cave Collembola in Thai Peninsula (cont.)

Order	Family	Genus	No.	Species	Distribution
Symphypleona Börner, 1901					
	Sminthuridae Lubbock, 1862				
		Pararrhopalites Bonet and Tellez, 1947			
			78.	*Pararrhopalites* sp.1	CPN01, CPN05, CPN08,
			79.	*Pararrhopalites* sp.2	NRT01
			80.	*Pararrhopalites* sp.3	STN05, STN06, STN07, STN08, STN09, STN10, STN12, STN15,
			81.	*Pararrhopalites* sp.4	YLA02, YLA03, YLA07
Neelipleona Massoud, 1971					
	Neelidae Folsom, 1896				
		Spinaethorax Papác and Palacios-Vargas, 2016			
			82.	*Spinaethorax* sp.1	SNI05, SNI06, ,
			83.	*Spinaethorax* sp.2	NRT01, KBI10, KBI11
			84.	*Spinaethorax* sp.3	PLG01
			85.	*Spinaethorax* sp.4	STN01, STN02, STN04, STN05, STN06, STN09, STN12,
			86	*Spinaethorax* sp.5	YLA02, YLA03,YLA07
		Neelus Folsom, 1896			
			87.	*Neelus* sp.1	SNI08, NRT04,
			88.	*Neelus* sp.2	PNA03, KBI11,
			89.	*Neelus* sp.3	TRG01, PLG02, PLG05,

Table 2. Species list of cave Collembola in Thai Peninsula

Order	Family	Genus	No.	Species	Distribution
		Neelus Folsom, 1896			
			90	*Neelus* sp.4	YLA03

* Asterisks indicate identified species based on MOTUs (*COI*).

2. **Key to the orders and families of cave Collembola in Thai peninsula**

This work provides an identification key to orders and families of cave Collembola in Thai peninsula as follows.

1) Abdominal tergal segmentation distinct, body elongate…………………..……………....…..…2

- Abdominal tergal segmentation indistinct, body subglobular…………………………………......3

2) Prothoracic tergum distinct (well-developed)..................... Order PODUROMORPHA……...…4

Prothoracic tergum indistinct (more or less reduced).........Order ENTOMOBRYOMORPHA….…5

3) Antennae as long as or longer than head, eyes usually present; 0 or 1+1 trichobothria on Abd. 5; anal appendages bent towards anal orifice...

....Order SYMPHYPLEONA, *SMINTHURIDAE*

Antennae shorter than head, eyes absent; Dentes subdivided; size small to very small (less than 0.7 mm)……………………………………………………..Order NEELIPLEONA, *NEELIDAE*

4) Pseudocelli on tergite absent..*HYPOGASTRUIDAE*

Pseudocelli on tergite present, with 4-5 protective papillae at sense organ of third antennal segment…………………….. *ONYCHIURIDAE*

5) . Fourth abdominal segment not more than twice the length of third abdominal segment 6

Fourth abdominal segment more than twice the length of third abdominal segment................... 7

6. Mucro elongate, trichobothria present on thorax, third antennal segment is not annulated…....

....*ONCOPODURIDAE*

- Mucro short; trichobothria absent on thorax and abdomen (sometimes present in abdomen), scales always absent... *ISOTOMIDAE*

7) Dens crenulate……………………………………..………………..……. *ENTOMOBRYIDAE*

- Dens not crenulate…………………………………………………………………….……………8

8) Eyes absent, dens with feathered scales…………….…………………….……*CYPHODERINAE*

Eyes present, dental spines present….……………………………….……..………*PARONELLINAE*

* Italic capitals indicate family level.

3. Occurrence and distribution pattern in cave of Collembola in Thai peninsula.

Generally, the occurrence and distribution of organisms in subterranean habitat is divided into four groups. They are (a) *troglobites*, animals that live permanently in the dark zone and are found exclusively in caves; they are totally blind, depigmented with modification of organ to cope with cave environment; (b) *troglophiles*, that are able to complete their life cycles both in the hypogean and in the surface habitats, and show some degree of reduction in those characters; (c) *trogloxenes*, that are regularly found in caves, but must leave it during some period(s) in order to complete their life cycles, organism without such reductions but still spending significant portions of their lives in cave; and (d) *accidentals*, organisms allegedly found in caves 'by chance' and not because they normally live there (Romero, 2009). In this work, four categories of cave collembola in Thai peninsula are characterized as follows.

1) Cave-restricted species (troglomorphy)

In this study, the cave-restricted Collembola is about 1/3 of overall identified species belonging to the genus *Coecobrya, Cyphoderopsis, Lepidonella, Oncopudora, Neelus, Pararrhopalites, Spinaethorax* and *Troglopedetes* with about 30 taxa exhibit clear troglomorphic traits. Troglomorphic character in Collembola is characterized by having elongated appendages (antennae, legs and furca), loss of pigment, reduced eyes to blindness and modified claw complex. Among these, 3 species have already been described as new to science, they are *Coecobrya cavicta* **sp. nov.,** *Coecobrya polychaeta* **sp. nov.** from Satun Province, and *Coecobrya chumphonensis* **sp. nov.** from Chumphon Province (see Areeruk *et al*., 2017) and more than 20 taxa is being described (unpublished data). Most of troglomorphic Collembola are linked to oligotrophic habitats in the dark zone with often wet and moist subterranean environment where food source and bat guano are scarce. Interestingly, the genus *Coecobrya, Cyphoderopsis* and *Lepidonella* has two morphological types and sometimes can found both forms in the same cave. One has short antennae and appendages with smaller size that is associated with guano (always a non-troglomorphy). The other one is very rare and highly troglomorphic with very long antenna and appendages with larger body size. The latter are narrow cave-restricted endemics of the cave and region. This coexistence obviously shed a light of evolution in the frame of sympatric speciation where two distinct species live at the same cave. In fact, the coexistence is rather common in tropical caves such as in *Coecobrya* and *Cyphoderopsis*, these two genera, if present in the same cave, also display a different trait of troglomorphy (Deharveng, 1987; Deharveng and Bedos, 2000; Jantarit *et al*., 2013). The genus *Pararrhopalites, Neelus, Spinaethorax* is narrow restricted to the oligotrophic microhabitats of dark zone in wet and humid environment around rock surface near the puddle and often floating themselves in the surface of standing water. Caves without puddle and dry habitat are hardly to find these Collembola genera. The troglomorphic traits are expected to find in the tropics but it has never showed such a large scale like this study confirming the idea that troglomorphy may develop in tropical subterranean habitats (Howarth 1983, Deharveng 1987; Deharveng and Bedos 2000, 2012; Gnaspini and Trajano 2000) and its number may increase as high as or more than the temperate region.

2) Guanobites-troglobites

The guanobite-troglobites Collembola in Thai peninsula is divided into 5 genera, they are *Acherontiella*, *Alloscopus, Cyphoderopsis, Coecobrya, Lepidonella* and *Rambutsinella*. Their occurrence is often in association with guano with some group like *Cyphoderopsis* and *Coecobrya* have a large population of the same cave. Their distribution in cave is frequent under bat roost around the twilight zone to dark zone of cave and exhibit slightly troglomorphic characters (reduced eyes and pale color). According to the fact that food source inside cave is extremely scarce and brought into caves by limited vectors. Hence, most of Collembola inside cave obtains source of food from either detritus and dissolved organic matter or guano (produced by swiftlets and bats) (Culver and Pipan, 2009; Deharveng and Bedos, 2000, 2012; Deharveng *et al*., 2011, Romero, 2009). Among these food sources, bat guano is the most importance exogenous energy supply as it is full of organic matter and can long term stay for the guanobionts community. In contrast, bacteria and fungi in cave can decompose guano into basic food and nutrients that attract cave invertebrate to utilize this secondary food source. So, the guanobite-troglobites Collembola are restricted to the guano in cave and their survival depends on bat community.

3) Guanophiles-troglophiles

Cyphoderus spp., *Folsomina onychiurina*, *Lepidocyrtus (Lanocyrtus)* spp. *Onychiurus* sp., *Willemia nadchatrami* and *Xenylla yucatana*. They are frequent found in twilight zone in several caves of Thai peninsula and never exhibit troglomorphic characters. They normally live in soil or guano found in wet and moist microhabitat. They are often foraging on the ground surface near guano and some group like *Cyphoderus* spp. and *Lepidocyrtus (Lanocyrtus)* spp. have a large population varying from hundreds to thousands individuals in the same cave. Some of them could be different from their edaphic relatives of the same region.

4) Accidental species

The accidental species is characterized by Collembola species normally linked to edaphic environment outside the cave in the soil of the whole SEA. They are genus *Acrocyrtus* (i.e. *Acrocyrtus* cf. *malayanus, Acrocyrtus* cf. *carosus gentingensis* and *Acrocyrtus* spp.), *Ascocyrtus* spp., *Folsomides centralis*, *Isotomiella* spp., *Salina* sp., *Seira* sp. accounting for 12 species (13%) of overall cave species in Thai peninsula. They all are found in the entrance of cave where bat guano and debris are presented. Collembola can disperse to cave by their active dispersal and can be brought to cave by various vectors for example human, wind, or flood during rainy season. Some can survive in detritus, dissolved organic matter or guano (produced by swiftlets and bats).

4. Genetic evaluation

The DNA barcoding using Cytochrome Oxidase Subunit I (*COI* marker) has proved to be an effective tool for identifying unknown species or assess whether species should be combined or separated when the taxa lack conspicuous morphological features or are difficult to distinguish (Hebert *et. al*., 2003). In this study, the genus *Cocoebrya* (20 caves), *Cyphoderopsis* (39 caves) and *Cyphoderus* (29 caves) were the most common group of Collembola found in cave throughout Thai peninsula. Obviously, species of a same genus or lineage is morphologically slightly different. They share most morphological character similarities and sometimes make a difficulty for species diagnosis. In particular the genus *Cyphoderus* in which its morphological characters among the population bear a strong resemblance to each other. Undoubtedly, there are some characters that differ from one another but it is not significantly importance, for example the claw complex and tenent hair, owing to the fact that these characters may vary among population, making a judgment in a dilemma.

With regard to the genus *Coecobrya*, there are 50 described species worldwide. In Thailand, only 4 species are recorded: *Coecobrya* cf. *hoefti* (Schäffer, 1896) in mixed dry deciduous forest and deforested area in Khon Kaen Province, *Coecobrya guanophila* Deharveng from cave, 1990, *Coecobrya similis* Deharveng, 1990 from forest soil and cave and *Coecobrya lanna* Zhang, Deharveng and Chen, 2009 from forest litter in Chiang Mai Province (Deharveng 1990; Jantarit *et al*. 2016; Areeruk et al., 2017). However, the *Coecobrya* has never been described from Thai peninsular. In this study, *Coecobrya* were found in 20 caves and three species has just described as new to science by using both morphological and genetic study (Areeruk *et al*., 2017). There are *C. cavicta* **sp. nov.,** *C. polychaeta* **sp. nov.** from Satun Province, and *C. chumphonensis* **sp. nov.** from Chumphon Province. Apart from 20 collected caves *Cocoebrya*, only 11 caves of 69 *COI* sequences were successfully sequenced (NRT01, SNI 02, NRT03, RNG01, CPN01, SNI08, STN02, CPN08, SNI01, STN15 and STN08). Neighbour-joining tree based on mitochondrial COI sequences is clearly separated the genus into 9 distinct species (fig. 6). All of them are being described as species new to science. Moreover, 8 *Coecobrya* caves (RNG02, NRT04, NRT05, PNA03, KBI11, STN05, STN10, YLA03) are not yet sequenced because they are small number of collected population (not having enough materials) and limited budget but the result is inclined to believe that all of them are separated species. However, they all are placed as *Coecobrya* spp. before strong evidences both morphology and molecular will be undertook.

With regard to the genus *Cyphoderopsis*, there are 14 described species worldwide. In Thailand, 4 species are recognized: *Cyphoderopsis phangnga, C. cavicola, C. khaophang* and

C. thachana all are from caves except *C. phangnga* that was found from secondary forest (Jantarit *et al*. 2013, 2016). In this research, *Cyphoderopsis* were the most common group found in 39 caves throughout the region. Jantarit *et al*. (2013) reported that the distribution of the genus is restricted to Thai-Malay peninsula and western Indonesia. However, only 17 caves of 40 *COI* sequences were successfully obtained (STN12, STN07, STN06, STN15, SNI04, STN02, STN01, PLG05, CPN06, SNI01, PNA02, STN05, STN04, STN03, NRT03, STN09, KBI02). Neighbour-joining tree based on mitochondrial COI sequences is distinct the genus into 17 differentiated species (fig 7). The result can imply that each cave in Thai peninsula has its own species of *Cyphoderopsis*. Moreover, 22 *Cyphoderopsis* caves (CPN01, CPN03, CPN04, RNG02, SNI06, SNI07, SNI08, NRT02, PNA03, PNA04, KBI03, KBI06, KBI10, KBI11, TRG01, PLG03, SKA02, STN08, STN10, SNT11, STN13, YLA07) are not yet sequenced because of small number of population and limited budget but the result strongly suggest that all of them are separated species. However, they all are put as *Cyphoderopsis* spp. before robust evidences both morphology and molecular will be undertook.

With regard to the genus *Cyphoderus*, all species of Thai peninsular belong to the *bidenticuli*-group by having their long, thin and ending with two subequal small teeth mucro (Delamare-Deboutteville, 1948). According to Bellinger *et al*. (1996-2017) website, they are 68 species of *Cyphoderus* worldwide, 16 species have been identified to bidentate-mucro group. In Thailand, only 3 species are recognized: *Cyphoderus javanus* and *C.* cf. *javanus* from forest, *C. khaochakanus* and *C. songkhlaensis* from caves (Jantarit *et al*. 2014, 2016). In this research, *Cyphodus* are among the most common group found in 29 caves throughout the region. In fact, this genus is very common in caves of Thailand and edaphic habitats (Jantarit *et al*. 2014, 2016). However, only 15 caves of 40 *COI* sequences were successfully sequenced (STN01, SNI01, SKA03, SKA02, PLG01, STN07, NRT02, PNA01, CPN05, STN13, STN06, STN09, STN05, STN03, STN04). Neighbour-joining tree based on mitochondrial COI sequences is divided the genus into 6 differentiated species (fig 8). However, the distribution pattern in *Cophoderus* is different from that in *Coecobrya* and *Cyphoderopsis* where the same taxa can occupy more than one cave implying that they are not true cave restricted species. Besides, 14 *Cyphoderus* caves (CPN02, CPN07, RNG01, RNG02, SNI03, SNI06, PLG02, PLG03, PLG04, STN02, STN10, STN11, STN12, STN15) are not yet sequenced because of the same reason above. So they all are placed as *Cyphoderus* spp. before powerful evidences both morphology and molecular will be undertook.

Overall, a total of 159 DNA sequences were successfully sequenced from the three genera. There are 658 bp of 69 *COI* sequences in *Cocoebrya* spp., 586 bp of 50 *COI* sequences in *Cyphoderopsis* spp. and 587 bp of 40 *COI* sequences in *Cyphoderus* spp. The neighbour-joining (NJ) tree based on mitochondrial *COI* sequences results resolve this taxonomic problem effectively in providing the fact that at least 11 species of *Coecobrya*, at least 17 species of *Cyphoderopsis* and at least 6 species of *Cyphoderus* are as differentiated as true species (Figs. 6, 7 and 8). It also reveals that each karstic unit has its own, well differentiated species of Collembola in particular the genus *Coecobrya* and *Cyphoderopsis* but it cannot be applied to genus *Cyphoderus*. All of them appear to be different species and narrow cave-restricted endemics, in spite of their close locations. This very high level of endemicity of Thai caves emphasize a need higher than expected for comservation and management, because of cave vulnerability in the face of quarrying and tourism in the area. The powerful evidence of molecular study obviously shad the light in alpha diversity and endemics of cave Collembola in Thai peninsular and number of richness of cave Collembola is undoubtedly increase when the numbers of sequences are growing.

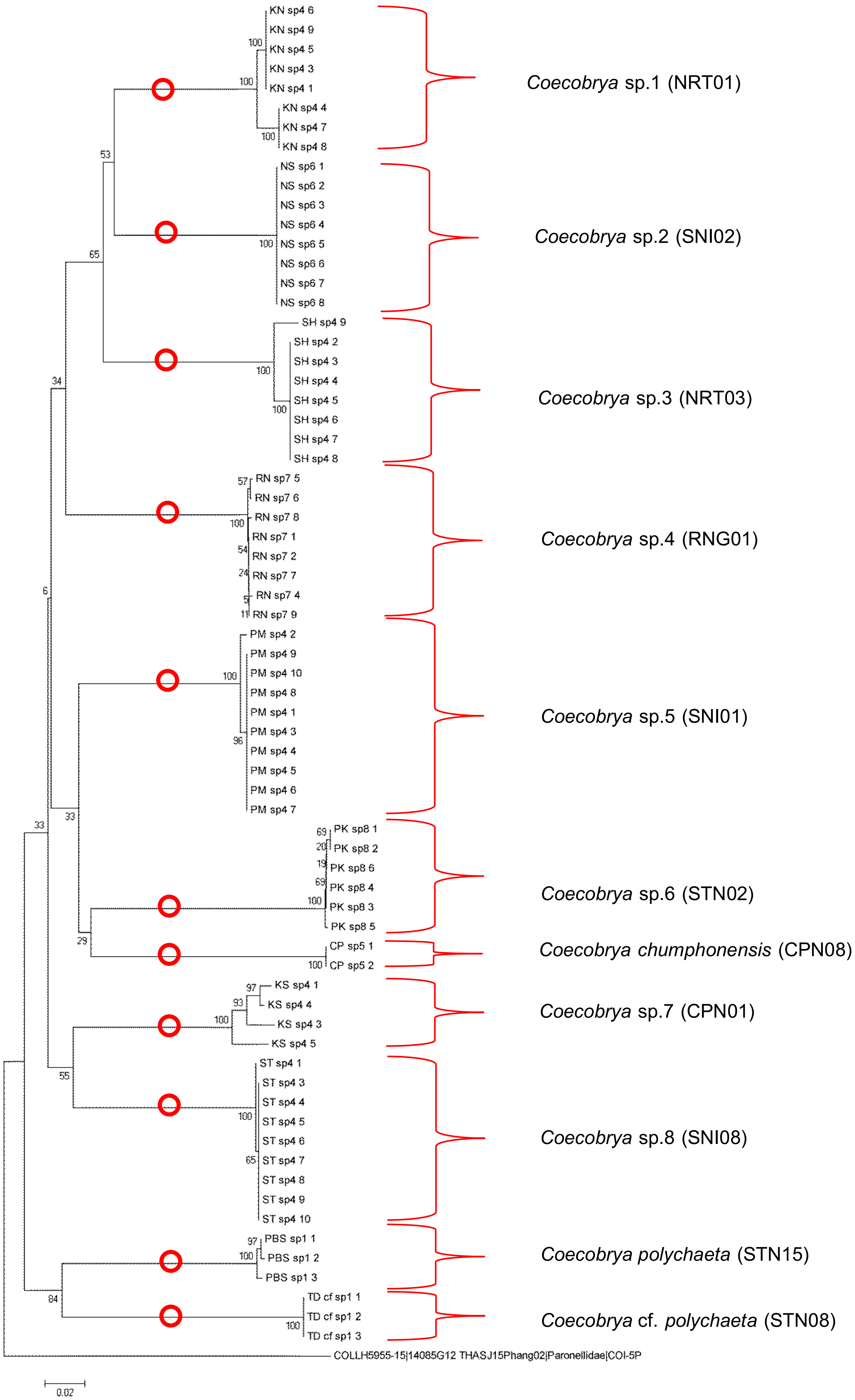


Figure 6: Neighbour-joining tree based on mitochondrial COI sequences, showing bootstrap values and species grouping of *Coecobrya* spp..

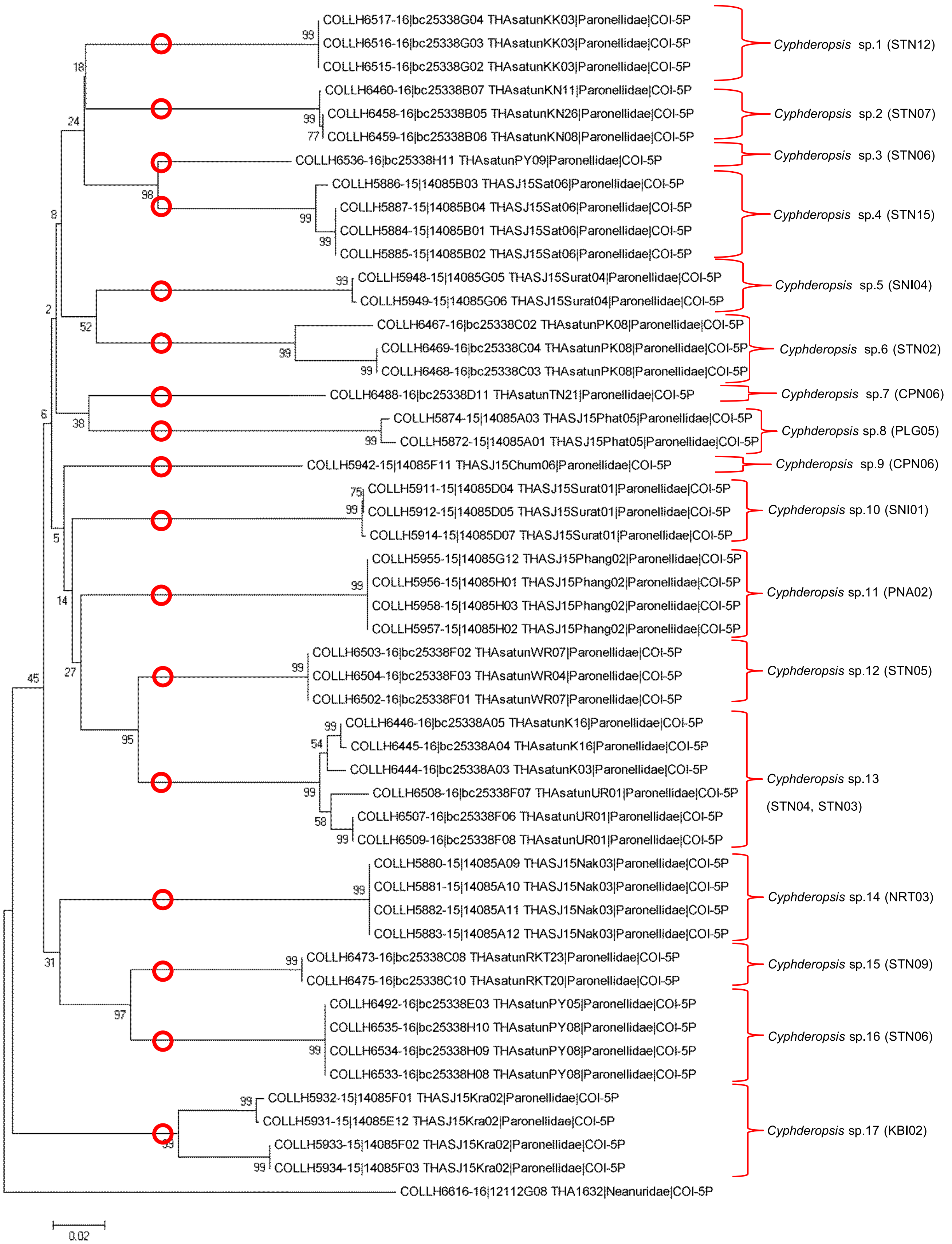


Figure 7: Neighbour-joining tree based on mitochondrial COI sequences, showing bootstrap values and 17 MOTUs species grouping of *Cyphoderopsis* spp..

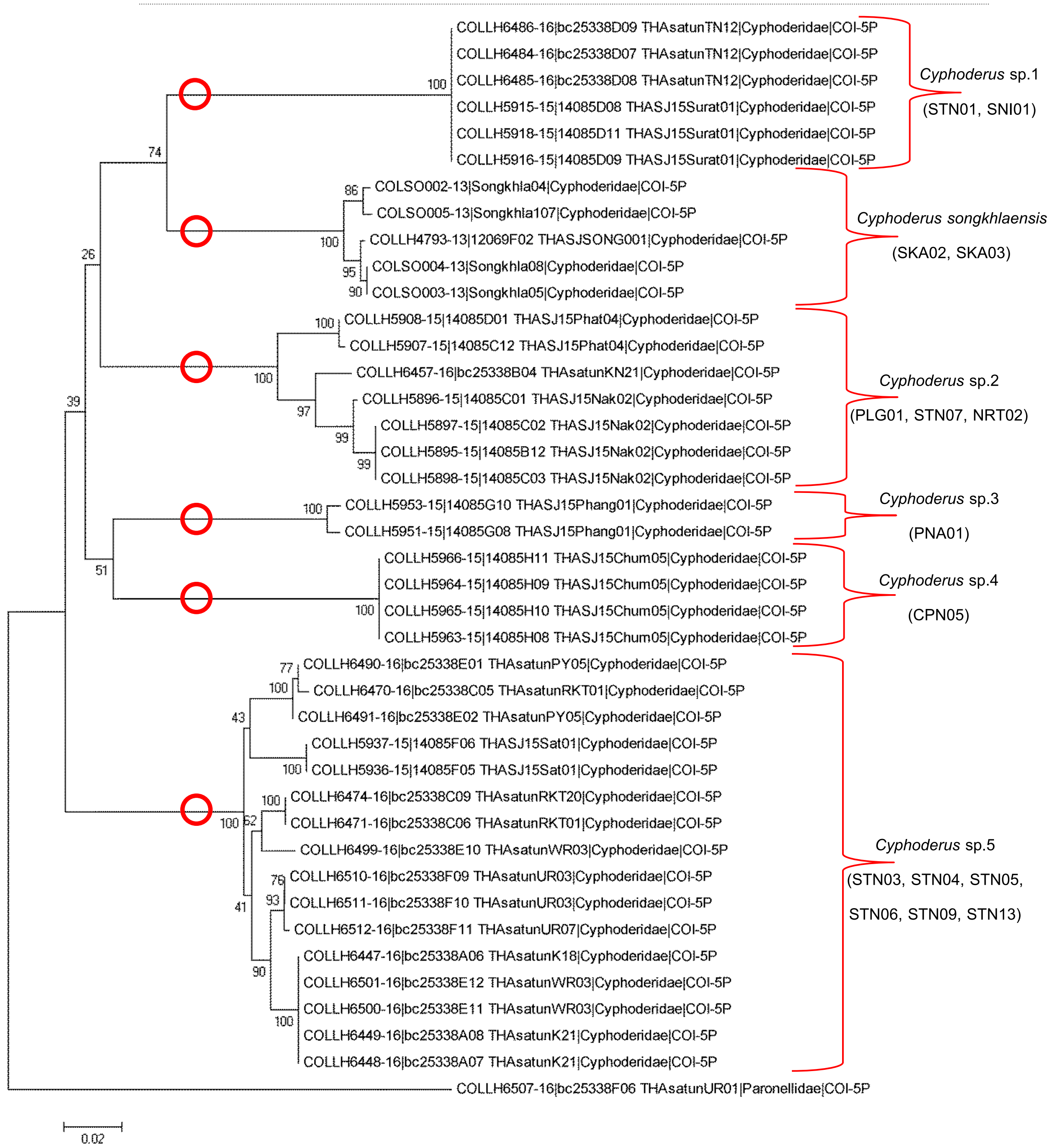


Figure 8: Neighbour-joining tree based on mitochondrial COI sequences, showing bootstrap values and species grouping of *Cyphoderus* spp..

4. Endemism and rareness

The speciation and endemism in tropical caves are poorly known. The results of this research firstly highlight that the Collembola are the most common and diverse group in caves, and by far the most diverse of terrestrial Hexapod in SEA. Secondly, most of the species found in Thai peninsula caves appear to be different species and narrow cave-restricted endemics, many species are being described as new to science. In fact, cave endemics are more narrowly distributed than surface endemics (Deharveng and Bedos, 2012). Molecular and morphological evidences reveal that each karstic unit has its own, well differentiated species of Collembola in particular in the family Paronellidae and Entomobryidae. Most collected species of *Cyphoderopsis* spp., *Coecobrya* spp., *Cyphoderus* spp. and *Lepidonella* spp. are in particular unknown to science and endemic to karst units of limited extent. Especially, *Coecobrya cavicta* **sp. nov.,** *Coecobrya polychaeta* **sp. nov.** from Satun Province, and *Coecobrya chumphonensis* **sp. nov.** from Chumphon Province, that have just described, as well as all troglobitic species, they are rare and restricted to the cave. They have remarkable vicariant distributions, suggesting that almost any isolated karst outcrop have its own species of those genera, in spite of their close locations. The karstic unit of Thai peninsula is extremely fragmented (see fig. 1 and 2) and apparently gene flow cannot easily move the limits of the limestone. Unlike in temperate region, the karstic systems are linked by superficial underground compartment (SUC) where most of troglobitic species use to genetically disperse beyond the limit (Deharveng, 1987). The presence of troglomorphic species among cave-restricted Collembola, limited to oligotrophic habitats, as well as the high level of endemism, is not exceptional, and a further support to the idea that troglomorphy may develop in tropical subterranean habitats (Howarth 1983, Deharveng 1987c; Deharveng and Bedos 2000, 2012; Gnaspini and Trajano 2000), contrary to previous assumptions. However, most caves in Thai peninsula are potentially vulnerable to the face of growing anthropic disturbance and habitat degradation which are continuously developing in Thailand karsts. It is obviously the fastest way to be the main cause of the extinction of a large number of the rarest subterranean micro-endemic species.

Conservation implication

Cave has been recognized as a biodiversity hotspot of high biological importance (Deharveng and Bedos, 2000; 2012 Clements *et al*., 2006; Latine *et al*., 2011, Romero, 2009). Karst units, that include caves, are also considered to be islands of biodiversity and host very high level of endemic species as well as species unknown to science. In Thai peninsula, many caves are being destroyed by certain human activities, which may in a way result in less problems for the taxonomists, but is ethically increasingly worrying. Cave has suffered a considerable degree of ecological change, as a result of demanding for cement consumption, unsustainable limestone quarrying, pollution, an increasing of temple caves, growing of tourism industry as well as the building of infrastructure and introduction of light energy inside the cave, bat guano mining, hunting and urbanization (Day and Urich, 2000; Clements *et al*., 2006; Vermeulen and Whitten, 1999; personal observation). Those human activities may cause organisms living there to become extinct as well as the entry of invasive ones. Thai limestone ecosystems are therefore under threat, especially in lowland, and there is no sign of stepping down at the moment. Importantly, no critical conservation issue has been detected so far regarding the genera/species listed here. As a consequence, this very high level of endemicity of Thai peninsula cave underlines a need higher than expected for better urgently protection the huge cave biodiversity and in the meanwhile the results will be used as a management tool for increasing subterranean environmental awareness and redirect cave conservation strategies in the future.

As a consequence, the result of this research is able to propose several conservation action plans for Collembola and their habitats. Although there is no such species regarding the status of IUCN, but many species of *Cyphoderopsis, Coecobrya, Lepidonella* for instance are known to be narrow cave-restricted species, rare and are endemic to the cave (see cave-restricted species (troglomorphy) above). An increasing of anthropic disturbance and habitat degradation could be a major threat to reducing Collembola diversity and population. So, several action plans herewith is in a hope to implement a subterranean policy as follows.

1. Red-list for the most endangered cave Collembola.

In result of this study provides a red-list status of the most endangered cave Collembola for example *Coecobrya cavicta* **sp. nov.,** *Coecobrya polychaeta* **sp. nov.** from Satun Province, and *Coecobrya chumphonensis* **sp. nov.** from Chumphon Province and all species diagnoses by DNA barcoding (*COI*) especially the genus *Cyphoderopsis*, *Cyphoderus* and *Coecobrya* as well as the genus *Lepidonella* all are narrow restricted to a cave and show very high level of endemic. However, most of them are species unknown to science and are waiting to be described. Once a good number of species will be described, will be obviously used as a management tool for increasing subterranean environmental awareness and redirect cave conservation strategies in the future.

2. Zonation for troglobitic species

The result highly recommends that the oligotrophic environment in the dark zone with wet and humid environment is an important habitat for troglobitic species like in *Coecobrya, Cyphoderopsis, Lepidonella, Oncopudora,* and *Troglopedetes*. The puddle in the dark zone as well as the surrounded areas hosts many cave-restricted species especially the genus *Neelus, Pararrhopalites* and *Spinaethorax*. Therefore, these habitats are strongly recommended to limit extreme modification of infrastructure for example the building of concrete walkways and the introduction of light energy. As all troglomorphic species are sensitive to habitat changes and light that can cause distress and extinction. Large guano piles of wet and humid area support a high level of guanobites-troglobites species in particular the genus *Acherontiella*, *Alloscopus, Cyphoderopsis, Coecobrya, Lepidonella* and *Rambutsinella*. They all are highly in association with guano and narrow restricted cave species. Then, the appropriate amounts of guano extraction and harvesting must be defined. In particular the wet and humid guano area should avoid to access guano deposit, however, dry guano area is accepted to collect the guano as this area often support very low to zero trogobitic species.

3. Managing habitat and roosting site for bats

Moreover, most karstic hills and caves of Thai peninsula are under significant human pressure that also has impact on the bat population which can affect population recruitment and so guano production. In particular extreme modification to the habitat as well as the introduction of light energy inside the cave cause negatively impact upon non-migratory bat and can force bats to abandon their roosting site resulting in the disappearance of guano. As a consequence, cave guano-restricted species may collapse as their main food supply count on bat community and at the same time they cannot adapt at long-distance dispersal outside the cave as limited by their evolutionary adaptation. Hence, it is important to conserve both subterranean habitat and bat communities to reassure that guano-invertebrate community will survive.

4. Increase local people knowledge about cave Collembola fauna.

Knowledge should be shared to local communities who live near the cave. Several methods could be enforceable for example educational poster, brochure and/or TV documentary summary of the findings and photography list of endangered important/common species as well as the important ecological role to local communities. This can be used as education materials for students at school such as elementary and secondary students and to the local government, and ecotourism agencies in the areas.

CHAPTER 4
CONCLUSIONS AND PERSPECTIVES

The research on cave-dwelling springtails (Hexapoda: Collembola) of Thai peninsula were carried out throughout the region. This work establishes to redress the lack of information on the cave Collembola faun with respect to their diversity, distribution, and taxonomic study. Then, an understanding of the species composition, taxonomic study and distribution patterns of cave-dwelling springtails is not only address the body of knowledge and an important database but also has implications of environmental awareness and considerable ecological value to cave managers and conservation strategies with respect to local and regional diversity. As a consequence, the results are adequate to draw firm conclusion as follows:

1) Caves in Thai peninsular were extensively sampled. A total of 76 caves in 65 limestone outcrops, located in 11 provinces (from 14 provinces in Thai peninsula) were studied throughout the region, as present in Fig. 2. Details of sampled caves were recorded in database.

2) A total of 4 orders, 9 families, 23 genera and at least 90 species or MOTUs were recognized. So, the results of this research highlight that the Collembola are among the most common and diverse group in caves, and by far the most diverse of terrestrial Hexapod of Thai peninsula caves. Thai peninsula caves support very high number of Collembola and each cave, one to maximum ten species was reported, with only 14 caves (18%) without any Collembola. The species richness of Thai cave Collembola is undoubtedly much more than observed number.

3) The genus *Cyphoderopsis* are the most common cave-dwelling Collembola in Thai peninsula with at least 18 taxa were recognized following by the genus *Coecobrya* (at least 13 taxa), genus *Lepidonella* (7 taxa) and *Cyphoderus* (7 taxa) respectively. With regard to number of individuals, the genus *Cyphoderus* were the largest population with a total of at least 6,479 individuals was captured, it follows by the genus *Lepidocyrtus* (5,031 individuals), *Cyphoderopsis* (4,435 individuals), *Xenylla* (3,182 individuals) and *Coecobrya* (2,592 individuals).

4) Both morphological and molecular evidences (COI) reveal that each karstic unite has its own species of Collembola highlighting a very high level of endemism particular the genus *Cyphoderopsis, Coecobrya, Lepidonella* and partly *Cyphoderus*. They are in particular unknown to science and are endemic to karst units of limited extent. This was expected but never shown at such a scale in tropical Asia supporting to the idea that troglomorphy may develop in tropical subterranean habitats.

5) Among them, at least 1/3 (30 taxa more or less) shows troglobitic characters, and more than 10 taxa exhibit clear troglomorphic traits (for example in *Coecobrya* spp. and *Lepidonella* spp.).

Needless to say, the study of cave Collembola in Thailand is at the beginning and the number of taxonomic richness, troglomorphic species and endemism is hoped to significantly increase if the karstic unit of all regional levels will be studied. According to the fact that only the Thai peninsula is extensively scientific sampled and yet it is still a very small proportion in the overall karst of the country. The northern and western parts of the Thailand (as well as western part of the north-east region) are extremely predominated by karst system but they have seldom been observed. Therefore species richness, taxonomy, evolution and biogeography of Thai Collembola remain poorly-known. Given these gaps, cave Collembola community survey is a basic need before any sound hypotheses can be drawn on their origin, evolution and regional distribution. It is further, on the other hand, shed light on environmental awareness and considerable ecological value to cave managers and conservation strategies. Karst ecosystem in SEA should urgently take into account this high biological importance.

PROBLEMS, SUGGESTIONS AND RECOMMENDATIONS

Several problems, suggestions and recommendations are summarized in the following.

1) Cave ecosystems are usually characterized by the absence of natural light, stable temperature, high relative humidity and geophysical structure with three zones (entrance, twilight and dark zone). However, the definition of cave for scientist and local people is often different. Most cases when the local people took the team to the cave, in fact, it was not a cave, it was just a small hole or lager chamber of entrance zone where light can penetrate into all areas. So, the required cave must be clearly explained to the local people in order for not wasting time and energy.

2) The specimens in most genera have small population (table 1 and 2), sometimes with a small collected individuals for example the genus *Onychiurus*, *Folsomides, Salina* and many species of a same genus or lineage. This is relatively common for cave fauna where food source is scarce. Unfortunately, they are mostly the juvenile rather than the adult (smaller size, not full development of chaetae and reproductive organ). It makes a difficulty for specimen identification as the taxonomic approach always use adult stage to identify. Then, those materials were kept in wet preservation instead of making a slide or for genetic analysis.

3) Most caves (90%) from my observation in Thai peninsular are simple and are not difficult to make an observation and collection. However, some rarely case, they are deep vertical cave (like in Tham Nam Tip (Khao Paela), Surat Thani province where the vertical cave would be around 10-20 meter height with a big chamber below). So, cave access is very difficult and high-risk situation at the same time. The need for safe-gear and well-equipped tools as well as team work in case of emergency is highly recommended. We ignore to sample the specimen in this case and hope to come back to observe again in the future.

4) Caves in National Parks are ignored to study in order to avoid any bureaucratic procedure. Unfortunately, most of pristine or natural caves are located in the National Park where anthropic disturbance are rarely exposed. So, cave in the National park is highly recommended to study the cave fauna as it is intended to support a rich cave fauna more than the disturbed caves.

5) Most of local people as well as monks of temple caves are believe in black magic, ghosts, spiritual or religion uses and history (rumor) of cave. They are afraid of entering to the cave and at the same time collecting organism in cave are prohibited in particular the temple caves. Many case, the team have to explain the purpose of the study to those people and to convince them to guild us upon the study sites. They also believed that most of animal living in the cave is the symbol of some spiritual. For example a bat-eating snake is believed as a cave

owner spiritual.

6) According to the unrest situation in the three provinces of Southern Thailand (Yala, Patthani and Narathiwat province plus some areas in Songkhla province), it made the observation and field expedition almost impossible. The team needs to contact with local government first before going to the field and we were always protected by solider and local security in the process of cave observation and collection. Some areas where there are extremely rich karst unit like in Yala province are never scientifically sampled.

7) Legal or customary ownership and management of the cave is rarely observed in the Thai peninsula comparing to the central part of the Thailand where many caves are licensed to collect the guano and are guarded or fence protection. However, some caves are occupied by local people and/or the owner of land surrounding the cave. So, it is recommended to contact with those people before entering to the cave in order to minimize the controversial encounter.

8) Respirator capable of filtering dust particle are highly recommended to use in order to minimize the risk of disease transmission and health risks in particular the guano mining cave or caves with a very large population of bat.

9) Radio communication is highly recommended for cave observation and specimen collection. Many times the team has to observe separately and in cave all mobile signal is dead, but radio communication works well.

10) Making fire is prohibited in the cave as fire and smoke can negatively affect bats and many invertebrates. Headlamps and heavy-duty flashlight are potential equipment.

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Appendices

Appendix 1. List of sampled caves throughout Thai peninsular.

Province	Abbr.	Code	No.	Cave name	Locality	Coordinate
Chumphon	CPN	THA_SJ_CPN01	1	Tham Tapan (Don Non)	Lang Suan district	N 09 54.238 E 99 02.685
		THA_SJ_CPN02	2	Tham Chang (Khao Ram Ro)	Tha Sae district	N 10 37.444 E 99 06.801
		THA_SJ_CPN03	3	Tham Ai Tae (Khao Ram Ro)	Tha Sae district	N 10 37.437 E 99 06.816
		THA_SJ_CPN04	4	Tham Pet (Khao Ram Ro)	Tha Sae district	N 10 37.500 E 99 06.736
		THA_SJ_CPN05	5	Tham Phitsadan	Pathio district	N 10 45.696 E 99 13.795
		THA_SJ_CPN06	6	Tham Nam	Sawi district	N 10 07.451 E 98 55.681
		THA_SJ_CPN07	7	Unknown cave (Near Tham Nam in Tepchinda temple)	Sawi district	N 10 07.419 E 98 55.688
		THA_SJ_CPN08	8	Tham Chang Peung	Mueang district	N 10.446402 E 99.035030
		THA_SJ_CPN09	9	Tham Phra	Pathio district	N 10 42.262 E 99 18.381
Ranong	RNG	THA_SJ_RNG01	10	Tham Phra Khayang	Kra Buri district	N 10.326629 E 98.764791
		THA_SJ_RNG02	11	Tham Knaddai	La-un district	N 10.031859 E 98.841999
Surat Thani	SNI	THA_SJ_SNI01	12	Tham Panthurat	Phanom district	N 08 54.028 E 98 31.498
		THA_SJ_SNI02	13	Tham Khromwanaram	Ban Na San district	N 08 46.194 E 99 22.106
		THA_SJ_SNI03	14	Tham Singkon 1 (tourist cave)	Khiri Rat Nikhom district	N 09 02.499 E 99 02.377
		THA_SJ_SNI04	15	Tham Singkon 2 (water cave)	Khiri Rat Nikhom district	N 09 02.439 E 99 02.509
		THA_SJ_SNI05	16	Tham Chong Hi	Khiri Rat Nikhom district	N 08 57.787 E 98 59.135
		THA_SJ_SNI06	17	Tham Wang Ba Dan	Khiri Rat Nikhom district	N 08 54.520 E 98 57.086
		THA_SJ_SNI07	18	Tham Khao niew kuan	Kanchanadit district	N 09 08.558 E 99 28.268

Appendix 1. List of sampled caves throughout Thai peninsular (cont.).

Province	Abbr.	Code	No.	Cave name	Locality	Coordinate
Surat Thani	SNI	THA_SJ_SNI08	19	Tham Mueang (Khao Paela)	Thachana district	N 09.559331 E 98.982274
		THA_SJ_SNI09	20	Tham Nam Tip (Khao Paela)	Thachana district	N 09.562082 E 98.982205
		THA_SJ_SNI10	21	Tham Pheung	Khiri Rat Nikhom district	N 09 00.940 E 98 52.644
Nakhon Si Thammarat	NRT	THA_SJ_NRT01	22	Tham Wang Thong	Kanom district	N 09 12.293 E 99 46.470
		THA_SJ_NRT02	23	Tham Kaew Surat Kan	Lan Saka district	N 08 21.677 E 99 47.112
		THA_SJ_NRT03	24	Tham Khao Pub Pha	Sichon district	N 08 59.996 E 99 46.692
		THA_SJ_NRT04	25	Tham Nang Chi	Tham Phannara district	N 08.415584 E 99.380742
		THA_SJ_NRT05	26	Tham Wong Wee	Chang Klang district	N 08 19.992 E 99 39.167
Phang Nga	PNA	THA_SJ_PNA01	27	Tham Meud (Suwankuha temple)	Takua Thung district	N 08 25.749 E 98 28.364
		THA_SJ_PNA02	28	Tham Nam (phutthatham temple)	Thap Put district	N 08 32.772 E 98 35.264
		THA_SJ_PNA03	29	Tham Tapan	Mueang district	N 08 27.288 E 98 31.659
		THA_SJ_PNA04	30	Tham Phraya Nakarach	Thap Put district	N 08.524530 E 98.568777
Krabi	KBI	THA_SJ_KBI01	31	Tham Klang	Ao Luek district	N 08 20.280 E 98 44.738
		THA_SJ_KBI02	32	Tham Phet	Ao Luek district	N 08 23.575 E 98 46.449
		THA_SJ_KBI03	33	Tham Khao Na Pru	Ao Luek district	N 08 17.821 E 98 44.566
		THA_SJ_KBI04	34	Tham Hub Pet Yoi	Ao Luek district	N 08 23.360 E 98 44.135
		THA_SJ_KBI05	35	Tham Sa Yuan Thong	Ao Luek district	N 08 21.743 E 98 44.756
		THA_SJ_KBI06	36	Tham Lang Rong Rean Tap Prik	Mueang district	N 08 10.802 E 98 52.875
		THA_SJ_KBI07	37	Tham Chang Si	Mueang district	N 08 05.342 E 98 52.566
		THA_SJ_KBI08	38	Tham Look Noo	Mueang district	N 08 05.455 E 98 52.776

Appendix 1. List of sampled caves throughout Thai peninsular (cont.).

Province	Abbr.	Code	No.	Cave name	Locality	Coordinate
Krabi	KBI	THA_SJ_KBI09	39	Tham Khang Khao	Mueang district	N 08 05.441 E 98 52.797
		THA_SJ_KBI10	40	Tham Prasat Nalakhiring	Plai Phraya district	N 08.558474 E98.860725
		THA_SJ_KBI11	41	Tham Prasat Wiman	Plai Phraya district	N 08.461825 E 98.839964
Trang	TRG	THA_SJ_TRG01	42	Tham Khao Chang Hai	Na Yong district	N 07.590272 E 99.668703
		THA_SJ_TRG02	43	Tham Nam Pray	Huay Yod district	N 07 43.928 E 99 37.079
Phatthalung	PLG	THA_SJ_PLG01	44	Tham Yee Lun	Kong Ra district	N 07.385414 E 99.984282
		THA_SJ_PLG02	45	Tham Phut Thakodom	Srinagarindra district	N 7 33.563 E 99 53.209
		THA_SJ_PLG03	46	Tham Kurum	Mueang district	N 7 38.138 E 100 05.091
		THA_SJ_PLG04	47	Tham Malai	Mueang district	N 7 38.122 E 100 05.100
		THA_SJ_PLG05	48	Tham Lo Ko	Khao Chaison district	N 7 26.887 E 100 07.509
Songkhla	SKA	THA_SJ_SKA01	49	Tham Than Maha	Rattaphum district	N 07.07314 E 100.24955
		THA_SJ_SKA02	50	Tham Khao Wang Thong	Rattaphum district	N 07.07673 E 100.16547
		THA_SJ_SKA03	51	Tham Khao Nui	Rattaphum district	N 07.07728 E 100.14078
		THA_SJ_SKA04	52	Tham Talod	Saba Yoi district	N 06.52318 E 100.82115
		THA_SJ_SKA05	53	Tham Nang Praya Lead Khao	Sadao district	N 06.74069 E 100.25772
		THA_SJ_SKA06	54	Tham unknown (near abandon temple)	Sadao district	N 06.70933 E 100.27651
Satun	STN	THA_SJ_STN01	55	Tham Tanan	Thung Wa district	N 07.06169 E 099.69222
		THA_SJ_STN02	56	Tham Phuttha Khriri	Thung Wa district	N 07.10288 E 099.81272
		THA_SJ_STN03	57	Tham U-rai Thong	La Ngu district	N 06.93683 E 099.76383

Appendix 1. List of sampled caves throughout Thai peninsular (cont.).

Province	Abbr.	Code	No.	Cave name	Locality	Coordinate
Satun	STN	THA_SJ_STN04	58	Tham Kae	La Ngu district	N 06.89466 E 099.77903
		THA_SJ_STN05	59	Tham Wang Kram	La Ngu district	N 06.93836 E 099.81552
		THA_SJ_STN06	60	Tham Pho Yom	La Ngu district	N 07.10286 E 099.85953
		THA_SJ_STN07	61	Tham Phai Du Son	Khuan Don district	N 06.80556 E 100.10446
		THA_SJ_STN08	62	Tham Thon Din	Khuan Don district	N 06.72636 E 100.16249
		THA_SJ_STN09	63	Tham Wat Rakang Thong	Manang district	N 07.09506 E 099.91759
		THA_SJ_STN10	64	Tham Phu Pha Phet	Manang district	N 07.12777 E 099.99609
		THA_SJ_STN11	65	Tham Pak Kok	Manang district	N 07.08780 E 099.95873
		THA_SJ_STN12	66	Tham Khao Khom	Khuan Kalong district	N 06.88089 E 100.03345
		THA_SJ_STN13	67	Unknown Cave (Tham near Khao wang cave)	Khuan Kalong district	N 06 52.856 E 100 02.009
		THA_SJ_STN14	68	Tham Tha Lu (near)	Khuan Kalong district	N 06.83913 E 100.04088
		THA_SJ_STN15	69	Tham Phraya Bang Sa	Mueang district	N 06.77549 E 100.04160
Yala	YLA	THA_SJ_YLA01	70	Tham Wat Khao Hin	Betong district	N 05 48.064 E 101 03.230
		THA_SJ_YLA02	71	Tham Batu Khor	Krong Pinang district	N 06.34293 E 101.21611
		THA_SJ_YLA03	72	Tham Namlod	Krong Pinang district	N 06.34482 E 101.21491
		THA_SJ_YLA04	73	Tham Masjid	Krong Pinang district	N 06.34680 E 101.21313
		THA_SJ_YLA05	74	Tham Meud (puppy dog)	Krong Pinang district	N 06.32444 E101.22109
		THA_SJ_YLA06	75	Unknown Cave (on top of mountain)	Krong Pinang district	N 06.34364 E101.21507
		THA_SJ_YLA07	76	Tham Wat Kuha Pimok	Mueang district	N 06.52833 E101.22515

Appendix 2. List of cave Collembola genera and number of individuals found in each sampled cave throughout Thai peninsula.

Cave code / Genera	*Acherontiella*	*Willemia*	*Xenylla*	*Onychiuridae*	*Folsomides*	*Folsomina*	*Isotomiella*	*Acrocyrtus*	*Ascocyrtus*	*Alloscopus*	*Coecobrya*	*Lepidocyrtus*	*Pseudosinella*	*Rambutsinella*	*Seira*	*Cyphoderopsis*	*Lepidonella*	*Salina*	*Troglopedetes*	*Cyphoderus*	*Oncopudura*	*Pararrhopalite*	*Spinaethorax*	*Neelus*
THA_SJ_CPN01	-	-	-	-	-	-	-	-	-	-	180	-	-	-	-	11	-	-	7	-	-	1	-	-
THA_SJ_CPN02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	-	-	-	-
THA_SJ_CPN03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-
THA_SJ_CPN04	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	6	-	-	-	-	-	-	-	-
THA_SJ_CPN05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	155	2	25	-	-
THA_SJ_CPN06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23	-	-	-	-	-	-	-	-
THA_SJ_CPN07	-	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	48	-	-	-	-
THA_SJ_CPN08	-	-	-	-	-	-	1	33	-	-	9	-	-	-	-	-	-	-	-	-	11	18	-	-
THA_SJ_CPN09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_RNG01	-	-	-	-	-	-	7	118	-	-	850	-	-	-	-	-	-	-	-	305	-	-	-	-
THA_SJ_RNG02	-	-	14	-	-	-	1	-	272	-	5	-	-	-	-	52	-	-	-	49	-	-	-	-
THA_SJ_SNI01	13	2	-	-	-	-	15	-	-	-	164	6	-	-	-	39	-	-	-	631	3	-	-	-
THA_SJ_SNI02	-	-	-	-	-	-	2	-	-	-	80	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_SNI03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34	-	-	-	-
THA_SJ_SNI04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	81	-	-	-	-	-	-	-	-
THA_SJ_SNI05	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	4	-
THA_SJ_SNI06	-	5	-	-	-	-	-	26	-	1	-	-	-	-	-	200	-	-	-	270	-	-	1	-

Appendix 2. List of cave Collembola genera and number of individuals found in each sampled cave throughout Thai peninsula (cont.).

Cave code / Genera	*Acherontiella*	*Willemia*	*Xenylla*	Onychiuridae	*Folsomides*	*Folsomina*	*Isotomiella*	*Acrocyrtus*	*Ascocyrtus*	*Alloscopus*	*Coecobrya*	*Lepidocyrtus*	*Pseudosinella*	*Rambutsinella*	*Seira*	*Cyphoderopsis*	*Lepidonella*	*Salina*	*Troglopedetes*	*Cyphoderus*	*Oncopudura*	*Pararrhopalite*	*Spinaethorax*	*Neelus*
THA_SJ_SNI07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-
THA_SJ_SNI08	-	-	-	-	-	-	-	-	-	-	59	-	-	-	-	28	-	-	-	-	-	-	-	1
THA_SJ_SNI09	-	-	-	-	-	-	-	-	4	62	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_SNI10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_NRT01	3	-	-	-	-	3	-	-	-	-	237	-	-	-	-	-	-	-	-	-	-	28	3	-
THA_SJ_NRT02	127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	134	-	-	508	-	-	-	-
THA_SJ_NRT03	1	-	-	-	-	-	-	-	-	-	450	-	-	-	-	37	-	-	-	-	-	-	-	-
THA_SJ_NRT04	-	-	-	-	-	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-	6	-	-	13
THA_SJ_NRT05	-	-	-	-	-	-	-	-	-	-	170	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_PNA01	-	-	-	-	-	-	-	-	-	-	-	3	-	-	2	-	-	-	-	276	-	-	-	-
THA_SJ_PNA02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	150	-	-	-	-	-	-	-	-
THA_SJ_PNA03	2	-	-	-	-	-	4	-	-	126	200	-	-	-	-	2	-	1	-	-	-	-	-	7
THA_SJ_PNA04	-	-	-	-	-	-	-	-	-	-	-	21	-	-	-	595	-	-	-	-	-	-	-	-
THA_SJ_KBI01	-	-	-	-	-	-	-	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_KBI02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	350	-	-	-	-	-	-	-	-
THA_SJ_KBI03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	185	-	-	-	-	-	-	-	-
THA_SJ_KBI04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_KBI05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_KBI06	-	-	-	-	-	-	-	-	-	-	-	18	-	-	-	5	-	-	-	-	-	-	-	-

Appendix 2. List of cave Collembola genera and number of individuals found in each sampled cave throughout Thai peninsula (cont.).

Cave code / Genera	*Acherontiella*	*Willemia*	*Xenylla*	*Onychiuridae*	*Folsomides*	*Folsomina*	*Isotomiella*	*Acrocyrtus*	*Ascocyrtus*	*Alloscopus*	*Coecobrya*	*Lepidocyrtus*	*Pseudosinella*	*Rambutsinella*	*Seira*	*Cyphoderopsis*	*Lepidonella*	*Salina*	*Troglopedetes*	*Cyphoderus*	*Oncopudura*	*Pararrhopalites*	*Spinaethorax*	*Neelus*
THA_SJ_KBI07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_KBI08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_KBI09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_KBI10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	138	-	-	-	-	9	-	14	-
THA_SJ_KBI11	-	-	-	-	-	-	-	-	-	206	2	-	-	-	-	47	-	-	-	-	-	-	4	2
THA_SJ_TRG01	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	37	-	-	-	-	-	-	-	3
THA_SJ_TRG02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_PLG01	13	-	4	2	6	-	4	51	-	-	-	33	-	-	-	-	2	-	-	424	-	-	8	-
THA_SJ_PLG02	70	22	321	-	-	-	1	26	-	-	-	22	-	-	-	-	-	-	-	41	-	-	-	2
THA_SJ_PLG03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-
THA_SJ_PLG04	-	-	1050	-	-	-	-	-	-	-	-	228	-	-	-	-	-	-	-	300	-	-	-	-
THA_SJ_PLG05	-	-	-	-	-	-	159	-	-	-	-	1	-	-	-	72	-	-	-	-	-	-	-	1
THA_SJ_SKA01	-	-	100	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_SKA02	-	4	-	-	-	-	-	2	-	-	-	-	-	-	-	4	4	-	-	31	-	-	-	-
THA_SJ_SKA03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	280	-	-	-	-
THA_SJ_SKA04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	-	-	-	-	-	-	-
THA_SJ_SKA05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_SKA06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

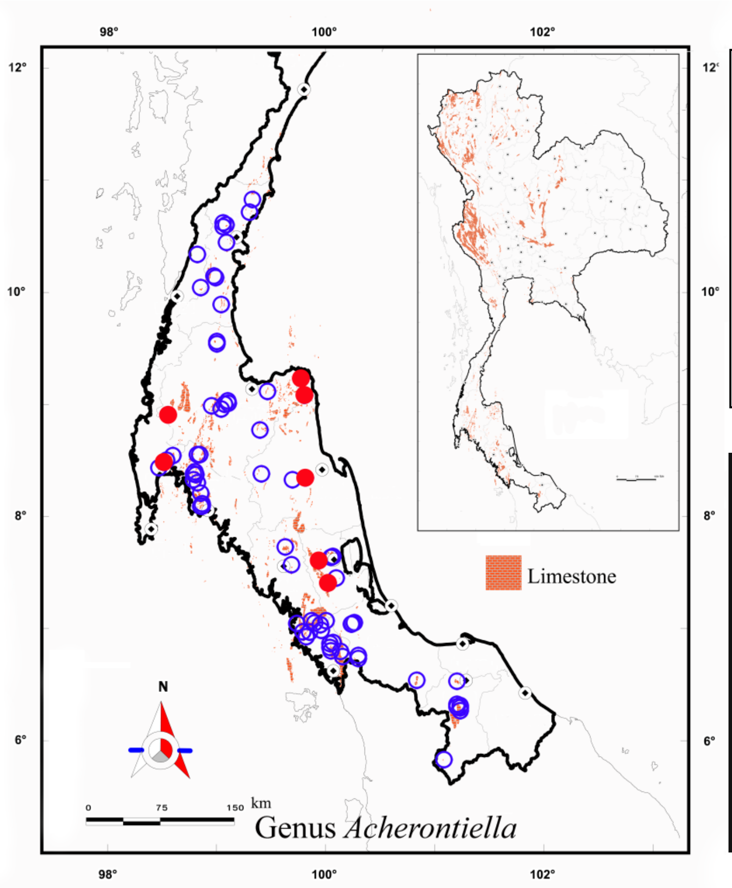
Appendix 2. List of cave Collembola genera and number of individuals found in each sampled cave throughout Thai peninsula (cont.).

Cave code / Genera	*Acherontiella*	*Willemia*	*Xenylla*	*Onychiuridae*	*Folsomides*	*Folsomina*	*Isotomiella*	*Acrocyrtus*	*Ascocyrtus*	*Alloscopus*	*Coecobrya*	*Lepidocyrtus*	*Pseudosinella*	*Rambutsinella*	*Seira*	*Cyphoderopsis*	*Lepidonella*	*Salina*	*Troglopedetes*	*Cyphoderus*	*Oncopudura*	*Pararrhopalites*	*Spinaethorax*	*Neelus*
THA_SJ_STN01	-	-	220	-	-	53	-	8	-	-	-	169	-	-	11	56	-	-	-	639	-	-	3	-
THA_SJ_STN02	-	-	67	-	-	17	-	209	-	-	14	34	-	-	-	109	11	-	-	41	-	-	1	-
THA_SJ_STN03	-	-	125	-	-	23	-	6	-	-	-	13	-	-	-	10	-	-	-	130	-	-	-	-
THA_SJ_STN04	-	-	-	-	-	12	-	54	-	-	-	2728	-	-	-	197	51	3	38	837	-	-	5	-
THA_SJ_STN05	-	-	1	-	-	-	-	4	-	-	1	170	-	49	-	566	85	-	-	168	-	3	13	-
THA_SJ_STN06	-	-	-	2	-	-	-	-	-	-	-	143	-	-	-	67	-	-	-	187	1	1	7	-
THA_SJ_STN07	-	-	-	-	-	8	-	31	3	-	-	450	-	-	3	241	32	-	-	979	-	2	-	-
THA_SJ_STN08	-	-	-	-	-	2	-	21	-	-	140	34	-	-	-	99	12	-	-	-	16	7	-	-
THA_SJ_STN09	-	-	1259	-	-	69	-	11	-	-	-	214	-	-	-	76	6	-	-	28	-	1	6	-
THA_SJ_STN10	-	-	-	-	-	1	-	116	-	-	4	112	-	-	-	17	19	-	-	7	-	6	-	-
THA_SJ_STN11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	5	-	-	1	-	-	-	-
THA_SJ_STN12	-	-	6	-	-	-	-	16	-	-	-	109	-	-	-	48	-	-	-	18	-	27	3	-
THA_SJ_STN13	-	-	-	-	-	-	-	34	-	-	-	-	-	-	-	3	-	-	-	40	-	-	-	-
THA_SJ_STN14	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-
THA_SJ_STN15	-	-	15	-	-	6	-	21	-	-	22	10	-	-	-	1234	73	-	-	20	-	8	-	-
THA_SJ_YLA01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_YLA02	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	5	-	-	-	-	2	5	-
THA_SJ_YLA03	-	-	-	-	-	-	-	1	-	-	-	-	52	-	-	-	-	-	-	-	-	1	-	3

Appendix 2. List of cave Collembola genera and number of individuals found in each sampled cave throughout Thai peninsula (cont.).

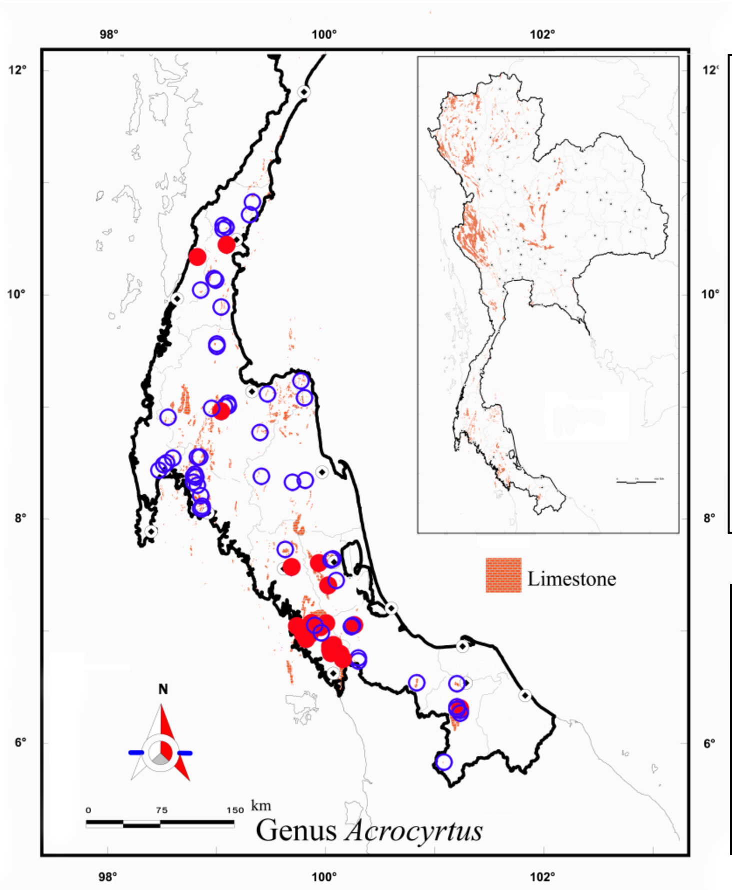
Cave code / Genera	*Acherontiella*	*Willemia*	*Xenylla*	Onychiuridae	*Folsomides*	*Folsomina*	*Isotomiella*	*Acrocyrtus*	*Ascocyrtus*	*Alloscopus*	*Coecobrya*	*Lepidocyrtus*	*Pseudosinella*	*Rambutsinella*	*Seira*	*Cyphoderopsis*	*Lepidonella*	*Salina*	*Troglopedetes*	*Cyphoderus*	*Oncopudura*	*Pararrhopalites*	*Spinaethorax*	*Neelus*
THA_SJ_YLA04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_YLA05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_YLA06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
THA_SJ_YLA07	-	-	-	-	-	5	-	-	-	-	4	285	-	-	-	65	-	-	-	-	20	9	14	-
Total	**229**	**35**	**3182**	**4**	**6**	**199**	**197**	**800**	**279**	**395**	**2592**	**5031**	**56**	**60**	**14**	**4435**	**483**	**4**	**45**	**6479**	**68**	**139**	**91**	**32**
Overall	**24,855**																							

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus.



Genus *Acherontiella* Absolon, 1931

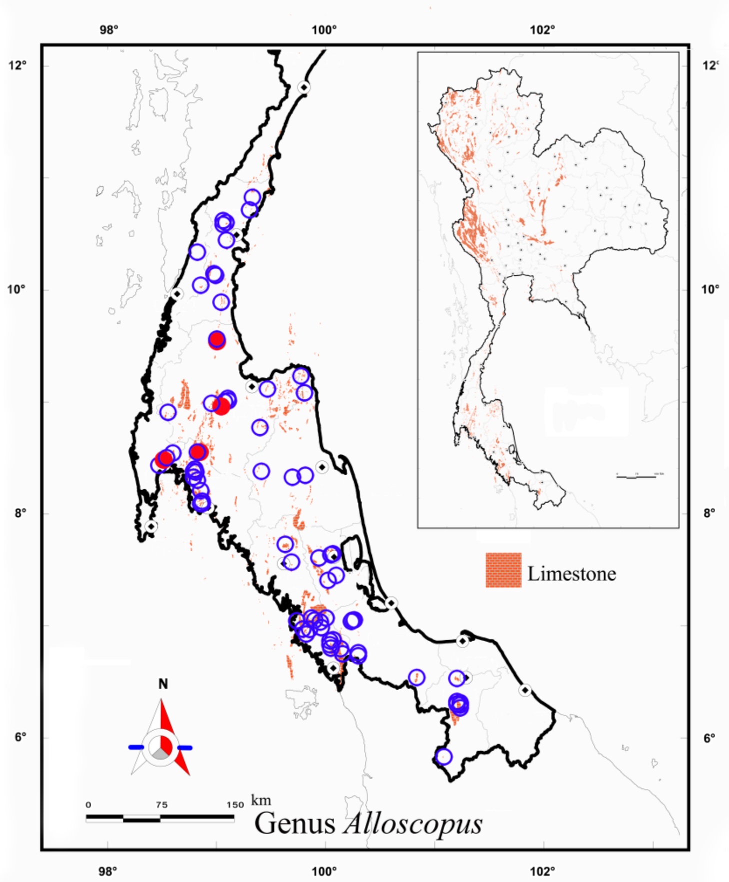
At least 3 different taxa were identified (*Acherontiella* sp.1, sp.2 and sp.3). In this study, they are found in 7 caves throughout the Thai peninsula as showed in the map



Genus *Acrocyrtus* Yosii, 1959

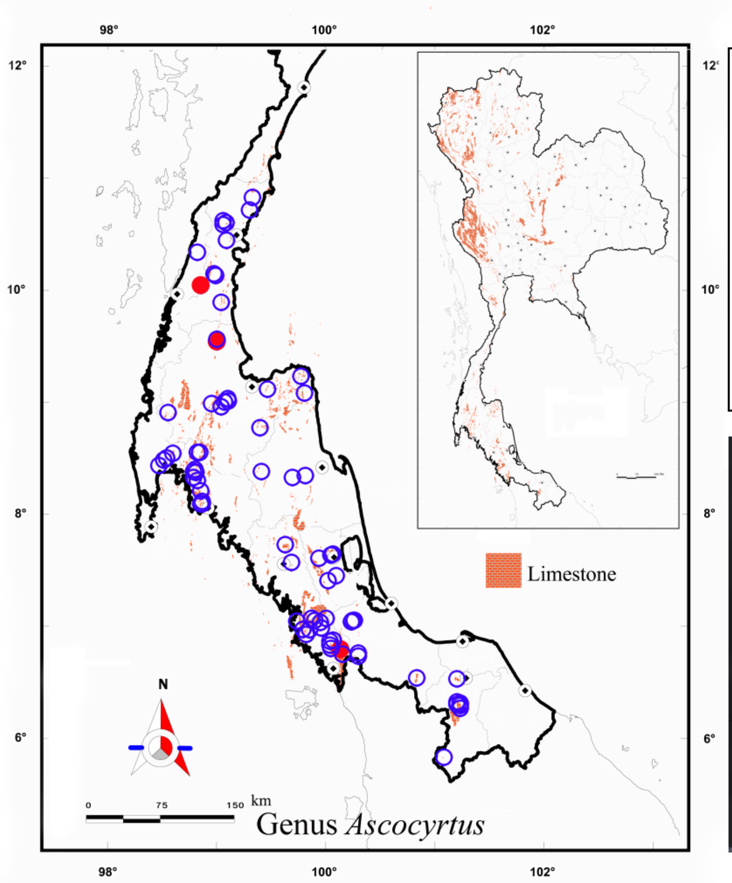
At least 4 species were identified (*Acrocyrtus* cf. *malayanus*, *Acrocyrtus* cf. *carosus gentingensis*, *Acrocyrtus* sp.1 and sp.2) In this study, they are found in 20 caves throughout the Thai peninsula as showed in the map

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Alloscopus* Börner, 1906

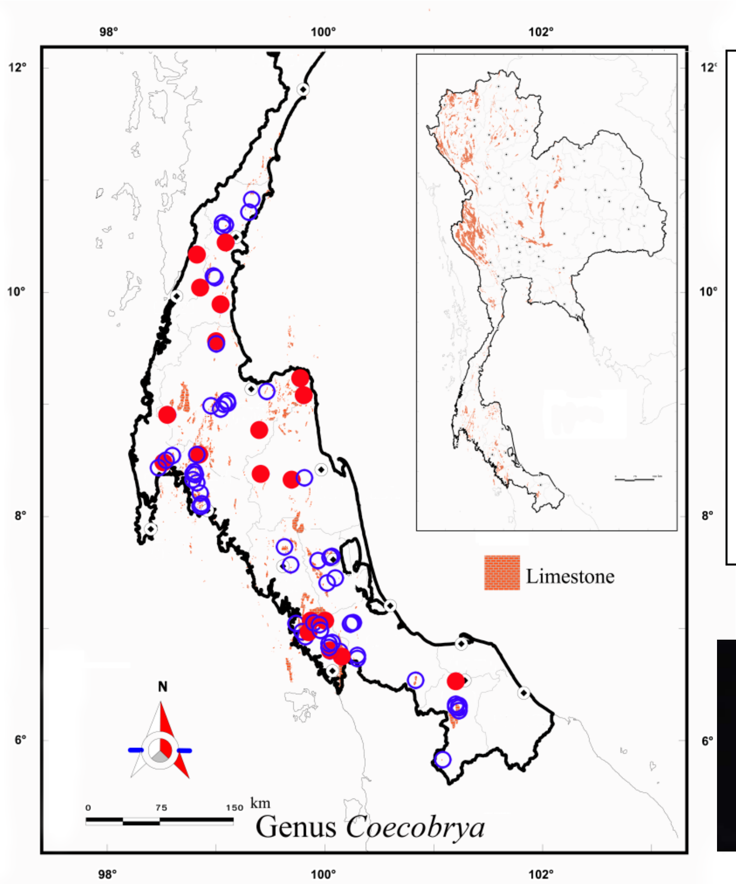
At least 3 different taxa were identified (*Alloscopus* sp.1, sp.2 and sp.3). In this study, they are found in 4 caves throughout the Thai peninsula as showed in the map.



Genus *Ascocyrtus* Yosii, 1963

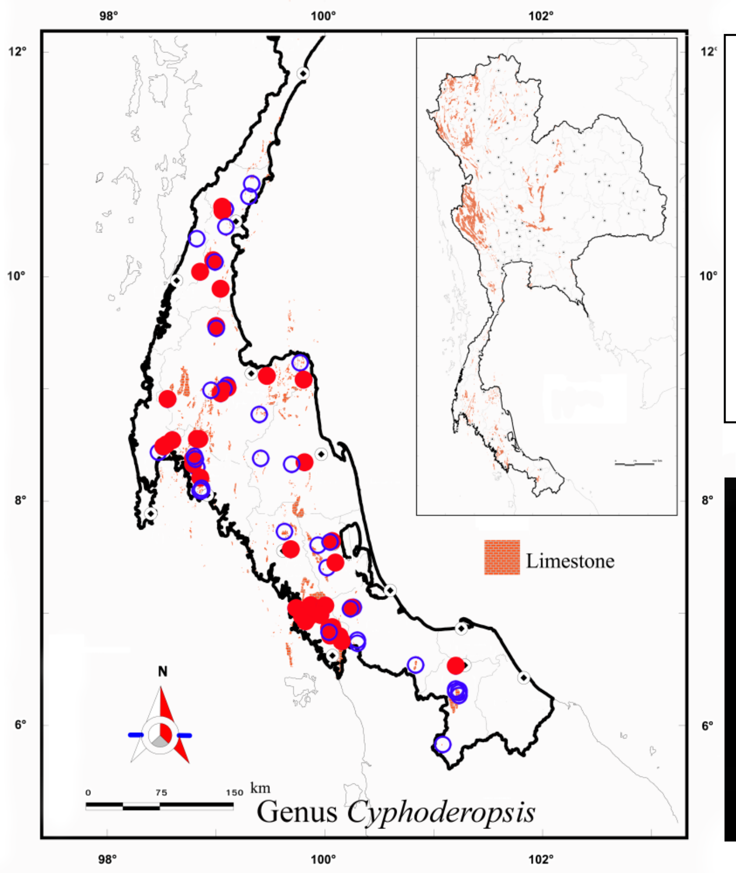
At least two different taxa were identified. There are *Ascocyrtus* sp.1 and sp.2). In this study, they are found only 3 caves throughout the Thai peninsula as showed in the map.

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Coeocbrya* Yosii, 1956

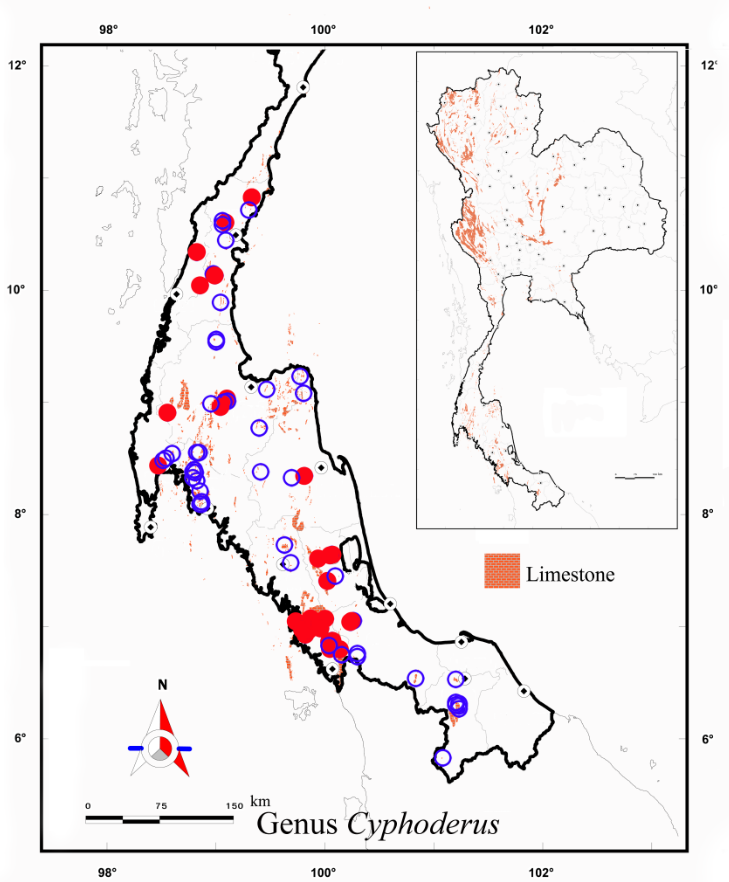
At least 13 species were identified. There are *Coeocbrya cavicta*, *C. chumphonensis*, *C. polychaeta, C.* cf. *polychaeta*, *C.* sp 1 - sp.8 and *C.* spp. Two morphological forms are found. In this study, they are found in 19 caves throughout the Thai peninsula as showed in the map.



Genus *Cyphoderopsis* Caroenter, 1917

At least 18 species were identified. There are *Cyphoderopsis* sp 1 - sp.17 and *C.* spp. In this study, they are found in 39 caves throughout the Thai peninsula as showed in the map.

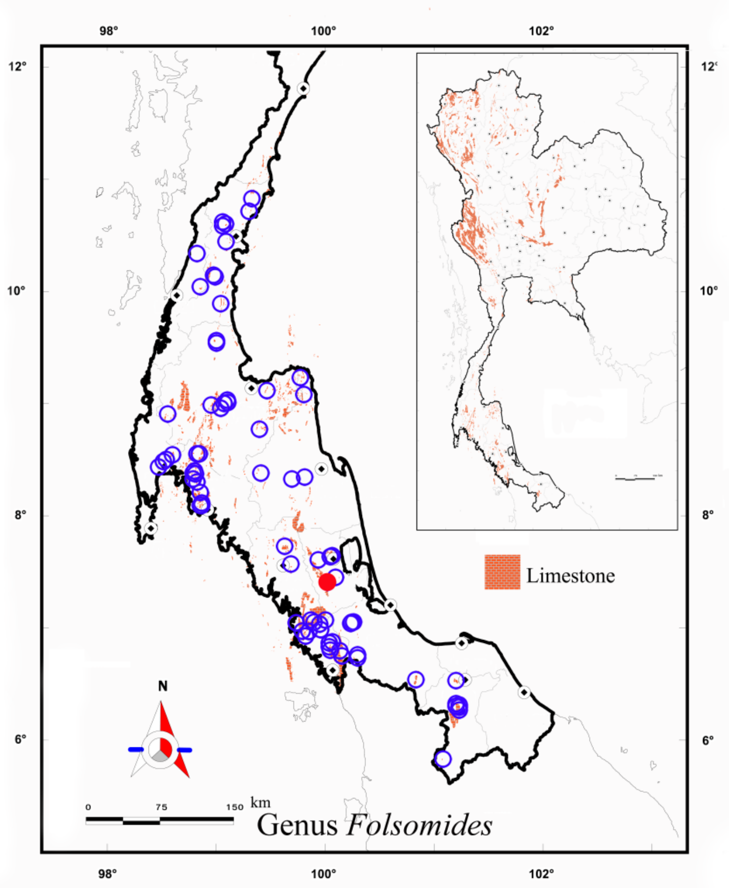
Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Cyphoderus* Nicolet, 1842

At least 7 species were identified.

There are *Cyphoderus* sp 1 - sp.6 and *C.* spp. In this study, they are found in 29 caves throughout the Thai peninsula as showed in the map.

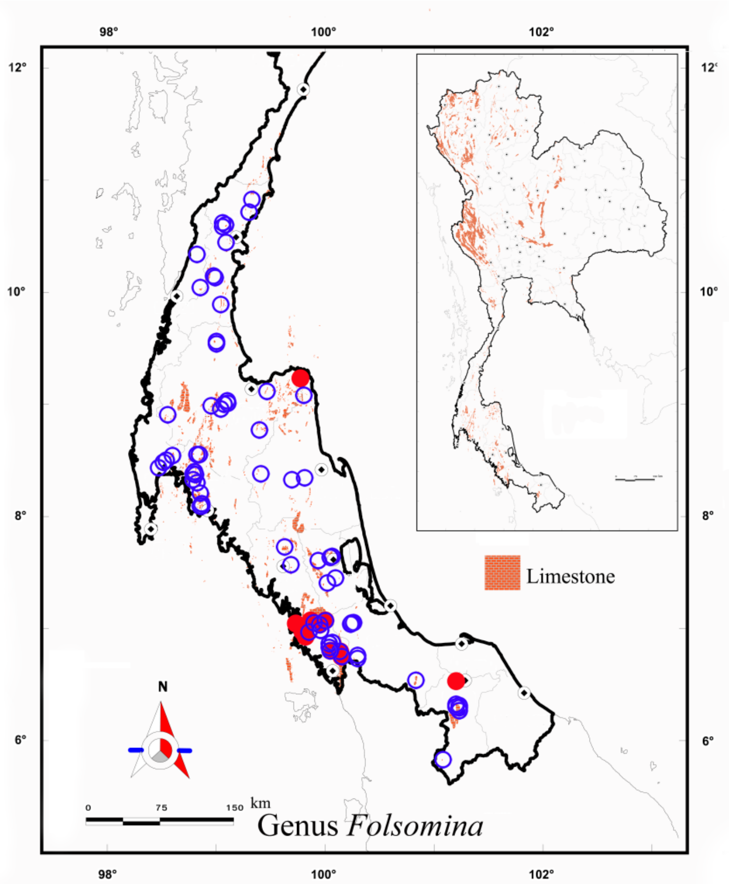


Genus *Folsomides* Stach, 1922

Only single species was recognized.

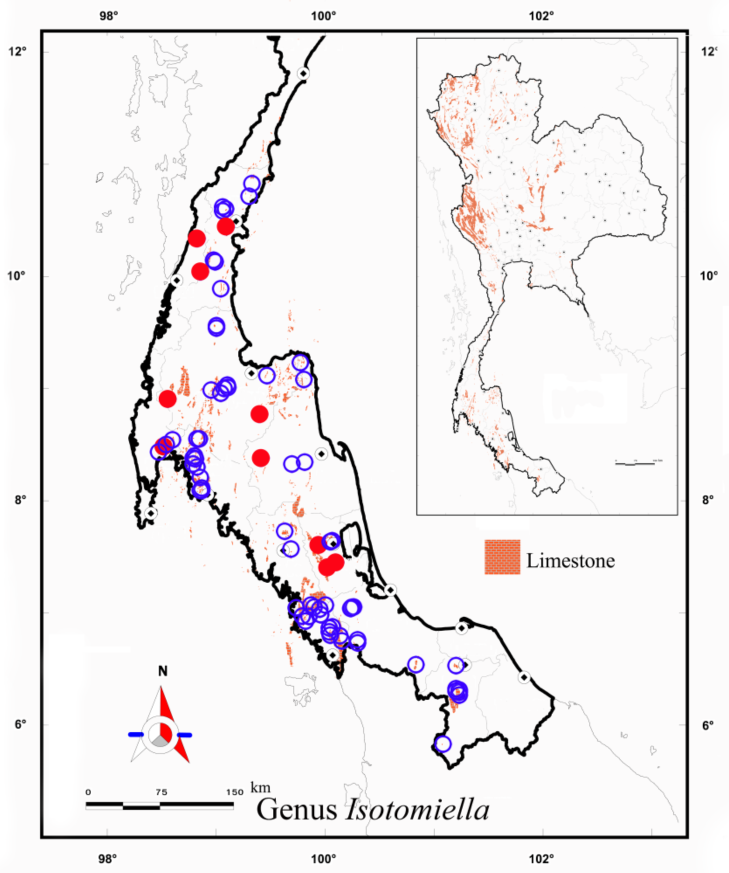
There is *Folsomides centralis*. In this study, they are found only one cave throughout the Thai peninsula as showed in the map.

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Folsomina* Denis, 1931

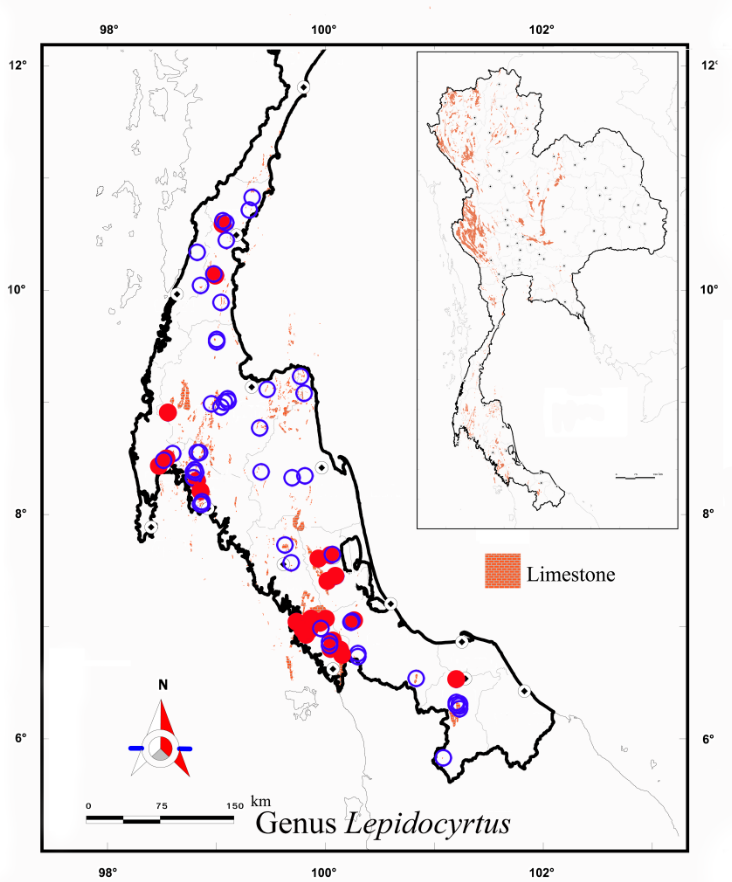
Only single species was recognized. There is *Folsomina onychiurina*. In this study, they are found in 11 cave throughout the Thai peninsula as showed in the map.



Genus *Isotomiella* Bagnall, 1939

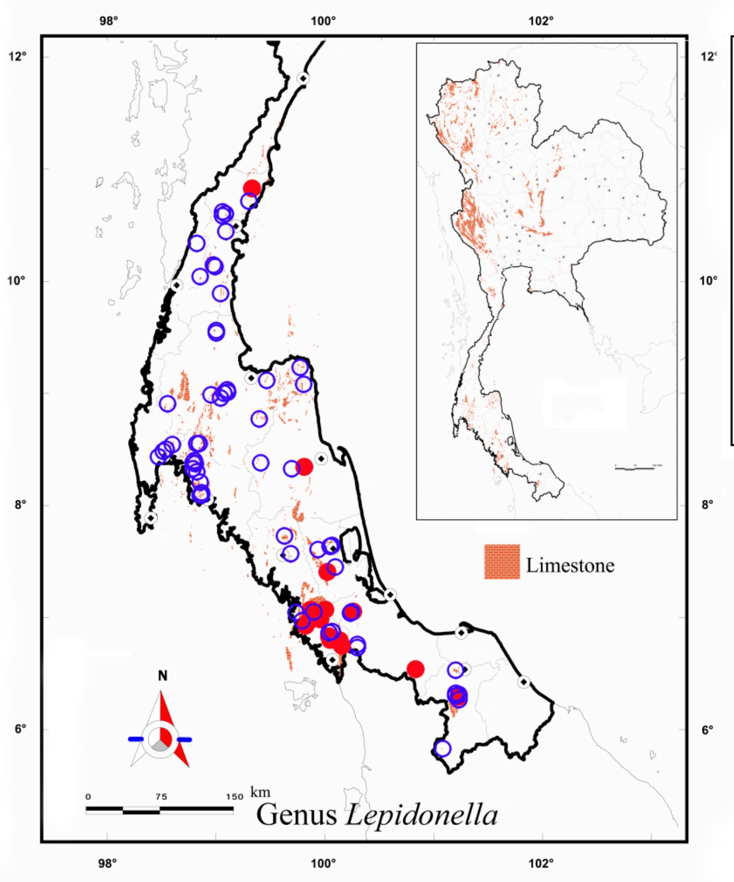
At least 3 different taxa were identified. There are *Isotomiella* sp.1 - sp.3. In this study, they are found in 10 caves throughout the Thai peninsula as showed in the map.

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Lepidocyrtus* Bourlet, 1839

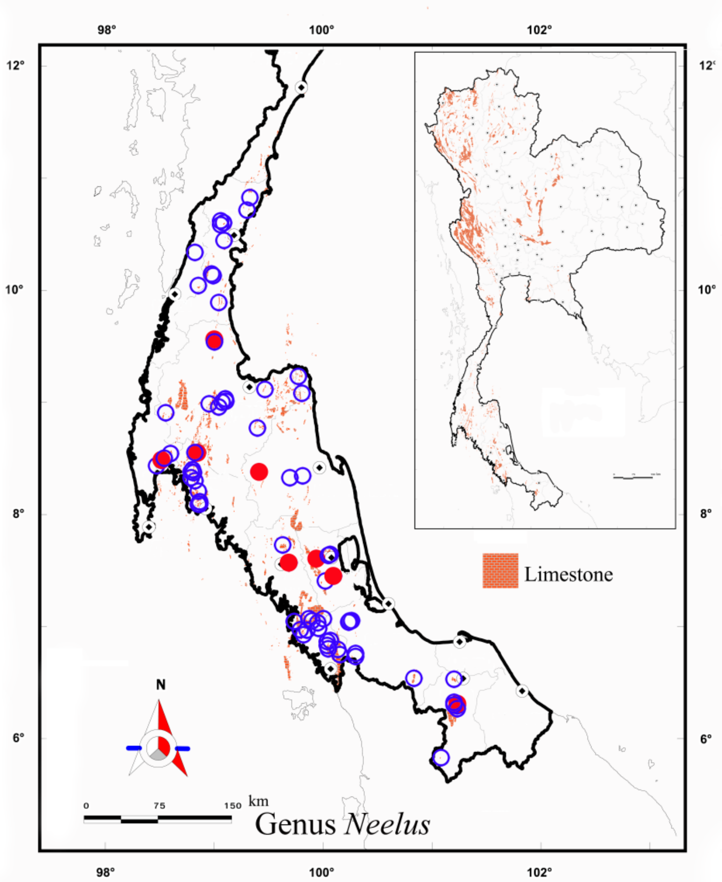
At least 2 different taxa under subgenus *Lanocyrtus* were identified. There are *Lepidocyrtus (Lanocyrtus)* sp.1 and sp.2. In this study, they are found in 25 caves throughout the Thai peninsula as showed in the map.



Genus *Lepidonella* Yosii, 1960

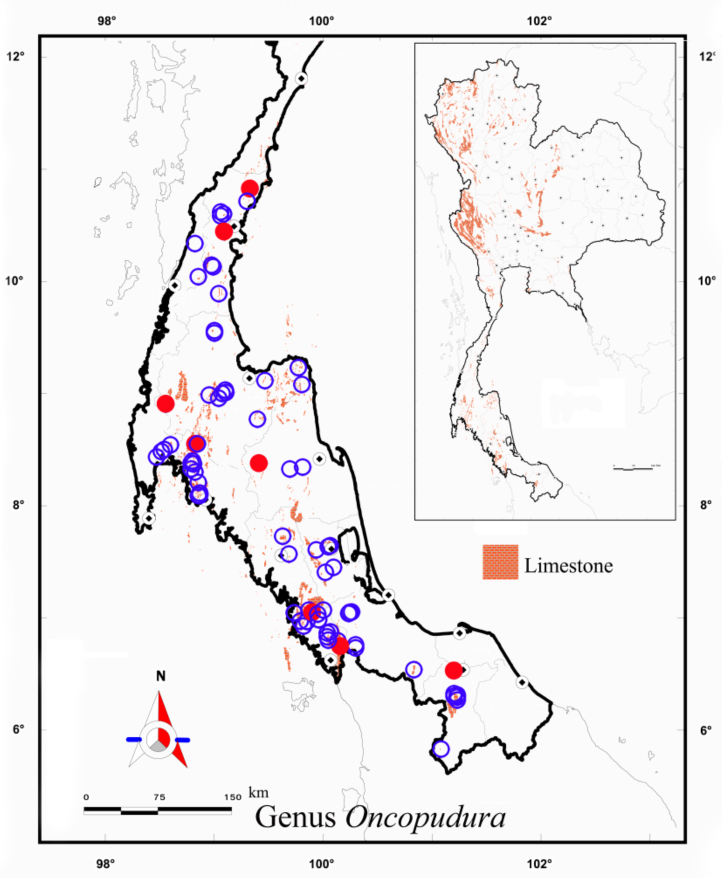
At least 7 different taxa were identified. There are *Lepidonella* sp.1 - sp.6. and *L.* spp.. Two morphological forms are found. In this study, they are found in 17 caves throughout the Thai peninsula as showed in the map

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Neelus* Folsom, 1896

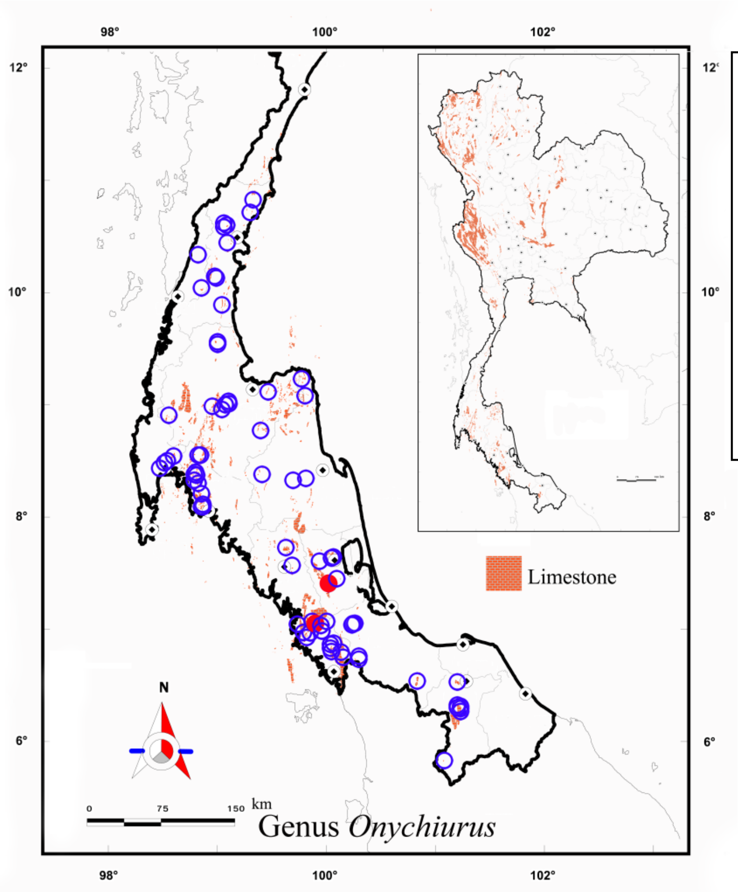
At least 4 different taxa were identified. There are *Neelus* sp.1 - sp.4. In this study, they are found in 8 caves throughout the Thai peninsula as showed in the map.



Genus *Oncopudura* Carl and Lebedinsky, 1905

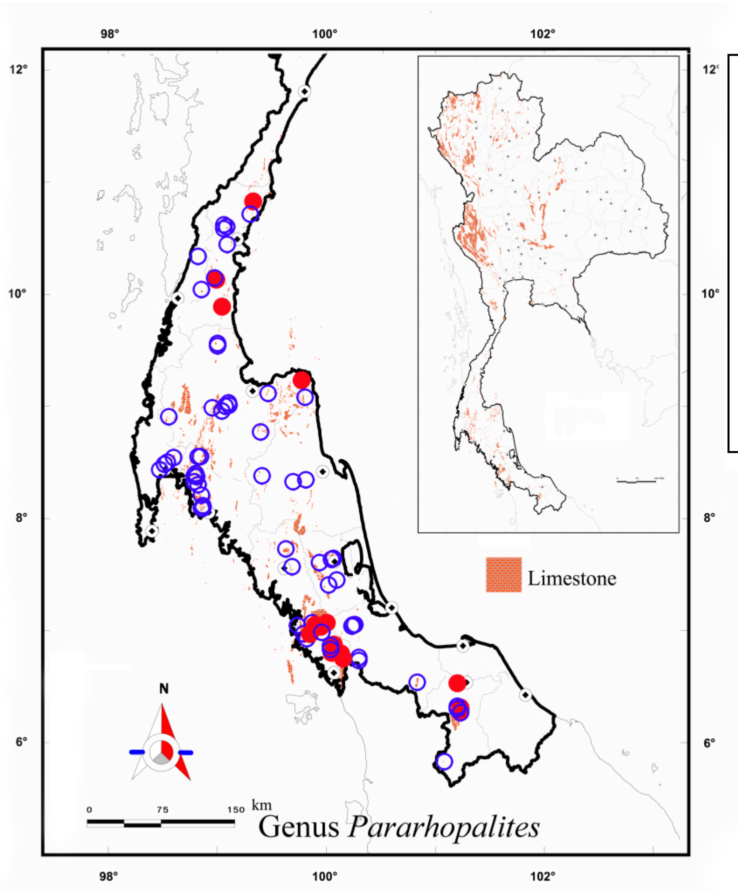
At least 4 different taxa were identified. There are *Oncopudura* sp.1 -sp.4. In this study, they are found in 8 caves throughout the Thai peninsula as showed in the map.

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Onychiurus* Gervais, 1841

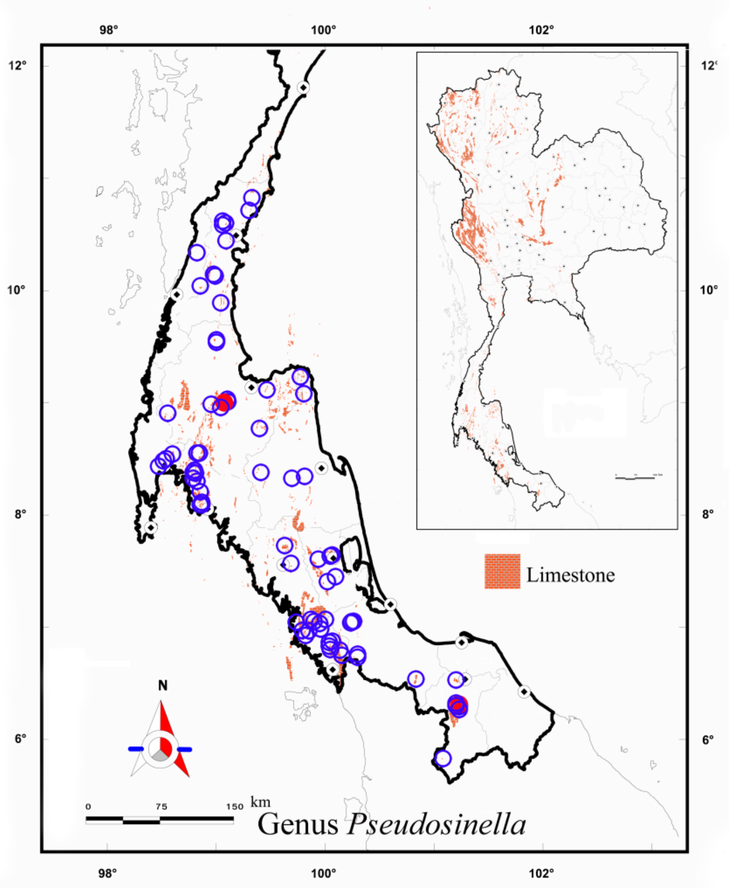
Only one taxa was identified. It is *Onychiurus* sp.1. In this study, they are found in 2 caves throughout the Thai peninsula as showed in the map. Unfortunately, there is no photograph for this genus.



Genus *Pararhopalites* Bonet and Tellez, 1947

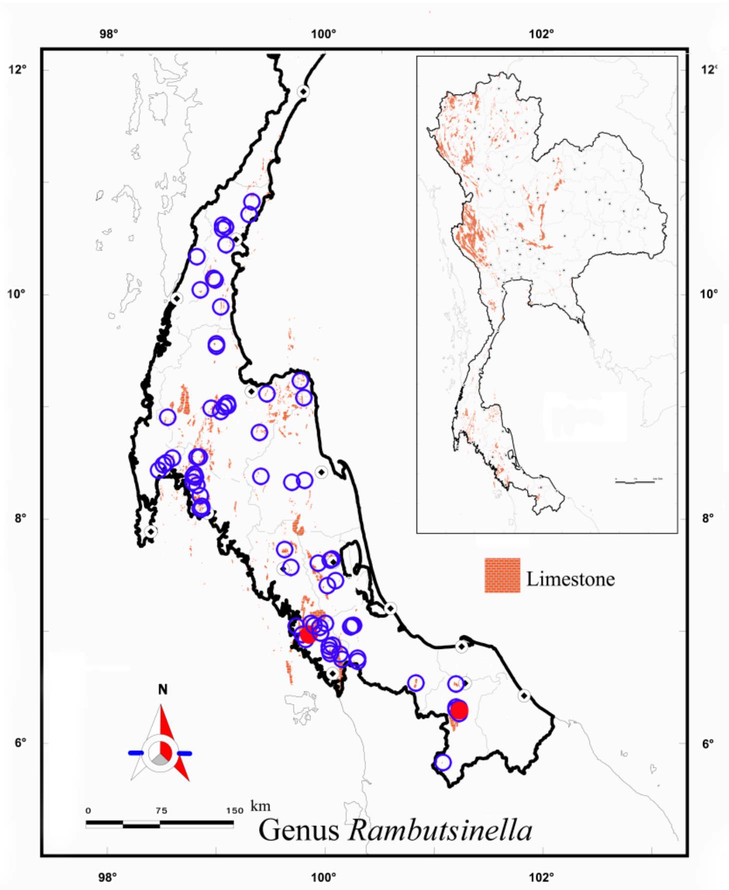
At least 4 different taxa were identified. There are *Pararhopalites* sp.1 - sp.4. In this study, they are found in 15 caves throughout the Thai peninsula as showed in the map.

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Pseudosinella* Schäffer, 1897

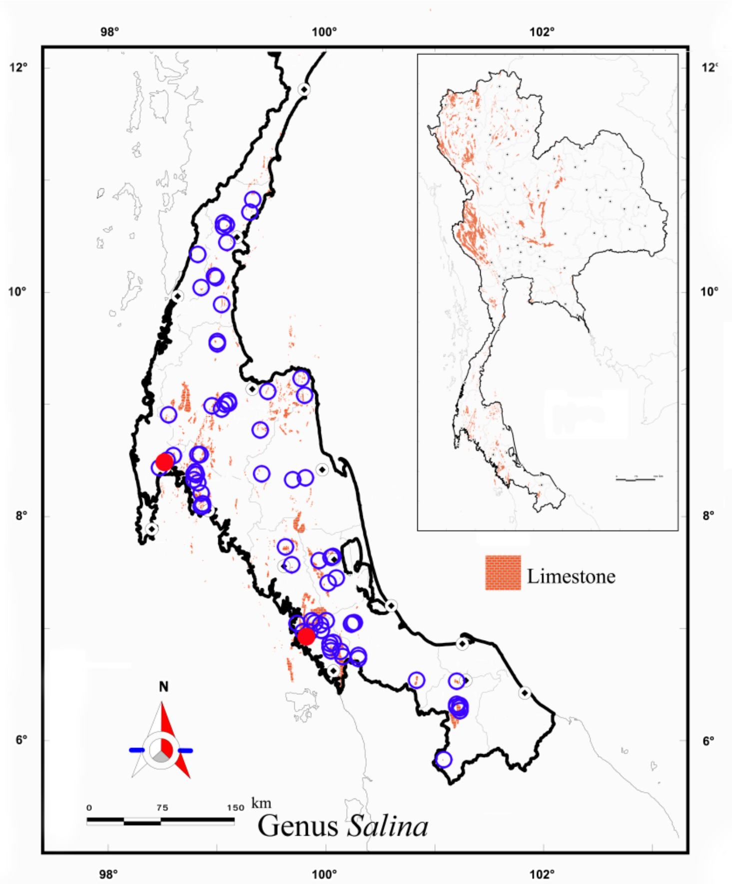
Only one taxa was identified. It is *Pseudosinella* sp.1. In this study, they are found in 2 caves throughout the Thai peninsula as showed in the map.



Genus *Rambutsinella* Deharveng and Bedos, 1996

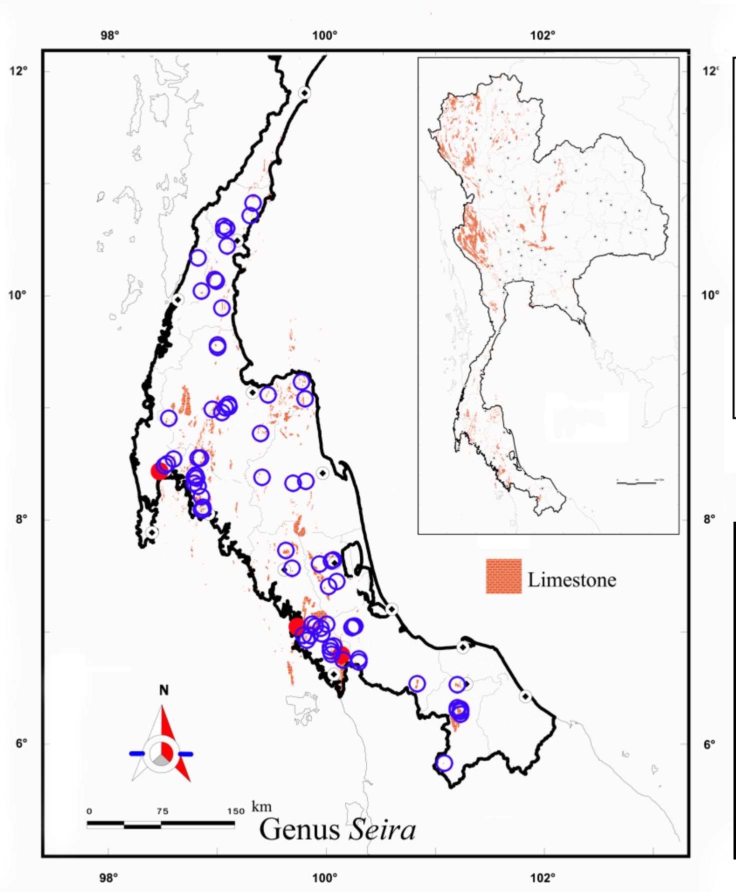
Only one taxa was identified. It is *Rambutsinella* sp.1. In this study, they are found in 2 caves throughout the Thai peninsula as showed in the map. Unfortunately, there is no photograph for this genus.

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Salina* Gillivray, 1894

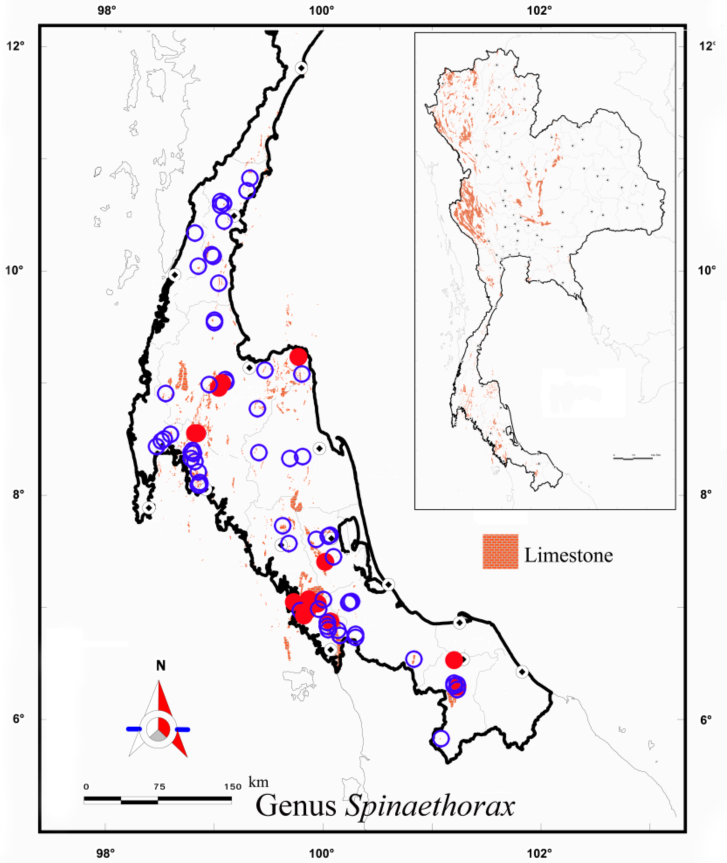
Only one taxa was identified. It is *Salina* sp.1. In this study, they are found in 2 caves throughout the Thai peninsula as showed in the map.



Genus *Seira* Lubbock, 1870

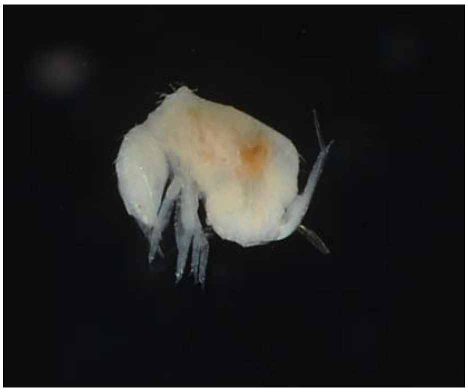
Only one taxa was identified. It is *Seira* sp.1. In this study, they are found in 3 caves throughout the Thai peninsula as showed in the map.

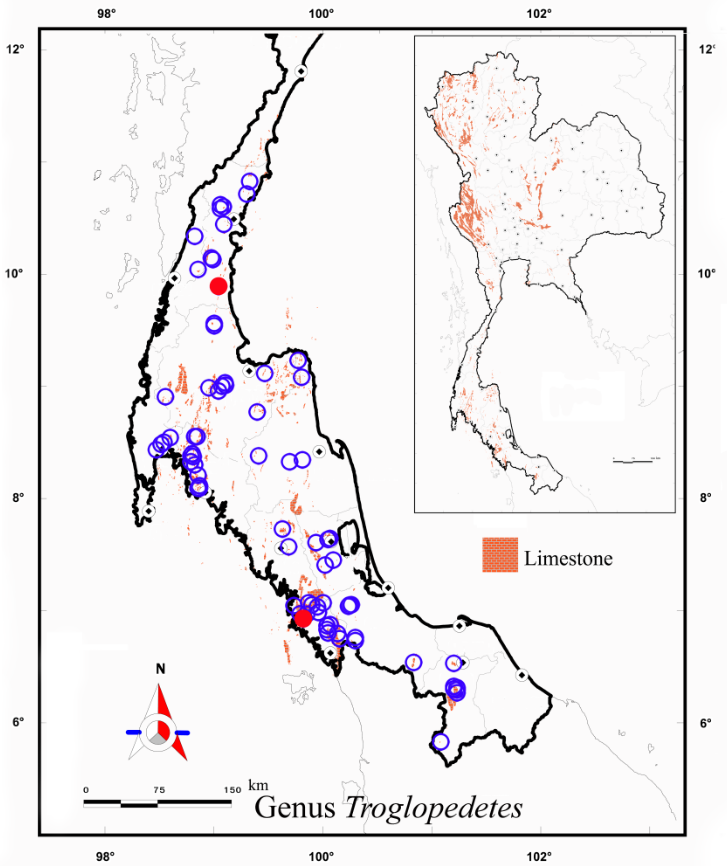
Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Spinaethorax* Papác and Palacios-Vargas, 2016

At least 5 different taxa were identified. There are *Pararhopalites* sp.1 - sp.5. In this study, they are found in 16 caves throughout the Thai peninsula as showed in the map.

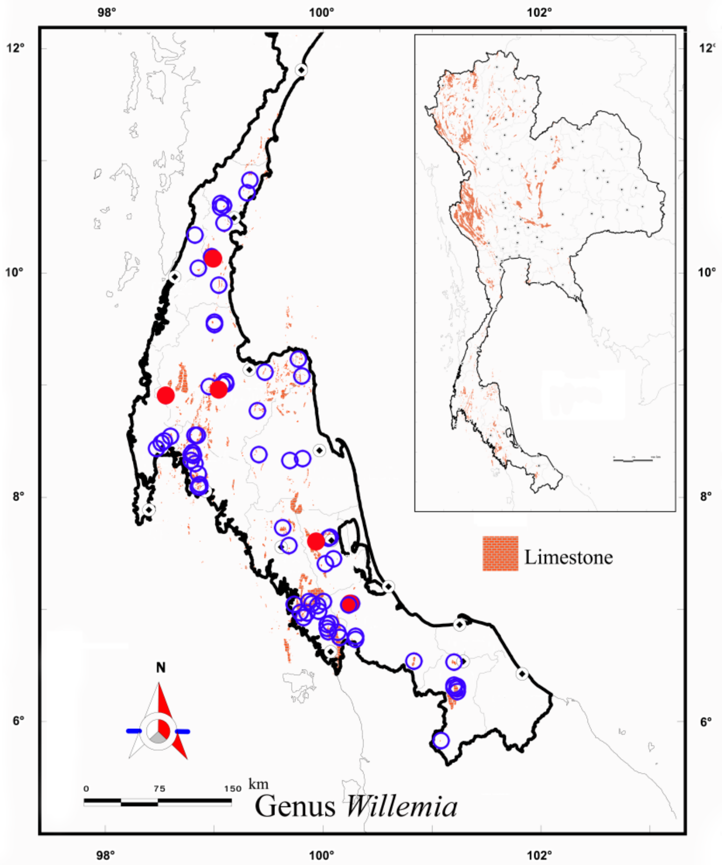




Genus *Troglopedetes* Absolon, 1907

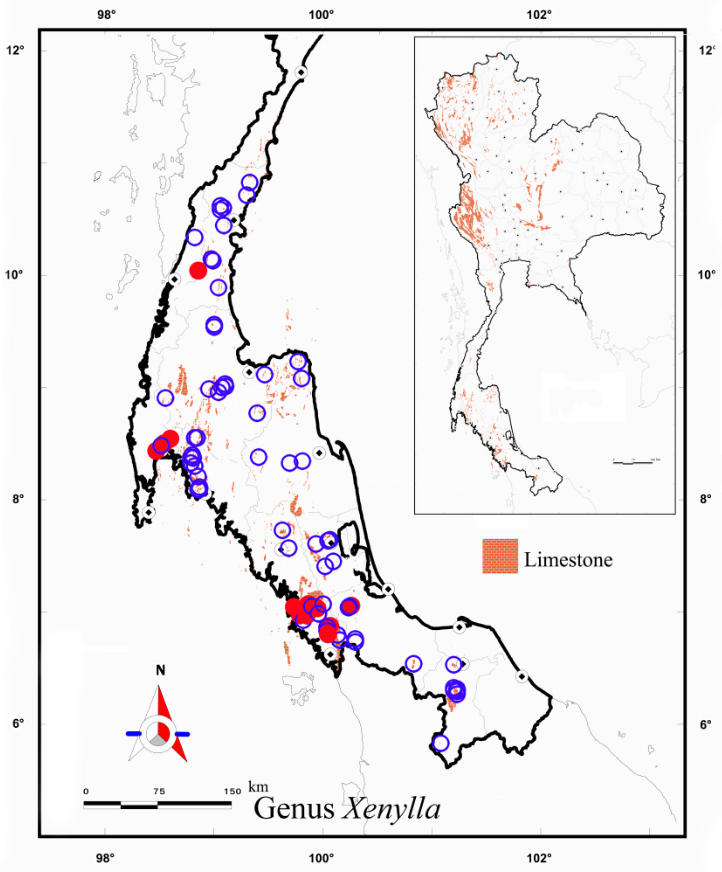
At least 2 different taxa were identified. There are *Troglopedetes* sp.1 - sp.2. In this study, they are found only 2 caves throughout the Thai peninsula as showed in the map.

Appendix 3. Distribution map and pictorial key to the cave Collembola in this study by genus (cont.).



Genus *Willemia* Börner, 1901

Only single species of *W. nadchatrami* is recognized in cave of Thai peninsula. In this study, they are found in 5 caves throughout the Thai peninsula as showed in the map.



Genus *Xenylla* Tullberg, 1869

Only *X. yucatana* is recognized in cave of Thai peninsula. In this study, they are found in 12 caves throughout the Thai peninsula as showed in the map.

Appendix 4. Publications

At least two articles have been published in the scientific journal index by SIS as follows.

1. Jantarit, S., Bedos, A. and Deharveng, L. 2016. An annotated checklist of the Collembolan fauna of Thailand. *Zootaxa*, 4169(2): 301–360.

2. Nilsai, A., **Jantarit, S**, Chutamas, S and Zhang, F. 2017. Three new species of *Coecobrya* (Collembola: Entomobryidae) from caves in the Thai Peninsula. *Zootaxa*, 4286(2): 187–202.

Appendix 5. Conference presentation

At least one international conference and one national meeting were attended to present the result of this research as follows.

1. **Jantarit, S.** and Deharveng, L. 2016. Cave Collembola of Southern Thailand. XVII International Colloquium on Soil Zoology and XIV International Colloquium on Apterygota, Nara, Japan, 22th–26th August 2016 (*oral presentation*).
2. **Jantarit, S.**, Satasook, C. and Deharveng, L. 2017. Cave springtails (Hexapoda: Collembola) of Thai peninsula. TRF-OHEC annual congress 2017, Cha-Am, Petchaburi Province, Thailand. January 11th-13th, 2017 (*poster presentation*)

ICA
NARA, JAPAN, 2016

The XIV International Colloquium on Apterygota

on 24-26 August 2016, in Japan

URL: http://soilzoology.jp/icsz_ica2016/

Email: icsz_ica_submission@soilzool.sakura.ne.jp

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Cave Collembola of Southern Thailand

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Abstract

Peninsular Thailand has extensive cave-containing karst areas across almost all the region. However, even if better documented than in surrounding countries, the diversity of these caves remains poorly known and has seldom been scientifically studied. In this presentation, we analyze a large collection of Collembola from 60 caves in 11 provinces. A total of 10 families, 22 genera and 40 species (including morphospecies) were recognized. In each cave, one to ten species were reported. Molecular and morphological evidences reveal that each karstic unit has its own species of Collembola in particular in the family Paronellidae and Entomobryidae. Most collected species of *Cyphoderopsis*, *Lepidonella* and *Coecobrya* were in particular unknown to science and are endemic to karst units of limited extent. Biogeographically, the presence of cave *Lepidonella* in the region indicates unexpected relationships with southern Vietnam, that are currently under investigations. Maps of distribution of all known species and morphospecies of troglobitic Collembola of Peninsular Thailand by genus have been set up. They are intended to be used as a management tool in the future, as several of the karstic hills and of the caves of the region are under significant human pressure.

Appendix 6. Type of cave in Thai peninsula




1. Pristine or natural caves:

This kind of cave is hardly seen in the lowland habitat of Thai peninsula but it can remain in the high altitude where cave is difficult to access and in the National Park where the cave access /or most parts are protected. This cave is rarely accessible by local people and no/little simple infrastructure inside. All natural structures inside cave (i.e. stalagmite, stalactite, flowstones, helictite, soda straws and columns) remain a good quality and gradually growing.

Appendix 6. Type of cave in Thai peninsula (continued.).

2. Cave temples

This cave is occupied by Buddhist temples and generally most or some parts of cave are modified, excavated and decorated. Buddha and related statues are commonly found in cave and are the symbol of the religion. Floor is replaced by concrete walkway or bricks as well as the light energy in order for religion rituals or dwelling purpose. Each cave temple, the degree of disturbance is not the same line and it depends on the number of visitor. Most famous cave temples attract a great deal of tourist attention and in the meanwhile it can be defined as tourist cave. Obviously infrastructures from simple to advance modification from entrance to the dark zone of cave are well-acknowledge. Light is always introduced and most animals are force to leave the cave (bats, snake for example) by direct and indirect manners. Infamous cave temple is, fortunately, partly modified the habitat and mostly only the entrance or twilight zone of cave.

Appendix 6. Type of cave in Thai peninsula (continued.)

3. Tourist or show caves:

This type of cave is developed by local government, only a few cave of each province are successful to be a good spot for tourism industry. Unfortunately, many are not popular and then become abandoned caves later on. However, the cave is fully modified with advance infrastructure i.e. long-distance concrete walkway, ladle (both woods and concrete) and introduction of light energy inside cave at least 8-12 hours daily. Pollution and rubbish are dumped inside the cave and easily noticed. To date, tourism industry and frequent human visitations inside cave is, however, growing.

Appendix 6. Type of cave in Thai peninsula (continued.)

4. Guano mining/harvesting cave

Nowadays, active guano mining cave is seldom available In Thai peninsular, however, in the past guano, in many caves, were seriously harvesting for agricultural and business purposes. This kind of cave is almost 100% destroyed and micro-habitats is extremely changed (from entrance to the dark zone) according to the severe digging shafts to access guano deposits from 1 meter up to 5 meter height. Most of former guano mining cave are in dry condition. However, many caves are recovering and migratory bats colony returns to use cave as a roosting site. It is important to say that guano harvesting by local people alone is not seriously harmful to the caves.

Appendix 7. Unsustainable limestone quarrying as a result of demanding for cement consumption.

Zootaxa 4169 (2): 301–360
http://www.mapress.com/j/zt/

Article

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An annotated checklist of the Collembolan fauna of Thailand

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Table of contents

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Abstract

The current knowledge of the Collembolan fauna of Thailand is reported here, based on the checklist of Bedos (1994) completed by data on several taxa described since this date, with an update of the taxonomic status of the species. A total of 194 species from 53 genera and 14 families are listed, that were mostly discovered and described during the last three decades. The updated checklist illustrates a strong unevenness in sampling efforts across space and habitats, and in the degree of taxonomic coverage of the different families of the group. Geographically, only the Doi Inthanon massif can be considered as relatively well known, but even there the species in several major habitats and microhabitats have not been sampled. Data are lacking or much more limited for all other regions of the country. The species richness of Thailand is undoubtedly much more than observed number.

Key words: Springtails, distribution, biodiversity, species richness

Introduction

Taxonomic checklists including data on the distribution and habitats of species, as well as on sources of information, are the basis of ecological and macroecological studies. They are also necessary to implement sound conservation policies. Regarding Collembola, such checklists more or less detailed have been recently published for Brazil (Abrantes *et al.* 2010), Ivory Coast (Zon *et al.* 2013) and South Africa (Janion-Scheepers *et al.* 2015).

Nothing comparable exists for Thailand, in spite of the large amount of data available for this country. Plants and vertebrates of Thailand have long been observed and are today well documented (Hutacharen *et al*. 2007). Like in other tropical regions, arthropods are much less well known, though largely dominant in terms of species richness. For example, a recent list of insects and mites of Thailand included 10,191 species (Hutacharen *et al*. 2007). In spite of being the most remarkable biodiversity reservoirs among terrestrial habitats in terms of the variety of animal and functional groups they host (Rusek 1998), soils have been particularly poorly investigated. Collembola, also known as springtails, are, together with mites, dominant in animal communities of these habitats by both their high abundance and local diversity (Cassagnau 1990). More than 8,000 species of Collembola have been described worldwide (Bellinger *et al*. 2016), but most of them are from temperate regions. The group is particularly under-sampled and under-recorded in the tropics, in comparison to taxonomically more well known hexapods like butterflies, beetles, or dragonflies.

This poor knowledge may be explained by the innocuousness of Collembola for man and the lack of charisma due to their small size and often cryptic coloration. As a result, Collembola were paid little attention until recently, even by tropical soil scientists, and are easily overlooked by non-specialist collectors. Their study is also seriously hampered by the lack of taxonomic revisions and identification keys.

Collembola in Thailand were first reported by Yosii (1961) who described 19 species in 10 genera. Thereafter, their study came to a standstill until the expeditions organized by the Association Pyrénéenne de Spéléologie from 1985 to 1988 (Association Pyrénéenne de Spéléologie 1986, 1987, 1988), followed by the dissertation of A. Bedos (1994), that generated the discovery of a large number of species that were identified and studied during the 1980s' and 1990s' (Bedos & Deharveng 1990, 1991, 1994; Deharveng 1987a, 1987b, 1988a, 1988b, 1989, 1990, 1991; Deharveng & Bedos 1991, 1992, 1993a, 1993b, 1995; Deharveng & Gers 1993; Deharveng & Suhardjono 1994; D'Haese & Weiner 1998; Mari Mutt 1985a, 1985b, 1988; Nayrolles 1989, 1990; Thibaud 1990). Other significant taxonomic publications include Kim *et al*. (1999a, 1999b), Yosii (1976) and Yoshii (1985). The last taxonomic studies were carried out by Jantarit *et al*. (2013, 2014). Lists of Doi Inthanon Collembola are given in Deharveng *et al*. (1989) and Deharveng & Bedos (1993b) based on original data. Other lists of Thai Collembola are compiled in Hutacharen *et al*. (2007) and Rojanavongse *et al*. (unpublished report, used with the permission of authors, available in the Kasetsart University library); this last report is not dated, but posterior to 1999, as it includes the species described in Kim *et al*. (1999a, 1999b); it also lacks information on distribution, ecology and literature sources for the listed species, but it is the most complete list published after Bedos (1994). Kim *et al*. (1999a) claimed that the known Thai Collembola included a total of 129 species in 26 genera and 5 families; the supporting species list was not given, but is provided in Rojanavongse *et al*. (unpublished report). Hutacharen *et al*. (2007) listed only 28 species of Collembola in their checklist of insects and mites of Thailand.

In contrast to taxonomic studies, investigations on biodiversity patterns and community ecology were much more limited. Takeda (1981) and Wiwatwitaya & Takeda (2005) studied the impact of shifting cultivation and seasonal changes on Collembolan communities in northeastern Thailand. Deharveng *et al*. (1989) analyzed the structure and composition of Collembola communities in the soil of the Doi Inthanon. The influence of various environmental parameters on biodiversity, including altitude, soil organic matter content, temperature and pH were investigated in the same mountain by Deharveng & Bedos (1993b).

All data prior to 1994 as well as many unpublished records are gathered in the dissertation of Bedos (1994). Detailed data on species and community ecology also are available in this work, with emphasis on Doi Inthanon in Chiang Mai province, from which we extracted succinct information for each species and morphospecies.

In the present paper, we provide a comprehensive checklist of the Collembola of Thailand, based on an exhaustive list of relevant bibliographical references. The geographical, ecological and taxonomical gaps in our knowledge are discussed.

Materials and methods

The checklist of Thai Collembola has been compiled from the available literature published until December 2015. Species, morphospecies, genera and morphogenera are included in the list. Taxa identified at species level or refered to named species (cf.) are numbered. The species designated species as cf. are undescribed or unidentified species, but not duplicate of other named species of the list. Those only identified at the level of species-group, genus or higher taxonomic level are listed but not numbered. The checklist follows the classification and systematic hierarchy proposed by Deharveng (2004), amended for Entomobryidae according to Zhang & Deharveng (2014). Alphabetical order is used to list the species within their genus, and the genera within their family or subfamily. Taxonomic order is used at higher taxonomic level. Each account includes: valid scientific name with author(s) and year of description, synonyms, distribution in Thailand (province and region), ecology, distribution outside Thailand, material deposit and source(s) of original citation(s). The material deposit is given only when the species is described from Thailand. For habitat, we give when available: the microhabitat, considering soil *sensu lato* (s.l.) when the layer (soil or litter) is not specified in the records, the altitudinal range, the macrohabitat and when relevant the name of the site to which the information applies. Remarks include comments on identifications, recent taxonomic changes as well as number of morphospecies when given in the source. Species name given in the list is the current one, with the name provided in the source of the records given when different from the current name. The cited references for each species are arranged chronologically. Confer (cf.) and subspecies are included in the list. Unidentified taxa and morphospecies (sp., spp.) are reported in the species list but not counted in species number. Species cited in Thai theses do not constitute formal publication and are not considered herein. The numbers of described and endemic species are given for each province in Figs 1 and 2. The occurrence of each species or morphospecies in the checklist is given by province and by biogeographic region according to Lekagul & Round (1991): North, North-East, Central plains, West, South-East and Peninsula.

Abbreviations

BDCM—Biology department, Chiang Mai University, Chiang Mai, Thailand
BPBM—Bishop Museum, Honolulu, Hawaii
CNU—Faculty of Biological Sciences, Chonbuk National University, Chonju, Korea
ISEA—Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland
KU—Department of Entomology, Kasetsart University, Thailand
LEITT—Laboratoire d'Ecologie des Invertébrés Terrestres, Université Paul Sabatier, Toulouse, France (= Laboratoire de Zoologie, Université Paul Sabatier, Toulouse, France); all this material will be deposited in 2017 in the MNHN.
MC—Zoological Museum of University of Coimbra, Portugal
MHNG—Musée d'Histoire Naturelle de Genève, Switzerland. The Yoshii collection of Collembola is deposited in MHNG. However, the presence of all Yoshii's species in these collections will need to be confirmed.
MNHN—Muséum national d'Histoire Naturelle, Paris, France
MZB—Museum Zoologicum Bogoriense, Bogor, Indonesia
PC—Personal Collection
PSU-NHMF—Princess Maha Chakri Sirindhorn Natural History Museum, Faculty of Science, Prince of Songkla University, Songkhla, Thailand
SAMA—The South Australian Museum, Adelaide, South Australia
soil s.l.—soil *sensu lato*, when the soil layer is not provied in the record
spp—several morphospecies; their number is given when given in the reference(s)
?—dubious record, dubious identification or unspecified subgenus
*—species present in Doi Inthanon

Abbreviations for Thailand regions
C—central part of Thailand
N—northern part of Thailand
NE—northeastern part of Thailand

P—peninsula of Thailand
SE—southeastern part of Thailand
W—western part of Thailand

Collembola of Thailand

Order Poduromorpha Börner

Family Brachystomellidae Stach

Genus *Brachystomella* Ågren

Brachystomella* spp.
Name in source. *Branchstomella* in Takeda (1981) (misspelling). Source: Takeda (1981), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Khon Kaen, Nakhon Ratchasima (NE), Phang Nga (P), Kanchanaburi (W). Habitat: soil s.l. at 1150 m and 1700 m in Doi Inthanon forest (Bedos 1994); soil s.l. in mixed dry deciduous forest at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Two morphospecies in Doi Inthanon (Bedos 1994); other forms present in other provinces of Thailand and other massifs of Chiang Mai province have not been characterized.

Family Hypogastruridae Börner

Genus *Acherontiella* Absolon

1. *Acherontiella colotlipana* Palacios-Vargas & Thibaud, 1985
Name in source. *Acherontiella* sp. in Deharveng (1987c). Source: Deharveng (1987c), Thibaud (1990), Bedos (1994), Deharveng & Bedos (2001).
Distribution in Thailand. Chiang Mai (N). Habitat: cave.
Distribution outside Thailand. Mexico.

2. *Acherontiella thai* Thibaud, 1990
Name in source. *Acherontiella* sp. in Deharveng (1987c). Source: Deharveng (1987c), Thibaud (1990), Bedos (1994), Deharveng & Bedos (2001). Type deposition: MNHN.
Distribution in Thailand. Lampang (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

Acherontiella* spp.
Source: Deharveng & Bedos (1988), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Phetchabun C), Surat Thani (P). Habitat: cave guano in Surat Thani and Phetchabun provinces; deep soil at 1150 m. in Doi Inthanon forest.
Remark. Probably different species.

Genus *Ceratophysella* Börner

Ceratophysella* gr. *armata* Börner, 1932 spp.
Name in source. *Hypogastrura* (*Ceratophysella*) group *armata* in Bedos (1994). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).

Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 700–1740 m. (sp.3), at 1740 (sp.2) and above 2000 m. (sp.1) in Doi Inthanon forest.
Distribution outside Thailand. *C. armata* is Palaearctic.
Remark. Three morphospecies in Doi Inthanon: *Ceratophysella* sp.1 in Bedos (1994); *Ceratophysella* n.sp.1 in Deharveng & Bedos (1993b) which is *C.* sp.3 in Bedos (1994); *Ceratophysella* n.sp.2 in Deharveng & Bedos (1993b) which is *C.* sp.2 in Bedos (1994).

3. *Ceratophysella* cf. *communis* (Folsom, 1898)*
Name in source. *Hypogastrura* (*Ceratophysella*) cf. *communis*. Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: at 1700 m. in Doi Inthanon forest.
Distribution outside Thailand. *C. communis* is distributed in East Asia.

4. *Ceratophysella duplicispinosa* (Yosii, 1954)*
Name in source. *Chinogastrura* cf. *duplicispinosa* in Deharveng *et al*. (1989), *Hypogastrura* (*Chinogastrura*) *duplicispinosa* in Bedos (1994). Source: Deharveng *et al*. (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at all altitudes in Doi Inthanon forest.
Distribution outside Thailand. East Asia.
Remark. The synonymy of *Chinogastrura* with *Ceratophysella* proposed by Babenko *et al*. (1994) is likely, but remains to be formally established.

5. *Ceratophysella* cf. *engadinensis* (Gisin, 1949)*
Name in source. *Ceratophysella* gr. *denticulata* in Deharveng *et al.* (1989), *Hypogastrura* (*Ceratophysella*) cf. *engadinensis* in Bedos (1994). Source: Deharveng *et al.* (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 2500 m. in Doi Inthanon forest.
Distribution outside Thailand. *C. engadinensis* is probably Palaearctic.

6. *Ceratophysella morula* Deharveng & Bourgeois, 1991
Name in source. *Hypogastrura* (*Ceratophysella*) *morula* in Bedos (1994). Source: Deharveng & Bourgeois (1991), Bedos (1994), Skarżyński & Smolis (2006), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: humus at the entrance of a shaft.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

7. *Ceratophysella mucronata* Deharveng & Bourgeois, 1991*
Name in source. *Ceratophysella* sp. in Deharveng *et al.* (1989), *Hypogastrura* (*Ceratophysella*) *mucronata* in Bedos (1994). Source: Deharveng & Bourgeois (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: wet litter and humus above 2000 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

8. *Ceratophysella* cf. *tergilobata* (Cassagnau, 1954)
Name in source. *Hypogastrura* (*Ceratophysella*) cf. *tergilobata*. Source: Bedos (1994).
Distribution in Thailand. Surat Thani (P). Habitat: not given.
Distribution outside Thailand. *C. tergilobata* is distributed in the Mediterranean region, East Asia and Sunda islands.

***Ceratophysella* sp.**
Name in source. *Hypogastrura* (*Chinogastrura*) in Bedos (1994). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai, Mae Hong Son (N), Kanchanaburi (W). Habitat: not given.
Remark. For the synonymy of *Chinogastrura* with *Ceratophysella,* see *C. duplicispinosa* above.

Ceratophysella* sp.

Name in source. *Cyclograna* sp. in Deharveng *et al.* (1989), *Hypogastrura* (*Cyclograna*) in Bedos (1994). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).

Distribution in Thailand. Chiang Mai (N), Phetchabun (C). Habitat: litter and soil above 1700 m. in Doi Inthanon forest.

Remark. We follow Skarżyński & Christiansen (2008) who considered *Cyclograna* Yosii and *Mitchellania* Wray as synonyms of *Ceratophysella*; two forms in Doi Inthanon.

Genus *Cosberella* Wray

Cosberella* sp.

Name in source. *Hypogastrura (Mucrella)*. Source: Bedos (1994).

Distribution in Thailand. Chiang Mai (N), Phetchabun (C). Habitat: litter and soil at 1150 m. in Doi Inthanon forest.

Remark. *Mucrella* is considered as a synonymy of *Cosberella* Wray by Bernard (2006). Two morphotypes live in syntopy in Doi Inthanon, one being possibly the epitoke form of the other (Bedos 1994).

Genus *Hypogastrura* Bourlet

***Hypogastrura* spp.**

Name in source. *Hypogastura* in Takeda (1981) (misspelling). Source: Takeda (1981), Wiwatwitaya & Takeda (2005).

Distribution in Thailand. Khon Kaen, Nakhon Ratchasima (NE). Habitat: soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).

Remark. Two morphospecies recognized by Takeda (1981) in Khon Kaen province, one by Wiwatwitaya & Takeda (2005) in Nakhon Ratchasima province.

Genus *Microgastrura* Stach

Microgastrura* sp.

Source: Bedos (1994).

Distribution in Thailand. Chiang Mai (N), Kanchanaburi (W). Habitat: litter and soil at low altitude in Doi Inthanon forest.

Genus *Willemia* Börner

9. *Willemia brevispina* Hüther, 1962

Source: D'Haese & Weiner (1998).

Distribution in Thailand. Kanchanaburi, ?Suphan Buri (W). Habitat: soil at entrance of cave.

Distribution outside Thailand. North, Central and South America, Hawaii.

Remark. The record from Suphan Buri province would need to be confirmed.

10. *Willemia deharvengi* D'Haese & Weiner, 1998*

Name in source. *Willemia* sp.2 in Bedos (1994). Source: Bedos (1994), D'Haese & Weiner (1998). Type deposition: MNHN, ISEA.

Distribution in Thailand. Chiang Mai (N). Habitat: soil at 1150 m. in Doi Inthanon forest

Distribution outside Thailand. New Caledonia.

11. *Willemia nadchatrami* Yosii, 1959
Name in source. *Willemia* sp. in Deharveng & Bedos (1988). Source: Deharveng & Bedos (1988), Bedos (1994), D'Haese & Weiner (1998), Deharveng & Bedos (2001).
Distribution in Thailand. Phang Nga, Surat Thani, Yala (P). Habitat: cave.
Distribution outside Thailand. SE Asia.

12. *Willemia neocaledonica* Weiner, 1991
Name in source. *Willemia* sp. in Deharveng (1987c). Source: Deharveng (1987c), D'Haese & Weiner (1998).
Distribution in Thailand. Phang Nga (P). Habitat: soil at see level.
Distribution outside Thailand. New Caledonia.

13. *Willemia wandae* Tamura, 1997
Source: D'Haese & Weiner (1998).
Distribution in Thailand. Chiang Mai (N). Habitat: decaying wood and litter in broadleaved forest on limestone.
Distribution outside Thailand. China, Nepal.

Willemia* spp.
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: soil at 375 m. and 1700 m. in Doi Inthanon forest.
Remark. Two morphospecies in Doi Inthanon.

Genus *Xenylla* Tullberg

14. *Xenylla malasica* Gama, 1969
Source: Gama (1986), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 600–700 m. in Doi Chiang Dao forest.
Distribution outside Thailand. Malaysia.

15. *Xenylla obscura* Imms, 1912
Source: Gama (1986), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter in forest and disturbed habitats at 500 and 2000 m. in Doi Chiang Dao.
Distribution outside Thailand. Tropical Asia.

16. *Xenylla stachi stachi* Gama, 1966
Source: Gama (1986), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: humus at 1500 m. at the entrance of a shaft in Doi Chiang Dao.
Distribution outside Thailand. Africa.

17. *Xenylla thailandensis* Gama, 1986*
Source: Gama (1986), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994). Type deposition: MC, MHNG, LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, soil, decaying wood and moss on ground in Doi Inthanon forest (Gama 1986), frequent at all altitudes (Bedos 1994).
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

18. *Xenylla yucatana* Mills, 1938
Source: Gama (1976), Bedos (1994).
Distribution in Thailand. Bangkok (C). Habitat: soil.

Distribution outside Thailand. Pan-tropical.
Remark. *X. yucatana* is often found in abundance on cave guano in Southeast Asia, but has not been reported so far from this habitat in Thailand.

***Xenylla* spp.**
Source: Deharveng & Bedos (1988), Bedos (1994).
Distribution in Thailand. Chumphon, Surat Thani (P).
Habitat. Cave guano.

Family Neanuridae Börner

Subfamily Frieseinae Massoud

Genus *Friesea* Dalla Torre

Remark. *Friesea* sp.1 to 6 cited from above 2000 m in Doi Inthanon without further details in Deharveng *et al.* (1989) correspond to species that were subsequently described and are listed below, but exact match cannot be established.

19. *Friesea chiangdaoensis* Deharveng & Bedos, 1991
Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 1700–2000 m. in Doi Chiang Dao.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

20. *Friesea* cf. *claviseta* Axelson, 1900
Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 1300 m. in forest.
Distribution outside Thailand. *F. claviseta* is cosmopolitan.

21. *Friesea furculata* Deharveng & Bedos, 1991*
Name in source. *Friesea* n.sp.3 in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1991, 1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 1700–2100 m. in Doi Inthanon forest.
Distribution outside Thailand. Vietnam (cited as *F.* cf. *furculata*).

22. *Friesea gracilispina* Deharveng & Bedos, 1991*
Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: decaying wood at 1700–2000 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

23. *Friesea inthanonensis* Deharveng & Bedos, 1991*
Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, humus and roots at 1700–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

24. *Friesea kanchanaburiensis* Deharveng & Bedos, 1991 and ***Friesea* cf. *kanchanaburiensis* Deharveng & Bedos, 1991**
Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition:

LEITT.

Distribution in Thailand. Chiang Mai (N), Kanchanaburi (W). Habitat: soil at a cave entrance at 350 m. in forest (Kanchanaburi) and soil at 700–1150 m. in Doi Inthanon forest.

Distribution outside Thailand. Only known from Thailand.

25. *Friesea lisu* Deharveng & Bedos, 1991*

Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.

Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 1700 m. in Doi Inthanon forest; 500–1000 m. in Doi Chiang Dao.

Distribution outside Thailand. Only known from Thailand.

26. *Friesea microphthalma* Deharveng & Bedos, 1991

Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.

Distribution in Thailand. Surat Thani (P). Habitat: soil at shaft entrance at 50 m. altitude.

Distribution outside Thailand. Only known from Thailand.

27. *Friesea* cf. *mirabilis* Tullberg, 1871*

Name in source. *Friesea* n.sp.2 in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1991, 1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report).

Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 700 m. in Doi Inthanon forest, common in other massifs of the province.

Distribution outside Thailand. *F. mirabilis* is cosmopolitan.

28. *Friesea* cf. *montechristii* Dallai, 1969

Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report).

Distribution in Thailand. Phang Nga (P). Habitat: litter at 20–50 m. altitude in forest.

Distribution outside Thailand. *F. montechristii* is European.

29. *Friesea paitooni* Deharveng & Bedos, 1991

Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.

Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil around 1100 m. in Doi Pui forest.

Distribution outside Thailand. Only known from Thailand (Doi Pui).

30. *Friesea palaciosi* Deharveng & Bedos, 1991*

Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.

Distribution in Thailand. Chiang Mai (N). Habitat: litter and moss on tree at 1300 and 2500 m. in Doi Inthanon forest.

Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

31. *Friesea rubeni* Deharveng & Bedos, 1991

Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.

Distribution in Thailand. Chiang Rai (N). Habitat: litter on rocks at 550 m.

Distribution outside Thailand. Vietnam (cited as *F.* cf. *rubeni*).

32. *Friesea tibiotarsalis* Deharveng & Bedos, 1991*

Source: Deharveng & Bedos (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.

Distribution in Thailand. Chiang Mai (N). Habitat: litter at 1700–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

Friesea* spp.
Source: Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Nakhon Ratchasima (NE). Habitat: soil s.l. at low altitude in Doi Inthanon (Bedos 1994); in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remarks. Several forms near *F. tibiotarsalis* and *F. gracilispina* in Doi Inthanon.

Subfamily Neanurinae Börner

Neanurinae n.g.1 spp.*
Name in source. cf. *Rambutanura* sp. in Deharveng *et al.* (1989). Source: Deharveng *et al.* (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai, Chiang Rai, Mae Hong Son (N). Habitat: at 2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from northern Thailand.
Remark. Near *Rambutanura* Deharveng (1988b), several morphospecies.

Neanurinae n.g.2 sp.*
Name in source. Neanurinae n.g.5 sp. in Deharveng *et al.* (1989). Source: Deharveng *et al.* (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand.
Remark. Paleonurini of very large size.

Genus *Blasconura* Cassagnau

33. *Blasconura* cf. *hirtella* (Börner, 1906)
Name in source. *Vitronura hirtella* in Yosii (1976), Deharveng (1986) and in Rojanavongse *et al*. (unpublished report). Source: Yosii (1976), Deharveng (1986), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Trang (P). Habitat: not given.
Distribution outside Thailand. *B. hirtella* is distributed in SE Asia and Australasia.
Remark. *Blasconura hirtella* is a complex of species according to Bedos (1994).

***Blasconura* spp.**
Source: Deharveng *et al.* (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai, Chiang Rai (N), Kanchanaburi, Prachuap Kiri Khan (W), Bangkok (C), Phang Nga, Surat Thani (P). Habitat: not given.
Remark. About ten morphospecies (Bedos 1994). The record of the genus in Deharveng *et al.* (1989) is not confirmed by Bedos (1994).

Genus *Blasconurella* Deharveng & Bedos

Remark. The genus is only known from Thailand.

34. *Blasconurella arcuata* Deharveng & Bedos, 1992
Source: Deharveng & Bedos (1992), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, humus and decaying wood at 500–1000 m. in Doi

Chiang Dao forest.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

35. *Blasconurella intermedia* Deharveng & Bedos, 1992
Source: Deharveng & Bedos (1992), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: forest litter at low altitude north of Doi Chiang Dao.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

36. *Blasconurella lobata* Deharveng & Bedos, 1992*
Name in source. Neanurinae n.g. in Deharveng *et al.* (1989). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1992), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, humus and soil above 2400 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

37. *Blasconurella* cf. *lobata* Deharveng & Bedos, 1992*
Source: Deharveng & Bedos (1992), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 1150 m. in Doi Inthanon forest.
Distribution outside Thailand. *B. lobata* is only known from Thailand (Doi Inthanon).
Remark. The morphospecies have been recognized as different from *B. lobata* on morphological character after Bedos (1994), it can be considered as a separate morphospecies.

38. *Blasconurella palmata* Deharveng & Bedos, 1992*
Name in source. Neanurinae n.g. in Deharveng *et al.* (1989). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1992), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: moss on tree at 2550 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

39. *Blasconurella quinquesetosa* Deharveng & Bedos, 1992*
Name in source. Neanurinae n.g.1 n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1992, 1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 700 and 1740 m. in Doi Inthanon forest; soil and barks at 500 m. in Doi Chiang Dao forest; litter at 1300 m. in Doi Mae Tho forest.
Distribution outside Thailand. Only known from Thailand (Chiang Mai mountains).

Genus *Chirolavia* Deharveng

Remark. The genus is only known from Thailand.

40. *Chirolavia gabaudei* Deharveng, 1991
Source: Deharveng (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: humus and decaying wood at 700 m. in Doi Chiang Dao forest.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

41. *Chirolavia murphyi* Deharveng, 1991*
Name in source. Neanurinae n.g. in Deharveng *et al.* (1989), Neanurinae n.g.2 n.sp. in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Deharveng (1991), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: soil, humus, decaying wood at 2000–2550 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

***Chirolavia* spp.**
Source: Deharveng (1991), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Phang Nga (P). Habitat: not given.
Remark. Two morphospecies.

Genus *Coecoloba* Yosii

***Coecoloba* n.sp.**
Source: Bedos (1994)
Distribution in Thailand. Surat Thani, Phang Nga (P). Habitat: not given.

Genus *Crossodonthina* Yosii

***Crossodonthina* n.sp.**
Source: Bedos (1994).
Distribution in Thailand. Phang Nga (P). Habitat: not given.

Genus *Digitanura* Deharveng

Remark. The genus is only known from Thailand.

42. *Digitanura quadrilobata* Deharveng, 1987
Source: Deharveng (1987a), Bedos (1994). Type deposition: LEITT.
Distribution in Thailand. Mae Hong Son (N), Tak, Kanchanaburi (W). Habitat: litter in forest in Mae Hong Son.
Distribution outside Thailand. Only known from Thailand.
Remark. A closely related species exists in southwestern Thailand.

Genus *Hyperlobella* Cassagnau

43. *Hyperlobella kraepelini* (Börner, 1906)
Name in source. *Lobella (Lobella) kraepelini* in Yosii (1976) and in Rojanavongse *et al*. (unpublished report).
Source: Yosii (1976), Deharveng (1986), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Trang (P). Habitat: not given.
Distribution outside Thailand. Nepal, Sri Lanka, SE Asia.

***Hyperlobella* n.spp.**
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Krabi (P), Chanthaburi (SE). Habitat: not given.

Genus *Neanura* MacGillivray

***Neanura* sp.**
Source: Takeda (1981), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Khon Kaen, Nakhon Ratchasima (NE). Habitat: soil s.l. in mixed dry deciduous forest at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Incorrect identification; the genus is limited to Europe except the widely distributed *Neanura muscorum* which has never been reliably recorded under tropical climate.

Genus *Paleonura* Cassagnau

44. *Paleonura dilatata* Deharveng & Bedos, 1993*
Name in source. Neanurinae n.g. in Deharveng *et al.* (1989), Neanurinae n.g.3 n.sp. in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993a, b), Bedos (1994), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 2100–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).
Remark. Forms similar to this species exist in Kanchanaburi, Surat Thani and Phang Nga. The species exhibit an unusual morphology which would perhaps deserve the erection of a new genus.

45. *Paleonura lanna* Deharveng & Bedos, 1993*
Name in source. *Paleonura* n.sp.1 in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993a,b), Bedos (1994), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 1150–2500 m. in Doi Inthanon forest; at 1650 m. in Doi Pui; at 1300 m. in Doi Mae Tho.
Distribution outside Thailand. Only known from Thailand.

46. *Paleonura monochaeta* Deharveng & Bedos, 1993*
Name in source. *Paleonura* n.sp.2 in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993a,b), Bedos (1994), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 700–1700 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

***Paleonura* spp.**
Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993a), Bedos (1994).
Distribution in Thailand. Widespread. Habitat: cave in Chaiyaphum, forest in Doi Inthanon, not given elsewhere.
Remark. Genus highly diversified in Thailand with 14 additional morphospecies recognized throughout the country, including two close to *P. monochaeta* (Bedos 1994).

Genus *Paralobella* Cassagnau & Deharveng

47. *Paralobella khaochongensis* (Yosii, 1976)
Name in source. *Lobella (Lobellina) khaochongensis* in Yosii (1976) and in Rojanavongse *et al*. (unpublished report). Source: Yosii (1976), Deharveng (1986), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Trang (P). Habitat: not given.
Distribution outside Thailand. Only known from Thailand.

48. *Paralobella apsala* (Yosii, 1976)
Name in source. *Lobella (Lobella) apsala* in Yosii (1976) and in Rojanavongse *et al*. (unpublished report), *Yosialina apsala* in Bedos (1994). Source: Yosii (1976), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Trang (P). Habitat: not given.
Distribution outside Thailand. Cambodia.

49. *Paralobella erawan* (Yosii, 1976)
Name in source. *Lobella (Lobella) erawan* in Yosii (1976) and in Rojanavongse *et al*. (unpublished report), *Yosialina erawan* in Bedos (1994). Source: Yosii (1976), Deharveng (1986), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Phetchaburi (W), Trang (P). Habitat: cave.
Distribution outside Thailand. Only known from West and Peninsular Thailand.

Genus *Paranura* Axelson

50. *Paranura bisetosa* Deharveng, 1989
Source: Deharveng (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter under reeds at 500 m. in Doi Chiang Dao.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

51. *Paranura chiangdaoensis* Deharveng, 1989
Source: Deharveng (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 700 m. in Doi Chiang Dao forest.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

52. *Paranura dalgeri* Deharveng, 1989
Source: Deharveng (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Kanchanaburi (W). Habitat: litter and soil at the entrance of a shaft.
Distribution outside Thailand. Only known from Thailand (Amphoe Si Sawat).

53. *Paranura globulifer* Deharveng, 1989
Source: Deharveng (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Phang Nga (P). Habitat: under bark of dead trees at 20 m. altitude.
Distribution outside Thailand. Only known from Thailand.

54. *Paranura leclerci* Deharveng, 1989
Source: Deharveng (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Phang Nga (P). Habitat: litter at 5 m. altitude in secondary forest.
Distribution outside Thailand. Only known from Thailand.

55. *Paranura meo* Deharveng, 1989*
Name in source. *Paranura* sp.2 in Deharveng *et al.* (1989). Source: Deharveng (1989), Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, humus at 1700–2100 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

56. *Paranura modesta* Deharveng, 1989*
Name in source. *Paranura* sp.1 in Deharveng *et al.* (1989). Source: Deharveng (1989), Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, humus, soil at 1700–2100 m., retrieved commonly from 1150 to 2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).
Remark. Some specimens differ slightly from *P. modesta* and may represent another species.

57. *Paranura tibiotarsalis* Deharveng, 1989
Source: Deharveng (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Chiang Mai (N). Habitat: bamboo litter at 1000 m. in Doi Chiang Dao forest. Type deposition: LEITT.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

Paranura* spp.
Name in source. *Paranura* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: dry lowland forest in Doi Inthanon and Doi Pui.
Remark. Two morphospecies in Doi Inthanon, one in Doi Pui and one in East and Southeast Thailand (Bedos 1994).

Genus *Pronura* Delamare Deboutteville

58. *Pronura dorsolateralis* Deharveng & Bedos, 1993*
Source: Deharveng & Bedos (1993a), Bedos (1994), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai, Mae Hong Son (N). Habitat: litter at 1150 m. in Doi Inthanon forest, at 1685 m. in Doi Pui forest, at 700 m. in Mae Hong Son forest.
Distribution outside Thailand. Only known from northern Thailand.

59. *Pronura ornata* Deharveng & Bedos, 1993*
Name in source. *Pronura* sp. in Deharveng *et al.* (1989). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993a), Bedos (1994), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil above 2000 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

***Pronura* sp.**
Source: Bedos (1994).
Distribution in Thailand. Lampang (N). Habitat: not given.

Genus *Propeanura* Yosii

***Propeanura* n.sp.**
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Remark. Validity of the genus dubious.

Genus *Rambutanura* Deharveng

60. *Rambutanura yoshiiana* Deharveng, 1988
Source: Deharveng (1988b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai, Mae Hong Son (N). Habitat: surface of the litter (at 725 m. in forest in Mae Hong Son province).
Distribution outside Thailand. Only known from northern Thailand.

***Rambutanura* spp.**
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai, Chiang Rai, Mae Hong Son, Nan (N), Tak (W), Khon Kaen (NE). Habitat: at low altitude in northern and northeastern Thailand.
Remark. Several morphospecies.

Genus *Siamanura* Deharveng

Remark. Most species of the genus were described from Thailand.

61. *Siamanura bisetosa* Deharveng, 1987
Source: Deharveng (1987b), Bedos (1994). Type deposition: LEITT.
Distribution in Thailand. Chiang Rai (N). Habitat: leaves and decaying wood.
Distribution outside Thailand. Only known from Thailand.

62. *Siamanura breviseta* Deharveng, 1987*
Source: Deharveng (1987b), Deharveng *et al*. (1989), Bedos (1994). Type deposition: LEITT, MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 2000–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

63. *Siamanura burckhardti* Deharveng, 1987
Source: Deharveng (1987b), Bedos (1994). Type deposition: LEITT, MHNG.
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: at 750 m. near headquarters and at 1150 m. in dry forest in Khao Yai National Park.
Distribution outside Thailand. Only known from Thailand (Khao Yai National Park).

64. *Siamanura clavata* Deharveng, 1987*
Source: Deharveng (1987b), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 1250–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

65. *Siamanura gouzei* Deharveng, 1987*
Name in source. *S.* cf. *gouzei* in Deharveng & Bedos (1993b). Source: Deharveng (1987b), Deharveng & Bedos (1993b), Bedos (1994). Type deposition: LEITT, MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: litter and humus at 1000–2200 m. in Doi Chiang Dao forest.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao and Doi Inthanon).

66. *Siamanura inthanonensis* Deharveng, 1987*
Source: Deharveng (1987b), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: mosses on rock at 2450–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

67. *Siamanura leksawasdii* Deharveng, 1987
Source: Deharveng (1987b), Bedos (1994). Type deposition: LEITT, MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: decaying wood at 1685 m. in Doi Pui (top of the mountain); at 1050–1150 m. in Doi Suthep.
Distribution outside Thailand. Only known from Thailand (Doi Pui-Doi Suthep).
Remark. The altitude of 1980 m. given in the original description for the Doi Pui is erroneous as the top of the massif is at 1685 m.

68. *Siamanura lisu* Deharveng, 1987*
Source: Deharveng (1987b), Deharveng *et al*. (1989), Bedos (1994). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai, Mae Hong Son (N). Habitat: litter, humus and mosses at 600–1000 m. in Mae Hong Son province; at 2000–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from northern Thailand.

69. *Siamanura loebli* Deharveng, 1987
Name in source. *S. löbli* in Deharveng (1987b). Source: Deharveng (1987b), Bedos (1994). Type deposition: LEITT, MHNG.
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: at 750–850 m. in Khao Yai National Park.
Distribution outside Thailand. Only known from Thailand (Khao Yai National Park).

70. *Siamanura maffrigali* Deharveng, 1987
Source: Deharveng (1987b), Bedos (1994). Type deposition: LEITT, MHNG.
Distribution in Thailand. Mae Hong Son (N). Habitat: decaying leaves at 600 m. in forest.
Distribution outside Thailand. Only known from Thailand.

71. *Siamanura media* Deharveng, 1987
Source: Deharveng (1987b), Bedos (1994). Type deposition: LEITT, MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: at 500–940 m. in Doi Chiang Dao.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

72. *Siamanura phyllioseta* Deharveng, 1987*
Source: Deharveng (1987b), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 2000–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

73. *Siamanura trisetosa* Deharveng, 1987*
Source: Deharveng (1987b), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: litter and decaying wood from 1720 to 2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

***Siamanura* spp.**
Name in source. Neanurinae n.g. in Deharveng *et al.* (1989), *Siamanura* n.sp. in Deharveng & Bedos (1993b).
Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. No detail (N, P and SE). Habitat: decaying wood in upper part of Doi Inthanon forest.
Remark. Three additional species restricted to Doi Inthanon, and several other morphospecies from various regions of Thailand.

Genus *Thaianura* Yosii

Remark. The genus is monospecific and endemic of Thailand.

74. *Thaianura umesaoi* Yosii, 1961*
Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: above 1700 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).
Remark. *Siamanura umesaoi* in Rojanavongse *et al*. (unpublished report) is a *lapsus calami*.

***Thaianura* spp.**
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai, Chiang Rai, Mae Hon Song, Nan (N), Loei (NE). Habitat: not given.
Remark. Several morphospecies in northern and northeastern Thailand.

Genus *Vitronura* Yosii

***Vitronura* sp.**
Source: Bedos (1994).
Distribution in Thailand. Phetchabun (C), Chaiyaphum, Nakhon Ratchasima (NE), Surat Thani (P). Habitat: not given.
Remark. Material not studied.

Genus *Yuukianura* Yosii

***Yuukianura* n.spp.**
Source: Bedos (1994).
Distribution in Thailand. Chiang Rai, Mae Hong Son (N), Phang Nga (P). Habitat: not given.
Remark. Dubious identification for Chiang Rai and Mae Hong Son records, *Yuukianura* species being usually restricted to littoral habitats.

Subfamily Pseudachorutinae Börner

Genus *Aethiopella* Handschin

Aethiopella* sp.
Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: above 1700 m. in Doi Inthanon forest.
Remark. The same species, or a very similar one, is present in other mountains of the province.

Genus *Anurida* Laboulbène

***Anurida* sp.**
Source: Takeda (1981), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Khon Kaen, Nakhon Ratchasima (NE). Habitat: soil s.l. in mixed dry deciduous forest at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Dubious generic identification; the genus *Anurida* is absent from the tropics or when present limited to littoral habitats.

Genus *Brasilimeria* Stach

Brasilimeria* spp.
Name in source. cf. *Brasilimeria* sp. in Deharveng *et al.* (1989). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos, (1994).
Distribution in Thailand. Chiang Mai, Mae Hong Son (N), Phang Nga (P). Habitat: at 2400–2550 m. in Doi Inthanon forest.
Remark. Several morphospecies (Bedos 1994); generic identification needs to be confirmed, as the genus is otherwise only known from South America.

Genus *Cephalachorutes* Bedos & Deharveng

Remark. *Cephalachorutes murphyi* Bedos & Deharveng, 1991 and *Cephalachorutes nakaoi* (Yosii, 1966) cited in the compilation of Rojanavongse *et al*. (unpublished report) have to be considered as erroneous citations, based on misunderstanding of the literature, not on collected specimens. These species are actually only known from Papua Niugini and Nepal respectively.

75. *Cephalachorutes asiaticus* Bedos & Deharveng, 1991
Source: Bedos & Deharveng (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MNHN.
Distribution in Thailand. Chiang Mai (N). Habitat: bamboo litter at 500 m. in a forest of Chiang Mai province.
Distribution outside Thailand. SE Asia.

76. ***Cephalachorutes barthae*** **Bedos & Deharveng, 1991***
Name in source. Pseudachorutinae n.g. sp.1 in Deharveng *et al.* (1989), Pseudachorutinae n.g. n.sp.2 in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Bedos & Deharveng (1991), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MNHN.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 1300 m. in Doi Mae Tho forest; litter and humus at 1700–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Mae Tho and Doi Inthanon).

77. ***Cephalachorutes caecus*** **Bedos & Deharveng, 1991**
Source: Bedos & Deharveng (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MNHN.
Distribution in Thailand. Chiang Mai (N). Habitat: wet litter, soil and humus at 500–1000 m. in Doi Chiang Dao forest; humus at 1300 m. in Doi Mae Tho forest.
Distribution outside Thailand. Only known from Thailand (Doi Chiang Dao).

78. ***Cephalachorutes centurionis*** **Bedos & Deharveng, 1991***
Name in source. Pseudachorutinae n.g. sp.1 in Deharveng *et al.* (1989), Pseudachorutinae n.g. n.sp.1 in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Bedos & Deharveng (1991), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MNHN.
Distribution in Thailand. Chiang Mai (N). Habitat: soil at 1700–2550 m and humus in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

79. ***Cephalachorutes pestilentiae*** **Bedos & Deharveng, 1991**
Source: Bedos & Deharveng (1991), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT, MNHN.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 600 m. in a forest of Chiang Mai province.
Distribution outside Thailand. Only known from Thailand.

Genus *Ceratrimeria* Börner

Ceratrimeria **spp.***
Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Widespread. Habitat: above 1700 m. in Doi Inthanon forest.
Remark. At least 4 morphospecies in Bedos (1994).

Genus *Furculanurida* Massoud

Furculanurida **spp.**
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Remark. Only found in Doi Chiang Dao. The citation from Doi Inthanon in Deharveng *et al*. (1989) refers to *Stachorutes* sp.

Genus *Grananurida* Yosii (cf.)

Grananurida **sp.**
Source: Bedos (1994).
Distribution in Thailand. Mae Hong Son (N). Habitat: not given.
Remark. The assignation of this species to the genus *Grananurida* needs confirmation.

Genus *Micranurida* Börner

80. *Micranurida pygmaea* Börner, 1901*
Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: in disturbed forest of mid-altitude in Doi Inthanon.
Distribution outside Thailand. Holarctic.

Micranurida* spp.
Source: Deharveng *et al.* (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Remark. Four forms of uncertain taxonomic status collected in Doi Inthanon.

Genus *Micranurida* Börner (cf.)

cf. *Micranurida* sp.
Name in source. Neanuridae n.gen. in Deharveng & Bedos (1988). Source: Deharveng & Bedos (1988), Bedos (1994).
Distribution in Thailand. Phang Nga (P). Habitat: cave.

Genus *Oudemansia* Schött

***Oudemansia* sp.**
Source: Bedos (1994).
Distribution in Thailand. No detail (P). Habitat: littoral.

Genus *Pratanurida* Rusek

Pratanurida* sp.
Source: Deharveng *et al*. (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: peat bog on the top of Doi Inthanon.
Remark. One of the two *Pratanurida* morphospecies cited in Deharveng *et al*. (1989) is actually *Protachorutes* sp.

Genus *Protachorutes* Cassagnau

Protachorutes* sp.
Name in source. *Pratanurida* sp. in Deharveng *et al*. (1989). Source: Deharveng *et al*. (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: on the top of Doi Inthanon.
Remark. Dubious record (pollution?), from a single specimen collected in Doi Inthanon; the genus has otherwise 2 species, one from Europe and another one from the USA.

Genus *Pseudachorudina* Stach

Pseudachorudina* spp.
Name in source. *Pseudachorudina* n.sp.1 and 2 in Deharveng & Bedos (1993b). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Widespread. Habitat: litter and soil between 1150 and 2550 m. in Doi Inthanon forest.
Remark. Several morphospecies including two in Doi Inthanon.

Genus *Pseudachorutes* Tullberg

81. *Pseudachorutes* cf. *longisetis* Yosii, 1961 spp.*
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Phang Nga (P). Habitat: not given.
Distribution outside Thailand. *P. longisetis* is distributed in Nepal, Japan, SE Asia.
Remark. Five forms in Doi Inthanon, several in other mountains of Chiang Mai province and in Phang Nga province.

Pseudachorutes* spp.
Source: Deharveng *et al.* (1989), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Nakhon Ratchasima (NE). Habitat: not given for morphospecies of Chiang Mai province; soil s.l. in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Ten morphospecies in Doi Inthanon (*P.* cf. *longisetis* excluded), of which eight present above 2000 m. (Deharveng *et al.* 1989); one morphospecies in Doi Mae Tho (Chiang Mai province); one in Nakhon Ratchasima province. The eleven species of *Pseudachorutes* cited by Deharveng *et al.* (1989) above 2000 m. in Doi Inthanon include in fact 2 species from lower elevation, and *P.* cf. *longisetis*.

Genus *Stachorutes* Dallai

***Stachorutes* sp.**
Name in source. *Furculanurida* sp. in Deharveng *et al*. (1989). Source: Deharveng *et al*. (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: decaying wood above 1700 m. in Doi Inthanon forest.

Subfamily Uchidanurinae Salmon

Genus *Denisimeria* Massoud

82. *Denisimeria caudata* (Denis, 1948)*
Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: at 1150–2500 m. in Doi Inthanon forest, at 500 m. in Doi Chiang Dao and 1700 m. in Doi Ang Khang.
Distribution outside Thailand. Vietnam.

***Denisimeria* sp.**
Source: Bedos (1994).
Distribution in Thailand. Chanthaburi (SE). Habitat: not given.

Family Odontellidae Massoud

Genus *Odontella* Schäffer

***Odontella* sp.**
Source: Takeda (1981), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Khon Kaen, Nakhon Ratchasima (NE). Habitat: soil s.l. in mixed dry deciduous forest at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Probably a *Superodontella,* the genus *Odontella* being limited to the southern hemisphere.

Genus *Superodontella* Stach

83. *Superodontella ciconia* Bedos & Deharveng, 1990*
Source: Bedos & Deharveng (1990), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N) and common across Thailand. Habitat: litter, humus and moss at 2000–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand.

84. *Superodontella flammata* Bedos & Deharveng, 1990*
Source: Bedos & Deharveng (1990), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter and humus at 2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

85. *Superodontella gouzei* Bedos & Deharveng, 1990*
Source: Bedos & Deharveng (1990), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N) and common across Thailand. Habitat: litter, humus and moss on rock at 2000–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand.

86. *Superodontella longispina* Bedos & Deharveng, 1990*
Source: Bedos & Deharveng (1990), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N) and common across Thailand. Habitat: litter, humus and moss on rock at 2000–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand.

Superodontella* spp.
Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), no detail (NE and SE). Habitat: litter and soil at 700–2550 m. in Doi Inthanon forest.
Remark. Three morphospecies were recognized in Doi Inthanon (Deharveng & Bedos 1993b), and several in East and South–East Thailand. The five morphospecies listed from Doi Inthanon above 2000 m. without more details in Deharveng *et al.* (1989) correspond to one undescribed morphospecies and to the four species subsequently described and listed above.

Family Onychiuridae Lubbock

Genus *Onychiurus* Gervais

Onychiurus* spp.
Source: Takeda (1981), Deharveng *et al*. (1989), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Khon Kaen, Nakhon Ratchasima (NE). Habitat: above 2000 m. in rainy season in Doi Inthanon forest; soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. The cited records are likely to belong to the genus *Allonychiurus* Yoshii, which is present in Thailand (unpublished observation), while there is no reliable citation of true *Onychiurus* in Southeast Asia.

Genus *Protaphorura* Absolon

Protaphorura* spp.
Source: Deharveng (1986), Deharveng (1987c), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: mostly above 800 m. in various massifs of the Chiang Mai province; litter and soil at 700–2550 m. in Doi Inthanon forest.
Remark. The cited records are likely to belong to the genus *Thalassaphorura* Bagnall, as the genus *Protaphorura* seems to be absent in the tropics. Six forms of uncertain taxonomic status have been recognized in Doi Inthanon (Bedos 1994).

Family Poduridae

Poduridae sp.
Source: Takeda (1981).
Distribution in Thailand. Khon Kaen (NE). Habitat: soil s.l. in mixed dry deciduous forest and deforested area at 800 m.
Remark. Wrong identification, possibly Hypogastruridae.

Family Tullbergiidae Bagnall

Genus *Mesaphorura* Börner

87. *Mesaphorura hygrophila* Rusek, 1971*
Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 2100 m. in Doi Inthanon forest.
Distribution outside Thailand. Europe, Asia.

88. *Mesaphorura* cf. *macrochaeta* Rusek, 1976*
Name in source. *Mesaphorura* sp. in Bedos (1994). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: soil at 1700 m. in Doi Inthanon forest.
Distribution outside Thailand. *M. macrochaeta* is cosmopolitan.

89. *Mesaphorura yosii* Rusek, 1967*
Name in source. *Mesaphorura yoshii* (misspelling) in Deharveng *et al*. (1989) and in Deharveng & Bedos (1993b). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N) and unspecified regions of Thailand. Habitat: litter and soil at 1700–2550 m. in Doi Inthanon forest.
Distribution outside Thailand. Cosmopolitan.

***Mesaphorura* sp.**
Source: Deharveng & Bedos (1988).
Distribution in Thailand. Ratchaburi (W), Surat Thani, Phang Nga (P). Habitat: cave, cave guano.

Genus *Prabhergia* Salmon

Prabhergia* sp.
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Phang Nga (P). Habitat: at low altitude in Doi Inthanon forest.

Genus *Tullbergia* Lubbock

***Tullbergia* sp.**
Source: Takeda (1981), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Khon Kaen, Nakhon Ratchasima (NE). Habitat: soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Dubious generic identification; possibly *Prabhergia,* the only genus of non-littoral *Tullbergiidae* larger than *Mesaphorura* in continental Southeast Asia.

Order Entomobryomorpha Börner

Family Isotomidae Schäffer

Genus *Anurophorus* Nicolet

***Anurophorus* sp.**
Source: Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: soil s.l. in dry evergreen lowland forest.
Remark. Identification to confirm, the genus is otherwise Holarctic.

Genus *Cryptopygus* Willem

***Cryptopygus* sp.**
Source: Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: soil s.l. in dry evergreen lowland forest.
Remark. Probably *Hemisotoma* Bagnall as the genus *Cryptopygus* is mostly limited to southern hemisphere according to Rusek (2002).

Genus *Desoria* Agassiz & Nicolet

***Desoria* sp.**
Name in source. *Isotoma* (*Desoria*). Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: about 1000 m. in Doi Chiang Dao.

Genus *Folsomia* Willem

90. *Folsomia* cf. *diplophthalma* (Axelson, 1902)*
Name in source. *Folsomia* sp. in Deharveng *et al*. (1989). Source: Deharveng *et al*. (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 1700–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. *F. diplophthalma* is widespread in northern palaearctic regions (Potapov 2001).

Folsomia* gr. *fimetaria* (Linnaeus, 1758) spp.
Name in source. *Folsomia* (gr. *candida*) in Rigal & Maffre (1988), *Folsomia* sp.1 in Deharveng *et al*. (1989) and Bedos (1994), *Folsomia* spp. in Deharveng & Bedos (2001). Source: Rigal & Maffre (1988), Deharveng *et al.* (1989), Deharveng & Bedos (2001), Bedos (1994).
Distribution in Thailand. Chiang Mai, Chiang Rai, Mae Hong Son (N). Habitat: cave and soil in northern Thailand; litter and soil at 1700–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. *F. fimetaria* is widespread in northern temperate regions (Potapov 2001).

Remark. Probably at least three different species, that Bedos (1994) placed in the *F. fimetaria* group *sensu* Deharveng (1979).

91. *Folsomia octoculata* Handschin, 1925*
Name in source. *Folsomia* sp. in Deharveng *et al.* (1989), *Folsomia* n.sp.1 in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 1700–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. East Asia, Hawaii.

Folsomia* gr. *quadrioculata* Tullberg, 1871
Name in source. *Folsomia* sp.3 (Bedos 1994). Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 1700–2500 m. in Doi Inthanon forest.
Distribution outside Thailand. *F. quadrioculata* is widespread in northern temperate regions.

***Folsomia* gr. *sensibilis* Kseneman, 1936**
Name in source. *Folsomia* sp. in Deharveng & Bedos (1988). Source: Deharveng & Bedos (1988).
Distribution in Thailand. Phang Nga (P). Habitat: cave.
Distribution outside Thailand. *F. sensibilis* is distributed in northern temperate regions and mountains of Europe.
Remark. Bedos (1994) placed this species in the *F. sensibilis* group *sensu* Deharveng (1979).

Folsomia* spp.
Name in source. *Folsomia* n.sp.2 and n.sp.3 in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b).
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil s.l. above 1700 m. in Doi Inthanon forest.

Genus *Folsomides* Stach

92. *Folsomides americanus* Denis, 1931*
Name in source. *Folsomides* sp. in Deharveng *et al.* (1989). Source: Deharveng *et al.* (1989), Bedos (1994).
Distribution in Thailand. Widespread. Habitat: at 1700–2000 m. in Doi Inthanon forest
Distribution outside Thailand. Cosmopolitan.
Remark. *F. americanus* was put in synonymy with *F. parvulus* by Fjellberg (1993). The two forms in our material were usually not mixed, and are therefore considered as good species.

93. *Folsomides centralis* Denis, 1931*
Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), no detail (P). Habitat: at low altitude in secondary forest of Doi Inthanon.
Distribution outside Thailand. Pan-tropical.

94. *Folsomides parvulus* Stach, 1922*
Name in source. *Folsomides exiguus* in Deharveng & Bedos (1988), in Deharveng *et al*. (1989), in Deharveng & Bedos (1993b) and in Bedos (1994), *F. purvus* in Takeda (1981) (misspelling), *F. parvus* in Deharveng (1986). Source: Takeda (1981), Deharveng (1986), Deharveng & Bedos (1988), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Khon Kaen, Nakhon Ratchasima (NE), Surat Thani, Phang Nga (P). Habitat: cave in Surat Thani and Phang Nga provinces; at 700–2500 m. in Doi Inthanon forest; soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Distribution outside Thailand. Cosmopolitan.

***Folsomides* sp.**
Source: Deharveng & Bedos (1988).
Distribution in Thailand. Surat Thani, Phang Nga (P). Habitat: cave.

Genus *Folsomina* Denis

95. *Folsomina infelicia* Greenslade, 1999*
Name in source. *Folsomina* n.sp. in Deharveng & Bedos (1993b), *Folsomina* sp. in Bedos (1994). Source: Deharveng & Bedos (1993b), Bedos (1994), Greenslade (1999). Type deposition: SAMA.
Distribution in Thailand. Chiang Mai (N). Habitat: soil at low altitude in Doi Inthanon forest.
Distribution outside Thailand. Pacific, SE Asia.

96. *Folsomina onychiurina* Denis, 1931*
Source: Takeda (1981), Deharveng (1986), Deharveng & Delnatte (1988), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994), Deharveng & Bedos (2001).
Distribution in Thailand. Widespread. Habitat: cave; litter and soil at all altitudes in Doi Inthanon forest; soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen province (Takeda 1981).
Distribution outside Thailand. Pan-tropical.

***Folsomina* sp.**
Source: Deharveng & Bedos (1988), Leclerc & Dalger (1988).
Distribution in Thailand. Surat Thani, Yala (P). Habitat: cave.

Genus *Hemisotoma* Bagnall

97. *Hemisotoma thermophila* (Axelson, 1900) and ***H.* cf. *thermophila* (Axelson, 1900)**
Name in source. *Isotomina thermophila* in Takeda (1981) and Deharveng (1986), *Cryptopygus* cf. *thermophilus* in Bedos (1994). Source: Takeda (1981), Deharveng (1986), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Khon Kaen (NE). Habitat: at low altitude in Doi Inthanon forest; soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen province (Takeda 1981).
Distribution outside Thailand. Cosmopolitan.

Genus *Isotoma* Bourlet

Isotoma* spp.
Name in source. *Isotoma* (*Isotoma*) in Deharveng *et al*. (1989) and Bedos (1994). Source: Deharveng (1986), Deharveng *et al*. (1989), Bedos, (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: two morphospecies in Doi Inthanon, one at 1000–2000 m., the other one near the summit at about 2500 m. and similar to a form present near the summit of Doi Chiang Dao at 2000 m.
Remark. Two or three morphospecies. The genus *Isotoma* s. str. is widespread in the Palaearctic, but its presence in tropical Asia was unexpected.

Genus *Isotomiella* Bagnall

98. *Isotomiella brevidens* Bedos & Deharveng, 1994*
Name in source. *Isotomiella* sp.4 in Bedos (1994). Source: Bedos & Deharveng (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.

Distribution in Thailand. Chiang Mai (N). Habitat: soil at 700–1700 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

99. *Isotomiella cribrata* Deharveng & Suhardjono, 1994*
Name in source. *Isotomiella* n.sp.5 in Deharveng & Bedos (1993b), *Isotomiella* sp.5 Bedos (1994), *Isotomiella* cf. *cribrata* in Deharveng & Suhardjono (1994). Source: Deharveng & Bedos (1993b), Bedos (1994), Deharveng & Suhardjono (1994), Bedos & Deharveng (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Chiang Mai (N). Habitat: at low altitude in Thailand.
Distribution outside Thailand. Vietnam *(*cited as *I.* cf. *cribrata)*, Sumatra.

100. *Isotomiella edaphica* Bedos & Deharveng, 1994
Name in source. *Isotomiella* n.sp.2 in Deharveng & Bedos (1993b) and *Isotomiella* sp.6 in Bedos (1994). Source: Deharveng & Bedos (1993b), Bedos & Deharveng (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai, Mae Hong Son (N). Habitat: humus, litter and soil at 650 m near Doi Chiang Dao and near Mae Hong Son.
Distribution outside Thailand. Only known from northern Thailand.

101. *Isotomiella hirsuta* Bedos & Deharveng, 1994*
Name in source. *Isotomiella* sp. in Deharveng *et al.* (1989), *Isotomiella* n.sp.3 in Deharveng & Bedos (1993b), *Isotomiella* sp.1 in Bedos (1994). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos & Deharveng (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, humus, soil and roots at 1700–2550 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

102. *Isotomiella inthanonensis* Bedos & Deharveng, 1994*
Name in source. *Isotomiella* sp. in Deharveng *et al.* (1989), *Isotomiella* n.sp.4 in Deharveng & Bedos (1993b), *Isotomiella* sp.2 in Bedos (1994). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos & Deharveng (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, humus and soil at 1700–2550 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

103. *Isotomiella leksawasdii* Bedos & Deharveng, 1994*
Name in source. *Isotomiella* sp. in Deharveng *et al.* (1989), *Isotomiella* sp.3 in Bedos (1994). Source: Deharveng *et al.* (1989), Bedos & Deharveng (1994), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: soil at 1700–2000 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

104. *Isotomiella nummulifer* Deharveng & Oliveira, 1990
Source: Bedos & Deharveng (1994), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. No detail (P). Habitat: not given.
Distribution outside Thailand. Pan-tropical.

105. *Isotomiella symetrimucronata* Najt & Thibaud, 1987*
Name in source. *Isotomiella* n.sp.1 in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos & Deharveng (1994), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Widespread. Habitat: at low altitude in Thailand, including in Doi Inthanon.
Distribution outside Thailand. Pan-tropical.

***Isotomiella* spp.**
Name in source. *Isotomiella minor* in Takeda (1981), Deharveng (1986) and Wiwatwitaya & Takeda (2005).

Source: Takeda (1981), Deharveng (1986), Deharveng & Delnatte (1988), Leclerc & Dalger (1988), Deharveng & Bedos (1988, 1993b, 2001), Deharveng *et al.* (1989), Bedos & Deharveng (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai, Chiang Rai (N), Ratchaburi (W), Phetchabun (C), Khon Kaen, Nakhon Ratchasima (NE), Phang Nga, Yala (P). Habitat: cave in Chiang Rai, Phang Nga, Phetchabun and Yala; cave guano in Ratchaburi; above 2000 m. in Doi Inthanon forest; soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen (Takeda 1981) and in dry evergreen forest in Nakhon Ratchasima (Wiwatwitaya & Takeda 2005).
Remark. The cited records probably all correspond to species of the *minor* group (Bedos 1994), but not to *I. minor* itself, which seems to be restricted to temperate regions (Bedos & Deharveng 1994). The four morphospecies listed from Doi Inthanon above 2000 m. without more details in Deharveng *et al.* (1989) correspond to one undescribed morphospecies and to three of the species subsequently described and listed above. The six morphospecies recognized in Bedos (1994) from Doi Inthanon correspond to the species listed above (species number 100–105). *Isotomiella* sp. was recognized in a cave of Chiang Rai in Deharveng & Bedos (2001).

Genus *Isotomodes* Axelson

106. *Isotomodes trisetosus* Denis, 1923
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai, Mae Hong Son (N), Kanchanaburi (W), Surat Thani (P). Habitat: secondary forest or disturbed habitats below 1000 m in its distribution area.
Distribution outside Thailand. Cosmopolitan.

Genus *Jestella* Najt

Jestella* sp.
Name in source. *Jestella* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: humid litter and soil at 1700 and 2000 m. in Doi Inthanon forest.
Remark. The genus includes two species, *J. siva* Najt, 1978 from Nepal and *J. armata* Potapov, 2005 from northeastern Russia.

Genus *Micranurophorus* Bernard

Micranurophorus* sp.
Name in source. *Micranurophorus* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: soil, humus at 2550 m. in Doi Inthanon forest.

Genus *Parisotoma* Bagnall

107. *Parisotoma* cf. *dichaeta* (Yosii, 1969)*
Name in source. *Isotoma* (*Parisotoma)* sp. in Deharveng *et al.* (1989), *Parisotoma* n.sp. in Deharveng & Bedos (1993b), *Isotoma* (*Parisotoma*) cf. *dichaeta* in Bedos (1994). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: above 2000 m. in Doi Inthanon forest.
Distribution outside Thailand. *P. dichaeta* is distributed in temperate East Asia.

108. *Parisotoma notabilis* (Schäffer, 1896)*
Name in source. *Isotoma (Parisotoma) notabilis* in Deharveng *et al*. (1989) and Bedos (1994). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: above 2000 m. in Doi Inthanon forest.
Distribution outside Thailand. Holarctic.

Genus *Proisotoma* Börner

Proisotoma* spp.
Source: Deharveng (1986), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Nakhon Ratchasima (NE). Habitat: one morphospecies at 1000 m., one at 1700–2550 m. (also present in Doi Pui), one above 2000 m., three at 2500 m. in Doi Inthanon forest; soil s.l. in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Six morphospecies in Doi Inthanon, of which two are also present in other massifs of Chiang Mai province (Bedos 1994). The five morphospecies listed from Doi Inthanon above 2000 m. without more details in Deharveng *et al.* (1989) correspond to five of these six morphospecies.

Genus *Pseudisotoma* Handschin

Pseudisotoma* spp.
Name in source. *Isotoma* (*Pseudisotoma*) in Deharveng *et al.* (1989) and Bedos (1994). Source: Deharveng *et al*. (1989), Bedos (1994), Janssens (1999).
Distribution in Thailand. Chiang Mai (N), Phuket (P). Habitat: numerous above 1700 m. in Doi Inthanon forest; near 600 m. in Doi Chiang Dao; 1300 m in Doi Mae Tho; litter near sea level in Phuket.
Remark. Three morphospecies in Chiang Mai province (Bedos 1994).

Family Entomobryidae Schäffer

Subfamily Entomobryinae Schäffer

Genus *Coecobrya* Yosii

109. *Coecobrya guanophila* Deharveng, 1990
Source: Deharveng (1990), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: MNHN, BPBM, BDCM, LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave guano.
Distribution outside Thailand. Only known from Thailand (Amphoe Chiang Dao).

110. *Coecobrya* cf. *hoefti* (Schäffer, 1897)*
Name in source. *Sinella* cf. *höfti* in Yosii (1961), *Sinella hofti* in Takeda (1981), ? *Sinella* cf. *höfti* in Deharveng (1986), *Sinella* cf. *hoefti* in Deharveng *et al*. (1989) and Rojanavongse *et al*. (unpublished report). Source: Yosii (1961), Takeda (1981), Deharveng (1986), Deharveng *et al*. (1989), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Chiang Mai (N), Khon Kaen (NE). Habitat: soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen province (Takeda 1981).
Distribution outside Thailand. Europe (Jordana 2012).
Remark. Identification needs to be confirmed.

111. *Coecobrya similis* Deharveng, 1990
Source: Deharveng (1990), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MNHN,

BPBM, BDCM, LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave near entrance, litter and soil at 500 m. near Tham Chiang Dao.
Distribution outside Thailand. Only known from Thailand.

***Coecobrya* spp.**
Name in source. *Sinella* (*Coecobrya*) gr. *caeca* in Deharveng (1987c), cf. *Coecobrya* spp. in Deharveng & Bedos (2001). Source: Deharveng (1987c), Deharveng & Delnatte (1988), Deharveng & Bedos (1988, 2001), Leclerc *et al.* (1988), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Widespread. Habitat: cave and soil s.l.; present at all altitudes in Doi Inthanon forest.
Remark. Several morphospecies (Bedos 1994).

Genus *Entomobrya* Rondani

Entomobrya* spp.
Source: Takeda (1981), Deharveng *et al*. (1989), Bedos (1994), Janssens (1999), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Khon Kaen, Nakhon Ratchasima (NE), Phuket (P). Habitat: one morphospecies above 2400 m. and two at 2000 m. or below in Doi Inthanon forest; soil s.l. in mixed dry deciduous forest at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005); litter near sea level in Phuket.
Remark. Three morphospecies in Doi Inthanon (Bedos 1994).

Genus *Homidia* Börner

112. *Homidia cingula* Börner, 1906
Source: Takeda (1981), Deharveng (1986), Bedos (1994).
Distribution in Thailand. Khon Kaen (NE). Habitat: soil s.l. in mixed dry deciduous forest at 800 m. (Takeda 1981).
Distribution outside Thailand. Tropical Asia.

113. *Homidia subcingula* Denis, 1948
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Vietnam.

***Homidia* sp.**
Source: Takeda (1981), Deharveng (1986), Bedos (1994).
Distribution in Thailand. Khon Kaen (NE). Habitat: soil s.l. in mixed dry deciduous forest at 800 m. (Takeda 1981).

Genus *Lepidosira* Schött

Remark. The genus *Lepidosira* has been recently transferred from Seirinae to Entomobryinae (Zhang & Deharveng 2014).

***Lepidosira* spp.**
Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: two morphospecies around 2500 m., one above 1700 m., one at 1150 m. in Doi Inthanon forest.
Remark. Four morphospecies in Doi Inthanon and one in Doi Pui.

Genus *Sinella* Brook

***Sinella* spp.**
Name in source. *Sinella* (*Sinella*) in Deharveng (1987c). Source: Deharveng (1986), Deharveng (1987c), Deharveng & Bedos (1988), Deharveng & Delnatte (1988), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Phetchabun, Saraburi (C), Nakhon Ratchasima, Khon Kaen, Chaiyaphum (NE), Surat Thani (P). Habitat: mostly cave and cave guano; soil s.l. in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Generic assignations need to be confirmed after the redefinition of *Sinella* and *Coecobrya* by Deharveng (1990); the morphospecies recorded in the cited papers having not been characterized, their exact number is unknown.

Genus *Willowsia* Shoebotham

Willowsia* sp.** or **cf. *Willowsia* sp.
Source: Takeda (1981), Deharveng *et al*. (1989).
Distribution in Thailand. Chiang Mai (N), Khon Kaen (NE). Habitat: at 2000–2500 m. in Doi Inthanon forest; soil s.l. in mixed dry deciduous forest at 800 m. in Khon Kaen province (Takeda 1981).

Subfamily Heteromurinae Absolon & Kseneman

Remark. Heteromurinae have been recently withdrawn from Orchesellinae on morphological and molecular grounds (Zhang & Deharveng 2014).

Genus *Alloscopus* Börner

114. *Alloscopus tetracanthus* Börner, 1906*
Name in source. *Heteromurus (Alloscopus) tetracanthus* in Mari Mutt (1988). Source: Mari Mutt (1988), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: at low altitude in Doi Inthanon and Doi Pui.
Distribution outside Thailand. SE Asia, Australasia.

115. *Alloscopus thailandensis* Mari Mutt, 1985*
Name in source. *Heteromurus (Alloscopus) thailandensis* in Mari Mutt (1985a) and in Deharveng (1986), *Alloscopus* sp. in Deharveng *et al.* (1989). Source: Mari Mutt (1985a), Deharveng (1986), Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994). Type deposition: Mari Mutt PC.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, soil, roots and barks at low altitude near Doi Chiang Dao; up to 1700 m., rarely 2000 m. in Doi Inthanon forest.
Distribution outside Thailand. Sumatra.

***Alloscopus* sp.**
Source: Deharveng & Bedos (1988).
Distribution in Thailand. Phang Nga (P). Habitat: cave.

Genus *Dicranocentrus* Schött

116. *Dicranocentrus fasciatus* Yosii, 1961*
Source: Yosii (1961), Mari Mutt (1988), Deharveng (1986), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.

Distribution in Thailand. Chiang Mai (N). Habitat: mostly in litter at 1700–2100 m. in Doi Inthanon forest; at 720–1330 m. in Doi Pui.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

117. ***Dicranocentrus indicus*** **Bonet, 1930**
Source: Takeda (1981), Deharveng (1986), Bedos (1994).
Distribution in Thailand. Khon Kaen (NE). Habitat: soil s.l. in mixed dry deciduous forest and deforested area at 800 m.
Distribution outside Thailand. Tropical Asia.

118. ***Dicranocentrus thaicus*** **Yosii, 1961***
Source: Yosii (1961), Mari Mutt (1985b, 1988), Deharveng (1986), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: litter, humid mosses and decaying tree trunks at 2000–2500 m., and common above 1700 m. in Doi Inthanon forest; litter and humus at 2000 m. in Doi Chiang Dao; at 530–1530 m. in Doi Pui.
Distribution outside Thailand. Only known from Thailand (Chang Mai mountains).

119. ***Dicranocentrus yoshiius*** **Mari Mutt, 1988**
Source: Mari Mutt (1988), Bedos (1994). Type deposition: Mari Mutt PC
Distribution in Thailand. Chiang Mai (N). Habitat: at 1330 m in Doi Pui.
Distribution outside Thailand. Only known from Thailand (Doi Pui).

Dicranocentrus **spp.***
Name in source. *Dicranocentrus* n.sp. in Deharveng & Bedos (1993b), *Dicranocentrus* sp.1, sp.2 in Bedos (1994). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai, Mae Hong Son (N). Habitat: two morphospecies above 2000 m. and one below 1700 m. in Doi Inthanon forest.
Remark. Three morphospecies in Doi Inthanon, including one only reported in Deharveng *et al*. (1989) and one also present in Mae Hong Son province.

Genus *Heteromurus* Wankel

Heteromurus **sp.***
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: at low altitude in Doi Inthanon forest.

Subfamily Lepidocyrtinae Wahlgren

Remark. For the *Lepidocyrtus* complex, we conservatively use here the genera redefined by Yoshii & Suhardjono (1989): *Lepidocyrtus* Bourlet, *Acrocyrtus* Yosii and *Ascocyrtus* Yosii. These taxonomic entities can accomodate easily almost all the *Lepidocyrtus*-complex species of Southeast Asia we have encountered, which is not the case at the moment for the numerous additional subgenera proposed by Yoshii & Suhardjono (1989), and re-summarized by Wang *et al.* (2003) and Mateos & Greenslade (2015).

Lepidocyrtinae n.g. spp.
Name in source. Entomobryidae sp.1 and sp.2 in Deharveng *et al.* (1989), Entomobryidae n.g.2 n.sp.in Deharveng & Bedos (1993b), Lepidocyrtinae n.g.2 spp. in Bedos (1994). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Kanchanaburi, Ratchaburi, Prachuap Khiri Khan (W), Phang Nga (P).

Habitat: two morphospecies in litter and soil up to 2000 m. in Doi Inthanon forest; one morphospecies in a cave.
Distribution outside Thailand. Unknown.
Remark. Two morphospecies in Chiang Mai, others in other cited provinces.

Genus *Acrocyrtus* Yosii

120. *Acrocyrtus bipunctatus* Yosii, 1961*
Name in source. The replacement name *Lepidocyrtus yosii* Salmon 1964 for *Acrocyrtus bipunctatus* Yosii (1961) proposed by Salmon (1964) is not relevant because *Acrocyrtus* is not a synonym of *Lepidocyrtus* in modern systematics. Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Chiang Mai (N). Habitat: at 2100 m in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

Acrocyrtus* spp.
Name in source. *Lepidocyrtus* sp. in Deharveng *et al*. (1989). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: two morphospecies at 700 m and four at 1150–2000 m. in Doi Inthanon forest.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).
Remark. Four to six morphospecies.

Genus *Ascocyrtus* Yosii

121. *Ascocyrtus medius* (Schäffer, 1898)*
Name in source. *Lepidocyrtus medius* in Yosii (1961), Deharveng (1986) and Deharveng *et al*. (1989). Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. SE Asia.
Remark. Generic assignation according to Yoshii & Suhardjono (1989).

122. *Ascocyrtus minimus* Park & Rojanavongse, 1999, in: Kim *et al*. (1999a)
Name in source. *Lepidocyrtus (Ascocyrtus) minimus* in Kim *et al*. (1999a) and Rojanavongse *et al*. (unpublished report), *Lepidocyrtus minimus* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999a), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: litter at 250 m. in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

123. *Ascocyrtus reductus* Park & Rojanavongse, 1999, in: Kim *et al*. (1999a)
Name in source. *Lepidocyrtus (Ascocyrtus) reductus* in Kim *et al*. (1999a) and Rojanavongse *et al*. (unpublished report), *Lepidocyrtus reductus* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999a), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: litter at 620 m. in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

124. *Ascocyrtus simplex* Park & Rojanavongse, 1999, in: Kim *et al*. (1999a)
Name in source. *Lepidocyrtus (Ascocyrtus) simplex* in Kim *et al*. (1999a) and Rojanavongse *et al*. (unpublished report), *Lepidocyrtus simplex* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999a), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Surat Thani (P). Habitat: litter at 300 m. in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

125. *Ascocyrtus sublobatus* (Yosii, 1961)*

Name in source. *Discocyrtus sublobatus* in Yosii (1961), in Deharveng (1986) and in Rojanavongse *et al*. (unpublished report), *Entomobryidae* n.g.1 n.sp. in Deharveng & Bedos (1993b), *Lepidocyrtinae* n.g.3 *sublobatus* in Bedos (1994). Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994), Rojanavongse *et al*. (unpublished report).

Distribution in Thailand. Chiang Mai (N). Habitat: common above 1700 m. in Doi Inthanon forest.

Distribution outside Thailand. Only known from Thailand.

Remark. The species was placed in the subgenus *Cinctocyrtus* Yoshii & Suhardjono (1989) by Wang *et al.* (2003). However, it does not match the definition of this subgenus given by these last authors (femur is scaled). We keep it provisionally in the genus *Ascocyrtus*; possibly representative of a new genus (Bedos 1994).

Ascocyrtus* spp.

Name in source. *Ascocyrtus* n.sp.1, 2, 3 in Deharveng & Bedos (1993b). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).

Distribution in Thailand. Chiang Mai (N), Ranong (P). Habitat: cave in Ranong; two morphospecies at 700–1150 m., two at 1700–2100 m. in Doi Inthanon forest.

Remark. Five morphospecies, including four in Doi Inthanon.

Genus *Lepidocyrtus* Bourlet

Remark. We retain *Lepidocyrtus* and *Lanocyrtus* Yoshii & Suhardjono, 1989 as subgenera of *Lepidocyrtus* following Yoshii & Suhardjono (1989).

***Lepidocyrtus* s.l. spp.**

Source: Takeda (1981), Deharveng & Bedos (1988), Janssens (1999); Wiwatwitaya & Takeda (2005).

Distribution in Thailand. Khon Kaen, Nakhon Ratchasima (NE), Chumphon, Phuket (P). Habitat: cave guano in Chumphon province (Deharveng & Bedos 1988); soil s.l. in mixed dry deciduous forest at 800 m (Takeda 1981) in Khon Kaen province, with only one of the four recognized morphospecies being also present in deforested area; soil s.l. in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005); litter near sea level in Phuket (Janssens 1999).

Remark. Four morphospecies in Khon Kaen province (Takeda 1981); several morphospecies ("*Lepidocyrtus* spp.") in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).

126. *Lepidocyrtus (Lanocyrtus)* cf. *cyaneus* Tullberg, 1871*

Name in source. *Lepidocyrtus* cf. *cyaneus* in Yosii (1961) and later references. Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report).

Distribution in Thailand. Chiang Mai (N). Habitat: not given.

Distribution outside Thailand. *L. (L.) cyaneus* is probably Holarctic.

Remark. The species was assigned to *Lepidocyrtus* by Yosii (1961). According to its characters, it would match the definition of the sugbenus *Lanocyrtus* following the system of Yoshii & Suhardjono (1989). However the record needs to be confirmed because no species similar to *L. cyaneus* in its color pattern (body entirely blue) has been found in Doi Inthanon, or elsewhere in Thailand.

Lepidocyrtus* (*Lanocyrtus*) spp.

Name in source. *Lepidocyrtus* sp. in Deharveng *et al*. (1989); *Lepidocyrtus* sp.1 to 5 listed in Deharveng & Bedos (1993b) are *Lanocyrtus*, but do not match the five morphospecies re-assessed in Bedos (1994) from a more abundant material. Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).

Distribution in Thailand. Chiang Mai (N). Habitat: one morphospecies at the summit, two above 1700 m., one at 1150–1700 m. and one at 700–1150 m. in Doi Inthanon forest.

Remark. At least five morphospecies.

127. *Lepidocyrtus (Lepidocyrtus) curvicollis* Bourlet, 1839
Name in source. *Lepidocyrtus curvicollis*. Source: Hutacharen *et al*. (2007, from unknown source).
Distribution in Thailand. Not given. Habitat: not given.
Remark. Probably erroneous citation; the subgenus *Lepidocyrtus* is unconfirmed for tropical Asia after Yoshii & Suhardjono (1989), and has no species in Thailand. The confusion may have arisen from the redescription of *L. curvicollis* by Yosii (1959) from Belgium, buried in a paper dealing with Malay and Singapore Collembola.

Genus *Pseudosinella* Schäffer

128. *Pseudosinella chiangdaoensis* Deharveng, 1990
Name in source. *Pseudosinella* sp. in Deharveng (1987c). Source: Deharveng (1987c), Deharveng (1990), Bedos (1994), Deharveng & Bedos (2001), Wang *et al*. (2004), Rojanavongse *et al*. (unpublished report). Type deposition: MNHN, LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand (Tham Chiang Dao).

***Pseudosinella* spp.**
Source: Takeda (1981), Leclerc *et al.* (1988), Deharveng *et al.* (1989), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai, Mae Hong Son (N), Phetchaburi, Ratchaburi (W), Khon Kaen, Nakhon Ratchasima (NE), Phang Nga, Surat Thani (P). Habitat: at 2000–2500 m. (Deharveng *et al.* 1989), soil at 1150 and 1700 m. in Doi Inthanon forest (Bedos 1994); cave in Phetchaburi and cave guano in Ratchaburi (Leclerc *et al.* 1988); cave and humid habitat in Phang Nga and Chiang Dao, humid habitat in Mae Hong Son and Surat Thani, sea shore in Phang Nga (Bedos 1994); soil s.l. in mixed dry deciduous forest at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Five morphospecies are cited in Bedos (1994), one from Ratchaburi assigned with doubt to *Pseudosinella* (Leclerc *et al.* 1988), several from northeastern Thailand (Takeda 1981, Wiwatwitaya & Takeda 2005).

Genus *Setogaster* Salmon

Remark. As stressed by Yoshii & Suhardjono (1992), the definition of the genus *Setogaster* is a complex problem, which remains to be solved in spite of the synthetic paper of Mateos & Greenslade (2015). The duplication of the basal spine of the mucro claimed as diagnostic by these authors is in particular not a reliable character as it is present as well in some *Acrocyrtus*. Resolving the question would need the redescription of the type species of both *Setogaster* (*Trichogaster bispinosus* Handschin, 1932 from Indonesia) and *Ascocyrtus* (*Lepidocyrtus suborientalis* Denis, 1948 from Vietnam), and the study of a large diversity of species drawn from the core area of diversification of these genera. At the moment and provisionally, we place in *Setogaster* the Thai species of Lepidocyrtinae characterized by lateral bundles of long flexible chaetae on Abd. III of adults and the presence of a rounded basal lobe of *Ascocyrtus*-type on dens.

***Setogaster* spp.**
Name in source. *Lepidocyrtus* sp. in Deharveng *et al*. (1989). Source: Deharveng *et al*. (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), no detail (P). Habitat: above 2000 m. in Doi Inthanon forest.
Remark. One morphospecies in Doi Inthanon, genus present in southern Thailand.

Genus *Rambutsinella* Deharveng & Bedos

***Rambutsinella* spp.**
Name in source. Lepidocyrtinae n.g.1 in Bedos (1994). Source: Bedos (1994), Deharveng & Bedos (1996).

Distribution in Thailand. Chiang Mai (N), Kanchanaburi (W), Chaiyaphum (NE), Phang Nga (P), Chanthaburi (SE). Habitat: litter at low altitude in disturbed habitats near Chiang Mai (two morphospecies); litter of secondary forest in other regions.

Subfamily Seirinae Yosii

Genus *Seira* Lubbock

129. *Seira thailandica* Yosii, 1961*
Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

Seira* spp.
Name in source. cf. *Seira* sp. in Deharveng & Bedos (1993b). Source: Deharveng & Delnatte (1988), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Phetchabun (C). Habitat: cave guano in Phetchabun; litter at 700 m. in Doi Inthanon forest.

Family Cyphoderidae Börner

Genus *Cyphoderus* Nicolet

130. *Cyphoderus javanus* Börner, 1906 and ***Cyphoderus* cf. *javanus* Börner, 1906***
Source: Yosii (1966), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Phetchaburi (W). Habitat: at 1700 m. in Doi Inthanon forest.
Distribution outside Thailand. SE Asia, Argentina (dubious).
Remark. The exact identification of the Thai specimens is uncertain, given the taxonomic confusion among *Cyphoderus* of the group *albinus* (Jantarit *et al.* 2014).

131. *Cyphoderus khaochakanus* Jantarit, Satasook & Deharveng, 2014
Source: Jantarit *et al*. (2014). Type deposition: PSU-NHM, MNHN.
Distribution in Thailand. Sa Kaeo (SE). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

132. *Cyphoderus songkhlaensis* Jantarit, Satasook & Deharveng, 2014
Source: Jantarit *et al*. (2014). Type deposition: PSU-NHM, MNHN.
Distribution in Thailand. Songkhla (P). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

Cyphoderus* spp.
Source: Leclerc *et al.* (1988), Deharveng & Bedos (1993b), Bedos (1994), Jantarit *et al*. (2014).
Distribution in Thailand. Chiang Mai (N), Phetchaburi, Ratchaburi, Tak (W), Chaiyaphum, Loei (NE), Chumphon, Surat Thani, Trang (P). Habitat: cave, cave guano and ant nests; litter at 1700 m. in Doi Inthanon forest.
Remark. *Cyphoderus* is very common in the caves of Thailand. It seems that different caves may harbour different species (Jantarit *et al*. 2014).

Family Paronellidae Börner

Paronellidae spp.*
Source: Deharveng *et al.* (1989).
Distribution in Thailand. Chiang Mai (N). Habitat: at 2000–2500 m. in Doi Inthanon forest.
Remark. Three morphospecies listed, unidentifed. They might be *Callyntrura* or *Salina* which are both represented above 2000 m. in Doi Inthanon, but often as juveniles in samples.

Subfamily Paronellinae Börner

Genus *Callyntrura* Börner

Callyntrura* spp.
Name in source. Paronellidae n.sp. and Paronellidae sp. in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Nakhon Ratchasima (NE). Habitat: litter between 700 and 2500 m. in Doi Inthanon forest; soil s.l. in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Several morphospecies of *Callyntrura* of unknown subgenera, usually juveniles, are recorded from litter in the Doi Inthanon forest (Bedos 1994).

133. *Callyntrura (?) spinifera* Yosii, 1961*
Name in source. *Callyntrura spinifera* in Yosii (1961), in Deharveng (1986), in Deharveng *et al*. (1989) and in Rojanavongse *et al*. (unpublished report). Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).
Remark. The subgenus is not given in the cited references.

134. *Callyntrura (Callyntrura) alpina* Lee & Rojanavongse, 1999, in: Kim *et al*. (1999b)
Name in source. *Callyntrura alpina* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Surat Thani (P). Habitat: litter in dry evergreen forest near a stream.
Distribution outside Thailand. Only known from Thailand.

135. *Callyntrura (Callyntrura) capitata* Lee & Rojanavongse, 1999, in: Kim *et al*. (1999b)
Name in source. *Callyntrura capitata* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: decayed debris near waterfall in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

136. *Callyntrura (Callyntrura) longicornis* (Oudemans, 1890)
Name in source. *Paronella anopla* Börner 1906. Source: Hutacharen *et al*. (2007, from unknown source).
Distribution in Thailand. not given. Habitat: not given.
Distribution outside Thailand. Java.
Remark. Synonymy according to Yoshii (1982).

137. *Callyntrura (Callyntrura) nigra* Lee & Rojanavongse, 1999, in: Kim *et al*. (1999b)
Name in source. *Callyntrura nigra* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: decaying bark and moss near waterfall in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

138. ***Callyntrura (Callyntrura) obscuriventris*** **Yoshii, 1982**
Source: Yoshii (1985), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Trang (P). Habitat: not given.
Distribution outside Thailand. Malaysia.

139. ***Callyntrura (Callyntrura) thoyaopongi*** **Yoshii, 1982**
Source: Yoshii (1985), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Trang (P). Habitat: not given.
Distribution outside Thailand. Malaysia.

140. ***Callyntrura (Gunungphysa) distincta*** **Lee & Rojanavongse, 1999,** in: Kim *et al*. (1999b)
Name in source. *Callyntrura distincta* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Surat Thani (P). Habitat: litter and surface of sandy soil of deciduous forest.
Distribution outside Thailand. Only known from Thailand.

141. ***Callyntrura (Gunungphysa) elongata*** **(Carpenter, 1917)**
Source: Yoshii (1985), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Trang (P). Habitat: not given.
Distribution outside Thailand. Myanmar.

142. ***Callyntrura (Gunungphysa) montana*** **Kim & Rojanavongse, 1999,** in: Kim *et al*. (1999b)
Name in source. *Callyntrura montana* in Hutacharen *et al*. 2007. Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Saraburi (C). Habitat: litter near stream in mixed deciduous forest in a botanical garden.
Distribution outside Thailand. Only known from Thailand.

143. ***Callyntrura (Handschinphysa) lineata*** **(Parona, 1892)**
Source: Yoshii (1985), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Kanchanaburi (W). Habitat: not given.
Distribution outside Thailand. Myanmar.

144. ***Callyntrura (Japonphysa) oligosetosa*** **Kim & Rojanavongse, 1999,** in: Kim *et al*. (1999b)
Name in source. *Callyntrura oligosetosa* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: grasses and litter in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

145. ***Callyntrura (Japonphysa) semilineata semilineata*** **Yosii, 1961***
Name in source. *Callyntrura semilineata* in Yosii (1961), in Deharveng (1986), in Deharveng *et al*. (1989) and in Rojanavongse *et al*. (unpublished report). Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

146. ***Callyntrura (Japonphysa) semilineata mediopunctata*** **Yoshii, 1985**
Name in source. *Callyntrura semilineata mediopunctata* in Hutacharen *et al*. (2007). Source: Yoshii (1985), Kim *et al*. (1999b), Bedos (1994), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Surat Thani, Trang (P). Habitat: not given.
Distribution outside Thailand. Malaysia.

147. *Callyntrura (Japonphysa) unilineata* Yosii, 1961*
Name in source. *Callyntrura unilineata* in Yosii (1961), in Deharveng (1986), in Deharveng *et al*. (1989) and in Rojanavongse *et al*. (unpublished report). Source: Yosii (1961), Yoshii (1982), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

148. *Callyntrura (Kudatphysa) bimaculata* Yosii, 1959
Source: Yoshii (1985), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Bangkok (C). Habitat: not given.
Distribution outside Thailand. Singapore.

149. *Callyntrura (Kudatphysa)* cf. *kudatensis* Yoshii, 1981
Source: Yoshii (1985), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Nakhon Nayok (C), Trang (P). Habitat: not given.
Distribution outside Thailand. *C. (K.) kudatensis* is distributed in tropical Asia.

150. *Callyntrura (Kudatphysa) marginata* Yosii, 1961*
Name in source. *Callyntrura marginata* in Yosii (1961), in Deharveng (1986) and in Deharveng *et al*. (1989). Source: Yosii (1961), Yoshii (1985), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N), Bangkok (C). Habitat: not given.
Distribution outside Thailand. Only known from Thailand.

151. *Callyntrura (Kudatphysa) modesta* Yoshii, 1985
Source: Yoshii (1985), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Nakhon Nayok (C). Habitat: not given.
Distribution outside Thailand. Only known from Thailand.

152. *Callyntrura (Kudatphysa) striatella* Kim & Rojanavongse, 1999, in: Kim *et al*. (1999b)
Name in source. *Callyntrura striatella* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Rayong (SE). Habitat: litter near waterfall in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

153. *Callyntrura (Murphysa) hirsuta* Kim & Rojanavongse, 1999, in: Kim *et al*. (1999b)
Name in source. *Callyntrura hirsuta* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Saraburi (C). Habitat: litter near dry stream in mixed deciduous forest litter in a botanical garden.
Distribution outside Thailand. Only known from Thailand.

154. *Callyntrura (Sultanaphysa) antennata* Kim & Rojanavongse, 1999, in: Kim *et al*. (1999b)
Name in source. *Callyntrura antenata* in Hutacharen *et al*. (2007). Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Surat Thani (P). Habitat: litter near stream in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

155. *Callyntrura (Sultanaphysa) putera* Yoshii, 1985
Source: Yoshii (1985), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Trang (P). Habitat: not given.
Distribution outside Thailand. Only known from Thailand.

Genus *Dicranocentroides* Imms

156. ***Dicranocentroides coomani* Delamare Deboutteville, 1948**
Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. SE Asia.

157. ***Dicranocentroides fasciculatus* Imms, 1912**
Source: Hutacharen *et al*. (2007, from unknown source).
Distribution in Thailand. Not given. Habitat: not given.
Distribution outside Thailand. India.

158. ***Dicranocentroides marginatus* Kim & Rojanavongse, 1999,** in: Kim *et al*. (1999a)
Source: Kim *et al*. (1999a), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Phetchaburi (W). Habitat: top soil of dried swamp at 250 m. in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

159. ***Dicranocentroides nigronotus* Kim & Rojanavongse, 1999,** in: Kim *et al*. (1999a)
Source: Kim *et al*. (1999a), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Surat Thani (P). Habitat: litter at 300 m. in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

160. ***Dicranocentroides nigroventris* Kim & Rojanavongse, 1999,** in: Kim *et al*. (1999a)
Source: Kim *et al*. (1999a), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Phetchaburi (W), Nakhon Ratchasima (NE). Habitat: litter near stream at 720 m. in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

161. ***Dicranocentroides orientalis* Kim & Rojanavongse, 1999,** in: Kim *et al*. (1999a)
Source: Kim *et al*. (1999a), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Phetchaburi (W), Surat Thani (P). Habitat: litter on sandy soil at 250–300 m. in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

162. ***Dicranocentroides thaius* Kim & Rojanavongse, 1999,** in: Kim *et al*. (1999a)
Source: Kim *et al*. (1999a), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report). Type deposition: CNU, KU.
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: litter near stream at 620 m. in evergreen forest.
Distribution outside Thailand. Only known from Thailand.

Genus *Lepidonella* Yosii

163. ***Lepidonella ceylonica* (Yosii, 1966)**
Name in source. *Microparonella ceylonica* in Takeda (1981) and in Deharveng (1986). Source: Takeda (1981), Deharveng (1986), Bedos (1994).
Distribution in Thailand. Khon Kaen (NE). Habitat: soil s.l. in mixed dry deciduous forest and deforested area at 800 m.
Distribution outside Thailand. Sri Lanka.

***Lepidonella* spp.**
Name in source. *Microparonella* sp. in Wiwatwitaya & Takeda (2005). Source: Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Nakhon Ratchasima (NE). Habitat: forest in Doi Chiang Dao in Bedos (1994); soil s.l. in dry evergreen lowland forest in Wiwatwitaya & Takeda (2005).
Remark. *Microparonella* has been synonymized with *Lepidonella* by Deharveng & Bedos (1995).

Genus *Salina* Mac Gillivray

164. *Salina cingulata* (Handschin, 1925)
Source: Kim *et al*. (1999b), Hutacharen *et al*. (2007), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Sakon Nakhon (NE). Habitat: not given.
Distribution outside Thailand. SE Asia.

165. *Salina grisescens* Yosii, 1961*
Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

166. *Salina pulchella* Goto, 1955
Source: Yosii (1961), Deharveng (1986), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report).
Distribution in Thailand. Chiang Mai (N). Habitat: cave (Tham Chiang Dao).
Distribution outside Thailand. Singapore.

167. *Salina transversalis* Yosii, 1961*
Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

168. *Salina yoshikawai* Yosii, 1961*
Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).

169. *Salina yosii* Salmon, 1964*
Name in source. *Salina maculata* in Yosii (1961), in Deharveng (1986), in Deharveng *et al*. (1989) and in Rojanavongse *et al*. (unpublished report). Source: Yosii (1961), Deharveng (1986), Deharveng *et al*. (1989), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MHNG.
Distribution in Thailand. Chiang Mai (N). Habitat: not given.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).
Remark. New name for *Salina maculata* Yosii (1961) (preoccupied) proposed by Salmon (1964).

Salina* spp.
Source: Takeda (1981), Bedos (1994), Janssens (1999), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Khon Kaen, Nakhon Ratchasima (NE), Phuket (P). Habitat: soil s.l. in mixed dry deciduous forest at 800 m. in Khon Kaen province (Takeda 1981) and in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005); litter near sea level in Phuket.

Subfamily Troglopedetinae, Börner

Remark. Deharveng (1987c) recognized two groups among *Troglopedetes* s.l.: group-A (= *Troglopedetes*) present in many caves in the northern and western Thailand and group-B (= *Cyphoderopsis*) from many caves in southern Thailand.

Genus *Cyphoderopsis* Carpenter

170. *Cyphoderopsis cavicola* Jantarit, Satasook & Deharveng, 2013
Name in source. *Troglopedetes* sp. in Deharveng & Bedos (1988). Source: Deharveng & Bedos (1988), Jantarit *et al*. (2013). Type deposition: PSU-NHM, MNHN.
Distribution in Thailand. Surat Thani (P). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

171. *Cyphoderopsis khaophang* Jantarit, Satasook & Deharveng, 2013
Name in source. *Troglopedetes* sp. in Deharveng & Bedos (1988). Source: Deharveng & Bedos (1988), Jantarit *et al*. (2013). Type deposition: PSU-NHM, MNHN.
Distribution in Thailand. Surat Thani (P). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

172. *Cyphoderopsis phangnga* Jantarit, Satasook & Deharveng, 2013
Source: Jantarit *et al*. (2013). Type deposition: PSU-NHM, MNHN.
Distribution in Thailand. Phang Nga (P). Habitat: secondary forest litter at sea level.
Distribution outside Thailand. Only known from Thailand.

173. *Cyphoderopsis thachana* Jantarit, Satasook & Deharveng, 2013
Name in source. *Troglopedetes* group B in Deharveng (1987c), *Troglopedetes* sp. in Deharveng & Bedos (1988). Source: Deharveng (1987c), Deharveng & Bedos (1988), Jantarit *et al*. (2013). Type deposition: PSU-NHM, MNHN.
Distribution in Thailand. Surat Thani (P). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

***Cyphoderopsis* spp.**
Name in source. *Troglopedetes* group B in Deharveng (1987c), *Troglopedetes* sp. in Deharveng & Bedos (1988). Source: Deharveng (1987c), Deharveng & Bedos (1988, 2001), Bedos (1994), Jantarit *et al*. (2013).
Distribution in Thailand. Southern Thailand. Habitat: cave.
Remark. Several morphospecies, from at least 7 caves in Phang Nga province; absent north of Kra isthmus.

Genus *Troglopedetes* Absolon

174. *Troglopedetes calvus* Deharveng & Gers, 1993
Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Kanchanaburi (W). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

175. *Troglopedetes centralis* Deharveng & Gers, 1993
Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

176. *Troglopedetes convergens* Deharveng & Gers, 1993
Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Ratchaburi (W). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

177. *Troglopedetes dispersus* Deharveng & Gers, 1993
Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Kanchanaburi (W). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

178. *Troglopedetes fredstonei* Deharveng, 1988
Source: Deharveng (1988a), Bedos (1994), Deharveng & Bedos (2001). Type deposition: BPBM.
Distribution in Thailand. Chiang Mai (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

179. *Troglopedetes leclerci* Deharveng, 1990
Source: Deharveng (1990), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: MNHN, BDCM, LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

180. *Troglopedetes longicornis* Deharveng & Gers, 1993
Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Mae Hong Son (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand

181. *Troglopedetes maffrei* Deharveng & Gers, 1993
Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Mae Hong Son (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

182. *Troglopedetes maungonensis* Deharveng & Gers, 1993
Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

183. *Troglopedetes microps* Deharveng & Gers, 1993
Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

184. *Troglopedetes multispinosus* Deharveng & Gers, 1993
Name in source. *Troglopedetes* sp. in Rigal & Maffre (1988). Source: Rigal & Maffre (1988); Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Chiang Rai (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

185. *Troglopedetes paucisetosus* Deharveng & Gers, 1993
Name in source. *Troglopedetes* sp. in Leclerc *et al.* (1988). Source: Deharveng & Gers (1993), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: LEITT.
Distribution in Thailand. Prachuap Khiri Khan (W). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

Troglopedetes* spp.
Source: Leclerc *et al.* (1988), Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai, Lampang, Mae Hong Son (N), Phetchaburi, Ratchaburi (W). Habitat: three morphospecies in litter and soil respectively above 2400 m., above 1700 m. and at 700–1300 m. in Doi Inthanon forest; soil s.l. (species from other locations of northern Thailand); cave in Phetchaburi and Ratchaburi provinces.
Remark. ten morphospecies from soil in northern Thailand (of which 3 from Doi Inthanon), one or two from caves in western Thailand. The morphospecies given from 700 m. to 2550 m. in Doi Inthanon by Deharveng & Bedos (1993b) has been split in three morphospecies by Bedos (1994).

Family Oncopoduridae Carl & Lebedinsky

Genus *Harlomillsia* Bonet

186. *Harlomillsia oculata* (Mills, 1937)*
Name in source. *Harlomillsia* sp. in Deharveng *et al.* (1989). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Kanchanaburi (W). no detail (P). Habitat: at all altitudes in Doi Inthanon forest.
Distribution outside Thailand. East Asia, Sumatra, Sulawesi, North America, Pacific.

Genus *Oncopodura* Carl & Lebedinsky

***Oncopodura* gr. *tricuspidata* Cassagnau, 1964**
Name in source. *Oncopodura* sp. gr. *tricuspidata* in Deharveng & Bedos (1988) and in Leclerc & Dalger (1988); *Oncopodura* gr. *tricuspidata* in Deharveng (1987c); *Oncopodura* sp. in Leclerc *et al.* (1988) and *Oncopodura* spp. in Deharveng & Bedos (2001). Source: Deharveng (1987c), Deharveng & Bedos (1988), Leclerc & Dalger (1988), Leclerc *et al.* (1988).
Distribution in Thailand. Chiang Mai, Mae Hong Son (N), Prachuap Khiri Khan (W). Surat Thani, Yala (P). Habitat: cave.
Distribution outside Thailand. *O. tricuspidata* is European.
Remark. Two morphospecies in northern Thailand caves after Deharveng (1987c) and Bedos (1994); in the South present in three caves (probably another species).

Family Tomoceridae Schäffer

Genus *Tomocerus* Nicolet

Tomocerus* spp.
Name in source. *Tomocerus* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: above 1150 m. in Doi Inthanon forest.
Remark. One or more probably two morphospecies in Doi Inthanon (Bedos 1994).

Order Symphypleona Börner

Remark. Symphypleona gen.sp. cited in Deharveng *et al.* (1989) is not retrieved in other cited works and is considered as an uncertain record.

Family Arrhopalitidae Stach

Genus *Arrhopalites* Börner

187. *Arrhopalites anulifer* Nayrolles, 1990
Name in source. *Arrhopalites* in Deharveng (1987c). Source: Deharveng (1987c), Nayrolles (1990), Bedos (1994), Rojanavongse *et al*. (unpublished report). Type deposition: MNHN, BPBM, BDCM, LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave, soil, decaying wood, up to 1720 m. in Doi Chiang Dao.
Distribution outside Thailand. Only known from Thailand.

188. *Arrhopalites chiangdaoensis* Nayrolles, 1990
Name in source. *Arrhopalites* in Deharveng (1987c). Source: Deharveng (1987c), Nayrolles (1990), Bedos (1994), Deharveng & Bedos (2001), Rojanavongse *et al*. (unpublished report). Type deposition: MNHN, BPBM, BDCM, LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: cave.
Distribution outside Thailand. Only known from Thailand.

Arrhopalites* spp.
Name in source. *Arrhopalites* n.sp.1 to 4 in Deharveng & Bedos (1993b). Source: Deharveng (1987c), Deharveng & Bedos (1988, 1993b, 2001), Deharveng *et al.* (1989), Bedos (1994).
Distribution in Thailand. Chiang Mai, Chiang Rai (N), Nakhon Ratchasima (NE), Phang Nga (P). Habitat: cave in Chiang Rai and Phang Nga province; mostly above 1700 m in Doi Inthanon forest; soil s.l. in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. Seven morphospecies of which four in Doi Inthanon (Bedos 1994), one in Chiang Rai province (Deharveng 1987c), one in Phang Nga province (Deharveng & Bedos 1988), one in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005). The taxonomic status of the different forms is not known, except the morphospecies of Doi Inthanon.

Family Collophoridae Bretfeld

Genus *Collophora* Richards in Delamare Deboutteville & Massoud

Collophora* spp.
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai, Mae Hong Son (N). Habitat: at 1150 m. in Doi Inthanon forest.
Remark. Possibly several morphospecies.

Family Dicyrtomidae Börner

Genus *Bothriovulsus* Richards

Bothriovulsus* sp.
Name in source. *Bothriovulsus* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 2550 m. Doi Inthanon.

Genus *Calvatomina* Yosii

189. *Calvatomina* cf. *calva* (Denis, 1948)*
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: at 1150 m. in Doi Inthanon forest.
Distribution outside Thailand. *C. calva* is distributed in Vietnam, ?Singapore.

Calvatomina* sp.
Name in source. cf. *Calvatomina* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: at 700 m. in Doi Inthanon forest.

Genus *Dicyrtoma* Bourlet

***Dicyrtoma* sp.**
Source: Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: soil s.l. in dry evergreen lowland forest.
Remark. Identification to confirm as the presence of the genus in SE Asia is dubious (Bellinger *et al.* 2016).

Genus *Ptenothrix* Börner

190. *Ptenothrix brouquissei* Nayrolles, 1989
Name in source. *Ptenothrix* nr. *brouquissei* in Deharveng & Bedos (1993b). Source: Nayrolles (1989), Deharveng & Bedos (1993b), Bedos (1994). Type deposition: LEITT.
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 500 m near Doi Chiang Dao.
Distribution outside Thailand. Only known from Thailand.

Ptenothrix* spp.
Name in source. Dicyrtomidae sp. and *Ptenothrix* sp. in Deharveng *et al.* (1989), *Papirioides* n.sp., *Ptenothrix* n.sp.1 and n.sp.2 in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: two morphospecies in the summit area, two at low altitude (1150 m. and 700 m.) and one at all altitudes in Doi Inthanon forest.
Remark. Five morphospecies in Doi Inthanon (Bedos 1994).

Family Katiannidae Börner

Genus *Sminthurinus* Börner

191. *Sminthurinus* cf. *igniceps* (Reuter, 1878)*
Name in source. *Sminthurinus* sp. in Deharveng *et al.* (1989), *Sminthurinus* cf. *niger* (Lubbock 1868) in Deharveng & Bedos (1993b). Source: Deharveng *et al.* (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: above 2400 m. in Doi Inthanon forest.
Distribution outside Thailand. *S. igniceps* is distributed in Europe, ?Japan.
Remark. Bedos (1994) mentions variations in color pattern, which may account for the two morphospecies recorded earlier by Deharveng *et al.* (1989).

192. *Sminthurinus* cf. *trinotatus* Axelson, 1905*
Source: Bedos (1994).

Distribution in Thailand. Chiang Mai (N). Habitat: at 1150 m. in Doi Inthanon forest.
Distribution outside Thailand. *S. trinotatus* is Palaearctic.

***Sminthurinus* spp.**
Source: Deharveng & Delnatte (1988), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Phetchabun (C), Nakhon Ratchasima (NE). Habitat: cave in Phetchabun; soil s.l. in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).
Remark. One morphospecies in Phetchabun province; several morphospecies ("*S.* spp.") in Nakhon Ratchasima province after Wiwatwitaya & Takeda (2005).

Family Sminthuridae Lubbock

Sminthuridae spp.
Source: Takeda (1981).
Distribution in Thailand. Khon Kaen (NE). Habitat: soil s.l. in mixed dry deciduous forest at 800 m.
Remark. Four morphospecies.

Genus *Afrosminthurus* Delamare Deboutteville & Massoud

Afrosminthurus* spp.
Name in source. *Sphyrotheca* n.sp.2 and n.sp.5 in Deharveng & Bedos (1993b). Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: three morphospecies at 2100–2550 m., 1700–1740 m. and 1150 m. in Doi Inthanon forest.
Remark. Three morphospecies in Doi Inthanon, one morphospecies in Doi Pui.

Genus *Allacma* Börner

Allacma* spp.
Name in source. Sminthuridae sp.1 and sp.2 in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: three morphospecies at 1700–2400 m., 1740 m. and 1150 m in Doi Inthanon forest.
Remark. Three morphospecies in Doi Inthanon.

Genus *Neosminthurus* Mills

Neosminthurus* sp.
Name in source. *Neosminthurus* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: at 1100–2550 m. in Doi Inthanon forest in rainy season.
Remark. The same morphospecies is present in Doi Pui and Doi Mae Tho.

Genus *Papirinus* Yosii

Papirinus* sp.
Name in source. *Papirinus* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 1700–1740 m. in Doi Inthanon forest.

Genus *Pararrhopalites* Bonet & Tellez

193. *Pararrhopalites* cf. *popei* Lawrence, 1968*
Name in source. *Pararrhopalites* n.sp. in Deharveng & Bedos (1993b). Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter and soil at 700 m. in Doi Inthanon forest.
Distribution outside Thailand. *P. popei* is distributed in Pacific islands.

Pararrhopalites* spp.
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai, Mae Hong Son (N). Phang Nga, Surat Thani (P). Habitat: one morphospecies at 1150 m. in Doi Inthanon forest, others at low altitude forest in northern Thailand; at sea level in southern Thailand.
Remark. One morphospecies in Doi Inthanon, one in Doi Chiang Dao and several forms in northern and southern Thailand.

Genus *Sminthurus* Latreille

***Sminthurus* sp.**
Source: Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Nakhon Ratchasima (NE). Habitat: soil s.l. in dry evergreen lowland forest.
Remark. Identification to confirm.

Genus *Sphyrotheca* Börner

Sphyrotheca* spp.
Name in source. cf. *Sphyrotheca* in Deharveng *et al.* (1989), *Sphyrotheca* n.sp.1, n.sp.3 and n.sp.4 in Deharveng & Bedos (1993b). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: two morphospecies mostly at 2550 m. in humid rainforest, three at 700–1150 m. in drier forest of Doi Inthanon; one at the summit of Doi Pui.
Remark. Five morphospecies in Doi Inthanon, one in Doi Pui.

Family Sminthurididae Börner

Sminthurididae n.g. sp.*
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: in low altitude dry forest of Doi Inthanon.
Distribution outside Thailand. Only known from Thailand (Doi Inthanon).
Remark. Genus intermediate between *Yosiides* Massoud & Betsch and *Pygicornides* Betsch (Bedos 1994).

Genus *Sminthurides* Börner

Sminthurides* spp.
Source: Deharveng & Bedos (1988), Deharveng & Bedos (1993b), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai (N), Nakhon Ratchasima (NE), Phang Nga, Surat Thani (P). Habitat: cave in Phang Nga province (Deharveng & Bedos 1988); near a pond in Surat Thani province; one morphospecies at 1700–1740 m. and one at 1150–1700 m. in Doi Inthanon forest (Bedos 1994); dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).

Remark. Two morphospecies in Doi Inthanon (Bedos 1994), probably two in the South; several species ("*S.* spp.") in Nakhon Ratchasima province after Wiwatwitaya & Takeda (2005).

Genus *Sphaeridia* Linnaniemi

Sphaeridia* spp.
Name in source. *Sphaeridia* n.spp. in Deharveng & Bedos (1993b). Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Widespread. Habitat: mostly in litter at all altitudes in Doi Inthanon forest, very abundant.
Remark. Genus not studied in detail.

Genus *Yosiides* Massoud & Betsch

Remark. Monospecific genus established for a species from Nepal.

Yosiides* spp.
Source: Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: one morphospecies at 1700–2400 m., one at 1700 m. in Doi Inthanon forest.
Remark. Two morphospecies in Doi Inthanon.

Order Neelipleona Massoud

Family Neelidae Folsom

Genus *Megalothorax* Willem

194. *Megalothorax* cf. *minimus* Willem, 1900 and ***Megalothorax* gr. *minimus* ***
Name in source. *Meganthrax minimus* in Takeda (1981) (misspelling), *Megalothorax* n.sp. in Deharveng & Bedos (1993b); considered as a species group in Deharveng *et al*. (1989) and in Bedos (1994). Source: Takeda (1981), Deharveng (1986), Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Khon Kaen (NE). Habitat: litter and soil below 1700 m. (orange form) and at all altitudes (white form) in Doi Inthanon forest (Deharveng & Bedos 1993b, Bedos 1994); soil s.l. in mixed dry deciduous forest and deforested area at 800 m. in Khon Kaen province (Takeda 1981).
Distribution outside Thailand. *M. minimus* is cosmopolitan.
Remark. Two morphospecies in Doi Inthanon forest (Bedos 1994), one in Khon Kaen (Takeda 1981). All identifications of *M. minimus* have to be confirmed according to the recent revision of Schneider & D'Haese (2013).

***Megalothorax* sp.**
Source: Deharveng & Bedos (1988), Rigal & Maffre (1988), Bedos (1994), Wiwatwitaya & Takeda (2005).
Distribution in Thailand. Chiang Mai, Chiang Rai (N), Nakhon Ratchasima (NE), Phang Nga (P). Habitat: cave in Chiang Rai and Phang Nga provinces (Deharveng & Bedos 1988, Rigal & Maffre 1988); soil s.l. in dry evergreen lowland forest in Nakhon Ratchasima province (Wiwatwitaya & Takeda 2005).

Genus *Neelides* Caroli

Neelides* sp.
Source: Deharveng *et al*. (1989), Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N). Habitat: litter at 1740 and 2100 m. in Doi Inthanon forest.

Genus *Neelus* Folsom

Neelus* spp.
Source: Deharveng & Bedos (1993b), Bedos (1994).
Distribution in Thailand. Chiang Mai (N), Surat Thani (P). Habitat: litter at 700–2100 m. in Doi Inthanon forest.
Remark. Number of morphospecies not given, at least one in Doi Inthanon and one in the South.

Discussion

A total of 194 described species, described of refered to described species, are reported for Thailand in the four orders of Collembola (Table 1). The majority of Thai Collembola belongs to the order Entomobryomorpha which includes 5 families, 24 genera and 97 species (50%), followed by Poduromorpha with 4 families, 23 genera and 89 species (45.9%); Symphypleona with 4 families, 5 genera and 7 species (3.6%) and Neelipleona with 1 family, 1 genus and 1 species (0.5%) (Table 1). The family Neanuridae has the highest number of species in Thailand (33%) followed by Paronellidae (27%), Entomobryidae (11%), Isotomidae (10%) and Hypogastruridae (9%) (Fig. 3). The four most species-rich genera are *Callyntrura* (23 species), *Friesea* (14 species), *Siamanura* (13 species) and *Troglopedetes* (12 species), which represent 32 % of all described species (Table 1). If morphospecies are considered, the total number of species-level taxa woud increase to at least 475 for 115 genera. Uncertainty on the validity of some records and the status of some morphospecies subsists, but they are unlikely to change significantly these values. Taxonomic unevenness is considerable. The most obvious is the under-representation of the subfamily Lepidocyrtinae, probably the most diversified group in the soils of Thailand (Bedos 1994). Another indication of this low taxonomic knowledge is that 62 genera from 15 families contained unidentified species.

With regard to distribution, all listed species were reported to biogeographical regions and to provinces (Fig. 1), except three cited in Hutacharen *et al*. (2007) on which we have no distribution data: *Lepidocyrtus curvicollis* Bourlet, 1839, *Callyntrura* (*Callyntrura*) *longicornis* Oudemans, 1890 and *Dicranocentroides fasciculatus* Imms, 1912. The number of recorded species is highest in the northern part of the country (Deharveng & Bedos 1993b; Bedos 1994). Among provinces, Chiang Mai is the richest (126 species) followed by Surat Thani (14 species), Trang (11 species), Nakhon Ratchasima (10 species), Mae Hong Son, Kanchanaburi and Phang Nga (nine species for each) while the rest is shown in Fig. 1. This is because most comprehensive surveys have been conducted in the Chiang Mai mountains of Doi Inthanon and Doi Chiang Dao (Deharveng & Bedos 1993b; Bedos 1994), all in the North region of Thailand. Limited attempts have been made to collect Collembola in other regions (Kim *et al*. 1999a, 1999b; Takeda 1981; Wiwatwitaya & Takeda 2005; Yoshii 1985; Yosii 1961, 1976). Out of the 77 provinces of Thailand, 22 were partially sampled (Fig.1) representing only 29%. Hence, the real number of species in Thailand is undoubtedly much larger than reported here, with the largest part of the country still unstudied. Published data reflect the few places that collembologists have sampled, and give a biased overview of the distribution of the species. Interestingly, of the known species in Thailand, none can be considered as introduced, while 116 species (60%) are only recorded in the country and considered endemic (Fig. 2). This is a very high level of endemicity, but the study of springtails in neighboring countries where they are less known (Myanmar, Laos, Cambodia and Peninsular Malaysia) may change the status of several. However, most are likely to remain narrowly distributed as indirectly suggested by observed vicariance patterns, for instance in the genera *Troglopedetes* (Deharveng & Gers 1993) and *Cyphoderopsis* (Jantarit *et al.* 2013).

Ecological gaps are also evident in the available dataset. Among the 17 types of forest vegetation that have been characterized by Santisuk (2012) in Thailand, six have been largely (but unevenly) sampled for Collembolan fauna (tropical rainforest, dry evergreen forest, lowland montane rainforest, lowland montane forest, cloud forest, montane peat bog). In contrast, records from montane oak, pine-oak and coniferous forests, mangrove forest, peat swamp forest, strand vegetation and deciduous forests (mixed deciduous forest, dry dipterocarp forest and pine-deciduous dipterocarp forest) are scarce or lacking. Similarly, records are scarce for non-forested habitats, like savannah, sand dunes, mountain open habitats, cultures and urban habitats. Furthermore, in each of these vegetation-characterized habitats, micro-habitats have also been unevenly sampled. Effort was focused on litter and soil Collembola, but those of mosses and lichens on rocks or on tree-trunks, decaying wood, epigean and tree canopy habitats, stream bank interstitial, which often harbor a rich and original Collembolan fauna in the tropics, have just been touched upon.

TABLE 1. Collembola genera with described species and species referred to described species (cf.) cited from Thailand. No., number of species.

Genus	Order / Family	No.	Genus	Order / Family	No.
	Order Poduromorpha			Order Entomobryomorpha	
	Hypogastruridae			Isotomidae	
Acherontiella Absolon		2	*Folsomia* Willem		2
Ceratophysella Börner		6	*Folsomides* Stach		3
Willemia Börner		5	*Folsomina* Denis		2
Xenylla Tullberg		5	*Hemisotoma* Bagnall		1
	Neanuridae: Frieseinae		*Isotomiella* Bagnall		8
Friesea Dalla Torre		14	*Isotomodes* Axelson		1
	Neanuridae: Neanurinae		*Parisotoma* Bagnall		2
Blasconura Cassagnau		1		Entomobryidae: Entomobryinae	
Blasconurella Deharveng & Bedos		6	*Coecobrya* Yosii		3
Chirolavia Deharveng		2	*Homidia* Börner		2
Digitanura Deharveng		1		Entomobryidae: Heteromurinae	
Hyperlobella Cassagnau		1	*Alloscopus* Prabhoo		2
Paleonura Cassagnau		3	*Dicranocentrus* Schött		4
Paralobella Cassagnau & Deharveng		3		Entomobryidae: Lepidocyrtinae	
Paranura Axelson		8	*Acrocyrtus* Yosii		1
Pronura Delamare Deboutteville		2	*Ascocyrtus* Yosii		5
Rambutanura Deharveng		1	*Lepidocyrtus* Bourlet		2
Siamanura Deharveng		13	*Pseudosinella* Schäffer		1
Thaianura Yosii		1		Entomobryidae: Seirinae	
	Neanuridae: Pseudachorutinae		*Seira* Lubbock		1
Cephalachorutes Bedos & Deharveng		5		Cyphoderidae	
Micranurida Börner		1	*Cyphoderus* Nicolet		3
Pseudachorutes Tullberg		1		Paronellidae: Paronellinae	
	Neanuridae: Uchidanurinae		*Callyntrura* Börner		23
Denisimeria Massoud		1	*Dicranocentroides* Imms		7
	Odontellidae		*Lepidonella* Yosii		1
Superodontella Stach		4	*Salina* Mac Gillivray		6
	Tullbergiidae			Paronellidae: Troglopedetinae	
Mesaphorura Börner		3	*Cyphoderopsis* Carpenter		4
			Troglopedetes Absolon		12
	Order Symphypleona			Oncopoduridae	
	Arrhopalitidae		*Harlomillsia* Bonet		1
Arrhopalites Börner		2			
	Dicyrtomidae				
Calvatomina Yosii		1		Order Neelipleona	
Ptenothrix Börner		1		Neelidae	
	Katiannidae		*Megalothorax* Willem		1
Sminthurinus Börner		2			
	Sminthuridae				
Pararrhopalites Bonet & Tellez		1			

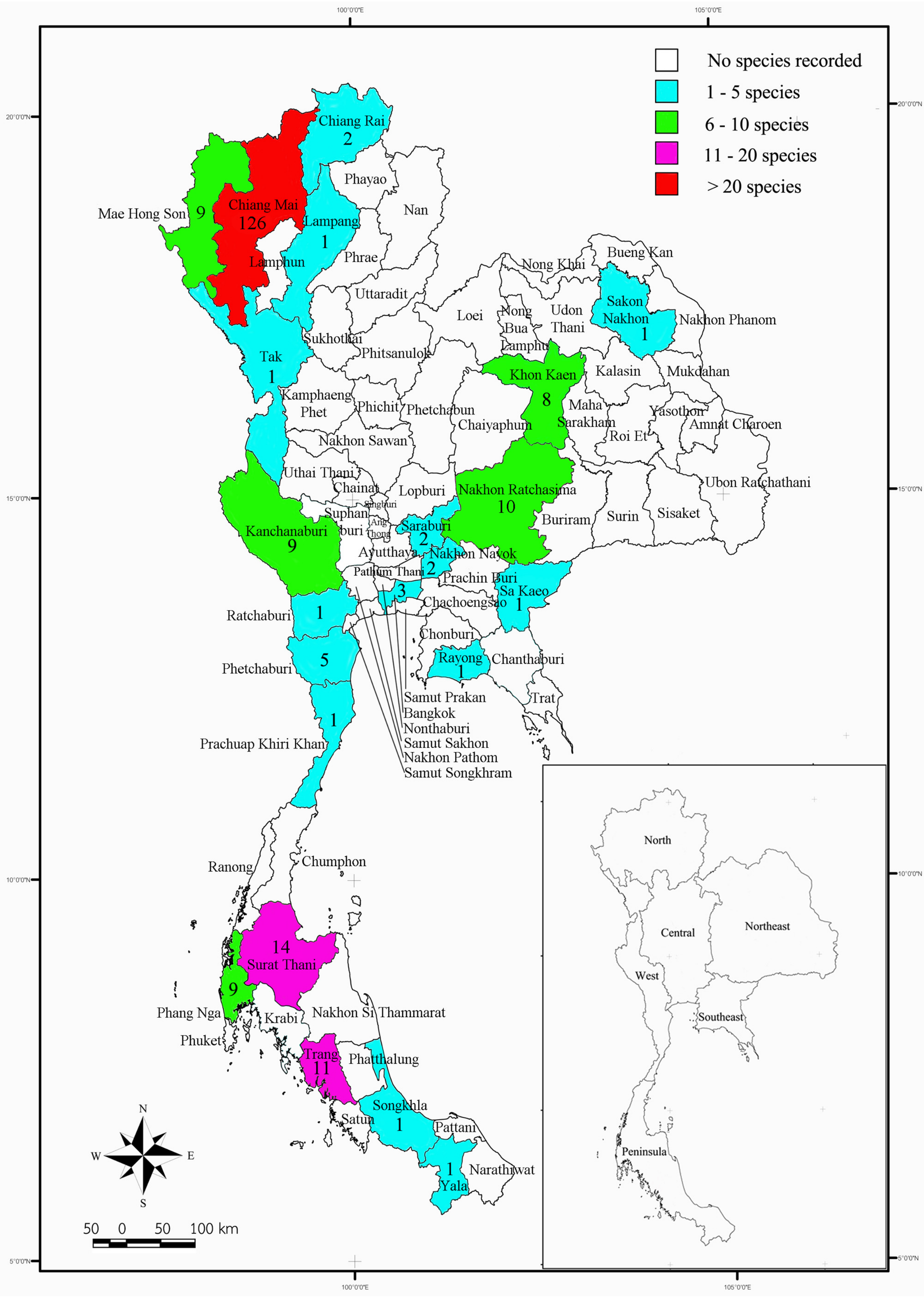

FIGURE 1. Provinces of Thailand with number of Collembola described species (large map) and biogeographic regions (small map).

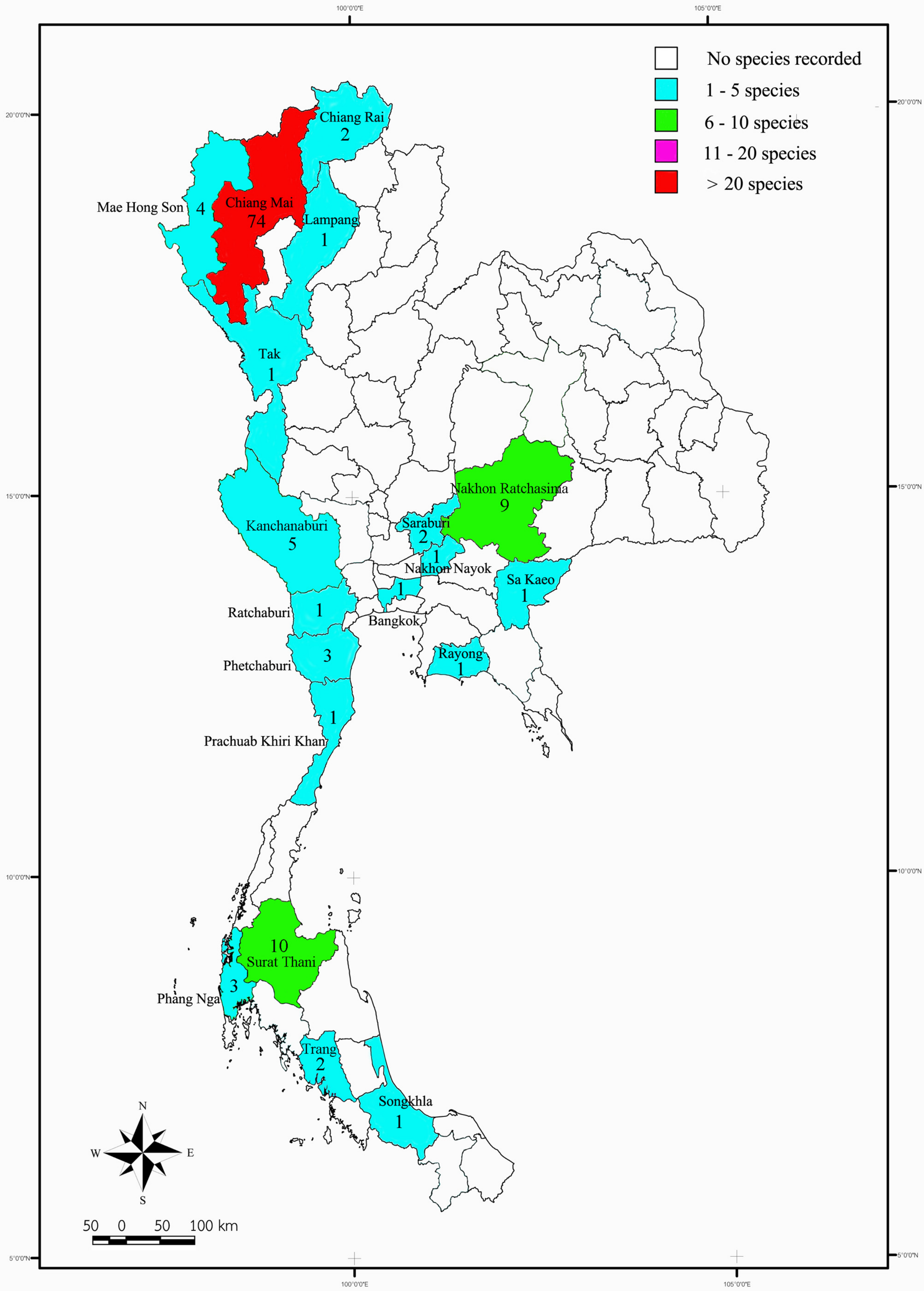

FIGURE 2. Provinces of Thailand with number of endemic Collembola species.

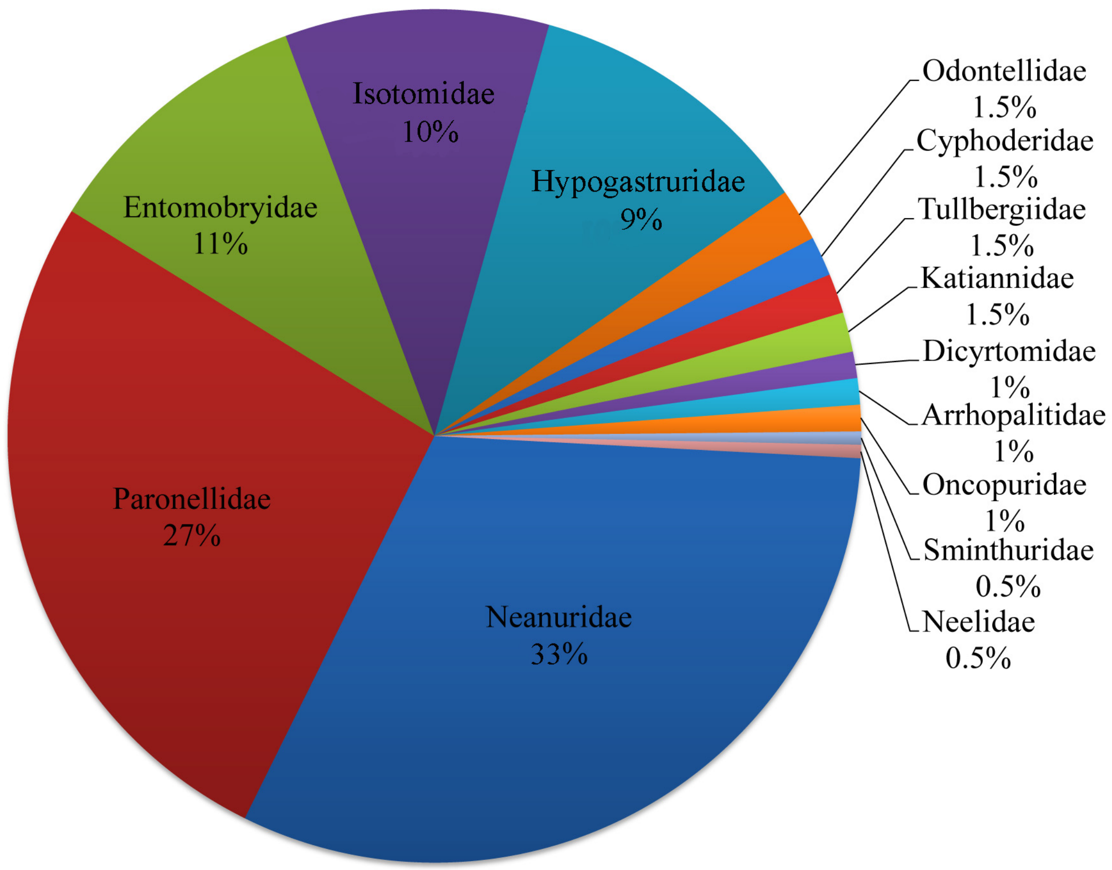

FIGURE 3. Percentage of Thai Collembola species by families.

Subterranean habitats have been more intensively sampled than any other habitat in Thailand, and than in any other surrounding countries. Out of the 194 species recorded for the country, 29 have been collected in caves, most of them probably obligate cave inhabitants. They belong to the genera *Acherontiella* (2 species), *Arrhopalites* (2 species), *Coecobrya* (2 species), *Cyphoderopsis* (3 species), *Cyphoderus* (2 species), *Folsomides* (1 species), *Folsomina* (1 species), *Paralobella* (1 species), *Pseudosinella* (1 species), *Salina* (1 species), *Troglopedetes* (12 species) and *Willemia* (1 species). This relatively high diversity for habitats usually poor in fauna partly reflects the intensity of the surveys carried out by biospeologists engaged in the caving expeditions of the Association Pyrénéenne de Spéléologie in the 1980s. It also partly reflects the importance of springtails in subterranean ecosystems as the dominant invertebrates in terms of abundance and diversity (after mites) in guano micro-habitats (Deharveng *et al*. 2011). Thailand has extensive cave-containing karst areas across almost the whole country. About 3,850 caves have been reported throughout the country so far (Ellis 2016). Among these, very few have been zoologically sampled. Thai karst is also extremely fragmented (Division of Economic Geology 2003), and surveys have been limited to few karstic units at the scale of the country. In spite of having been more sampled than any other habitat, cave fauna therefore remains poorly known in Thailand. Most of the 29 species found in caves appear to be narrow cave-restricted endemics. Some like *Troglopedetes* spp. have remarkable vicariant distributions, suggesting that almost any isolated karst outcrop may have its own species in western Thailand. The presence of troglomorphic species among cave-restricted Collembola, limited to oligotrophic habitats, is not exceptional, and a further support to the idea that troglomorphy may develop in tropical subterranean habitats (Howarth 1983, Deharveng 1987c; Deharveng & Bedos 2000, 2012; Gnaspini & Trajano 2000), contrary to previous assumptions. These cave species being all narrow endemics are potentially vulnerable to disturbance from quarrying and tourism which are continuously developing in Thailand karsts. However, no critical conservation issue has been detected so far regarding the species listed here.

Doi Inthanon is unique in Southeast Asia by its richness in Collembola. It is partly the result of intensive sampling in this massif (Bedos 1994), but it may also reflect a really exceptional biodiversity. The presence of 10 species of *Pseudachorutes* or at least 8 species of *Friesea* in an area the size of Doi Inthanon is unmatched elsewhere in the tropics. Ten species of *Siamanura* represent as well the highest local diversification reported on earth for a genus of Neanurinae. Many species of Doi Inthanon, in particular among Neanurinae, the best studied subfamily, have not been found in surrounding massifs, where they are often represented by vicariant species. Such a species richness is obviously exceptional, but not at risk, most of the Doi Inthanon being protected as a national park.

The geographical, ecological and taxonomical heterogeneity in our knowledge of Thai Collembolan biodiversity reported above opens up avenues for future research in these fields, which could turn this functionally important group into a promising model for more fundamental studies on tropical biodiversity. To achieve this objective, the pace of studies on the Collembolan taxonomy in Thailand needs to steeply increase. This paper is also intended to encourage young entomologists to pay attention to the Collembolan fauna of the country.

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Three new species of *Coecobrya* (Collembola: Entomobryidae) from caves in the Thai Peninsula

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Abstract

Three new species of the genus *Coecobrya* are described from caves in the Thai Peninsula for the first time: *C. cavicta* **sp. nov.** and *C. polychaeta* **sp. nov.** from Satun Province, and *C. chumphonensis* **sp. nov.** from Chumphon Province. These species differ in antennal length, clypeal chaetae, labial palp, sublobal chaetae of maxillary outer lobe, labial and postlabial chaetae, claw, ventral tube, manubrial plaque, and dorsal cephalic and tergal chaetotaxy. They are similar to *C. annulata* Zhang, Bedos & Deharveng, 2016 but differ from the latter in the combination of antennal length, claw and dorsal chaetotaxy. DNA barcoding COI sequences are provided for two species and three populations and key to the Thai species is also given. One population, which exhibits a great genetic distance (0.219–0.239) and minor but stable morphological differences from *C. polychaeta* **sp. nov.**, cannot be accepted as a full species as the evidence is insufficient.

Key words: taxonomy, Entomobryinae, polymacrochaetotic, barcoding

Introduction

Coecobrya was erected by Yosii (1956) as a subgenus of *Sinella* for *Coecobrya akiyoshiana* Yosii, 1956 from caves in Akiyoshi, Japan. It is characterised by polymacrochaetotic chaetotaxy, absent or reduced eye number, absence of or weak pigmentation, four segmented antennae, falcate mucro with a basal spine, and absence of body scales, labral papillae and dental spines (Zhang *et al*. 2009). So far, 50 species have been described worldwide (Cipola & Bellini 2016), almost a half (21) are cave-dwelling species. In Thailand, *Coecobrya* is widespread in both caves and soils throughout the country (Jantarit *et al*. 2016) but poorly described. Four species have been recorded so far: *Coecobrya* cf. *hoefti* (Schäffer, 1896) in mixed dry deciduous forest and deforested area in Khon Kaen Province, *Coecobrya guanophila* Deharveng, 1990 from cave, *Coecobrya similis* Deharveng, 1990 from forest soil and cave and *Coecobrya lanna* Zhang, Deharveng & Chen, 2009 from forest litter in Chiang Mai Province, with several forms from the Northern region being undescribed (Deharveng 1990; Jantarit *et al*. 2016). Here we describe species of *Coecobrya* from the Thai Peninsula for the first time. They are non-guanobiont species and are restricted to the dark caves, in wet and humid subterranean habitat. All these species display troglomorphic characters by having elongated antennae, loss of eyes and pigment, larger body size, pointed tenent hairs, thinner and simpler claw.

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Material and methods

Specimens were collected from caves in the Thai Peninsula by aspirator, pitfall traps, soil and bait traps and were stored in 95% ethanol. They were cleared in Nesbitt's fluid before mounting in the Hoyer's solution. Morphological characters were studied using Nikon 80i and SMZ-1000 microscopes. Figures were improved with Photoshop CS5 (Adobe Inc.). The dorsal and ventral chaetotaxy of head and the antennae III organ are described after Chen & Christiansen (1993). Tergal chaetotaxy is designated following Szeptycki (1979), Zhang *et al*. (2011) and Zhang & Deharveng (2015). Clypeal chaetae follow Zhang *et al*. (2016). The number of macrochaetae was provided by half-tergite in the descriptions. Types are deposited in the Princess Maha Chakri Sirindhorn Natural History Museum (PSU-NHM), Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, Thailand and the Department of Entomology, College of Plant Protection, Nanjing Agricultural University (NJAU), P.R. China.

DNA was extracted using an Ezup Column Animal Genomic DNA Purification Kit (Sangon Biotech, Shanghai, China) following the manufacturer's standard protocols. Specimens were transferred to a small tube after lysis for further morphological examination. Primers were LCO1490/HCO2198 commonly used for metazoa (Folmer *et al*. 1994). PCR amplification of mitochondrial COI was performed in 25 µL volumes containing 12.5 µL of Premix Taq (TaKaRaTaq Version 2.0 plus dye), 1.25 µL of each primer, 8 µL of ddH_2O, 2 µL of template DNA, with PCR programs following Zhang *et al*. (2014). All PCR products were checked on a 1% agarose gel. Successful products were purified and sequenced in both directions by Majorbio (Shanghai, China) on a ABI 3730XL DNA Analyser (Applied Biosystems). Sequences were assembled in Sequencher 4.5 (Gene Codes Corporation, Ann Arbor, USA), and deposited in GenBank. Six individuals with initial letters "COLLH" within names were sequenced under the help of Dr. Deharveng's group (Museum National d'Histoire Naturelle, Paris, France), who permitted us to use them in this study. Sequences were preliminarily aligned using MAFFT v7.149 by the L-INS-I strategy (Katoh & Standley 2013) and corrected manually, with a final 658 bp alignment. Neighbour-joining (NJ) tree and Kimura-2 parameter (K2P, Kimura 1980) distances were calculated in MEGA 5.0 (Tamura *et al*. 2011). Node supports were evaluated through 1000 bootstrap replications.

Abbreviations used in the descriptions: Gr.—group; Ant. I–IV—antennal segment I–IV; Th. I–III—thoracic segment I–III; Abd. I–VI—abdominal segment I–VI; mac—macrochaeta, -ae; mic—microchaeta, -ae; ms—s-microchaeta, -ae (microsensillum, -a); sens—ordinary S-chaeta, -ae on terga.

Results

Three populations and 14 individuals were successfully barcoded. The neighbour-joining (NJ) tree based on mitochondrial COI sequences is provided in Fig. 1 with *C. cavicta* **sp. nov.** not included. Pairwise K2P distances between individuals were calculated (Table 1). Distances within populations vary from 0–0.051, the maximum value of 0.051 in *C. polychaeta* **sp. nov.** Mean distances between populations are 0.231–0.272.

Taxonomy

Coecobrya chumphonensis **Zhang & Nilsai sp. nov.**
Figs 2, 6–24, Tables 2–3

Types. Holotype: female on slide, Thailand: Chumphon Province: Mueang District: Chang Puak cave, 10.446402°N, 99.035030°E, altitude 70 m., 6.iv.2016, S. Jantarit leg. (collection #THA_SJ_CPN08). Paratypes: three females on slides and three in alcohol, same data as holotype. One paratype on slide and one in alcohol deposited in NJAU and others in PSU-NHM.

Description. Body length up to 2.82 mm. Body whitish in alcohol (Fig. 2).

Antennae 3.70–4.48 times as long as cephalic diagonal. Antennal segment ratio as I: II: III: IV = 1: 1.55–1.78: 1.75–1.83: 3.00–3.11. Smooth spiny mic at base of antennae: three dorsal, two ventral on Ant. I, one internal, one external and two ventral on Ant. II. Long smooth straight chaetae absent on antennae. Distal Ant. II with 2–4 paddle-like chaetae (Fig. 6). Two internal S-chaetae of Ant. III organ paddle-like (Fig. 7). Subapical organ on Ant. IV not distinctly knobbed (Fig. 8).

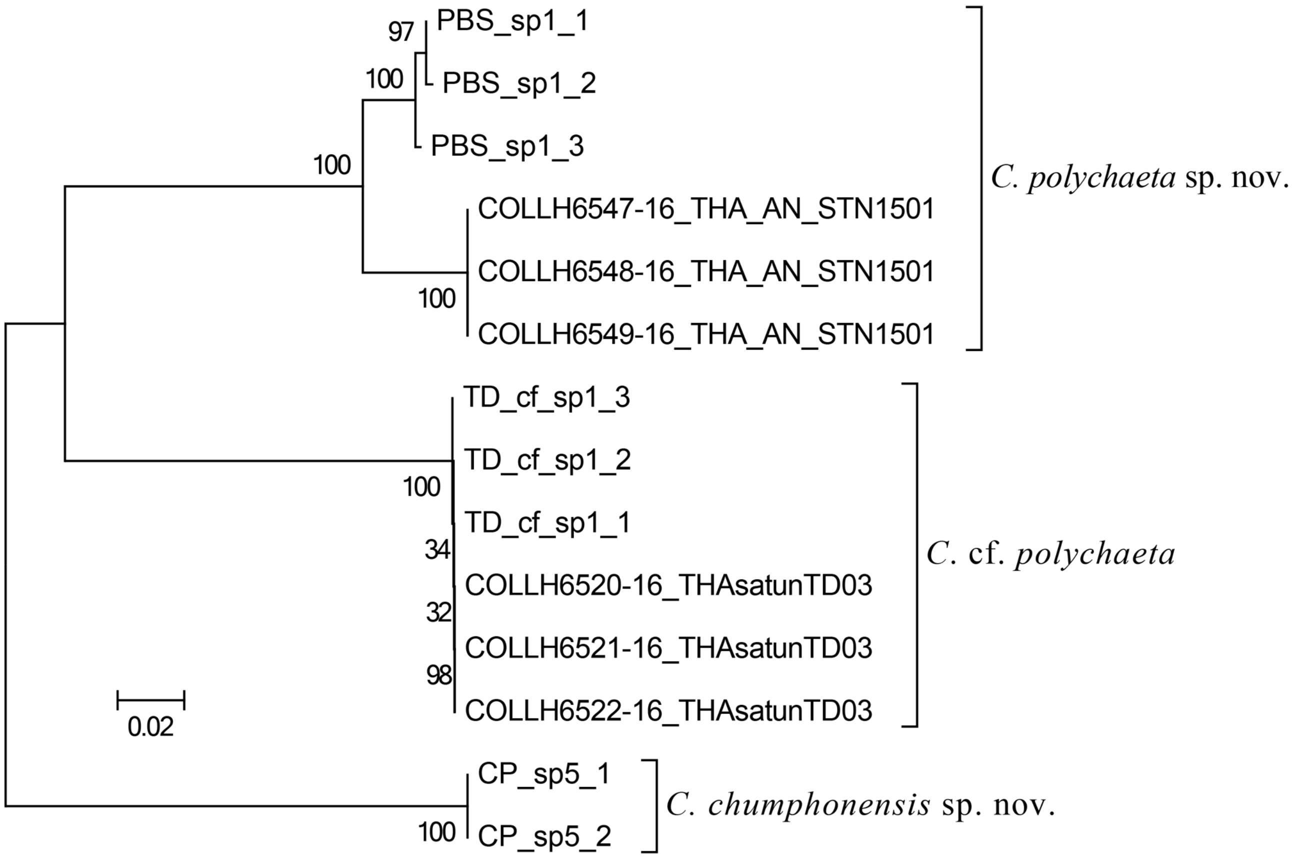


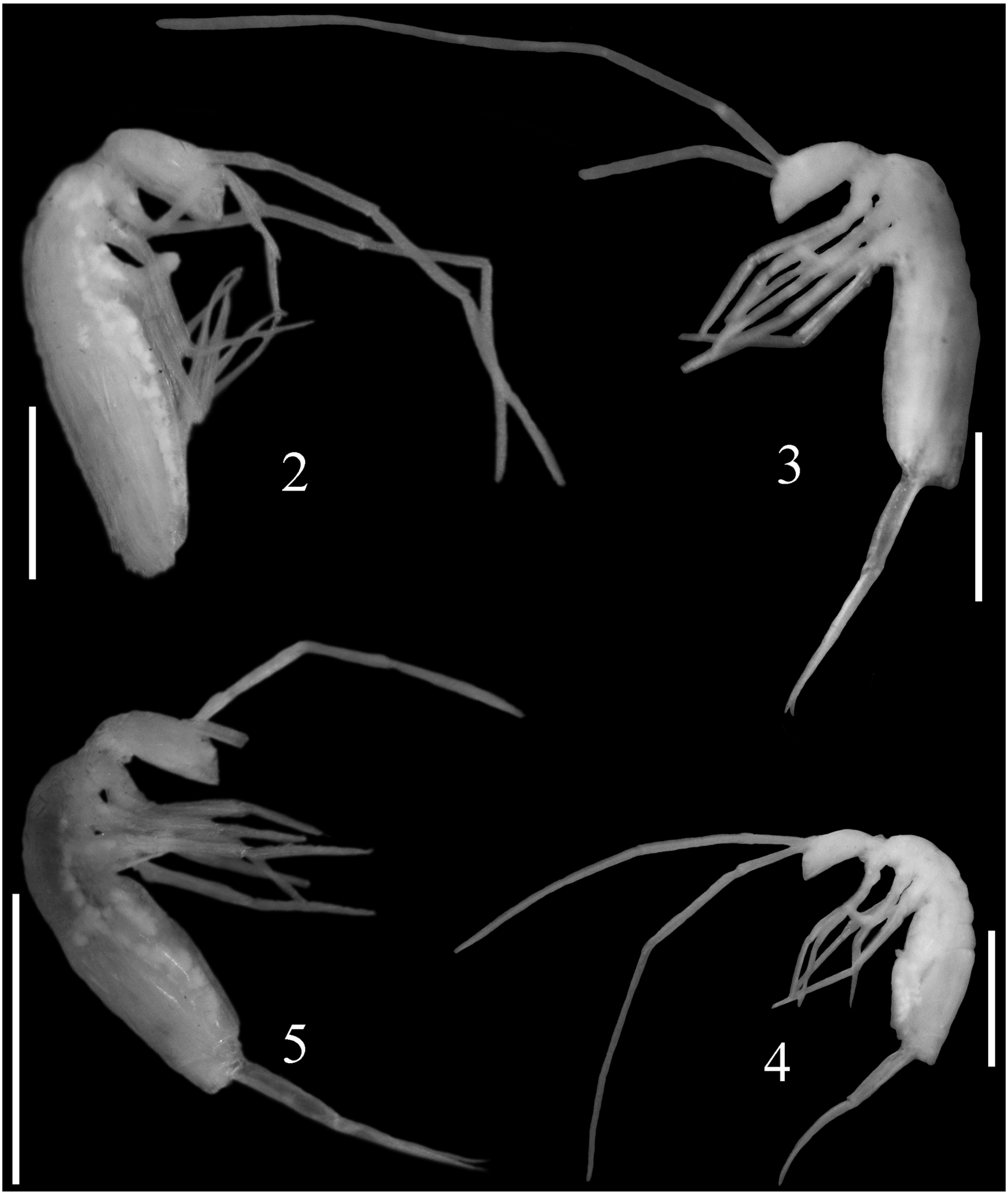
FIGURE 1. Neighbour-joining tree based on mitochondrial COI sequences, showing bootstrap values and species grouping. Sequences were named mainly using the combination of abbreviation of collection locality and numerical coding: PBS, Phraya Bangsa cave; STN, Satun Province; TD, Ton Din cave; CP, Chang Puak cave; THA, Thailand.

Eyes absent. Prelabral and labral chaetae 4/5, 5, 4, all smooth; three median chaetae of the first and the second rows longer than lateral ones. Clypeus with three prefrontal and eight facial chaetae; six facial chaetae minute; lateral chaetae often weakly ciliate (Fig. 9). Dorsal cephalic chaetotaxy with two antennal (An), four median (M) and eight sutural (S) mac; Gr. II with 6(7) mac (Fig. 10). Mandibles with 4+5 (4 left, 5 right) large apical teeth. Three smooth sublobal hairs on maxillary outer lobe (Fig. 11). Lateral process of labial palp thicker than normal chaetae, with tip slightly beyond apex of labial papilla (Fig. 12). Labial chaetae as $mRel_1l_2$, all smooth except R, ratio of R to m 0.44–0.55; chaetae X, X_2 and X_4 smooth and minute; chaeta X_2 absent in one side of one specimen. Chaetae along cephalic groove 9–11; anterior three and the fifth smooth; small chaetae on posterior part often weakly ciliate (Fig. 13).

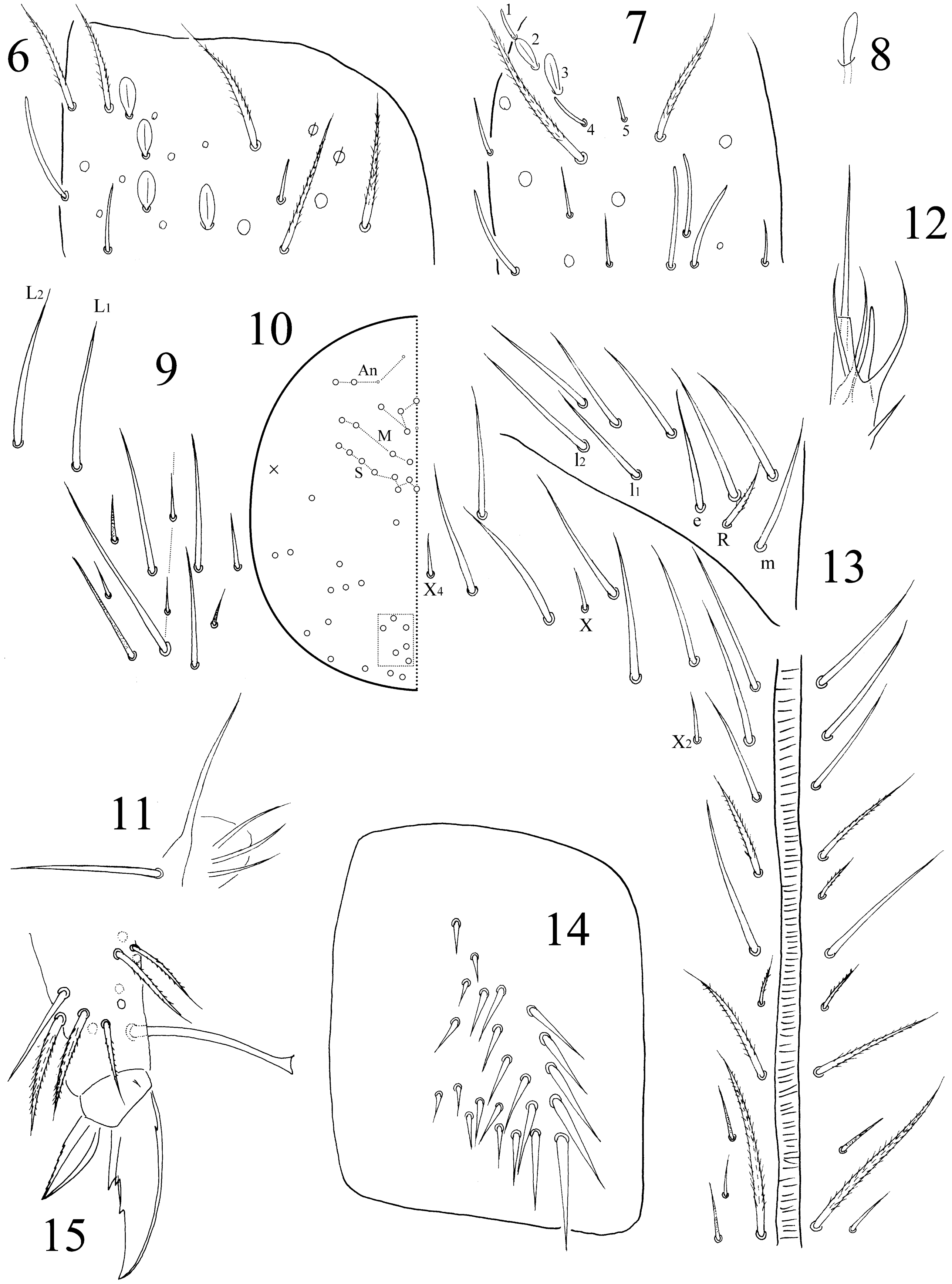
Trochanteral organ with 12–22 smooth spine-like chaetae; 7–10 in arms and 5–12 between them (Fig. 14). Partial inner differentiated tibiotarsal chaetae finely ciliate with ciliations not closely appressed to axis. Tibiotarsi distally with 10 chaetae in a whorl. Unguis with three inner teeth; two paired teeth unequal, outer one slightly larger. Unguiculus swollen with outer edge serrate. Tenent hairs usually pointed and II–III clavate in one specimen (Fig. 15). Abd. IV 4.25–4.40 times as long as Abd. III along dorsal midline. Ventral tube anteriorly with 9–12 ciliate chaetae on each side and 2(3) of them much larger (Fig. 16); posteriorly with four apical and about nine proximal chaetae (Fig. 17), lateral two chaetae of apical ones ciliate in one specimen (Fig. 18), proximal chaetae often weakly ciliate; each lateral flap with 7(10), 3–4 of them smooth (Figs 16–17). Furcula without smooth chaetae. Distal part of manubrium ventrally with 11–15 ciliate chaetae on each side (Fig. 19). Manubrial plaque with two pseudopores and 4–7 ciliate chaetae (Fig. 20). Distal smooth part of dens 0.89–1.13 times as long as mucro. Mucro falcate with a long basal spine, nearly reaching the tip of the apical tooth (Fig. 21).

Th. II with 4–6 medio-medial, three (m4, m4i, m4p) medio-sublateral and 25–32 posterior mac; ms inner to sens. Th. III with 32–35 mac; p3ip2 present in one side of one specimen (Fig. 22, Table 2). Abd. I with 6–7 (a2–3, m2–4, m2i, m4p) mac; a2 often as mic. Abd. II with three (m3, m3e, m3ep) central and one (m5) lateral mac. Abd.

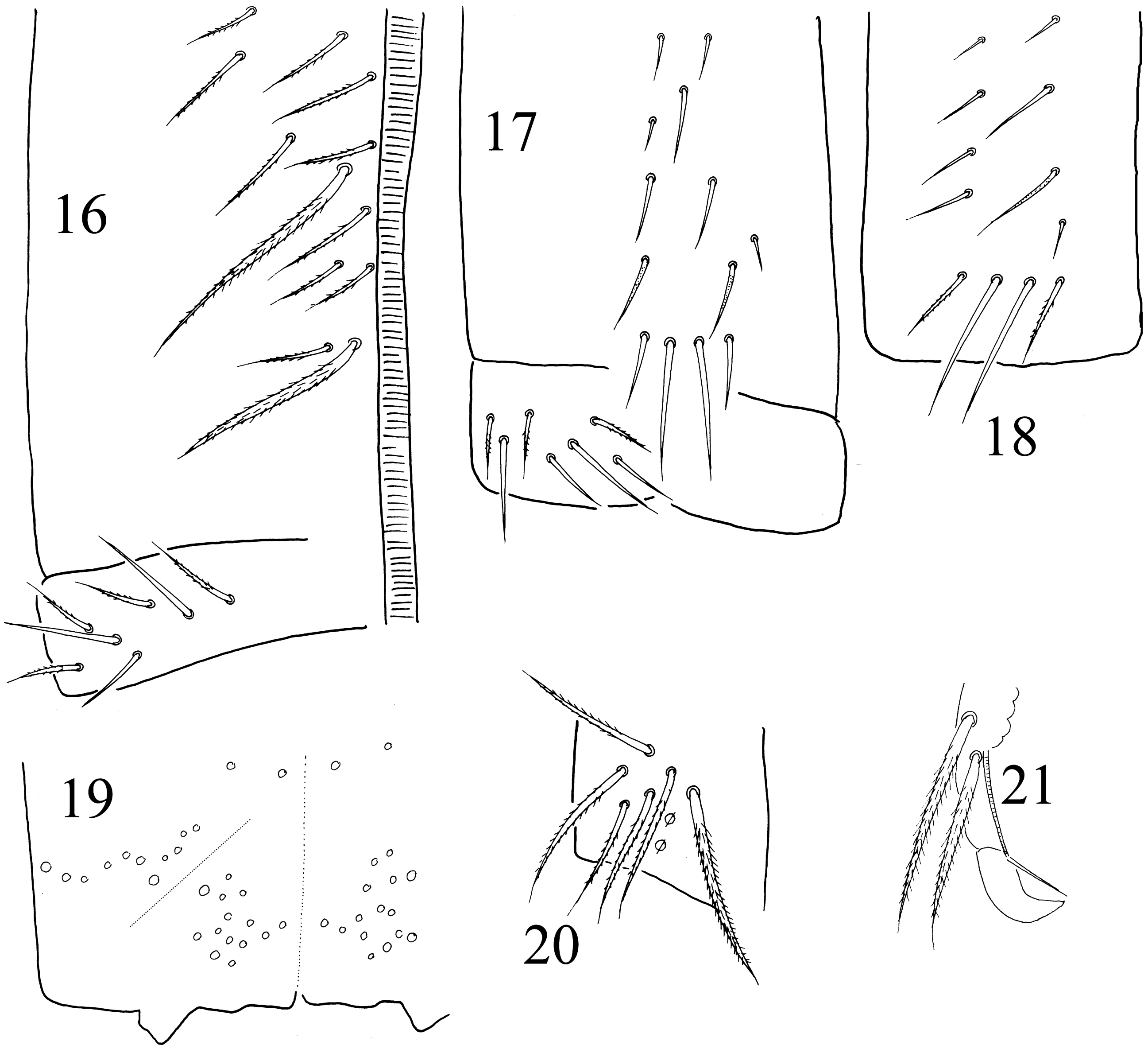
III with two (a2, m3) central and three (am6, pm6, p6) lateral mac; Abd. IV with seven central (I, M, B4–6, A5–6) and 10–12 lateral mac; F1p and F3p sometimes absent (Fig. 23). S-chaetae formula: 2+ms, 2/1+ms, 2, 2, ≥20, 3; sens usually outer to ms but inner to ms on Abd. I in one specimen; lateral sens (acc.p6) of Abd. II–III as long as 0.6 times central as; as and ps on Abd. IV 1/4 length of others. Sens acc.p5 anterior to m5 (Figs 22–24).



FIGURES 2–5. Habitus: 2, *Coecobrya chumphonensis* **sp. nov**.: 3, *Coecobrya polychaeta* **sp. nov.**; 4, *Coecobrya* cf. *polychaeta* **sp. nov.**; 5, *Coecobrya cavicta* **sp. nov.** Scale bar: 1 mm.



FIGURES 6–15. *Coecobrya chumphonensis* **sp. nov.** 6, distal part of Ant. II of right antenna, dorsal view; 7, Ant. III organ of left antenna, dorsal view; 8, subapical organ of Ant. IV; 9, clypeal chaetae; 10, dorsal cephalic chaetotaxy; 11, maxillary outer lobe; 12, lateral process of labial palp; 13, labial and postlabial chaetae; 14, trochanteral organ; 15, hind claw.



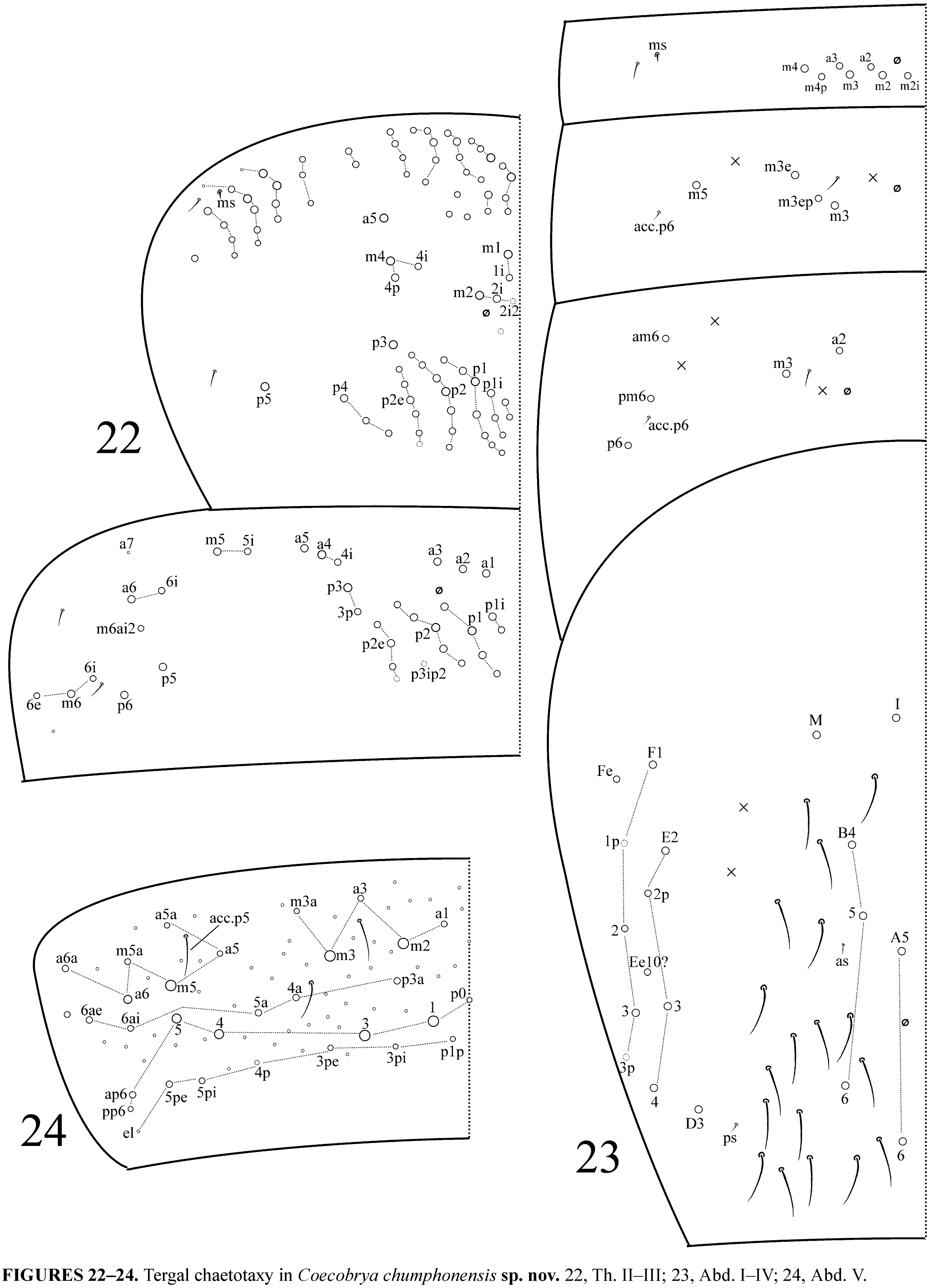
FIGURES 16–21. *Coecobrya chumphonensis* **sp. nov.** 16, anterior face and lateral flap of ventral tube; 17–18, posterior face of ventral tube; 19, distal part of manubrium ventrally; 20, manubrial plaque; 21, mucro.

GenBank number. KY704919–KY704920.

Ecology. A small population of the species was collected in the dark, deep zone of the cave, ca 30 meters from cave entrance in a wet and humid habitat near a pool, stalagmites, rock surfaces and floor.

Etymology. Name after the province "Chumphon" where this species was discovered.

Remarks. *Coecobrya chumphonensis* **sp. nov.** can be separated from other *Coecobrya* species by the combination of large size, long antennae, two antennal mac and 6(7) Gr. II mac on dorsal head, ciliate labial chaeta R, serrate outer edge on unguiculus, 4–6 medio-medial mac on Th. II, two central mac on Abd. III, 10–12 lateral mac on Abd. IV, and short, lateral sens acc.p6 on Abd. II–III. The position of lateral sens acc.p5 on Abd. V is also unique in the genus. The three new species described in this study and *Coecobrya annulata* Zhang, Bedos & Deharveng, 2016 are very similar in elongate antennae, labrum, minute postlabial chaetae X_2 and X_4, abundant chaetae on ventral chaetae, and relatively abundant mac on thorax, Abd. I and IV. They can be distinguished by the combination of characters listed in Table 3. It differs from other three species in two antennal, four median and 6(7) Gr. II mac on dorsal head, ciliate labial chaeta R, and 2+2 central mac on Abd. III.



FIGURES 22–24. Tergal chaetotaxy in *Coecobrya chumphonensis* **sp. nov.** 22, Th. II–III; 23, Abd. I–IV; 24, Abd. V.

TABLE 1. K2P genetic distances between 14 individuals. Abbreviations for population localities: CP, Chang Puak cave; PBS/STN, Phraya Bangsa cave; TD, Ton Din cave.

Species	Individuals													
***Coecobrya chumphonensis* sp. nov.**	CP_sp5_1													
	CP_sp5_2	0.000												
***Coecobrya polychaeta* sp. nov.**	PBS_sp1_1	0.277	0.277											
	PBS_sp1_2	0.280	0.280	0.002										
	PBS_sp1_3	0.277	0.277	0.005	0.006									
	COLLH6547-16_STN	0.262	0.262	0.049	0.051	0.049								
	COLLH6548-16_STN	0.262	0.262	0.049	0.051	0.049	0.000							
	COLLH6549-16_STN	0.262	0.262	0.049	0.051	0.049	0.000	0.000						
***Coecobrya* cf. *polychaeta* sp. nov.**	TD_cf_sp1_1	0.271	0.271	0.221	0.223	0.219	0.239	0.239	0.239					
	TD_cf_sp1_2	0.271	0.271	0.221	0.223	0.219	0.239	0.239	0.239	0.000				
	TD_cf_sp1_3	0.271	0.271	0.221	0.223	0.219	0.239	0.239	0.239	0.000	0.000			
	COLLH6520-16_TD	0.273	0.273	0.223	0.225	0.221	0.239	0.239	0.239	0.000	0.000	0.000		
	COLLH6521-16_TD	0.273	0.273	0.223	0.225	0.221	0.239	0.239	0.239	0.000	0.000	0.000	0.000	
	COLLH6522-16_TD	0.273	0.273	0.223	0.225	0.221	0.239	0.239	0.239	0.000	0.000	0.000	0.000	0.000

TABLE 2. The number variation of mac in sets of chaetae on thorax among three species. Character states in parentheses are rarely observed.

Species	Th. II									Th. III				
	m1+	m2+	p1i2+	p1i+	p1+	p2+	p3	p2e+	p4+	p1i2+	p1i+	p1+	p2+	p2e+
Coecobrya chumphonensis **sp. nov.**	2	2–3	1–2	2–4	6–8	6–8	1–3	5–6	3–4	0(1)	2(1)	4(5)	5–7	3–4
Coecobrya polychaeta **sp. nov.**	3(2)	4	1–5	5–7	8–10	6–9	1–3	4–5	2(1, 3)	1(2)	3–4	5–6	5–6	4–5(3)
Coecobrya cavicta **sp. nov.**	1	2	2	5	6	7	2	4–5	3	1	3	5	4	3

***Coecobrya polychaeta* Zhang & Nilsai sp. nov.**
Figs 3, 25–40, Tables 2–3

Types. Holotype: female on slide, Thailand: Satun Province: Mueang District: Phraya Bangsa cave, 6.77541°N, 100.04161°E, altitude 23 m, 4.x.2016, S. Jantarit and A. Nilsai leg. (collection #THA_SJ_STN08). Paratypes: one male and three females on slides and 24 in alcohol, same data as holotype. Two paratypes on slides and four in alcohol deposited in NJAU and others in PSU-NHM.

Description. Body length up to 2.58 mm. Body whitish in alcohol (Fig. 3).

Antennae 5.91–7.12 times as long as cephalic diagonal. Antennal segment ratio as I: II: III: IV = 1: 1.52–1.76: 1.78–2.10: 2.78–4.62. Smooth spiny mic at base of antennae: 3(4) dorsal, 3(2) ventral on Ant. I, one internal, one external and one ventral on Ant. II. Long smooth straight chaetae absent on antennae. Distal Ant. II with one paddle-like S-chaeta. Ant. III organ not clearly seen.

Eyes absent. Prelabral and labral chaetae 4/5, 5, 4, all smooth; three median chaetae of the first and the second rows longer than lateral ones (Fig. 25). Clypeus with five long, smooth and 7–10 short, ciliate chaetae (Fig. 26). Dorsal cephalic chaetotaxy with four antennal (An), three median (M) and eight sutural (S) mac; Gr. II with three mac; A_0 as mic (Fig. 27). Mandibles with 4+5 (4 left, 5 right) large apical teeth. Four smooth sublobal hairs on maxillary outer lobe (Fig. 28). Lateral process of labial palp very long and as thick as normal chaetae (Fig. 29). Labial chaetae as $M_1m_2rel_1l_2$; M_1 only smooth in one side of one specimen; r minute. Postlabial chaeta X smooth; chaeta X_2 smooth and minute; chaeta X_4 ciliate and minute. Cephalic groove with 6–7 smooth and 5–10 ciliate chaetae (Fig. 30).

Trochanteral organ with 15–25 smooth spine-like chaetae; 6–9 in arms and 9–16 between them (Fig. 31). Partial inner differentiated tibiotarsal chaetae finely ciliate with ciliations not closely appressed to axis. Unguis with three inner teeth; two paired teeth subequal. Unguiculus basally swollen with an inner tooth and a serrate outer edge. Tenent hairs pointed (Fig. 32). Abd. IV 3.90–4.62 times as long as Abd. III along dorsal midline. Ventral tube anteriorly with 12 ciliate chaetae on each side and two of them much larger (Fig. 33); posteriorly with 20–31 chaetae, at least six of them smooth; each lateral flap with 9–12 smooth chaetae (Fig. 34). Furcula without smooth chaetae. Distal part of manubrium ventrally with 15–25 ciliate chaetae on each side (Fig. 35). Manubrial plaque with two pseudopores and 4–10 ciliate chaetae (Fig. 36). Distal smooth part of dens 0.72–0.85 times as long as mucro. Mucro falcate with a long basal spine, nearly reaching the tip of the apical tooth (Fig. 37).

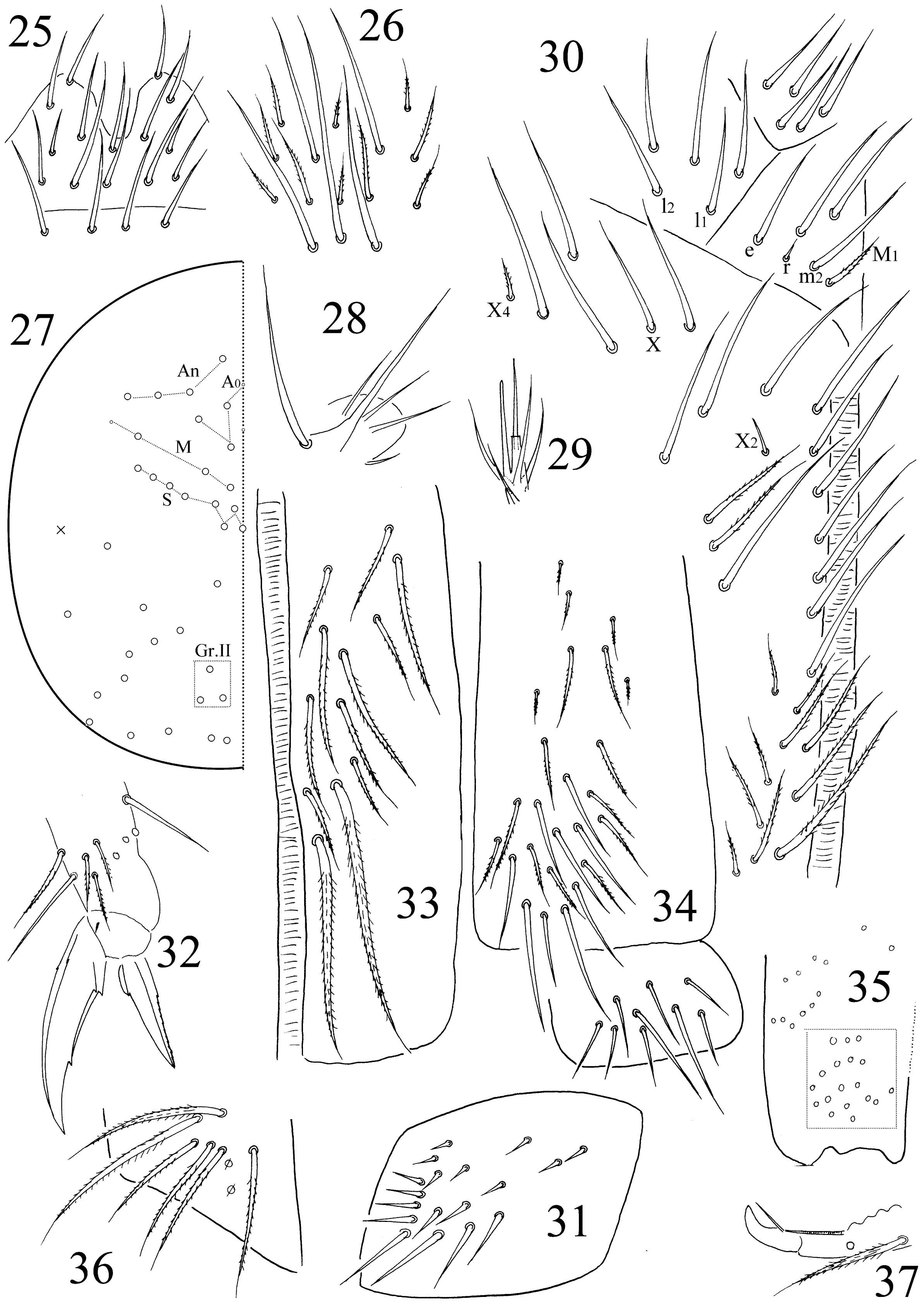
Th. II with 7(6) (m1, m1i, m1i2, m2, m2i, m2i2, m2i3) medio-medial, three (m4, m4i, m4p) medio-sublateral and 29–40 posterior mac; ms inner to sens. Th. III with 35–43 mac; a1a as mac (Fig. 38, Table 2). Abd. I with 89 (a2–3, a5, m2–4, m2i, m4p, p5) mac; mac p5 rarely present. Abd. II with 4(3) (a2, m3, m3e, m3ep) central and one (m5) lateral mac; mac m3ep absent in one side of one specimen. Abd. III with one (m3) central and three (am6, pm6, p6) lateral mac; Abd. IV with six central (I, M, B4–5, A5–6) and nine (D3, E2–4, E2p, F1–3, F3a) lateral mac (Fig. 39). S-chaetae formula: 2+ms, 2/1+ms, 2, 2+ms, ≈21, 3; as and ps on Abd. IV 1/4 length of others (Figs 38–40).

GenBank number. KY704921–KY704926.

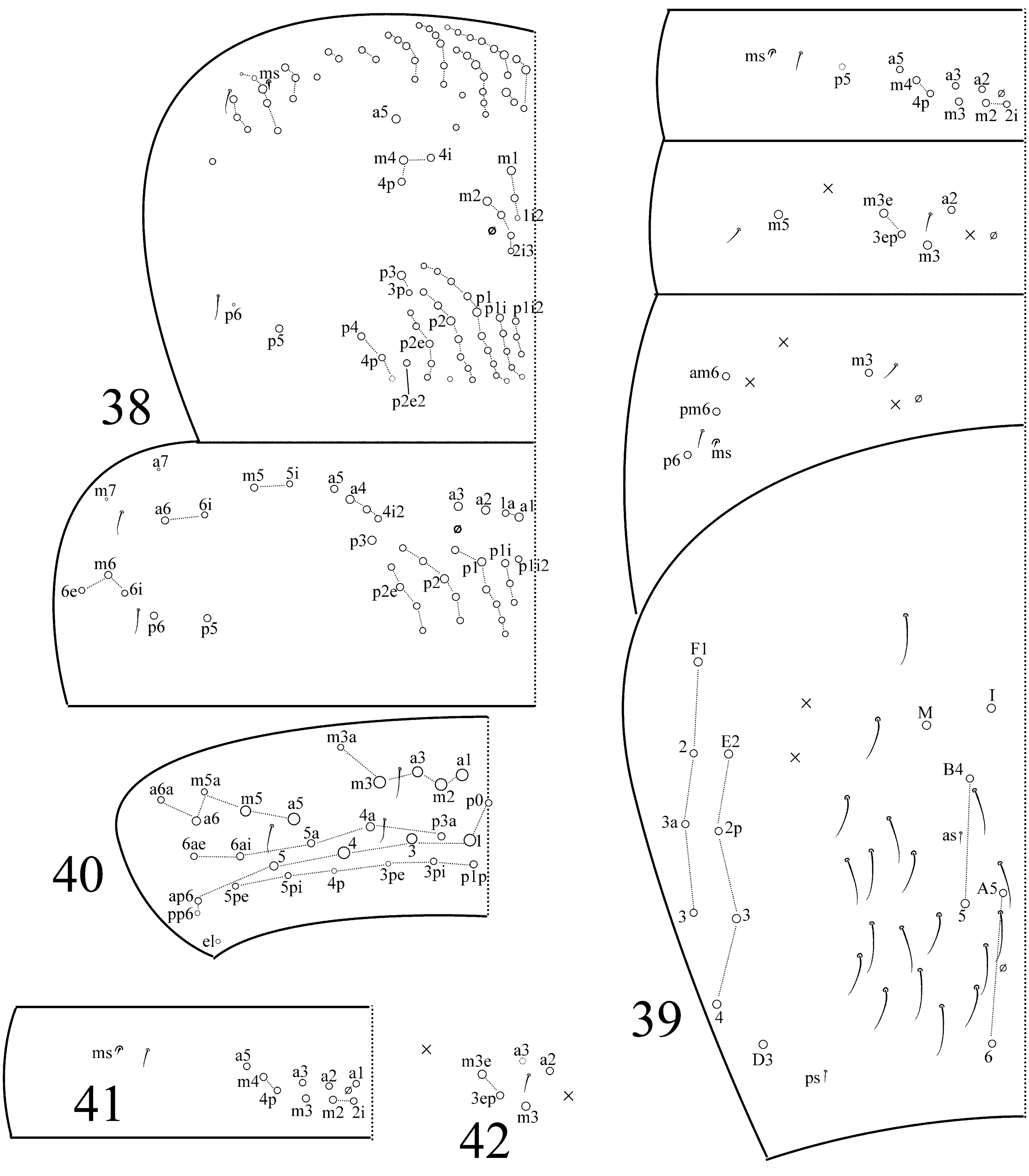
Ecology. This species was indigenous to the small chamber in the dark zone on surface of muddy ground in a humid environment. Bat guano was absent in this area.

Etymology. Name after the abundant chaetae on ventral tube and both sides of distal part of manubrium.

Remarks. *Coecobrya polychaeta* **sp. nov.** can be separated from other *Coecobrya* species by the combination of large size, extremely long antennae and long lateral process of labial palp, four sublobal hairs on maxillary outer lobe, A_0 as mic on dorsal head, labial chaetae $M_1m_2rel_1l_2$, minute postlabial chaetae X_2 smooth and X_4 ciliate, paired teeth subequal on unguis, serrate outer edge on unguiculus, abundant chaetae on ventral tube and both sides of distal part of manubrium, 7(6) medio-medial mac on Th. II, four antero-medial mac on Th. III, 8(9) mac on Abd. I, four central mac on Abd. II, six central and nine lateral mac on Abd. IV, and presence of ms on Abd. III. Antennae of the new species, as those in *Coecobrya nupa* Christiansen & Bellinger, 1992, are the longest one in the genus. Elongated lateral process of labial palp and four sublobal hairs on maxillary outer lobe are also observed for the first time within the genus. Additional differences from closely related species are included in Table 3; it can be distinguished from them by mic A0 and 3+3 Gr. II mac on dorsal head, ciliate labial chaeta M_1, four sublobal hairs on maxillary outer lobe, long lateral process of labial palp, 8–9 mac on Abd. I, and 4(3) central mac on Abd. II.



FIGURES 25–37. *Coecobrya polychaeta* **sp. nov.** 25, labrum; 26, clypeal chaetae; 27, dorsal cephalic chaetotaxy; 28, maxillary outer lobe; 29, lateral process of labial palp; 30, labial and postlabial chaetae; 31, trochanteral organ; 32, hind Claw; 33, anterior face of ventral tube; 34, posterior face and lateral flap of ventral tube; 35, distal part of manubrium ventrally; 36, manubrial plaque; 37, mucro.



FIGURES 38–42. Tergal chaetotaxy: 38–40 for *Coecobrya polychaeta* **sp. nov.** and 41–42 for *Coecobrya* cf. *polychaeta* **sp. nov.** 38, Th. II–III; 39, Abd. I–IV; 40, Abd. V; 41, Abd I; 42, central mac on Abd. II.

***Coecobrya* cf. *polychaeta* Zhang & Nilsai sp. nov.**
Figs 4, 41, 42

Material examined. Five females on slides and 30 in alcohol, Thailand: Satun Province: Khuan Don District: Ton Din cave, 6.72636°N, 100.16249°E, altitude 115 m, 8.ix.2016, S. Jantarit and A. Nilsai leg. (collection #THA_SJ_STN15). Four in alcohol deposited in NJAU and others in PSU-NHM.

GenBank number. KY704927–KY704932.

Ecology. These animals were found in a large population along a stream bank, on stalagmites, clay, gravels and rock surfaces in a humid environment where bat guano was absent.

Remarks. *Coecobrya* cf. *polychaeta* **sp. nov.** is almost identical to *C. polychaeta* **sp. nov.** in morphology, including having specialised, unique characters, such as extremely long antennae, elongate lateral process of labial palp, and four sublobal hairs on maxillary outer lobe. It differs from the latter only in having mac a1 on Abd. I (Fig. 41) and smooth postlabial mic X_4. Mac a3 on Abd. II (Fig. 42) is present in one specimen. The great mean genetic distance 0.231 (0.219–0.239) between two populations has exceeded the mean interspecific distances reported in Porco *et al*. (2014), Katz *et al*. (2015) and Schneider *et al*. (2016). Two populations are only approximately 10 km distant from each other. Following the conservative line, the population from Khuan Don District is not here considered to be a separate species because widely accepted species delimitation criteria not established across divergent collembolan groups. It is better to be conservative in assigning specimens to new species than to incorrectly recognize artificial entities (Carstens *et al*. 2013).

Coecobrya cavicta **Nilsai & Zhang sp. nov.**

Figs 5, 43–55, Tables 2–3

Type. Holotype: female on slide, Thailand: Satun Province: Khuan Don District: Ton Din cave, 6.72636°N, 100.16249°E, altitude 115 m, 8.ix.2016, S. Jantarit and A. Nilsai leg. (collection #THA_SJ_STN08), deposited in PSU-NHM.

Description. Body 1.72 mm. Body whitish in alcohol (Fig. 5).

Antennae 2.67 times as long as cephalic diagonal. Antennal segment ratio as I: II: III: IV = 1: 1.48: 1.52: 2.39. Smooth spiny mic at base of antennae: three dorsal and three ventral on Ant. I, one internal, one external and one ventral on Ant. II. Long smooth straight chaetae present on the ventral side of Ant. I. Distal part of Ant. II and Ant. III organ not clearly seen.

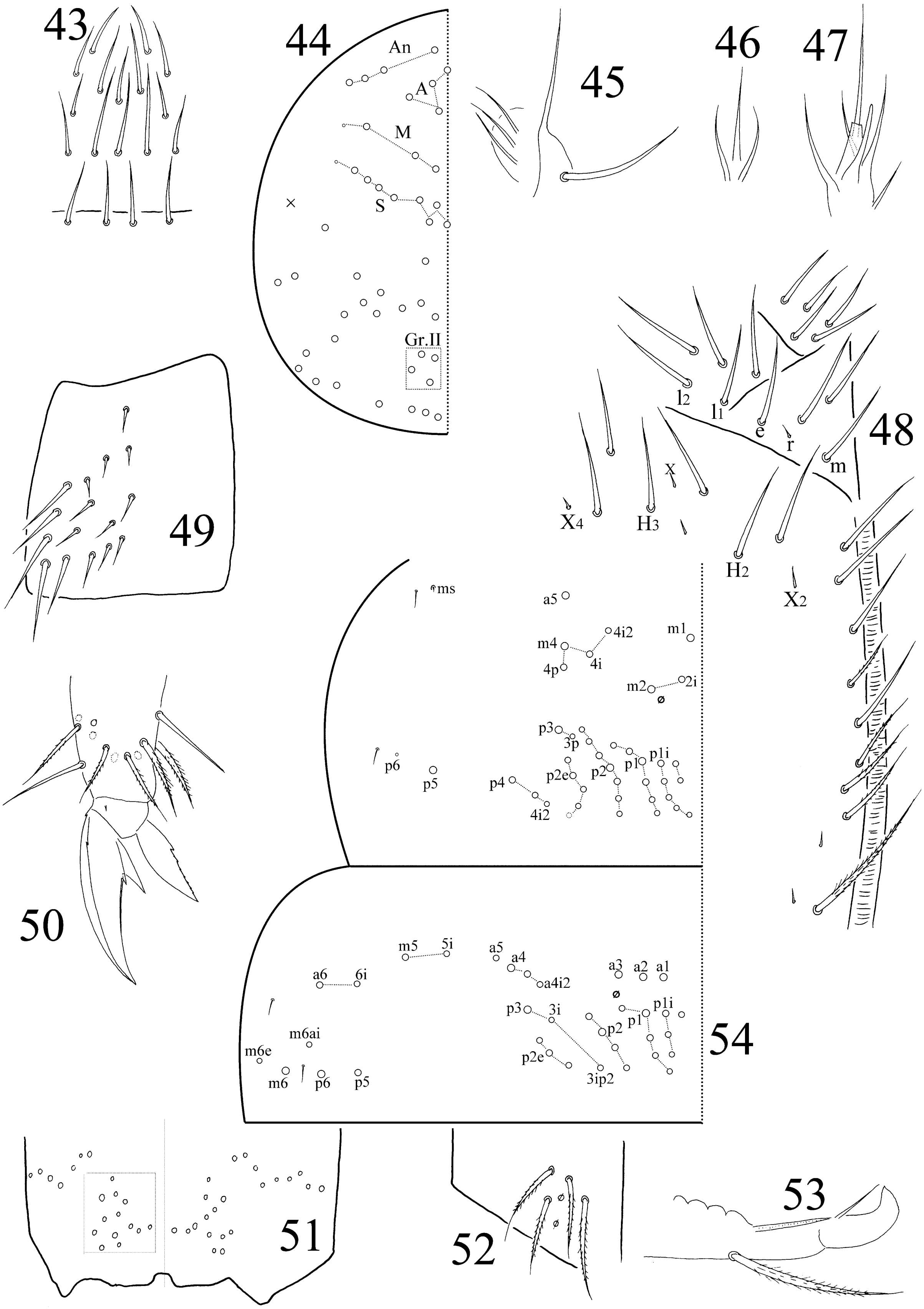
Eyes absent. Prelabral and labral chaetae 4/5, 5, 4, all smooth; three median chaetae of the first and the second rows longer than lateral ones (Fig. 43). Clypeal chaetae smooth but their arrangement unclear. Dorsal cephalic chaetotaxy with four antennal (An), three median (M) and eight sutural (S) mac; Gr. II with four mac (Fig. 44). Mandibles with 4+5 (4 left, 5 right) large apical teeth. Subapical chaeta of maxillary outer lobe thicker than apical one; three smooth sublobal hairs on maxillary outer lobe (Fig. 45). Hypostomal chaetae h_1 and h_2 curved and subequal (Fig. 46). Lateral process of labial palp as thick as normal chaetae, with tip beyond apex of labial papilla (Fig. 47). Labial chaetae as $mrel_1l_2$, all smooth; r, X, X_2, X_4, and a chaeta between H_2 and H_3 smooth and minute. Chaetae along cephalic groove 11, of which 3–4 smooth and two minute (Fig. 48).

Trochanteral organ with 15–16 smooth spine-like chaetae; eight in arms and 7–8 between them (Fig. 49). Partial inner differentiated tibiotarsal chaetae ciliate with ciliations not closely appressed to axis. Tibiotarsi distally with 10 chaetae in a whorl. Unguis with two paired inner teeth, unequal and 0.28 distance from base; unpaired tooth absent. Unguiculus lanceolate with outer edge serrate; the basal tooth clearly seen but the distal teeth extremely minute and often indistinct. Tenent hairs pointed (Fig. 50). Abd. IV 4.41 times as long as Abd. III along dorsal midline. Ventral tube not clearly seen. Furcula without smooth chaetae. Distal part of manubrium ventrally with 13+13 ciliate chaetae (Fig. 51). Manubrial plaque with two pseudopores and four ciliate chaetae (Fig. 52). Distal smooth part of dens 0.90 times as long as mucro. Mucro falcate with a long basal spine, nearly reaching the tip of the apical tooth (Fig. 53).

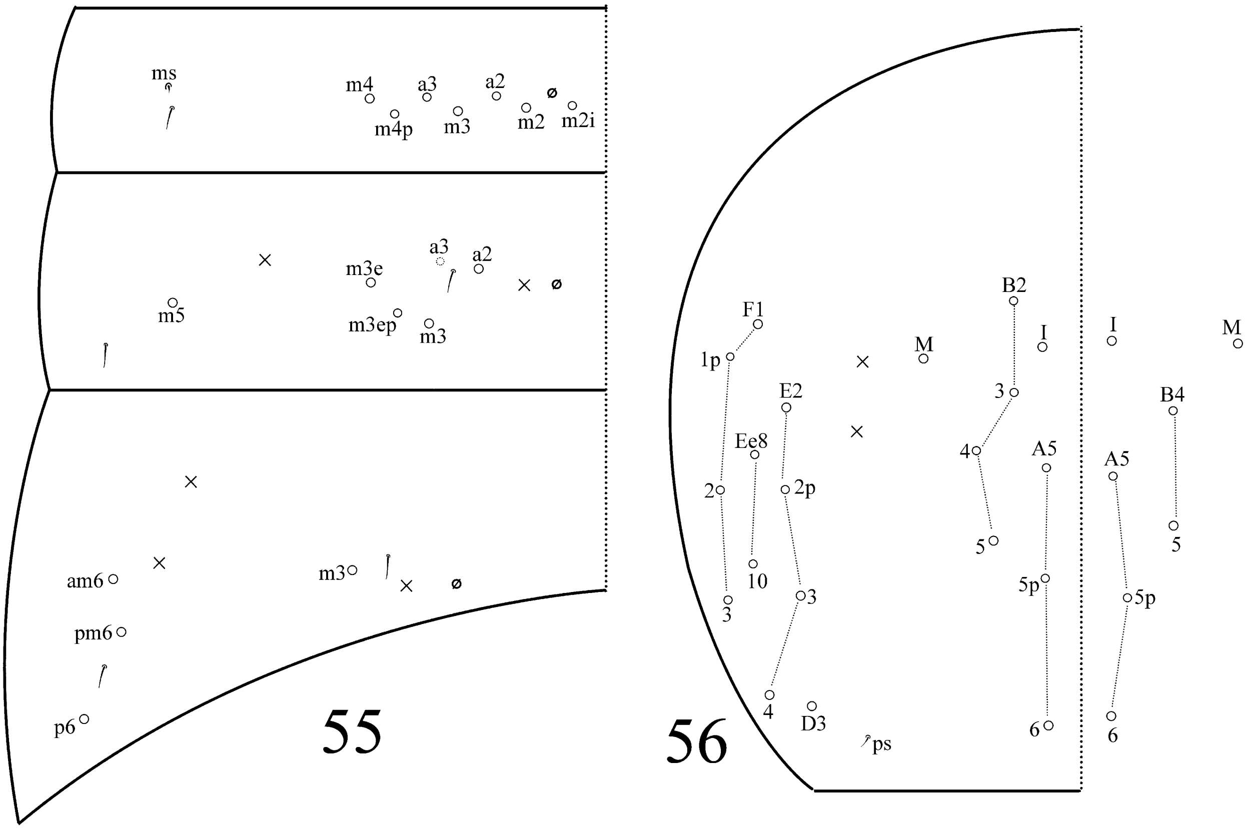
Th. II with three (m1, m2, m2i) medio-medial, four (m4, m4p, m4i, m4i2) medio-sublateral and 30–31 posterior mac; ms inner to sens; p5 as mac. Th. III with 35 mac; a4i2, m5i, a6i and m6ai as mac (Fig. 54, Table 2). Abd. I with seven (a2, a3, m2–4, m2i, m4p) mac; sens posterior to ms. Abd. II with 4+5 (a2, a3, m3, m3e, m3ep) central and one (m5) lateral mac; a3 as mic on left side. Abd. III with one (m3) central and three (am6, pm6, p6) lateral mac (Fig. 55). Abd. IV with 7+9 central (I, M, A5, A5p, A6, B2–5) and 11 lateral mac (D3, E2–4, E2p, Ee8, Ee10, F1–3, F1p); B2 and B3 as mac on left side (Fig. 56). S-chaetae formula: 2+ms, 2/1+ms, 2, 2, ?, 3; ps on Abd. IV 1/3 length of others.

Ecology. This species was found in a dark, humid cave near a stream bank, without bat guano.

Etymology. Named after the Latin word cavi- ("cave") + victa ("living").



FIGURES 43–54. *Coecobrya cavicta* **sp. nov.** 43, labrum; 44, dorsal cephalic chaetotaxy; 45, maxillary outer lobe; 46, hypostomal chaetae; 47, lateral process of labial palp; 48, labial and postlabial chaetae; 49, trochanteral organ; 50, hind claw; 51, distal part of manubrium ventrally; 52, manubrial plaque; 53, mucro; 54, thoracic chaetotaxy.



FIGURES 55–56. Abdominal chaetotaxy in *Coecobrya cavicta* **sp. nov.** 55, Abd. I–III; 56, Abd. IV.

Remarks. *Coecobrya cavicta* **sp. nov.** can be separated from other *Coecobrya* species by the combination of abundant posterior mac on dorsal head, labial chaetae r and six smooth and minute postlabial chaetae, two inner teeth on unguis, serrate outer edge on unguiculus, 13+13 chaetae on distal part of manubrium ventrally, four median-lateral mac on Th. II, five or four mac on Abd. II, and nine or seven central and 11 lateral mac on Abd. IV. It differs from closely related species in absence of unpaired tooth on unguis and four medio-sublateral mac on Th. II (Table 3).

Key to the Thai species of *Coecobrya*

*Cave-dwelling species

1.	Antennae more than 2.5 times as long as the cephalic diagonal	2
-	Antennae less than 2.5 times as long as the cephalic diagonal	5
2.	Unguis without unpaired inner teeth	*C. cavicta* Nilsai & Zhang **sp. nov.***
-	Unguis with unpaired inner tooth	3
3.	Labial chaetae as $mRel_1l_2$; Abd. IV with 7+7 central mac	*C. chumphonensis* Zhang & Nilsai **sp. nov.***
-	Labial chaetae as $M_1m_2rel_1l_2$; Abd. IV with 6+6 central mac	4
4.	Postlabial chaeta X_4 ciliate; mac a1 present on Abd. I	*C. polychaeta* Zhang & Nilsai **sp. nov.***
-	Postlabial chaeta X_4 smooth; mac a1 absent on Abd. I	*C.* cf. *polychaeta* Zhang & Nilsai **sp. nov.***
5.	Abd. IV with more than 4+4 central mac	6
-	Abd. IV with 3+3 or 4+4 central mac	7
6.	Abd. III with 1+1 central mac	*C.* cf. *hoefti* (Schäffer, 1896)
-	Abd. III with 2+2 central mac	*C. lanna* Zhang, Deharveng & Chen, 2009
7.	Abd. I with 4+4 central mac; Abd. II with 2+2 central mac	*C. similis* Deharveng, 1990*
-	Abd. I with 5+5 central mac; Abd. II with 3+3 central mac	*C. guanophila* Deharveng, 1990*

TABLE 3. Comparison among *C. chumphonensis* **sp. nov.**, *C. polychaeta* **sp. nov.**, *C. cavicta* **sp. nov.**, and *C. annulata*. s, smooth; c, ciliate. Character states in parentheses are rarely observed.

Characters	*C. chumphonensis* **sp. nov.**	*C. polychaeta* **sp. nov.**	*C. cavicta* **sp. nov.**	*C. annulata*
Ant./head	3.70–4.48	5.91–7.12	2.67	2.1–2.8
Long smooth straight chaetae on antennae	absent	absent	present	absent
Clypeus				
prefrontal	3s	3s	?	3s
facial	8s	2s7–10c	?	6c
Dorsal head				
An	2	4	4	4
A0	mac	mic	mac	mac
M	4	3	3	3
Gr. II	6(7)	3	4	4(5)
Sublobal hairs on maxillary outer lobe	3	4	3	3
Lateral process of labial palp	short	long	short	short
Labial chaetae	$mRel_1l_2$	$M_1m_2rel_1l_2$	$mrel_1l_2$	$mrel_1l_2$
Postlabial chaeta X	minute	normal	minute	minute
Chaetae along cephalic groove	4s5–7c	6–7s5–10c	3–4s7–8c	4s4c
Ungual inner teeth	3	3	2	3
Unguiculus outer edge	serrate	serrate	serrate	a tiny tooth
Ventral tube				
anterior face	9–12	12	?	7
posterior face	13	20–31	?	11–14
lateral flap	7(10)	9–12	?	8–11
Chaetae on manubrial plaque	4–7	4–10	4	4(5)
Chaetotaxy of Th. II				
medio-medial mac	4–6	7(6)	3	3
medio-sublateral mac	3	3	4	3
Mac on Abd. I	6–7	8–9	6–7	6
Central mac Abd. II	3	4(3)	3	3
Chaetotaxy of Abd. III				
central mac	2	1	1	1
lateral mac	3	3	3	2
ms	absent	present	absent	present
Chaetotaxy of Abd. IV				
central mac	7	6	7+9	6
lateral mac	10–12	9	11	8

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