ซิสเทแมติกส์ของไร Anystae Krantz, 1978 ในประเทศไทย

นายมารุต เฟื่องอาวรณ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
สาขาวิชาสัตววิทยา ภาควิชาชีววิทยา
คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2558

SYSTEMATICS OF MITE ANYSTAE KRANTZ, 1978 IN THAILAND

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A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Zoology
Department of Biology
Faculty of Science
Chulalongkorn University
Academic Year 2015

Thesis Title	SYSTEMATICS OF MITE ANYSTAE KRANTZ, 1978 IN THAILAND
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มารุต เฟื่องอาวรณ์ : ซิสเทแมติกส์ของไร Anystae Krantz, 1978 ในประเทศไทย (SYSTEMATICS OF MITE ANYSTAE KRANTZ, 1978 IN THAILAND) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร. บัณฑิกา อารีย์กุล บุทเชอร์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: ศ. ดร. โดนัล ควิก, 269 หน้า.

สปีชีส์ในไฮโปเดอร์ Anystae Krantz, 1978 (*sensu* Zhang *et al*. 2011) เป็นไรตัวห้ำที่มักพบได้ตามพื้นดิน ซากพืชทับถม มอส เปลือกไม้ บนต้นพืช หรือในดินชั้นลึกๆ ในประเทศไทยมีรายงานไร Anystae แล้วเพียง 1 สปีชีส์คือ *Adamystis thailandensis* Fuangarworn & Lekprayoon, 2010 (วงศ์ Adamystidae) การศึกษาซิสเทแมติกส์ของไร Anystae โดยเฉพาะในประเทศไทยครั้งนี้ถือเป็นครั้งแรก โดยศึกษาจากตัวอย่างที่เก็บได้ระหว่าง พ.ศ. 2554-2558 กับตัวอย่างเก่าที่เก็บรักษาไว้ในพิพิธภัณฑ์ พร้อมทั้งวิเคราะห์หาความสัมพันธ์เชิงวิวัฒนาการระดับวงศ์ของไร Anystae กับไรที่เกี่ยวข้องโดยใช้ลักษณะทางสัณฐานวิทยาซึ่งถือเป็นครั้งแรกเช่นกันที่วิเคราะห์ครอบคลุมไร Anystae ทุกวงศ์ พบไร Anystae ในประเทศไทยเพิ่มขึ้นรวมเป็น 18 สปีชีส์ ในจำนวนนี้เป็นสปีชีส์ใหม่ 12 สปีชีส์ และสปีชีส์บันทึกใหม่ 5 สปีชีส์ สามารถจัดจำแนกได้เป็น 15 สกุล ใน 10 วงศ์ โดยเป็นสกุลใหม่ 1 สกุลคือ *Chulacarus* n. gen. ในวงศ์ใหม่ 1 วงศ์คือ Chulacaridae n. fam ทั้งนี้ได้ให้คำบรรยายลักษณะพร้อมจัดทำภาพประกอบสำหรับสปีชีส์ที่พบใหม่ได้แก่ *Anystis siamensis* n. sp., *Walzia chamrasae* n. sp., *W. monosetosa* n. sp. (วงศ์ Anystidae); *Neocaeculus orientalis* n. sp. (วงศ์ Caeculidae); *Chulacarus elegan* n. sp. (วงศ์ Chulacaridae); *Lactyoscythis kanchanaburiensis* n. sp., *Tarsolarkus pilosus* n. sp., *Tarsotomus ottoi* n. sp. (วงศ์ Erythracaridae); *Apomerantzia pasak* n. sp. (วงศ์ Pomerantziidae); *Anoplocheylus corticicola* n. sp. (วงศ์ Pseudocheylidae); *Stigmocheylus bochkovi* n. sp. (วงศ์ Stigmocheylidae) และ *Austroteneriffia sunthorni* n. sp. (วงศ์ Teneriffiidae) ได้ให้คำบรรยายใหม่หรือคำบรรยายเพิ่มเติมสำหรับสปีชีส์บันทึกใหม่ได้แก่ *Erythracarus nasutus* Otto, 1999 (วงศ์ Erythracaridae); *Tanytydeus kakadu* Seeman & Walter, 1999, *Tan.* cf. *egypticus* (Soliman, 1975) (วงศ์ Paratydeidae); *Pomerantzia philippina* Bochkov & Walter, 2007 (วงศ์ Pomerantziidae) และ *Anoplocheylus aegypticus* Baker & Atyeo, 1946 (วงศ์ Pseudocheylidae) นอกจากนี้ยังได้ให้คำบรรยายเกี่ยวกับระยะต่าง ๆ ตลอดวงชีวิตของ *Ano. corticicola* n. sp., *Ano. aegypticus* Baker & Atyeo, *N. orientalis* n. sp. และ *Tan. kakadu* Seeman & Walter, 1999 อีกด้วย ซึ่งถือเป็นรายงานครั้งแรกและนำข้อมูลไปแปรผลใหม่เกี่ยวกับการเจริญเติบโตของไรในวงศ์ Pseudocheylidae และ Paratydeidae ส่วนการวิเคราะห์หาความสัมพันธ์เชิงวิวัฒนาการระดับวงศ์ พบว่าไร Anystae ไม่ใช่กลุ่มที่มีความสัมพันธ์ระหว่างวงศ์แบบโมโนไฟเลทิก มักจัดกลุ่มแบบพาราไฟเลทิกหรือโพลีไฟเลทิก อย่างไรก็ตามเมื่อพิจารณาเป็นรายวงศ์พบว่าทุกวงศ์เป็นกลุ่มแบบโมโนไฟเลทิก แต่ความสัมพันธ์ในระดับที่ลึกกว่านี้ยังไม่อาจสรุปได้เนื่องจากผลที่ได้ยังแปรผันอันเนื่องมาจากตัวแปรบางประการ (เช่น แอดดิทิวิตี แต่แอดดิทิวิตีมีส่วนเพิ่มค่าสนับสนุนความสัมพันธ์) โดยรวมพบว่าความสัมพันธ์ระดับวงศ์ของไร Anystae ไม่สอดคล้องกับการศึกษาในอดีต กล่าวคือวงศ์ Pseudocheylidae มักจัดกลุ่มใกล้ชิดกับ Eleutherengona การจัดหมวดหมู่ระดับวงศ์ใหญ่อย่าง Anystoidea และ Paratydeoidea โดย Walter *et al*. (2009) ก็ไม่เป็นแบบโมโนไฟเลทิก และวงศ์ Chulacaridae ก็ไม่ได้อยู่ในวงศ์ใหญ่ Anystoidea อย่างที่เคยเสนอไว้แต่มีความสัมพันธ์ใกล้ชิดกับกลุ่มที่ประกอบขึ้นเป็น Paratydeidae + ((Stigmocheylidae + Pomerantziidae) + (Pseudocheylidae + Eleutherengona))

ภาควิชา	ชีววิทยา	ลายมือชื่อนิสิต	....
สาขาวิชา	สัตววิทยา	ลายมือชื่อ อ.ที่ปรึกษาหลัก	....
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5472842723 : MAJOR ZOOLOGY

KEYWORDS: ACARI / TROMBIDIFORMES / TAXONOMY / CLADISTIC ANALYSIS

MARUT FUANGARWORN: SYSTEMATICS OF MITE ANYSTAE KRANTZ, 1978 IN THAILAND. ADVISOR: ASST. PROF. BUNTIKA AREEKUL BUTCHER, Ph.D., CO-ADVISOR: PROF. DONALD L.J. QUICKE, Ph.D., 269 pp.

Species in the hyporder Anystae Krantz, 1978 (sensu Zhang *et al*. 2011) are predatory mites usually found in soil and litter, moss, bark, on vegetation, or in deep soil habitats. In Thailand, only one known anystaen species was previously documented: *Adamystis thailandensis* Fuangarworn & Lekprayoon, 2010 (Adamystidae). The systematics of the Anystae in Thailand was comprehensively studied for the first time, based on specimens collected during 2011-2015 and old materials in the museums. The phylogenetic analysis including representatives from all anystaen families was also conducted for the first time to assess the interfamilial relationship of Anystae and related taxa, based on morphological characters. Eighteen species of the ansystaen mites are recognized in this study. Of these, 12 species are new to science and 5 species are new records for the Thai fauna. They are classified into 15 genera, in 10 families, one of which is a new genus, *Chulacarus* n. gen., in a new family, Chulacaridae n. fam. The new species were described and illustrated, including *Anystis siamensis* n. sp., *Walzia chamrasae* n. sp., *W. monosetosa* n. sp. (Anystidae); *Neocaeculus orientalis* n. sp.(Caeculidae); *Chulacarus elegan* n. sp. (Chulacaridae); *Lactyoscythis kanchanaburiensis* n. sp., *Tarsolarkus pilosus* n. sp., *Tarsotomus ottoi* n. sp. (Erythracaridae); *Apomerantzia pasak* n. sp. (Pomerantziidae); *Anoplocheylus corticicola* n. sp. (Pseudocheylidae); *Stigmocheylus bochkovi* n. sp. (Stigmocheylidae) and *Austroteneriffia sunthorni* n. sp. (Teneriffiidae). The redescriptions and supplementary descriptions were given for the new recorded species: *Erythracarus nasutus* Otto, 1999 (Erythracaridae); *Tanytydeus kakadu* Seeman & Walter, 1999, *Tan*. cf. *egypticus* (Soliman,1975) (Paratydeidae); *Pomerantzia philippina* Bochkov & Walter, 2007 (Pomerantziidae) and *Anoplocheylus aegypticus* Baker & Atyeo, 1946 (Pseudocheylidae). The descriptions of complete life cycles of *Ano*. *corticicola* n. sp., *Ano*. *aegypticus* Baker & Atyeo, *N. orientalis* n. sp., and *Tan*. *kakadu* Seeman & Walter, 1999 were also given for the first time, resulting in a new interpretation of the ontogeny of Pseudocheylidae and Paratydeidae. The phylogenetic analyses revealed that Anystae as a group is not monophyletic; it was retrieved as para- or polyphyletic. All families were recovered as a monophyletic group but deeper relationships are ambiguous due to changes in parameters (i.e. additivity, but additivity increases clade support). The overall results show incongruence with the previous studies concerning relationships of Anystae: the family Pseudocheylidae was retrieved as a sister group to the Eleutherengona; the superfamilial groupings in the previous classifications are not monophyletic; and Chulacaridae, once thought to belong to the superfamily Anystoidea, was recovered as a sister taxon of Paratydeidae + ((Stigmocheylidae + Pomerantziidae) + (Pseudocheylidae + Eleutherengona)) in the preferred tree.

Department:	Biology	Student's Signature	
Field of Study:	Zoology	Advisor's Signature	
Academic Year:	2015	Co-Advisor's Signature	

ACKNOWLEDGEMENTS

I would like to thank my major advisor, Assistant Professor Dr. Buntika Areekul Butcher who let me develop my own project but always available when problem inevitably arose, for help and support throughout the graduate program and my co-advisor, Professor Dr. Donald Quicke, for help and advising me, especially on the phylogenetic analysis. Thanks also go to my committee members, Dr. Noppadon Kitana, Associate Professor Chariya Lekprayoon, Professor Dr. Somsak Panha and Assistant Professor Dr. Chirasak Sutcharit, for their willingness to serve on my thesis committee and for their invaluable suggestions.

The following colleagues are thanked for correspondence and reprints: Mr. Gholamreza Beyzavi, Dr. Andre Bochkov, Dr. Qing-Hai Fan, Dr. Bruce Halliday, Dr. Mark Judson, Dr. Mohammad Khanjani, Dr. Alexander Khaustov, Dr. Hans Klompen, Dr. Jurgen Otto, Dr. Christopher Taylor, Dr. Eddie Ueckermann, and Dr. Luo Youzhen. I am very grateful to Dr. Pieter Theron and Dr. Owen Seeman for loans of type materials under their care, and Dr. Eddie Ueckermann for providing a comparative material. I thank Dr. Angoon Lewvanich, Mr. Sunitsorn Pimpasalee, Mrs. Sae-aroon Wangsook, Mr. Narathip Chantarasawat and Dr. Ekachai Jirathitikul for allowing me to accompany them in several field trips and for their help in the fields. Additional field trips were also supported by the staff of the Plant Genetic Conservation Project under the Royal initiate of Her Royal Highness Princess Maha Chakri Sirindhorn (especially those in the sections of the Royal Thai Navy, Royal Thai Army, and the Electricity Generating Authority of Thailand), I am very grateful to all.

Special thanks are due to Dr. David Walter and Dr. Owen Seeman for carefully reviewing of selected manuscripts.

This research was financially supported by the 90th Anniversary of Chulalongkorn University Fund (Ratchadaphiseksomphot Endowment Fund).

Finally, I am very grateful to my parents, Sunthorn and Chamras Fuangarworn, for their encouragement and support for my studies.

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PREFACE

This thesis is composed of 12 chapters, 9 of which are original manuscripts that have been published or will be submitted for publication in refereed journals. Introductory and summary chapters provide structure for the compilation of the papers. It should be noted that all new taxon names, and new combinations proposed in this thesis are not valid within the meaning of the International Code of Zoological Nomenclature, Fourth Edition (Article 8.2) until they are published.

CHAPTER 1

GENERAL INTRODUCTION

1.1 Rationale

Mites of the hyporder Anystae Krantz, 1978 [*sensu* Zhang *et al*. (2011) or cohort Anystina *sensu* Lindquist *et al.* (2009)] comprise free-living predatory species which have exploited a range of terrestrial habitats, from coastal sea shore to the mountain at high altitude. Many occur in habitats such as soil and litter, on rocks, tree bark, and lower vegetation of rather dried and exposed areas. Others have rather colonized in deep soil strata (Walter *et al.* 2009).

They are medium to large bodied mites (between 500-1500 micrometers) and are characterized by following combination of characters (Walter *et al.* 2009): having short, sickle-like movable cheliceral digits, arising terminally from broad unfused bases; the fixed digits are greatly reduced or absent; a well defined palpal thumb-claw process is present throughout the group, but may be reduced or absent in some subgroups; prodorsal ocelli and post cheliceral stigmata and peritremes are usually distinct, and a naso and one or two pairs of bothridial organs may be present; larval urstigmata and postlarval genital papillae are retained in most taxa; and male lack an aedeagus, and copulation involving direct sperm transfer is still unknown. None of these character states is unique to them.

The Anystae currently includes 9 families (Pepato & Klimov 2015; Walter *et al.* 2009; Zhang *et al.* 2011), grouped in 5 superfamilies: Caeculoidea (Caeculidae); Adamystoidea (Adamystidae); Anystoidea (Anystidae, Erythracaridae, Teneriffiidae, Pseudocheylidae); Paratydeoidea (Paratydeidae, Stigmocheylidae) and Pomerantzioidea (Pomerantziidae). Compared to other equivalent groups, Anystae is not species rich taxon. Collectively, about 255 species are described from every continent except for the Polar Regions. However, the world fauna is still poorly known and many undescribed taxa await description. This group of mites contains species (particularly in the family Anystidae) of agricultural importance as potential biological control agents of agricultural pests; and those soil-litter inhabiting species may be useful as bioindicators for the environmental health.

In Thailand, despite their potentially economic importance, Thai anystaen fauna has been received little attention. Only one known anystaen species was previously documented, namely *Adamystis thailandensis* Fuangarworn & Lekprayoon, 2010 (family Adamystidae; Fuangarworn & Lekprayoon 2010). Other exiting reports refer only to the family Anystidae as an unidentified species (Chandrapatya 2010). This is possibly due to an under-collecting efforts and the lack of taxonomic tools. Therefore, inventory of the species diversity of anystaen mites in Thailand is essential to improve Thai biodiversity knowledge. Moreover, there is no specific study devoted to the comparative morphology and phylogeny of the Anystae, and the current internal classification of this group is not based on hypotheses of the phylogenetic relationships (i.e., some familial groupings are artificial). As a result, such classification of the Anystae has little predictive power and is of limited use for evolutionary considerations. Therefore, the study of the phylogenetic relationships within the Anystae is essential as well. Although the current classification of the Anystae has not been originally proposed as hypotheses of phylogenetic relationships, they may be treated as such and tested using cladistic method.

1.2 Research objectives

The primary objectives of this research were to study the diversity of anystaen mites in Thailand and provide taxonomic descriptions as well as identification key to the Thai species, (each family is treated individually, and alphabetically, in Chapters 2A-I) and to test the hypothesis of the higher-level relationships of mites within the Anystae, based on morphological characters using cladistic methods (Chapter 3).

CHAPTER 2A

THREE NEW SPECIES OF THE FAMILY ANYSTIDAE (ACARI, TROMBIDIFORMES) FROM THAILAND*

2A-1 Abstract

Three new species of the prostigmatic mites family Anystidae, namely *Anystis siamensis* n. sp., *Walzia chamrasae* n. sp., and *Walzia monosetosa* n. sp., from Thailand are described and illustrated. Updated checklist of known species of the family Anystidae and key to species of the genus *Walzia* are provided.

Keyword.—Prostigmata, predatory mites, taxonomy, Thailand.

2A-2 Introduction

Species in the cosmopolitan family Anystidae are red, yellow or orange in colour; moderately large (500-1500 μm), long legged, and fast moving predatory mites (Meyer & Ueckermann 1987). They are found on vegetation and on soil surface. Some species in the genus *Anystis* are potential biological control agents of agricultural pests. For example, *Anystis wallacei* Otto, 1992 has been used to assist in the biological control of pasture mites in Australia (Otto 1992) and *Anystis baccarum* (L.), an important generalist predatory mite, has been integrated in the pest management programme of apple orchards (Cuthbertson *et al.* 2014). However, despite their potential applications in biological control, this family as a whole has been received little attentions.

Historically, the family Anystidae was erected by Oudemans (1936) and subdivided into two subfamilies: Anystinae and Erythracarinae. This classification has long been recognized in several major acarological works (Baker & Wharton 1952; Krantz 1978; Otto 2000; Walter *et al.* 2009), but until recently, Pepato and Klimov

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* This chapter is a manuscript in preparation for submission as:
Fuangarworn, M. Three new species of the family Anystidae (Acari, Trombidiformes) from Thailand.

(2015), based on molecular analysis, showed that Anystidae is not monophyletic and elevated Erythracarinae to familial rank. Therefore the family Anystidae now includes only the subfamily Anystinae. According to Oudemans (1936), Anystinae comprises 7 genera and about 40 species (Table 1) but most of which are poorly known, old descriptions do not meet modern requirements and their status need clarification. Taxonomic revision of this group of mites is critically needed; however, this is beyond the scope of our study. Since the revisionary work by Oudemans (1936), there have been a few studies on anystid mites. Womersley (1942) described a new species of *Walzia* from Australia. It was until 1984 that one more new species of *Anystis* from Uzbekistan was added by Barilo (1984). Meyer and Ueckermnn (1987), based mostly on South African materials, studied taxonomy of Anystidae, re-describing *Anystis baccarum* (L.) and *A. salicinus* (L.) and describing new species in the genus *Tencateia* (1 species) and *Walzia* (2 species). Later, (Gupta 1991, 1992) described three new species of anystids, two in *Anystis* and one in *Tencateia* from India(Gupta 1991). In the same period, Otto (1992) added one new species *Anystis* originally known from France. In Otto's (1992) work, two species of *Anystis* described by Oudemans (1936), *A. rosae* and *A. kochi*, has been proven to be junior synonyms of *A. salicinus* (L.). List of anystid species is given in Table 1.

In Thailand, no known species of Anystidae has been previously recorded. Only unidentified species, as 'Anystidae', were documented by Kongkanjana *et al.* (2001) and Chandrapatya (2010). In this paper, we present the detailed diagnosis of the family and descriptions of three new species of anystid mites from Thailand, one species in the genus *Anystis* and two species in the genus *Walzia*. This is first report of these two genera in Thailand.

2A-3 Materials and methods

Mites were collected by hand or extracted from soil and leaf-litter samples using Tullgren funnels (Walter & Krantz 2009), and stored in 70% ethanol (see *Material examined* for collection data). The specimens were observed in temporary cavity slides using lactic acid as the medium under a bright-field compound microscope and phase contrast microscope. Drawings were made with the aid of a drawing tube attached to the microscope. Terminology follows that of Kethley (1990). Measurements are in micrometers (μm).

2A-4 Taxonomic results

Family Anystidae Oudemans, 1936

Type genus: *Anystis* von Heyden, 1826

Diagnosis. *Gnathosoma*. Chelicerae with fixed digit hook-like; movable digit reduced, stylet-like process absent; each with 2 cheliceral setae, both situated on anterior half of the segment. Palpi 4-segmented, femur and genu fused (incompletely); palp setation hypertrichous; tibial claw present, with 2 subterminal claws; tarsus well developed, longer than tibia, with (among other setae) terminal spine-like seta, three peg-like setae, and one erected solenidion. Palp supracoxal setae present. Subcapitulum with post larval neotrichy of subcapitular setae; adoral setae (*or1-2*) present; lateral lips with lacinae; ventral lip absent; dorsal lip with brush-like processes dorsally and lacinae-like processes ventrally; capitular apodeme with reticulate pattern. Peritremes situated transversely at cheliceral bases and distally emergent.

Idiosoma. Short, broader than long. Naso distinct. Prodorsal shield usually present, and separated from naso; with 4 pairs of prodorsal setae (*vi*, *ve*, *sci*, *sce* of which 2 pairs, *vi* and *sci*, are thinner and trichobothrial); neotrichous setae present or absent; *vi* at base of naso; other setae on prodorsal shield; two pairs of lens-like eyes present; supracoxal setae *eI* and *eII* present; dorsal hysterosomal setae holotrichous or hypertrichous; 4 pairs of lyriffissures (*ia*, *im*, *ip*, *ih*) present. *Epimeral region*. Coxal shield I-IV contiguous, but medially separate, and more or less radially arranged; coxal setation hypertrichous; sagittal apodeme and post coxal IV apodeme present. *Anogenital regions*. Genital opening flankend by genital valve; hypertrichous setae present on genital valve and aggenital region; anal opening ventrally. Anamorphic addition of setae *ad* present; genital papillae present, associated setae *k* absent; ovipositor and eugenital setae present; male genitalia with slender eugenital setae.

Legs. Femur subdivided, tarsus entire (not subdivided into pseudosegments); ventral trichobothrium on basifemora I-II present; formulae of genual solenidia (σ) 1-1-1-0; tibial solenidia (φ) 2-2-2-0; tarsal solenidia (ω) 1-2-0-0; genual famulus (k) 1-1-

0-0; tibial famulus (*k*) 1-1-0-0; tarsal famulus (*ε*) 1-1-0-0. Pretarsal claws present, claw-like with setules; pretarsal empodia bell-shaped; brush-like setae present at base of claws.

Selected characters of ontogenetic transformations. Two subterminal claws on palptibia protonymphal; 3 peg-like setae (*x*, *y*, *z*) on palp tarsus tritonymphal/adult; larval Claparede's organs reduced in larva and situated anterior-dorsad of coxa II; pretarsal empodia claw-like in larva, becoming bell-shaped in later instars.

Genus *Anystis* von Heyden, 1826

Diagnosis. With characters of the family and a combination of following characters: prodorsal shield smooth, neotrichous setae absent on prodorsum, dorsal opisthosoma holotrichous.

Anystis siamensis n. sp.

(Figs 1 – 2)

Diagnosis. With characters of the genus *Anystis* and a combination of following characters: posterior margin of prodorsal shield with two weak concavities and one median strong concavity; female with two pairs of slender aggenital setae (*ag1-2*), aggenital plates absent; male with two pairs of spatulate aggenital setae; male anal tubercles and clustering setae absent.

Description. *Female*. Colour pale red; body length (naso posterior end of idiosoma; n = 1: holotype) 1030; width 825. *Gnathosoma*. Indistinctive; chelicerae 225 long, *cha* 65 long, *chb* 175 long; palp femur about 175 long; palp trochanter without setae; palp femorogenu with about 20 setae; palp tibia with about 20 slender setae and three claw-like setae; palp tarsus with one rod-like solenidion, 3 peg-like setae, and one terminal spine-like setae; and about 30 slender setae. Subcapitulum 235 long; 135 wide at base, with 7-8 pairs of setae; palp supracoxal seta *ep* rod-like. Peritreme linear with few rows of alveolae, expanded distally.

Idiosoma. Naso 40 long, anterior margin entire; prodorsal shield smooth; muscle sigillae evident; anterior margin almost straight, posterior margin with weak concavity near lateral ends and stronger concavity at midway (Fig. 1B). Propodosomal setae at normal position; their length: *vi* 75; *ve* 200; *sci* 75; *sce* 185; bothridial setae *vi* and *sci* thin and barbed; setae *ve*, *sce* thicker, attenuate, and strongly barbed. Two pairs of lens-like eyes subequal. Dorsal opisthosomal setae normal; neotrichous setae absent; with distribution as illustrated (Fig. 1A); their length: *c1* 175, *c2* 150, *d* 175, *e* 190, *f1* 165, *f2* 165, *h1* 135, *h2* 110, *h3* 90, *ps1* 60, *ps2* 60, *ps3* 75, *ps4*. Lyrifissures normal. *Epimeral region*. Coxal setation 8/9-9/10-9/10-8/9; all setae slender and barbed; saggital apodeme about 25 long; post coxal-IV apodemes about 125 long.

Anogenital region (Fig. 2A). Hypertricous setae present; genital opening about 225 long; genital valve with 6-8 genital setae, about 30-50 long, and barbed; aggenital setae *ag1-2* about 125 long, slender with minute barbs, born without platelet (but with dense circular striation around setal insertions). Anal opening about 160 long, with 3-4 setae (*ad*) on anal valves.

Legs. Typical of the family; leg lengths, approximately: I 1250, II 1380, III 1240, IV 1275; supracoxal setae *eI* and *eII* rod-like; leg setation similar to *Walzia chamrasae* n. sp. (described below).

Male. Similar to female except setae on palp tarsus distally dilated (not illustrated); genital valves with 14-16 genital setae; aggenital setae (*ag1-2*) ribbon shaped; with 6 pairs of setae (*ad*) on anal valves (Fig. 2B); and presence of genitalia, with about 12 pairs of smooth eugenital setae.

Immature stages: Unknown.

Material examined. Holotype, female: THAILAND, Chaingmai Province, Fang District, Fang Agricultural Research Center, 22 Jan 2014, col. M. Fuangarworn, ex soil surface (hand collecting at night). Five paratypes (2 females and 3 males) with same data of holotype. *Other materials*: three females, and two males, Nan Province, about 2 km. to Doi Phu Ka National Park (19°12'32.75''N, 101°4'12.70''E), 7 Feb 2012, col. M. Fuangarworn (Field no. 2012-10), ex. soil surface under leaf litter, along bank of road.

Etymology. The new species is named after the country of its ‘origin’, Siam or Thailand.

Distribution. Thailand (provincial records: Chiangmai, Nan).

Remaks. *Anystis siamensis* n. sp. is similar to *Anystis baccarum* (L.) in having the distally expanded peritremes, smooth prodorsal shield. However, the female of the new species may be distinguished from that of *A. baccarum* by the shape of the prodorsal shield which is strongly concaved on the posterior margin and has additional concavity near posterior corners (Fig. 1) while that of *A. baccarum* is slightly concaved and does not have additional concavity in *A. baccarum*. The new species lacks the microsclerites at the base of dorsal and aggenital setae while *A. baccarum* has them. Womersley (1933) recorded *A. baccarum* from Australia and later provided a description of the male of this species (Womersley 1942). However, Meyer and Ueckermann (1987), based on South African populations, reported that *A. baccarum* apparently has no male. Based on Womersley (1942), males of the new species differ from that of *A. baccarum* in the shape of aggenital setae: spatulate in the new species (vs. attenuate in *A. baccarum*) and in the absence of a pair of setal clusterings on anal vales (vs. present).

Genus *Walzia* Oudemans, 1936

Diagnosis. With characters of the family and a combination of following characters: prodorsal shield absent or present (as transversely striated shield, similar to surrounding membrane); neotrichous setae absent on prodorsal shield; dorsal opisthosoma holotrichous or with weak neotrichy.

Walzia chamrasae n. sp.

(Figs 3–9)

Diagnosis. With characters of the genus *Walzia* and a combination of following characters: anterior margin of naso entire; prodorsal shield densely striated; posterior margin strongly concaved; dorsal opisthosomal setae holotrichous (i.e., neotrichous setae absent); female with 2 pairs of slender aggenital setae (*ag1-2*), aggenital plates absent; male with two pairs of spatulate aggenital setae; male ‘anal tubercles’ and clustering setae absent.

Description. Female. Colour pale red; body length (naso to posterior end of idiosoma, n = 1: holotype) 824; width 721. *Gnathosoma*. Indistinctive; chelicerae (Fig. 3C) 250 long; *cha* 40 long; *chb* 60 long; palp (Fig. 3D) about 350 long; palp trochanter without setae; palp femorogenu with 21 setae; palp tibia with 18 slender setae and three claw-like setae; palp tarsus with one rod-like solenidion, 3 peg-like setae, one terminal spine-like setae, and 32 slender, barbed setae. Subcapitulum (Fig. 3E) 225 long; 125 wide at base with 8-9 pairs of setae; palp supracoxal seta *ep* rod-like. Peritreme about 125 long, expanded distally.

Idiosoma (Fig. 2A). Naso 75 long, anterior margin entire. Prodorsal shield present, transversely striated (i.e., striation finer and denser than surrounding integument); muscle sigillae evident; anterior margin almost straight, posterior margin strongly concaved at halfway. Propodosomal setae at normal position; their length: *vi* 85, *ve* 195, *sci* 110, *sce* 200; bothridial setae *vi* and *sci* thin and barbed; setae *ve*, *sce* thicker, attenuate, and strongly barbed. Two pairs of lens-like eyes subequal. Dorsal opisthosomal setae normal, neotrichous setae absent, with distribution as illustrated (Fig. 2A); their length: *c1* 160, *c2* 190, *d* 170, *e* 190, *f1* 155, *f2* 160, *h1* 140, *h2* 140, *h3* 110, *ps1* 100, *ps2* 100, *ps3* 85, *ps4* 85. Lyrifissures normal. *Epimeral region*. Coxal setation 9/10-8/10-5/8-5/7, all setae slender and barbed, sagittal apodeme 25 long, post-coxal-IV apodemes 125 long.

Anogenital region (Fig. 4A). Hypertricous setae present, genital opening 175 long, genital valve with 10-12 genital setae, about 30-40 long and barbed, aggenital setae *ag1-2* 115-130 long, slender with minute barbs, born without platelet (but with dense circular striation, Fig. 4B). Anal opening about 150 long, with 3-4 setae (*ad1-4*) on anal valves. Progenital chamber with 3 pairs of small, genital papillae, ovipositor with 2 groupings of eugenital setae: anterior one with 2 pairs of short setae, and posterior one with 7 setae.

Legs (Figs 5C-F, 6-9). Typical of the family, leg length: I 1030, II 1185, III 1030, IV 1174, each segment with hypertichous setae; solenidia and famuli normal, homologies of them and macrosetae as depicted in Figs 6-9, supracoxal setae *eI* and *eII* rod-like.

Male. Similar to female except setae on palp tarsus distally dilated (not illustrated); genital valves with 11-12 pairs of genital setae, aggenital setae (*ag1-2*) spatulate and barbed; with 3 pairs of setae (*ad*) on anal valves; and genitalia with about 12-13 pairs of smooth eugenital setae.

Material examined. Holotype, female: THAILAND, Ayutthaya Province, Tha Ruea District, Salaloy Sub-District, 11 Feb 2014, col. M. Fuangarworn, ex soil surface and bamboo litter (hand collecting). Six paratypes (3 females and 3 males) with same data of holotype. *Other materials*: three females, and two males, Chonburi Province, Sattahip District, Chuang Island, 20 Aug 2012, col. M. Fuangarworn, ex. beating from low vegetation. One female and one male, Chonburi Province, Sattahip District, Jan Island, 18 Sep 2012, col. M. Fuangarworn, ex. beating from low vegetation. One female and two males, Chonburi Province, Sattahip District, Samaesan Island, 20 Dec 2012, col. M. Fuangarworn, ex. beating from low vegetation. Two females and one male, Chonburi Province, Sattahip District, Samaesan Island, Luk-lom Beach, 23 Jan 2010, col. M. Fuangarworn (field no. 2010-10), ex. litter under *Barringtonia sp*. Five adults, Prachuap Khiri Khan Prov., Kho Thalu, 15 Mar 2011, ex low vegetation (bearing technique), col. M. Fuangarworn (field no. MF2011-43).

Etymology. The new species is named after the senior author's mother.

Distribution. Thailand (provincial records: Ayutthaya, Chonburi, Prachuap Khiri Khan).

Remarks. *Walzia chamrasae* n. sp. is similar to *W. darjilingensis* Gupta, 1992 from India in having a naso with smooth anterior margin and not having the aggenital plates at the base of aggenital setae. However, the new species may be distinguished from *W. darjilingensis* by the position of dorsal opishthosomal setae. Based on the original description of *W. darjilingensis*, there are two setae closely associated at the normal position of seta *e*—we interpret them as a seta *e* and an unusually displaced seta *f2*—and setae *f1* and *h1* are unusually located close to their pairs (Gupta 1992, Fig. 120). In the new species, the relative position of these setae is normal (i.e., seta *f2* is aligned with *f1* than *e*, and setae *f1* and *h1* are situated far apart from their pairs). The key to known species of the genus *Walzia* is given below.

Walzia monosetosa n. sp.

(Figs 10–11)

Diagnosis. With characters of the genus *Walzia* and a combination of following characters: anterior margin of naso entire, prodorsal shield absent or poorly define, dorsal opisthosomal setae with 2 neotrichous setae below seta *f2,* female with one pair of aggenital setae (*ag1*), aggenital plates absent, male with one pair of slender aggenital setae, male anal valves with tubercles and clustering setae.

Description. Female. Colour in life specimen not observed; body length (naso to posterior end of idiosoma, n = 1: holotype) 665, width 545. *Gnathosoma* (Fig. 10A). Indistinctive, chelicerae 200 long, *cha* 45 long, *chb* 50 long, palp about 350 long, palp trochanter without setae, palp femorogenu with about 20 setae, palp tibia with about 20 setae and three claw-like setae, palp tarsus with one rod-like solenidion, 3 peg-like setae, one terminal spine-like setae and about 30 slender setae. Subcapitulum 175 long, 100 wide at base, with 7-10 pairs of setae, palp supracoxal seta *ep* rod-like. Peritremes ribbon shaped, not expanded distally.

Idiosoma (Fig. 10). Naso 50 long, anterior margin entire, prodorsal shield poorly defined (i.e., density of striations almost indifferentiated from surrounding integument), muscle sigillae weakly developed, anterior margin almost straight, posterior margin slightly concaved. Prodorsal setae at normal position, their length: *vi* 100, *ve* 200, *sci* 105, *sce* 200, bothridial setae *vi* and *sci* thin and barbed, setae *ve*, *sce* thicker, attenuate, and strongly barbed. Two pairs of lens-like eyes subequal. Dorsal opisthosomal setae normal, distributed as illustrated (Fig. 10); their lengths: *c1* 180, *c2* 200, *d* 175, *e* 180, *f1* 150, *f2* 150, *h1* 95, *h2* 125, *h3* 75, *ps1* 75, *ps2* 50, *ps3* 50, *ps4* 50; two neotrichous setae present below setae *f2* (Fig. 10A, asterisked), about 100-110 long. Lyrifissures normal. *Epimeral region*. Coxal setation 11/12-11/12-6/7-8/9, all setae slender and barbed, sagittal apodeme 25 long, post-coxal-IV apodemes 125 long.

Anogenital region (Fig. 11A). Hypertrichous setae present, genital opening 150 long, genital valve with 16-19 pairs of barbed genital setae, about 10-20 long, one pair of aggenital setae *ag1* present, about 110 long, slender with minute barbs, born without platelet. Anal opening about 100 long, with 3-4 setae (*ad*) on anal valves.

Legs. Typical of the family, leg length: I 875, II 1080, III 925, IV 1030; supracoxal setae *eI* and *eII* rod-like; each segment with hypertichous setae, solenidia and famuli normal, setation of macrosetae similar to *W. chamrasae* n. sp;

Male. Similar to female except setae on palp tarsus distally dilated (not illustrated); genital valves with 20-23 pairs of genital setae, with 4-5 pairs of setae (*ad*) on anal valves, anal valves with a pair of tubercles each terminated with a cluster of 5 slender setae (Fig. 11B), genitalia with about 12 pairs of smooth eugenital setae.

Immature stages. Unknown.

Material examined. Holotype, female: THAILAND, Ayutthaya Province, Tha Ruea District, Salaloy Sub-District, 16 Nov 2014, col. M. Fuangarworn (Field no. 2014-66), ex bark of dead tree 5 m above ground, (water washing). 11 paratypes (3 females and 8 males) with same data of holotype. *Other materials*: one female, and two males, Ayutthaya Province, Tha Ruea District, Salaloy Sub-District, 19 Feb 2011, col. M. Fuangarworn, ex soil surface and bamboo litter (hand collecting).

Etymology. The new species named after its presence of only one pair of aggenital setae.

Distribution. Thailand (provincial record: Ayutthaya).

Remarks. *Walzia monosetosa* n. sp. is unique within the genus *Walzia* (adults) in having only one pair of aggenital setae (vs. two pairs in others species). Males of *Walzia monosetosa* n. sp. possess a pair of 'anal tubercles', protruding from anal valves and ending with a cluster of a numbers of setae. This structure has been recorded in the male of *Anystis bacarum* (L.) by Womersley (1942). He also described a similar structure in the male of *W. australica* Womersley, 1942 (Australia) but the terminal setae are broom-like, hence similar to the male of *Tencateia villosa* Meyer & Ueckermann, 1987 (South Africa). The function of this structure is unknown and its distribution across anystid genera needs further study.

Key to species of the genus *Walzia* (female)

1. Two pairs of aggenital setae present ……………………………………….…. 2
- One pair of aggenital setae present ……………………... *Walzia monosetosa* n. sp.
2. Aggenital setae (*ag1*, *ag2*) located on common shield ……….*W. hammeni* Meyer & Ueckermann, 1987
- Aggenital setae (*ag1*, *ag2*) located separately …………………………………. 3
3. Naso entire on anterior margin ………………………………………….…. 4
- Naso denticulate on anterior margin ….…. *W. Indiana* Meyer & Ueckermann, 1987
4. Aggenital plate distinct at base of aggenital setae ……………………………..… 6
- Aggenital plate absent at base of aggenital setae ……………………..……. 5
5. Seta *f2* associated with seta *e* ……………..………… *W. darjlingensis* Gupta, 1992
- Seta *f2* at normal position (i.e., aligned in setal row *f*) ..…. *Walzia chamrasae* n. sp.

6. Aggenital setae relatively short (i.e., subequal to neotrichous setae), with 6 pairs of setae on anal valves………………..……………*W. australicus* Womersley, 1942

- Aggenital setae relatively long (i.e., twice as long as neotrichous setae), with 5 pairs of setae on anal valves ……………….……………… *W. antiguensis* (Stoll, 1886)

Table 1. List of species of Anystidae of the world, based on Oudemans (1936) with update.

Genus *Anystis* von Heyden, 1826
- *Anystis andrei* Oudemans, 1936
- *Anystis baccarum* (L.)
  - Syn. *Anystis agilis* (Bank, 1894)
- *Anystis borussica* Oudemans, 1936
- *Anystis germanica* Oudemans, 1936
- *Anystis indica* Gupta, 1992
- *Anystis langei* Barilo, 1984
- *Anystis nagalandensis* Gupta, 1991
- *Anystis salicinus* (L.)
  - Syn. *Anystis rosae* Oudemans, 1936
  - Syn. *Anystis kochi* Oudemans, 1936
- *Anystis sellnick* Oudemans, 1936
- *Anystis siamensis* **n. sp.**
- *Anystis voigtsi* Oudemans, 1936
- *Anystis wallacei* Otto, 1992

Species inquirendae
- *Anystis astripus* (Karsch, 1881)
- *Anystis coccinea* (Targ-Tozz, 1878)
- *Anystis cornigerum* (Hermann, 1844)
- *Anystis cornutum* (Hermann, 1804)
- *Anystis cursorium* (Gerv, 1844)
- *Anystis citreola* Oudemans, 1936
  - [=A. flaveola (Stoll, 1887)]
- *Anystis pallescens* (Koch, 1838)
- *Anystis pini* (Koch, 1838)
- *Anystis rabuscula* (Koch, 1838)
- *Anystis rapida* (Suworow, 1907)
- *Anystis retalteca* (Stoll, 1887)
- *Anystis setosa* (Koch, 1879)
- *Anystis subnuda* (Menge, 1854)
- *Anystis triangularis* (Koch, 1838)
- *Anystis venustula* (Koch, 1854)
- *Anystis vitis* (Schrk, 1781)

Genus *Scharfenbergia* Oudemans, 1936
- *Scharfenbergia hilaris* (Koch, 1836)
- *Scharfenbergia authieri* Oudemans, 1936

Genus *Snartia* Oudemans, 1936
- *Snartia nepenthus* Oudemans, 1936

Genus *Tencateia* Oudemans, 1936
- *Tencateia besselingi* Oudemans, 1936
- *Tencateia toxopei* Oudemans, 1936
- *Tencateia flaveola* (Koch, 1836)
- *Tencateia jabanica* (Berlese, 1905)
- *Tencateia kanthiensis* Gupta, 1992
- *Tencateia villosa* Meyer & Ueckermann, 1987

Genus *Autenriethia* Oudemans, 1936
- *Autenriethia velvox* (Berlese, 1905)

Genus *Barellea* Oudemans, 1936
- *Barellea sinensis* (Berlese, 1923)

Genus *Walzia* Oudemans, 1936
- *Walzia antiguensis* (Stoll, 1886)
- *Walzia australica* (Womersley, 1942)
- *Walzia chamrasae* **n. sp.**
- *Walzia darjilingensis* Gupta, 1992
- *Walzia hammeni* Meyer & Ueckermann, 1987
- *Walzia indiana* Meyer & Ueckermann, 1987
- *Walzia monosetosa* **n. sp**

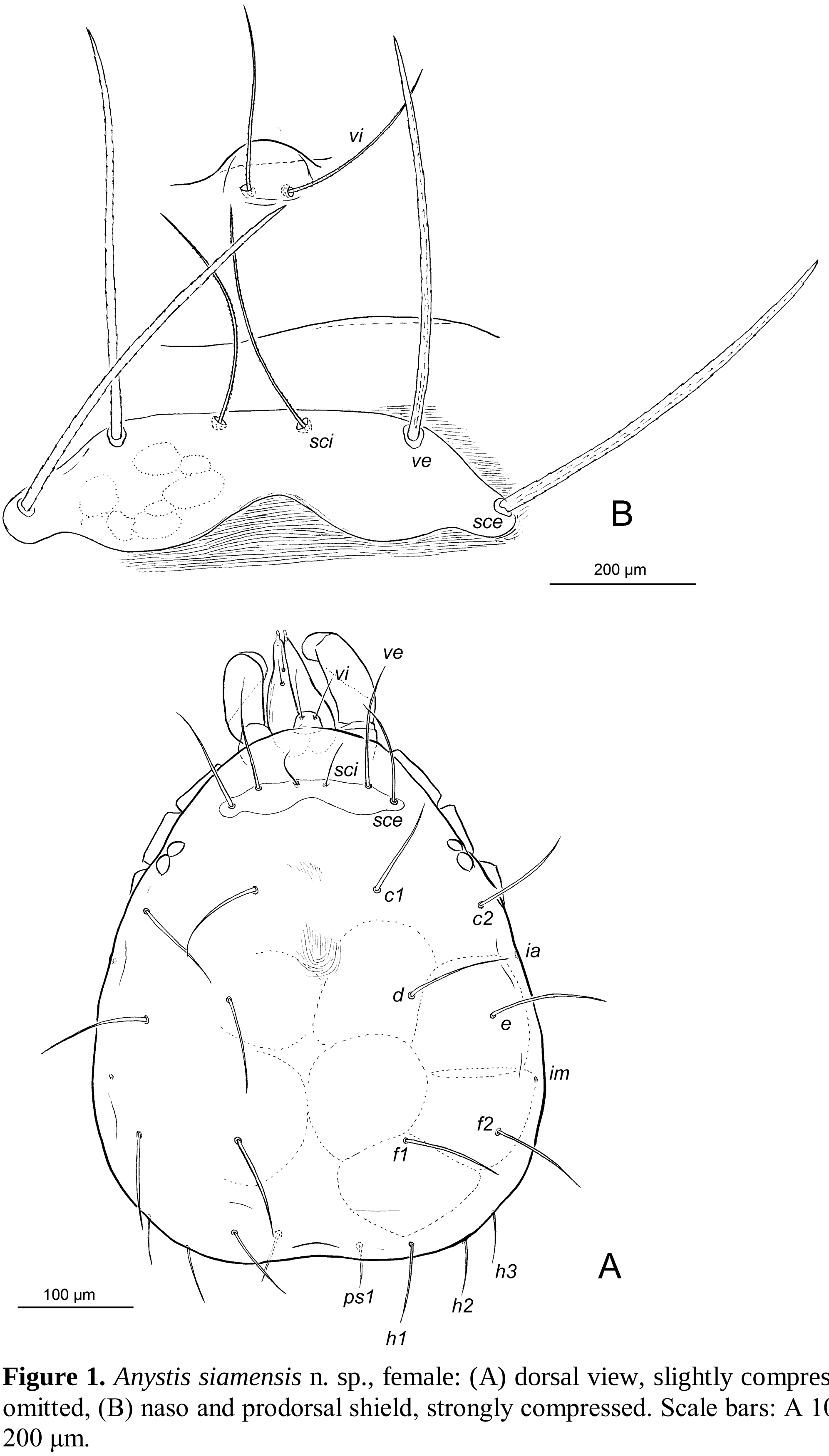

Figure 1. *Anystis siamensis* n. sp., female: (A) dorsal view, slightly compressed, legs omitted, (B) naso and prodorsal shield, strongly compressed. Scale bars: A 100 µm, B 200 µm.

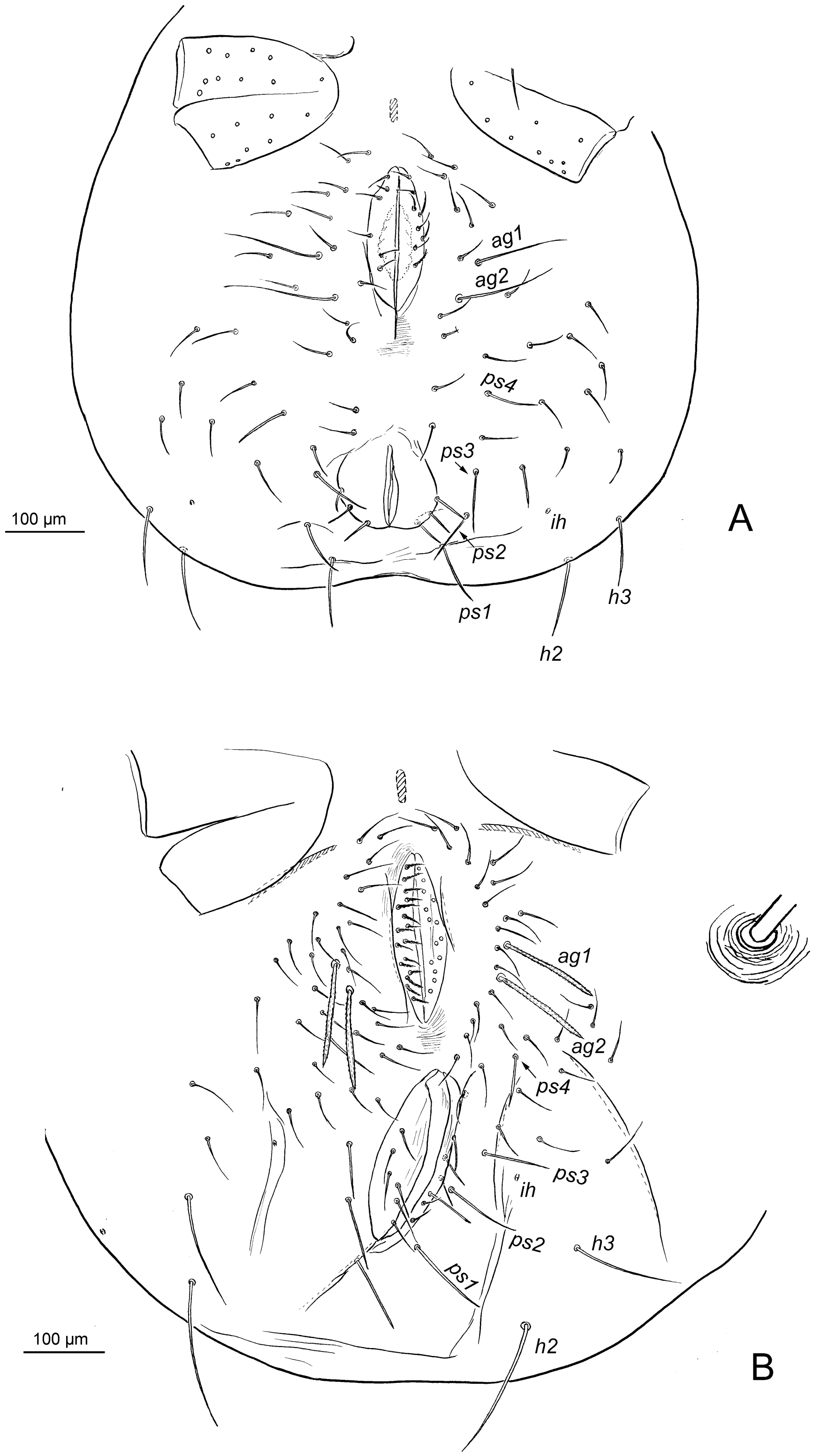

Figure 2. *Anystis siamensis* n. sp.: (A) female opisthosoma, ventral view, slightly compressed, (B) male opisthosoma, ventral view, strongly compressed. Scale bars: A and B 100 µm.

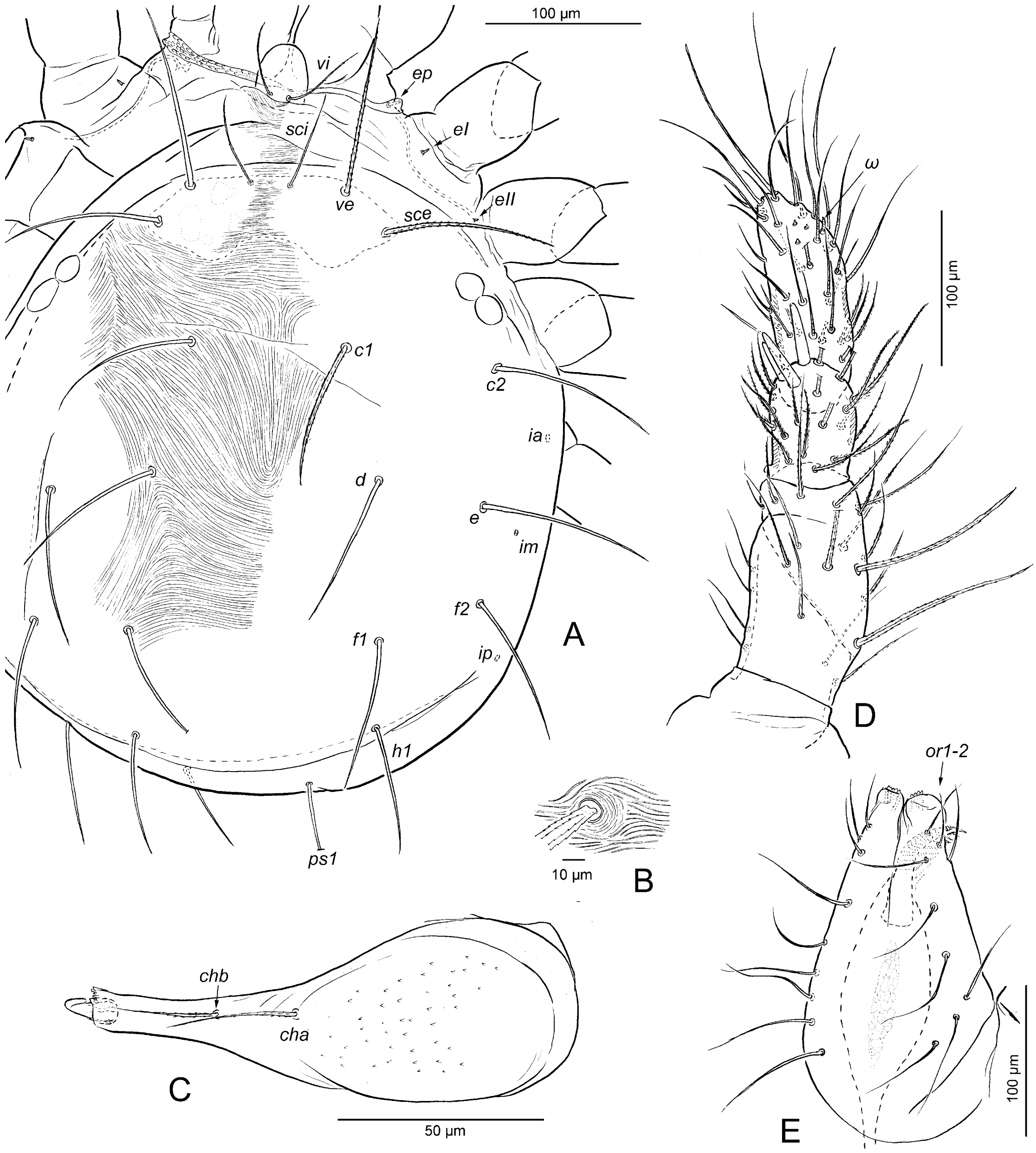

Figure 3. *Walzia chamrasae* n. sp., female, compressed: (A) idiosoma, dorsal view, legs omitted, (B) base of dorsal seta, (C) chelicerae, dorsal view, (D) palp, dorsal view, (E) subcapitulum, ventral view. Scale bars: A, D, E 100 µm, B 10 µm, C 50 µm.

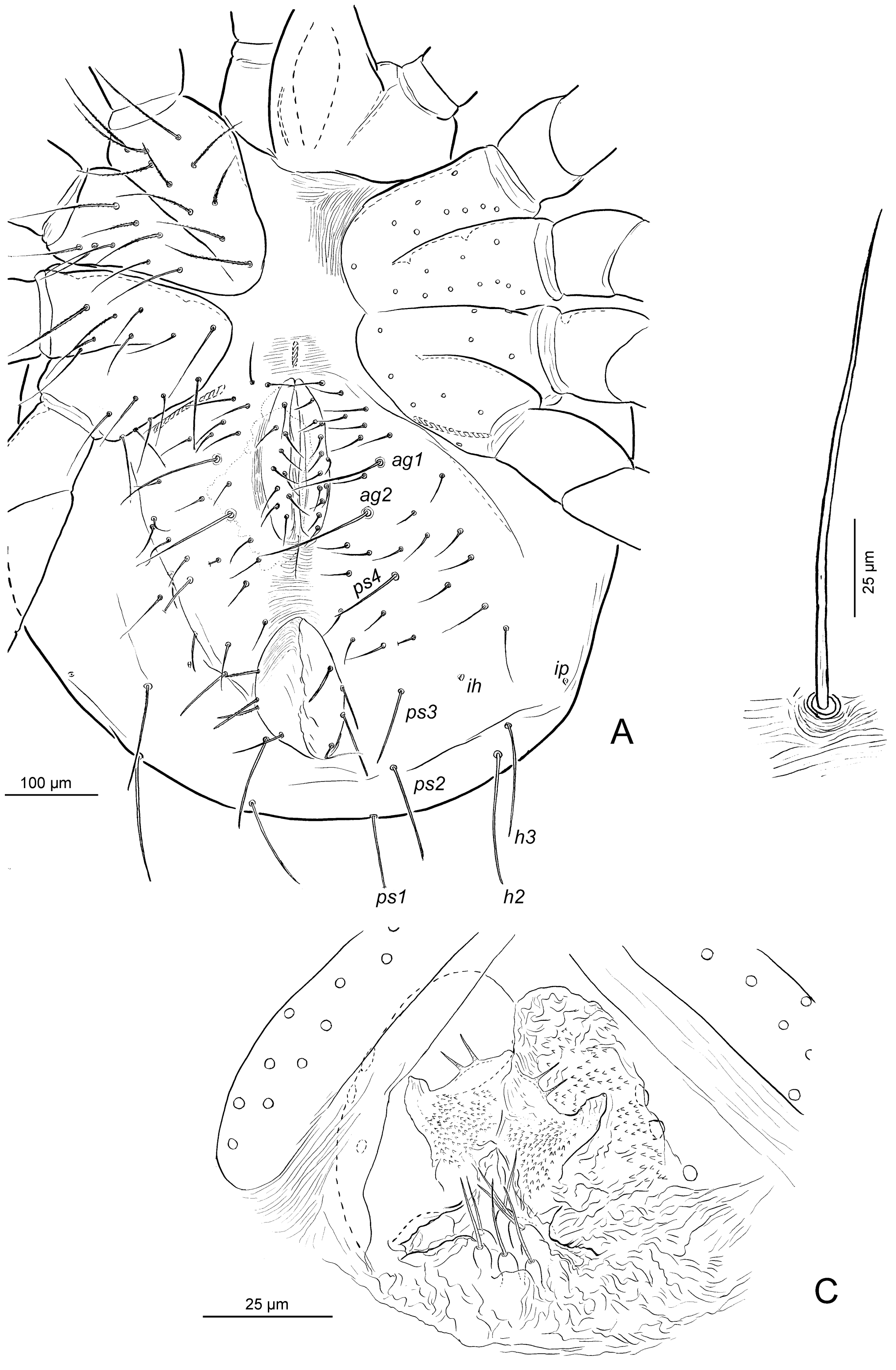

Figure 4. *Walzia chamrasae* n. sp., female, compressed: (A) idiosoma, ventral view, legs omitted, (B) aggenital seta, (C) ovipositor, compressed, ventral view. Scale bars: A 100 µm, B, C 25 µm.

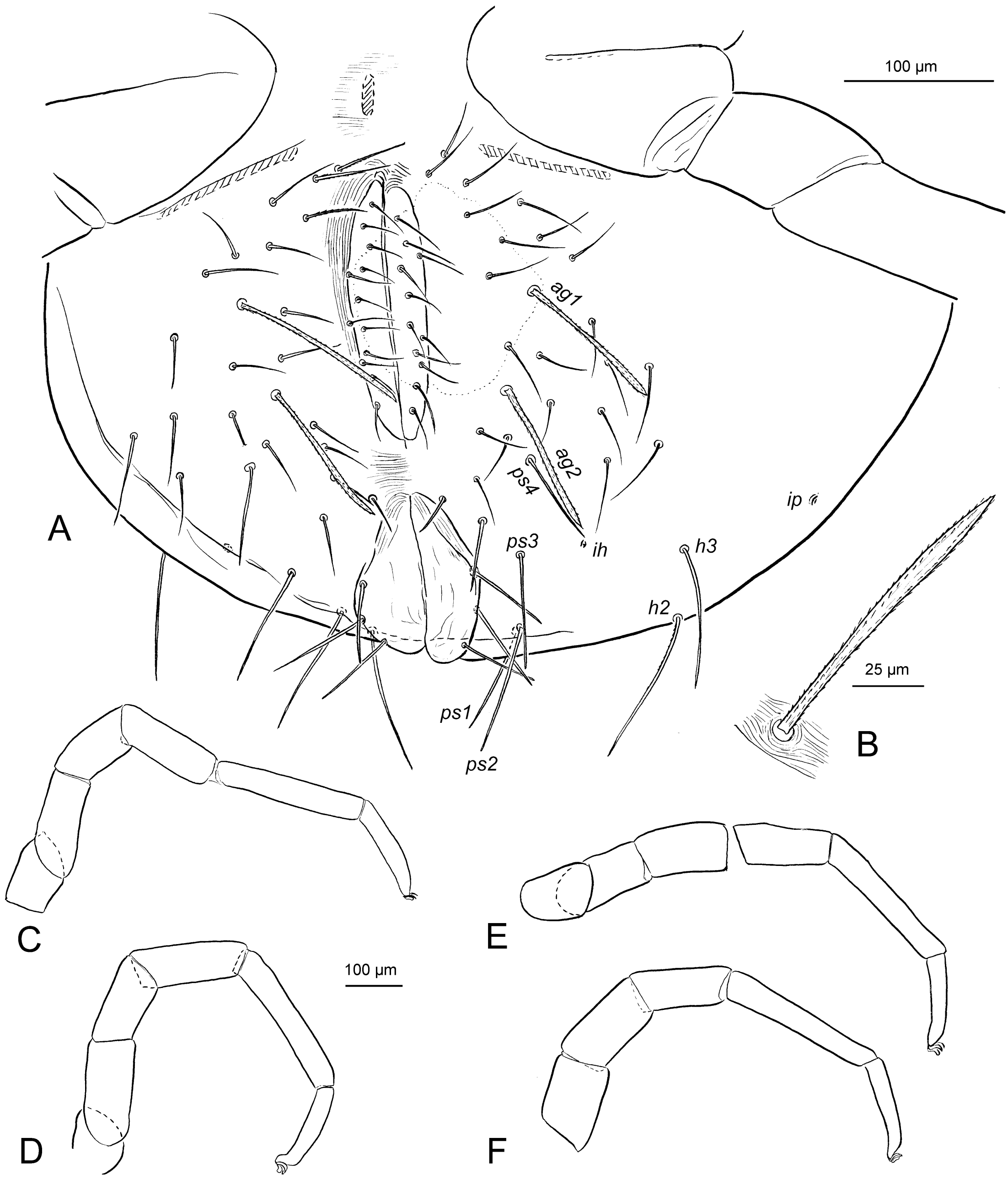

Figure 5. *Walzia chamrasae* n. sp., compressed: (A) male opisthosoma, ventral view, (B) male aggenital seta, (C-F) outlines of legs I – IV respectively. Scale bars: A 100 µm, B 25 µm, C-F (same scale) 100 µm.

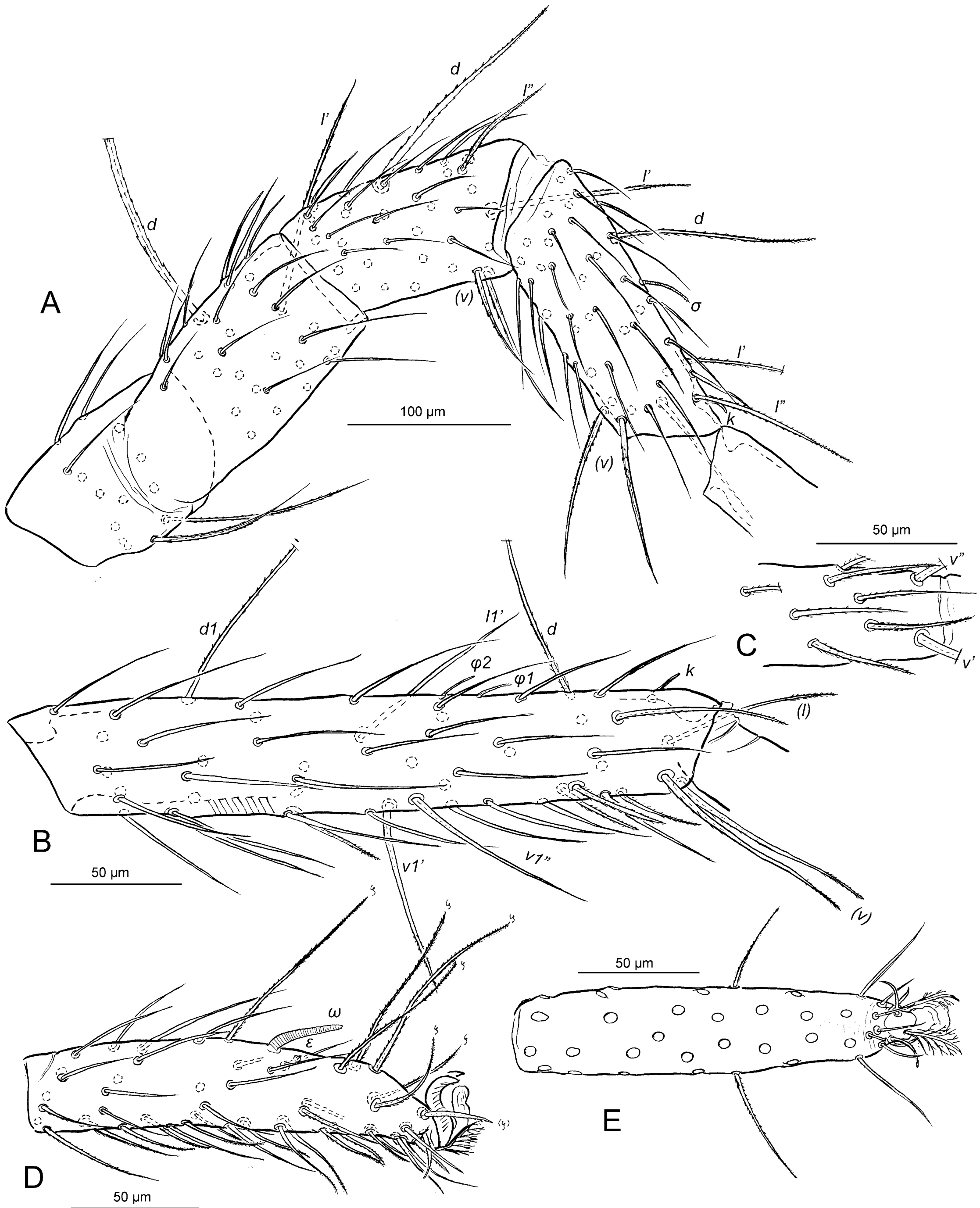

Figure 6. *Walzia chamrasae* n. sp., female, leg I: (A) trochanter to genu, (B) tibia, (C) same, ventral view of distal portion, (D) tarus, lateral view, (E) same, ventral view, most setae drawn by their alveoli. Scale bars: A 100 µm, B-E 50 µm.

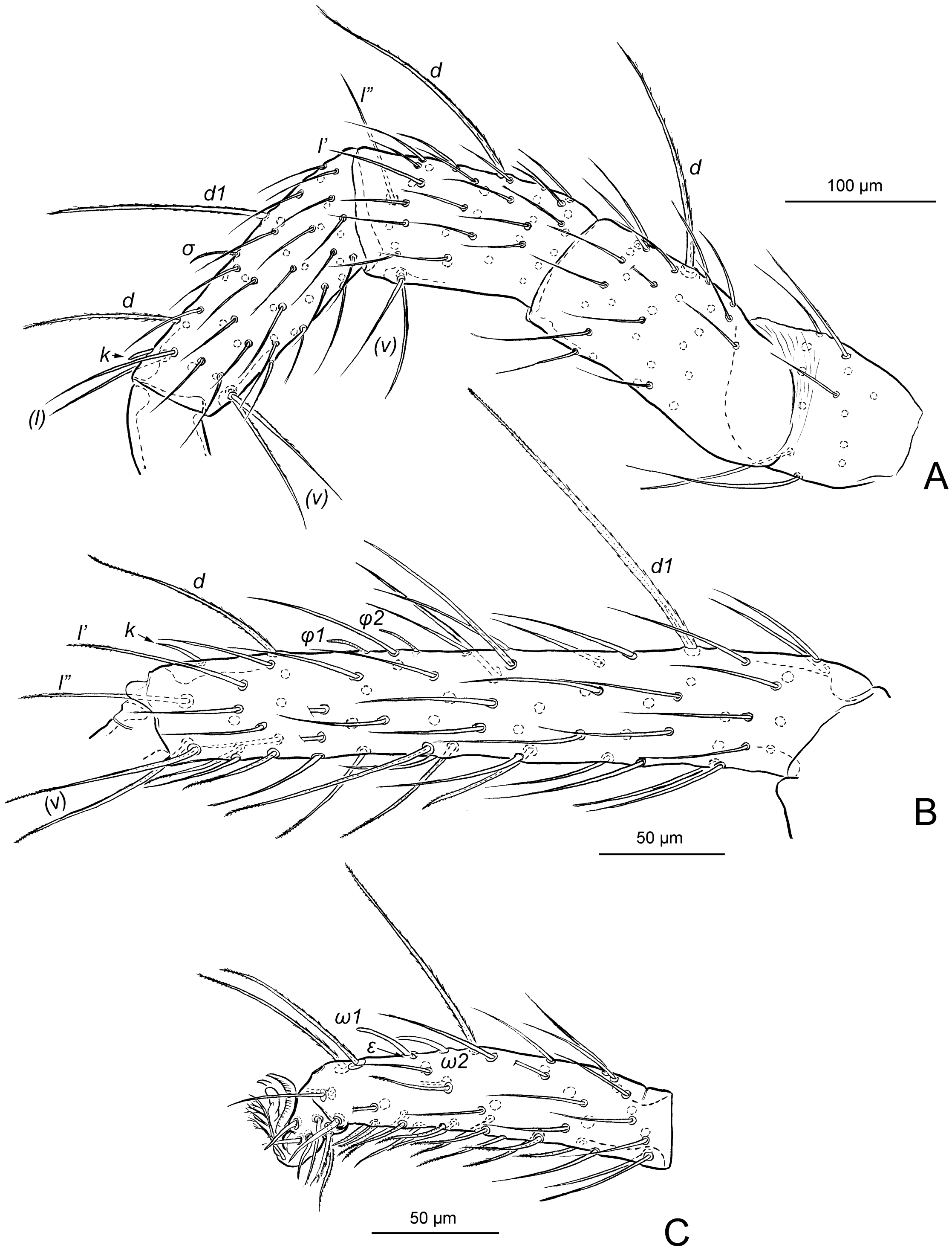

Figure 7. *Walzia chamrasae* n. sp., female, leg II: (A) trochanter to genu, (B) tibia, (C) tarsus, all in lateral view. Scale bars: A 100 µm, B-C 50 µm.

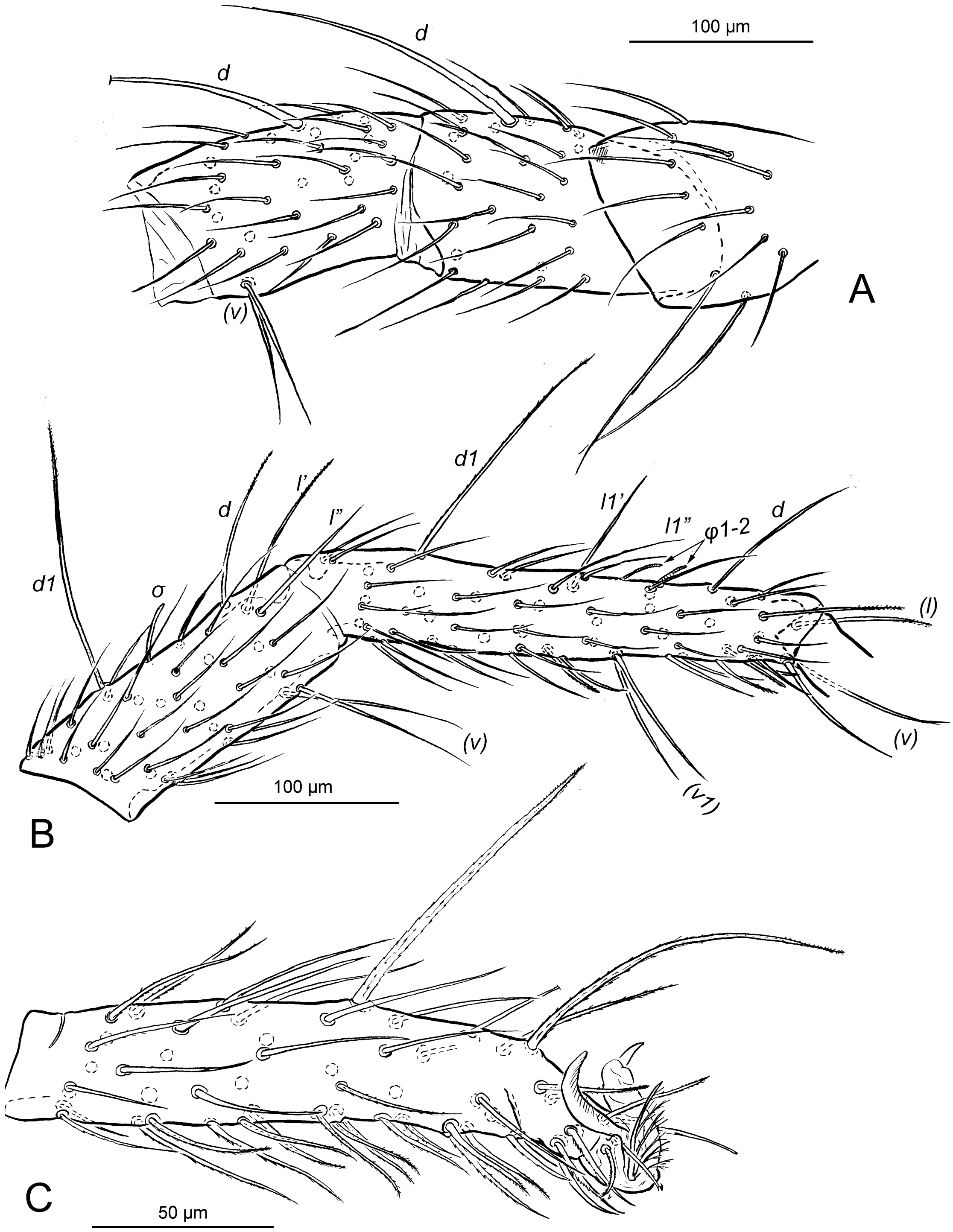

Figure 8. *Walzia chamrasae* n. sp., female, leg III: (A) trochanter to telofemur, (B) genu to tibia, (C) tarsus, all in lateral view. Scale bars: A, B 100 µm, C 50 µm.

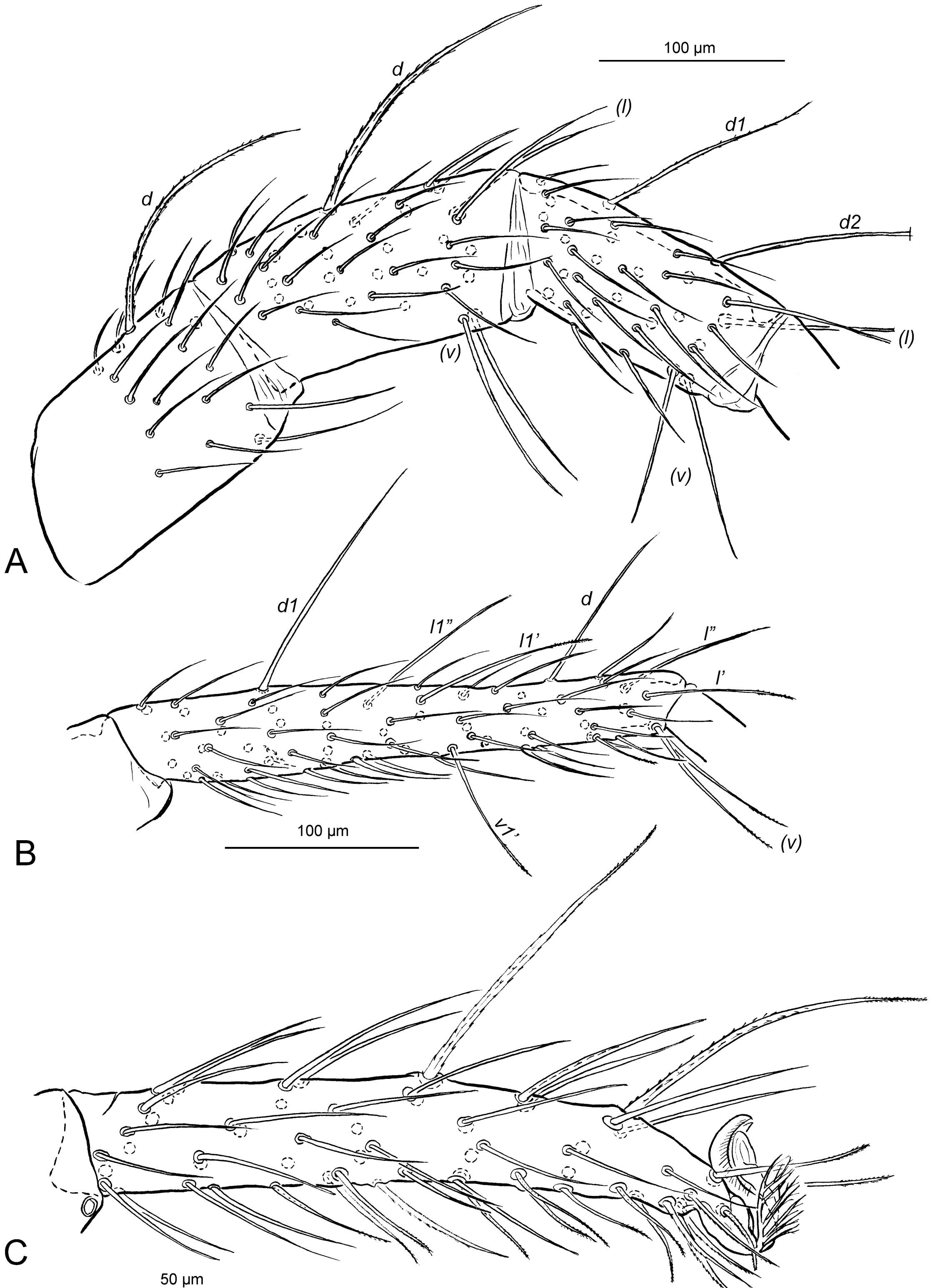

Figure 9. *Walzia chamrasae* n. sp., female, leg IV: (A) basifemur to genu, (B) tibia, (C) tarsus, all in lateral view. Scale bars: A, B 100 µm, C 50 µm.

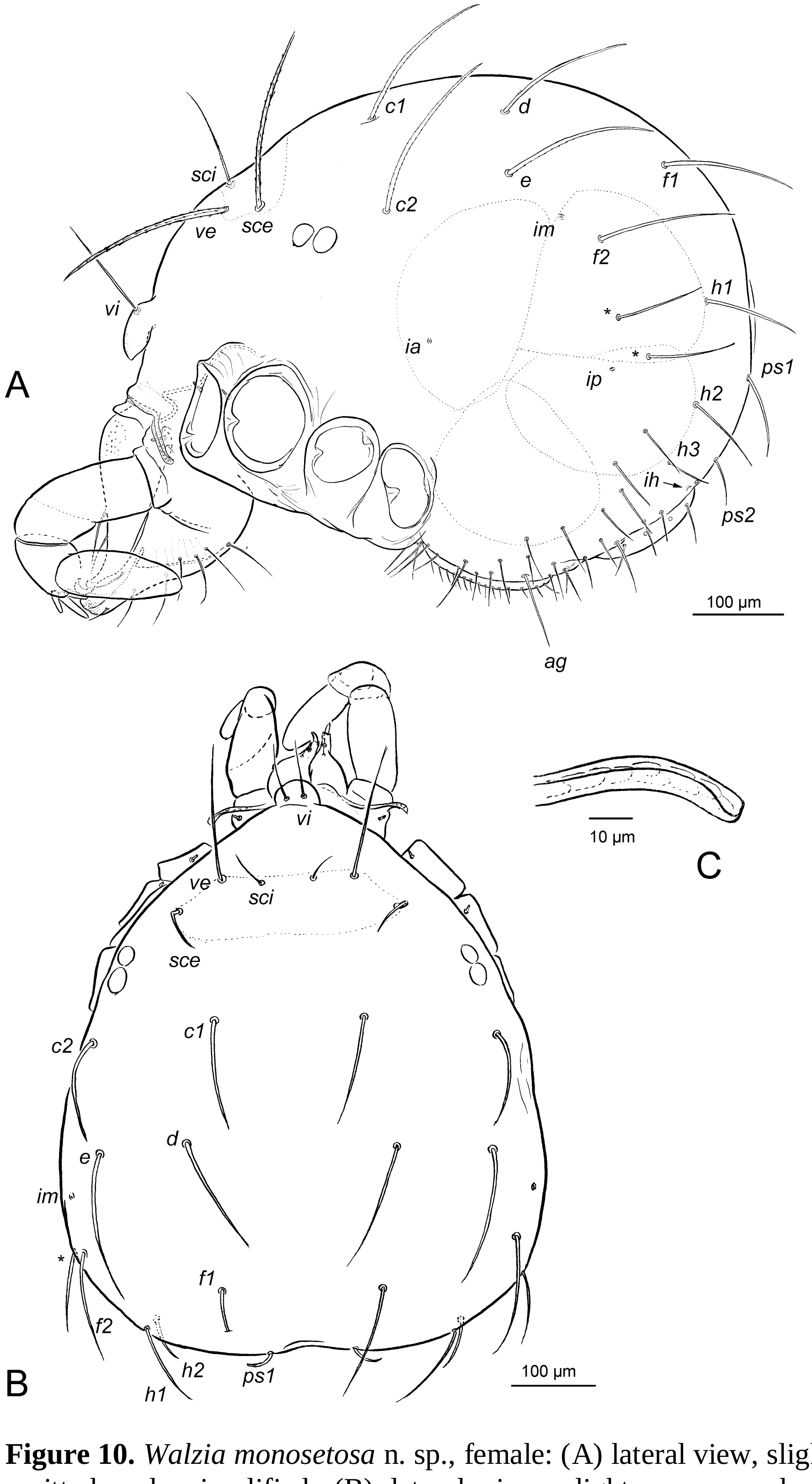

Figure 10. *Walzia monosetosa* n. sp., female: (A) lateral view, slightly distended, legs omitted, palp simplified, (B) lateral view, slight compressed, legs omitted, palp simplified, (C) distal portion of peritreme, dorsal view. Scale bars: A, B 100 µm, C 10 µm.

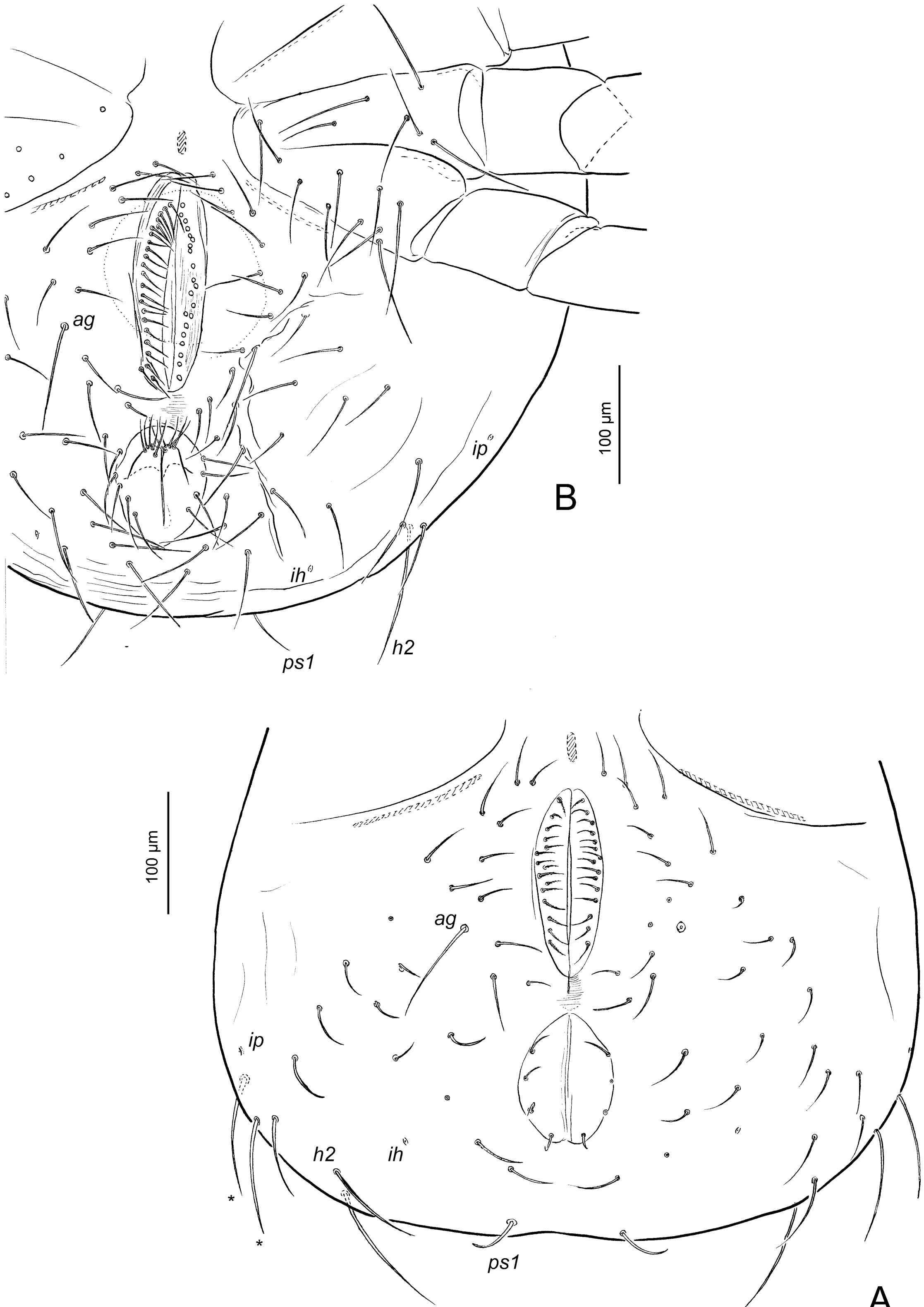

Figure 11. *Walzia monosetosa* n. sp. adults: (A) female opisthosoma, distended, ventral view, (B) male opisthosoma, compressed. Scale bars: A, B 100 µm.

CHAPTER 2B

NEOCAECULUS ORIENTALIS N. SP. (ACARI, TROMBIDIFORMES, CAECULIDAE) FROM THAILAND*

2B-1 Abstract

A new species of the predatory mite family Caeculidae, *N. orientalis* n. sp., is described and illustrated, based on adult and all active immature instars from moss and forest litter of various localities in Thailand. *Neocaeculus orientalis* n. sp. differs from its congeners in uniquely having the adult femur I divided but femora II–IV entire, adult coxal setation of 5-1-2-1 (*4a* excluded), and heterogeneous coxal setae. It is the first *Neocaeculus* species known to have no seta *vi* (= *po*) in all stages. A comparison of the diagnostic characters of known *Neocaeculus* species is given.

2B-2 Introduction

The family Caeculidae is a group of predatory mites characterized by their large (ca. 1000-3000 μm long), heavily sclerotized body with characteristically arranged idiosomal plates and leg I usually equipped with spine-like setae on its anterior face (Walter *et al*. 2009). Due to the latter, they are also called "rake-legged mites". Caeculids are usually found in dry exposed habitats such as beaches, beach vegetation, tree bark, rocky niches in desert and mountain habitats (Coineau 1974a; Walter *et al*. 2009). However, their ambush behavior and camouflage integument may make them hardly noticeable. This family currently comprises about 100 known species, including two species from fossil amber, in seven genera: *Allocaeculus* Franz, *Andocaeculus* Coineau, *Caeculus* Dufour, *Microcaeculus* Franz, *Neocaeculus* Coineau, and *Procaeculus* Jacot (Coineau & Poinar 2001; Taylor *et al*. 2013). A key to genera and a

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* This chapter is a version of a manuscript which has been published as:
Fuangarworn, M. & Butcher, B.A. (2015) *Neocaeculus orientalis* sp. nov. (Acari, Trombidiformes, Caeculidae) from Thailand. *Zootaxa*, 4048, 251–268.

checklist of the world species of Caeculidae were recently provided by Taylor *et al*. (2013).

Coineau (1967) proposed the genus *Neocaeculus* for *N. luxtoni* Coineau, 1967 from New Zealand. Later, Coineau and Enns (1969) described two new species from Australia: *N. knoepffleri* Coineau & Enns, 1969 and *N. bornemisszai* Coineau & Enns, 1969. Coineau (1974a) briefly described one more new species from South Africa: *N. lamorali* Coineau, 1974a, and also assigned the South American species, *N. bruchi* (Berlese, 1916)—from *Caeculus*—to *Neocaeculus*. In the same year, Coineau (1974b) described two new species from Australia: *N. johnstoni* Coineau, 1974b and *N. womersleyi* Coineau, 1974b. Recently, three more new species of *Neocaeculus* were described from this continent by Taylor *et al*. (2013) and Taylor (2014): *N. imperfectus* Taylor *et al.*, 2013, *N. kinnearae* Taylor, 2014 and *N. nudonates* Taylor, 2014. The complete ontogeny of *Neocaeculus* species is known only in *N. luxtoni* and *N. knoepffleri* (Coineau 1967; Coineau & Enns 1969). In this paper, we describe all active instars of the first member of the genus known outside Southern Hemisphere: *N. orientalis* n. sp. from moss and forest soil and litter of various localities in Thailand. This is also the first record of family Caeculidae in Thailand.

2B-3 Materials and methods

Mites were collected by hand or extracted from soil and leaf-litter samples using Tullgren funnels for seven days (Walter & Krantz 2009), and stored in 70% ethanol (see *Material examined* for collection data). The specimens were cleared in 80% lactic acid and incubated at 50 ºC for 24–48 hrs, depending on their sclerotisation and darkness. They were observed in temporary cavity slides using lactic acid as the medium (Coineau 1974a) under a bright-field compound microscope and phase contrast microscope. Drawings were made with the aid of a drawing tube attached to the microscope. An eyepiece micrometer calibrated with a stage micrometer was used for measurements, which are given in micrometers (μm) as the mean followed by range (if relevant) in parentheses. Terminology generally follows that of Coineau (1974a) and Krantz (2009) for general structures; Kethley (1990) for idiosomal chaetotaxy (see his appendixes 1 and 2 for setal equivalents); Coineau (1974a, b) for leg chaetotaxy.

Descriptions of immature instars emphasize characters that differ from adults or change during ontogeny.

2B-4 Taxonomic results

Family Caeculidae Berlese, 1883

Genus *Neocaeculus* Coineau, 1967

***Neocaeculus orientalis* n. sp.**

(Figs 1–11)

Diagnosis. Adult female unique among known *Neocaeculus* in having the following combination of characters: body length 978–1164; seta *vi* absent; trichobothrium *sci* clavate; anterior margin of prodorsal plate strongly downturned but without projection; lateral eye plates separated from prodorsal plate; dorsal plate *P* divided; pleural plates absent; seta *ve* anterior to *sce* and situated far apart from its pair; seta *c1* situated far apart from its pair; unpaired dorsomedian setae present; coxal setation of 5-1-2-1(*4a* excluded); aggenital plates small with one pair of aggenital setae; one pair adanal setae; palp setation (tibial claw excluded) 0-4-4-5(ω); leg femur I divided but femora II–IV entire; and trichobothrium present on tarsi III–IV.

Description. *Female*. Body length (including gnathosoma; n = 5) 1038 (978–1164); body width (greatest width) 683 (638–752). Gnathosoma black in Colour; sclerotized plates on idiosoma usually black, membranous integument pale cream in Colour; legs also black except articulations and tarsi being pale cream in Colour; body and appendages with thick cerotegument.

Gnathosoma. Anterior thirds of gnathosoma visible from above (Figs 1–3). Chelicera typical for family, about 55 wide at base, 210 long (including proximal part of chelicera inserted into body); oriented obliquely about 45° to level of its insertion (Fig. 3A); movable digit hook-like, with minute teeth; cheliceral seta, *cha*, slender, 10–12 long. Palp (Fig. 3B) 4-segmented, trochanter short, without setae; femorogenu with 4 clavate setae; tibia with prominent terminal claw set on projecting tubercle, 2 clavate setae and 2 spiniform setae; tarsus subcylindrical, swollen near middle, with recessed solenidion ω, 2 spiniform setae and 3 eupathidia; supracoxal seta *ep* peg-like.

Subcapitulum posteriorly round, anteriorly subconical, 194 (185–200) wide at level of palp insertion, 192 (175–200) long; with two pairs of slender subcapitular setae: *m*, 46 (40–50) long, *n*, 40(35–50) long, *m* situated anterior to *n*; two pairs of short slender adoral setae, *or1–2*, about 14 long. Lateral lips and labrum typical for family (Coineau 1974a). Peritreme linear, segmented, situated on cheliceral shaft (Fig. 3A, *per*).

*Idiosoma***.** In dorsal view (Fig. 1), broad ovate, 926 (876–1030) long (including naso). Striated integument moderately sclerotized, pattern of striations as illustrated. Nasal plate, subrectangular, 102 (100–110) long, 148 wide, well sclerotized. Prodorsal plate subtrapezoidal, 277 (215–350) long, posterior margin 293 (275–300) wide, anterior margin 153 (140–175) wide; lateral margin of plate concave; surface with shallow depressions and low ridges; in lateral view (Fig. 3A), anterior fourths (ca. from level of *sce* to *ve*) of plate downturned to dorsal profile of nasal plate and chelicerae; anterior margin of plate not projected but slightly overhanging posterior margin of nasal plate. All normal prodorsal setae clavate, slightly flattened and barbed; seta *vi* absent, trichobothrium *sci* clavate, 107 (90–120) long, bothridial opening elevated and situated at posterior corner of nasal plate; seta *ve*, 59 (50–65) long, on anterior corner of prodorsal plate; seta *sce*, 34 (30–35) long, located 74 (60–100) posteriad *ve*; distance from *sci–sci* 122 (105–130), *ve–ve* 108 (100–125), *sce–sce* 137 (100–180); a pair of neotrichous setae (Fig. 1, asterisked) present, 41 (35–45) long, near posterior margin of plate. Lateral eye plates separated from prodorsal plate; anterior pair of lateral eyes 40 (35–45) diameter, posterior pair 33 (33–35) diameter; unpaired median eye, under naso, 26 (25–30) diameter.

Opisthosoma with seven dorsal plates: unpaired dorsal plate (D), subrectangular, 285 (260–315) long, 273 (250–290) wide, with incision on lateral margin; paired lateral plates (L), obliquely flanking plate D, elongate and subrectangular, 350 (300–400) long, 108 (75–150) wide; paired median plates (M) subrectangular, 63 (50–75) long, 175 (150–210) wide; and smaller paired posterior plates (P), 47 (35–50) long, 134 (115–150) wide. All dorsal opisthosomal setae clavate, slightly flattened and barbed; setae *c1, d1, e1* on plate D; setae *c2, d2, e2* on plate L; setae *f1* and *f2* on plate M; setae *h1* and one lateral seta on plate P; seta *h2* located on striated cuticle below plate P; three unpaired median setae present (Fig. 1, asterisked) between *f1–f1*, *h1–h1*, and *h2–h2*, respectively; measurements: *c1* 50(45–55), *c2*

56(40–75), *d1* 54(45–60), *d2* 51 (35–75), *e1* 70(55–85), *e2* 57(40–75), *f1* 59(50–70), *f2* 60(40–80), *h1* 53(45–70), *h2* 48(40–60), *ps1* 36(25–40), *ps2* 40(35–45), *ps3* 40(35–45). Lyrifissures normal (Fig. 1): *ia* and *im* on plate L, *ip* lateral to plate M, *ih* on ventral side.

In ventral view (Fig. 2), membranous integument striate with pattern as illustrated; coxal plates I–IV normally radial arranged; distal end of coxa I well projected dorsally such that insertion of leg I situated above that of leg II (Fig. 3A). Coxal setation (I–IV): 5-1-2-1(*4a* excluded); coxal setae clavate of various length, most setae relatively short but *1c*, *1d*, *1e* much elongate and situated on tubercle which increasing in size from *1c* to *1e*; broad tubercle (*tb*) present between base of seta *1e* and insertion of leg I; *4a* situated on membranous integument; supracoxal seta *eI* peg-like; measurements of coxal setae: *1a* 26(20–35), *1b* 50(45–60), *1c* 117(100–140), *1d* 148(130–165), *1e* 154(125–175), *2a* 37(35–40), *3a* 45(35–65), *3b* 36(35–40), *4a* 34(30–40), *4b* 29(20–35). Genital opening (Figs 2, 4A) 155(125–175) long, genital plate 42(25–50) wide, usually with 6 pairs of genital setae (*g1–6*; 5–7 setae may be asymmetrically present), short, slender, about 15–20 long, and arranged in longitudinal row. Aggenital plate small, 95(75–100) long, 25 wide, anterolateral to genital plate, with 1 pair of clavate setae (*ag*). Anal opening 144(125–160) long; adanal plate 46(40–50) wide, 1 pair of adanal setae (*ad*) present, clavate, 22(15–30) long. Pseudoanal plate 145(125–175) long, 31(25–40) wide, with 3 pairs of clavate setae (*ps1–3*); with 11 pairs of setae on membranous integument (*4a* excluded). Three pairs of genital papillae (*Va*, *Vm*, *Vp*) present, diameter about 15; *Vm* closer to *Vp* than *Va*; associated setae *k* absent. Ovipositor (Fig. 4A) roughly plicated; relatively short when protruded, about 95 long; distally with 3 pairs of minute eugenital setae: 2 anterior pairs, and 1 posterior pair on short lobe.

Legs. Measurements (from trochanter to tarsus, pretarsus excluded): leg I 1205(1030–1339), leg II 803(773–855), leg III 754(670–906), leg IV 848(773–948); femur I divided, but femora II–IV entire (Figs 5–6); trichobothrium present on tarsi III–IV; claws on leg I–IV typical for genus; Chaetotaxy of legs I–IV (famuli *k* and *ε* included, solenidia in parenthesis): trochanters 6-8-3-4; [basi+telo]femora [8+7]-15-10-10; genua 19-17-10-9; tibiae 22(1)-21(1)-15(1)-16(1); tarsi 28(1)-27/25(1)-17-17; on tarsus II, *v1''*, *v2'* absent in one specimen. Solenidion *ω* on tarsi I–II, *φ* on tibia I–

IV, seta *k* on tibia I and seta *ε* on tarsi I–II recessed; trichobothrium *bt* on tarsi III–IV slightly dilate and barbed; following setae on leg I hypertrophied, spine-like: trochanter, *l'*, *l1'*; femur, *v'*, *v1'*, *v1"*; genu, *v'*, *v1'*, *v"*; and tibia, *v'*, *v"*, *v1'*, *v1"*. Homology of leg setae and solenidia depicted in Figs 5–6.

Male. Body length (including gnathosoma, *n*=2) 916(783–1050); body width 670(577–762); generally similar to female, except aggenital setae more slender (Fig. 9D) and genitalia present (Fig. 4B). Genitalia outline with 2 pairs of lateral wing-like extensions; 2 pairs of densely denticulated lobes in middle region; 8 pairs of eugenital setae: setae *1*, *2* and *4* large, spine-like and slightly curved, seta *8* spine-like but smaller, setae *3*, *5*, *6* and *7* minute, distributed as illustrated.

Ontogeny. Larva (*n*=5): body length 350(325–390), width 270(260–290); protonymph (*n*=2): 450, 338(335–340); deutonymph (*n*=3): 573(515–608), 415(381–433); tritonymph (*n*=2) 773, 540(515–567).

Gnathosoma. similar to female, except lateral lips with 1 pair of adoral setae (*or1*) in larva, 2 pairs in protonymph (*or2* added); palp femorogenu with 2 setae (*dF*, *dG*) in larva (Fig. 7F) and protonymph, 3 in deutonymph (*d1* added) and tritonymph, and 4 in adult (*d2* added); palp tibia with 3 setae in larva and protonymph (*1"*, *1'*, *v'*; tibial claw, *d*, excluded), 4 in deutonymph (*d1* added) and later instars; palp tarsus similar to adult, except *1"* becoming eupathidial in adult (Fig. 3B)

Idiosoma. Nasal plate subtriangular in larva (Fig. 7A) but anterior margin broader in succeeding instars. Prodorsal plate with 2 pairs of setae (*ve* and *sce*) in larva, seta *ve* short spiniform; 3 pairs in protonymph (a pair of clavate setae added near posterior margin of plate; Fig. 8A, asterisked), *ve* becoming clavate. Opisthosoma with 3 dorsal plates (unpaired plate D and a pair of plate L) in larva; plate M form in deutonymph (Fig. 9A), plate P form in tritonymph. Larva with 7 pairs of opisthosomal setae (*c1*, *c2*, *d1*, *e1*, *f1*, *h1*, *h2*; *h2* on ventral side), pseudoanal seta *ps* or its vestige absent from pseudoanal valves; protonymph with 12 pairs and 1 unpaired median seta (*d2*, *e2*, unpaired median seta between setae *h2*, and *ps1–3* added); adanal seta *ad* or its vestige absent from adanal plate; deutonymph with 14 pairs and 2 unpaired setae (*f2*, unpaired median seta between setae *f1*, and 1 pair of setae lateral to *h1* added), a pair of vestige of *ad* present on adanal plate; tritonymph similar to deutonymph in numbers of dorsal opisthosomal setae, but *ad* becoming thickened spiniform or clavate; adult with 14 pairs and 3 unpaired setae (unpaired median seta between setae *h1* added). Seta *c2* relatively longer than other setae in larva but gradually shortened in succeeding instars until subequal to other setae in adult.

Coxal setation 2-0-1 in larva (Fig. 7B); Claparede's organs typical; 3-1-2-2(*4a* included) in protonymph (Fig. 8B; *1c*, *3b*, *4a*, *4b* added; *4a* located on membranous integument); 5-1-2-2 in later instars (Fig. 9B–C; *1d*, *1e* added in deutonymph). Genital opening absent in larva, present since protonymph, with normal development of genital papillae: 1, 2, 3 pairs from protonymph to tritonymph, respectively; development of genital setae from protonymph to adult: 1-1-4-6; aggenital setae could not determined, obscured by neotrichous setae in para- and pro-genital region (Figs 8B, 9B–C), pool numbers of these setae, deutonymph to adult, 3-6-11.

Legs. Leg form generally similar to adult but femur I entire in larva (Fig. 7C–E), proto- and deutonymph; faintly divided in tritonymph, and completely divided in adult. Solenidion present each on larval tibiae I–IV (φ) and tarsi I–II (ω) and constant throughout ontogeny; development of leg setae as follows.

—Trochanters: larva, 0-0-0; protonymph 3(*l′*, *v′*, *l″* added)-3(*d*, *l′*, *v′* added)-1(*d* added)-0; deutonymph 4(*v″* added)-4 (*v″* added)-1-1(*d* added); tritonymph 6(*l1′*, *l1″* added)-6(*l″*, *v1′* added)-2(*l″* added)-3(*l″*, *l1″* added); adult 6-8(*d1*, *l1′* added)-3(*v′* added)-4(*v′* added).

—Femora: larva 6(*d*, *l′*, *l″*, *v′*, *v″*, *v1″*)-4(*d*, *l′*, *l″*, *v′*)-4(*d*, *l′*, *l″*, v′); protonymph 7(*d1* added)-5(*d1* added)-4-1(*d*); deutonymph 10(*d2*, *v1″*, *v2″* added; *l″* becoming eupathidial)-6(*v″* added; *l″* becoming eupathidial)-4-4(*l′*, *l″*, *v′* added); tritonymph 12(*l1′*, *l1″*; *l′* becoming eupathidial)-11(*d2*, *d3*, *l1′*, *v1′*, *l1″* added)-7(*d2*, *l1″*, *v″*)-6(*d1*, *v″* added); adult 15(*d3*, *l2′ζ*, *l2″ζ* added)-15(*l2′ζ*, *l2″ζ*, *v1″*, *v2″* added; *l′* becoming eupathidial)-10(*l1′*, *v1′*, *v1″* added; *l′*, *l″* becoming eupathidial)-10(*l1′*, *v1′*, *l1″*, *v1″* added; *l′* becoming eupathidial).

—Genua: larva 6(*d*, *d1*, *l′*, *l″*, *v′*, *v″*)-6(*d*, *d1*, *l′*, *l″*, *v′*, *v″*)-5(*d*, *l′*, *l″*, *v′*, *v″*); protonymph 9(*l1′*, *l1″*, *v1′* added)-8(*l1′*, *l1″* added)-5-5(*d*, *l′*, *l″*, *v′*, *v″*); deutonymph 13(*d2*, *l2′*, *v1″*, *v2″* added; *l″* becoming eupathidial, *v1″* unusually distal to *v″*)-11(*d2*, *l2′*, *l2″* added; *l″* becoming eupathidial)-5-5; tritonymph 17(*d3*, *l3′*, *l2″*, *v2′* added; *l′* becoming eupathidial)-14(*d3*, *l3′*, *v1′* added; *l1″* becoming eupathidial)-7(*l1′*, *v1′* added; *l″* becoming eupathidial)-5; adult 19(*l4′*, *l3″* added; *l2″* becoming eupathidial)-17(*l3″*, *v1"*, *v2'* added; *l2'* becoming eupathidial)-10(*l1"*, *l2"*, *v1"* added; *l'* becoming eupathidial)-9(*l1'*, *v1'*, *l1"*, *v1"* added; *l'* , *l"* becoming eupathidial).

—Tibiae: larva 10(*d*, *k*, *l'*, *l"*, *v'*, *v"*, *l1'*, *l1"*, *v1'*, *v1"*)-8(*d*, *l'*, *l"*, *v'*, *v"*, *l1'*, *l1"*, *v1'*)-6(*d*, *l'*, *l"*, *v'*, *v"*, *v1'*); protonymph 11(*v2'* added)-8-6-6(*d*, *l'*, *l"*, *v'*, *v"*, *v1'*); deutonymph 15(*d1*, *l2'*, *l2"*, *v2"* added)-13(*d1*, *l2'*, *v2'*, *l2"*, *v1"* added; *l"* becoming eupathidial)-10(*l1'*, *l1"*, *v2'*, *v1"* added)-8(*v1"*, *v2"* added); tritonymph 20(*d2*, *l3'*, *v3'*, *l3"*, *v3"* added)-16(*d2*, *l3'*, *l3"* added)-12(*l2'*, *v2"* added; *l"* becoming eupathidial)-13(*l1'*, *v2'*, *v3'*, *l1"*, *l2"* added); adult 22(*l4'*, *l4"* added; *l3"* becoming eupathidial)-21(*d3*, *l4'*, *l4"*, *v3'*, *v2"* added; *l2"*, *l3"* becoming eupathidial)-15(*l3'*, *v3'*, *l2"* added; *l1"ζ* becoming eupathidial or not)-16(*l2'*, *v4'*, *v3"* added; *l"* becoming eupathidial).

—Tarsi (Figs 7C–E, 8C, 10–11): larva 15(*l'*, *l"*, *p'ζ*, *p"ζ*, *v'*, *v"*, *l1'*, *l1"*, *v1'*, *v1"*, *l2'*, *l2"*, *v2'*, *v2"*, *ε*)-13(*l'*, *l"*, *p"ζ*, *v'*, *v"*, *l1'*, *l1"*, *v1'*, *v1"*, *l2'*, *l2"*, *v2'*, *ε*)-8(*l'*, *bt*(=*l"*), *v'*, *v"*, *l1'*, *l1"*, *v1'*, *v1"*); protonymph 15-13-8-7(*bt*(=*l"*), *v'*, *v"*, *l1'*, *l1"*, *v1'*, *v1"*); deutonymph 21(*er'*, *er"*, *v3'*, *v3"*, *l3'*, *l3"* added; *l"* becoming eupathidial)-18(*v2"*, *l3'*, *l3"*,*v3'*, *l4'* added; *l'*, *l"* becoming eupathidial)-12(*er"*, *l2'*, *v2'*, *v2"* added)-11(*er'*, *er"*, *v2'*, *v2"* added); tritonymph 24(*l4'*, *l4"*, *v4"* added; *l'*, *l1"* becoming eupathidial, *v1'*, *v1"* becoming so or not)-22(*er'*, *er"*, *v3"*, *l4"* added; *l1"* becoming eupathidial)-15(*er'*, *l2"*, *v3"* added)-14(*l2'*, *l2"*, *v3'* added); adult 28(*l5'*, *l5"*, *v4'*, *v5'* added; *l1'* becoming eupathidial, *l4"* becoming so or not)-27(*v4'*, *v4"*, *l5'*, *l5"*, *v5'* added; *l1'*, *l4"* becoming eupathidial, *v1'* becoming so or not)-17(*v3'*, *v4'* added; *l'* becoming eupathidial)-17(*v3"*, *v4'*, *v4"* added; *er'* becoming eupathidial).

Material examined. Holotype (female): THAILAND, Nan Prov., Wiang Sa Dist., Lai Nan Sub-dist (18°33'29.81"N, 100°47'48.67"E), 20 Mar 2012, col. M. Fuangarworn, ex moss on barks, 1 foot above ground. 20 paratypes (5 adults, 3 tritonymphs, 10 deutonymphs, 2 protonymphs) with same data as holotype. Other studied materials: One adult, Ayutthaya Prov., Tharua Dist., Salaloy Sub-dist. (14°31'75"N, 100°42'26"E), 23 Mar 2003, col. M. Fuangarworn, ex litter under *Senna siamea* (Lam.), field no. MF2003-29. One adult, Samut Songkram Prov., Bang Khan Taek Sub-dist. (13°22'55"N, 99°59'40"E), 25 Mar 2003, col. M. Fuangarworn, ex tamarind litter, field no. MF2003-41. One adult, 2 deutonymphs, Nakon Nayok Prov., Sarika Sub-dist. (14°18'05"N, 101°18'17"E), 7 Apr 2003, col. M. Fuangarworn, ex leaf litter in IPM pomelo orchard, field no. MF2003-66. Thirty adults, 5 tritonymphs, Nan

Prov., Sri Nan National Park, 4 May 2006, col. Naratip Chantarasawat, ex forest litter. One adult, 1 tritonymph, 1 deutonymph, Tak Prov., Sam Ngao Dist., Bhumipol Dam (17°14'46.35"N, 98°59'46.21"E), 2 Mar 2008, col. M. Fuangarworn, ex litter and soil, field no. MF2008-6. One adult, Chonburi Prov., Sattahip Dist., Kho Chuang, 19 Mar 2011, col. M. Fuangarworn, ex forest litter, field no. MF2011-44. Five adults, 1 tritonymph, 1 protonymph, Prachuap Khiri Khan Prov., Kho Thalu (11°4'14.40"N, 99°33'12.73"E), 14 Mar 2011, col. M. Fuangarworn, ex dry litter and topsoil under cliff, field no. MF2011-28. Three adults, 3 tritonymphs, Saraburi Prov., Kaengkoi Dist., Chulalongkorn University Forest Reserve (14°31'33.78"N, 101°1'40.51"E), 3 Mar 2012, col. M. Fuangarworn, ex forest floor, hand collected. One adult, Krabi Prov., Mo Koh Lanta National Park, Koh Rok Nai (7°13'29.78"N, 99°4'13.48"E), 3 May 2013, col. M. Fuangarworn, ex root and rhizome of ferns on trunk, 1 foot above ground, field no. MF2013-16. Three adults, Chaiyaphum Prov., Nong Bua Daeng Dist., Wat Pah Koeng (16°0'18.78"N, 101°53'33.49"E), 9 Jun 2013, col. M. Fuangarworn, ex bamboo litter, hand collected, field no. MF2013-33. One protonymph, 1 larva, Mae Hong Son Prov., Mae Sariang Dist., ca. 30 km to Ban Sam Laeb (Rd. no. 1194), 14 Dec 2013, col. M. Fuangarworn, ex debris in fern basket at 1 m above ground, field no. MF2013-57-58. Nine adults, Kanchanaburi Prov., Sai Yok Dist., Ban Wang Khamen, Plant Genetic Conservation Forest Reserve, near Manao Pee Cave, 22 Apr 2014, col. M. Fuangarworn, ex forest floor (hand collected), field no. MF2014-22. Thirty adults, 5 tritonymphs, Kanchanaburi Prov., Sai Yok Dist., Ban Wang Khamen (14°12'3.28"N, 98°57'24.01"E), 22 Apr 2014, col. M. Fuangarworn, ex litter and soil, field no. MF2014-23. Ten adults, 30 larvae, Ranong Prov., Ngaw Sub-dist., Ngaw Waterfall (9°51'17.27"N, 98°37'42.04"E), 24 Mar 2014, col. M. Fuangarworn, ex moss growing at base of a tree, field no. MF2014-53. Holotype and most paratypes deposited in the Acarology Collection at the Chulalongkorn University Museum of Natural History, Bangkok, Thailand. One female paratype will be deposited in the Acarology Collection at the Ohio State University, Columbus, USA.

Etymology. The specific epithet of the new species 'orientalis' refers to its occurrence in the Oriental region. This species is widely distributed in Thailand and may be wider within the SE Asian mainland.

Distribution. Thailand (provincial records: Ayutthaya, Chaiyaphum, Chonburi, Kanchanaburi, Krabi, Mae Hong Son, Nakon Nayok, Nan, Prachuap Khiri Khan, Ranong, Samut Songkram, Saraburi, and Tak).

2B-4 Discussion

Neocaeculus orientalis **n. sp.** is similar to *N. nudonates* Taylor, 2014 from Australia in having the trichobothrium *sci* clavate-capitate and the dorsal plate P divided. However, the new species may be distinguished from the latter by having the idiosoma rather broadly ovate (vs. narrower); the anterior margin of the prodorsal shield downturned and not projected (vs. not downturned but projected anteriorly); coxal setation of 5-1-2-1 (vs. 4-1-1-1; *4a* excluded); adanal setae present (vs. absent); and leg femur I divided (vs. entire). Comparisons of selected morphological characters of *Neocaeculus* species are presented in Table 1.

Ontogenetically, the idiosoma of the new species differs from that of *N. luxtoni* Coineau, 1967, the type species, in a) having reduced seta *ve* (as small spiniform setae) in larva (Fig. 7A) but becoming clavate since protonymph; b) having relatively longer seta *c2* but gradually shortened in succeeding instars; c) lacking of vestiges of pseudoanal setae on pseudoanal valves (segment *PS*) in larva; d) lacking of vestiges of adanal setae on paraproctal valves (segment *AD*) in protonymph but present in deutonymph and becoming clavate since tritonymph; e) seta *e2* present since protonymph; and f) having setation of genital setae (protonymph to adult) of 1-1-4-6 while *N. luxtoni* Coineau, 1967 has a) normal clavate seta *ve* since larva; b) seta *c2* subequal to other dorsal setae throughout the developmental stages; c) vestiges of pseudoanal setae on pseudoanal valves (segment *PS*) in larva; d) vestiges of adanal setae on paraproctal valves (segment *AD*) in protonymph and becoming clavate since deutonymph; e) seta *e2* present since deutonymph; and f) the setation of genital setae of 1-1-3-6.

Thailand is situated in the tropical monsoon climate zone, having alternating dry and wet periods, which seems to be unfavorable for caeculid mites—they are usually reported from dry and exposed habitats (Walter *et al*. 2009). Thus, it is not surprising that, despite a reasonably large number of collections from various localities, Thailand has only this new species of Caeculidae recorded so far. However, it is worth noting that this species seems well adapted to the environments in this biogeographic region. As shown above, this species has a nationwide (but disjunct) distribution, and can be found in litter and surface soils, moss on logs and tree bases, or basket ferns near ground level in forest habitats with a relatively closed canopy (evergreen and deciduous forests) as well as in scrub and plantations in rural areas. This species is abundant during the dry season, from about February to May (pers. obs.).

Table 1. Comparison of selected morphological traits of nine species of *Neocaeculus*; data taken from original descriptions of adults; – no information available; *N. lamorali* Coineau, 1974a and *N. bruchi* (Berlese, 1916) excluded as their original descriptions lack most o comparable information.

	1) *N. bornemisszai* Coineau & Enns, 1969	2) *N. imperfectus* Taylor *et al.* 2013	3) *N. johnstoni* Coineau, 1974b
Total length	1120 µm	885–1147 µm	1410 µm
Seta *vi* (= *po*)	present	–	present
Trichobothrium *sci*	dilate	capitate	dilate
Anterior margin of prodorsal plate and position of setae *ve* (= *pa*)	slightly downturned and projected forward; *ve* situated anterior to *sce* and close to its pair	slightly downturned and projected forward; *ve* situated anterior to *sce* and far apart from its pair	not downturned, only slightly projected forward; *ve* near level of *sce* and far apart from its pair
Lateral eye plates	fused with prodorsal plate	separated from prodorsal plate	fused with prodorsal plate
Paired plate P	fused	fused	fused
Pleural plates	absent	absent	absent
Seta *c1*	situated far apart from its pair	situated far apart from its pair	close to its pair
Unpaired seta in row *f* (=*ds*)	absent	absent	present
Unpaired seta in row *h* (=*es*)	present	absent	present
Coxal setation (*4a* excluded)	6-2-1-1	4-1-1-1	7-1-2-2
Setae on aggenital plates	four or five pairs	one pair	three pairs
Adanal setae	one pair	one pair	one pair
Palp setation (tibial claw excluded)	–	0-3-5-7(ω)	0-5-4-7(ω)
Leg femora	I–IV entire	I–IV entire	I–II divided, III–IV entire
Trichobothrium on tarsi III–IV	present	present	absent

...continued on the next page.

Table 1. continued.

	4) *N. kinnearae* Taylor, 2014	5) *N. knoepffleri* Coineau & Enns, 1969	6) *N. luxtoni* Coineau, 1967
Total length	1130–1179 µm	1320–1170 µm	1460–1130 µm
Seta *vi* (= *po*)	–	present	present
Trichobothrium *sci*	dilate	dilate	capitate
Anterior margin of prodorsal plate and position of setae *ve* (= *pa*)	slightly downturned and projected forward; *ve* situated anterior to *sce* and close to its pair	strongly downturned and projected downward; *ve* situated anterior to *sce* and close to its pair	strongly downturned and projected downward; *ve* situated anterior to *sce* and far apart from its pair
Lateral eye plates	fused with prodorsal plate	fused with prodorsal plate	separated from prodorsal plate
Paired plate P	fused	fused	fused
Pleural plates	absent	present	absent
Seta *c1*	situated far apart from its pair	situated far apart from its pair	situated far apart from its pair
Unpaired seta in row *f* (=*ds*)	absent	absent	present
Unpaired seta in row *h* (=*es*)	present	present	present
Coxal setation (*4a* excluded)	6-1-1-1	6-2-1-1	3-1-1-1
Setae on aggenital plates	four pairs	five pairs	two pairs
Adanal setae	one pair	one pair	one pair
Palp setation (tibial claw excluded)	0-4-3-8(ω)	0-5-4-9(ω)	0-3-4-7(ω)
Leg femora	I–IV entire	I–IV entire	I–IV entire
Trichobothrium on tarsi III–IV	present	present	present

…continued on the next page.

Table 1. continued.

	7) *N. nudonates* Taylor, 2014	8) *N. orientalis* **n. sp.**	9) *N. womersleyi* Coineau 1974b
Total length	608–667 µm	978–1164 µm	1250 µm
Seta *vi* (= *po*)	–	absent	present
Trichobothrium *sci*	capitate	clavate	dilate
Anterior margin of prodorsal plate and position of setae *ve* (= *pa*)	not downturned, but projected forward; *ve* anterior to *sce* and far apart from its pair	strongly downturned, without projection; *ve* anterior to *sce* and far apart from its pair	not downturned, only slightly projected forward; *ve* near level of *sce* and far apart from its pair
Lateral eye plates	separated from prodorsal plate	separated from prodorsal plate	fused with prodorsal plate
Paired plate P	separated	separated	fused
Pleural plates	absent	absent	absent
Seta *c1*	situated far apart from its pair	situated far apart from its pair	close to its pair
Unpaired seta in row *f* (=*ds*)	present	present	present
Unpaired seta in row *h* (=*es*)	absent	present	present
Coxal setation (*4a* excluded)	4-1-1-1	5-1-2-1	7/6-1-2-2/3
Setae on aggenital plates	four pairs	one pair	six or seven pairs
Adanal setae	absent	one pair	one pair
Palp setation (tibial claw excluded)	0-3-4-5(ω)	0-4-4-5(ω)	0-4-4-7(ω)
Leg femora	I–IV entire	I divided, II–IV entire	I–II divided, III–IV entire
Trichobothrium on tarsi III–IV	present	present	present

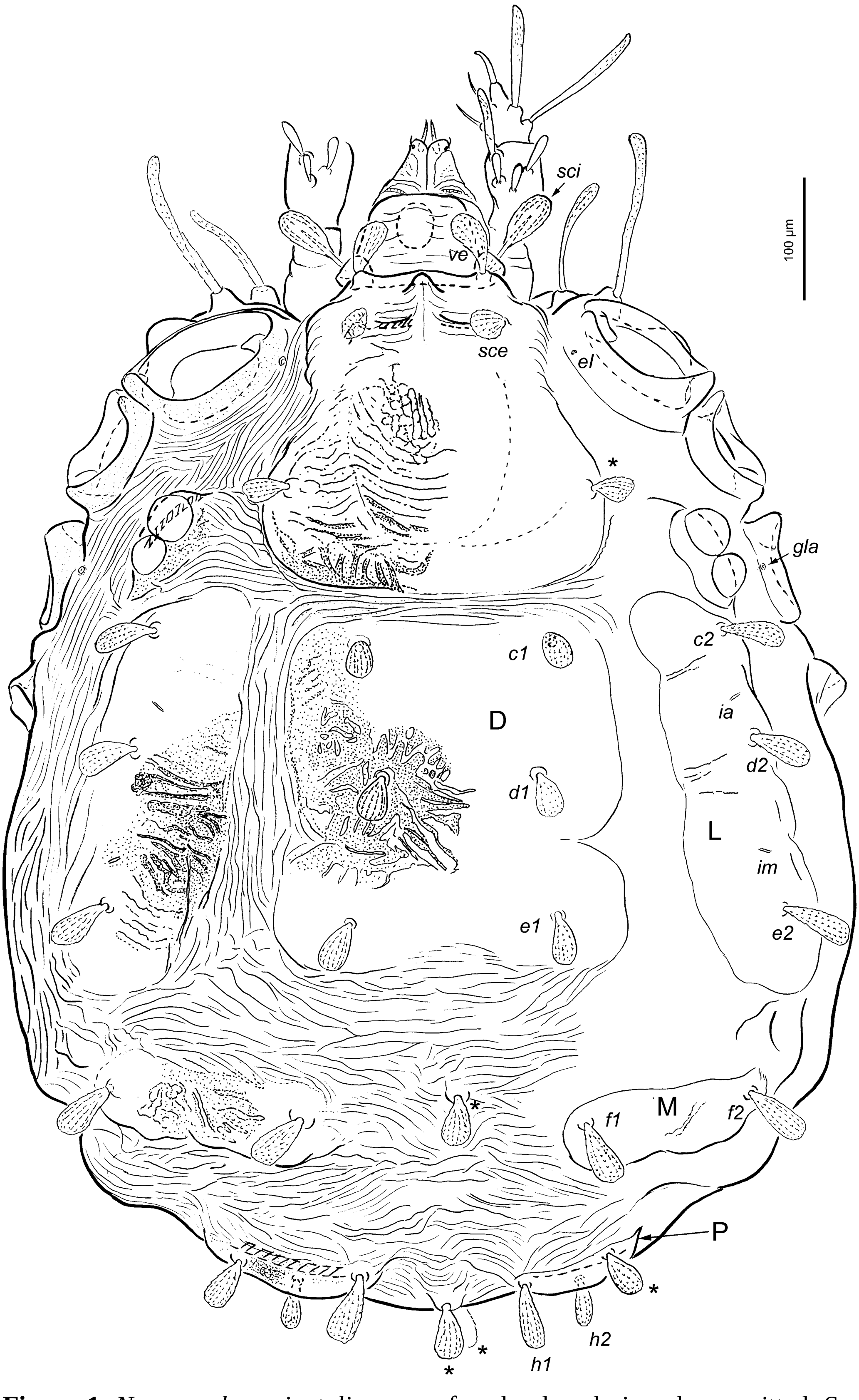

Figure 1. *Neocaeculus orientalis* **n. sp.**, female, dorsal view, legs omitted. Scale bar 100 µm.

Figure 2. *Neocaeculus orientalis* **n. sp.**, female, ventral view, legs omitted. Scale bar 100 µm.

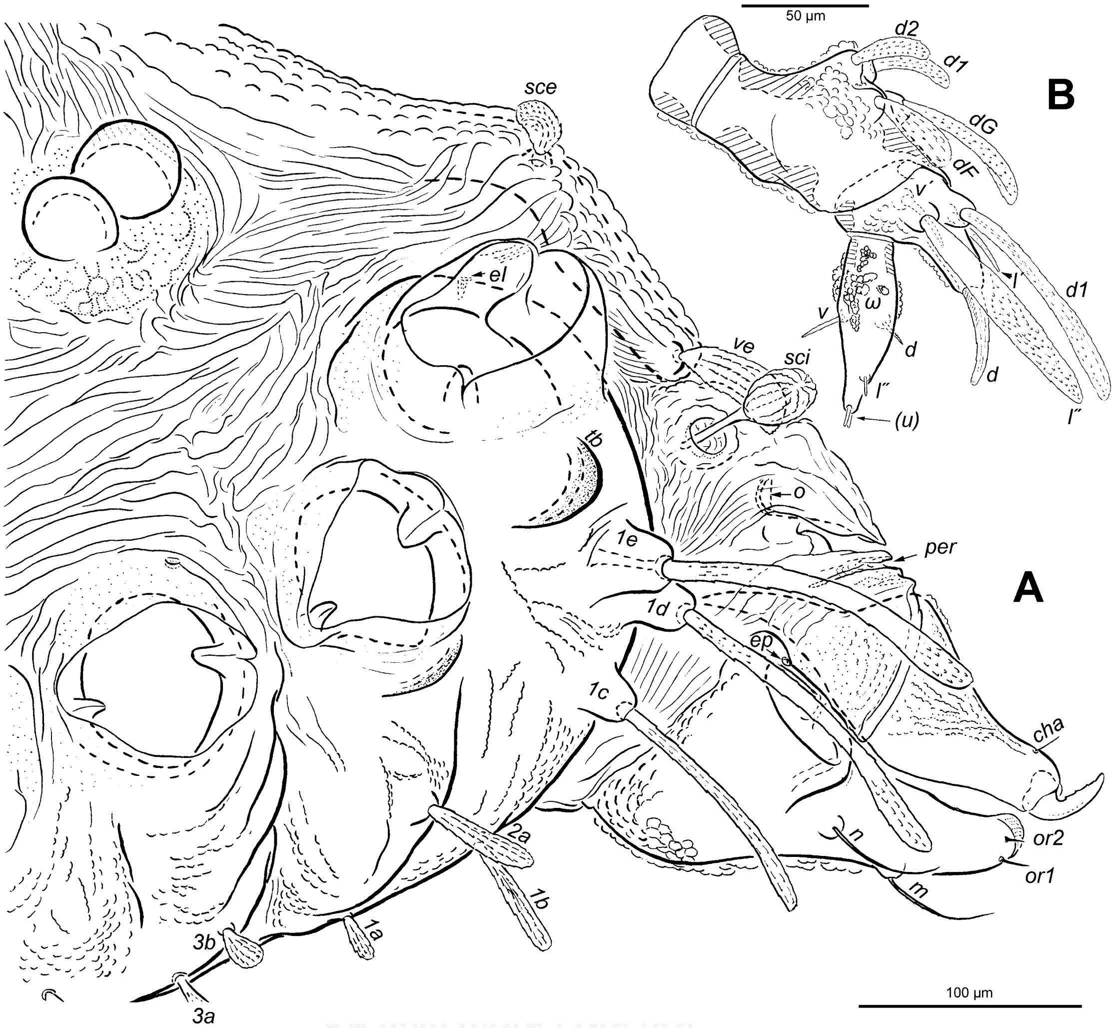

Figure 3. *Neocaeculus orientalis* **n. sp.**, female: (A) gnathosoma and anterior thirds of idiosoma, lateral view, legs and palp omitted; (B) palp, abaxial view. Scale bars: A 100 µm, B 50 µm.

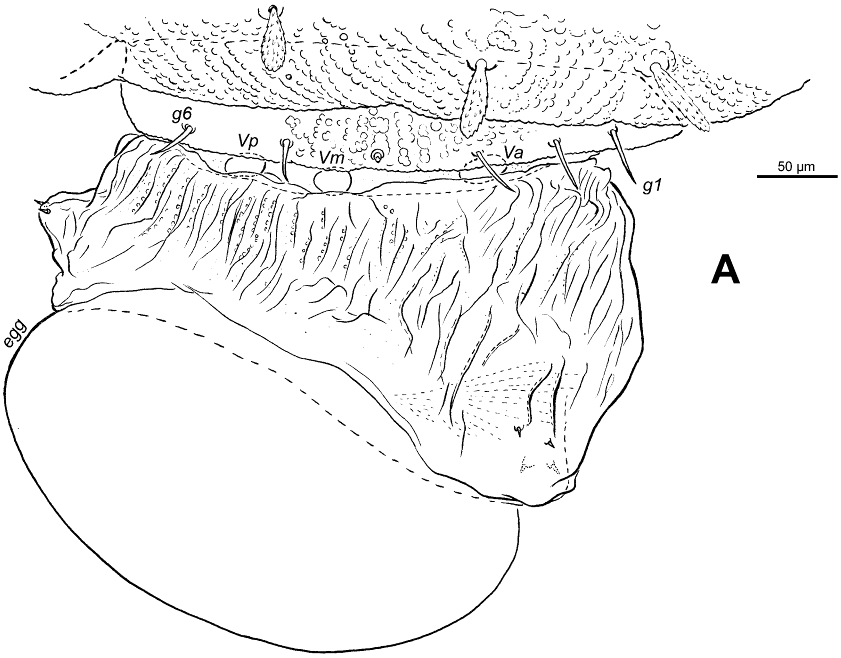

Figure 4. *Neocaeculus orientalis* **n. sp.**, adult: (A) protruding ovipositor, lateral view, anterior to right; (B) male genitalia, ventral view, anterior to top, left half of genitalia simplified by omitting covering membrane and denticulations of central lobes. Scale bars 50 µm.

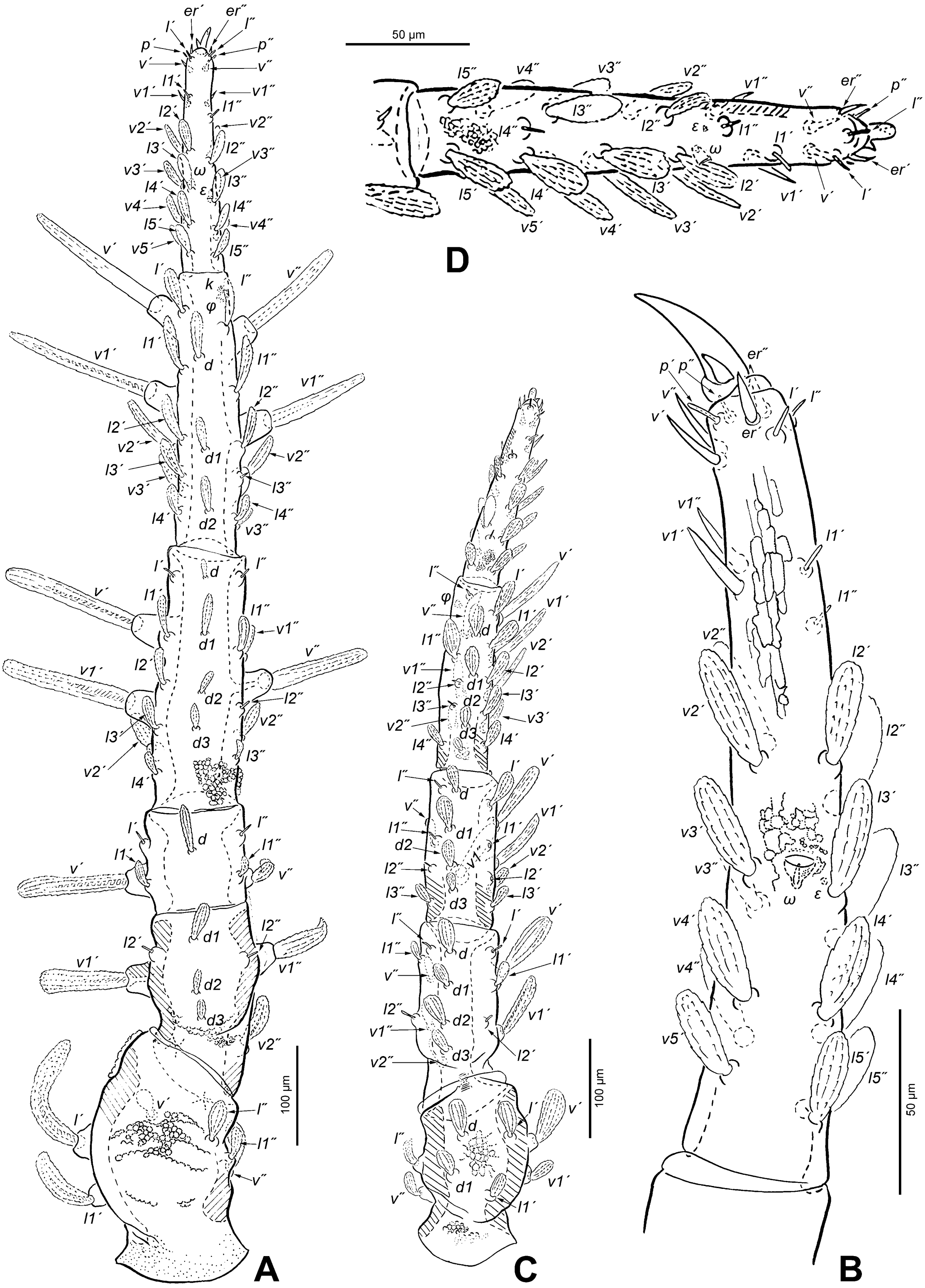

Figure 5. *Neocaeculus orientalis* **n. sp.**, female: (A) leg I, dorsal view; (B) tarsus I, adaxial view; (C) leg II, dorsal view; (D) tarsus II, dorsal view. Scale bars: A, C 100 µm; B, D 50 µm.

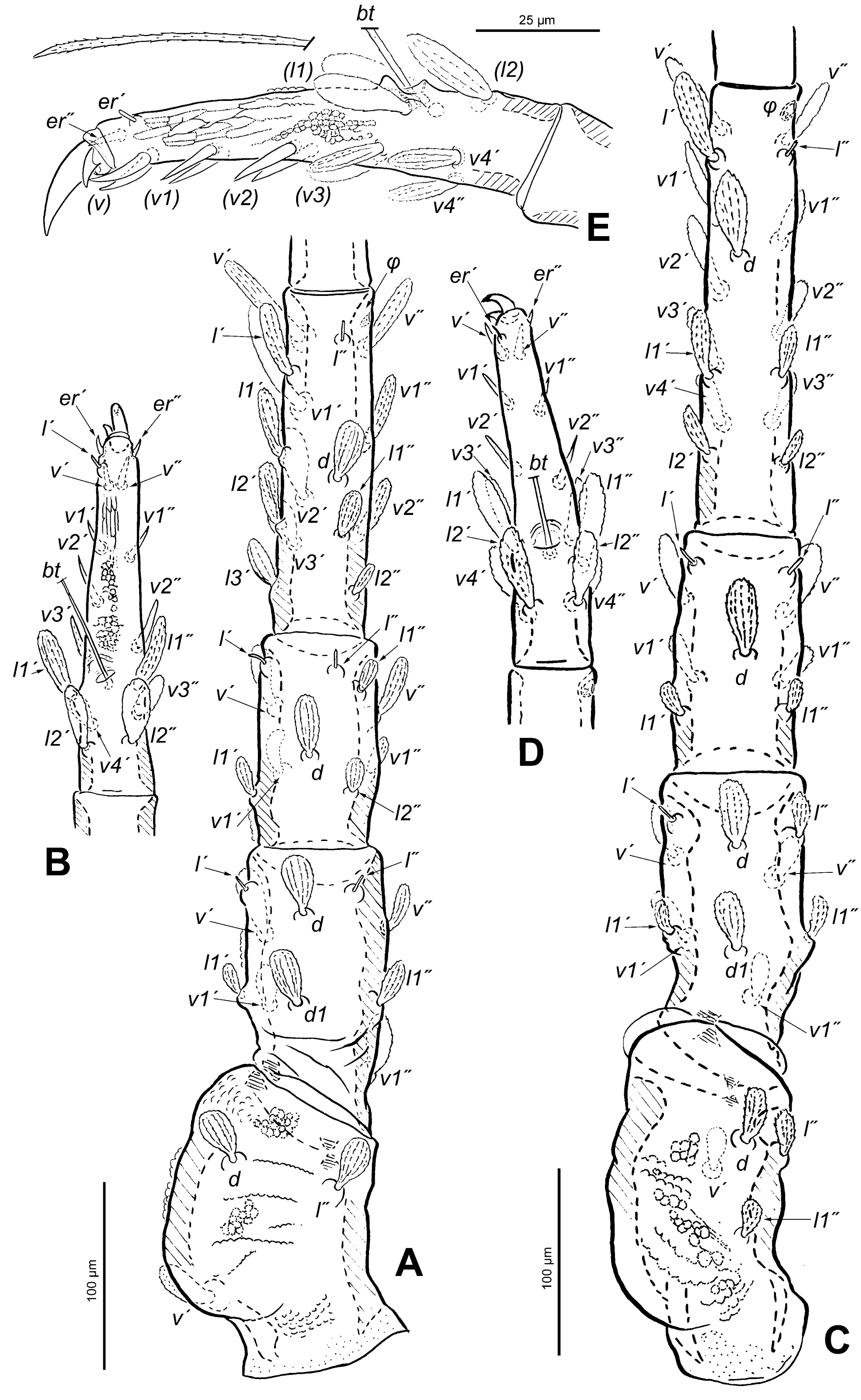

Figure 6. *Neocaeculus orientalis* **n. sp.**, female: (A) leg III, trochanter to tibia, dorsal view; (B) tarsus III, dorsal view; (C) leg IV, trochanter to tibia, dorsal view; (D) tarsus IV, dorsal view; (E) same, adaxial view. Scale bars: A–D 100 µm; E 25 µm.

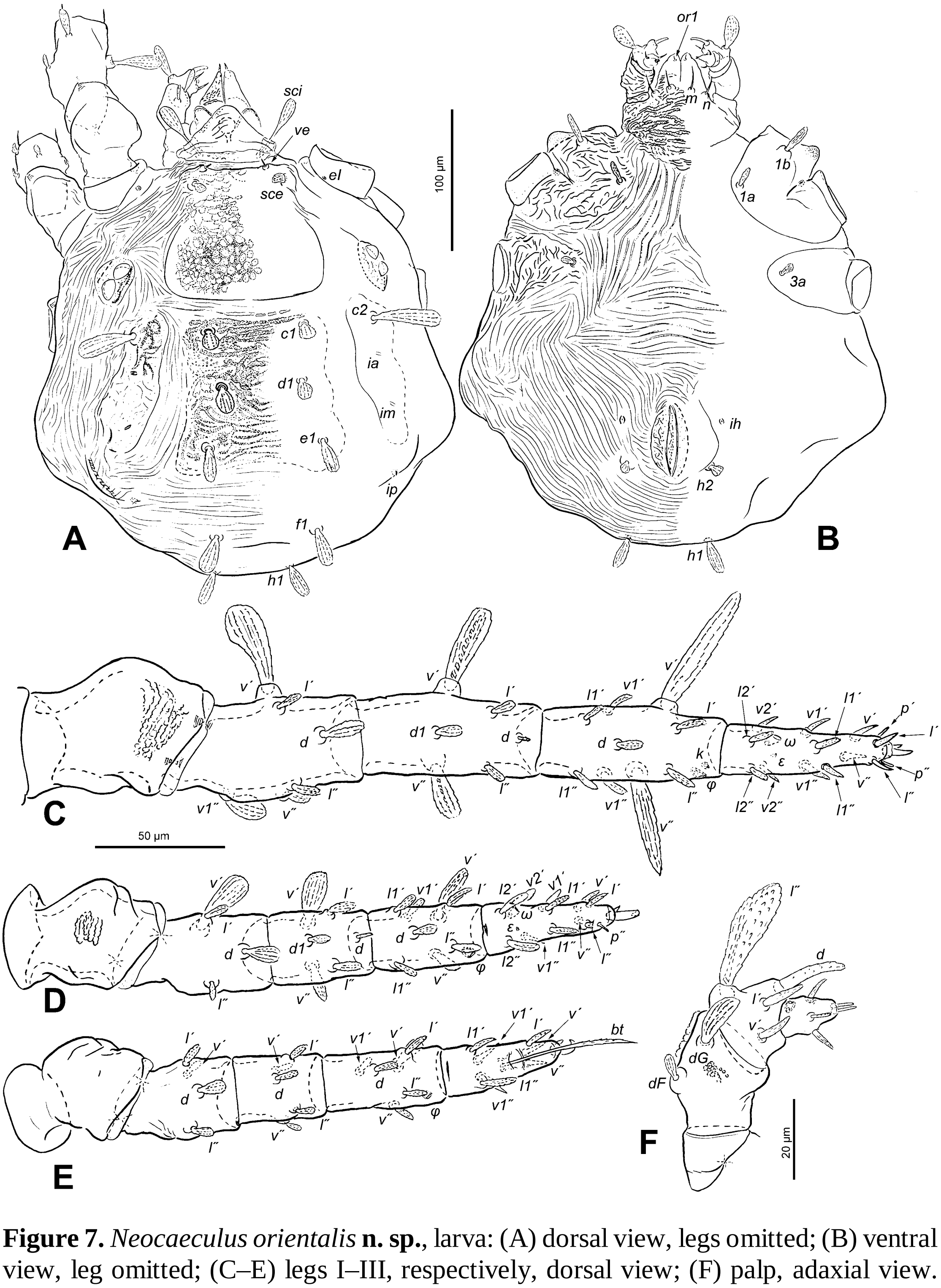

Figure 7. *Neocaeculus orientalis* **n. sp.**, larva: (A) dorsal view, legs omitted; (B) ventral view, leg omitted; (C–E) legs I–III, respectively, dorsal view; (F) palp, adaxial view. Scale bars: A, B 100 μm; C–E 50 μm; F 20 μm.

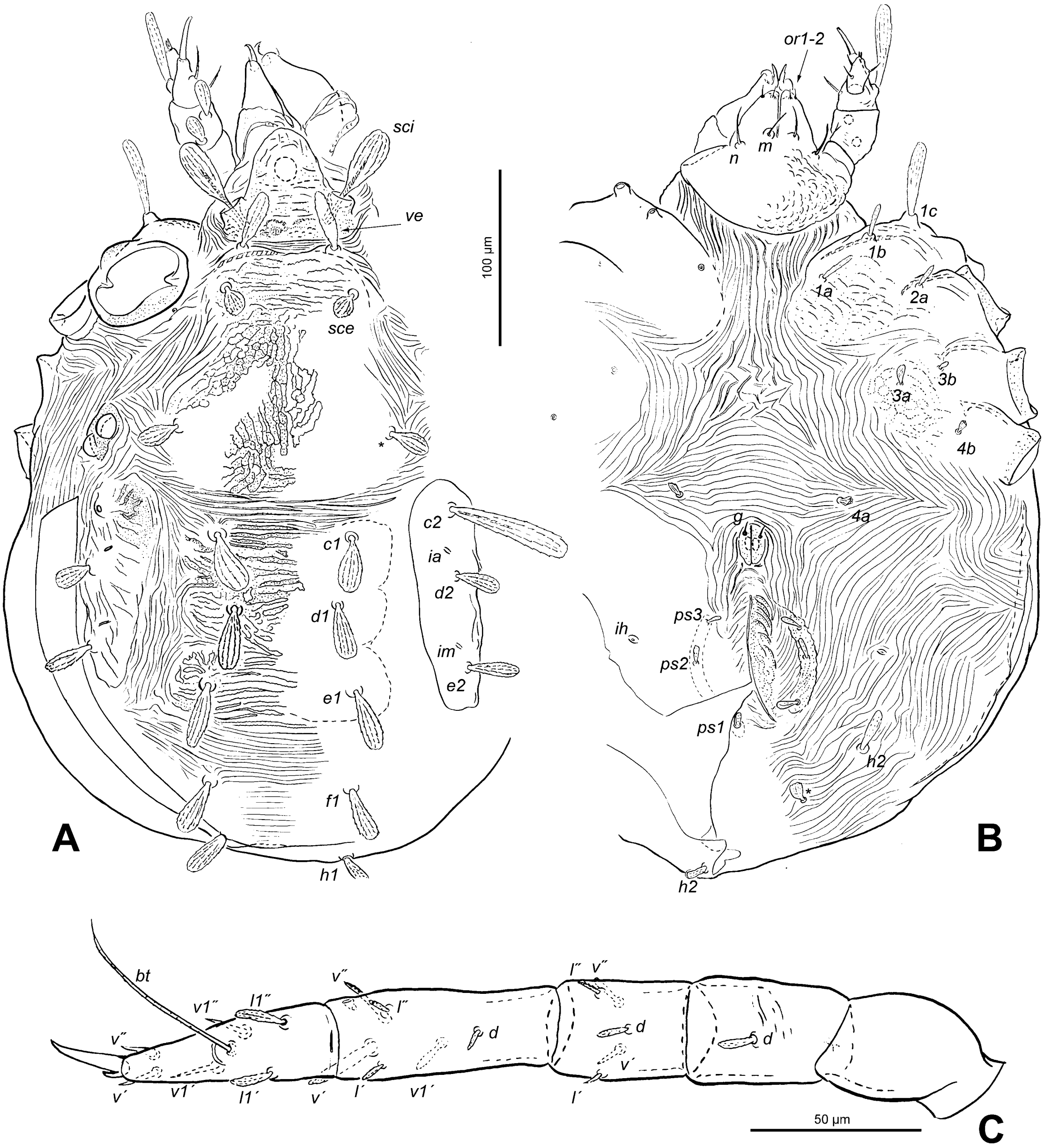

Figure 8. *Neocaeculus orientalis* **n. sp.**, protonymph: (A) dorsal view; (B) ventral view, leg omitted, opisthosoma broken; (C) leg IV, dorsal view. Scale bars: A, B 100 µm; C 50 µm.

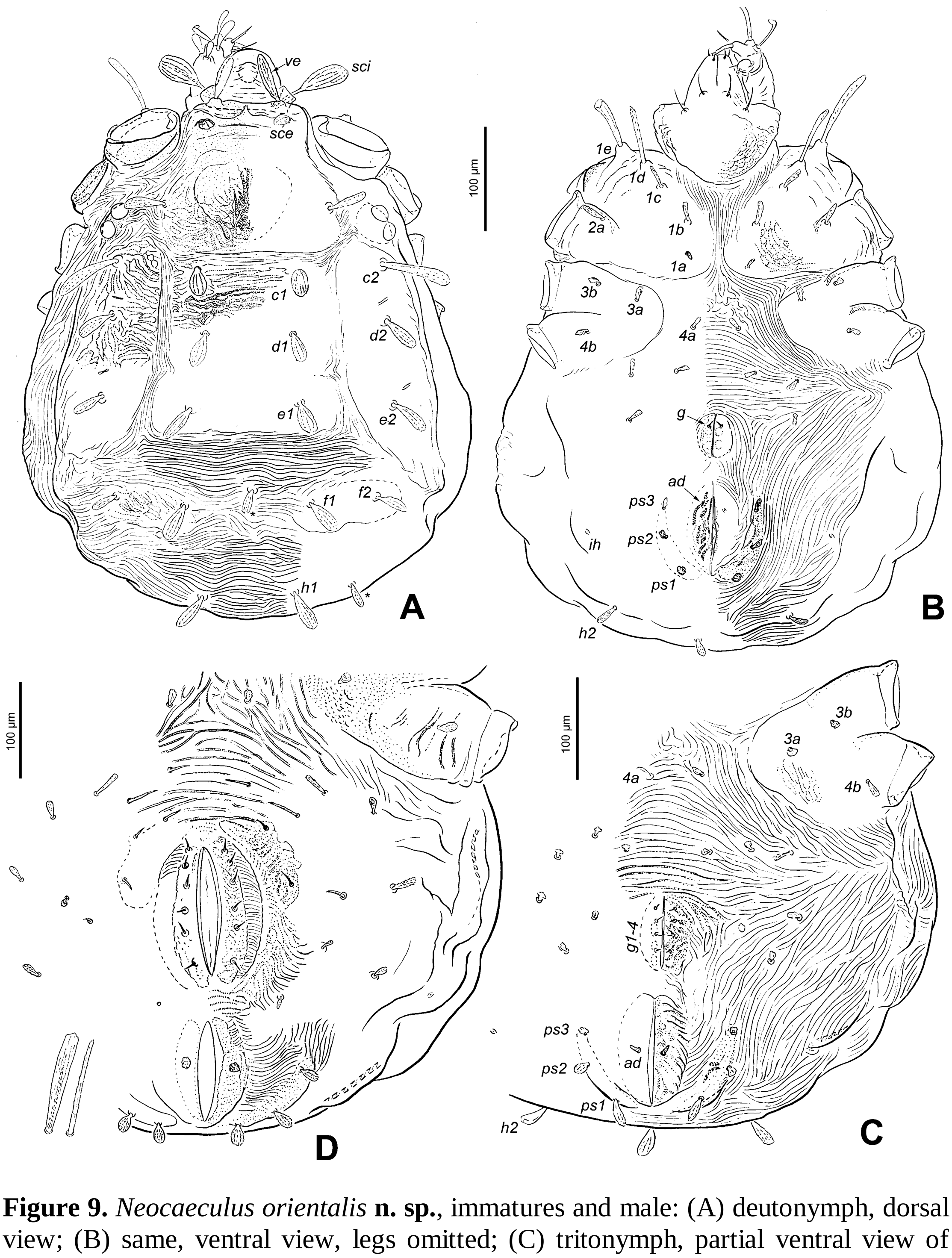

Figure 9. *Neocaeculus orientalis* **n. sp.**, immatures and male: (A) deutonymph, dorsal view; (B) same, ventral view, legs omitted; (C) tritonymph, partial ventral view of opisthosoma; (D) male, partial ventral view of opisthosoma, with two variations of ventral setae (not in scale) enlarged on lower left. Scale bars 100 µm.

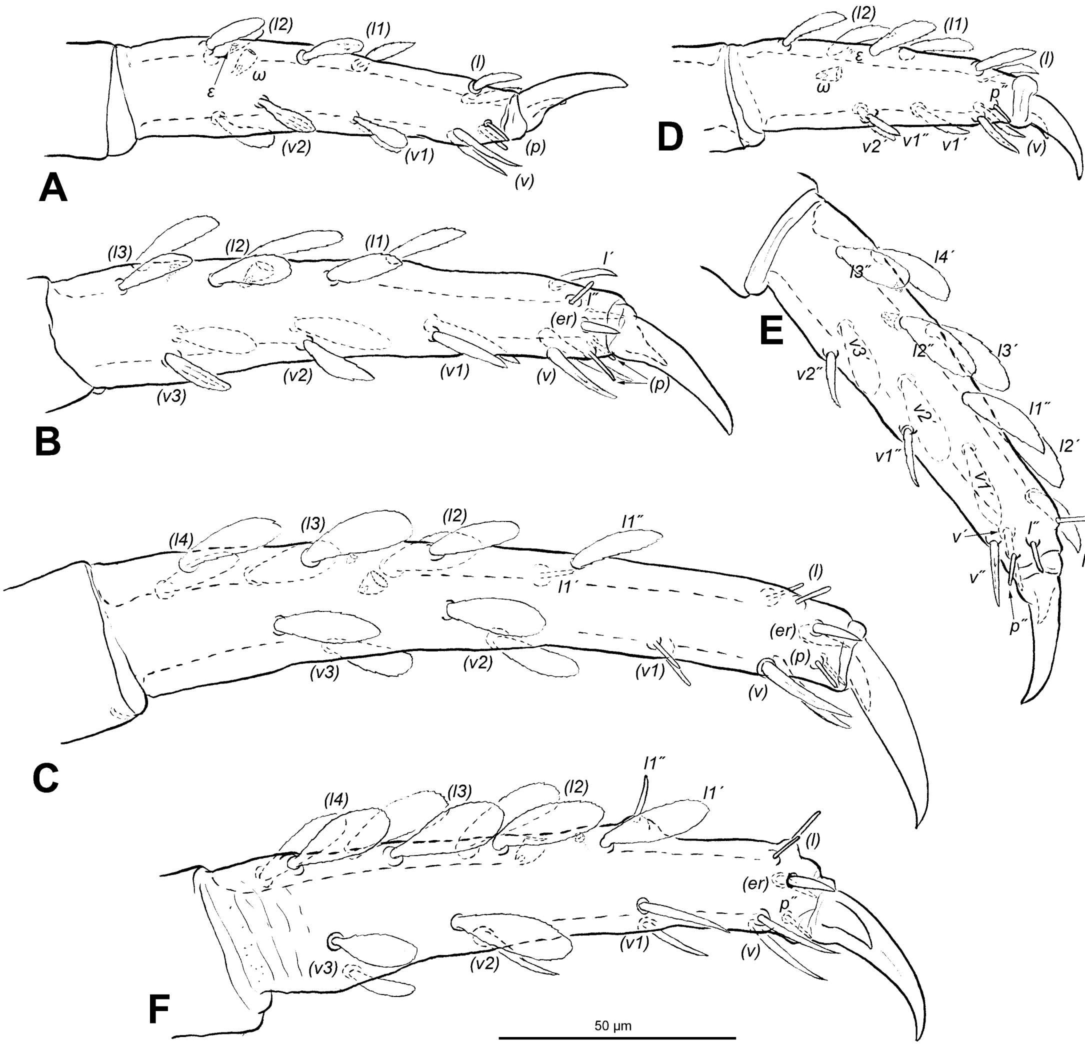

Figure 10. *Neocaeculus orientalis* **n. sp.**, immatures: (A–C) tarsus I of protonymph, deutonymph and tritonymph, respectively, abaxial view; (D–F) tarsus II of protonymph, deutonymph and tritonymph, respectively, D and E in abaxial view, F in adaxial view. Scale bar 50 µm.

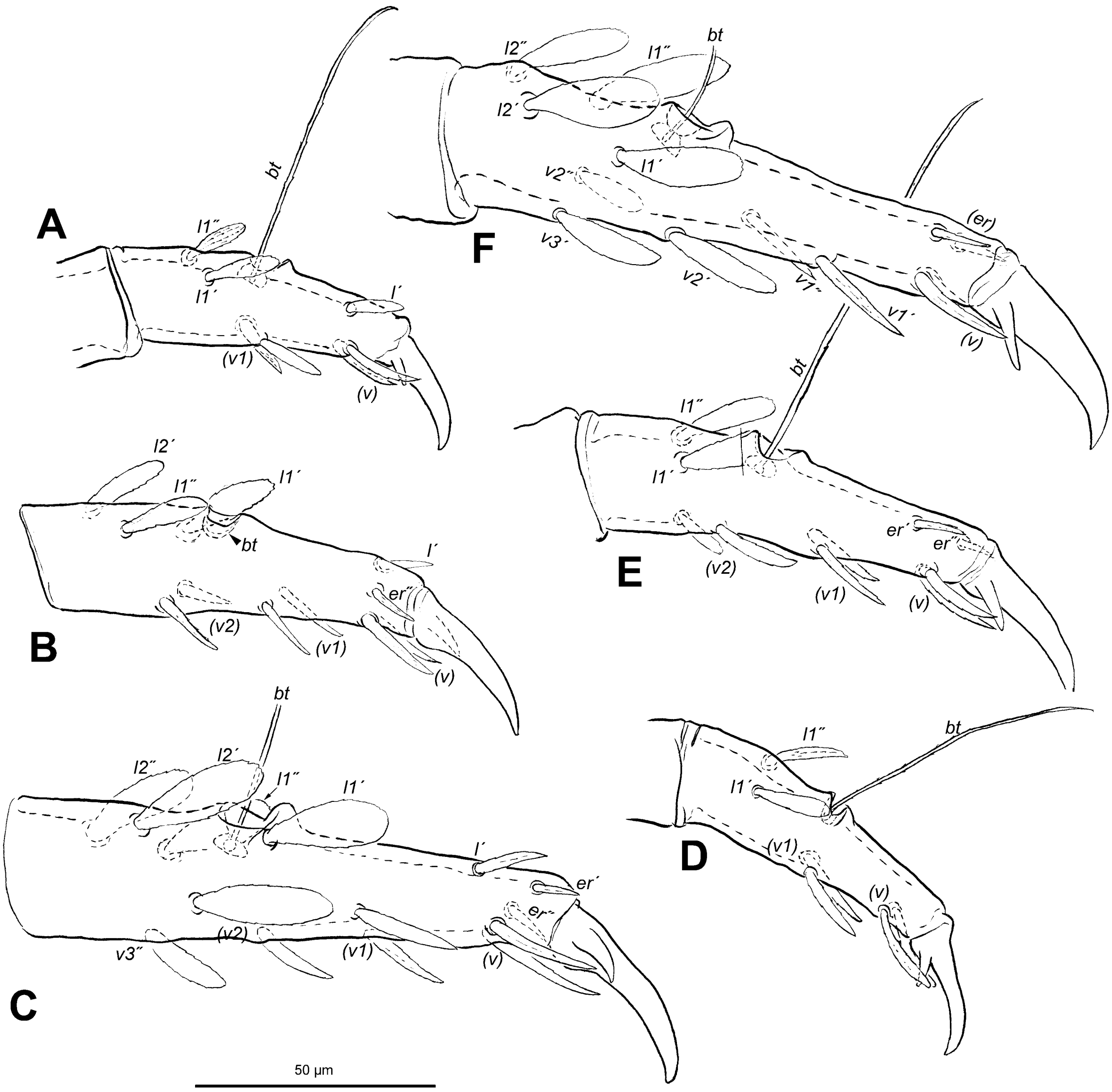

Figure 11. *Neocaeculus orientalis* **n. sp.**, immatures: (A–C) tarsus III of protonymph, deutonymph and tritonymph, respectively, A and C in abaxial view, B in adaxial view, *bt* dislodged in B; (D–F) tarsus IV of protonymph, deutonymph and tritonymph, respectively, all in abaxial view. Scale bar 50 µm.

CHAPTER 2C

CHULACARIDAE, A NEW FAMILY OF PROSTIGMATIC MITES (ACARI, TROMBIDIFORMES) FROM THAILAND[*]

2C-1 Abstract

A new family of prostigmatic mites (Acari: Trombidiformes), Chulacaridae **n. fam.** based on *Chulacarus elegans* **n. g. et n. sp.**, is described from adult females and immature instars collected from soil and litter in Thailand. The new family is monobasic and is placed in the hyporder Anystae (*sensu* Zhang *et al*. 2011), and tentatively grouped with other families in the superfamily Anystoidea. In addition to the typical features of Anystina, Chulacaridae **n. fam.** is characterized by the presence of enlarged, raptorial legs I uniquely with bipectinate setae on their anterior face, the presence of thick and blunt adoral setae (*or1* and *or2*), the fusion of the palpal femur and genu, the absence of any femoral subdivision of legs I–IV, the presence of 8–10 pairs of small genital papillae, and the presence of unipectinate claws (without empodium) on pretarsi I and normal claws (with claw-like empodium) on pretarsi II–IV. Some morphological characters and its systematic position are discussed.

2C-2 Introduction

The hyporder Anystae *sensu* Zhang *et al*. (2011) — or cohort Anystina *sensu* Lindquist *et al.* (2009) — is a relatively small, and loose, assemblage of about 280 species of prostigmatic mites (Acari: Trombidiformes). Eight families are currently recognized and tentatively grouped into 5 superfamilies: Adamystoidea (Adamystidae), Caeculoidea (Caeculidae), Anystoidea (Anystidae, Pseudocheylidae, Teneriffiidae), Pomerantzioidea (Pomerantziidae), and Paratydeoidea (Paratydeidae, Stigmocheylidae). Collectively, they are cosmopolitan, but are rarely collected for most

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[*] This chapter is a version of a manuscript which has been published as:
Fuangarworn, M., Lekprayoon, C. & Butcher, B.A. (2015) Chulacaridae, a new family of prostigmatic mites (Acari, Trombidiformes) from Thailand. *Zootaxa*, 4061, 527–552.

families. These mites are presumably predators, usually found in soil and litter, on rocks, tree bark, and lower vegetation of rather dried and exposed habitats; some members (Pomerantziidae and Stigmocheylidae) were collected from deep soil strata (Walter *et al*. 2009). The hypothesis on the phylogenetic positions of each family is not well established. The cladogram proposed by Kethley (in Norton *et al*. 1993) is the most inclusive by suggesting relationships between all anystaen families, but the characters that served as the basis for this concept were not mentioned; and subsequent analyses—either using only morphological data (Bochkov *et al.* 2008), molecular data (Dabert *et al.* 2010; Pepato & Klimov 2015), or a combination of both (Pepato *et al.* 2010)—include only selected representatives of this group since, of course, it was not the aim of their studies. Within its larger grouping, the 'Anystina-Eleutherengona complex', Anystae as a group is apparently paraphyletic. No strong apomorphies define it; rather it is characterized by plesiomorphic or uninformative traits: chelicerae with sickle-like movable digits, fixed digit greatly reduced or absent, and separate cheliceral bases; palps with a thumb-claw process (reduced or absent in Adamystidae and Paratydeidae); prodorsal ocelli present (absent in Pomerantziidae, Stigmocheylidae, and a few genera of Paratydeidae); with postcheliceral stigmata and peritremes; naso present or absent; with 1-2 pairs of prodorsal trichobothria (absent in Pomerantziidae); larval urstigmata and post-larval genital papillae present (absent in Pseudocheylidae); anamorphic additions of adanal setae (and further anal setae in Adamystidae) usually present during ontogeny (absent in Pseudocheylidae, Pomerantziidae, and Teneriffiidae); and males lack an aedeagus (Kethley 1982; Lindquist 1976; Walter *et al.* 2009).

During a survey of soil and litter inhabiting mites in Thailand, we found specimens of an unusual species that fits into no known families of the Prostigmata, and clearly belongs to the 'Anystina-Eleutherengona complex' in having the peritremes, palptibial claw, and chelicerae with a hook-like movable digit and reduced fixed digit (Lindquist 1976; Walter *et al*. 2009). This species also exhibits a set of character states indicating that it probably lies amongst the basal lineages of the 'Anystina-Eleutherengona complex'. The aims of this paper are to describe this unusual mite, *Chulacarus elegans* **n. g. et n. sp.**, and—because of its large morphological differences from other anystaen families—to propose a new family, Chulacaridae **n.**

fam., to accommodate this new genus and species. Some morphological characters and its systematic position are also discussed.

2C-3 Materials and methods

Specimens were obtained from previous collections and were recently collected in the course of the survey of soil mites in Thailand led by MF (see *Material examined* for collection data). In the latter case, samples of leaf-litter and top soil layer (400 cm^2 of surface) were collected into plastic bags and brought back to the laboratory within 48 hrs. Mites were extracted from the samples into 70% (v/v) ethyl alcohol using Tullgren funnels with 25 W tungsten bulbs as heat sources for seven days. Mites were prepared and observed in both temporary and semi-permanent slides using 80% (v/v) lactic acid and Hoyer's solution as a medium, respectively (Walter & Krantz 2009). The specimens in the latter preparation were measured using an eyepiece micrometer calibrated with a stage micrometer; the specimens were therefore somewhat compressed and distorted. Measurements, in microns, are presented as means with the range (min.–max.) in parentheses. Polarized light was used to distinguish setae, solenidia and other structures of setal origin. Drawings were made with the aid of a *camera lucida* attached to a microscope (Olympus CX 31). The terminology generally follows that of Grandjean's system overviewed by Kethley (1990) for idiosomal chaetotaxy, and by Norton (1977) for leg chaetotaxy. The palpal chaetotaxy is not well established among the prostigmatic families, especially for the palptarsus whose setae are enumerated in a conventional manner, following Judson (1994, 1995). Descriptions of immature stages emphasize characters that differ from adults and change during ontogeny.

2C-4 Taxonomic results

Chulacaridae n. fam.

Type genus: *Chulacarus* n. g.

Diagnosis. Adult females and immatures immediately distinguished from those of all other known families of Trombidiformes by following unique attributes: enlarged and raptorial legs I which uniquely equipped with bipectinate setae on anterior face of genu, tibia and tarsi; pretarsi I with unipectinate claws and without empodium whilst pretarsi II–IV with a pair of normal claws and a small claw-like empodium; progenital chamber in females with proliferated numbers of genital papillae (8–10 pairs and very small in size). Additional attributes include: subcapitulum with 2 pairs of thick and blunt adoral setae (*or1* and *or2*); palpi with 4 segments (femur and genu fused) and 'thumb-claw' complex, but tarsus reduced to small knob; chelicerae separate, fixed digit absent, movable digit hook-like; peritremes linear, transversely located on cheliceral bases; prodorsum with naso, 1 pair of lateral eyes, 4 pairs of prodorsal setae, of which 2 pairs trichobothrial; larva with urstigmata; adanal setae added in protonymph; adult female with ovipositor and eugenital setae; all leg femora and tarsi undivided; famulus present on tarsi I-II.

In Walter *et al*. (2009)'s key to families of Prostigmata (their Key 13.4), Chulacaridae n. fam. runs to couplet 28, between families Teneriffiidae (28a) and Anystidae (28b). However, the new family, based on adult females, may be distinguished from both families by modifying this couplet as follow:

28a. Naso weakly developed, palptarsus reduced, not extending beyond palptibial claw; adoral setae thickened and truncated; pretarsal empodium I absent.......28b

\- Naso usually present; palptarsus extending beyond palptibial claw; adoral setae simple; pretarsal empodium I usually pad-like or claw-like................Anystidaae

28b. Posterior prodorsal bothridia with rostte pattern; peritremes (linear or sinuous) usually produced onto anterior corner of prodosoma; tarsi III-IV divided ………………………………………………………………………Teneriffiidae

\- Posterior prodorsal bothridia simple; peritremes (linear) produced transversely on cheliceral bases; tarsi III-IV entire………………............Chulacaridae n. fam.

Description of Adult (female). *Gnathosoma***.** Subcapitulum with 2 pairs of adoral setae (*or1* and *or2*) being short, thickened and blunt, and 2 pairs of simple subcapitular setae: *n* located laterally, *m* ventrally. Supracoxal setae (*ep*) small, rod-like. Palp with 4 segments; trochanter very short, femur and genu fused, with 2 setae; tibia with well developed claw, 2 simple setae and 1 thickened-blunt seta (=accessory claw); tarsus reduced to small knob, with 8 setae and one solenidion ω. Chelicerae separate, each with 2 setae (*cha* and *chb*); movable digit hook-like; fixed digit absent, replaced by membranous hyaline process and bearing styliform process. Stigmata and simple linear peritremes (not emergent) at bases of chelicerae.

Podosoma. Dorsal shield smooth and subrectangular. Naso present. 4 pairs of prodorsal setae (*vi*, *ve*, *sci* and *sce*), of which 2 pairs (*vi* and *sci*) trichobothrial, all filiform, finely and sparsely barbed. Trichobothrium *vi* at base of naso, trichobothrium *sci* and setae *ve* and *sce* located on prodorsal shield. Lateral eyes present on membrane, postero-lateral to *sce*; median eye under naso not observed. *Hysterosoma*. With 13 pairs of setae located on small platelets, all filiform and finely barbed. Setation on segments C, D, E, F, H, PS and AD 2–1–1–1–2–3–3; with 4 pairs of lyrifissure (*ia*, *im*, *ip* and *ih*); lyrifissure *ips* and *iad* absent.

Epimeral region. Coxisternal plates I and II contiguous on either side but separated medially by striated soft membrane; coxisternal plates II and III separated by transverse band of sejugal cuticle. Coxal plates III and IV also contiguous on either side and separated medially by soft membrane. Coxal setae setiform, finely barbed.

Genital region. Genital and anal openings widely separated. Genital opening covered by genital valves. Progenital chamber with 8–10 pairs of small genital papillae, an ovipositor, and eugenital setae.

Legs. Legs I–IV lacking trichobothria; all femora and tarsi undivided. Leg I, remarkably modified for likely raptorial function, equipped with bipectinate setae on genu, tibia and tarsus. Pretarsus I with pair of unipecinated claws but empodium absent. Pretarsi II–IV with paired claws and claw-like empodium. Famulus present on tarsi I–II.

***Chulacarus* n. g.**

Type species: *Chulacarus elegans* n. sp.

Diagnosis and Description. As for family.

Etymology. The genus name is a Latinized combination of the Thai name of our university ‘Chula’ (officially known as Chulalongkorn University) to celebrate her 99th anniversary in the year 2016, and the Latin *acarus*, meaning mites.

***Chulacarus elegans* n. sp.**

(Figs 1–14)

Female. Colour in alcohol pale yellow. Body length (from apex of naso to posterior end of idiosoma; *n*=5) 405 (370–450). Body width (greatest width at the level of seta *c2*) 230 (215–245). Idiosoma (Fig. 1A) ovoid, ca. two times longer than wide, posterior end rounded.

Gnathosoma (Figs 1A, 3). Subcapitulum 121 (115–125) long, 139 (140–150) wide; integument striate; subapically on lateral lips with 2 pairs of short thickened and truncated adoral setae (*or1* and *or2*); subcapitular setae *n* and *m* simple, seta *n* located laterally, seta *m* located ventrally. Ventral lip (labium) present, short triangular; dorsal lip (labrum) triangular in outline, appearing smooth. Supracoxal seta *ep* small, rod-like. Palp (Figs 3A, D–E) 4-segmented: trochanter very short, femur and genu fused, 60 (55–65) long, 40 (35–45) wide, with 2 barbed filiform setae (*dF* and *dG*); tibia with well developed terminal claw, 2 simple setae (*l’* and *l’’*) and 1 thickened blunt seta *d* (= accessory claw); tarsus reduced, knob-like, situated at subterminal position on tibia (forming a ‘thumb-claw’ complex structure), with 8 setae (*1*, *2*, *3*, *4*, *5*, *6*, *7* and *8*) and one short rod-like solenidion (ω); setae *3* and *5* eupathidial. Chelicera (Figs 3B–C) 104 (100–110) long, greatest width at shaft base 47 (45–50), and relatively flat; cheliceral seta *cha* short and simple, located laterally; seta *chb* thicker, about twice as long as *cha*, located more anterior-medially; movable digit hook-like; fixed digit absent, replaced by membranous hyaline process through which a short slender styliform process pierces out (Fig. 3C). Two pairs of stigmatic openings present: paraxial stigmata ($st\pi$), between base of chelicerae and produced on to linear, segmented peritremes; peritremes, not elevated, transversely passing on dorsum of cheliceral bases and ending at their lateral face; subcheliceral stigmata (*sti*) at normal position, opening as simple broad slit and leading to tracheal trunk which narrows to join tracheal trunk of $st\pi$ (Figs. 4A–B), forming X-shaped tracheal system.

Idiosoma (Figs 1, 2A). Integument with striation as illustrated; dorsally, with prodorsal shield, 102 (100–105) long and 119 (105–130) wide, smooth, subrectangular in shape, anterior margin concaved. Naso present, surface smooth and separated from prodorsal shield by narrow striae (Fig. 4C). Four pairs of prodorsal setae (*vi*, *ve*, *sci* and *sce*) of which 2 pairs (*vi* and *sci*) trichobothrial; all these setae filiform and finely barbed. Trichobothrium *vi* situated posterior to naso, its bothridium with (2–3) or without radial chambers (Fig. 4C). Trichobothrium *sci*, 84 (80–90) long, situated on anterior margin of prodorsal shield, usually on striae, its bothridium larger than that of *vi*, and with 3–5 radial chambers (Fig. 4C). Seta *ve* 50 (40–55) long, situated on anterior corner of shield. Seta *sce* 105 (100–110) long, situated near halfway of lateral margin of shield. One pair of small lens-like eyes present on membrane postero-lateral to *sce* (Fig. 1A, *ocellus*); a pair of internal spots present, posterior to lateral eyes; median eye under naso not observed.

With 13 pairs of hysterosomal setae (*c1*, *c2*, *d1*, *e1*, *f1*, *h1*, *h2*, *ps1*, *ps2*, *ps3*, *ad1*, *ad2* and *ad3*), all filiform, finely barbed and on small platelets. Their lengths: *c1* 63 (55 –75), *c2* 108 (100–115), *d1* 67 (60–75), *e1* 68 (65–75), *f1* 75 (70–85), *h1* 69 (65–75), *h2* 64 (60–75), *ps1* 67 (65–70), *ps2* 53 (50–60), *ps3* 45 (40–55), *ad1* 37 (35–40), *ad2* 41 (40–45), *ad3* 39 (40–45). With 4 pairs of lyrifissures (*ia*, *im*, *ip* and *ih*) at normal position (Figs 1, 2A). Anal opening terminal, anal valve devoid of setae.

Epimeral region. Coxal plates smooth; membrane striated (Fig. 1B). Coxal plates I and II contiguous on either side but separated medially by soft membrane as are coxal plates III and IV. Coxal plates II and III separated by transverse band of sejugal cuticle. Apodeme 1 (*apo.1*) triangular in form, well developed and deeper than apodemes 2–4. Coxal setae slender and finely barbed; coxal setation: 4–2–3–2; setae *1b*, *1d* longest.

Genital region (Fig. 1B). Genital opening 107 (100–115) long, with well defined genital valve, 6 or 7 pairs of genital setae (ca. 20–25) arranged in longitudinal row, and 3 or 4 pairs of aggenital setae (ca. 25–27). Ovipositor (Fig. 4D) present usually with 5 pairs of eugenital setae: *eug1–5* on superimposed tubercle; *eug1–4* (about 8–12 long) widely spaced, sometimes *eug4* absent; *eug5* (about 5 long) coupled to its pair. Genital papillae small, hard to discern, 8–10 pairs, presumably multiplied from typical three pairs of genital papillae (*Va*, *Vm* and *Vp*); setae *k2* and *k3* present, seta *k1* not discernable (Fig. 4D).

Legs (Figs 5–6). Integument smooth. All legs shorter than idiosoma. Leg I raptorial, relatively large and robust, about two times wider than other legs; hinge joints on antiaxial side and extensive arthrodial membrane on paraxial face. All femora and tarsi undivided. Leg lengths (from base of trochanter to distal end of tarsus, excluding apotele): I 239 (225–250), II 194 (175–210), III 204 (190–215) and IV 235 (220–245). Supracoxal seta *e1* short rod-like. Setation of legs I–IV (famulus included, solenidia in brackets): trochanters 1-1-1-1, femora 6-4-3-3, genua 10-5-5-5, tibiae 10 (2)-4/5(2)-4(2)-4(1), and tarsi 16(1)-13(1)-9/10-11. For leg I, tarsus shorter than tibia, and genu longest. Most leg setae filiform and finely barbed, except some setae on leg I: genual seta *l'*, tibial setae *l'*, *l1'* and *l2'* and tarsal setae *pl'*, *pv'* and *v'*, being bipectinate (Fig. 6A). Solenidion *ω1* of tarsus I rod-like, situated laterally on segment and coupled with famulus *ε*, which is spiniform and birefringent. Solenidia *φ1*and *φ2* on tibiae I–III rod-like; *φ1* distal while *φ2* proximal to middle of segment. Solenidion *ω1* of tarsi II short, rod-like, also coupled with famulus *ε*. Solenidion *φ2* of tibia IV short, rod-like, situated proximal to middle of segment. Pretarsus I with unequal claws, adaxial claw longer, each serrated along basal half of adaxial face (Fig. 5A), i.e. unipectinate; empodium absent; pretarsi II–IV with normal claws, smooth, and claw-like empodium.

Male. Unknown.

Ontogeny (Figs 7–14). *Size*. Larva (*n* =1, Figs 7–8): body length (including gnathosoma) 315 long, 195 wide. Protonymph (*n*=2, Figs 9–11) 370 (350–390) long, 180 (170–195) wide. Deutonymph unknown (among the specimens collected, deutonymphs were absent; the individuals identified as tritonymph (below) are based on their size which is rather close to that of adults, and on a similar number of genital papillae). Tritonymph (*n*=2, Figs 12–14) 488 (475–500) long, 233 (225–240) wide.

Gnathosoma. Similar to adult except chelicera with 1 simple seta *cha* in larva (Fig. 7C), 2 in protonymph (*chb* added) and later instars; lateral lips with 1 pair of adoral setae of adult form in larva, 2 pairs in protonymph (*or2* added).

Idiosoma. Similar to adult except naso distinctly pointed in larva and nymphs; 10 pairs dorsal hysterosomal setae in larva (*c1*, *c2*, *d1*, *e1*, *f1*, *h1*, *h2*, *ps1*, *ps2* and *ps3*), 13 pairs in protonymph (*ad1–3* added) and later instars. Lengths of dorsal setae: larva, *vi* 60, *ve* 33, *sci* 63, *sce* 65, *c1* 70, *c2* 80, *d1* 50, *e1* 50, *f1* 57, *h1* 53, *h2* 50, *ps1* 28, *ps2* 27 and *ps3* 25; protonymph: *vi* 55 (50–60), *ve* 38 (35–40), *sci* 67 (65–70), *sce* 78 (75–80), *c1* 53 (50–55), *c2* 90 (85–95), *d1* 55 (50–60), *e1* 50 (50), *f1* 53 (50–55), *h1* 50 (50), *h2* 53 (50–55), *ps1* 30 (30), *ps2* 30 (30), *ps3* 33 (30–35), *ad1* 23 (20–25), *ad2* 23 (20–25) and *ad3* 23 (20–25); tritonymph: *vi* 73 (70–75), *ve* 45 (45), *sci* 70 (65–75), *sce* 95 (90–100), *c1* 60 (55–65), *c2* 88 (88), *d1* 65 (60–70), *e1* 60 (55–65), *f1* 65 (60–70), *h1* 68 (65–70), *h2* ca. 55, *ps1* ca. 33, *ps2* 40 (40), *ps3* 35, *ad1* 30 (30), *ad2* 33 (30–35), and *ad3* 30 (30).

Epimeral region. Similar to adult except coxal setae formula 3-1-2 in larva (Fig. 7B); urstigmata present between coxae I and II, having circular head and covered by scale of coxa I (= scaliform seta *1c*); 3-1-3-0 in protonymph, seta *1c* becoming setiform and *3c* added; 4-2-3-2 in tritonymph (*1d*, *2b*, *4a*, *4b* added but their origin, deutonymphal or tritonymphal, uncertain). Homology of coxal setae depicted in Figs 7B, 9B, 12B.

Genital region. Genital opening absent in larva, present in later instars; genital setae absent in larva, 1 pair (*g*) present in protonymph, ca. 15 long, and tritonymph, ca. 18 long. Aggenital setae absent in larva and protonymph; 2 pairs (*ag1–2*) present in tritonymph, ca. 20–23 long. Genital papillae present in protonymph (but exact numbers could not be determined due to their extremely small size and hard to discern); and 7–8 pairs in tritonymph (Fig. 12D).

Legs. Generally similar to adult in form, larva with 3 pairs of legs, 4 pairs in later instars. Larval pretarsi II–III, and protonymphal pretarsus IV tridactyle, with smooth claws and slender, claw-like empodium, which becomes smaller in later instars. Lengths of legs: larva, leg I 125, leg II 115, leg III 128; protonymph, I 165 (160–170), II 128 (125–130), III 143 (140–145) and IV 143 (140–150); tritonymph, I 200 (200), II 150 (150), III 173 (170–175) and IV 188 (185–190). Setation of legs I–III (famulus included, solenidia in brackets) in larva: trochanters 0-0-0, femora 6-3-3, genua 5-5-5, tibiae 7(2)-4(2)-4(2), and tarsi 13(1)-12(1)-9; on leg I, genual seta *l'*, tibial seta *l'*, tarsal setae *pl'* and *pv'* strongly thickened and bipectinate (Fig. 8A–B); tarsal setae *p'* and *p"* eupathidial, *tc'* coupled with *p'* (their alveoli touch). Protonymph: trochanters 1-1-1-0; femora 6-3-3-0; genua 7-5-5-0; tibiae 8(2)-4(2)-4(2)-0 and tarsi 15(1)-12(1)-9-7; on tarsus I, *a'* added as eupathidion, *tc'* dissociated from eupathidion *p'* and becoming more distal; small seta *a"* added and coupled with eupathidion *p"* (their alveoli touch). Tritonymph: trochanter 1-1-1-1; femora 7-4-3-3; genua 8-5-5-5; tibiae 9(2)-4(2)-4(2)-4(1); tarsi 16(1)-13(1)-10-11. Homology of leg setae depicted in Figs 8, 10–11, 13–14. Addition of leg setae during development summarized in Table 1.

Material Examined. Female holotype (slide mounted): THAILAND, Tak Prov., Srisawad Dist., Sam-Ngoa Subdist., RSPG Forest Reserves at Bhumibol Dam (17°14'46.87"N, 98°59'45.66"E); ex. forest litter; 2-III-2008; leg. M. Fuangarworn (Field No. MF2008-9). Six female paratypes: (2 slide-mounted and 4 in alcohol); One female paratype (slide-mounted), same data as holotype except on 8-IX-2007 and leg. Ekachai Jirathitikul. One female paratype (slide-mounted); Sakaerat Biosphere Reserve, Pakthongchai District, Nakorn-Ratchasima Province; ex. Soil; 19-I-1975; leg. Samrit. Three tritonymphs (all slide-mounted), four protonymphs (2 slide-mounted and 2 in alcohol) and one larva (slide-mounted) with same data as holotype. Most of type materials are deposited in the Acarology collection of the Chulalongkorn University Museum of Natural History, Bangkok, Thailand. One female paratype will be deposited in the Acarology Collection of the Ohio State University, Columbus, USA.

Etymology. The specific epithet is from the Latin *elegans*, meaning ‘elegant’.

Distribution. Known only from Thailand: Nakorn-Ratchasima and Tak Provinces (Fig. 2C).

2C-5 Discussion

Morphological notes. The selected characters of *Chulacarus elegans* that are unusual or relevant for further comparisons in the next section are discussed below. Most comparisons are made against the members of Anystae, in which the new taxon probably belongs and, unless other sources are indicated, are based on the original descriptions, reviewed and revisionary studies (below), along with overviews by Walter *et al*. (2009) and unpublished observations by the authors on the representatives of each family collected in Thailand.

Adamystidae: (Ueckermann 1989); Fuangarworn and Lekprayoon (2010); Fuangarworn *et al.* (2012); Fernandez *et al.* (2014) ; Coineau *et al.* (2006); unpublished observations on *Adamystis* sp., adults, deutonymphs and tritonymphs.

Anystidae: Grandjean (1943); Meyer and Ueckermann (1987); Otto (1992, 1999a, 1999b, 1999c, 2000); unpublished observations on *Anystis* sp., all active stages, *Erythracarus* sp., all active stages, *Tarsotomus* sp., adults.

Caeculidae: Coineau (1974a and references therein, 1974b); Otto (1993); Mangová *et al.* (2014); Ott and Ott (2014); Taylor *et al.* (2013); Taylor (2014); unpublished observations on *Neocaeculus* sp., all active stages, *Microcaeculus* sp., all juveniles stages.

Paratydeidae: Theron *et al.* (1969); Kuznetsov (1973); Seeman and Walter (1999); Dönel *et al.* (2012); Khanjani *et al.* (2014b); unpublished observations on *Tanytydeus* sp., all active stages, *Scolotydaeus* sp., adult.

Pomerantziidae: Fan and Chen (2005); Bochkov and Walter (2007); unpublished observations on *Pomerantzia* sp., all active stages.

Pseudocheylidae: Baker and Atyeo (1964); van Dis and Ueckermann (1991); Ueckermann and Khanjani (2004); Navaei-Bonab *et al*. (2011); Bagheri *et al*. (2013); Skvarla *et al*. (2013); Khanjani *et al*. (2014); Khaustov and Tolstikov (2015); unpublished observations on *Anoplocheylus* sp., all active stages.

Stigmocheylidae: Bochkov (2008); unpublished observations on *Stigmocheylus* sp., all post-larval stages.

Teneriffiidae: Ehara (1965); Strandtmann (1965); Shiba and Furukawa (1975); McDaniel *et al*. (1976); Luxton (1993); Judson (1994, 1995); Ueckermann and Khanjani (2002); Khanjani *et al*. (2011); Bernadi *et al.* (2012); Khanjani *et al*. (2013); unpublished observations on *Austroteneriffia* sp., all active stages.

1. Ventral lip. The presence of a ventral lip (labium) in *Chulacarus elegans* (Fig. 3A) is considered retention of a plesiomorphic state exhibited in the early derivative lineages of Acariformes (Jesionowska 2003; Lindquist & Palacios-Vargas 1991). Among the members of Anystae, this labial structure is known only in Adamystidae (Coineau & Naudo 1986) and the erythracarine Anystidae (Otto 1999a; pers. obs.).

2. Adoral setae. Regardless of their lengths, the adoral setae are usually similar in form with the subcapitular setae. In *Chulacarus elegans*, the adoral setae are thickened and truncated opposed to the slender subcapitular setae (Fig. 3A). This form of the adoral setae is also found in all known species of Teneriffiidae. The specialization of these setae is present in Pseudocheylidae (they are minute, spine-like) and Pomerantziidae (spine-like inserted without alveolus, apparently immobile). Other members of Anystae (i.e. Adamystidae, Anystidae, Caeculidae, Paratydeidae, and Stigmocheylidae) have the adoral setae similar in shape to the subcapitular setae.

3. Cheliceral stylet. Judson (1994, 1995) reported the presence of a cuticular stylet, probably representing a duct of the cheliceral glands (Judson 1994), on the hyaline process of the chelicerae in the teneriffiid genera *Neoteneriffiola* and *Austroteneriffia*. *Chulacarus elegans* has such a stylet in the similar form: slender, sigmoid and pointing downward; and its tip protrudes from the hyaline process (Fig. 3C). However, there are no records of its absence or presence in other members of Anystae, but based on our preliminary observations this cheliceral stylet is absent in most of the representatives of each family examined. An exception is the Pseudocheylidae which although possesses a similar structure but its tip is remarkably expanded and not protruded from hyaline process (Fuangarworn & Butcher 2015). The genus *Adamystis* (Adamystidae) has a forked process at the cheliceral tip; it is interpreted as a remnant of the fixed-digit.

4. Cheliceral setae. Primitively, the chelicerae bear two setae: *cha* and *chb*, and both are larval. *Chulacarus elegans* has two cheliceral setae but they are developmentally unusual: only *cha* first forms in the larva, *chb* is then added in the protonymph (Figs 7C, 9C). The delay of *chb* has not been previously reported in other families of Anystae having two cheliceral setae.

5. Palptibial claws. In addition to the terminal 'thumb' claw, *Chulacarus elegans* has one subterminal accessory claw on the palptibia and this accessory claw is larval (Figs 3D, 7E–F). This developmental aspect among Anystae whose juveniles are described is known in Pomerantziidae, and possibly Stigmocheylidae (larva unknown). Teneriffiidae and Pseudocheylidae also have larval, but two, accessory claws. In the anystine Anystidae (Grandjean 1943; Meyer & Ueckermann 1987), the two accessory claws are added in the protonymphs, thus are developmentally unique, and these two accessory claws do not seem homologous to those of other Anystae. The accessory claw(s), once formed, are constant in shape throughout ontogeny of the aforementioned taxa. However, in the erythacarine Anystidae, the development of the accessory claw(s) shows at least two variations (based on 4 of 10 recognized genera): being slender setae in larvae and then transformed to spine-like setae (=accessory claw) in nymphs and adults (*Pedidromus, Tarsotomus*; Otto 1999c, 2000), or being spine-like (*Chaussieria*; or feather-like in *Erythracarus*; Otto 1999a, 1999b) in larvae and remaining so until the adult. In Caeculidae, the palptibia has 1 or 2 accessory claw(s) which are often indistinct, i.e. they are often in an intermediate form between normal setae and spine-like setae, especially the proximal member. However, these setae are clearly larval (Coineau 1967, 1974a) and then, like some erythacarine Anystidae, transform more or less into the form of the accessory claw during ontogeny (per. obs.). Outside Anystae, it is worth noting that most members of Tarsocheylidae, a basal group within Heterostigmata, have apparently two larval accessory setae, but these are fused, giving a bifid appearance (Khaustov 2015; Lindquist 1976).

6. Peritremes. The presence of the peritremes is hypothesized to be one of the synapomorphies of the 'Anystina-Eleutherengona complex' (Lindquist 1976; Walter *et al*. 2009). Within this group, the shapes of the peritremes vary greatly, or are even lost, and are usually the diagnostic characters at familial or generic level. In Anystae, the peritremes are usually linear, 'segmented' (an impression of its alveolae ornamentations), transversely lying at the bases of the chelicerae; their distal end may be emergent (Anystidae, Paratydeidae, some Pseudocheylidae, some Teneriffiidae, and Stigmocheylidae) or not (Adamystidae, Caeculidae, Pomerantziidae, and *Chulacarus*, Fig. 3B). The peritremes may be produced onto the anterior corners of the idiosoma as in some Pseudocheylidae and most Teneriffiidae.

7. Stigmata and tracheae. According to Pepato & Klimov (2015), the presence of the dorsal stigmata ($st\pi$; = neostigmata), in addition to the sub-cheliceral stigmata, is apomorphic relative to the plesiomorphic presence of only the sub-cheliceral stigmata found in Labidostommatidae, the basal prostigmatic clade in their analysis. Based on a few existing studies, the tracheal trunk of the dorsal stigmata (which are located at the inter-cheliceral position) usually converge with those from the sub-cheliceral stigmata and exhibit various connections with the latter: (i) running along each other without fusion as found in the tydeid genus *Tydaeolus* (Grandjean 1938b; Judson 1994); or (ii) fused to the latter into a single tracheal trunk, giving a 'Y-shaped' appearance as found in the bdellid genera *Odontoscirus* and *Neomolgus* (Grandjean 1938a; Judson 1994), or (iii) fused to the latter but then diverged, giving an 'X-shaped' tracheal system as found in the teneriffid *Neoteneriffiola coineaui* Judson, Tetranychidae (André & Remacle 1984; Judson 1994), and in *Chulacarus elegans* (Fig. 4B). In addition, there is perhaps an intermediate type of tracheal system as found in Caeculidae: the two stigmata (the smaller paraxial one and the larger antiaxial one) are arranged transversally, both in the sub-cheliceral position, and it is only the latter stigma that gives rise to the tracheal trunk. Coineau (1974a) considered that there is only one trachea with two stigmata and interpreted this as representing an intermediate state between having a single trachea with a single stigma (as in Labidostommatidae) and two trachea with two stigmta (or a Y-shaped trachea; Coineau 1974a; M. Judson per. com.). Heterostigmata display another unique variant of stigmata-tracheal system (Sidorchuk *et al.* 2016).

8. Naso. The naso is variably expressed across taxa within Anystae. It may be remarkably large, auriculate with the distinct ornamentation (Adamystidae); well sclerotzied and plate-like (Caeculidae); narrow and pointed (some Anystidae); rather broader and short (some Anystidae, Teneriffiidae); or vestigial or absent (Some erythracarine Anystidae, Stigmocheylidae, Paratydeidae, Pseudocheylidae, Pomerantziidae). The adults of *Chulacarus elegans* have the rather broad and short naso (Fig. 4C); and, ontogenetically, it is relatively longer and pointed in the larvae (Fig. 7G) and gradually shortened in the subsequent instars (Figs 9A, 12A). An immature stage with a pointed naso is found at least in the teneriffiid genus *Neoteneriffiola* (Bernardi *et al*. 2012), but not in the genus *Austroteneriffia* of the same family (Khanjani *et al*. 2013).

9. Lateral Eyes. Among families of Anystae, when the lateral eyes present, there are usually two pairs of which the anterior pair are clearly lens-like while the posterior pairs may be lens-like, or finely striated as in the anystid genus *Erythracarus* (Otto 1999a). The presence of one pair of lateral eyes in *Chulacarus elegans* is considered unusual. They are lens-like and unusually small, only about an alveolus diameter of the seta *sce* (Fig. 1A). The posterior lateral eyes are absent, i.e. there is no change in striation patterns (density) that would indicate such eyes; however, in recently collected specimens, internal spots are evident posterior to the anterior lateral eyes (Fig. 2A). This condition appears to be similar to that of Pseudocheylidae, having one pair of lens-like lateral eyes (probably anterior ones) but at the anterior corners of the prodorsal shield; the (external) posterior eyes of Pseudocheylidae are absent but a pair of internal spots is evident at its normal position, i.e. near level of the setae *sce* (Skvarla *et al*. 2013; Fuangarworn & Butcher 2015). Some members of Paratydeidae (*Walytydeus tauricus* Kunetzov, 1973 and *Scolotydaeus bacillus* Berlese, 1910) were described as having one pair of lateral eyes but, like Pseudocheylidae, these eyes are situated more anteriorly, close to the level of setae *ve* (as do the other paratydeids bearing two pairs of eyes). In Adamystidae, one pair of lateral eyes is present in the genus *Adamystis*, and in one species of *Saxidromus*, *S. delamarei* Coineau, 1974 (Coineau 1974c); the lateral eyes of the former are often associated with the 'post-ocular bodies' of unknown function.

10. Urstigmata and genital papillae. The larva of *Chulacarus elegans* have a pair of urstigmata in a primitive form (Fig. 7B): with short stalk, dome headed and covered by a scale (= modified seta *1c*) of coxa I (Baker 1985; Grandjean 1942; Theron & Ryke 1975). This condition is also retained in Pomerantziidae (Bochkov & Walter 2007) and Paratydeidae (Theron *et al*. 1969). The urstigmata may be variously reduced, being papilla-like with a central pore (as in Caeculidae), or papilla-like on the anterior-dorsad of coxa II (the anystid mite genus *Anystis*), or absent in Pseudocheylidae.

For nymphs and adults of *Chulacarus elegans*, the presence of the multiple, small genital papillae (adults with 8-10 pairs) in excess of the basic number of three pairs is remarkably unusual and not known in other terrestrial mites. These papillae are dome-like in a cross section and situated in the normal position within a progenital chamber but the exact numbers of them could not be determined due to their small size (Fig. 4D). A multiplication of the genital papillae is known in many species of water mites (Alberti & Coons (1999) and references therein) but their multiplied genital papillae are relatively large and are external.

11. Leg I. Chulacarus elegans has the first pair of legs uniquely constructed among known species of mites. It is relatively massive, slightly curved paraxially, and increasingly twisted from proximal to distal segments such that the unipectinated claws are vertically overlapped and oriented in the same way of the pectinate setae of the genu, tibia and tarsus (Fig. 6A). Its overall structure suggests a raptorial function, but we were unable to observe them alive to confirm this. However, further consideration of the gnathosoma morphology and lack of any solid particles in gut contents suggest that the new species is a predatory mite using the raptorial legs for grasping and securing their prey in soil and litter habitats. Caeculidae also have the raptorial front legs, but in a very different construction, i.e. for example, they are the members of the ventral setae that are hypertrophied and spine-like in caeculids (vs. lateral setae in *Chulacarus elegans*).

12. Leg femora. Adults and juveniles of *Chulacarus elegans* have undivided femora of all legs (Fig. 5). This state is contrasted to the subdivision of such segments, usually occurring at post-larval stages, in most members of Anystae, including Adamystidae, Anystidae, Pomerantziidae, Pseudocheylidae, Teneriffiidae, Stigmocheylidae and most Caeculidae. Paratydeidae have divided femora I and IV while that of II and III are undivided. The undivided femora of all legs present in various superfamilies (or more major groupings) in Eleutherengona (Lindquist 1996), some Caeculidae (Taylor *et al*. 2013; Taylor 2014), the water mite families Libertiidae and Oxidae (Parasitigona) (Bochkov & O'Connor 2006), and elsewhere among acariformes mites (Grandjean 1954).

13. Solenidia. Solenidia on legs are absent from all genua in *Chulacarus elegans*, but present on all tibiae and on tarsi I–II, with formulas of 2-2-2-1 and 1-1-0-0, respectively. It is worth noting that one combination of these states—genua I–II and tarsi III–IV lacking solenidia—is similar to that of Heterostigmata (Lindquist 1976; Lindquist & Krantz 2002) and this state is hypothesized to be one of the synapomorphies of the latter group. However, other members of Anystae, including Caeculidae, erythracarine Anystidae, Pseudocheylidae and Stigmocheylidae, also share this state; and rather common in the raphignathinan Tetranychoidea (Eleutherengona).

14. Famulus. *Chulacarus elegans* has a famulus on the tarsi I and II which is spiniform, erect, and long relative to the length of the solenidion, with which it forms a duplex (Figs 6A, C). Within Anystae, the presence of a famulus on the tarsi I and II is found in Adamystidae, Caeculidae, and Anystidae, they are peg-like, and sometimes in an integumental sink. It is present only on tarsus I in Pomerantziidae; and absent in Pseudocheylidae, Teneriffiidae, Paratydeidae and Stimocheylidae. Kethley (1990) reviewed the distribution of these setae across the prostigmatic families.

15. Empodium. In terms of presence (1) or absence (0), the empodial formula (I–IV) of *Chulacarus elegans* is 0-1-1-1 which is unknown in other families of Anystae, but similar to most Heterostigmata. Some erythracarine Anystidae (*Tarsotomus*), and most Teneriffiidae have lost the empodium on anterior legs, having the formula of 0-0-1-1, and those that completely lack them (0-0-0-0) are the teneriffiid genus *Heteroteneriffia*, Stigmocheylidae, Pomerantziidae and most Caeculidae. The normal formula (1-1-1-1) is present in most Anystidae, Adamystidae, Anystinae and most Erythracarinae, Paratydeidae, Pseudocheylidae, and some Caeculidae (*Caeculus*).

Systematic placement. In the recent classifications of the suborder Prostigmata (Lindquist *et al*. 2009; Walter *et al*. 2009; Zhang *et al*. 2011), *Chulacarus elegans* n. g. et n. sp. clearly belongs to the infraorder (cohort) Anystina, particularly in the hyporder Anystae, *sensu* Zhang *et al*. 2011, since it exhibits several attributes diagnostic of this group: a) the presence of separate chelicerae with a hook-like movable digit and the absence of a fixed digit; b) the presence of a palpal 'thumb-claw' complex; c) the presence of peritremes, d) a naso, e) prodorsal trichobothria (two pairs), and f) adanal setae. In addition, the larva of the new species retain the urstigmata; and the females possess an ovipositor, the eugenital setae, as well as the genital papillae. The presence of undivided femoral segments of legs I–IV might suggest the placement of the new taxon in Eleutherengona, but this seems unlikely since this character state is apparently homoplastic, hence has a limited value in arguing for a sister relationship (Lindquist 1996); and, more importantly, the new taxon lacks most of the synapomorphies of Eleutherengona, viz., 1) the adnate chelicerae, 2) the movable cheliceral digits being partially retractable, 3) the absence of the genital papillae and urstigmata, 4) the closely adjacent anal and genital openings; (Bochkov 2009; Lindquist 1976; Walter *et al.* 2009). Two other synapomorphies: 5) the absence of one nymph in the life-cycle (some Tuckerellidae are exceptions) and 6) the presence of an aedeagus, could not be tested for *Chulacarus* due to the unavailability of specimens. *Chulacarus* is clearly not the member of Parasitengona as it lacks the obvious unique apomorphy of this group, an heteromorphic life cycle (Walter *et al*. 2009).

Further consideration of the position of *Chulacarus* within the Anystae, however, is problematic and is further complicated by the fact that the phylogenetic relationships among families of the Prostigmata remain unresolved (Mironov & Bochkov 2009). Of the eight anystaen families currently recognized (Walter *et al*. 2009; Zhang *et al.* 2011), *Chulacarus* shares two apomorpies only with Teneriffiidae (discussed later). Other families can be rejected rather easily as a 'home' for *Chulacarus* since the new taxon lacks character states considered apomorphic for each of them. We list the selected characters of each family (1–7) that have different states in *Chulacarus*, and those considered uniquely apomorphic for the group in question are in *italic* font. If not specifically cited, the data are taken from various sources as listed in the previous section.

1) Adamystidae, in a broad sense, includes two subfamilies: Adamystinae and Saxidrominae—some workers recognize the latter as a separate family Saxidromidae (Coineau *et al*. 2006; Fernandez *et al*. 2014). They have 1-3 shields partially or completely covering dorsum; *auriculate naso with reticulate ornamentation*; 1-2 pairs of lateral eyes; *a pair of prodorsal lyrifissures present posterior to eyes*; setal elements of opisthosomatic segments AN added developmentally; 2 pairs of genital papillae in adult; chelicerae weakly chelate to hook-like, base bulbous; palpi linear, with 5 free segments, palptibial claw complex absent; coxal plates I–IV contiguous, weakly radiate; leg femora divided.

2) Anystidae comprises two subfamilies: Anystinae and Erythracarinae (Meyer & Ueckermann 1987; Otto 2000; Walter *et al*. 2009). But, until recently, Pepato and Klimov (2015), based on molecular analysis, showed that Anystidae is not monophyletic and elevated Erythracarinae to familial rank. Anystidae (*sensu stricto*) are relatively large bodied, rather short and broad; peritremes elevated; with 2 pairs of lateral eyes; post-larval hypertrichous setae present on body and legs; *palptibia with 3 claws which are developmentally unique* (Note 5); palptarsus well developed, inserted terminally and longer than tibial claws; sagittal apodeme present between coxae IV; coxal plates I–IV contiguous and radiate; leg femora divided; and *leg tarsus with a pair of brush-like setae at bases of claws*. Erythracaridae, *sensu* Pepato and Klimov (2015), were cladistically analyzed by Otto (2000). According to this author, this group is unique among Prostigmata in having *the flexible tarsi on all legs of the adults and nymphs* (Otto 2000), a resultant of multidivision of tarsal segments. Teneriffiidae also have a subdivision of tarsi (only on legs III–IV) but in a different fashion (Judson 1994) from that of Erythracaridae, and is considered to occur independently.

3) Caeculidae have a large body, heavily sclerotized integuments, *8 dorsal shields in the characteristic arrangement*, chelicerae each with one subterminal seta (*cha*), coxal plates I–IV contiguous, leg solenidia in an integumental sink, trichobothrium on leg tarsi, and *raptorial front legs*; the latter is very differently constructed from that of *Chulacarus* (Note 11).

4) Paratydeidae are elongate mites; legs I-II widely separated from legs III-IV; with distinct constrictions posterior to segment C and D (postpedal furrows); naso absent; prodorsal shield poorly defined, narrowly elongate (or crista-like); with 3 pairs of prodorsal setae of which 1 pair trichobothria (*sci*) always inserted on shield; 0–2 pairs of eyes; *lyrifissure* ia *unusually located in setal row* c *(below insertion of setae* c2*)*; peritremes linear, located at cheliceral bases and distally elevated; chelicerae each with one subterminal seta (*cha*); without tibial claw complex; with 2 or 3 pairs of genital papillae; *femora of legs I and IV subdivided while II-IV entire*; pretarsi I–IV with smooth claws and claw like empodium.

5) Pomerantziidae are elongate mites with *a series of dorsal sclerites corresponding to segments C, D, E, F, and H*; legs I-II widely separated from legs III-IV; prodorsal shield bearing 3 normally developed setae (*ve*, *sci*, and *sce*); eyes and trichobothria absent; *cupules* ia, im, ip *absent*; peritremes short confined in between bases of chelicerae; chelicerae each with one subterminal seta (*cha*); *adoral setae inserted without alveolus*; 3 pairs of genital papillae in adult; *ovipositor tubular in form and pleated*; leg femora I-IV subdivided; pretarsi with claws, empodia absent.

6) Pseudocheylidae have weak to strong post-larval hypertrichy on idiosoma and legs; naso absent; with 4 pairs of prodorsal setae (bothridial setae *sci*, normal setae *vi*, *ve*, and *sce*; neotrichous setae excluded); *1 pair of lateral lens-like eyes at anterior corner of prodorsal shield*; setal elements of opisthosomatic segment AD absent; genital papillae absent; peritremes linear, passing onto anterior corner of propodosoma, sometimes emergent distally; palptibia usually with 3 claw-like setae, *palptarsus strongly reduced, scar-like, and lacking solenidion*; leg femora I-IV subdivided; *tarsi terminating as annulated stalk*; pretarsi with padlike empodium; claws present or absent.

7) Stigmocheylidae are elongate mites; legs I-II widely separated from legs III-IV; and with weak constrictions posterior to segments C and D (postpedal furrows); prodorsum with poorly defined shield bearing 1 pair of bothridial setae *sci* and normally developed setae *vi* and *v*e (*sce* off shield); naso weakly developed; eyes absent; peritremes linear, located at cheliceral bases and distally elevated; with 3 pairs of genital papillae; leg femora I-IV subdivided, *pretarsi I with small smooth claws and pretarsi II–IV with setulated claws*; empodia absent from all legs.

As *Chulacarus* is most similar to the Teneriffiidae, this family is examined separately here. In addition to the characters of Anystina (Walter *et al*. 2009), Teneriffiidae are characterized by the following combination of character states (probable apomorphies are underlined): medium to relatively large bodied; with or without post-larval hypertrichy on coxal fields and opisthogaster; peritremes linear located at cheliceral bases and distally emergent (*Teneriffia*), or passing onto anterior corner of propodosoma (other genera) in the form of linear or numerous elongate alveolae; prodorsal shield well developed or absent (probably derived); all 4 prodorsal setae (2 bothridial setae and 2 normal setae) inserted on prodorsal shield; posterior bothridium with 'rosette'; naso (in adults) weakly developed bearing anterior bothridial setae; naso fused to prodorsal shield; with 2 pair of lateral eyes; median eyes under naso present or absent; setal elements of opisthosomatic segment AD absent; cheliceral stylet-like process present in the position of reduced fixed digit; with 2 cheliceral setae; palptibia with 3 claw-like setae; palpal oncophysis present or absent (probably derived) between genu and tibia; palptarsus strongly reduced, disc-like; ventral lip absent; dorsal lip with denticles; adoral setae *or1–2* thickened and truncated; coxal plates I-II and II-IV contiguous or proximate, and radiate; coxal plates I-II meet postero-medially or not; sagittal apodeme present; with 3 pairs genital papillae; femora I–IV divided; tarsi I-II entire, tarsi III-IV uniquely divided into 2 subsegments; trichobothrium present on tarsi III–IV and absent from tarsi I–II; pretarsi with pectinate claws; empodia absent from all legs (*Heteroteneriffia*) or present (claw-like) only on legs III-IV.

From above characters, *Chulacarus* is probably closely related to Teneriffiidae based on sharing at least two apomorphies:

1) *The adoral setae (or1–2) being thickened and truncated*—In *Chulacarus* and all known species of Teneriffiidae, the adoral setae are remarkably thickened and truncated (Note 2). We know no other prostigmatic families with the setae of this form;

2) *The presence of the cuticular stylet on hyaline process of the chelicerae*—the cheliceral stylet (Note 3) was recorded in the teneriffiid genera *Neoteneriffiola* and *Austroteneriffia* (Judson 1994, 1995), and possibly present in all Teneriffiidae. *Chulacarus* shares this structure. To our knowledge no other members of Anystae exhibit this structure except Pseudocheylidae (Note 3).

In terms of classification, however, *Chulacarus* exhibits several conflicts of character states with all teneriffiid genera, i.e. it has a different state to most of the characters listed above for Teneriffiidae. Among these, the most important differences are 1) the presence of the ‘rosette’ of the posterior prodorsal bothridia—an unique apomorphy of teneriffiids not known in other Prostigmata—(*Chulacaus* has instead a few septa on the dorsal chambers of the bothridia, giving the impression of radial chambers (Fig. 4C); they are very different from the teneriffiid ‘rosette’), 2) the presence of a subdivision—in a unique fashion—of tarsi III–IV (vs. entire in *Chulacaus*), and 3) the absence (vs. presence) of anamorphic segment AD—a familial character (Baker & Lindquist 2002; Walter *et al.* 2009). Therefore, the large character gaps between *Chulacarus* and Teneriffiidae (and other anystaen taxa) justifies the proposal of a monotypic new family, Chulacaridae n. fam. Further superfamilial affiliation of Chulacaridae is considered uncertain pending further research; it is placed tentatively within the superfamily Anystoidea.

Table 1. Ontogeny of the leg setae of *Chulacarus elegans* **n. sp.**[1]

	Trochanter	Femur	Genu	Tibia	Tarsus
Leg I					
La	–	*d*, *d1*, (*l*), (*v*), *bv*"	*d*, (*l*), (*v*)	*d*, (*l*), (*v*), *d1*, *v1*", *φ1*, *φ2*	(*ft*), (*tc*), (*p*), (*u*), *s*, (*pv*), *pl*', *ε*, *ω*
Pn	*v*'	–	*d1*,*v1*"	*l1*'	(*a*)
Dn/Tn[2]	–	–	*l1*'	*l1*"	*v*'
Ad	–	–	*d2*, *l1*"	*l2*'	–
Leg II					
La	–	*d*, *l*', *bv*"	*d*, (*l*), (*v*)	*d*, *l*',(*v*), *φ1*, *φ2*	(*ft*), (*tc*), (*p*), (*u*), (*pv*), *s*, *ε*, *ω*
Pn	*v*'	–	–	–	–
Dn/Tn[2]	–	*v*'	–	–	*pl*"
Ad	–	–	–	–	–
Leg III					
La	–	*d*, *v*', *ev*"	*d*, (*l*), (*v*)	*d*, *l*",(*v*), *φ1*, *φ2*	(*tc*), (*p*), (*u*), (*pv*), *s*
Pn	*v*'	–	–	–	–
Dn/Tn	–	–	–	–	–
Ad	–	–	–	–	–
Leg IV					
Pn	–	–	–	–	*ft*', (*tc*), (*u*), (*pv*)
Dn/Tn[2]	*v*'	*d*, *v*', *ev*"	*d*, (*l*), (v)	*d*, (*l*), (*v*), *φ2*	*ft*", (*p*), *s*
Ad	–	–	–	–	–

[1] Placement indicates instar of 1st appearance; dash indicates no change and parentheses indicates a given pair. Abbreviations: La, larva; Pn, protonymph; Dn, deutonymph; Tn, tritonymph; Ad, adult.

[2] The deutonymphs are not available, so setal and solenidial origin in tritonymph are uncertain as to whether they are deuto- or tritonymphal in origin.

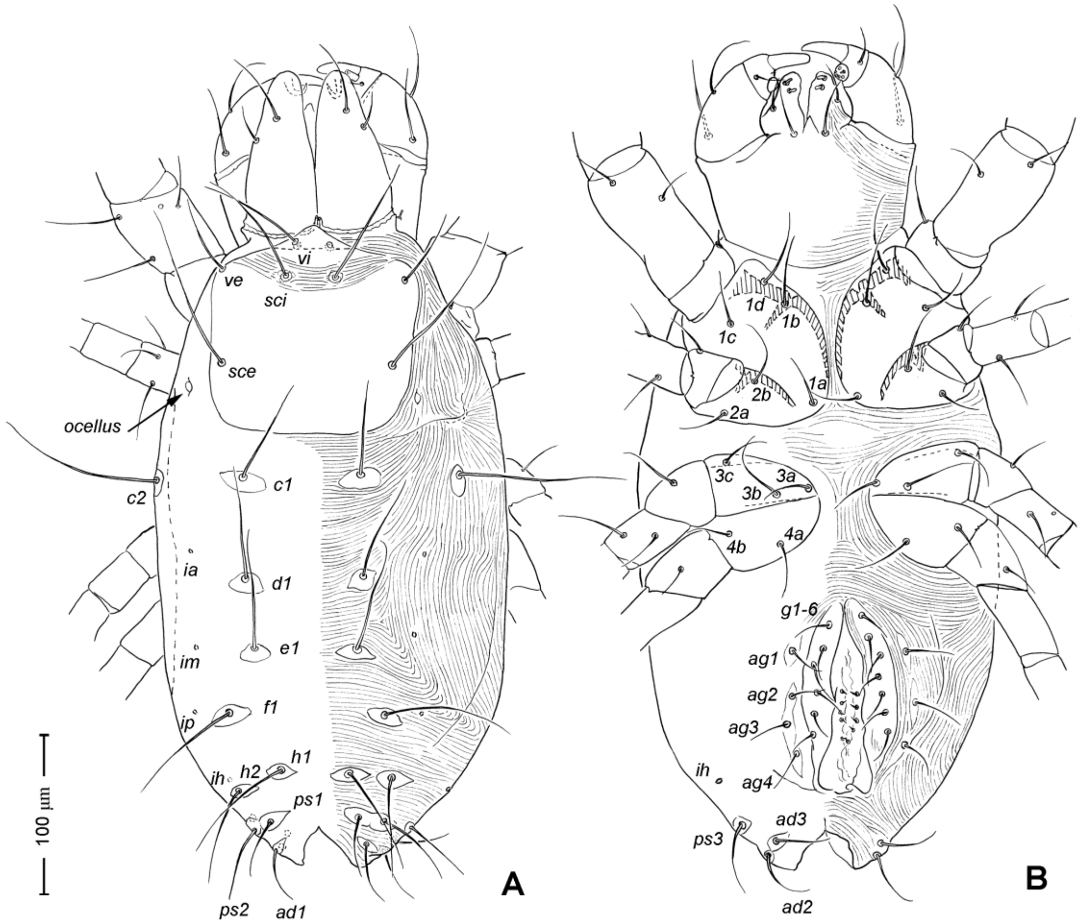

Figure 1. *Chulacarus elegans* **n. sp.**, female: (A) dorsal view; (B) ventral view; palps and legs partial drawn.

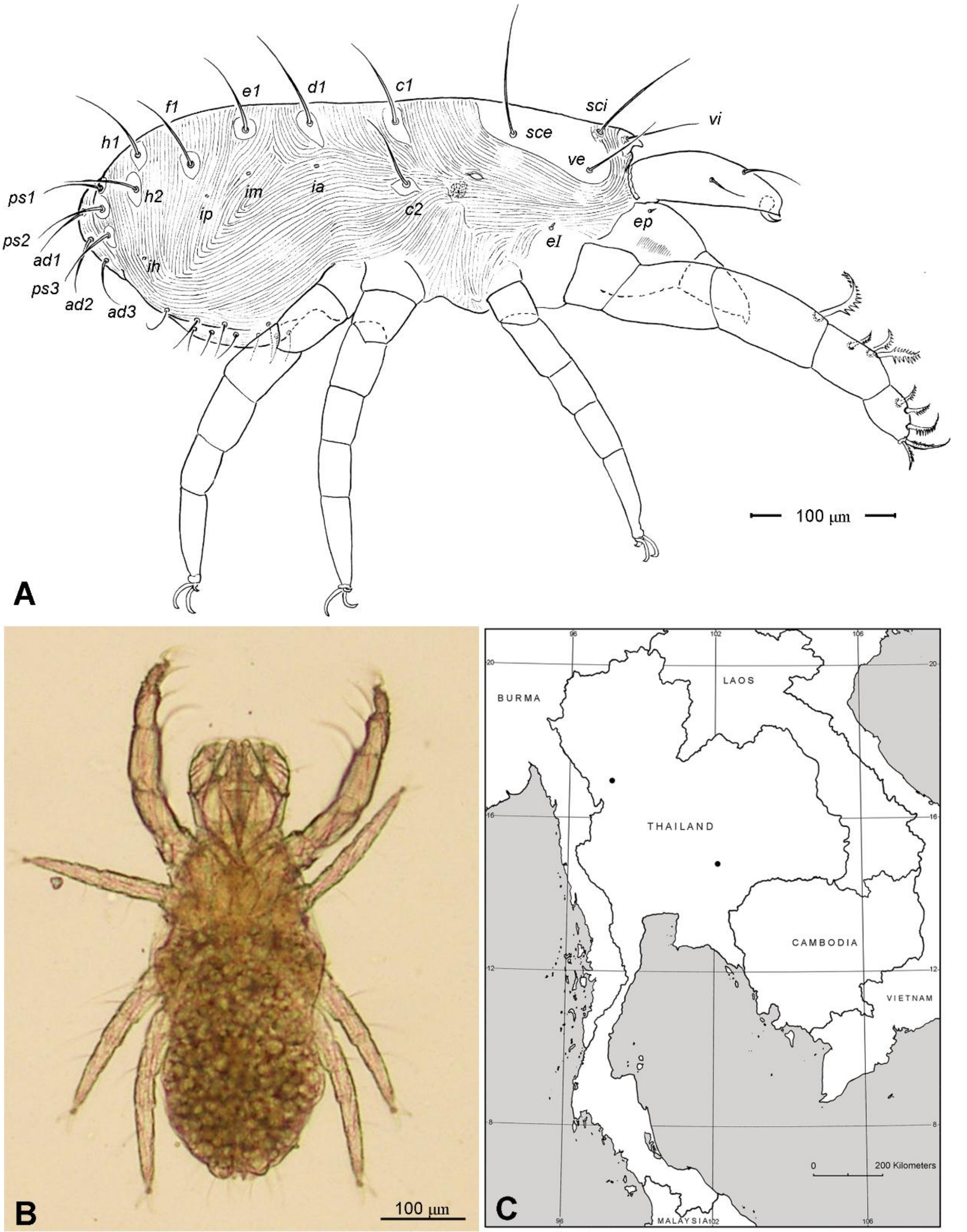

Figure 2. *Chulacarus elegans* **n. sp.**, female: (A) lateral view, legs simplified; (B) transmitted light compound-microscope image of uncleared specimen; (C) map showing the localities (black circles) of *Chulacarus elegans* **n. sp.**

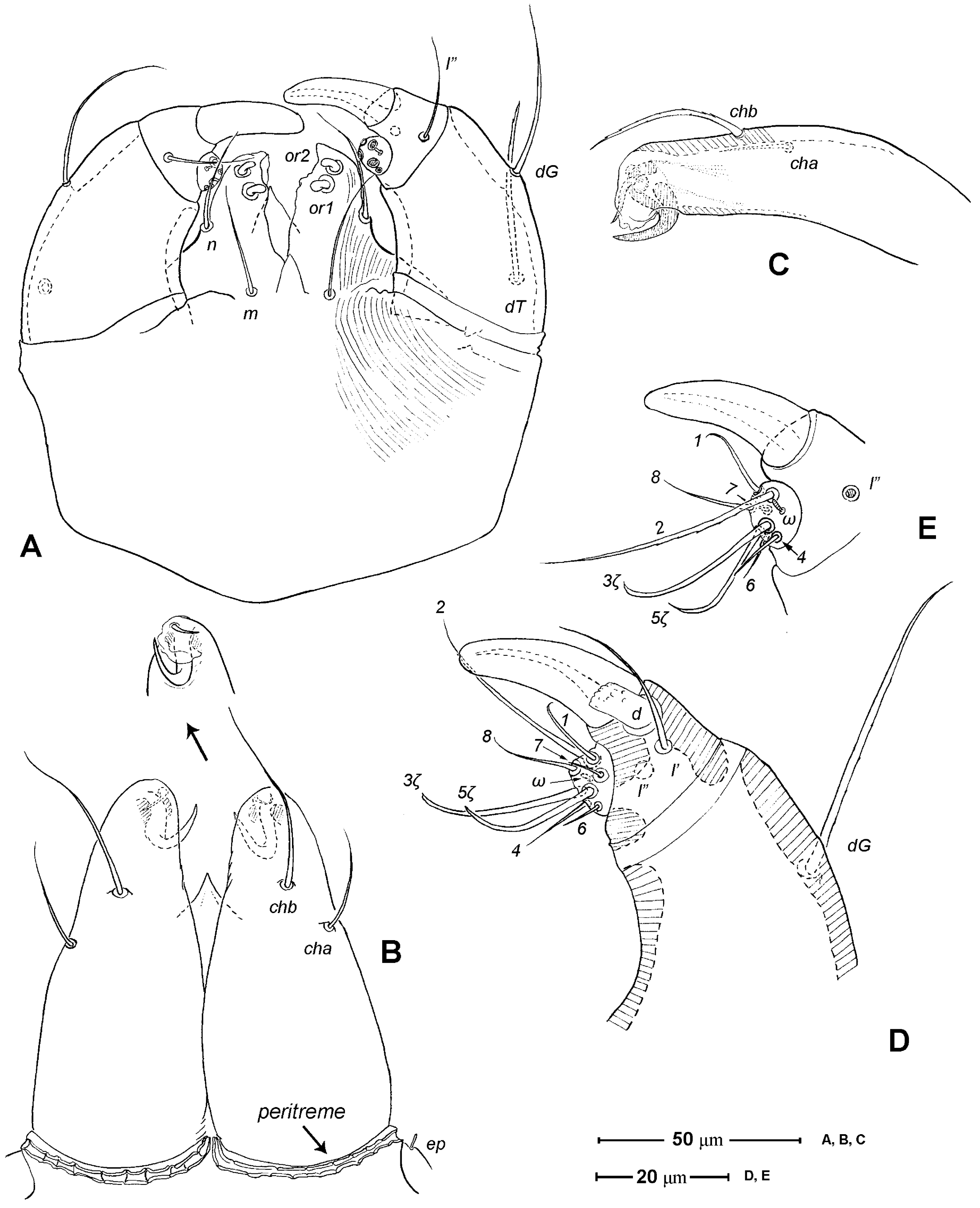

Figure 3. *Chulacarus elegans* **n. sp.**, female: (A) subcapitulum, ventral view; (B) chelicerae, dorsal view with insert showing ventral side of their tip; (C) chelicera, adaxial view; (D) distal part of palp femorogenu, tibia and tarsus, dorsal view; (E) palp tibia and tarsus, ventral view.

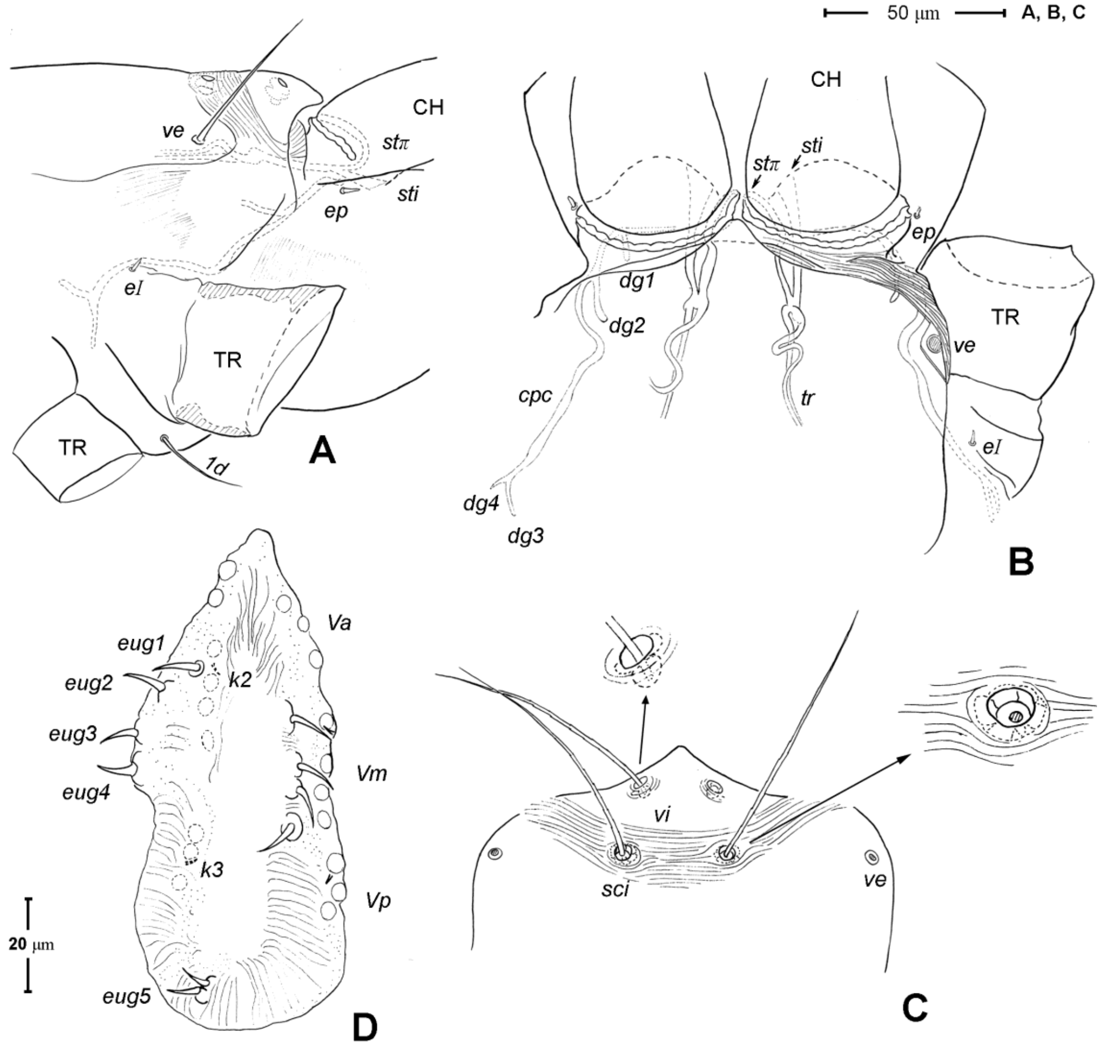

Figure 4. *Chulacarus elegans* **n. sp.**, female: (A) anterior propodosoma, lateral view; (B) same, dorsal view, most of integument removed; (C) naso and anterior portion of propodosomal plate, dorsal view, inserts showing bothridia *vi* and *sci*; (D) ovipositor, ventral view. Abbreviations: *CH*, chelicerae; *TR*, trochanter; *cpc*, podocephalic canal; *dg*, gland duct; *tr*, trachea.

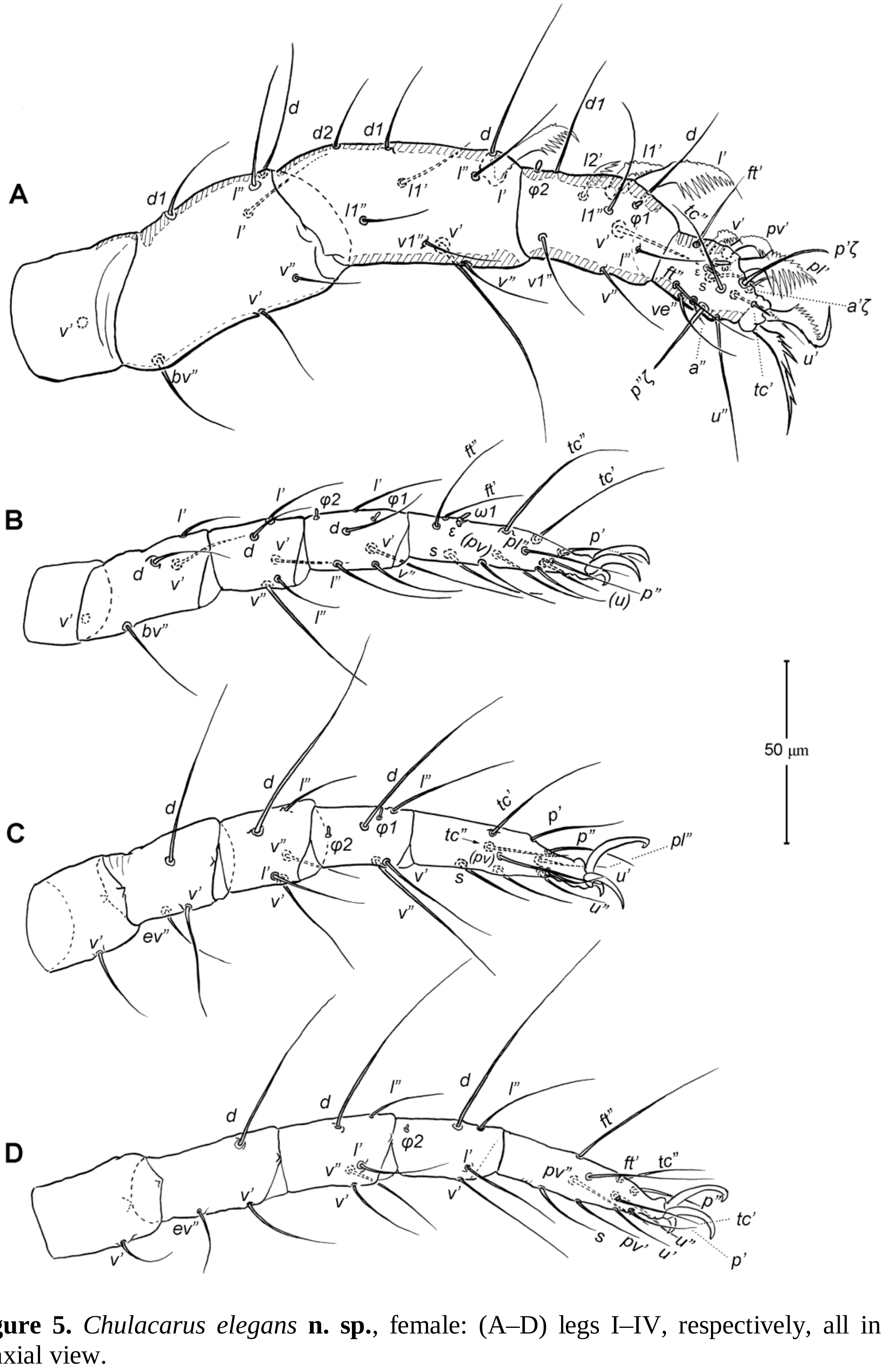

Figure 5. *Chulacarus elegans* **n. sp.**, female: (A–D) legs I–IV, respectively, all in abaxial view.

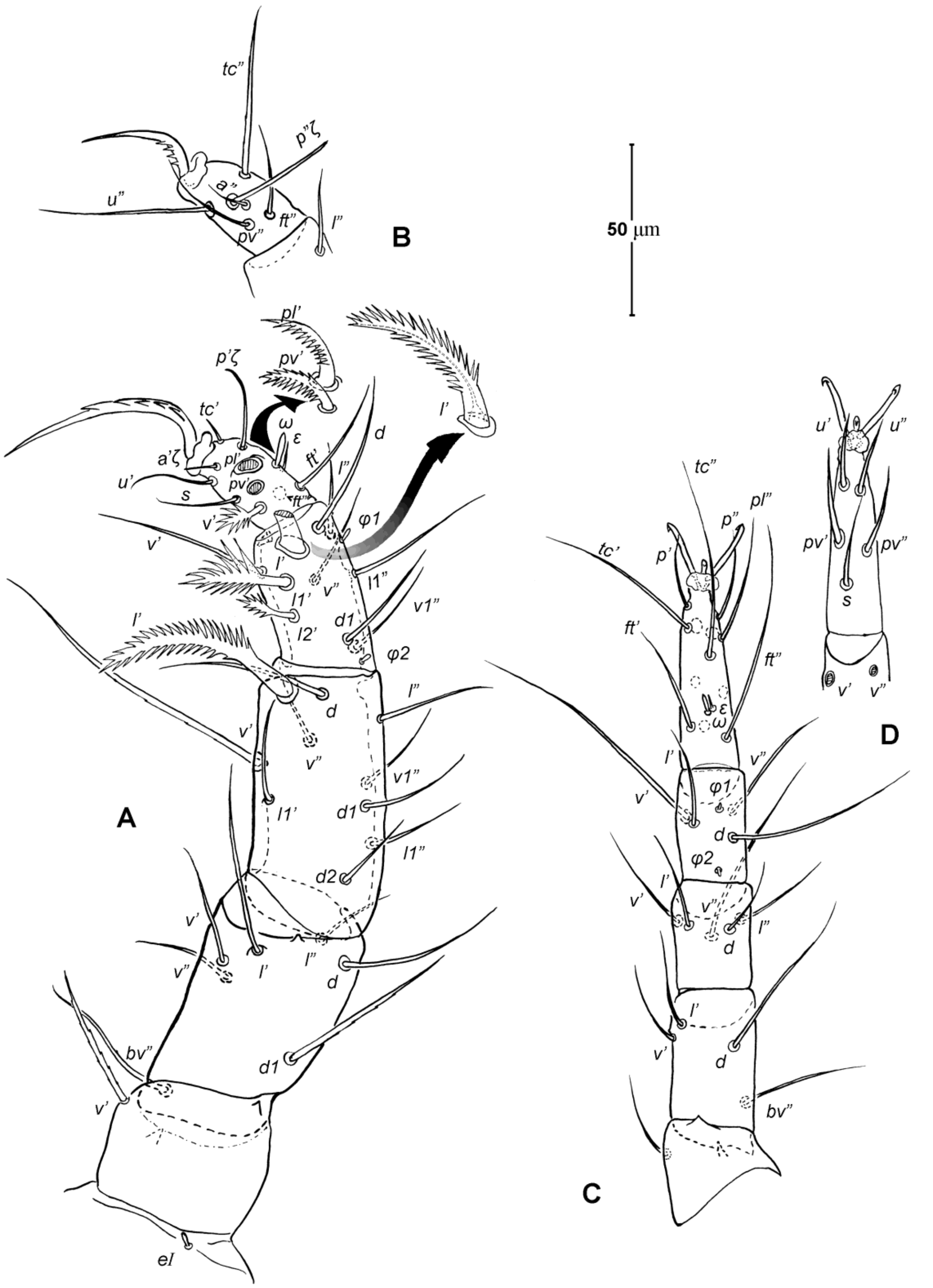

Figure 6. *Chulacarus elegans* **n. sp.**, female: (A) leg I, dorsal view, ventral setae on tarsus not shown; (B) tarsus I, ventral view showing tarsal setae and claw omitted from A; (C) leg II, dorsal view; (D) tarsas II, ventral view showing setae omitted from C.

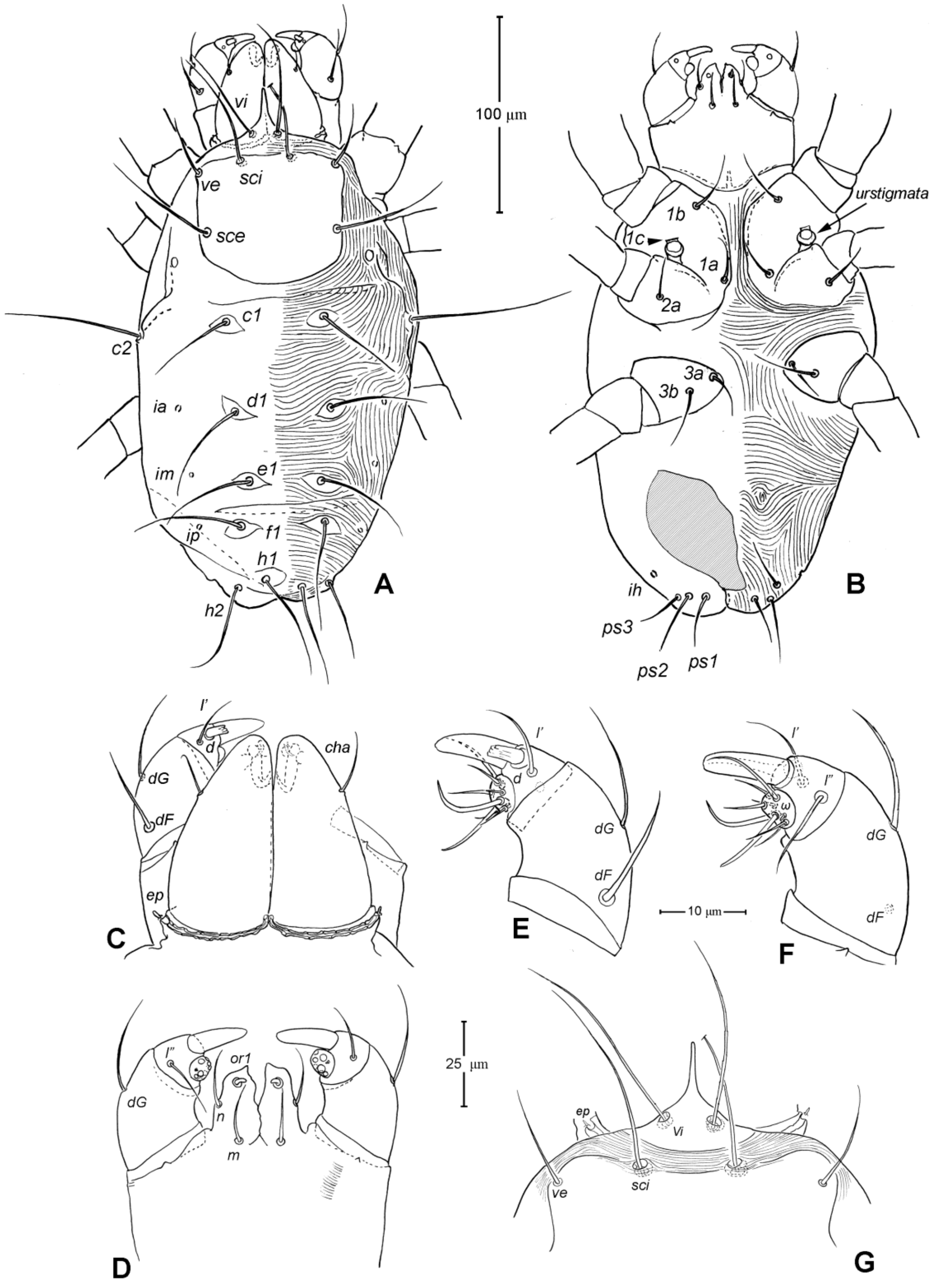

Figure 7. *Chulacarus elegans* **n. sp.**, larva: (A) dorsal view; (B) ventral view, opisthosoma broken, palps and legs partial drawn; (C) gnathosoma, dorsal view; (D) same, ventral view, palptarsal setae shown by their alvoli; (E) palp, dorsal view; (F) same, ventral view; (G) anterior portion of idiosoma, dorsal view.

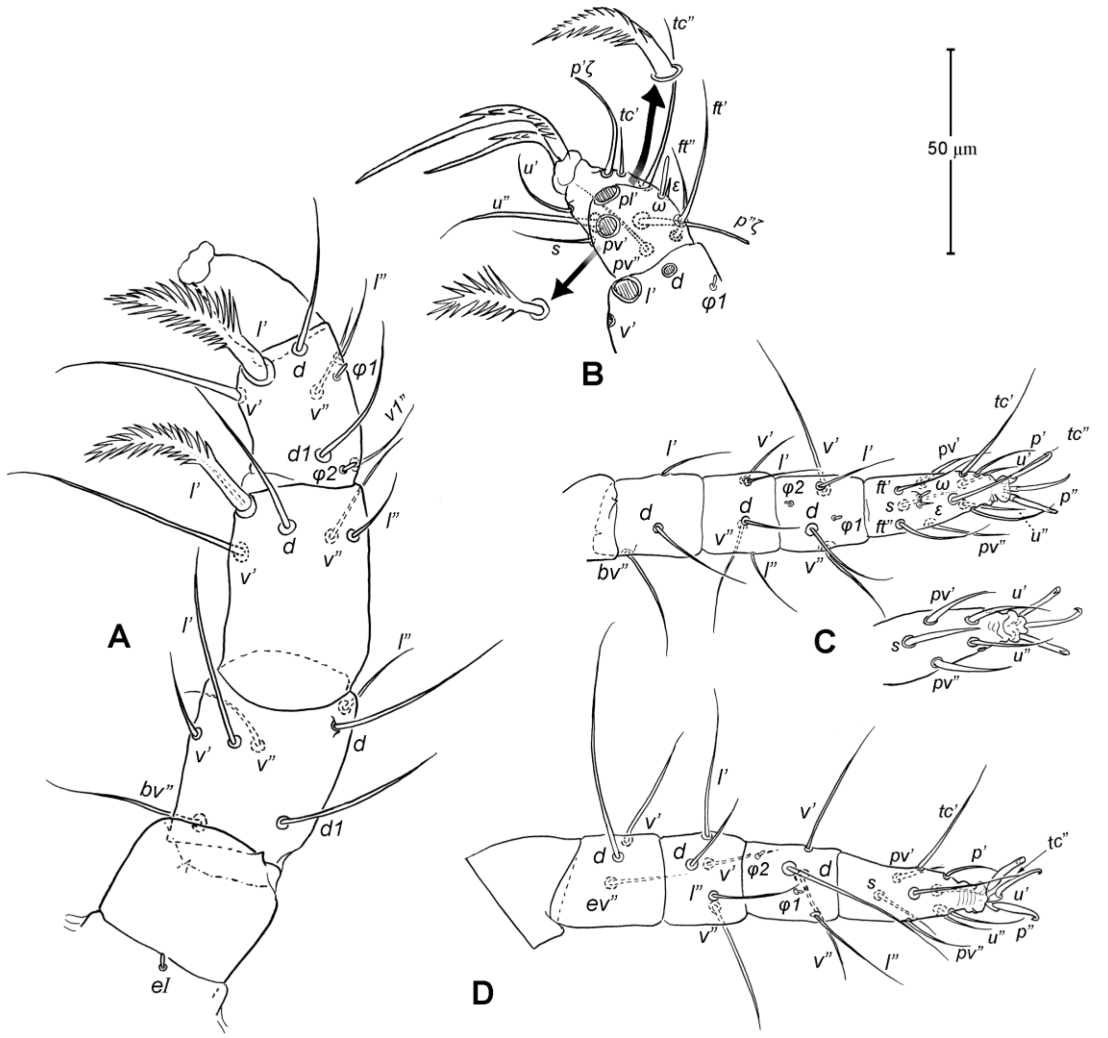

Figure 8. *Chulacarus elegans* **n. sp.**, larva: (A) leg I, dorsal view, tarsus partial drawn; (B) tarsus I, dorsal view; (C) leg II, dorsal view, insert showing ventral side of its tarsus; (D) leg III, dorsal view.

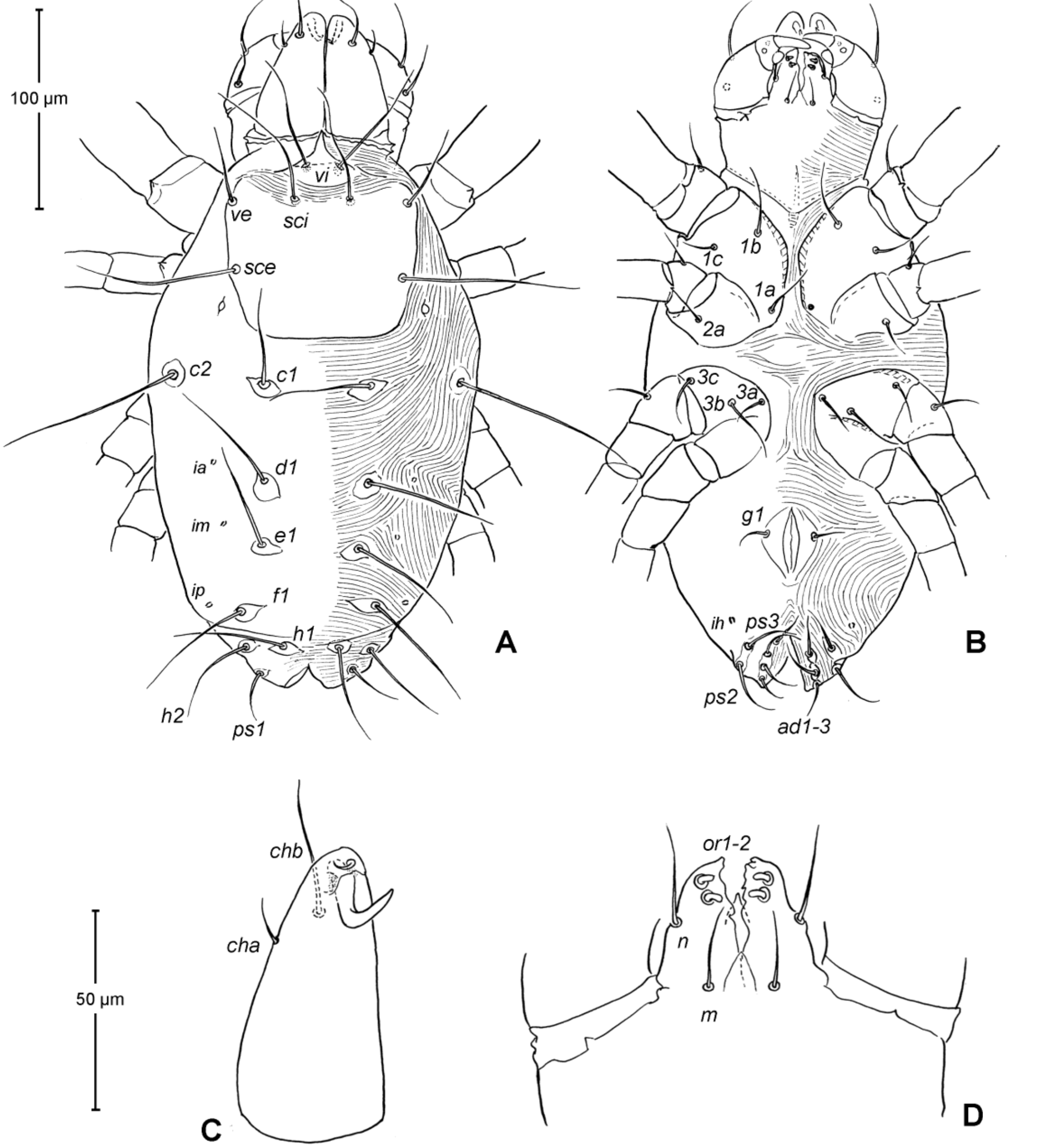

Figure 9. *Chulacarus elegans* **n. sp.**, protonymph: (A) dorsal view; (B) ventral view, palps and legs partial drawn; (C) chelicera, ventral view; (D) subcapitulum ventral view.

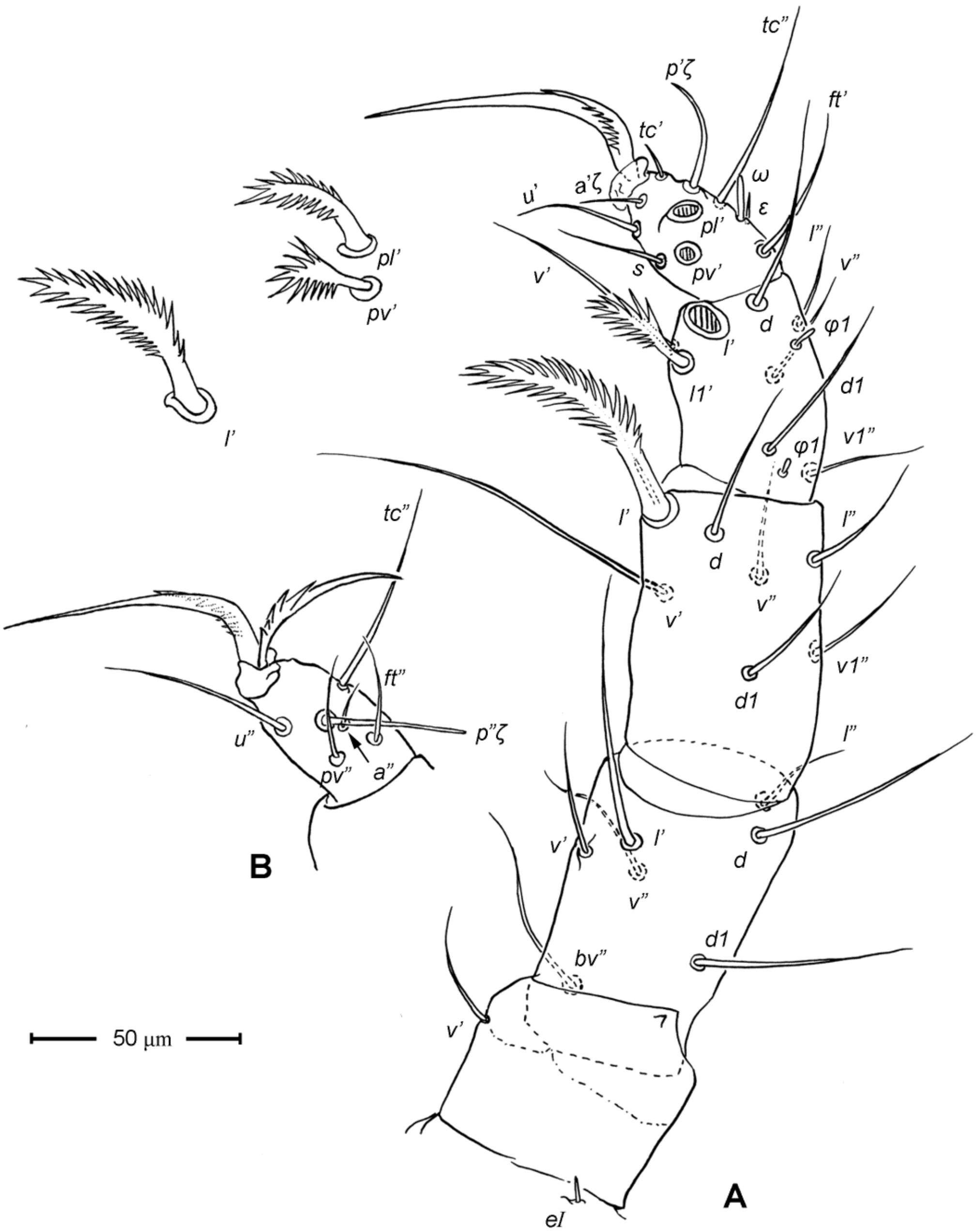

Figure 10. *Chulacarus elegans* **n. sp.**, protonymph: (A) leg I, dorsal view, inserts showing tarsal and tibial pectinate setae, denoted; (B) tarsus I, ventral view.

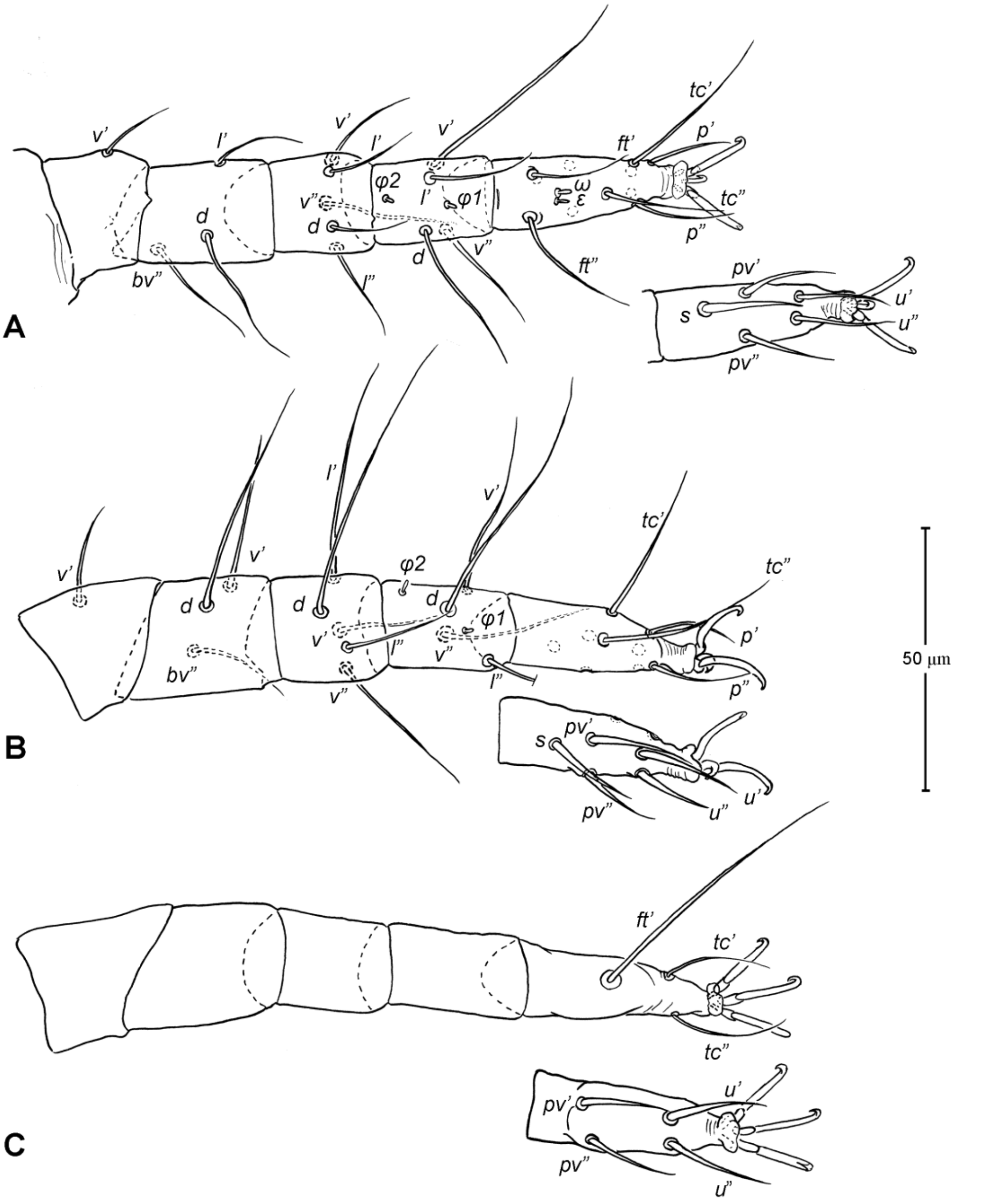

Figure 11. *Chulacarus elegans* **n. sp.**, protonymph: (A–C) legs II-IV, respectively, all in dorsal view with inserts of their respective tarsus in ventral view.

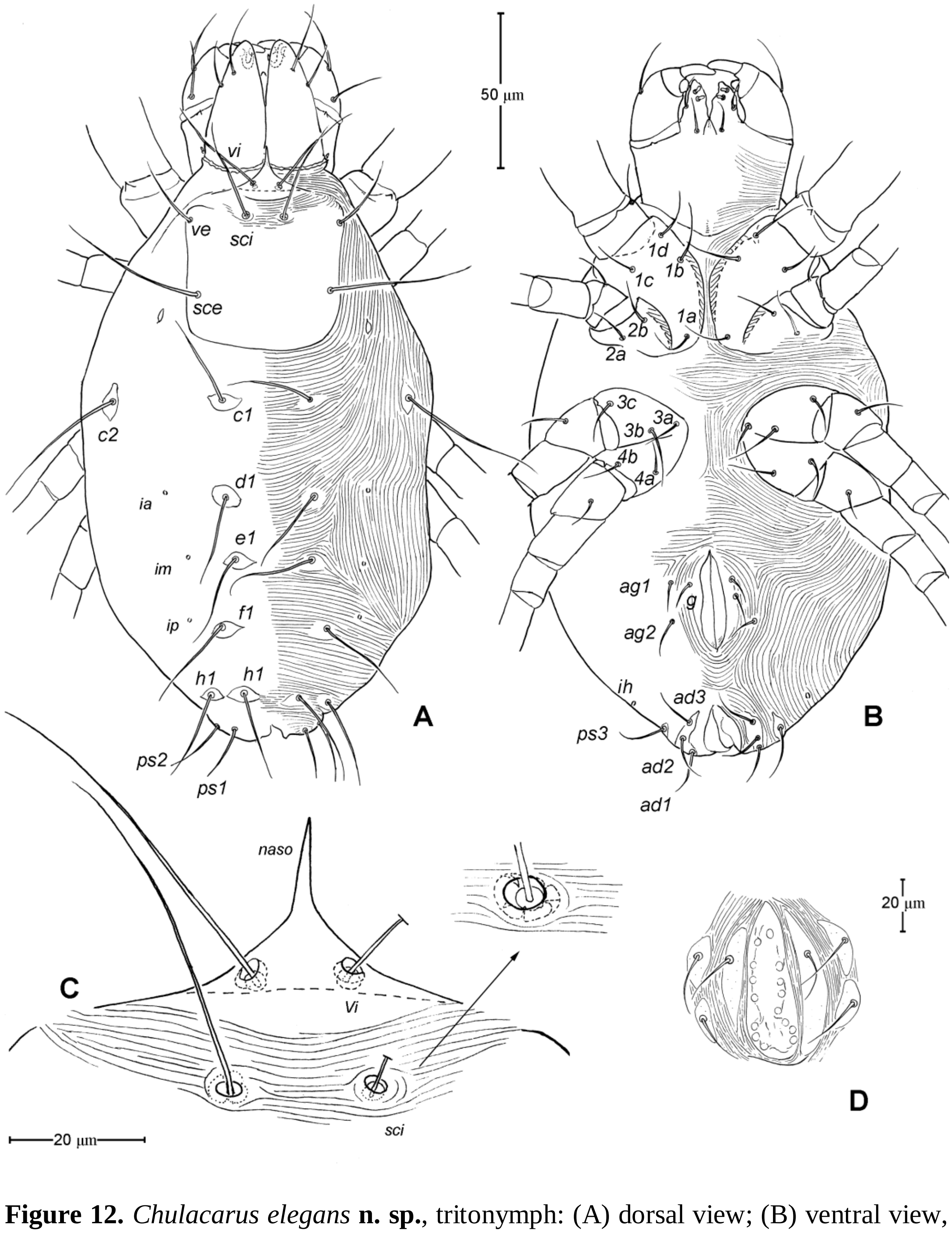

Figure 12. *Chulacarus elegans* **n. sp.**, tritonymph: (A) dorsal view; (B) ventral view, palps and legs partial drawn; (C) anterior portion of idiosoma, dorsal view, insert showing bothridium of *sci*; (D) genital region.

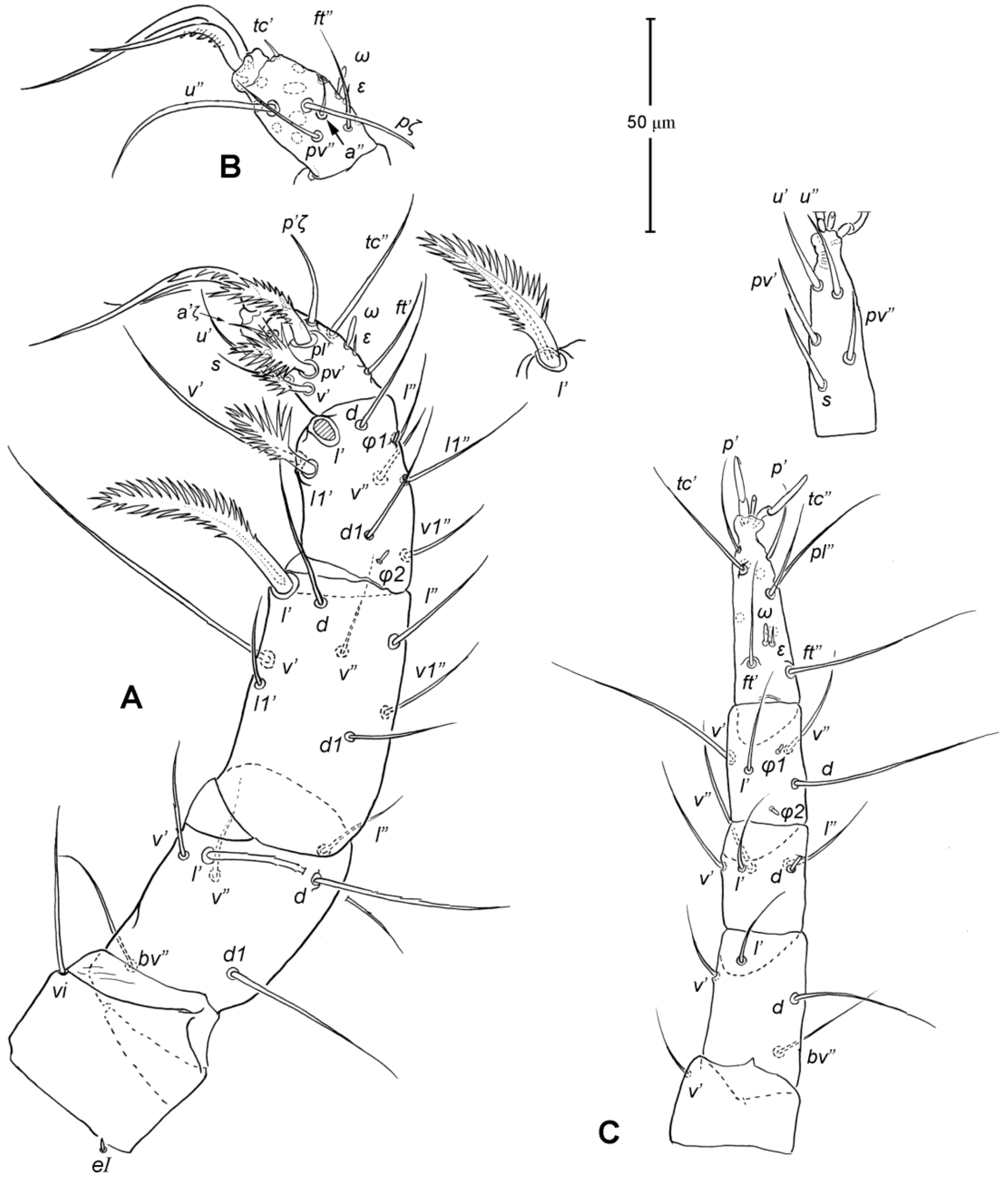

Figure 13. *Chulacarus elegans* **n. sp.**, tritonymph: (A) leg I dorsal view, insert showing tibial seta *l'*; (B) tarsus I ventral view; (C) leg II, dorsal view, insert showing ventral side of its tarsus.

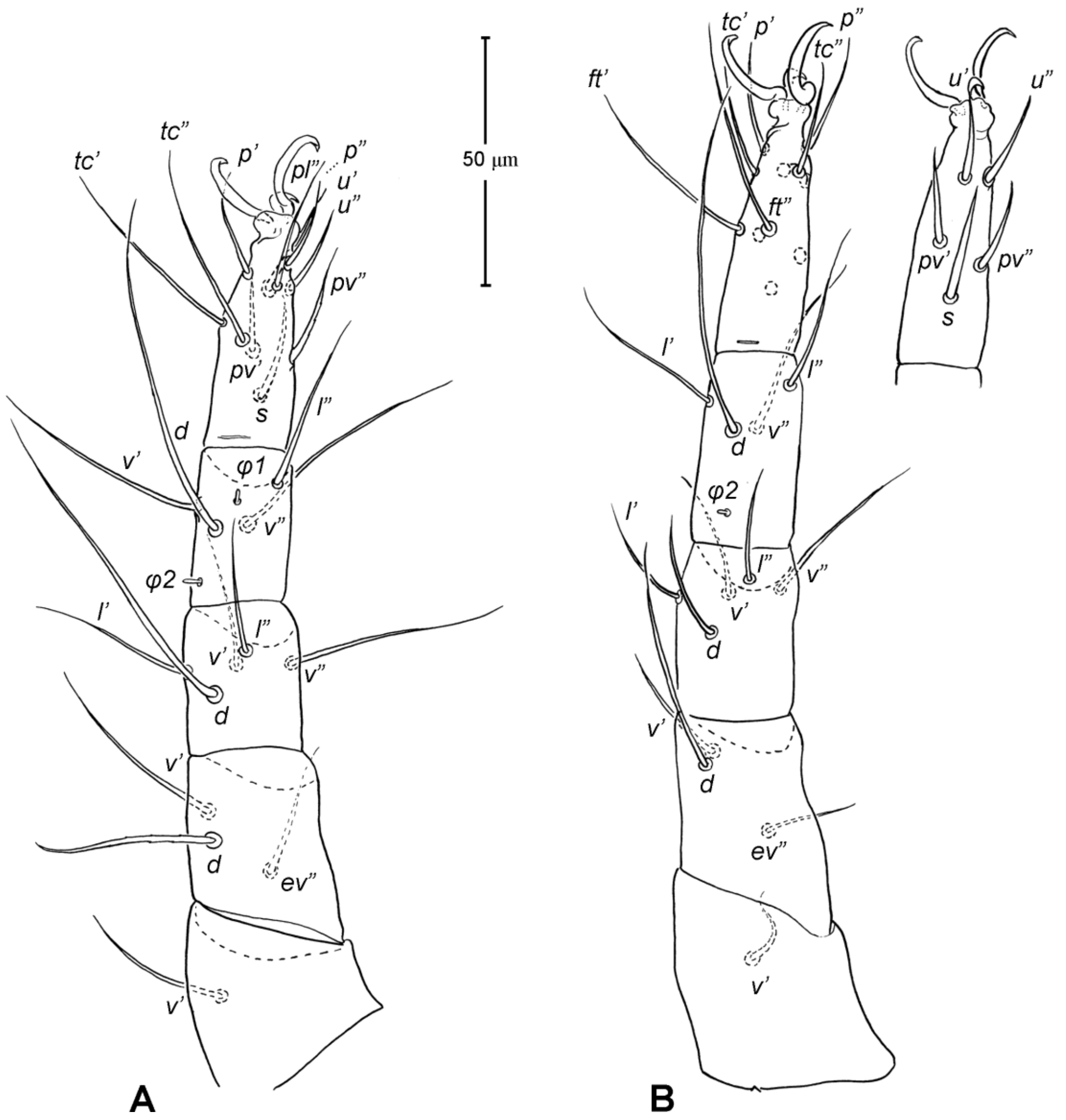

Figure 14. *Chulacarus elegans* **n. sp.**, tritonymph: (A) leg III, dorsal view; (B) leg IV, dorsal view, insert showing ventral side of its tarsus.

CHAPTER 2D

THE FAMILY ERYTHRACARIDAE (ACARI, TROMBIDIFORMES) IN THAILAND: NEW RECORDS AND DESCRIPTION OF NEW SPECIES*

2D-1 Abstract

The family Erythracaridae is recorded for the first time in Thailand, represented by one known species, *Erythracarus nasutus* Otto, 1999a, and three new species: *Tarsotomus ottoi* n. sp., *Tarsolakus pilosus* n. sp., and *Lacteoscythis kanchanaburiensis* n. sp. which are described and illustrated.

Keywords.—Prostigmata, predatory mites, taxonomy, Thailand.

2D-2 Introduction

Based on the molecular phylogenetic analysis, Pepato and Klimov (2015) elevated the Erythracarinae, one of the two subfamilies within Anystidae Oudemans 1936, to familial rank, leaving Anystidae with only a single subfamily Anystinae. According to these authors, Erythracaridae forms a sister clade with Caeculidae but the morphological synapomorphies are not suggested. Unlike Anystinae, members of the Erythracaridae are relatively well known regarding to their morphology and taxonomy which meet the minimum modern requirements. Moreover, the hypothesis about the phylogenetic relationship among the included genera and species is well formed. These are mostly due to the revisionary works made by Meyer and Ueckermann (1987) and Otto (1999a, 1999b, 1999c, 2000). The family Erythracaridae is readily recognized and easily separated from other prostigmatic mites by having the flexible tarsi on all legs (Otto 2000), and it currently consists of 10 genera and 67 species: *Chaussieria*

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* This chapter is a manuscript in preparation for submission as:
Fuangarworn, M. The family Erythracaridae (Acari, Trombidiformes) in Thailand: new records and description of new species.

Oudemans, 1936 (9 species), *Erythracarus* Berlese, 1903 (13), *Lacteoscythis* Pogrebnyak, 1995 (1), *Mesoanystis* Zacharda, 1985 (in Zacharda & Krivolutsky 1985) (1), *Namadia* Meyer & Ueckermann, 1987 (1), *Pedidromus* Otto, 2000 (6), *Paratarsotomus* Kuznetsov, 1983 (5), *Syblia* Oudemans, 1936 (1), *Tarsolarkus* Thor, 1912 (4), and *Tarsotomus* Berlese, 1882 (26). A recent list of valid erythracarid species can be found in Otto (2000). Collectively, Erythracaridae has a worldwide distribution but none has been recorded from Thailand (Chandrapatya 2010), simply because of an undersampling bias. Here we present the first record of the family Erythracaridae from Thailand, represented by one known species, *Erythracarus nasutus* Otto, 1999a, and three new species: *Tarsotomus ottoi* n. sp., *Tarsolakus pilosus* n. sp., and *Lacteoscythis kanchanaburiensis* n. sp. which are described herein.

2D-3 Materials and methods

Mites were collected by hand or extracted from soil and leaf-litter samples using Tullgren funnels (Walter & Krantz 2009), and stored in 70% ethanol (see *Material examined* for collection data). The specimens were observed in temporary cavity slides using lactic acid as the medium under a bright-field compound microscope and phase contrast microscope. Drawings were made with the aid of a drawing tube attached to the microscope. Terminology follows that of Kethley (1990). Measurements are in micrometers (μm).

2D-4 Taxonomic results

Family Erythracaridae Oudemans, 1936

Genus *Erythracarus* Berlese, 1903

***Erythracarus nasutus* Otto, 1999**

(Fig. 1)

Erythracarus nasutus Otto, 1999: Otto (1999a), López-Campos & Vázquez-Rojas (2010), Bernardi *et al.* (2010).

Diagnosis. With characters of the genus *Erythracarus* (cf. Otto 1999a) and following combination of characters: naso terminating in a broad lobe (Fig. 1A), subterminal claw on palp tibia crooked basally, proximal seta *p* on palp tarsus clavate; setation of basifemora I-IV 7-7-7-8, that of telofemora I-IV 5-5-6-7.

Material examined. Three females, Chiangmai Province, Orb Luang (18°13'26.31"N, 98°29'3.67"E), 29 Aug 2013, col. M. Fuangarworn (Field no. 2013-45), ex litter in bamboo-mixed deciduous forest. Two females, Nakon Ratchasima Province, Paktongchai District, Sakaerat Environmental Research Station, (14°31'36.48"N, 101°55'47.68"E), 8 Feb 2015, col. M. Fuangarworn (Field no. 2015-27), ex forest litter. One female, Loei Province, Na Haew District, Saeng Pa Sub-District (17°32'21.07"N, 100°56'21.36"E), 12 Jun 2013, col. M. Fuangarworn (Field no. 2013-37), ex forest litter. One female, 1 male, Tak Province, Srisawad District, Sam Ngao Sub-District, Bhumibol Dam (17°14'46.87"N, 98°59'45.66"E), 2 Mar 2008, col. M. Fuangarworn (Field no. 2008-8), ex leaf-litter and upper soil layer. Three females, 2 males, as previous data but 19 Aug 2012 (Field no. 2012-34), ex soil and litters (hand collecting). Three females, Kanchanaburi Province, Sai Yok District, Ban Khao Wang Kamen, Forest Reserve of the Plant Genetic Conservation Project, 24 Apr 2010, col. M. Fuangarworn (Field no. 2010-37), ex tree hole, 1 feet above ground. One female, 1 male, Kanchanaburi Province, Sai Yok District, Ban Khao Wang Kamen, Forest Reserve of the Plant Genetic Conservation Project, near Tham Pra (cave), 12 Feb 2011, col. M. Fuangarworn (Field no. 2011-4), ex litter. Two females, 1 male, Kanchanaburi Province, Thong Pha Phoom District, Hui-Kayeng Sub-district, Huai Pakkok - Pong Puron forest area (14°39'1.71"N, 98°31'25.72"E), 9 Mar 2014, col. M. Fuangarworn (Field no. 2014-30-32), ex litter, moss and hand collecting from rock outcrops. Five females, 5 males, Ranong Province, Ban Bang-Ben, Laem-Son Pier (9°35'48.26"N, 98°28'9.14"E), 23 Jun 2014, col. M. Fuangarworn (Field no. 2014-49), ex leave litter accumulated on tree branches 2 m above ground (water washing). One female, Pang-Nga Province, Hard Thai Muaeang N.P., 15 May 2007, col. M. Fuangarworn (Field no. 2007-27), ex litter sifted in *Melaleuca* forest. Two females, Krabi Province, Lanta Island (ca. 7°28'25.36"N, 99°5'50.39"E), 5 May 2013, col. M. Fuangarworn (Field no. 2013-23), ex low vegetation, beating along trails. Five females, 5 males, Singburi Province, Bang Rachan District, Pho Chon Kai Sub-district, (14°54'56"N, 100°17'27"E), 28 Mar 2003, col. M. Fuangarworn (Field no. 2003-42), ex litters in a traditional home garden. Two females, Lopburi Province, Pattananikom District, Rd.

#3017, 15th km stone (14°15'18"N, 101°00'11"E), 7 Apr 2003, col. M. Fuangarworn (Field no. 2003-70), ex litter under coconut in sugarcane field. Two females, Ayutthaya Province, Tharuea District, Salaloy Sub-district, (14°31'51.34"N, 100°42'4.12"E), 3 May 2014, col. M. Fuangarworn (Field no. 2014-29), ex beating from low vegetation. One female, 2 males, Chonburi Province, Sattahip District, Samaesan Island (12°35'17.09"N, 100°56'48.00"E), 2 Mar 2014, col. M. Fuangarworn (Field no. 2014-27), ex soil and litter in beach forest. Three females, Chonburi Province, Sattahip District, Samaesan Island (12°34'56.37"N, 100°56'45.21"E), 21 Jul 2012, col. M. Fuangarworn (Field no. 2012-53), ex soil and litter in beach forest.

Distribution. South Africa (Otto 1999a), Brazil (Bernardi *et al*. 2010), Mexico (López-Campos & Vázquez-Rojas 2010), Thailand (this study; provincial records: Ayutthaya, Chiangmai, Chonburi, Kanchanaburi, Krabi, Lopburi, Nakon Rachasima, Pang-Nga, Ranong, Singburi, Tak).

Remarks. The specimens from Thailand agree well with the original description of *Erythracarus nasutus* Otto, 1999 from South Africa (Otto 1999a). This species is also reported from the Neotropical region where it was collected from soil in Mexico, and in caves (on soil surface, organic debris) in Brazil (López-Campos & Vázquez-Rojas 2010; Bernardi *et al*. 2010). The occurrence of this species in Thailand extends its range to the Oriental realm, and it is probably a pan-tropical and subtropical species. In Thailand, *Erythracarus nasutus* is rather widespread collected from soil and litter, on rock outcrops, tree bark, and low vegetation.

Genus *Lacteoscythis* Pogrebnyak, 1995

Lacteoscythis kanchanaburiensis n. sp.

(Figs 2–5)

Diagnosis. The new species can be distinguished from other erythracarid species in having following combination of characters: neotrichous setae absent on prodorsum, dorsal hysterosoma hypertrichous, claw-like empodium present on tarsi I-II.

Description. *Female*. Colour red or pale red; body length (naso to posterior end of idiosoma, n = 1: holotype) 980; width 720. *Gnathosoma*. Indistinctive; chelicerae (Fig. 4B) about 515 long; *cha* 140 long; *chb* 35 long; palp (Fig. 4C) about 325 long;

palp trochanter without setae, femur and genu each with 2 setae, tibia with 2 setae and 2 claw-like setae whose ventral surface with 2 rows of denticles; palp tarsus with relatively large, spiniform solenidion (ω), ca. 15 long, and 25 setae, all setiform including the most dorso-basal one (Fig. 4C). Subcapitulum (Fig. 4A) about 200 long; seta *m* 30 long, *n* 85 long, all with minute barbs, adoral setae (*or1-2*) simple, about 25 long; palp supracoxal seta *ep* rod-like.

Idiosoma (Figs 2-3). Naso reduced. Peritremes with few row of alveolae, linear but expand distally. Prodorsal shield smooth; two pairs of eyes at normal position; hypertrichous setae absent on prodorsum; four pairs of prodorsal setae normally present (*vi*, *ve*, *sci*, *sce*); trichobothria *vi* and *sci* thin and barbed, other setae remarkably thickened, barbed and truncate; setal length: *vi* 105, *ve* 130, *sci* 105, *sce* 155. Hypertrichous setae present on hysterosoma, but setal rows still recognizable; principle hysterosomal setae longer and thicker than hypertrichous ones (Fig. 2); setal length: *c1* 350, *c2* 160, *d1* 275, *e1* 300, *f1* 250, *h1* 200; hypertrichous setae about 75-125 long. Lyrifissures normal. *Epimeral region*. Coxal setation 23-20-38-29 including one remarkably thiner seta each coxa; setae on the most anterior rim on coxa I thinner than other coxal setae; sagittal apodeme not observed.

Anogenital region (Fig. 3). Hypertrichous setae present, about 40-75 long; genital opening 210 long; genital valves with 25-30 genital setae, about 25 long and barbed (Fig. 3). Anal opening about 150 long, with 4 or 5 pairs of setae (*ad*) on anal valves. Progenital chamber with 3 pairs of small genital papillae; ovipositor with 6 pairs of eugenital setae in two groupings (3+3), apparently smooth.

Legs (Fig. 5). Claw-like empodium (Figs 5D-E) present on legs I-IV; supracoxal setae *eI* rod-like; numbers of pseudosegments (PS) on tarsi I-IV 11-18-18-19; on tarsus I, solenidia *ωa* and *ωp* erected, located on PS1 and PS2, respectively, *ωa* about 3-times longer than *ωp* (Fig. 5A); on tibia I, solenidion *φa* erected, *φp* sink (Fig. 5A); on tarsus II, *ωa* and *ωp* erected, located on PS11 and PS12, respectively, *ωa* about 4-times longer than *ωp* (Fig. 5B); on tibia II, solenidion *φa* sink, *φp* erected (Fig. 5B); solenidion *φ* on tibia III erected (Fig. 5C); famulus *ε* peg-like, incompletely sink, located on basal pseudosegments (PS1) on tarsi I-II. Lengths of leg segments (trochanter,TR, basifemur, BF, telofemur, TB, genu, GE, tibia, TI, tarsi, TA):

I – TR 100, BF 75, TF 100, GE 150, TI 225, TA 310;

II – TR 100, BF 75, TF 115, GE 225, TI 310, TA 475;

III – TR 140, BF 100, TF 115, GE 225, TI 375, TA 560;

IV – TR 150, BF 100, TF 125, GE 210, TI 425, TA 600.

Male and Immature stages. Unknown.

Material examined. Holotype, female (slide), THAILAND: Kanchanaburi Province, Sai Yok District, Loom Soom Sub-District, in front of Wat Khao Sam Chan (temple), 23 Apr 2010, col. M. Fuangarworn (field no. 2010-34), ex. soil along bank of road (hand collecting). 5 paratypes, adults: 1 (slide) and 4 (in alcohol), with same data as holotype. Type material deposited in the Acarology collection of Chulalongkorn University Museum of Natural History.

Etymology. Named after the provincial type locality, Kanchanaburi, of the new species.

Distribution. Known only from the the type locality in Thailand (Kanchanaburi)

Remarks. The systematic position of the new species is uncertain, and placing it in *Lacteoscythis* is tentative, as it best fit to this genus after generic amendation. It is excluded from other erythracarid genera primarily due to the lack of the synapomorphy(ies), in parenthesis, of the given genera: *Tarsotomus* (empodium on leg I-II absent), *Tarsolakus* (empodium on leg I-II brush-like), *Pedidromus* (a pair of neotricous setae present on prodorsal shield; palp genu with neotrichy, at least 3 setae), *Erythracarus* (mutual distance of *sce*-*sce* < *ve*-*ve*), *Chaussieria* (setae *sce* aligned with posterior trichobotria *sc*, tarsi I-II divided into 2 pseudosegments by narrow band of wrinkle cuticle); *Namadia* (3 solenidia present on tarsi I-II), and *Paratarsotomus* (peritremes swollen).

The genus *Lacteoscythis* was previously monobasic with *L. arenaria* as type species (Pogrebnyak 1995). According to Otto (2000), *Lacteoscythis* is defined by (1) having the setae on coxal field I differ from those of coxal fields II-IV in morphology, and (2) the combination of (2a) a hypertrichous prodorsum, (2b) a hypertricous hysterosoma, and (2c) a claw-like empodium on tarsi I-II. The new species possesses the thinner setae on coxal field I (Fig. 3), a trend similar to character (1) of *L. arenaria*, however, it should be noted that this characters need reexamination or confirmations in other genera since at least one species of *Tarsotomus* descried below, also has it (Fig.

10A). The rest of character states are also true for *L. kanchanaburiensis* n. sp. except the character (2a)—a hypertrichy is absent in the prodorsum of *L. kanchanaburiensis* n. sp.—but we view that this might be not enough to exclude the new species from *Lacteoscythis* since the hypertrichy is rather homoplastic trait as mentioned earlier.

It is worthy to note that *L. kanchanaburiensis* n. sp. and *L. arenaria* share the presence of solenidia on minor pseudosegments (= segments beyond basal ones) on tarsi II (Fig. 5B) such that the basal pseudosegment (PS1) devoids of solenidia. A similar condition is also found in *Paratarsotomus* and *Namadia* (Otto, 2000), but not shared by other erythracarid species. This character may be a potential synapomorphy for this assemblage. Further evaluation of this and other characters is needed by reexamination of the type materials of all species.

Genus *Tarsolarkus* Thor, 1912

Tarsolarkus pilosus n. sp.

(Figs 6–8)

Diagnosis. With characters of the genus *Tarsolarkus* (cf. Otto 2000) and following combination of characters: hypertrichous setae present both on prodorsum and dorsal hysterosoma; unpaired median seta on prodorsal shield absent; coxa III with specialized seta, solenidia ωa and ωp on tarsus I erected; solenidion φa on tibia I erected, φp sink; solenidia ωa and ωp on tarsus II erected; solenidion φa on tibia II sink, φp erected; solenidion φ on tibia III erected.

Description. *Male*. Colour pale red; body length (naso to posterior end of idiosoma, n = 1: holotype) 885; width 535. *Gnathosoma*. Indistinctive; chelicerae (Fig. 8A) about 130 long; *cha* longer and thicker than *chb*; movable digit with cluster of small hyaline spines at base; palp (Fig. 8B) about 300 long; palp trochanter without setae; palp femur and genu each with 1 seta; palp tibia 2 setae and 2 claw-like setae whose ventral surface with two rows of denticles; palp tarsus with one rod-like solenidion, ω, (completely sink) and 25 setae of which the most dorso-basal one claw-like (Fig. 8B). Subcapitulum (Fig. 8C) with slender seta *m* and *n*, subequal, with minute barbs; adoral setae (*or1-2*) simple shorter than *m* and *n*; palp supracoxal seta *ep* rod-like.

Idiosoma (Figs 6-7, 8D). Naso greatly reduced. Peritremes ribbon shaped, distally elevated (Fig. 8D). Prodorsal shield ill defined; two pairs of eyes at normal position; hypertrichous setae present of 2 types: a) elongate, barbed and truncate tipped setae (ca. 100 long) which clustering on anterior end of idiosoma, and b) shorter, narrowly lanceolate and apparently smooth setae (ca. 60-90 long), which uniformly distributed (Fig. 6); medial seta typical for *Tarsolarkus* species absent; principal prodorsal setae normally present but their homologies obscured by hypertrichous setae except for trichobothria *vi* and *sci*, thin and barbed, about 90, and 145 long, respectively. Dorsal opisthosomal setae with hypertrichous setae type b), uniformly distributed (Fig. 6); principal opisthosomal setae elongate, barbed and bluntly tipped; their length: *c1* 275; *c2* 200; *c3* 175; *d1* 250; *e1* 250; *f1* 215; *h1* 150; other setae (*h2-3, ps1-3*) broken. Lyrifissures not observed. *Epimeral region*. Coxal setation 20-21-28-ca.15; all setae slightly dilate, barbed and bluntly tipped, ca. 40-90 long, except one specialized seta on coxa III, thickened with fine barbs (Fig. 7B), ca. 90 long.

Anogenital region (Fig. 7A). Hypertrichous setae type *b* present; genital opening 160 long; genital valves with 18-20 genital setae, all densely barbed, inner setae about 10-15, outer setae about 40 long (Fig. 7A). Anal opening about 75 long; with 5 pairs of setae (*ad*) on anal valves. Progenital chamber with 3 pairs of small, genital papillae; genitalia with several hypertrophies eugenital setae (details not observed).

Legs (Figs 8E-H). Typical of the genus; empodium brush-like on all legs; supracoxal setae *eI* rod-like; numbers of pseudosegments on tarsi I-IV 12-11-11-13; solenidia *ωa* and *ωp* on tarsus I erected (Fig. 8E); solenidion *φa* on tibia I erected, *φp* sink (Fig. 8F); solenidia *ωa* and *ωp* on tarsus II erected; solenidion *φa* on tibia II sink, *φp* erected (Fig. 8G); solenidion *φ* on tibia III erected (Fig. 8H). Lengths of leg segments: I – BF 60, TF 60, GE 140, TI 190, TA 225; other legs not suitable for measurements.

Female and immature stages. Unknown.

Material examined. Holotype, male, THAILAND: Kanchanaburi Province, Sai Yok District, Ban Khao Wang Kamen, Forest Reserve of the Plant Genetic Conservation Project, near Tham Thep Nimit (cave), 23 Apr 2013, col. M. Fuangarworn

(Field no. 2013-9), ex. on rock (hand collecting). Type material deposited in the Acarology collection of Chulalongkorn University Museum of Natural History.

Etymology. Named after the extraordinary hypertrichy on the body of the new species (‘*pilosus*’, Latin, meaning hairy).

Distribution. Known only from the type locality, Thailand (Kanchanaburi).

Remarks. *Tarsolarkus pilosus* n. sp. is included in the genus *Tarsolarkus* on the basis of the presence of a brush-like empodium on pretarsi I-IV. However, the new species stands far from all known species of *Tarsolarkus* (adult) in not having an unpaired median seta on the prodorsal shield and in having hypertrichous setae on prodorsum. These may suggest the placement of *Tarsolarkus pilosus* n. sp. in another taxon, i.e. a new genus or subgenus, but doing so seems premature, pending further study of the immature stages. The hypertrichy is rather a homoplastic character, also present in several species of the genus *Tarsotomus* (Otto, 1999c).

Genus *Tarsotomus* Berlese, 1882

***Tarsotomus ottoi* n. sp.**

(Figs 9–12)

Diagnosis. With characters of the genus *Tarsotomus* (cf. Otto 1999c) and following combination of characters: palp femur with one seta; palp genu with two setae; hypertrichous setae on prodorsum absent; setation of hysterosomal setae in row *c*, *d*, *e*: 2-2-3; coxa III without specialized seta; tarsi I-II without plumose setae; solenidion *ωa* on tarsus I sink, *ωp* erected; solenidia *φa* and *φp* on tibia I sink; solenidion *ωa* on tarsus II sink, *ωp* erected; solenidion *φ* on tibia II sink; solenidion *φ* on tibia III sink.

Description. *Male.* Colour red or pale red; body length (naso to posterior end of idiosoma, n = 1: holotype) 1340; width 875. *Gnathosoma*. Indistinctive; chelicerae (Fig. 11A) about 330 long; *cha* 140 long; *chb* 50 long; movable digit with cluster of small hyaline spines at base; palp (Fig. 11C) about 175 long; palp trochanter without setae, femur with one seta, genu with 2 setae, tibia with 2 setae and 2 claw-like setae whose ventral surface with single row of denticles; palp tarsus with 1 rod-like solenidion (*ω,* completely sink), 23 setae of which the most dorso-basal one claw-like (Fig. 11C). Subcapitulum (Fig. 11A) about 300 long; seta *m* 40 long, *n* 25 long, all with minute barbs, adoral setae (*or1-2*) simple, 10-15 long; palp supracoxal seta *ep* rod-like.

Idiosoma (Figs 9-10). Naso greatly reduced. Peritremes expand distally. Prodorsal shield ill defined; two pairs of eyes at normal position; hypertrichous setae absent; four pairs of prodorsal setae present (*vi*, *ve*, *sci*, *sce*); trichobothria *vi* and *sci* thin and barbed; setal length: *vi* 100, *ve* 120, *sci* 100, *sce* 160. Setation of dorsal hysterosomal setae rows *c*-*e*: 2-2-3; with weak hypertrichy near posterior end of idiodoma (Fig. 9); setae length: *c1* 140, *c2* 135, *d1* 130, *d2* 110, *e1* 110, *e2* 75, *e3* 90; setae in row *f* about 75-125 long, in row *h* about 100 long. Lyrifissures normal. *Epimeral region*. Coxal setation 15-18-20-15; setae on the most anterior rim on coxa I thinner than other coxal setae; sagittal apodeme ca. 100 long.

Anogenital region (Fig. 10A). Hypertrichous setae present; genital opening 100 long; genital valves with 28-30 pairs of barbed genital setae, about 15-40 long (Fig. 10B); with 5 pairs of setae (*ad*) on anal valves. Progenital chamber with 3 pairs of small genital papillae; genitalia with several hyperthrophied eugenital setae (details not observed).

Legs (Fig. 12). Typical for the genus; empodium absent on legs I-II, claw-like on legs III-IV; supracoxal setae *eI* rod-like; numbers of pseudosegments on tarsi I-IV 10-10-13-15; coxa III without specialized seta; tarsi I-II without plumose setae; solenidion *ωa* on tarsus I sink, *ωp* erected (Fig. 12A); solenidia *φa* and *φp* on tibia I sink (Fig. 12A); solenidion *ωa* on tarsus II sink, *ωp* erected (Fig. 12B); solenidion *φ* on tibia II sink (Fig. 12C); solenidion *φ* on tibia III sink (Fig. 12D). Leg length:

I – TR 110, BF 75, TF 100, GE 260, TI 300, TA 350;

II – TR 125, BF 125, TF 125, GE 250, TI 400, TA 375;

III – TR 150, BF 125, TF 150, GE 275, TI 425, TA 550;

IV – TR 175, BF 150, TF 175, GE 350, TI 485, TA 600.

Female. Similar to male, but with two rows of genital setae (Fig. 10C), ovipositor with 3 pairs of eugenital setae, all slender, smooth and curved.

Immature stages. Unknown.

Material examined. Holotype, female (slide), Thailand: Ayutthaya Province, Tharuea District, Salaloy Sub-District (14°31.75'N, 100°42.26'E), 3 Jan 2012, col. M. Fuangarworn, ex soil surface in a traditional home garden (hand collecting). Six paratypes adults (alcohol) with same data of holotype. *Other materials*: 2 adults (alcohol), with same data as holotype except 6 Dec 2013. One adult (alcohol), with same data as holotype except 23 Mar 2003, Field no. 2003-28, ex litter (Berlese extraction). One female (slide), 6 adults (alcohol), Kanchanaburi Province, Sai Yok District, Ban Khao Wang Kamen, Forest Reserve of the Plant Genetic Conservation Project, 24 Apr 2010, col. M. Fuangarworn, ex forest floor (hand collecting). Two adults (alcohol), with same data except 20 Feb 2012. One adult (alcohol), Kanchanaburi Province, Sai Yok District, Ban Khao Wang Kamen, Forest Reserve of the Plant Genetic Conservation Project, near Tham Manao Phee (cave), 22 Apr 2014, col. M. Fuangarworn, ex. forest floor (hand collecting). Three females, 1 male (slide), 10 adults (alcohol), Saraburi Province, Kaengkoi District, Chulalongkorn University Area, 14 Jan 2006, col. M. Fuangarworn (field no. 2006-3), ex on rocks in forest (hand collecting). Type material deposited in the Acarology collection of Chulalongkorn University Museum of Natural History.

Etymology. Named after J. Otto whose useful revision of Erythracarinae (Otto 1999a, 1999b, 1999c, 2000) formed a basis for this study.

Distribution. Thailand (provincial records: Ayutthaya, Kanchanaburi, Saraburi).

Remarks. *Tarsotomus ottoi* n. sp. is similar to *T. primitive* Otto, 1999c from Australia in not having plumose setae on tarsi I-II and neotrichous setae on prodorsum, and in having two setae on palp genu. However, the new species may be distinguished from *T. primitive* by having relative short setae on dorsal hysterosoma (vs. relatively longer in *T. primitive*); three pairs of setae in row *e* (vs. two pairs); and having different configurations of solenidia on leg segments: for example, solenidia ωa on tarsus I sink, ωp erected (vs. both erected); both solenidia φa and φp on tibia I sink (vs. only φp on tibia erected).

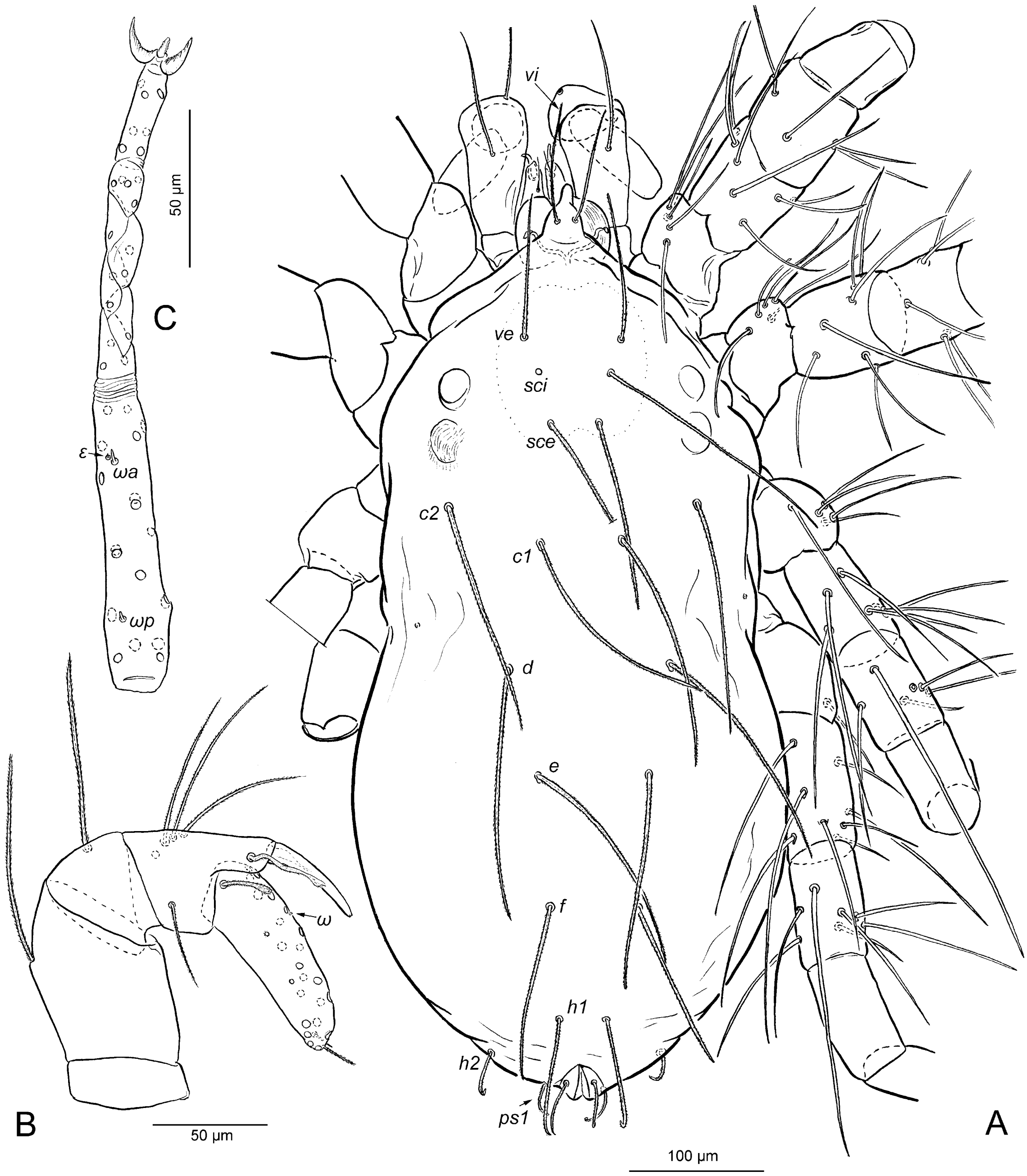

Figure 1. *Erythracarus nasutus* Otto, 1999, female, distended: (A) dorsal view, palps simplified, legs partially drawn (setae on right legs illustrated only on segments trochanter to telofemur); (B) palp, abaxial view, setae on tarsus shown by their alveoi; (C) tarsus I, dorsal view, setae shown by their alveoli. Scale bars: A 100 µm, B-C 50 µm.

Figure 2. *Lacteoscythis kanchanaburiensis* n. sp., female, compressed: idiosoma, dorsal view. Scale bars: 100 µm.

Figure 3. *Lacteoscythis kanchanaburiensis* n. sp., female, compressed: idiosoma, ventral view, partially drawn, most coxal setae shown by their alveoli. Scale bar: 100 µm.

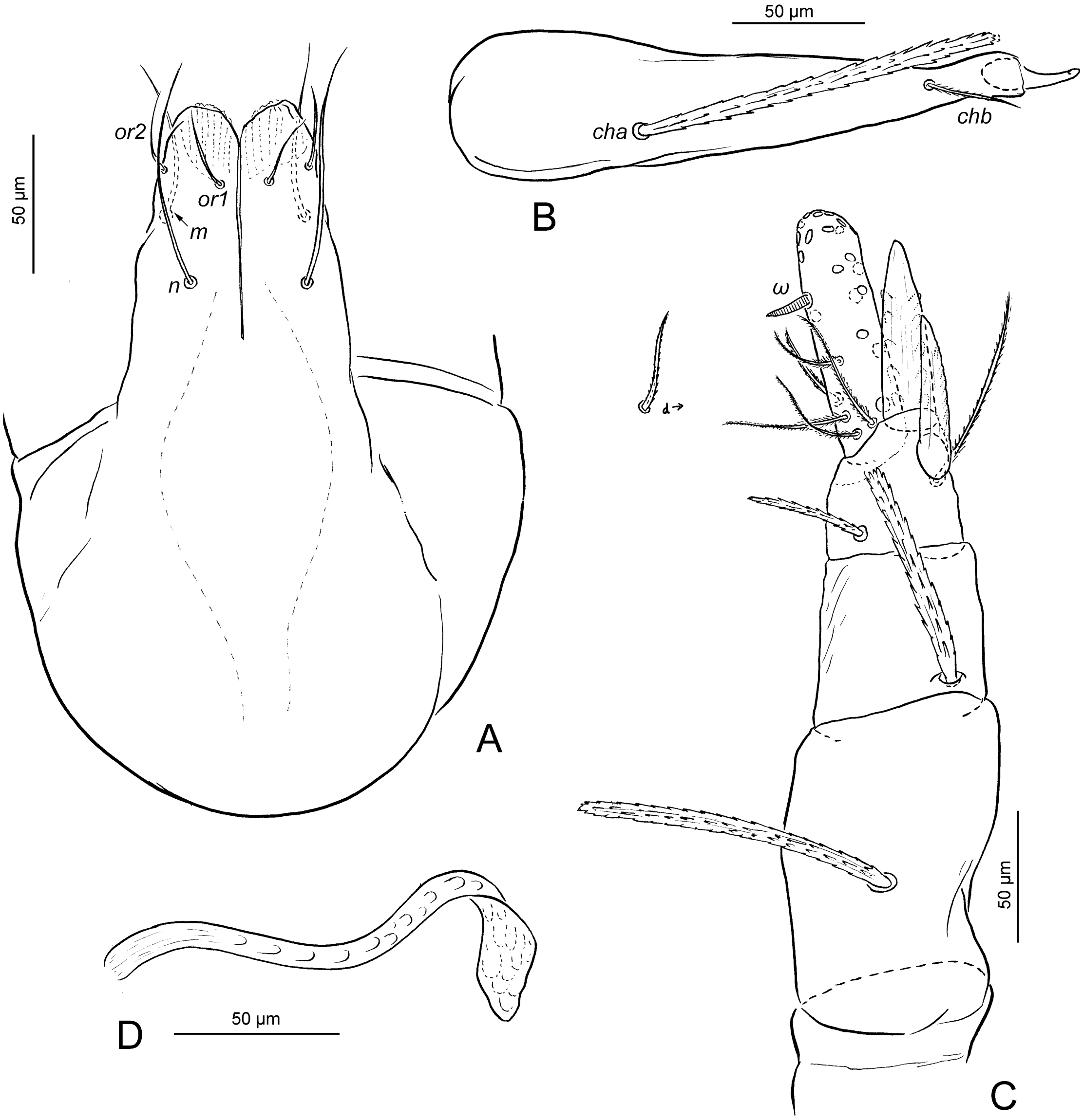

Figure 4. *Lacteoscythis kanchanaburiensis* n. sp., female, compressed: (A) subcapitulum, ventral view, (B) chelicera, dorsal view, (C) palp, dorsal view, (D) peritreme, dorsal view. Scale bars: A-D 50 µm.

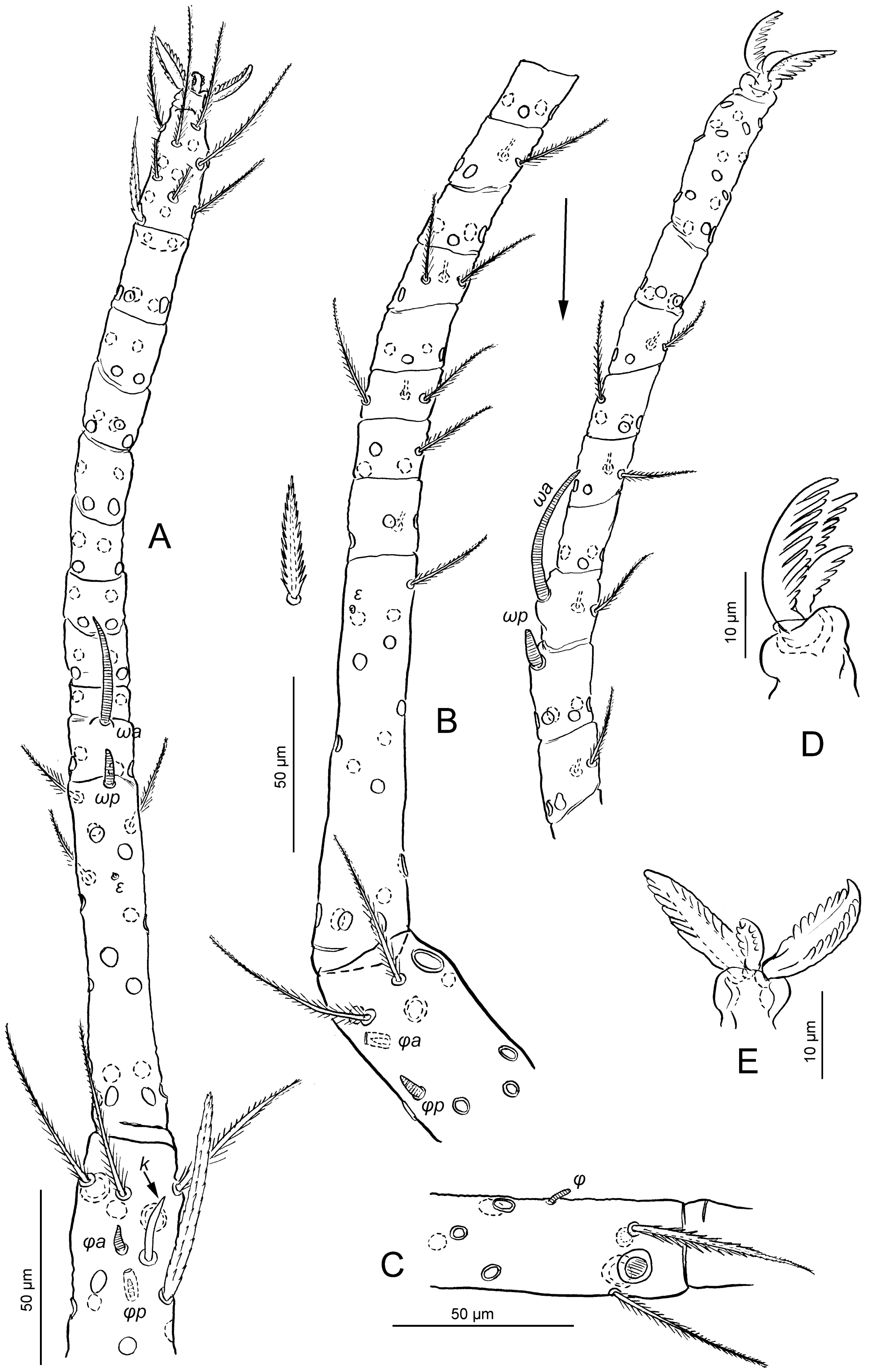

Figure 5. *Lacteoscythis kanchanaburiensis* n. sp., female, compressed: (A) tarsus I and distal portion of tibia I, dorsal view, (B) tarsus II and distal portion of tibia II, lateral view, (C) distal portion of tibia III, lateral view, (D) pretarsus I, lateral view, (E) pretarsus II, ventral view. Most setae shown by their alveoli. Scale bars: A-C 50 µm, D-E 10 µm.

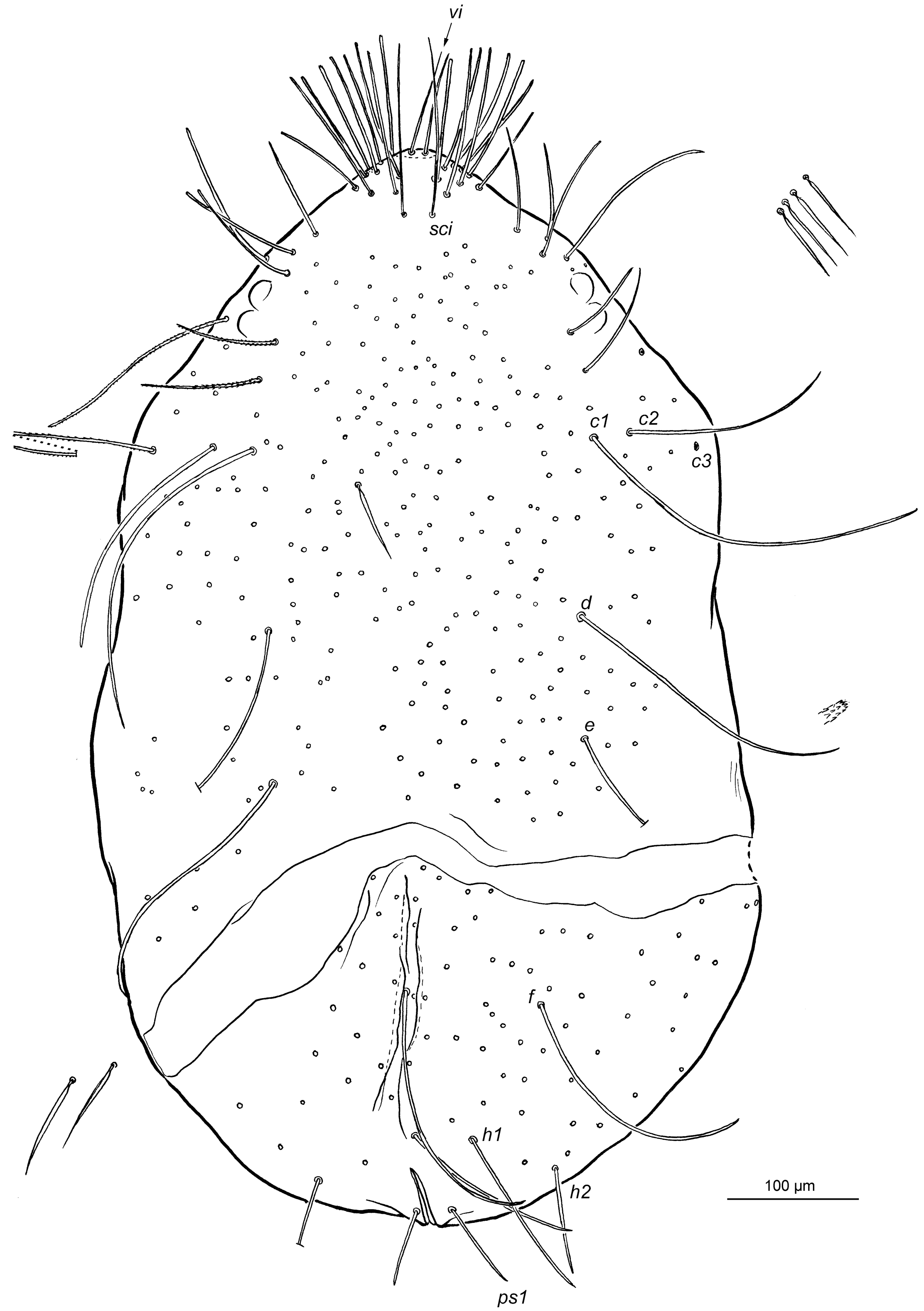

Figure 6. *Tarsolarkus pilosus* n. sp., male, compressed: Idiosoma (broken), dorsal view, neotrichous setae (inserted on upper right and lower left) shown by their alveoli. Scale bar: 100 µm.

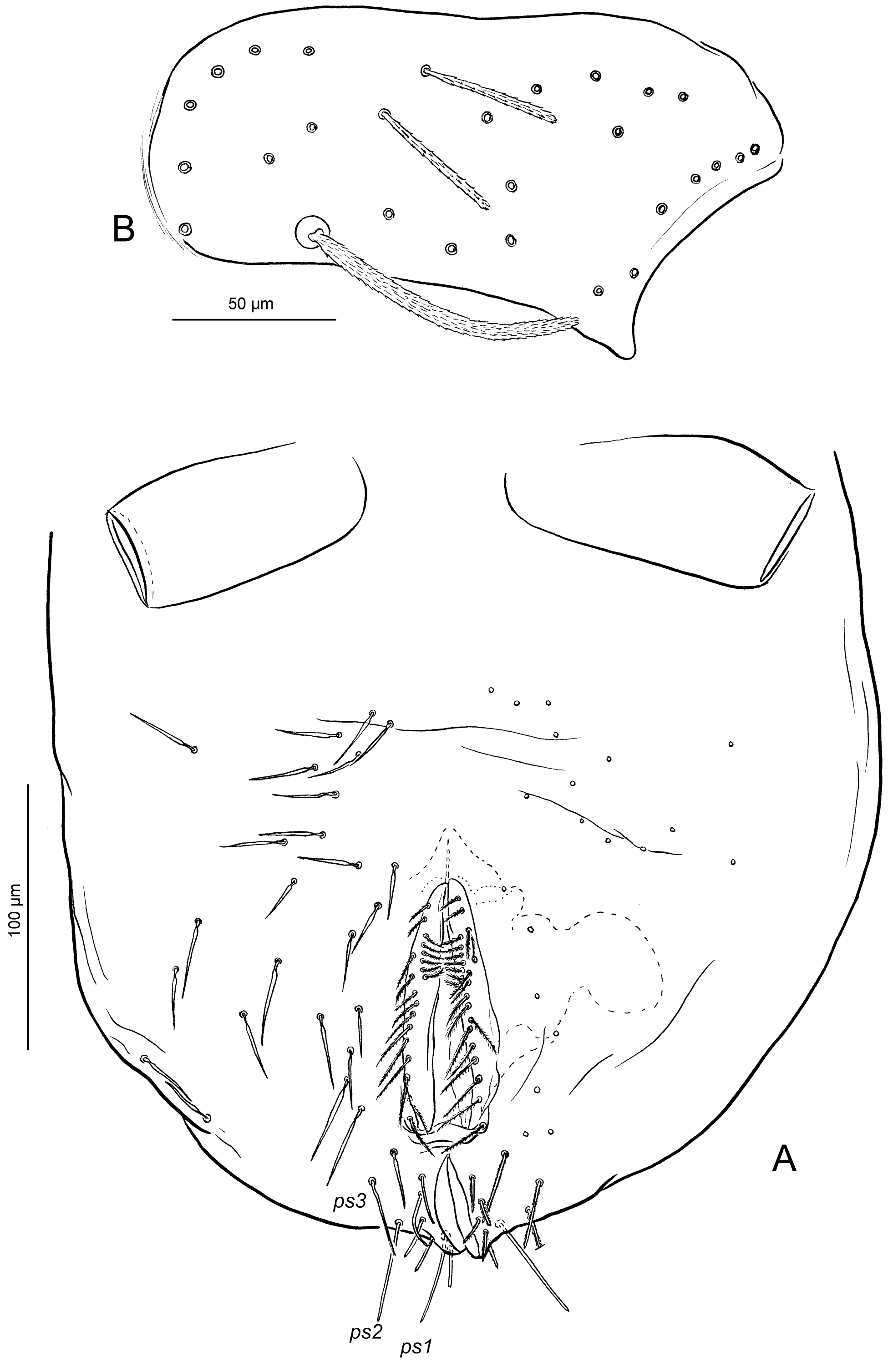

Figure 7. *Tarsolarkus pilosus* n. sp., male, compressed: (A) opisthosoma, ventral view; (B) right coxa III, most setae shown by their alveoli. Scale bars: A 100 µm, B 50 µm.

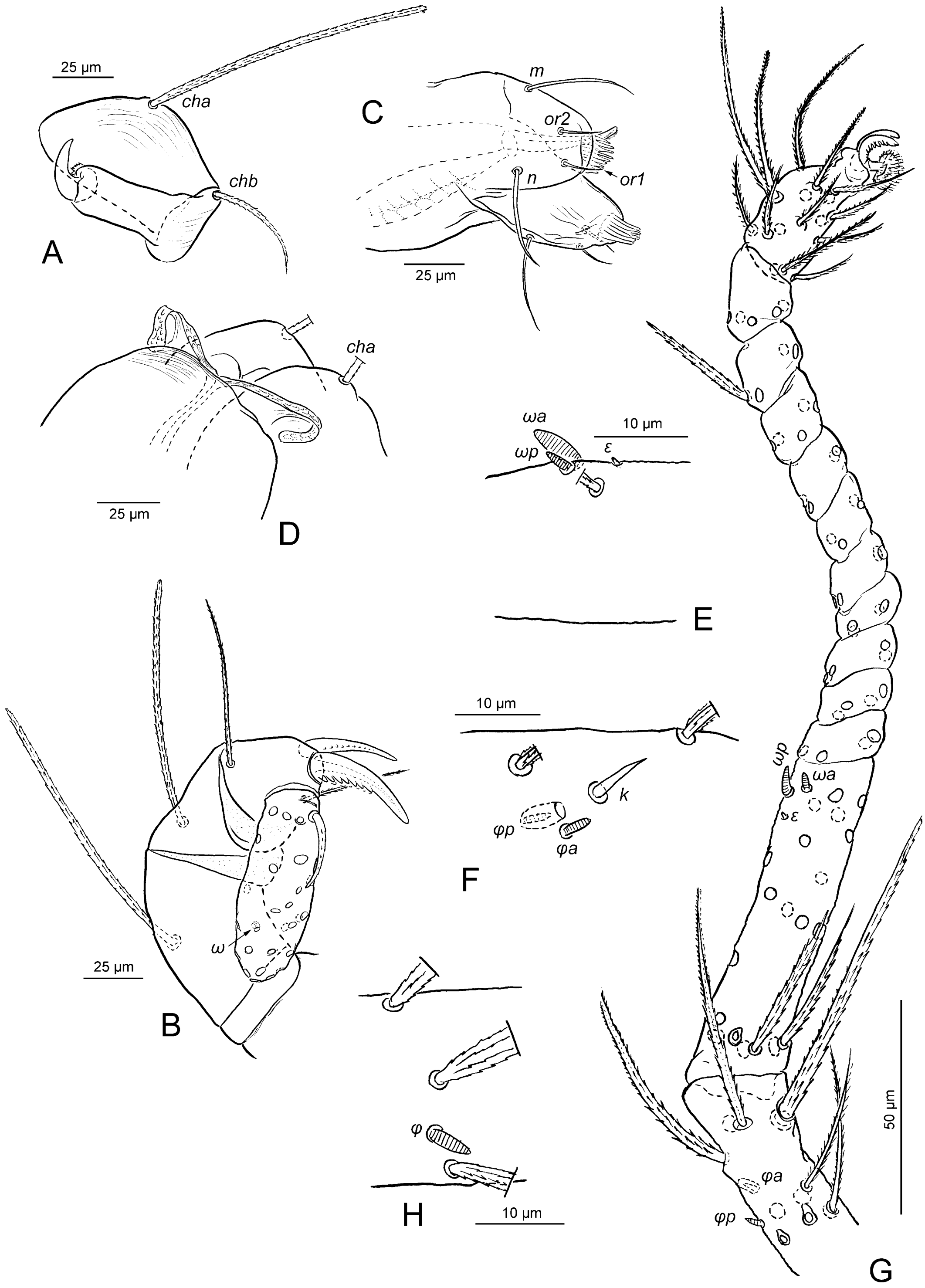

Figure 8. *Tarsolarkus pilosus* n. sp., male, compressed: (A) chelicera, (B) palp, tarsal setae shown by their alveoli, (C) subcapitulum, lateral view, (D) anterior end of idiosoma showing peritremes, chelicerae partially drawn, (E) solenidia and famulus on tarsus I, lateral view, (F) seta *k* and solenidia on tibia I, dorsal view, (G) tarsus II and distal portion of tibia II, lateral view, most setae shown by their alveoli, (H) solenidion and adjacent setae on tibia III, dorsal view. Scale bars: A-D 25 µm, E, F, H 10 µm, G 50 µm.

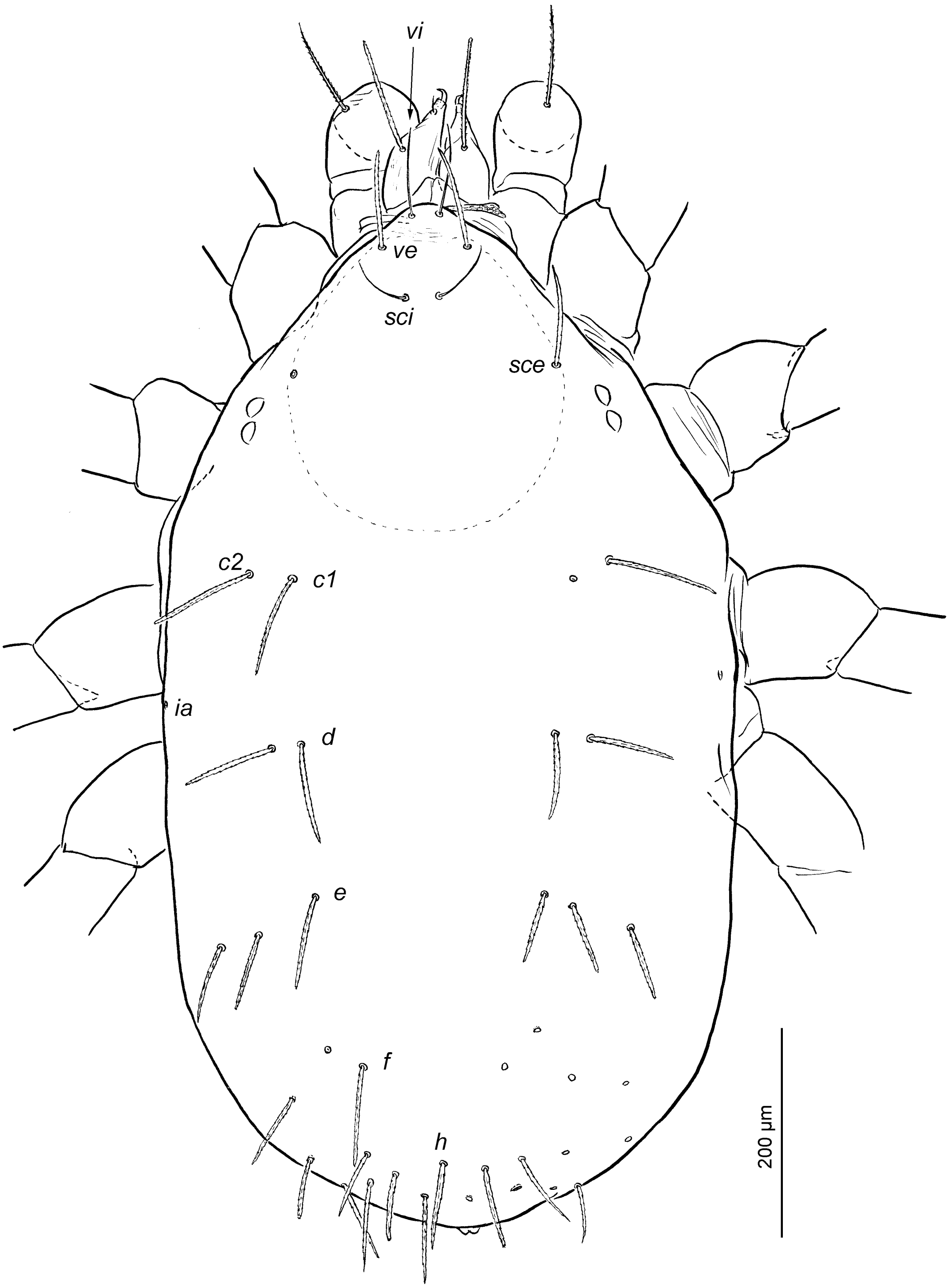

Figure 9. *Tarsotomus ottoi* n. sp., male, distended: dorsal view, palps and legs partially drawn. Scale bar: 200 µm.

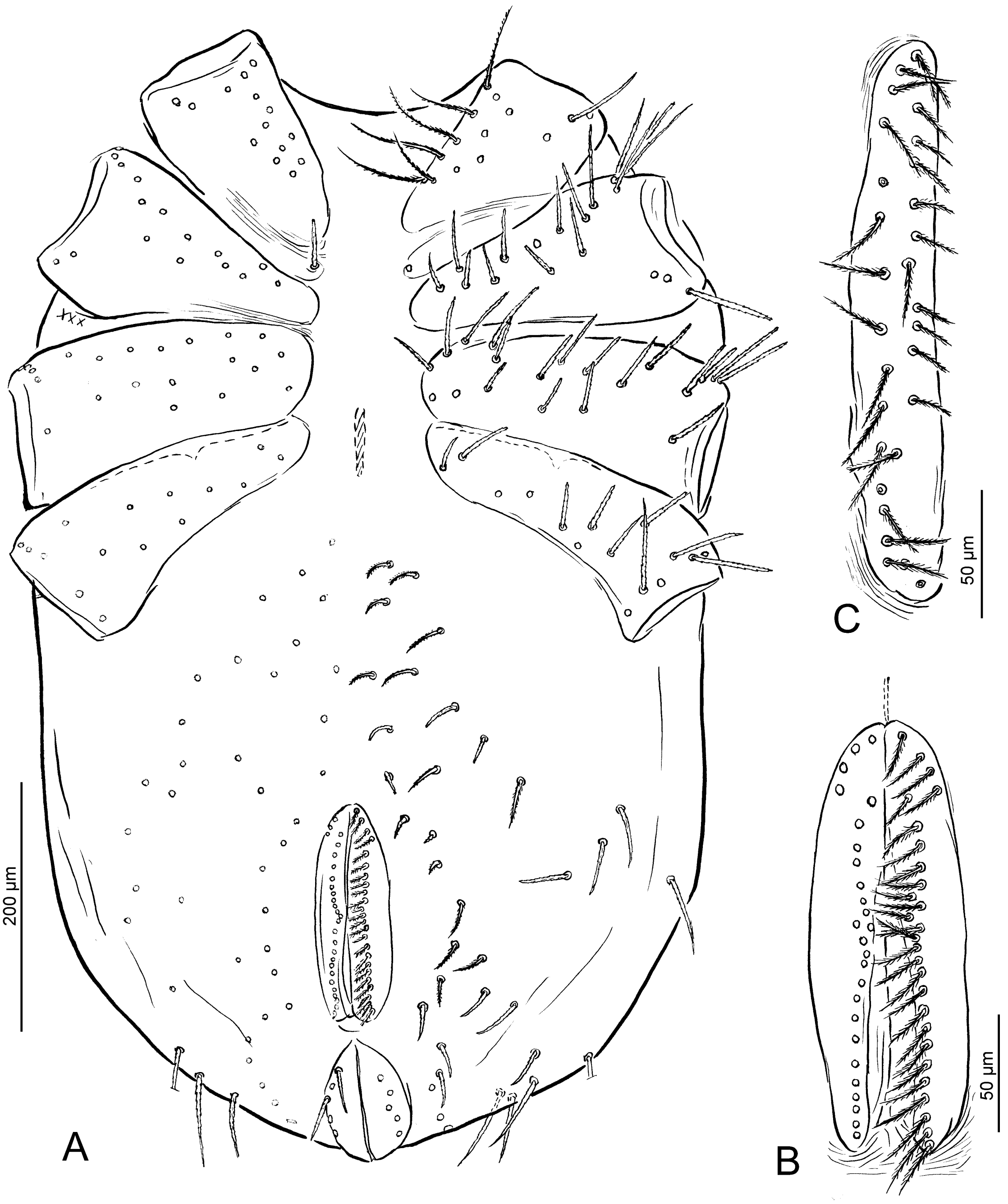

Figure 10. *Tarsotomus ottoi* n. sp., adults: (A) idiosoma of male (distended), ventral view, legs omitted, (B) genital valves of male, (C) left genital valve of female. Scale bars: A 200 µm, B, C 50 µm.

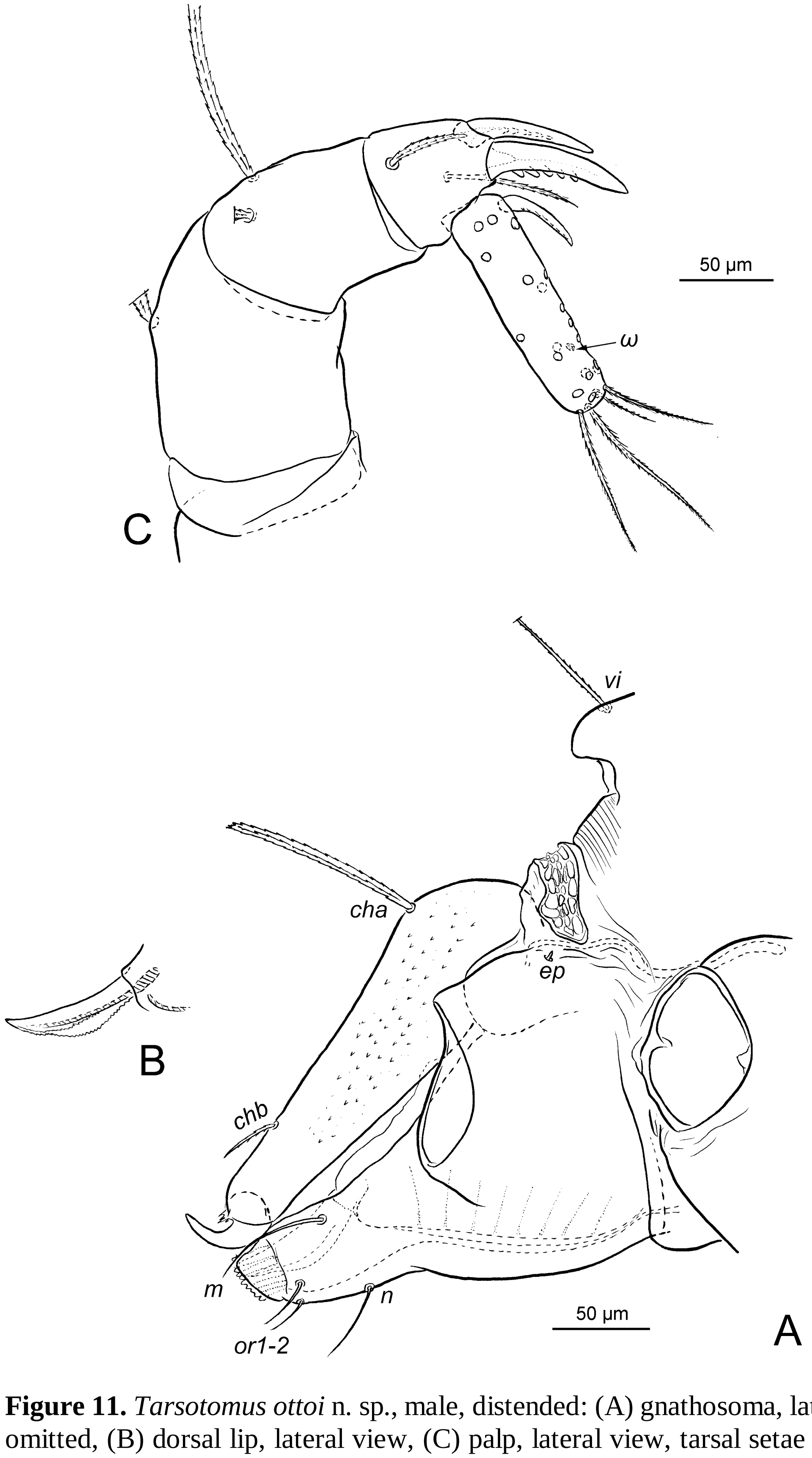

Figure 11. *Tarsotomus ottoi* n. sp., male, distended: (A) gnathosoma, lateral view, palp omitted, (B) dorsal lip, lateral view, (C) palp, lateral view, tarsal setae shown by their alveoli. Scale bars: A-C 50 µm.

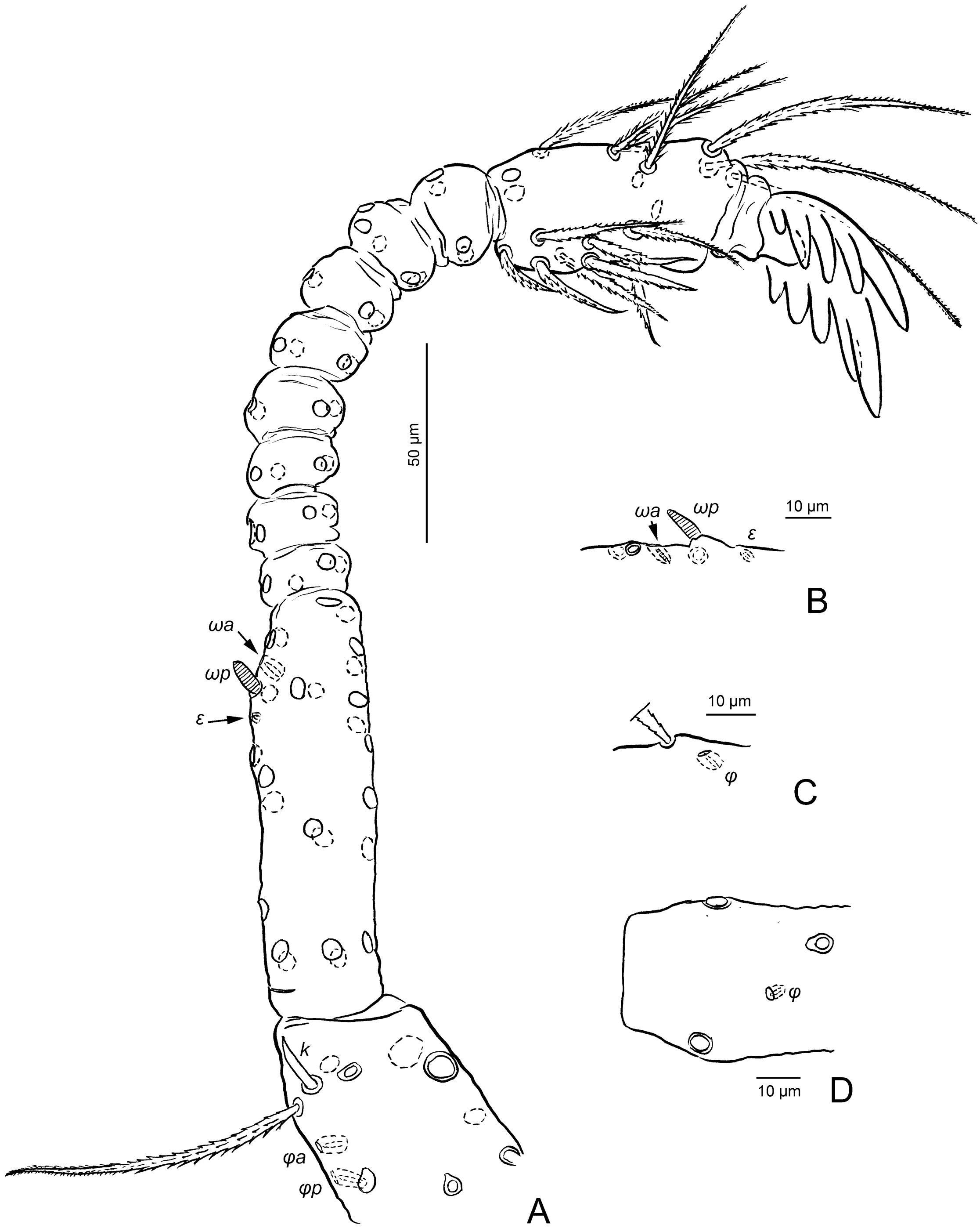

Figure 12. *Tarsotomus ottoi* n. sp., male, compressed: (A) tarsus I and distal portion of tibia I, lateral view, most setae shown by their alveoli, (B) solenidia and famulus of tarsus II, (C) solenidion on tibia II, lateral view, (D) solenidion on tibia III, dorsal view, nearby setae shown by their alveoli. Scale bars: A 50 µm, B-D 10 µm.

CHAPTER 2E

CONTRIBUTION TO THE FAMILY PARATYDEIDAE (ACARI, TROMBIDIFORMES) FROM THAILAND: TWO NEW RECORDS OF *TANYTYDEUS* THERON *ET AL*., 1969 WITH OBSERVATIONS ON THEIR ONTOGENY*

2E-1 Abstract

The family Paratydeidae is reported for the first time in Thailand, represented by two species of the genus *Tanytydeus* Theron *et al*., 1969: *T. kakadu* Seeman & Walter, 2002 and *T.* cf. *egypticus* (Soliman, 1974) formerly known from Australia and Egypt, respectively. *Tanytydeus kakadu* is re-described based on the holotype and new materials from Thailand including adults of both sexes and all juvenile stages. Supplements descriptions of *T.* cf. *egypticus* are also given based on females and all juvenile stages except the tritonymph from Thailand. The ontogeny of *T. cristatus*, the type species described from South Africa, is re-interpreted. It was found that some paratypes of *T. cristatus* are actually *T.* cf. *egypticus*, hence a wide distribution of the later species.

Keywords.—Paratydeidae, *Tanytydeus*, Acari, Prostigmata, ontogeny, soil mites, Thailand.

2E-2 Introduction

Members of the family Paratydeidae are small (ca. 360-560 µm long), elongate, soft-bodied mites with white, orange or violet Colour. They predominantly live in soil and litter habitats; some species are reported from bark, moss, and bird nests (Seeman & Walter 1999; Walter *et al*. 2009). They are presumably predators but little is known

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* This chapter is a manuscript in preparation for submission as:
Fuangarworn, M. Contribution to the family Paratydeidae (Acari, Trombidiformes) from Thailand: two new records of *Tanytydeus* Theron *et al*., 1969 with observations on their ontogeny.

about their biology and ecology. Currently, 14 species (in 6 genera: *Paratydeus*, *Neotydeus*, *Sacotydeus*, *Tanytydeus*, *Scolotydaeus*, *Walytydeus*) have been described from the USA (Baker 1950; Delfinado & Baker 1974), Mexico (Baker 1950), Brazil (Flechtmann 1992), Ukraine (Kuznetzov 1973), Italy (Berlese 1910), Egypt (Kandeel 1992; Kandeel & Hoda 1984; Soliman 1974), South Africa (Theron *et al*. 1969), Australia (Seeman & Walter 1999) and Turkey (Dönel *et al*. 2012). Water and Seeman (1999) suggested that the family Paratydeidae is in need of complete critical revision, because several genera have been poorly defined and many older species were insufficiently described. Not to mention their ontogeny which remain mostly undescribed. Water and Seeman (1999) and Dönel *et al*. (2012) doubted that several species may be described from the immature stages (deutonymph or tritonymph).

In this paper, we recorded the occurrence of the family Paratydeidae in Thailand for the first time, represented by two species of the genus *Tanytydeus* Theron *et al*, 1969: *T. kakadu* Seeman & Walter, 2002 and *T*. cf. *egypticus* (Soliman, 1974), and provide a re-description for the first species including the first description of male and juveniles. Although the identity of the second species is uncertain (see Discussion), the description of its female and juveniles are also provide here to highlight the ontogenetic variation within the genus *Tanytydeus* and this information will hopefully facilitate further comparisons with the type specimens (holotype or topotypes) in the future. In the light of our observations, remarks on the ontogeny of *T. cristatus* Theron *et al*. 1969, the type species, are also given.

2E-3 Materials and methods

Mites were extracted from litter and soil sample (see *Material examined* for locality data) using Tullgren funnels over 70% ethanol. The specimens were cleared in 80% lactic acid overnight and then observed in the cavity slide in this medium. Some specimens were prepared as semi-permanent slides using Hoyer's solution as a medium (Walter & Krantz 2009). Drawings were made, with the aid of a *camera lucida*. Measurements, in micron, are presented as a mean followed by the range in parenthesis. Notation applied to the body and leg setae follow that of Grandjean's system, overviewed by Kethley (1990) and Norton (1977), respectively. Descriptions of male and juveniles emphasize characters that differ from female and change during ontogeny. Vouchers specimens are deposited in the Acarology collection of Chulalongkorn University Museum of Natural History, Bangkok, Thailand.

2E-4 Taxonomic results

Family Paratydeidae Baker, 1949a

Genus *Tanytydeus* Theron *et al*., 1969

***Tanytydeus kakadu* Seeman and Walter, 1999**

(Figs 1-7)

Tanytydeus kakadu Seeman and Walter, 1999: 399. Dönel *et al*. 2012: 443; Khanjani *et al*. 2014: 170.

Diagnosis. With character of the genus *Tanytydeus* (Theron *et al*. 1969; Khanjani *et al*. 2014) and following combination of character states (female): seta *ve* anterior to *sci*, 3 pairs of genital papillae, 6-7 pairs of genital setae, 5-8 pairs of aggenital setae, basifemur I with 4 setae, genu IV with 3 setae, seta *d* on tibia I rod-like and located anterior to sensory bump.

Material examined. AUSTRALIA: Holotype female, Northern Territory, Kakadu N.P., Baroallba Gorge, Gubara Walk, 12°50'S, 132°52'E, 13 May 1996, soil under rocks, D.E Walter & H.C. Proctor. THAILAND: One female, Krabi Prov., Mo Koh Lanta National Park, Koh Rok Nai (7°13'29.78"N, 99°4'13.48"E), 3 May 2013, ex rhizome of ferns on trunk, 1 foot above ground, col. M. Fuangarworn (field no. MF2013-16). One female, Pang-Nga Province, Similan Archipelago National Park, Payan Is., (8°30'56"N, 97°39'18"E), 5 Apr 2010, ex. forest soil, col. Jirawat Damkaew (Field No. MF2010-23). Seven females, 5 male, 1 larva, 1 protonymph, 1 deutonymph, 1 tritonymph, Prachuap Khiri Khan Prov., Kho Thalu (11°4'14.40"N, 99°33'12.73"E), 14 Mar 2011, ex dry litter and topsoil under cliff, col. M. Fuangarworn (field no. MF2011-28). Four females, 1 larva, with previous data but ex forest litter, field no. MF2011-27. One female, with previous data but on 15 Mar 2011, ex soil under a decomposing log, field no. MF2011-29.

Remarks. Thai specimens agree well with the holotype (female) of *Tanytydeus kakadu*, except that Thai population has longer idiosomal length (515-555 vs. 455), slightly longer idiosomal setae (i.e. c1/c2 = 15/20 vs. 18.7/45.9, Figs 4E, F). Thai specimens have variable, usually asymmetrical, numbers of aggenital and genital setae between 5-6 and 5-8 pairs, respectively (Figs. 3A, 4B, C) while Australian specimens (the holotype and one paratype) have 6 pairs of aggenital setae and 5-7 pairs of genital setae (also asymmetrically). We consider these differences are intraspecific variations. Measurement of setae are given in Table 1.

Distribution. Australia (Seeman & Walter 1999), Thailand (new record).

Re-description. *Female*. Body length, from naso to posterior end of idiosoma, 523 (515-525); width at level of setae *c* 176 (160-185); Colour white or pale yellow.

Gnathosoma (Figs 1, 2). Subcapitulum postiorly round, laterally oblique to level of palpal insertions; with four pairs of subcapitular setae (*m*, *n*, *or1*, *or2*), *n* longest, located ventrally, *m* shorter located laterally on lateral libs, *or1*, *or2* shortest almost longitudinally aligned. Lateral libs (Figs 2A, C, D) paraxailly with preoral sclerites (*p.sc*), forming preoral cavity; with 3-5 short lacinae. Dorsal lib (Fig. 2D) shorter than lateral lib, about 5 long, triangular in dorsal aspect and apparently smooth. Palp (Fig. 2B) about 45 long, 4-segmented; femur fused with genu; trochanter short and nude, femurogenu with two barbed setae (*dG*, *dF*); tibia with three setae; tarsus with seven setae of which four setae slender and three setae (*ul'*, *ul''*, *sul*) eupathidial, smooth, ampullately tipped; antiaxial rised sensory bump relatively small, discernable at higher magnification (1000x). Palpal supracoxal setae (*ep*) rod-like. Chelicera (Fig. 2A) normal, about 15 long, seta *cha* about 40 long, curved downward.

Peritremes, stigmata and tracheal complex (Figs 1A, 2A, 4E, F). Peritremes normal, linear situated at cheliceral base, distally with 5-8 alveolae roughly aligned in two rows. Stigmata (*st*) opening near ventral base at intercheliceral position, leading to trachea trunk (*trπ*) and then connected with tracheal trunk (*tri*) from subcheliceral stigmata by thin granulated membrane-like structure along its length without any branchings (Figs 2A, 4G); one tracheal trunk, *tri*?, ended at level of leg IV (Fig. 4H) while another tracheal trunk, *trπ*?, further extended to anogenital region.

Idiosoma. Ratio of idiosomal length and width (at level of setal row *c*) 2.97; with five constrictions. Dorsal propodosoma subtriangular in outline; anteriorly round, sometimes overhanging peritremes and bases of chelicerae; naso absent; propodosomal sheild about 110 long, smooth, crista-like, with apodeme along mesial plane; seta *ve* anteriad of *sci* and situated on margin of propodosomal sheild; *sce* posteriolaterad of *sci* and situated on striated cuticle. Podocephalic canal normal (Fig. 2A; *cpc*) with 4 pairs of gland ducts (*dg1-4*), and unpaired tracheal duct (*dt*) opened at intercheliceral region (not illustrated). Hysterosoma with 14 pairs of setae; all slender, distributed as depicted in Fig. 1; with 4 pairs of lyrifissures (*ia*, *im*, *ip*, and *ih*), *ia* located in setal row *c* (Fig. 1). Setal length given in Table 1.

Ventrally, coxal plate smooth, coxal setation 4-3-2-2, *3a* on striated cuticle, all coxal setae slender. Genital opening about 120 long, and about 5 from anal opening; with 5-8 pairs of genital setae and 5-6 pairs of aggenital setae (*ag*); progenital chamber with 3 pairs of genital papillae (*Va*, *Vm*, and *Vp*); *Va* subequal to *Vm*, *Vp* smallest; each papillae anteriorly with small setae *k1*, *k2* and *k3*, respectively (Figs 3A, 4A, B, C).

Legs (Fig. 5). Lengths (from trochanter to tarsus, pretarsus excluded): leg I 186.7 (180-190); leg II 125; leg III 143.3 (135-150); leg IV 170 (160-175). Femur I fully divided by arthrodial membrane, femur II entire, femur III-IV incompletely divided (i.e. suture developed only on ventral half, dorsal half rigid). Legs I-IV setation (rod-like setae in square brackets): trochanters 0-1-1-0; (basi)femora (4)5-3-(1)2-(1)2; genua 7-4-2-3; tibiae 4[3]+k -4-3-3; tarsi 8[6]-7[1] -6-5. Tarsi I with two rised sensory bumps, paraxial one longer; genua I-II, tibiae I-III and tarsi II each with one short rised sensory bump (=modified solenidion *ω*); setae *ft'*, *ft"*, *tc'*, *tc"*, *p'* and *p"* on tarsus I and *p'* on tarsus II eupathidial, rod-like with ampullate tip; seta *k* of tibia I setiform but laterodistal half abruptly narrower; setae *d*, *l'* and *l"* on tibia I eupathidial, rod-like, *d* located anteriorly to sensory bump (*φ*); seta *ft"* (but see Discussion) of tarsi II minute, blunt tip, adjacent to rised sensory bump (*ω*). Pretarsi with 2 claws and a small claw-like empodium, setulae absent; condylophores short, connecting to small basal sclerite.

Male. Body length 511 (500-525), width 165 (140-200); setal lengths given in Table 1. Generally similar to female except genital region with 5 pairs of aggenital setae, and 10-11 of genital setae, genital setae dendriform (Figs 3B, 4D). Genitalia typical for the genus of family, with 10 eugenital setae (Fig. 3C), seta *6* with a subterminal barb.

Ontogeny. *Larva* (n =1) - Body length 265; width at level of setae *c* 90. Leg I, 130; leg II, 80; leg III, 100. Body constrictions and gnathosoma similar to adult except subcapitulum with 3 pairs of subcapitular setae (*m, n, or1*). Dorsal propodosoma similar to female, hysterosoma with 12 pairs of setae (*c1*, *c2*, *c3*, *d1*, *e1*, *f1*, *f2*, *h1*, *h2*, *ps1*, *ps2*, *ps3*). Ventrally, Claparede's organs (*Cl*) between coxae I and II with globular head and short stalk; coxal setation (I-III): 3-1-1; *1c* scale-like, protecting *Cl*. Legs I-III setation: trochanters 0-0-0; (basi)femora (2)5-3-3, femur I with faint division on ventral half, femur II-III entire; genua 7-4-2; tibiae 7+*k*-4-3, seta *k* of tibia I similar to female; tarsi[rod-like setae] 10[2]-5[1]-4. Setae *p'* and *p"* on tarsus I and *p"* on tarsus II rod-like, eupathidial; one rised sensory bump present on genua I-II, tibia I-III and tarsi I-II. Homologies of setae depicted in Figs 6C-F, and Table 2. Pretarsi I-III with 2 claws and relatively elongate claw-like empodium.

Protonymph (n=1) - Body length 340; width at level of setae *c* 100. Leg I, 130 ; leg II, 80; leg III, 100, leg IV 100. Gnathosoma similar to larva except subcapitulum with four pairs of setae (*or2* added); hysterosoma with 15 pairs of setae (*ad1-3* added). Coxal setation 4-2-1-1 (*1d*, *2b*, *4b* added; *1c* becomes setiform); genital opening present, about 35 long, situated far apart from anal opening; with one pair of aggenital setae (*ag1*), one pair of genital papillae (*Va*) and associated seta *k1* (Fig. 7A). Legs I-IV setation: trochanters 0-0-1-0; (basi)femora (2)5-3-3-0; genua 7-4-2-3; tibiae 5[2]+*k* -4-3-2. Tarsi 8[6]-7[1] -6-3. On tibia I, setae *l'* and *l"* becoming rod-like; on tarsi I, one sensory bump (*ω2*) added, setae *tc'* and *tc*" added as rod-like euphathidial; *ft'* and *ft*" becoming rod-like euphathidial; on tarsus II, setae *a'* and *a"* added; on trochanter III, seta *v* added; on tarsus III setae *p'* and *p"* added. Pretarsi I-III with 2 claws and small claw-like empodium (hence they are reduced in size at this stage); pretarsi IV similar to larva.

Duetonymph (n=1) - Body length 375; width at level of setae *c* 110. Leg I, 155; leg II, 115; leg III, 130; leg IV, 140. Gnathosoma and idiosoma similar to preceding instar. Coxal setation 4-3-2-2 (*2c*, *3c*, *4b* added); genital opening about 40 long, with two pairs of genital setae (*g1-2* added), two pairs of aggenital setae (*ag2* added), two pairs of genital papillae and two associated setae (*Vm* and *k2* added) (Fig. 7B). Legs I-IV setation: trochanters 0-1-1-0; (basi)femora (2)5-3-3-3; genua 7-4-2-3; tibiae 4[3]+k-4-3-3. Tarsi[rod-like] 8[6]-8[1]-6-3. On tibia I, seta *d* becoming rod-like euphathidial; on trochanter II seta *v* added; on tibia IV, *v"* added; on femur IV *d*, *l*, *ev"* added; on tarsus IV *p'* and *p"* added. Pretarsi IV becoming adult form.

Tritonymph (n=1) - Body length 485; width at level of setae *c* 135. Leg I, 175; leg II, 110; leg III, 130, leg IV 150. Gnathosoma and idiosoma similar to preceding instars. Genital opening situated far apart from anal opening; with three pairs of genital setae (*g3* added); three pairs of aggenital setae (*ag3-4* added) and three pairs of genital papillae and three pairs of associated (*Vp*, *k3* added; Fig. 7C). Legs I-IV setation: trochanters 0-1-1-0; (basi)femora (4)5-3-3-3; genua 7-4-2-3; tibiae 4[3]+k -4-3-3. Tarsi[rod-like] 8[6]-8[1]-6-5. On basifemur I *l1'* and *l1*" added.

In adult female, *g4-7* and *ag4-5* added; no change in leg setation from tritonymph to adult. Development of leg setae are summarized in Table 2.

***Tanytydeus* cf. *egypticus* (Soliman)**

(Figs 8-10, 11B, 12, 13C)

Hexatydeus aegypticus Soliman, 1974: 197. Kandeel, 1992: 6; Seeman and Walter, 1999: 395. Dönel *et al*. 2012: 443;

Tanytydeus egypticus (Soliman): Khanjani *et al*. 2014: 171.

Diagnosis. With character of the genus *Tanytydeus* (Theron *et al*. 1969; Khanjani *et al*. 2014) and following combination of character states (female): seta *ve* anteriolateral to *sci*, 2 pairs of genital papillae, 2 pairs of genital setae, 3 pairs of aggenital setae, basifemur I with 3 setae, genu IV with 2 setae, seta *d* on tibia I normal and located posterior to sensory bump.

Material Examined. SOUTH AFRICA: Two females on same slide, paratypes of *T. cristatus* [misidentified], slide no. 6/B/1, Weivelf-Potch., Maart 1967; vers: P.F.S. Mulder. One protonymph, paratype of *T. cristatus* [misidentified], slide no. 6/B/4, Weivelf-Potch., Desmber 1962, vers: G.C. Loots. One larva, paratype of *T. cristatus* [misidentified], slide no. 6/B/7, Weivelf-Potch., Maart 1967, vers: P.F.S. Mulder. THAILAND: Two females, 2 deutonymphs, Chonburi Prov., Sattahip Dist., Ko Samaesan, Look-lom Bay, 20 Jul 2010, ex sandy soil (20 cm. depth) in a costal grassland, col. M. Fuangarworn. 9 females, 4 deutonymphs, 1 protonymph, 1 larva, Chonburi Prov., Sattahip Dist., Ko Chuang, 19 Mar 2011, ex forest litter, col. M. Fuangarworn. Two females, Chonburi Prov., Sattahip Dist., Ko Samaesan, Look-lom

Bay, 19 Mar 2011, ex sandy soil in a costal grassland col. M. Fuangarworn. Three females, Chonburi Prov., Sattahip Dist., Ko Samaesan, (12°35'8.09"N, 100°57'5.97"E), 23 Jan 2010, ex litter under a tamarind tree, col. M. Fuangarworn. Two females, Chonburi Prov., Sattahip Dist., Ko Samaesan, Look-lom Bay (12°35'6.62"N, 100°56'48.66"E), 21 Jul 2012, ex sandy soil in a costal grassland, col. M. Fuangarworn (field no. MF2012-49). One female with previous data but on 23 Apr 2013, water washing technique, field no. MF2013-44. Four females, Chonburi Prov., Sattahip Dist., Ko Samaesan, forest on hill near the reservoir (12°34'50.64"N, 100°56'43.53"E), 23 Jan 2010, ex soil and litter, col. M. Fuangarworn (field no. MF2010-12). Three females, Chonburi Prov., Sattahip Dist., Ko Chuang, 20 Mar 2010, ex litter under a tamarind tree, col. M. Fuangarworn (field no. MF2010-17). One female, Kanchanaburi Prov., Sai Yok Dist., Ban Wang Khamen, Forest Reserve of the Plant Genetic Conservation Project (ca. 14°24'27"N, 98°52'1.50"E), 22 Apr 2014, ex forest litter and top soil, col. M. Fuangarworn (field no. MF2014-20). One female with previous data but near Manao Pee Cave, field no. MF2014-22. One female, Mae Hong Son Prov., Mae Sariang Dist., ca. 30 km to Ban Sam Laeb (Rd. no. 1194), 14 Dec 2013, ex moss on forest floor, col. M. Fuangarworn (field no. MF2013-57). One female: Mae Hong Son Prov., Mae Sariang Dist., Ban Tha Tafang, Salawin river bank (18°3'58.71"N, 97°40'59.00"E), 14 Dec 2013, ex forest litter, col. M. Fuangarworn (field no. MF2013-60). Two females, Nakon Rachasima Prov., Si Cute Dist., Klong Pai Subdist., Forest Reserve of the Plant Genetic Conservation Project (14°51'38.68"N, 101°34'21.17"E), 14 Feb 2010, ex soil and litter, col. M. Fuangarworn (field no. MF2010-1). Three females, Nakon Rachasima Prov., Pak Thongchai Dist., Sakaerat Environmental Research Station (ca. 14°30'31.62"N, 101°57'5.07"E), 5 Apr 2013, ex soil and litter in dry deciduous forest, col. M. Fuangarworn (field no. 2013-4). One female, with previous data but on 7 Feb 2015, ex soil and litter in dry evergreen forest (ca. 14°30'36.48"N, 101°55'47.68"E), and field no. 2015-26. Four females, Pang Nga Prov., Thai Mueang Sub-dist., Khao Lampi Hart Thai Mueang National Park, 17 May 2006, ex moss at base of a *Syzygium* tree, col. M. Fuangarworn. Three females, Tak Prov., Sam Ngao Dist., Bhumipol Dam (17°14'N, 98°59'E), 2 Mar 2008, ex litter and soil, col. M. Fuangarworn (field no. MF2008-8). One female, with previous data but on 18 Aug 2012. Two females, Samut

Songkram Prov., Bang Khan Taek Sub-dist. (13°32'55"N, 99°57'40"E), 25 Mar 2003, ex litter under a tamarind tree, col. M. Fuangarworn (field no. MF2003-41).

Remarks. *Tanytydeus egypticus* (Soliman) was thought to be described from the nymphal stage (Dönel *et al*. 2012) due to the presence of two pairs of genital papillae and few numbers of aggenital (3 pairs) and genital (2 pairs) setae. However, we believe that it was described based on adult female which has a well developed genital opening as depicted in the illustration of the holotype (Soliman, 1974; his Fig. 1). To date, 2 species of *Tanytydeus*: *T. aegypticus* (Soliman) (=*Hexatydeus aegypticus* Soliman) and *T. neocristatus* Kandeel & Honda, 1984, both from Egypt, have been described as having a combination of these characters. Unfortunately, the type specimens of both species are unavailable to us and their original descriptions are insufficient for comparisons, so the identity of Thai specimens is uncertain at present. We tentatively identified our specimens as *Tanytydeus* cf. *egypticus* (Soliman) based on the fact that we found our specimens are identical to specimens (part of types of *T. cristatus* Theron *et al*; see below) from South Africa and a specimen submitted to us for identification from Iran. They are considered conspecific and this species may be actually widespread, but poorly sampled. It is likely that *T. neocristatus* is junior synonym of *T. aegypticus* (Soliman), only studying their suitable types will prove this.

Distribution. Egypt (Soliman 1974), South Africa (new record), Thailand (new record**)**.

Supplementary description. *Female* - Body length (n = 3) 372.5 (325-425); width at level of setae *c* 121.6 (90-150). Colour white, yellow, or purple.

Gnathosoma (Figs 8, 10A). Gnathosoma similar to *T. kakadu*; subcapitulum about 36 wide and 30 long. Palp (Fig. 10A), about 30 long, setation normal; palp tarsus antiaxially with relatively large rised sensory bump (modified ω). Supracoxal seta (*ep*) rod-like. Chelicera normal, about 30 long; cheliceral setae about 8 long. Peritreme, stigmata, tracheal complex and podocephalic canal similar to *T. kakdu*.

Idiosoma. Ratio of idiosomal length and width (at level of setal row *c*) 3.06. Propodosoma subtriangular in outline; anteriorly round, naso absent; propodosomal sheild about 45 long, smooth, crista-like, and with apodeme along mesial plane; *ve* 11.7 (10-15), *sci* 36.7 (30-40), *sce* 15.5 (10-20) long; *ve* anterolaterad of *sci*, and situated on striated cuticle; *sce* posteriolaterad of *sci*, situated on striated cuticle. Hysterosoma with

14 pairs of setae; all slender, distributed as depicted in Fig. 8; with 4 pairs of lyrifissures (*ia*, *im*, *ip*, and *ih*); *ia* located in setal row *c* (Fig. 8B).

Ventrally, coxal setation 4-3-2-2; genital opening about 65 long, contiguous with anal opening; with two pairs of genital setae (*g1*, *g2*), 5-10 long, and three pairs of aggenital setae (*ag1-ag3*), about 10 long; progenital chamber with two pairs of genital papillae (*Va*, *Vm*), each papillae anteriorly with associated setae *k1* and *k2*, respectively; posterior genital papillae (*Vp*) absent but seta *k3* present (Figs 8B, 9B).

Legs (Figs 10B – E). Lengths: leg I 127.5 (100-130); leg II 71.6 (60-80); leg III 77.5 (70-90); leg IV 85.8 (75-100). All pretarsi with two small claws and small claw-like empodium. Femur I fully divided as suture (which seem less flexible than *T. kakadu*), femur II entire, femur III-IV, incompletely divided by suture only on ventral half, dorsal half rigid. Legs I-IV setation (rod-like in square brackets): trochanters 0-1-1-0; (basi)femora (3)5-2-(2)1-(1)2; genua 7-3-2-2; tibiae 5[2]+k -4-3-3; tarsi 8[6]-7-6-5; tarsus I with two rised sensory bumps (*ω1-2*), paraxial one longer; genua I-II, tibia I-III, and tarsi II each with one rised sensory bump; setae *ft'*, *ft"*, *tc'*, *tc"*, *p'* and *p"* of tarsus I eupathidial, rod-like with ampullate tip; seta *k* of tibia I setiform but its distolateral half abruptly slender; seta *d* of tibia I simple, not eupathidial, posteriad of sensory bump (*φ*); seta *ft"* (but see Discussion) of tarsi II minute, adjacent to rised sensory bump.

Male. Unknown.

Ontogeny. *Larva* (n=1) - Body length 220; width at level of setae *c* 65. Leg I, 95; leg II, 58; leg III, 65. Body constrictions and gnathosoma similar to female except subcapitulum with three pairs of setae (*m*, *n*, *or1*). Dorsal propodosoma similar to female, hysterosoma with 12 pairs of setae (*c1, c2, c3, d1, e1, f1, f2, h1, h2, ps1, ps2, ps3*). Ventrally, Claparede's organ (*Cl*) similar to *T. kakadu*; coxal setation (I-III): 3-1-1; *1c* scale-like, protecting *Cl*. Legs I-III setation: trochanters 0-0-0; (basi)femora (2)5-2-3; genua 7-3-2; tibiae 7+k-4-3. Tarsi[rod-like] 10[2]-5-4; one rised sensory bump present on genua I-II, tibiae I-III and tarsi I-II; seta *k* of tibia I similar to female; setae *p'*and *p"* of tarsus I rod-like, eupathidial; femur I with faint division on ventral half, femora II-III entire.

Protonymph (n=1) - Body length 290; width at level of setae *c* 75. Leg I, 100; leg II, 55; leg III, 60, leg IV, 65. Gnathosoma similar to larva except with four pairs of subcapitular setae (*or2* added); hysterosoma with 15 pairs of setae (*ad1-3* added). Coxal setation 4-2-1-0 (*1b*, *2a* added; *1c* becoming setiform); genital opening present, with one pair of aggenital setae (*ag1*); one pair of genital papillae (*Va*) and associated seta *k1*. Legs I-IV setation: trochanters 0-1-1-0; (basi)femora (2)5-2-3-0; genua 7-3-2-2; tibiae 7+k -4-3-2. Tarsi[rod-like] 8[6]-7-6-3. On tarsi I, one sensory bump (*ω2*) added, setae *tc'* and tc" added as rod-like, *ft'* and *ft*" become rod-like, eupathidial; on tarsus II, setae *p'* and *p"* added; on trochanters II-III, seta *v* added; on tarsus III setae *p'* and *p"* added.

Duetonymph (n=1) - Body length 295; width at level of setae *c* 80. Leg I, 110; leg II, 58; leg III, 75, leg IV, 75. Gnathosoma similar to preceding instars; coxal setation 4-3-2-2 (*2c*, *3c*, *4b*, *4c*, added); genital opening with two pairs of genital setae (*g1-2* added), two pairs of aggenital setae (*ag2* added), two pairs of genital papillae and two associated setae (*Vm* and *k2* added; Fig. 9A) . Legs I-IV setation: trochanters 0-1-1-0; (basi)femur (2)5-2-3-3; genua 7-3-2-2; tibiae 6[1]+k -4-3-3. Tarsi[rod-like] 8[6]-7-6-5. On tibia I, seta *l'* becoming rod-like, euphathidial; on tibia IV, *v"* added; on femur IV *d*, *v'*, *ev"* added; on tarsus IV, *p'* and *p"* added.

Tritonymph. Unknown.

Development of leg setae are summarized in Table 3.

Observation on ontogeny of *Tanytydeus cristatus* Theron *et al*., 1969

In light of new ontogenetic data of the above two species, re-examination of the type materials of *Tanytydeus cristatus* revealed that paratypes of *T. cristatus* are mixture of specimens of two species: *Tanytydeus cristatus* (slide no. 6/A/10, containing the holotype female and 2 deutonymphs; slide no. 6/B/6, containing 2 females; slide no. 6/B/5, containing 2 females and 1 deutonymph; slide no. 6/B/2 containing 1 female and 2 tritonymphs; and slide no. 6/A/11, containing 1 male) and *Tanytydeus* cf. *egypticus* (Soliman) (slide no. 6/B/1, containing 2 females; slide no. 6/B/7 containing 1 larva; slide no. 6/B/4 containing 1 protonymph). The former species has seta *d* on leg tibia I situated anterior to a sensory bump (*φ*) (Fig. 13A, B; arrowed) while in the latter species this seta is situated posterior to sensory bump (*φ*) (Figs 12A, D, 13C; arrowed). Their juveniles and adults are linked primarily on this character states.

Females of *Tanytydeus cristatus* differs from that of *T.* cf. *egypticus* in having a) 9 setae (*l"* present) on leg basifemur I (vs. 8 setae, *l"* absent), and b) seta *d* on leg tibia I situated anterior to sensory bump *φ*, this seta becomes rod-like in tritonymph (Fig. 13A) [vs. seta *d* on tibia I situated posterior to sensory bump *φ* and remain simple throughout ontogeny (Figs 12A, D, 13C)]. If the leg chaetotaxy is not taken into account, tritonymphs of *T. cristatus* (Fig. 11A) may be superficially looked like adult female of *T.* cf. *egypticus* (Fig. 11B), i.e. they have the same numbers of genital setae (2 pairs), aggenital setae (3 pairs), genital papillae (2 pairs) and associated setae *k* (3 pairs); but the adult female of *T.* cf. *egypticus* differs from the tritonymphs of *T. cristatus* one in having a well developed genital opening, which approaches to an anal opening (Fig. 11B).

Therefore, we propose a new interpretation of the ontogenic change, particularly in the genital region, from deutonymphs (larvae and protonymphs unknown) to adult (female) of *Tanytydeus cristatus* as follows:

- deutonymph: size 337-351, 2 pairs of genital papillae, 2 associated setae *k*; 2 genital setae, and 2 aggenital setae (Figs 18, 19 of Theron *et al*. 1969);

- tritonymph: size 370-410, 2 pairs of genital papillae, 3 associated setae *k*; 2 genital setae, and 3 aggenital setae (Fig. 20 of Theron *et al*. 1969);

- adult (female): size 430-452, 2 pairs of genital papillae and 3 associated setae *k*; 4 genital setae, and 5 aggenital setae (Figs 15, 16, 17 of Theron *et al*. 1969).

Note that the adult female has more developed genital opening than the tritonymph; and genital papillae associated setae *k1-3* are actually present in *Tanytydeus cristatus,* they were overlooked in the original description.

Finally, when comparing specimens of *Tanytydeus* cf. *egypticus* from South Africa with that from Thailand as well as a single female specimen from Iran submitted to MF for identification, we are unable to detect any differences between them, except for size (idiosomal length is about 300 in Thai population vs. 350 in South African populations). In other words, they are very similar and we consider they are conspecific; hence a wide distribution of this species. It is also worthy noting that known immature stages (the larva and protonymph) of South African population has similar ontogenetic change to that of Thai population.

2E-4 Discussion

1. Genital papillae and associate setae k. Primitively, adult of acariform mites have three pairs of genital papillae and each pair forms ontogenetically from the protonymph to tritonymph (Oudeman-Grandjean'rule). Paratydeidae is among several prostigmatic families that show trend in reduction of the number of genital papillae. The posterior pair (*Vp*) is reduced in size in species whose adults bearing 3 pairs of genital papillae, and *Vp* is lost in species whose adults bearing 2 pairs of genital papillae. Interestingly, in a progenital chamber, there are setae termed *k1-3* (not to confuse with eugenital setae on ovipositor which apparently absent in Paratydeidae) that associated with respective papillae and are ontogenetically correlated with them. These setae are apparently present only in some members of Anystina (the caeculid genus *Microcaeculus*, Adamystidae, Anystidae, Teneriffiidae). For Paratydeidae, these setae are useful in distinguishing the deutonymph (*k1-2*) from the tritonymph (*k1-3*) of the species whose a posterior genital papillae, *Vp*, is supressed.

2. Seta ft" on tasrsi II. A small seta adjacent to the rised sensory bump on tarsus II has been tentatively denoted as a fastigial seta, *ft*, in the present study, following recent authors (Dönel *et al*. 2012; Khanjani *et al*. 2014). However, an alternative interpretation that this seta is a famulus: *ε* could not rule out. We noticed that, unlike other normal setae, this seta inserts in slightly sink integument and has internal canal lead to it, a characteristic of famulus in the primitive acariformes. A study of fine structures may prove its identity.

3. Sensory bump. Adults and juveniles of *Tanytydeus* have rised sensory bump on leg genua I-III, tibiae I-II, tarsi I-II and on palp tarsus in the exact position of solenidia. In addition, these structures have the same ontogenetic pattern as the latter structures, i.e. the abaxial bump (=*ω1*) is larval, and the adaxial one (=*ω2*) is protonymphal. Thus they are considered the modified form of normal erected solenidia. These modified solenidia are found only in *Tanytydeus* and possibly synapomorphic for it (the pitted form in *T. lamington* Seeman & Walter, 1999 is possibly a further step of transformation).

4. Position of lyrifissures. The position of the lyrifissure *ia* in paratydeid mites is unusually located with setal row *c*, below seta *c2*. In other prostigmatic mites, *ia* is located along with setal row *d*, although it may be more anteriolateral in some taxa, it never reach the level of setal row *c* as in Paratydeidae. This state is probably a synapomorphy of Paratydeidae.

5. Tracheal complex. The species of *Tanytydeus*, and possibly all member of Paratydeidae, have the trachea trunk from the inter-cheliceral stigmata conversing to those from the sub-cheliceral stigmata and then runs parallelly; these trunks are not touched but instead connected by thin granulated membrane-like structure. This complex seem to be intermediated between the separated trachea as found in the tydeid genus *Tydaeolus* (Grandjean 1938a) and the fused trachea trunk, giving a ‘Y-shaped’ appearance as found in the bdellid genera *Odontoscirus* and *Neomolgus* (Grangjean 1938a; Judson 1994).

Table 1. The measurements (range, if relevant, and mean) of morphological characters of *Tanytydeus kakadu* Seeman & Walter based on the holotype (female) and adult specimens from Thailand.

	Holotype	Female (n=5)	Male (n=5)
Body length (naso to post. end of idiosoma)	450	515-525; 523	500-525; 511
Body width (at level of setae *c*)	175	160-185; 176	140-200; 165
Length of setae *ve*	20	15-20; 17.8	15-25; 19.5
sci	40	50-60; 52.2	55-60; 57.5
sce	20	30-35; 32.2	30-35; 32.2
c1	15	15-20; 18.7	20-25; 21.8
c2	20	40-50; 45.9	45-50; 47.9
d1	15	15-20; 19.9	20-25; 20.1
e1	15	15	15-20; 19.8
f1	14	15-20; 18.5	20-25; 24.3
f2	19	20-30; 25.9	25-35; 31.5
h1	28	25-30; 28.9	35-45; 40.9
h2	26	30-40; 38.3	45-55; 49.6
ps1	15	20-30; 24.9	20-25; 24.5
ps2	26	30	40-45; 43.3
ps3	26	30	30-35; 32.6
ad1	15	15-25; 22.2	15-25; 19.2
ad2	19	15-25; 22.9	25-30; 26.9
ad3	20	20	20

Table 2. Development of leg setae of *Tanytydeus kakadu* Seeman & Walter, 1999[1]

	Coxa	Trochanter	Femur	Genu	Tibia	Tarsus
Leg I						
La	1a, 1c, 1d	–	d, (l), (v), d1, bv	d, (l), (v), (l1), σ	d, k, (l), (v), (l1), φ	(ft), (a), (pζ), (u), vs, (ve), pl', ω1
Pn	1b	–	–	–	– ; [(l)]ζ	(tcζ), ω2; [(ft)]ζ
Dn	–	–	–	–	– ; [d]ζ	–
Tn	–	–	(l1)	–	–	–
Ad	–	–	–	–	–	–
Leg II						
La	2d	–	d, l', bv	d, l', (v), σ	d, l', (v), φ	(tc), p', (u), ft'', ω
Pn	2a	–	–	–	–	(a)
Dn	2b	v	–	–	–	–
Tn	–	–	–	–	–	–
Ad	–	–	–	–	–	–
Leg III						
La	3b	–	d, l', bv	l', v	d, (v), φ	(tc), (u)
Pn	-	v	–	–	–	(p)
Dn	3c	–	–	–	–	–
Tn	–	–		–	–	–
Ad	–	–	–	–	–	–
Leg IV						
Pn	4b	–	–	d, l', v,	d, v'	tc, (u)
Dn	4c	–	d, l', bv	–	v''	(p)
Tn	–	–	–	–	–	–
Ad	–	–	–	–	–	–

[1]Placement indicates instar of first appearance; setal pairs are in parentheses, dash indicates no setal additions, ζ denotes eupathidion, square brackets indicate setae transformed to euphathidia.

Table 3. Development of leg setae of *Tanytydeus* cf. *egypticus* (Soliman, 1974) (See note of Table 1)

	Coxa	Trochanter	Femur	Genu	Tibia	Tarsus
Leg I						
La	1a, 1c, 1d	–	d, (l), (v), d1, bv	d, (l), (v), (l1), σ	d, k, (l), (v), (l1), φ	(ft), (a), (pζ), (u), vs, (ve), pl', ω1
Pn	1b	–	–	–	–	(tcζ), ω2; [(ft)]ζ
Dn	–	–	–	–	–; [l']ζ	–
Tn/ Ad*	–	–	l1'	–	–; [l"]ζ	–
Leg II						
La	2d	–	d, bv	d, l', v", σ	d, l', (v), φ	(tc), (u), ft", ω
Pn	2a	v	–	–	–	(p)
Dn	2b	–	–	–	–	–
Tn /Ad	–	–	–	–	–	–
Leg III						
La	3b	–	d, l', bv	l', v	d, (v), φ	(tc), (u)
Pn	3c	v	–	–	–	(p)
Dn	–	–	–	–	–	–
Tn /Ad	–	–	–	–	–	–
Leg IV						
Pn	–	–	–	l', v,	d, v'	tc, (u)
Dn	4b, 4c	–	d, l', bv	–	v"	(p)
Tn/Ad	–	–	–	–	–	–

* Since Tn is not obtained, the origin of the femoral seta *l1'* on leg I may be tritonymphal or adult, and the tibial seta *l"* of leg I may transforms to eupathid in Tn or Ad.

Figure 1. *Tanytydeus kakadu* Seeman & Walter, female, distended: (A) dorsal view, (B) ventral view. Scale bar: 100 µm.

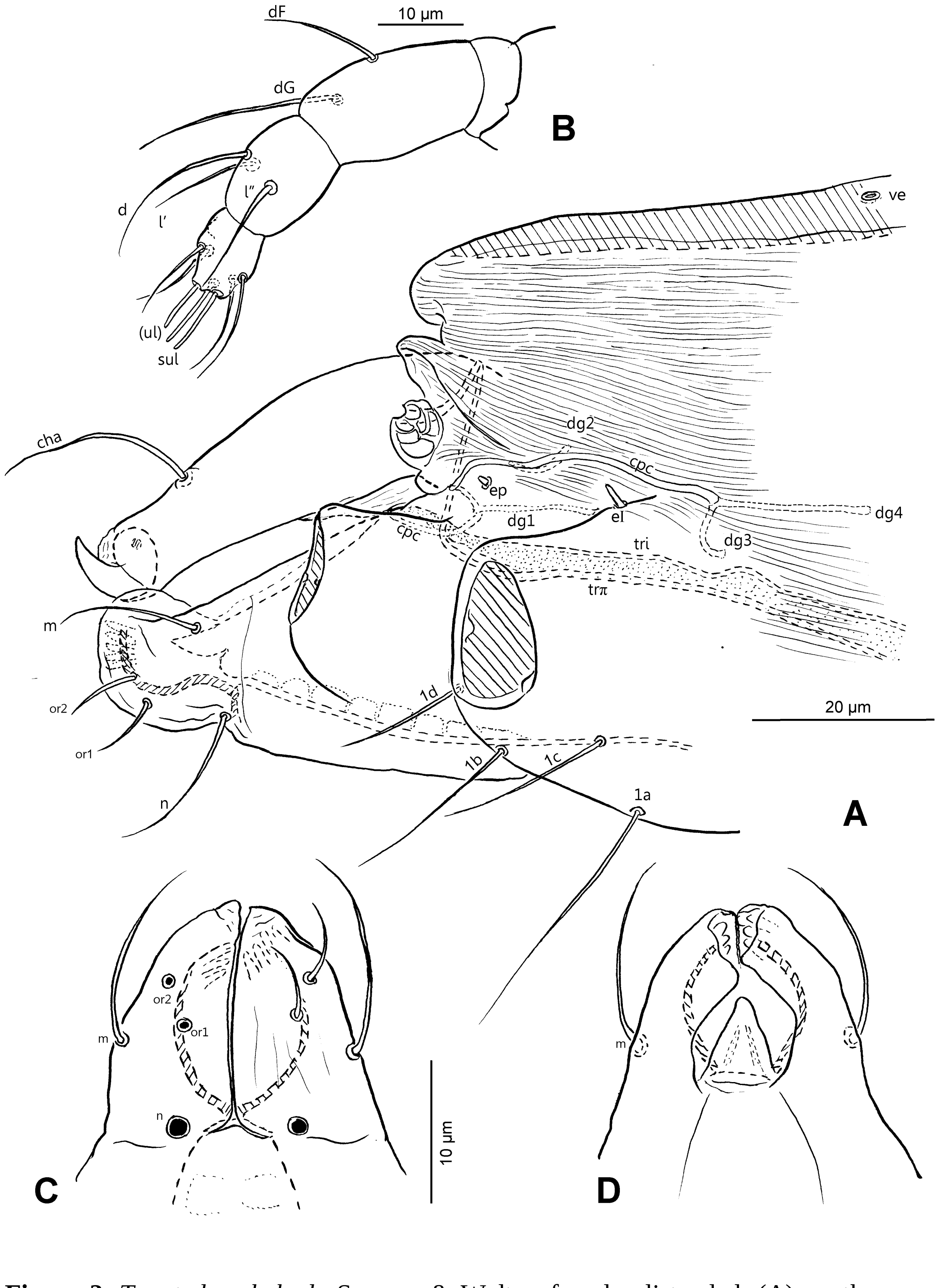

Figure 2. *Tanytydeus kakadu* Seeman & Walter, female, distended: (A) gnathosoma and anterior portion of idiosoma, palp and leg I omitted, (B) palp, abaxial view, (C) subcapitulum, ventral view, (D) same, dorsal view. Scale bars: A 20 µm, B, C, D 10 µm.

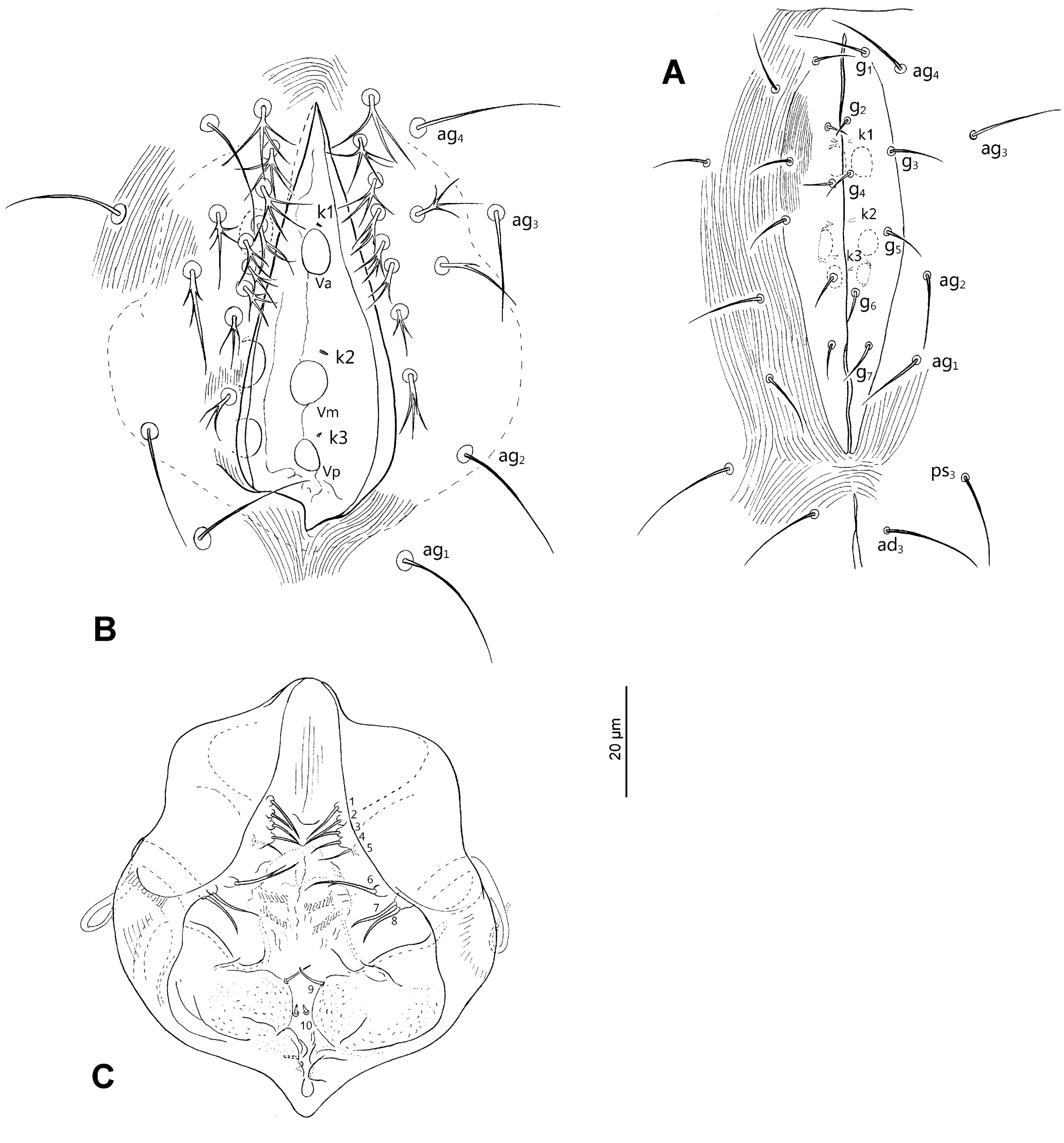

Figure 3. *Tanytydeus kakadu* Seeman & Walter, adults: (A) genital opening of female, (B) genital opening of male, (C) male genitalia. Scale bar: 20 µm.

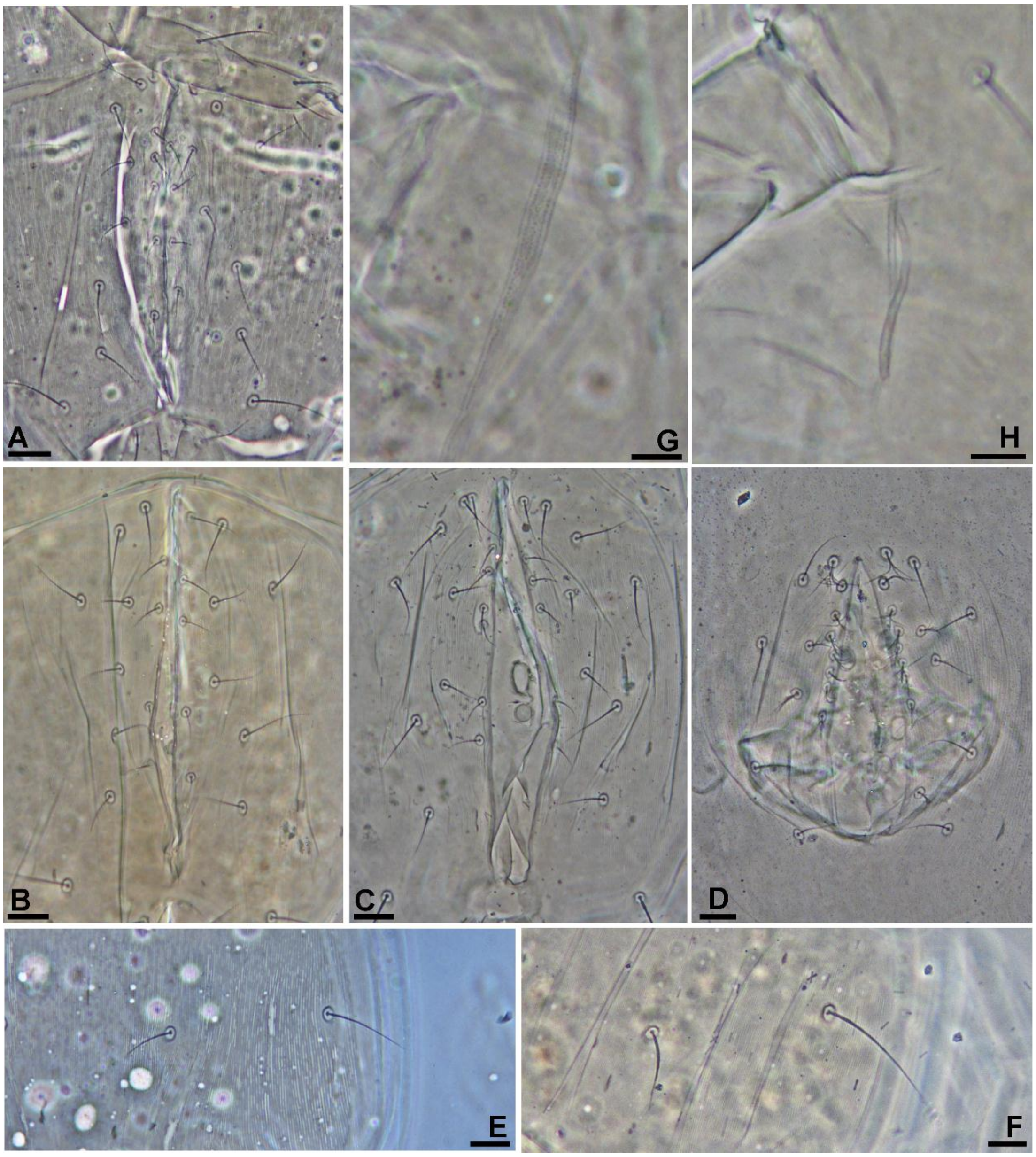

Figure 4. *Tanytydeus kakadu* Seeman & Walter, adults, phase-contrast microscope images: (A) genital opening of female (holotype), (B-C) genital opening of female specimens from Thailand, (D) genital opening of male specimen from Thailand, (E) setae *c1* and *c2* of holotype, (F) same, but specimen from Thailand, (G) trachea at level of setae *c*, (H) same, at level of coxa IV. Scale bars: 20 μm.

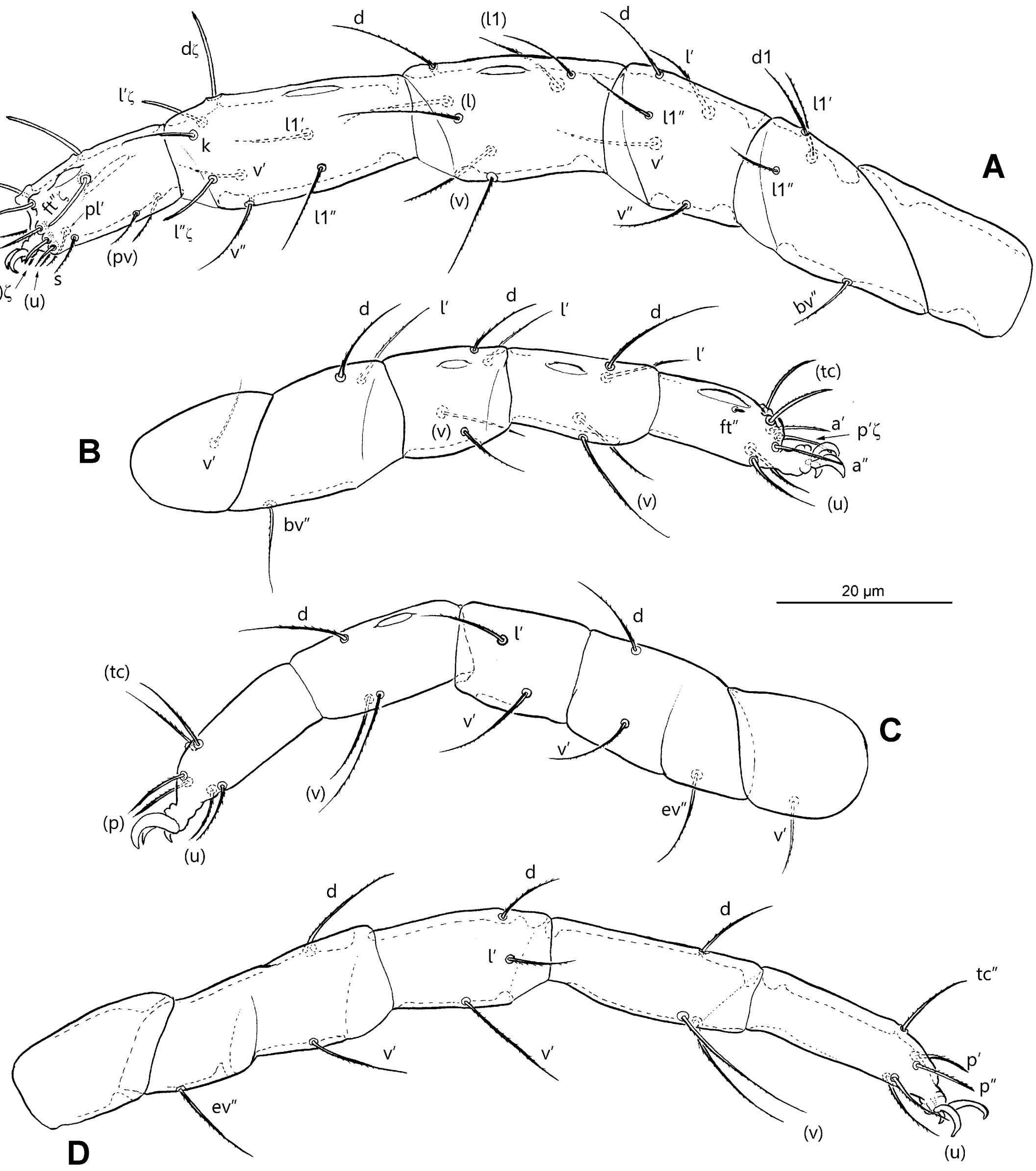

Figure 5. *Tanytydeus kakadu* Seeman & Walter, female: (A-D) legs I-IV, respectively. Scale bar: 20 µm.

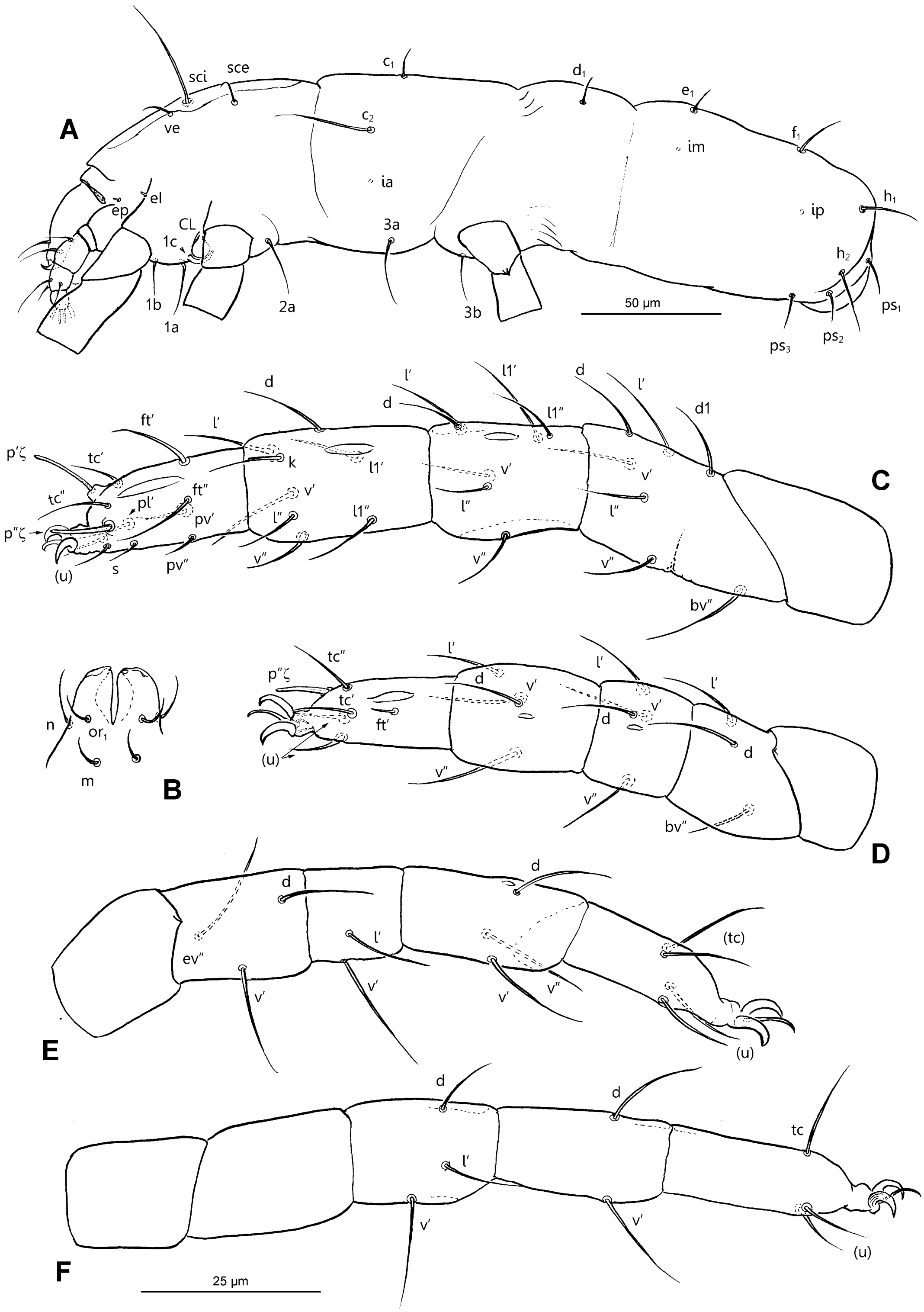

Figure 6. *Tanytydeus kakadu* Seeman & Walter, immatures: (A) larva, lateral view, legs omitted, (B) subcapitulum of larva, (C-E) legs I-III of larva, respectively, (F) leg IV of protomymph. Scale bars: A 50 µm, B-F 25 µm.

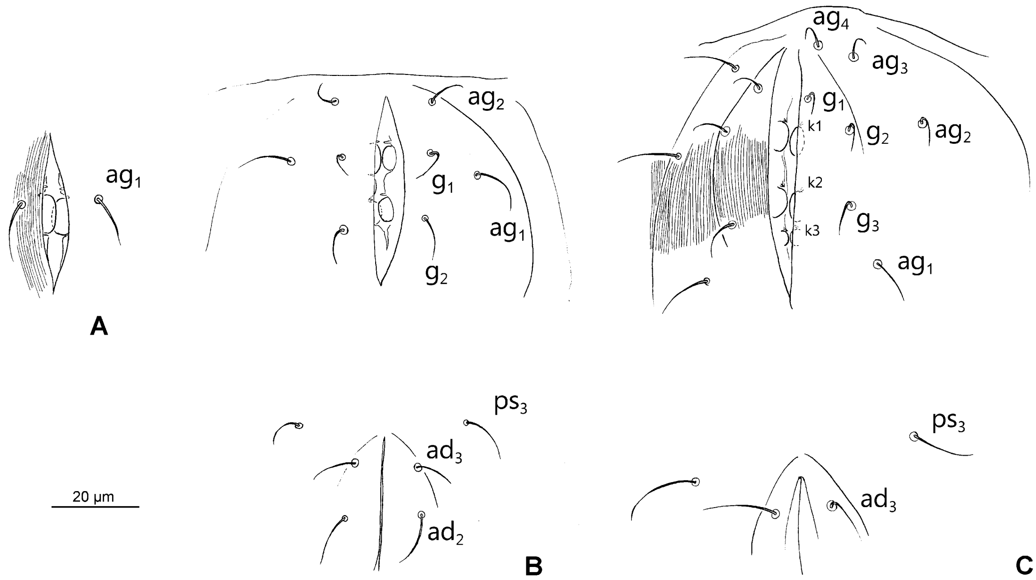

Figure 7. *Tanytydeus kakadu* Seeman & Walter, immatures: (A) genital opening of protonymph, (B) anogenital region of deutonymph, (C) same, but tritonymph. Scale bar: 20 µm.

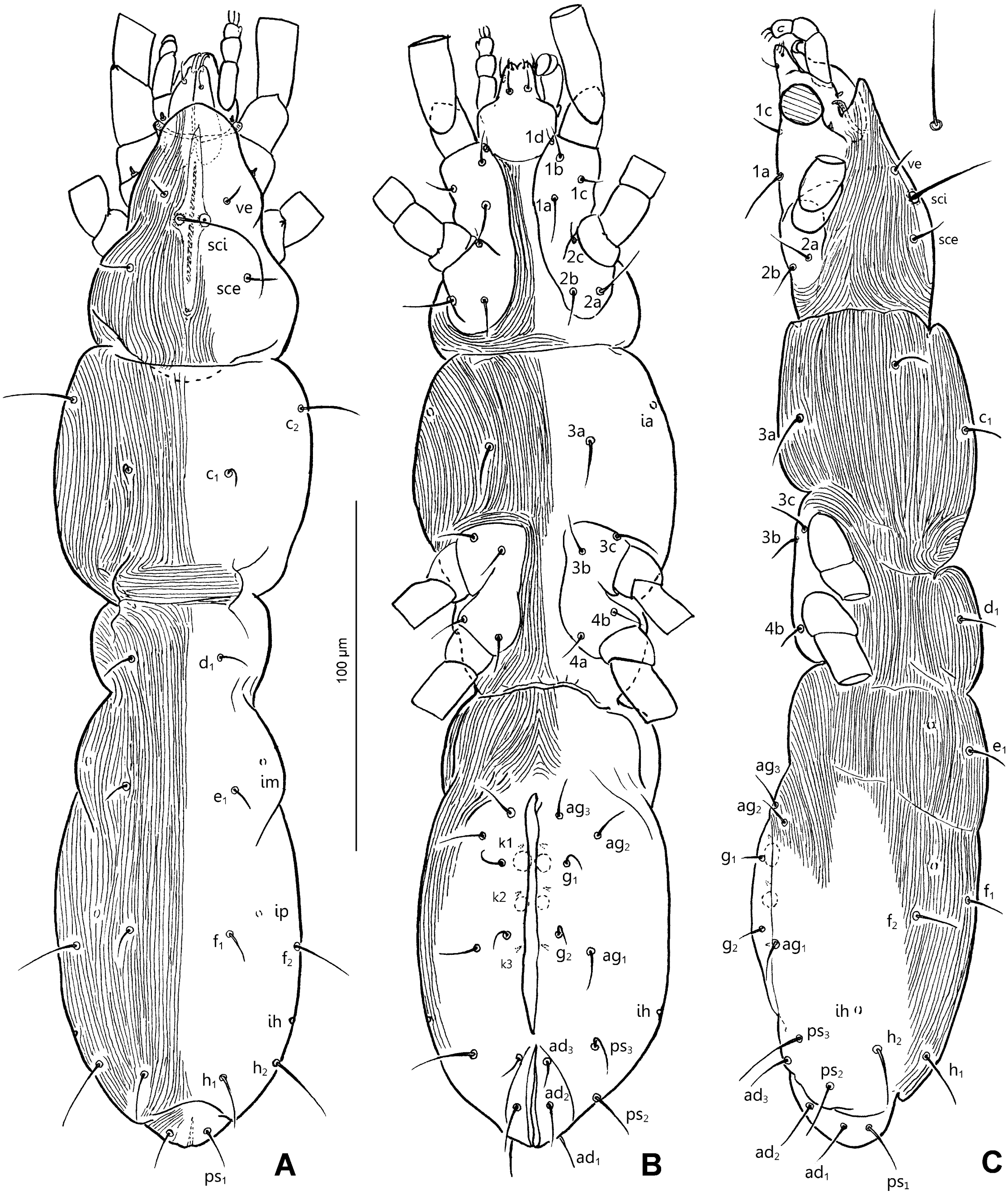

Figure 8. *Tanytydeus* cf. *egypticus* (Soliman), female: (A) dorsal view, (B) ventral view, (C) lateral view. Scale bar: 100 µm.

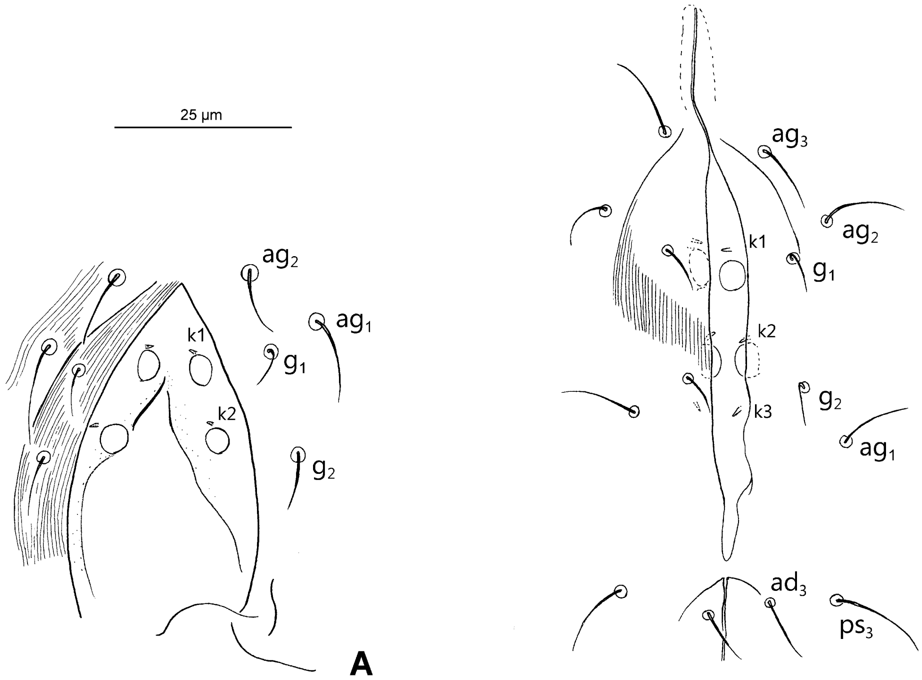

Figure 9. *Tanytydeus* cf. *egypticus* (Soliman): (A) genital opening of deutonymph, (B) genital opening of adult. Scale bar: 25 µm.

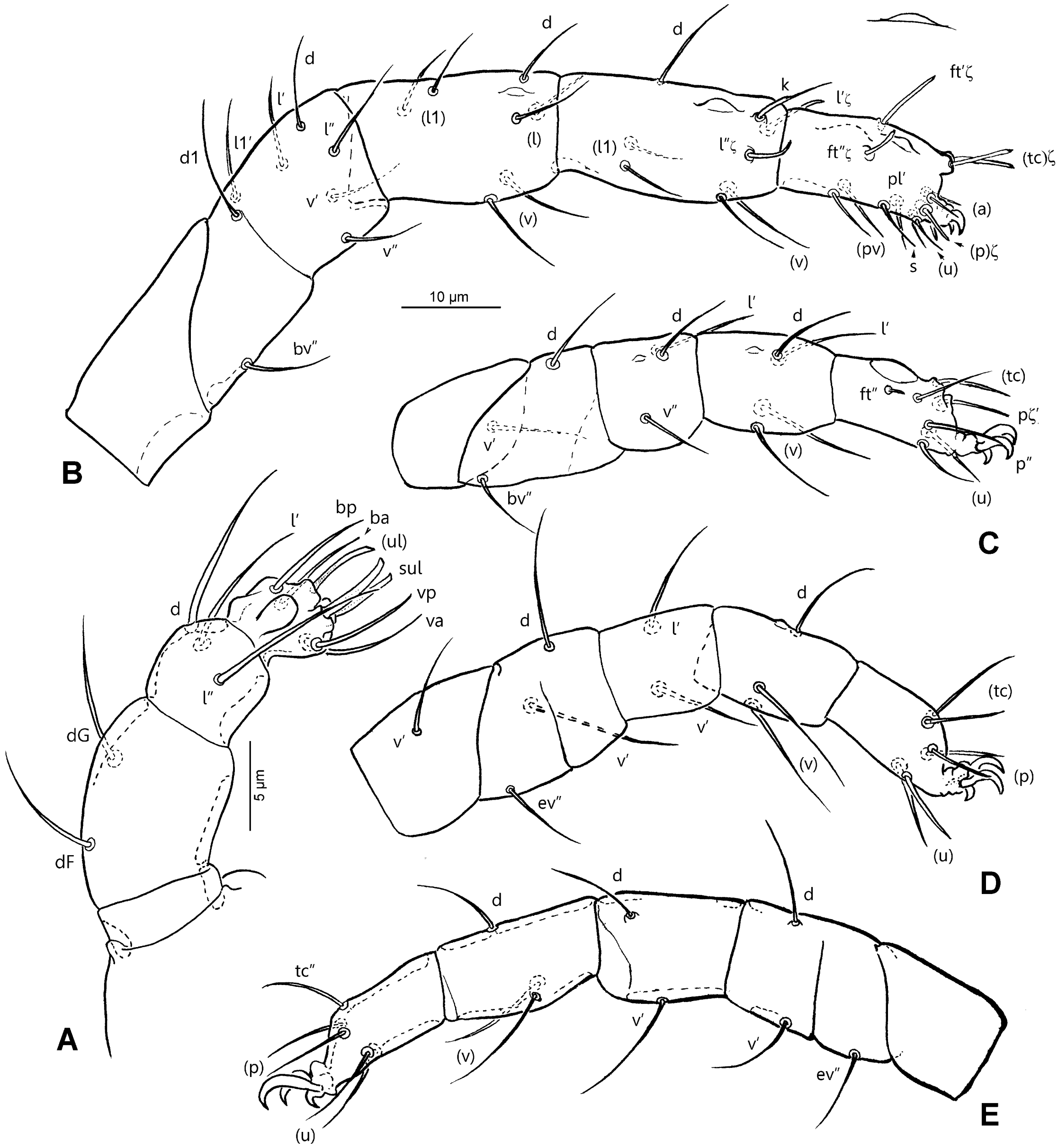

Figure 10. *Tanytydeus* cf. *egypticus* (Soliman), female: (A) palp, abaxial view, (B-E) legs I-IV, respectively. Scale bars: A 5 µm, B-E 10 µm.

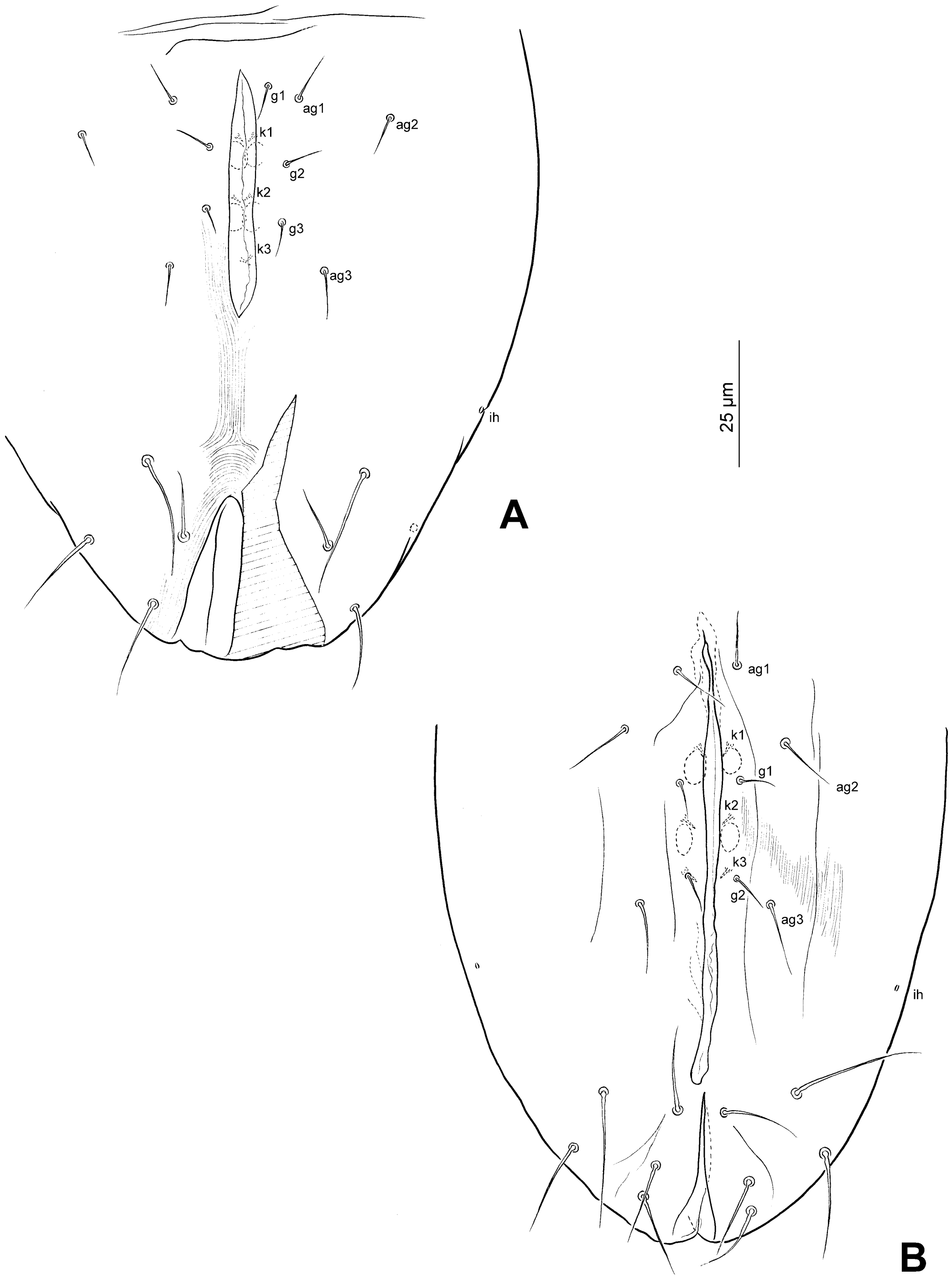

Figure 11. *Tanytydeus* spp. (South African materials): (A) *T. cristatus* (paratype, slide no. 6/B/2), opisthogaster of tritonymph, (B) *T.* cf. *egypticus* (= 'adult of *T. cristatus*' in Theron *et al*. (1969), paratype, slide no. 6/B/1), opisthogaster of adult. Scale bar: 25 µm.

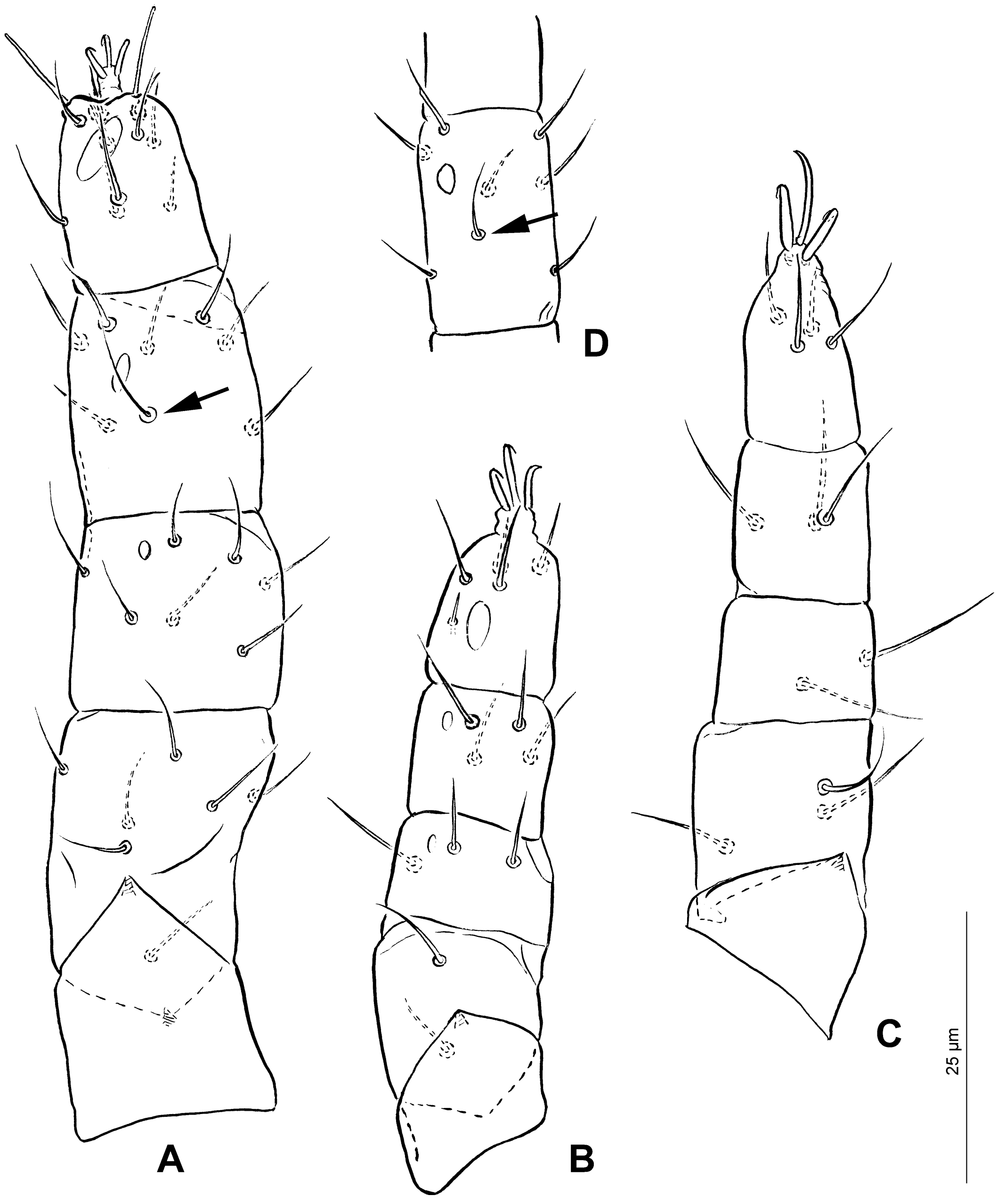

Figure 12. *Tanytydeus cristatus* Theron *et al*. (immatures): (A-C) legs I-III of larva (paratype, slide no. 6/B/7), (B) tibia I of protonymph (paratype, slide no. 6/B/4). Scale bar: 25 µm.

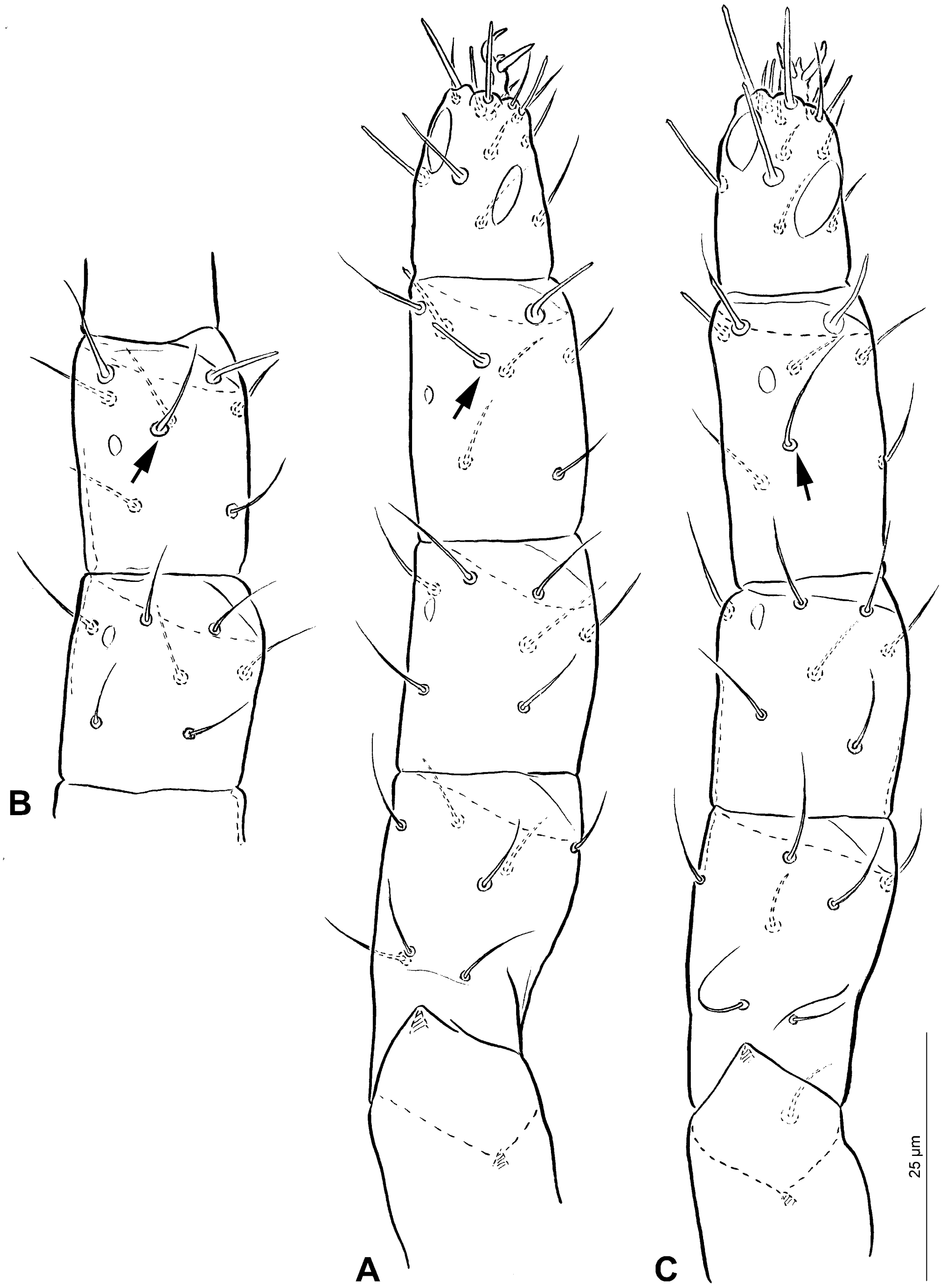

Figure 13. *Tanytydeus* spp. (South African materials): (A) *T. cristatus* (paratype, slide no. 6/A/10), leg I of tritonymph, (B) *T. cristatus* (paratype, slide no. 6/B/2), genu and tibia I of deutonymph, (C) *T.* cf. *egypticus* (= 'tritonymph of *T. cristatus*' in Theron *et al*. (1969), paratype, slide no. 6/B/1), leg I of adult; all in dorsal view. Scale bar: 25 µm.

CHAPTER 2F

THE FAMILY POMERANTZIIDAE (ACARI, TROMBIDIFORMES) IN THAILAND: *APOMERANTZIA PASAK* N. SP. AND *POMERANTZIA PHILIPPINA* BOCHKOV & WALTER[*]

2F-1 Abstract

Two species of the soil mite family Pomerantziidae—*Apomerantzia pasak* **n. sp.** and *Pomerantzia philippina* Bochkov & Walter—are recorded for the first time in Thailand. *Apomerantzia pasak* **n. sp.** is described and illustrated. It was collected from sandy soil of a river bank and differs from its congeners in having three pairs of genital setae, four pairs of aggenital setae, tibia IV with eight setae, tasus IV with 12 setae, and tarsi I-II with six and five solenidia, respectively. *Pomerantzia philippina* Bochkov & Walter, previously known from the Philippines, was collected from sandy soil of the coastal grassland area. Key to known species of Pomerantziidae is given.

Keywords.—Pomerantziidae, Prostigmata, new species, new record, soil mites, Thailand

2F-2 Introduction

Members of the family Pomerantziidae (Acari, Prostigmata) are elongated mites usually found in deep soil horizons (Walter *et al.* 2009). They were collected from pine forests at depth of 3.8–87.6 cm (Fan & Chen 2005; Price & Benham 1976), prairie grasslands, at depth of 35–65 cm (Price 1975) and agricultural crop fields, at depth of 22.9–249.8 cm (Price & Benham 1976) but may occur near surface (0-10 cm) in coarse sand and gravel in the sand ridge of the lake (Kethley 1989). One species is described from the sandy beach habitat (Bochkov & Walter 2007). Currently, the family

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[*] This chapter is a manuscript in preparation for submission as:
Fuangarworn, M. The family Pomerantziidae (Acari, Trombidiformes) in Thailand: *Apomerantzia pasak* n. sp. and *Pomerantzia philippina* Bochkov & Walter.

Pomerantziidae comprises two genera and six species, namely *Pomeratzia charlesi* Baker, 1949b, *P. benhami* Price, 1974 (both from the USA), *P. subterranean* Fan & Chen, 2005 (China), *P. philippina* Bochkov & Walter, 2007 (the Philippines), *Apomeraztia prolata* (Price, 1971) and *A. kethleyi* (Price, 1975), both from the USA. They are presumed to be predatory mites. However, their biology is poorly known. Possibly due to their cryptic micro-habitats, pomerantziids are rarely collected, but the wide distribution of collecting sites suggest that this family is collectively world wide distributed. Additional records are from Canada (Behan-Pelletier & Kanashiro 2010) and Malaysia (Kethley 1990).

In this paper, we report the occurrence of the family Pomerantziidae in Thailand, represented by *Apomerantzia pasak* **n. sp.** and *Pomerantzia philippina* Bochkov & Walter, 2007 collected from sandy soil of a river bank and coastal grassland area, respectively. *Apomerantzia pasak* **n. sp.** is the first species of *Apomerantzia* known outside the Nearctic region and is described herein. Key to known species of pomeranziid mites is given.

2F-3 Materials and methods

Mites were qualitatively collected from sandy soil at depth 0-50 cm (see *Material examined* for collection data), and extracted by the flotation method (Kethley 1991), water phase only. The specimens were sorted under a stereomicroscope and later observed while specimens were in a temporary cavity slide (using lactic acid as the medium) or on permanent slides using Hoyer's solution (Walter & Krantz 2009) under a bright-field compound microscope and a phase contrast microscope. Drawings were made with the aid of a *camera lucida* attached to a microscope. An eyepiece micrometer calibrated with a stage micrometer was used for measurements which are given in micrometers (µm). The terminology generally follows that of Grandjean's system overviewed by Kethley (1990) for idiosomal chaetotaxy, and by Norton (1977) for leg chaetotaxy.

2F-4 Taxonomic results

Family Pomerantziidae Baker, 1949b

Genus *Apomerantzia* Fan & Chen, 2005

Type species: *Pomeratzia prolata* Price, 1971

Diagnosis (modified from Fan & Chen 2005). Peritremes each with 6-5 chambers, seta *c2* anterior to *c1*, ventrolateral plates fused with from coxae III, no more than 4 pairs of genital setae, coxa I with two peg-like setae, genu IV with 6 setae, tarsus II with 3-6 solenidia, and setae *a'* on tarsus II short, spine-like.

***Apomerantzia pasak* n. sp.**

(Figs 1–4)

Diagnosis. Adult female unique among *Apomerantzia* in having following combination of characters: body length about 100–150 long; 3 pairs of genital setae, 4 pairs of aggenital setae, tibia IV with 8 setae, tasus IV with 12 setae, and tarsi I-II with 6 and 5 solenidia, respectively.

Description. *Female*. Body length (from tip of gnathosoma to posterior end of idiosoma, n = 3) 129 (100-150); body width (greatest width of idiosoma) 37.5 (30-40).

Gnathosoma. Chelicera (Fig. 2A) 75.8 (75-80) long, cheliceral seta *cha* 14.2 (10-15) long, Palp (Fig. 2B) typical, palpfemur about 10 long and 25 wide; palp setation: 0-1-1-4(terminal- and subterminal claws included)-8+ω, seta *acm* spine-like; supracoxal setae short rod-like; subcapitulum 88.3 (80-95) wide at level of palp insertions, subcapitular seta *n* slender, 21.7 (20-25) long; adoral setae *or1-2* spine-like inserted without alveolus (Fig. 2C). Peritremes with 6-8 chambers at normal position.

Idiosoma. In dorsal view (Fig. 1A), propodosomal plate roughly flak-shaped, 135.8 (125-145) long; muscle sigillae present as illustrated; setal lengths: *ve* 15 (10-20), *sci* 20, *sce* 30, *ve-ve* 20, *sci-sci* 51.6 (50-55), *sce-sce* 57.5 (55-60); *sce* aligned almost posteriorly to *sci*; Measurement of dorsal opisthosomal plates: C 102.5(90-110) long, 46.6 (40-50) wide; D 40, 46.6 (45-50); E 35.8 (35-40), 45; F 35 (30-40), 43.3 (40-45); H 20, 55. Seta *c1* located 38.3 (30-50) from anterior margin of plate C, seta *c2* situated on small platelet. Setal lengths: *c1* 20, *c2* 34.2 (30-40), *d1* 20, *e1* 17.5 (15-20), *f1* 20, *f2* 10, *h1* 25 (20-30), *h2* 14 (10-15), *ps1* 10, *ps2* 10, *ps3* 10. Lyrifissures *ia*, *im*, *ip*, absent; only *ih* present near anteriolateral corner of plate H.

In ventral view (Fig. 1B), coxae I-IV setation 5-4-4-4; *3a* at normal position, on ventrolatral plate. Setal lengths: *1a* 10, *1b* 15.8 (15-20), *1c* 18.3 (15-20), *1c* 10, *2a* 15, *2b* 40, *2c* 25, *2d* 10, *3a* 13.3 (10-15), *3b* 20, *3c* 13.3 (10-20), *3d* 32.5 (30-35), *4a* 14.6 (10-15), *4b* 16.6 (15-20), *4c* 10. Genital plate 48 (45-50) long with 3 genital setae, about 10 long; aggenital plate 76.6 (75-80) long with 4 aggenital setae, about 10 long; *ag3* close to *ag4*. Genital papillae about 5 diameter. Ovipositor (Fig. 3A) with 22 eugenital setae.

Legs. Lengths: leg I 293 (280-310), leg II 185 (175-190), leg III 196 (190-210), leg IV 256 (250-265). Legs I-IV setation: trochanters 1-1-2-1, basifemora 5-4-3-3, telofemora 5-5-4-5, genua 10+σ-5-5-6, tibiae 12+3φ-5+φ-5+φ-8+φ, tarsi 19+ε+6ω-14+5ω-11-12. Setae *a'* on tarsus II short spine-like. Homologies of leg setae depicted in Fig. 4.

Male. Unknown.

Immature instars. Larva and protonymph unknown. Deutonymph (n = 2) 412 (360-460) long, 128 (100-150) wide; tritonymph (n = 2) 151 long, 154 wide. Deutonymph similar to female except coxal setation of 5-4-4-2; genital region with 2 pairs of genital papillae, 1 pair of genital setae, and 2 pairs of aggenital setae (Fig. 33); legs I-IV setation: trochanters 1-1-2-1, basifemora 3/4-2-2-1, telofemora 5-5-4-4, genua 8+σ-5-5-5, tibiae 10+2φ-5+φ-5+φ-6+φ, tarsi 19+ε+5ω-14+3ω-11-11. Tritonymph with coxal setation of 5-4-4-3; genital region with 3 pairs of genital papillae, 2 pairs of genital setae, and 3 pairs of aggenital setae (Fig. 3C); legs I-IV setation: trochanters 1-1-2-1, basifemora 5-4-2-3, telofemora 5-5-4-5, genua 9+σ-5-5-5/6, tibiae 12+3φ-5+φ-5+φ-7/9+φ, tarsi 19+ε+6ω-14+4ω-11-11.

Material examined. Holotype (female): THAILAND, Ayutthaya Province, Tha Ruea Dist, Salaloy Sub-dist., bank of Pasak River (14°31'48.84"N, 100°42'5.38"E), ex. sandy soil at 20–30 cm (water washing), 30 Aug. 2015, coll. M. Fuangarworn. Five paratypes (females) with same data as holotype. *Other materials*: 2 deutonymphs, 2 tritonymphs with same data as holotype. All materials deposited in the Acarology Collection at the Chulalongkorn University Museum of Natural History, Bangkok, Thailand.

Etymology. The specific epithet is derived from the name of the river, Pasak, whose sand depositions are the habitat of the new species.

Distribution. Known only from the type locality (Ayutthaya, Thailand)

Remark. See Discussion.

Genus *Pomeratzia* Baker, 1949

Type species: *Pomeratzia charlesi* Baker, 1949.

Diagnosis (modified from Fan & Chen 2005). Peritremes each with 3-5 chambers, seta *c2* posterior to *c1*, ventrolateral plates separate from coxae III, 5 pairs of genital setae, coxa I with one peg-like setae, genu IV with 5 setae, tarsus II with 2 solenidia, and setae a' on tarsus II setiform.

Pomerantzia philippina Bochkov & Walter, 2007

(Figs 5–9)

Pomerantzia philippina Bochkov & Walter, 2007: 159.

Diagnosis. Adult female unique among *Pomeratzia* in having following combination of characters: body length about 400–430 long, tarsus I with $19 + 7\omega + \varepsilon$, tarsi III-IV with 12 setae, and genu II with 6 setae.

Material examined. Six females**,** 2 larvae, 3 protonymphs, 4 deutonymphs, and 1 tritonymph: THAILAND, Chonburi Province, Sattahip district, Samae-sarn Island, Luk-lom beach, ~ 12°35'6"N, 100°56'48"E, ex. soil at depth of 10-20 cm in coastal grassland (*Spinifex littoreus* Merr.), 24 Jul 2010, coll. M. Fuangarworn (field no. MF2010-52). Several adults and juveniles with previous data but 23 Nov 2013, field no. MF 2013-54.

Distribution. The Philippines (Bochkov & Walter 2007); Thailand (new record)**.**

Morphological notes. The specimens from Thailand (Figs 5-8) agree well with the original description of *Pomerantzia philippina* except having a relative larger opisthosomal plate F (i.e. subequal in length to plate E). Those in *P. philippina* is shorter, about half length of the plate E (Bochkov & Walter 2007), which is possibly due to the intraspecific variation. An additional variation observed in adults includes leg setae: setae *l3'*on tibia I and *l'*on tibia IV present or absent. Measurements of females (n = 5): body length (from tip of gnathosoma to posterior end of idiosoma) 412 (400-430); body width (greatest width of idiosoma) 134 (120-150); larva (n = 2) xx 235 long, 75 wide; protonymph (n = 3) 271 (260-280) long, 80 (75-90) wide; deutonymph (n = 3) 310 (300-330) long, 86 (80-90) wide; tritonymph (n = 1) 400 long, 125 wide.

The ontogenetic change is similar to that of *Pomerantzia philippina* Bochkov & Walter, 2007 except noted as follows. 1) Larva has three plate-like structures on opisthogastric region: one unpaired at genital region [as illustrated by Bochkov & Walter (2007)] and one paired posterior to coxae III. 2) Setal clusterings are present in larval tarsi I-II: 2a) on tarsus I, *tc'ζ* coupled with *a'* which is very small and their alveoli fused (Fig. 9A), and 2a) on tarsus II, *tc'* (not euphatidial) coupled with *a'* which is very small and their alveoli are also fused (Fig. 9C); these setal clustering are disassociated in protonymph (Figs 9B, D, respectively); hence seta *a'* is larval. Homologies of leg setae are depicted in Figs 7-9 and their development are present in Table 1.

2F-4 Discussion

1. *Differential diagnosis of* Apomerantzia pasak *n. sp.* Female of *Apomerantzia pasak* **n. sp.** can be distinguished from *A. kethleyi* (Price, 1975), from the USA, by having 3 pairs of genital setae (vs. 4), tibia IV with 8+φ setiform organs (vs. 9+φ), and tarsus I with 6 solenidia (vs. 7). The new species also differs from *A. prolata* (Price, 1971), from the USA, in having 4 pairs of aggenital setae (vs. usually 3 pairs, varied from 2-4), tibia IV with 8+φ setiform organs (vs. 9+φ), tarsus I with 6 solenidia (vs. 5), tasrsus II with 5 solenidia (vs. 2), and tarsus IV with 12 setae (vs. 11 setae).

2. *Setal couplings in* Pomerantzia philippina *Bochkov & Walter*. The presence of setal couplings on tarsi I-II (setae *a'* and *tc'*) in larva of *Pomerantzia philippina* is recorded here for the first time in the family Pomerantziidae, and possibly occurs throughout the family. Seta *a'* is very small and may be easily overlooked in previous study on the ontogeny of *P. philippina* by Bochkov and Walter (2007). These setal coupling is also has been reported in the Pseudocheylidae (Fuangarworn & Butcher 2015a). The similar phenomenon also occurs in many taxa of Raphignathoidea (Swift 2001) but, they are the members of setae *(tc)* and eupathidial *(p)* that form clusters in the larva.

Key to genera and species of Pomerantziidae (female), modified from Fan and Chen (2005)

1. Each peritreme with 3-5 chambers; seta *c2* posterior to *c1*; ventrolateral shields separate from coxae III, coxa I with two peg-like setae ………. *Pomerantzia* ….. 2
- Each peritreme with 6-8 chambers; seta *c2* anterior to *c1*; ventrolateral shields fused coxa III, coxa I one two peg-like setae ………………………. *Apomerantzia* ….. 5
2. Tarsi III-IV with 12 setae; genu II with 6 setae …………………………………... …………………………………………….. *P. philippina* Bochkov & Walter, 2007
- Tarsi III-IV with 11 setae; genu II with 5 setae …………………………………. 3
3. Tarsus I with 19 setae (excl. famulus and solenidia) ……………………………. 4
- Tarsus I with 18 setae (excl. famulus and solenidia) .... …………………………………………………. *P. subterranea* Fan & Chen, 2005
4. Tibia IV with 8 setae …………………………….………… *P. charlesi* Baker, 1949
- Tibia IV with 9 setae ………………………………..……. *P. benhami* Price, 1974
5. With 4 pairs of aggenital setae; tarsus II with 5 setae ……………..……………. 6
- With 3 pairs of aggenital setae; tarsus II with 2 setae …… *A. prolata* (Price, 1971)
6. With 4 pairs of genital setae; tibia IV with 9 setae; tarsus I with 7 solenidia ……….. ………………………………………………………….*A. kethleyi* (Price, 1975)
- With 3 pairs of genital setae; tibia IV with 8 setae; tarsus I with 5 solenidia ……... ……………………………………………………………….. *A. pasak* **n. sp.**

Table 1. Ontogeny of setae and solenidia in *Pomerantzia philippina* Bochkov & Walter, based on specimens from Thailand

	Trochanter	Femur	Genu	Tibia	Tarsus
Leg I					
La	-	d, (l), (v), bv	d, (l), (v), σ	d, k, (l), (v), (l1), φ	(ft), (tc), (pl), a', (p), (u), s, (pv), (l), ε, ω
Pn	v	[d1, bv]+ [d, (l), (V)]; d1 added	l1"	- ; +1φ	a", v"; +3ω
Dn	-	[l1', v1]+[-]	(v1)	(v1)	-; +1ω
Tn	-	[l1"]+[-]	d1, (l1), l2"	(l2); +1φ	-; +1ω
Ad	-	[-]+[-]	-	l3'	-; +1ω
Leg II					
La	-	d, (l),(v),(bv)	d, (l), (v)	d, (l), (v), φ	(ft), (tc), a', (p), (u), s, (pv), (pl), ω
Pn	v	[d1,v]+ [d, (l),(v)]	-	-	-; +1ω
Dn	-	[l1"]+[-]	-	-	-
Tn	-	[l1']+[-]	d1	-	-
Ad	-	[-]+[-]	-	-	-
Leg III					
La	-	d, (l), (v), bv	d, (l), (v)	d, (l), (v), φ	(ft), (tc), (p), a", pl", s, (pv), (u)
Pn	v, l'	[d1,v1, bv]+ [d, (l), v]	-	-	-
Dn	-	[-]+[-]	-	-	-
Tn	-	[-]+[-]	-	-	-
Ad	-	[-]+[-]	-	-	-
Leg IV					
Pn	-	-	-	(v)	ft, (tc), (p), (u), s (pv)
Dn	v	[bv]+ [d,(l),v']	d, (l), (v)	d, (l), dl, φ	a", pl"
Tn	-	[d1]+[v"]	-	l1'	-
Ad	-	[l1"]+[-]	-	v1', l1"	l1' (added or not)

[1]Setae and solenidia are first added at the indicated instar (La, Pn, Dn, Tn, Ad = larva, protonymph, deutonymph, tritonymph, adult, respectively) and remain present in subsequent instars; dash indicates no addition. Setae in parentheses represent pseudosymmetrical pairs, brackets indicate subdivision of femur.

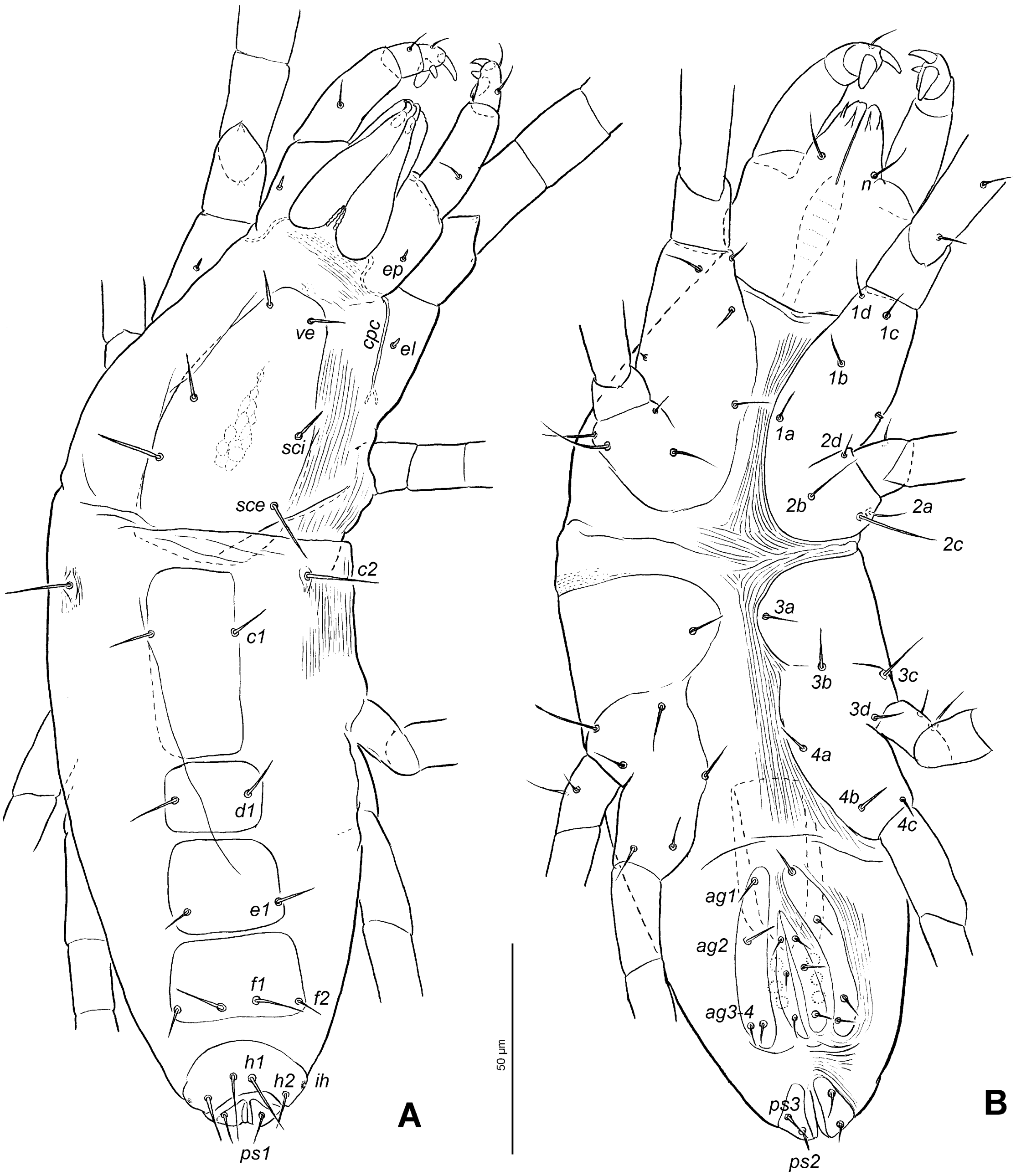

Figure 1. *Apomerantzia pasak* **n. sp.,** female, compressed: (A) dorsal view, (B) ventral view; legs omitted. Scale bar: 50 µm.

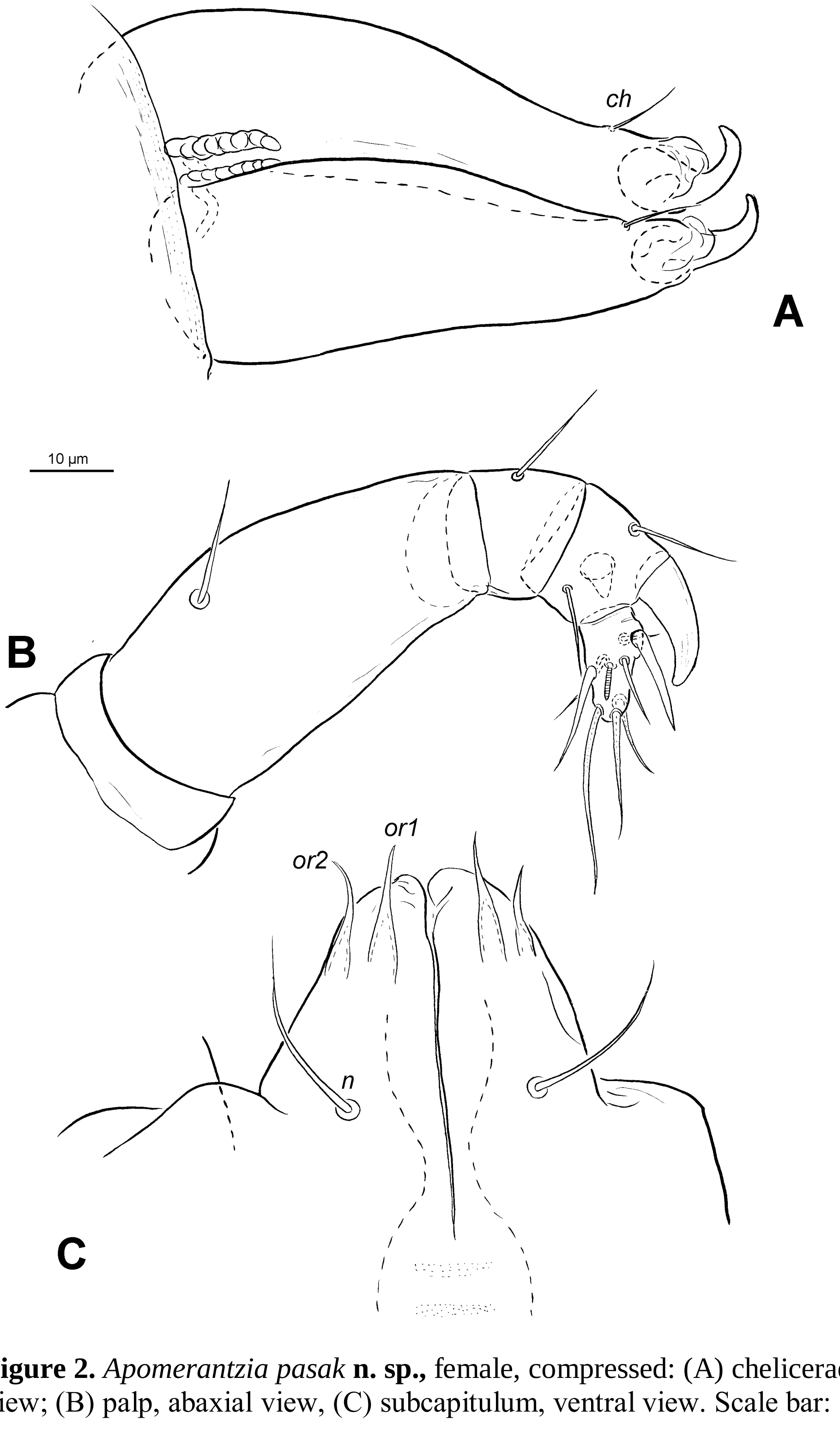

Figure 2. *Apomerantzia pasak* **n. sp.,** female, compressed: (A) chelicerae, dorsolateral view; (B) palp, abaxial view, (C) subcapitulum, ventral view. Scale bar: 10 µm.

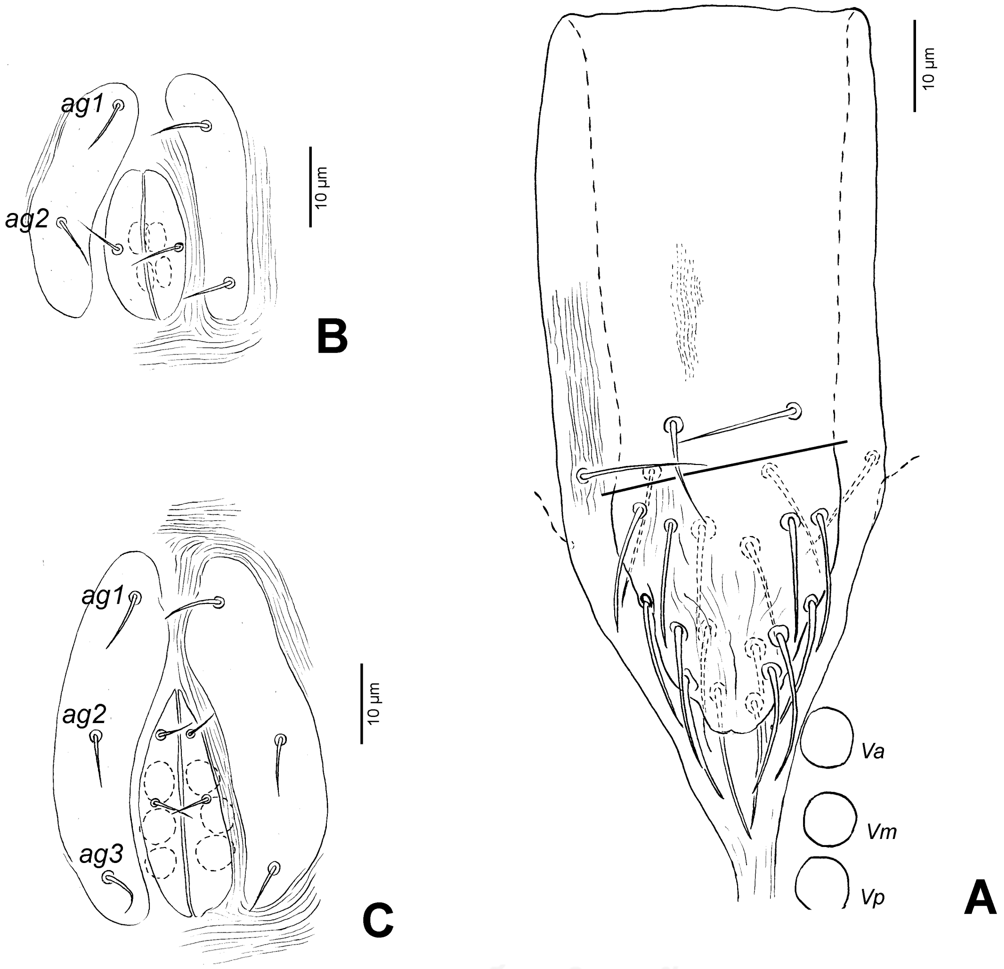

Figure 3. *Apomerantzia pasak* **n. sp.,** compressed: (A) ovipositor, ventral view, folded portion below oblique line drawn intact, (B) genital region of deutonymph, (C) same of tritonymph. Scale bars: A, 10, B-C, 10 µm.

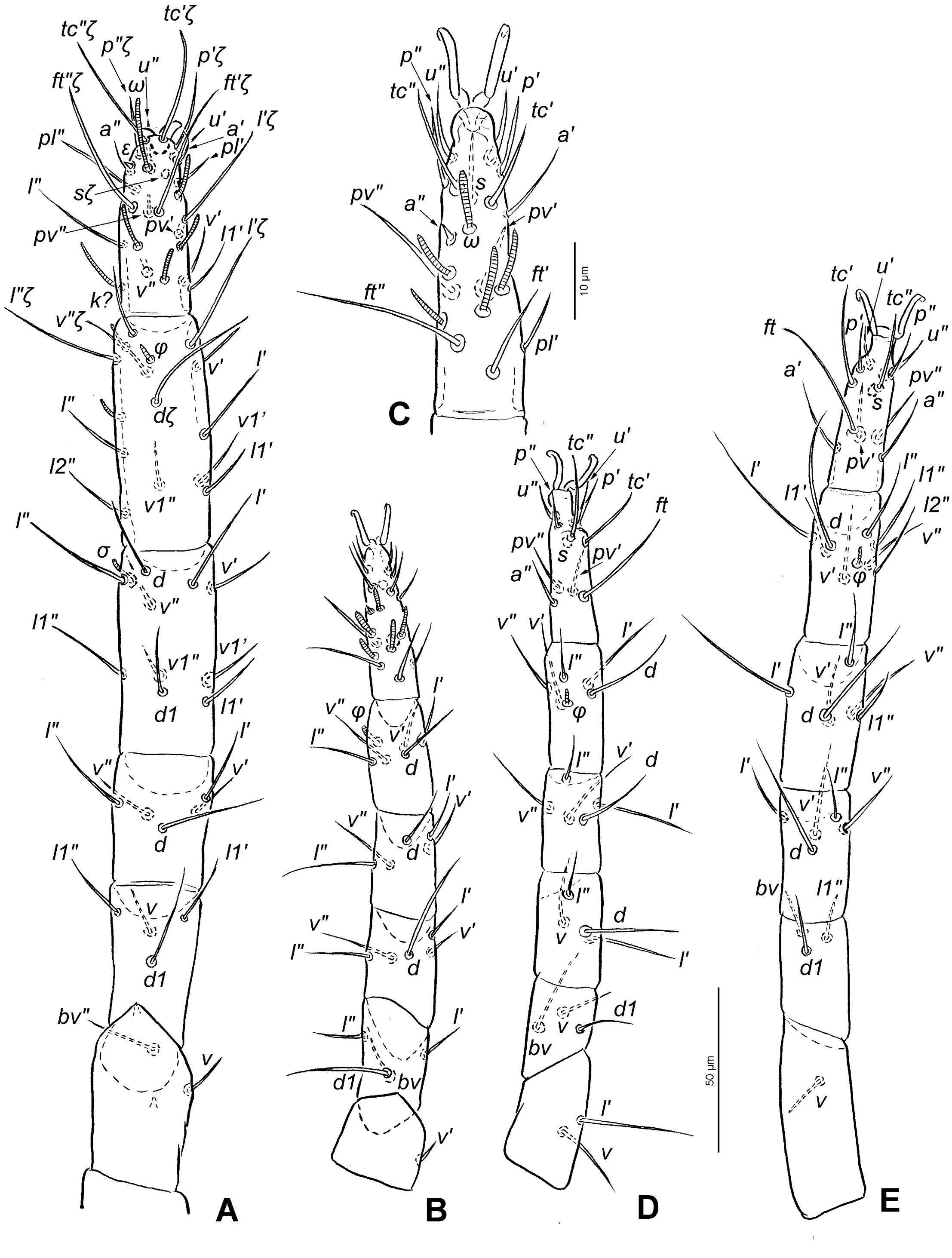

Figure 4. *Apomerantzia pasak* **n. sp.**, female, compressed: (A) leg I, (B) leg II, (C) tarsus II, (D) leg III, (E) leg IV, all in dorsal view. Scale bars: A, B, D, E 50 µm, C 10 µm.

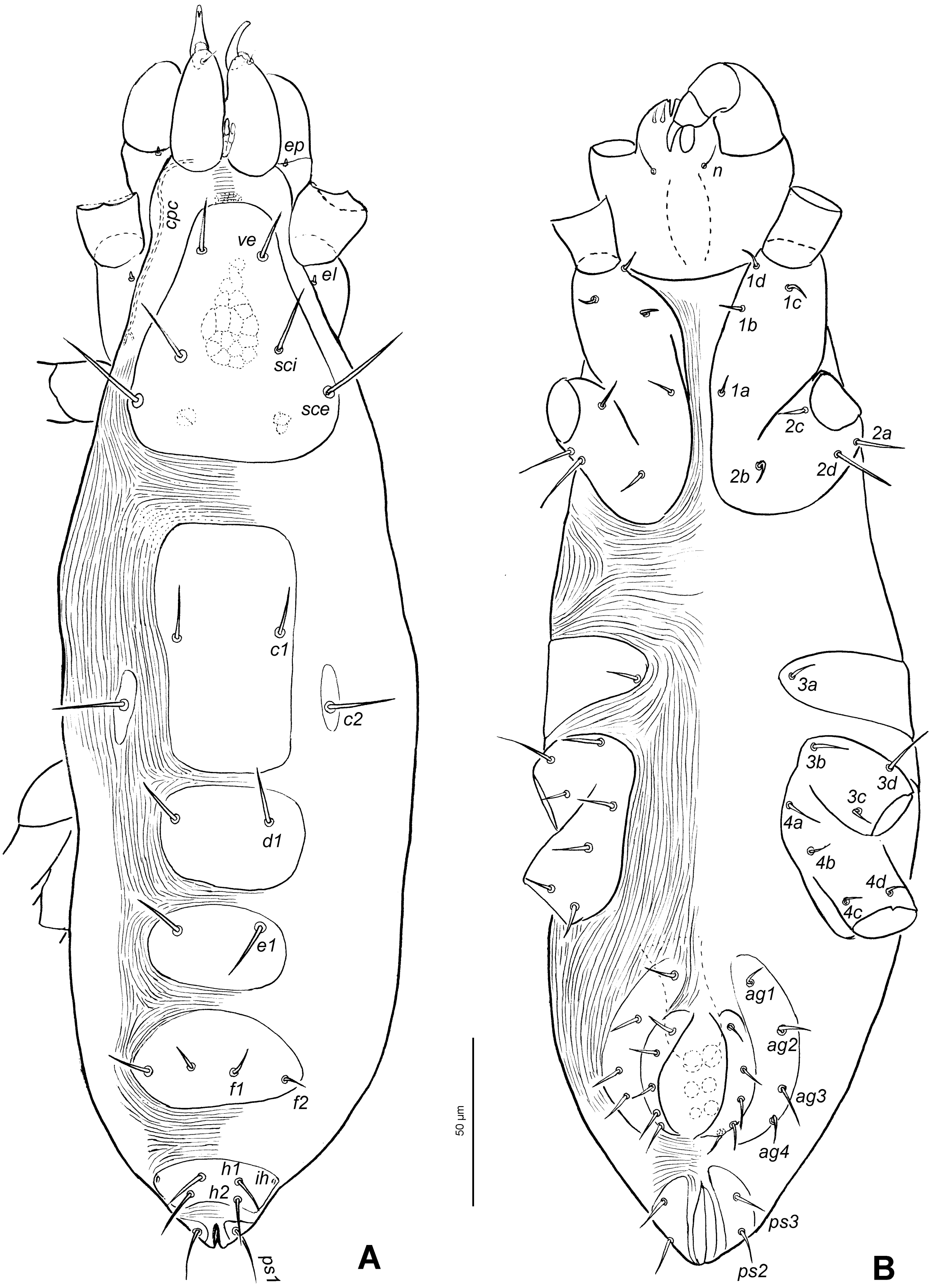

Figure 5. *Pomerantzia philippina* Bochkov & Walter, female, distended: (A) dorsal view, (B) ventral view, palps and legs omitted. Scale bar: 50 µm.

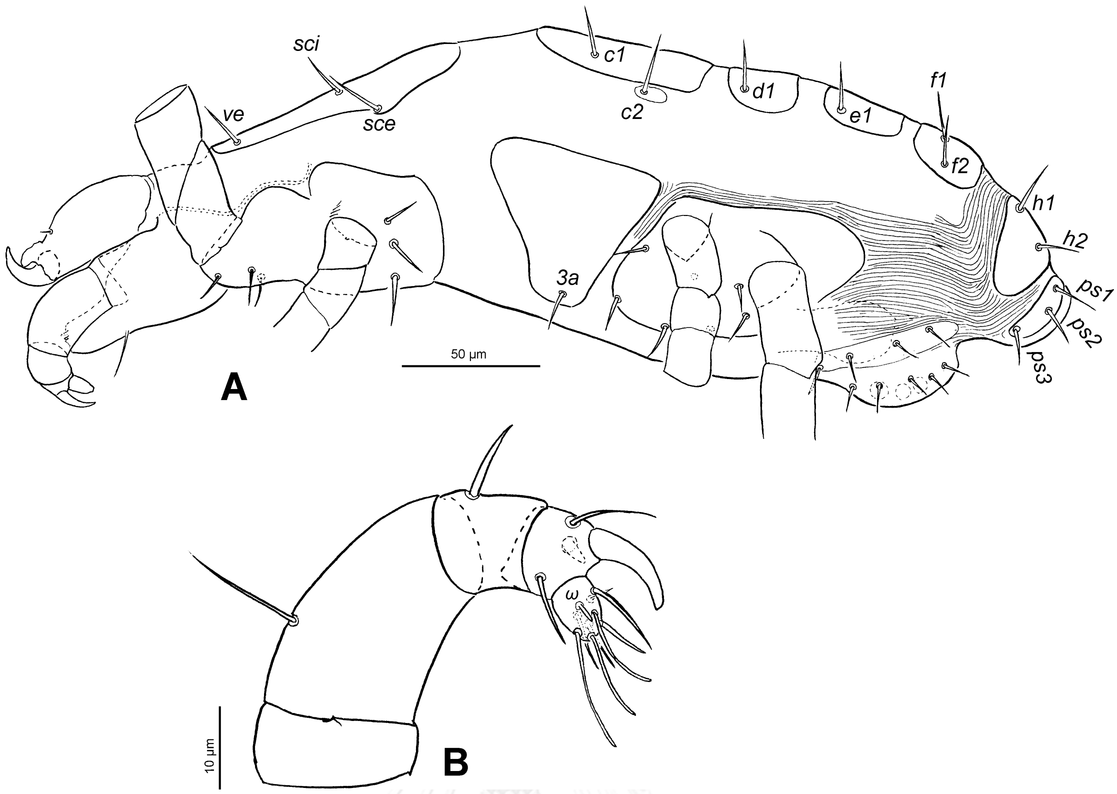

Figure 6. *Pomerantzia philippina* Bochkov & Walter, female, distended: (A) lateral view, legs omitted, palp partial drawn, (B) palp, abaxial view. Scale bars: A 50 µm, B 10 µm.

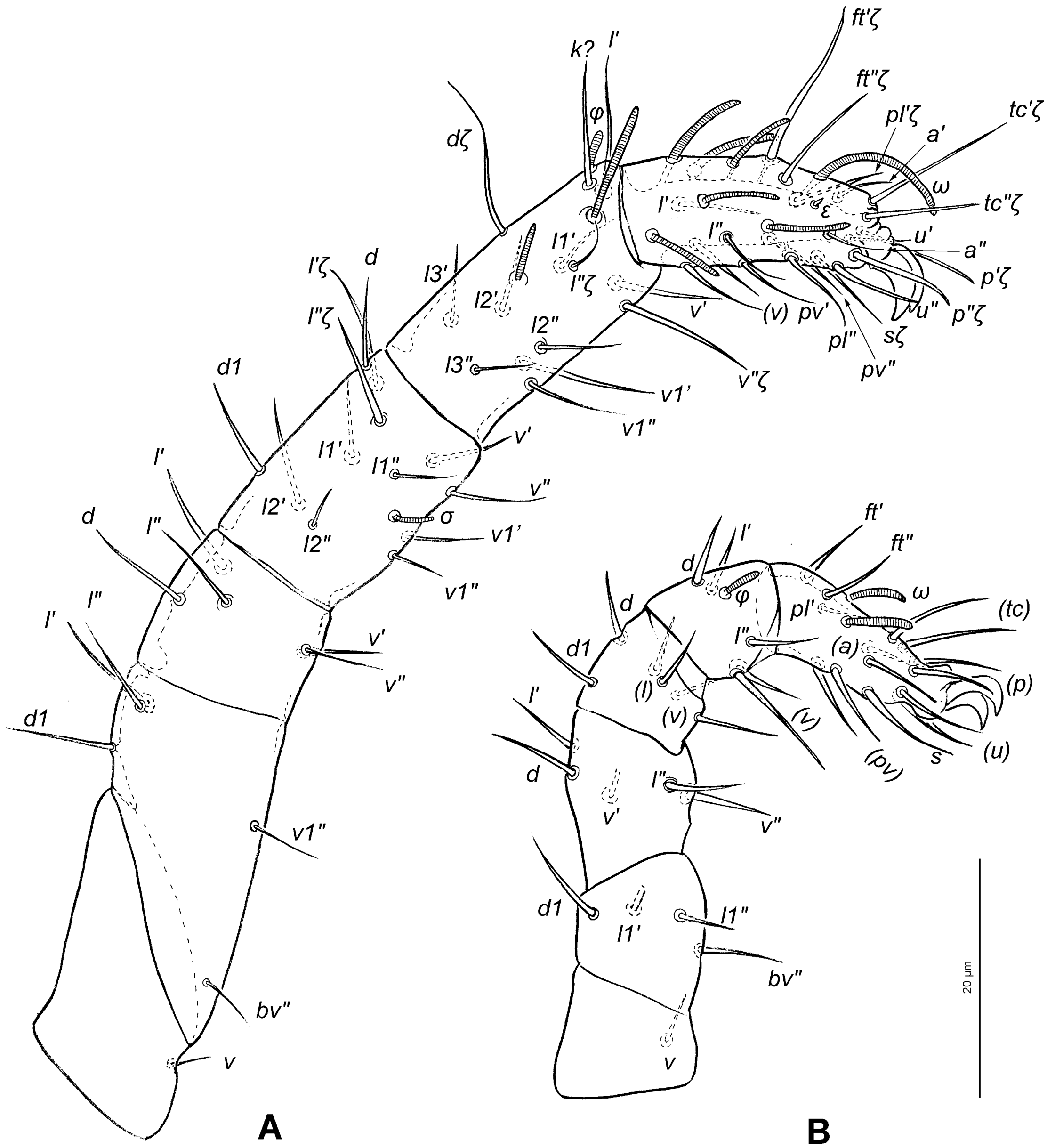

Figure 7. *Pomerantzia philippina* Bochkov & Walter, female, compressed: (A) leg I, (B) leg II, abaxial view. Scale bar: 20 µm.

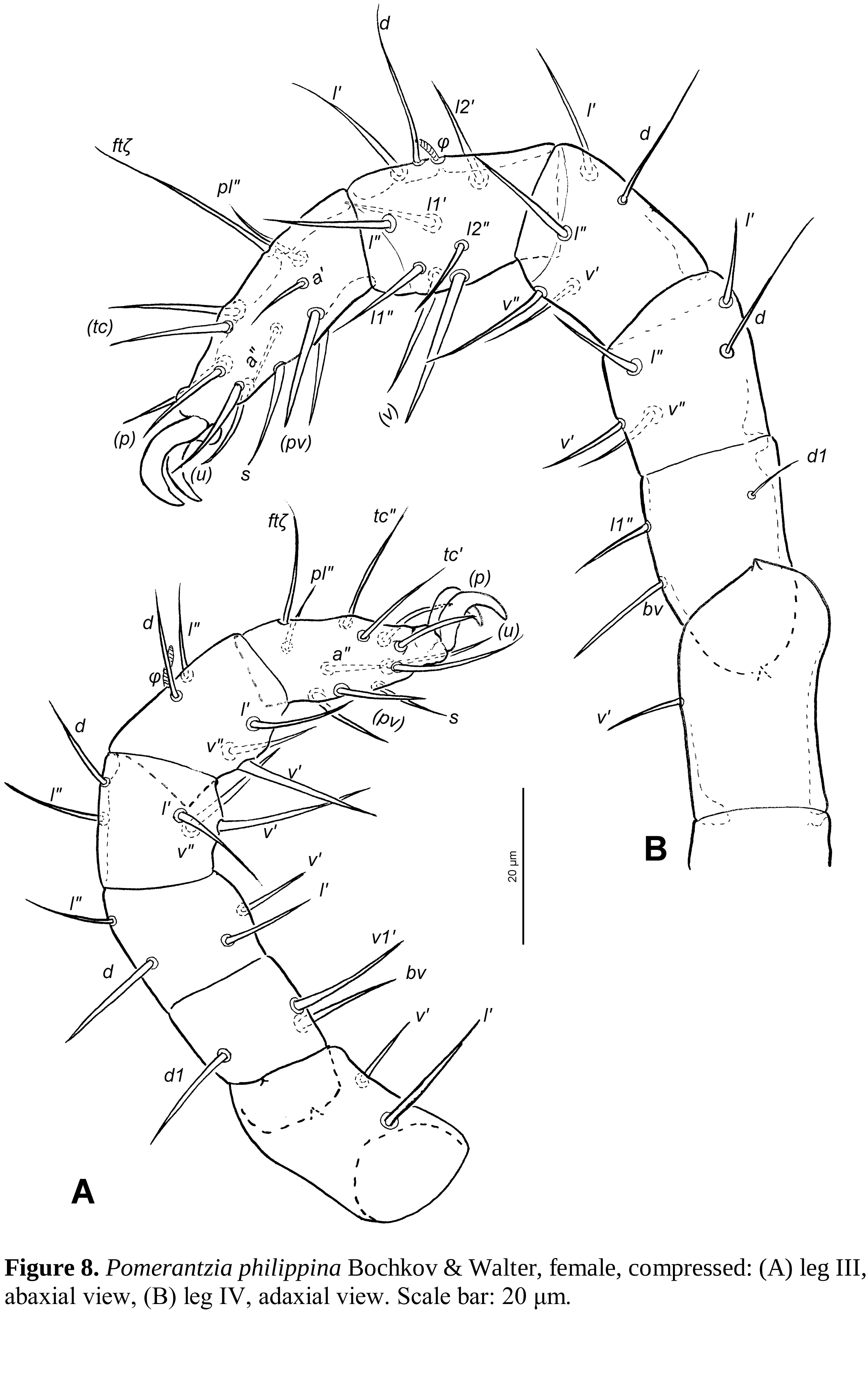

Figure 8. *Pomerantzia philippina* Bochkov & Walter, female, compressed: (A) leg III, abaxial view, (B) leg IV, adaxial view. Scale bar: 20 µm.

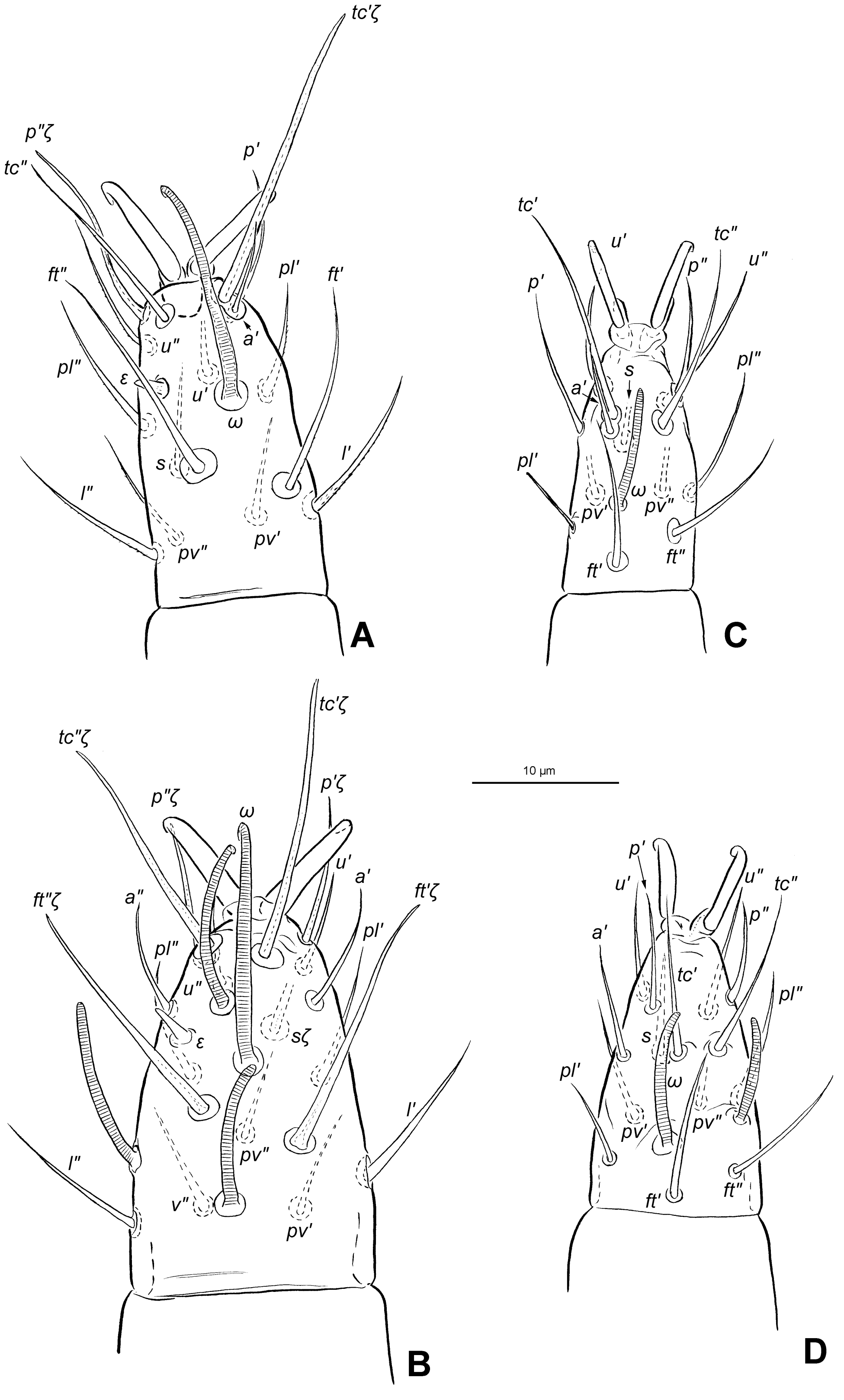

Figure 9. *Pomerantzia philippina* Bochkov & Walter, immatures: (A) tarsus I of larva, (B) tarsus I of protonymph, (C) tarsus II of larva, (D) tarsus II of protonymph; all in dorsal view. Scale bar: 10 μm.

CHAPTER 2G

CONTRIBUTION TO THE FAMILY PSEUDOCHEYLIDAE (ACARI, TROMBIDIFORMES) FROM THAILAND: ONE NEW SPECIES AND ONE NEW RECORD OF *ANOPLOCHEYLUS* BERLESE, WITH OBSERVATIONS ON THEIR ONTOGENY[*]

2G-1 Abstract

We describe a new species of pseudocheylid mite in the genus *Anoplocheylus* Berlese, *Anoplocheylus corticicola* **n. sp.**, based on adults and immatures, and record the occurrence of *A. aegypticus* Baker & Atyeo, 1964 from Thailand. Immature (deutonymphal) dimorphism in *A. corticicola* **n. sp.** is reported for the first time in Pseudocheylidae. The discovery of pharate females of *A. corticicola* **n. sp.** in deutonymphal exuviae indicates that the tritonymphal stage is absent in the female ontogeny. Males presumably develop directly from the male deutonymphal morph, but we could not confirm this. The ontogeny of *A. aegypticus* is also described for the first time. Remarks on selected morphological characters of *Anoplocheylus* are given.

2G-2 Introduction

Mites in the family Pseudocheylidae have an elliptical body (about 400–1000 μm long), reddish orange in colour, short raptorial palps and characteristically annulated, stalk-like pretarsi with membranous pad-like empodia (Walter *et al.* 2009). They have been collected from moss, soil and leaf litter, bird nests and bark and are thought to be predators in these habitats. An unidentified species (*Pseudocheylus* spp.) was reported phoretic on the southern pine beetle, *Dendroctonus frontalis* Zimmerman, 1868 (Stephen & Kinn 1980). However, their biology and ecology are still poorly

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[*] This chapter is a version of a manuscript which has been published as:
Fuangarworn, M. & Butcher, B.A. (2015) Contribution to the family Pseudocheylidae (Acari, Trombidiformes) from Thailand: one new species and one new record of *Anoplocheylus* Berlese, with observations on their ontogeny. *International Journal of Acarology*, 41, 625-641.

known. This family currently contains 21 species within three genera: *Pseudocheylus* Berlese (with two species), *Anoplocheylus* Berlese (16) and *Neocheylus* Trägårdh (three). Species in *Pseudocheylus* are known from Brazil, Paraguay, and the USA (van Dis & Ueckermann 1991); those in *Neocheylus* are known from Australia, South Africa and Uganda (Van Dis & Ueckermann 1991). *Anoplocheylus* is more widespread and is known from Australia, Brazil, Egypt, Iran, Israel, Italy, South Africa, Ukraine, and the USA (Khaustov & Tolstikov 2015; Ueckermann & Khanjani 2004). None are reported from the Oriental region, including Thailand.

In this contribution, we describe a new species of *Anoplocheylus*—*Anoplocheylus corticicola* **n. sp.** —and record the occurrence of *A. aegypticus* Baker & Atyeo, 1964 in Thailand. The availability of all active immature instars allows us to study their ontogeny for the first time. Remarks on selected morphological characters of *Anoplocheylus* (e.g. body setation, genital opening) that have received little attention in the past are also given.

Keys to world genera and species of Pseudocheylidae were created by Baker and Atyeo (1964) and Van Dis and Ueckermann (1991). Keys to species of *Anoplocheylus* are provided by Ueckermann and Khanjani (2004), Navaei-Bonab *et al.* (2011), Bagheri Bagheri *et al.* (2013), Khanjani *et al.* (2014a), and Khaustov and Tolstikov (2015).

2G-3 Materials and methods

Depending on the substrate types, we extracted specimens from soil and leaf litter using Tullgren funnels, while those from barks and twigs were extracted by the method of water washing (Walter and Krantz 2009); all specimens were stored in 70% ethanol (see *Material examined* for collection data). We sorted the specimens under a stereomicroscope, and later prepared them for examination either on temporary cavity slides using lactic acid as the medium or on semi-permanent slides using Hoyer's solution (Walter and Krantz 2009). They were observed under a bright-field compound microscope and a phase contrast microscope. Drawings were made with the aid of a camera lucida attached to the microscope. An eyepiece micrometer calibrated with a stage micrometer was used for measurements, which are given in micrometres (μm) as the mean followed by range (if relevant; not shown, if less than 5 μm) in parentheses. It should be noted that, for the drawings of specimens prepared in a cavity slide, several structures are seen foreshortened (i.e. setae directed towards the observer); but we measured them when flat. Terminology follows that of Hammen (1980), Judson (1994) and Krantz (2009) for general structures; Kethley (1990), and Khaustov and Tolstikov (2015) for idiosomal setation; Khaustov and Tolstikov (2015) for leg setation, except for coxal setae which follows the epimeral setation of Grandjean (1934)—setae on each epimere in the larva are designated in alphabetical order outward from the midline, and the labelling of post-larval setae is continued in the order of addition. Setation of the palptarsus is not well established and we enumerated them in a conventional manner. Description of setae is as follows: (i) bluntly lanceolate setae (cf. Figure 1C) refer to those with short stalk-like base, but abruptly wider and become gradually narrower to rounded tip, these types of setae always with minute barbs; (ii) slender setae refer to those with tapered tip; (iii) eupathidia are smooth, rod-like with truncated tip and minute ampoule. Descriptions of immature stages emphasize characters that differ from adults or change during ontogeny.

2G-4 Taxonomic results

Family Pseudocheylidae Oudemans, 1909

Genus *Anoplocheylus* Berlese, 1910

***Anoplocheylus corticicola* n. sp.**

(Figs 1–13)

Diagnosis. Adult female isunique among known *Anoplocheylus* in having the following combination of characters: body length about 825–875 long; palptibia with 2 accessory (subterminal) claws; trichobothrium *sci* simple; *vi* and *sci* well apart from their pair (i.e. *vi*–*vi* about 2 times of length of *vi*); seta *c2* relatively short, not reaching setal base *e1*; seta *e1* relatively short, not reaching setal base *f1*; setation of basifemora I–IV 10-4-3-2; and tarsus III lacking solenidia.

Description. *Female*. Body length (including gnathosoma) 840 (825–875); body width (greatest width at level of leg III) 300 (295–310). Colour in recently collected specimens is reddish orange but becomes white after long storage in alcohol.

Gnathosoma. In dorsal view (Figs 1A, 2), chelicera about 40 wide at base, 145 (135–150) long; principal segment asymmetrical, its outline almost straight along adaxial face but curved on abaxial face; giving impression of stylophore when cheliceral pair mesially appressed (cf. Figure 12A); cheliceral seta *cha* 16 long, thin and slender situated apically; seta *chb* about 40 long, slender, situated dorsolaterally at anterior third of chelicera; anterior to *cha*, with short hyaline extension supported internally by flattened sclerotization, overall structure directed obliquely to mesial plane; movable digit blade like, keel (*k.md*) present on abaxial face of digit. Palp with short trochanter, about 8 long, without setae; femur 57 (50–60) wide, 94 (85–100) long, with 4 slender setae; genu 14 (10–15) wide, 38 (35–40) long, with 2 slender setae; tibia about 30 wide, 35 long, with 1 prominent terminal claw and 2 subterminal claws (distal one shorter and thicker) and 1 slender seta on abaxial face, claw and subterminal claws with finely longitudinal striae; tarsus greatly reduced, scar-like, but delineated by faint suture encircling 9 tarsal setae: *1* eupathidial, falcate; *2*, *4*, *5*, *9* also eupathidial, slightly curved; *3*, *6*, *7*, *8* slender. Seta *3* coupling with *2*. Supracoxal seta *ep* short, peg-like, about 3 long. Supcapitulum subconical, 158 (155–160) wide at level of palp insertion, and 166 (160–175) long; with 2 pairs of slender subcapitular setae: *m*, 23 (20–25) long, *n*, 48 (45–50) long. Lateral lips about 20 long with 2 pairs of minute adoral setae, *or1–2*, about 3 long, spine-like, situated on low tubercle; 3–5 lacinae of lateral lips present apially, in preoral cavity. Labrum 33 (30–35) long, tongue-like on distal half, basal half with bilateral wing-like extensions that curve ventrally, apparently forming into tube; 2 longitudinal rows of minute spines present along near margin on ventral surface of tongue-like portion; similar spines also present on wing-like portion on ventral side but irregularly distributed (Figs 2C–E); Integument of subcapitulum, palps, and chelicera with fine striations and sparsely distributed pores.

Idiosoma. In dorsal view (Fig. 1A), roughly elliptical, with greatest width at level of coxae III. Membranous integument striate, pattern of striations as illustrated in Figure 1A. Peritreme linear, segmented, situated on anterior corner of idiosoma, originating from level of coxa I and leading to paraxial stigma (*st*π) between cheliceral bases (Figs 3, 4); inferior stigma (*sti*) present beneath insertion of chelicerae; trachea from these stigmata (*tri* and *trπ*) conversed and then connected each other by series of short sclerotisations, and then fused laterally, forming X-shaped tracheal complex (Fig. 3), from which 2 or 3 superior trachea (*tri*) and a larger inferior trachea (*trπ*) posteriorly arise. Podocephalic canal (*cpc*) opened, originating above coxa I; an unpaired (*dt*) and 5 paired gland ducts (*dg1-5*) present (Figs 3, 4): *dt* narrowest, located between *trπ*, and cheliceral bases, *dg1* open to *cpc* under cheliceral insertions, *dg2* to near anterior corner of idiosoma, *dg3* and *dg4* to origin of *cpc*, *dg5* hardly discernible but its opening evidence on posterodorsad of coxa II (Figs 3, 4).

Prodorsal shield subrectangular, 130 (125–135) wide, 158 (155–160) long; surface finely striated with sparsely distributed pores, muscle sigillae well marked. Lens-like eyes, 13 wide, situated on anterior corner of shield; seta *ve* thin, slender, 24 (20–25) long, situated anterior to eyes, trichobothrium *sci* slender and glabrous, 61 (55–65) long, situated posteromedial to eyes, its bothridium relatively small, about 3 diameter, internal wall with 2–3 circular striation; seta *vi* bluntly lanceolate, 43 (35–50) long, located posteromedially to *sci*; both *vi* and *sci* situated far apart from their pair: *vi*–*vi* 73 (70–75), *sci*–*sci* 87 (85–90); seta *sce* bluntly lanceolate and elongate, 76 (70–80) long, situated about 25 from posterior margin of shield; 2 pairs of neotrichous setae present near lateral margin of shield, all bluntly lanceolate, 15–20 long. Two pairs of internal spots (red in recently collected specimens) present: anterior pair under eye lens, posterior pair—not associated with lens— located between 2 neotrichous setae (Figs 1A, 3–4).

All dorsal opisthosomal setae bluntly lanceolate, their lengths: *c1* 18 (15–20), *c2* 57 (55–60), *d1* 21, *e1* 44 (40–45), *f1* 28 (25–30), *h1* 46, *h2* 36, *ps1* 37 (35–40), *ps2* 65 (60–70). Neotrichous setae about 15–25 long: 4 pairs anterior to row *c*, 2 pairs each between rows *c*–*d* and *d*–*e*, and 1 pair between rows *e*–*f*. Four pairs of normal cupules present: *ia* about 60 from *d1*, *im* 22 (15–25) from *e1*, *ip* about 30 from *f1*, *ih* situated ventrally. Anal opening terminal, relatively large, dorsal commissures reaching near level of setal row *h*.

In ventral view (Fig. 1B), membranous integument striate with pattern as illustrated; coxal plates I–II and III–IV smooth, with few pores; coxal apodeme, *apo.1–4*, small, triangular in shape located near halfway of anterior margin of respective coxae; coxal setation: 5-3-3-3 (including *4a* on membranous integument); *1a*, *1c*, *1d*, short bluntly lanceolate, *1b* elongate, bluntly lanceolate, *1e* slender and thinnest; supracoxal seta *eI* peg-like, 2–3 long; *2a*, *2c* short bluntly lanceolate, *2b* elongate; *3a*, *3c* bluntly lanceolate, *3b* elongate; *4b* medium long, *4c* short, bluntly lanceolate; seta *4a* situated on membranous integument. Lengths of coxal setae: *1a* 26, *1b* 78 (75–80), *1c* 28 (25–30), *1d* 22, *1e* 19 (15–20), *2a* 27 (25–30), *2b* about 66, *2c* 19 (15–20), *3a* 23 (20–25), *3b* about 71, *3c* 27 (25–30), *4a* 18 (15–20), *4b* 29 (25-30), *4c* 21. Neotrichous setae, 15–25 long, present on membranous integument: 2 pairs between coxae I, 9–10 pairs between coxae II–III; 1 pair between coxae III, anterior to *4a*; 9–10 (excluding genital setae) pairs posterior to *4a*.

Genital opening (Figs 1B, 5) situated adjacent to anal opening, about 10 from their nearest margin. Gonopore located anterior to ovipore; surrounded by smooth membranous integument which is anteriorly tongue-like and connected to striated cuticle, lateral two-thirds and posterior portion free, with deep posterior incision to near middle region (under which seminal receptacle located) giving appearance of triangular bifid extension; tongue-like portion with shallow medial groove; gonopore apparently situated between triangular bifid. Spherical seminal receptacle (*sr*) present, about 15 wide, well sclerotized with thick wall and short tube leading to ovipositor (Fig. 5B). Ovipore (Fig. 5A) roughly V-shaped, covered by triangular bifid extension described above; surrounding striation continuously convoluted inside and apparently served as basal wall of ovipositor (see also those of *A. aegypticus* described below, Figure 17D); ovipore usually flanked by 2 pairs of genital setae (*g1–2*), thin, bluntly lanceolate, 10–15 long (variations seen 1–3 pairs and usually asymmetrical). Numbers of aggenital setae not determined, obscured by neotrichous setae.

Legs. Normal for genus, generally tubular in form (Figs 6, 7). Femora I–IV divided. Tarsus I abruptly truncated and giving rise to (pre)tarsal stalk of which basal half annulated but distal half smooth and membranous; pretarsus (cf. Figure 7E) with pad-like empodium which internally with Y-shaped thickening; claw absent; condylophore (*cp*) elongate, contained within smooth membranous portion of tarsal stalk and articulated to wall of tarsal stalk, near distal end of annulated portion. Tarsi II–IV much thinner, less truncated but with similar tarsal stalk and pretarsus of leg I; leg integument apparently smooth with sparsely distributed pores, pores distinct on all segments of leg I; but not well developed on leg II–IV, few pores present only on tarsi II–IV, usually absent on other segments. Lengths (from trochanter to tarsus, tarsal stalk and pretarsus excluded): leg I 504 (485–515), leg II 255 (245–260), leg III 321 (310–330), leg IV 370 (360–380). Setation of legs I–IV (*ζ* denotes eupathidial): trochanters 1(*v'*)-1(*v'*)-2(*l'*, *v'*)-1(*v'*); basifemora 10(*d1*, *d2*, *d3*, *l1'*, *v1'*, *v2'*, *v3'*, *v1"*, *v2"*, *bv"*)-4(*d1*, *l1'*, *v1"*, *bv"*)-3(*d1*, *l1'*, *v1'*)-2(*d1*, *v'*); telofemora 6(*d*, *l'*, *l"*, *li"*, *v'*, *v"*)-4(*d*, *l'*, *l"*, *v"*)-3(*d*, *l'*, *l"*)-3(*d*, *l'*, *l"*); genua 7(*dζ*, *l'*, *l"ζ*, *v'ζ*, *v"*, *d1ζ*, *l1'*)-5(*d*, *l"*, *l'*, *v'*, *v"*)-5(*d*, *l"*, *v'*, *l'*, *v"*)-5(*d*, *l'*, *l"*, *v'*, *v"*); tibiae 11(*d ζ*, *k*, *l'ζ*, *l"*, *v'ζ*, *v"*, *v1"*, *d1*, *l1'*, *v1'ζ*, *v2'*,)+*φ*-5(*d*, *l'*, *l"*, *v'*, *v"*)-6(*dζ*, *l'*, *l"*, *v'*, *v"*, *v1'*)- 6(*dζ*, *v'*, *l'*, *l"*, *v"*, *v1'*); tarsi 21(*ft'ζ*, *ft"ζ*, *tc'ζ*, *tc"ζ*, *a'ζ*, *a"ζ*, *p'ζ*, *p"ζ*, *u'*, *u"*, *vs*, *pv'ζ*, *pv"ζ*, *pl'ζ*, *pl"*, *l'ζ*, *l"ζ*, *d*, *v'ζ*, *v"ζ*, *l1"*)+*ω*-9(*ft"ζ*, *tc'ζ*, *tc"ζ*, *p'ζ*, *p"ζ*, *u'*, *u"*, *pv'*, *pv"*)+*ω*-10(*ft"ζ*, *tc'ζ*, *tc"ζ*, *p'*, *p"*, *u'*, *u"*, *pv'*, *pv"*, *v'*)-10(*ft"ζ*, *tc"*, *tc'*, *p'*, *p"*, *u'*, *u"*, *pv'*, *pv"*, *v'*). Solenidion *ω* on tarsi I–II short, 3 long; on tibia I, seta *k* elongate, rod-like, slightly falcate, about 4 long, solenidion *φ* rod-like, about 2 long. On tarsus I, fastigial setae *(ft)* having slightly anterior (′) disjunction (i.e. *ft'* is more distal); primilateral setae *(pl)* having anterior disjunction and *pl"* more ventral than usual; seta *s* more *'* position while *pv"* near midline. On tarsi II-III, tectal setae *(tc)* having posterior (″) disjunction (i.e. *tc"* is more distal). Homology of leg setae and solenidia depicted in Figures 6 and 7.

Male. Generally similar to female except as noted below. Body length (including gnathosoma) 595; body width 200; leg I 410, leg II 200, leg III 280, leg IV 340; seta *vi* 45, *ve* 30, *sci* 60, *sce* 100, *c1* 35, *c2* 75, *d1* 30, *e1* 65, *f1* 35, *h1* 75, *h2* 55, *ps1* 60, *ps2* 90. Numbers of neotrichous setae differing from female: 1 pair between row *c–d* (vs. 2 pairs), 1 pair between row *d–e* (vs. 2 pairs), absent between row *e–f* (vs. 1 pair). Genital region (Fig. 8A) with 5 pairs (vs. 9) of neotrichous setae, 4 pairs of slender aggenital setae (*ag1–4*), 10–15 long, and 5 short slender genital setae, about 5 long. Genital opening simple, slit-like, about 30 long and situated relatively far apart (about 40) from anal opening. Male genitalia (Figs 8B, C) well sclerotized and highly complex with numbers of lobes (structures overlapped or hidden not investigated); eugenital setae absent.

Ontogeny. Larva: body length (*n*=3) 380 (375–385), width 148 (140–155); protonymph (*n*=3): 498 (490–505), 193 (190–200); female deutonymph (*n*=3): 620

(610–630), 232 (225–235); male deutonymph (*n*=2): 615 (610–620), 365 (360–370); tritonymph absent, hence female develops directly from deutonymph (Remark 6).

Gnathosoma. similar to adult, except that lateral lips with a pair of adoral setae, *or1*, in larva, *or2* added in protonymph; palpfemur with 1 seta (*d*) in larva, 2 setae in protonymph (*l″* added), 3 setae in deutonymph (*v* added), 4 setae in adult (*v1* added); palpgenu with 1 seta (*d*) in larva, 2 in protonymph (*l″* added) as in adult; palptarsus with 8 setae in larva, of which eupathidion *2* coupled with seta *3* and eupathidion *4* coupled with seta *5*; 9 setae in protonymph (eupathidion *9* added), seta *5* disassociated from *4*, and become eupathidial (Figs 11D, E) and remaining so until adult.

Idiosoma. Dorsally, larva (Fig. 9) with 4 pairs of setae (*vi*, *ve*, *sci*, *sce*) on prodorsal shield, without netotrichous setae; 1 pair of neotrichous setae added anterior to *sce* in protonymph, and second pair added in adult. On opisthosoma anterior to setal row *c*, 1 pair of neotrichous setae added in protonymph (Fig. 11A), 3 more pairs added in deutonymph (Fig. 12A), and 1 more pair added in adult. Between setal rows *c* and *d*, 1 pair of neotrichous setae added in deutonymph, 1 more pair added in adult. Similarly, between setal rows *d* and *e*, 1 pair added in deutonymph, and 1 more pair added in adult. Between setal rows *e* and *f*, only 1 pair of neotrichous setae added in adult. Seta *ps2* added on row *ps* in protonymph (Figs 9C, 11C; Remark 2). Relative length of principle opisthosomal setae as follows: larva, *vi* 16 (15–20), *ve* 14 (10–15), *sci* 38 (35–40), *sce* 33, *c1* 16 (15–20), *c2* 31, *d1* 14, *e1* 18 (15–20), *f1* 20, *h1* 28 (25–30), *h2* 48(45–50), *ps1* 26; protonymph, *vi* 20, *ve* 18 (15–20), *sci* 60, *sce* 44 (40–45), *c1* 16, *c2* 27 (25–30), *d1* 19 (15–20), *e1* 30, *f1* 26, *h1* 31, *h2* 25, *ps1* 27, *ps2* 46; female deutonymph, *vi* 24, *ve* 23 (20–25), *sci* 63 (60–65), *sce* 56, *c1* 18 (15–20), *c2* 44 (40–45), *d1* 19, *e1* 33, *f1* 21, *h1* 39 (35–40), *h2* 27 (25–30), *ps1* 28 (25–30), *ps2* 53 (55–55).

Ventrally, coxal setation in larva 3-1-2 (Fig. 9B); *2a* located more laterally, *3a* located on medial margin of coxal plate, sometime situated on membranous integument. In protonymph, coxal setation 4-2-2-1 (Fig. 11B); *1d* added anteriorly, *2b* added medially, *4a* (and *ag*) added on membranous integument between coxa IV. In deutonymph, coxal setation 4-3-3-1 (Fig. 12B); *2c*, *3c*, and *4b* added. Neotrichous setae added as follows: in protonymph, 1 pair added between coxa I, 3 pairs added between coxae II–III; in deutonymph, 1 more pair added between coxa I, 2 more pairs between coxae II–III, 3 pairs added (*4a* and *ag* excluded) on hysterogastric region. In adult female, 4–5 more pairs added between coxae II–III, 7–8 more pairs added on hysterogastric region. Genital opening absent in larva, protonymph, and deutonymph; but striation at this region differentiated as illustrated (Figs 9B, 11B, 12 B, 13); dimorphic deutonymph present (Remark 6): female (Figs 12, 13B) and male deutonymph (Fig. 13A.); with same body and leg setation but latter morph differs from former in having short slit like (pro)genital opening flanked by a pair of short and slender genital setae, and relatively far apart from anal opening.

Legs. Leg form generally similar to adult but femora I–III in larva, and femur IV in protonymph entire (Fig. 10A, C, D, I), these segments become divided in succeeding instars; development of leg setation (I–III for larva, I–IV for nymphs and adults) as follows.— Trochanters: larva, 0-0-1; protonymph, 1-1-2-0; deutonymph, 1-1-2-1; adult, 1-1-2-1.—Femora[telo+basifemora]: larva, 5-4-3; protonymph, 8[5+3]-4[3+1]-3[3+0]-0; deutonymph, 14[6+8]-6[3+3]-5[3+2]-3[3+0]; adult, 16[6 + 10]-8[4+ 4]-6[3+3]-5[3+ 2];—Genua: larva, 5-3- 3; protonymph, 5-3-3-0; deutonymph, 7-5-4-4; adult, 7-5-5-5.—Tibiae: larva, 6+*φ*-5-5; protonymph, 6+*φ*-5-5-2; deutonymph, 9+*φ*-5-5-5; adult, 11+*φ*-5-6-6.—Tarsi: larva, 13+*ω*-9+*ω*-7; protonymph, 17+*ω*-9+*ω*-7-6; deutonymph, 20+*ω*-9+*ω*-9-9; adult, 21+*ω*-9+*ω*-10-10. Additions of setae during ontogeny are presented in Table 1.

Setae transformed to euphathidia as follows: protonymph, *ft'*, *ft''*, *pl'*, *pv''* on tarsus I, *ft''* on tarsus II, *d*, *l'*, *l''* on tibia I; deutonymph *a'*, *a''*, *l''* on tarsus I, *ft''* on tarsus IV, *v''* on tibia I, *d* on genu I (other euphathidia in adult are transformed at that stage). On tarsus I of larva, paired setae *(a)* minute and coupled to respective paired *(tc)ζ* (Fig. 10A) but become larger and disassociated from *(tc)ζ* in protonymph (Fig. 10G). On tarsus IV of protonymph, *ft''* and *tc''* located near midline. Leg lengths: larva, leg I 193 (190–200), leg II 108 (105–110), leg III 147 (145–150); protonymph, leg I 261, leg II 143 (140–145), leg III 200 (195–205), leg IV 213 (210–215); female deutonymph, leg I 373 (370–375), leg II 196 (195–200), leg III 238 (235–240), leg IV 281 (280–285).

Material examined. Holotype (female): THAILAND, Bangkok, Pathumwan Dist., Chulalongkorn University Campus, 8 Oct 2014, M. Fuangarworn coll., ex barks of fallen twigs of *Samanea saman*; 40 Paratypes (13 females, 1 male, 17 larvae, 3 protonymphs, 9 female deutonymphs: 2 male deutonymphs, 5 female deutonymphs, 2 pharate females in deutonymph exuviae) with same data as holotype. Three paratypes (females): Pang Nga Prov., Thai Mueang Sub-dist., Khao Lampi Hart Thai Mueang National Park, 18 May 2006, M. Fuangarworn coll., ex bark of *Syzygium* sp. Holotype and most of paratypes deposited in the Acarology Collection at the Chulalongkorn University Museum of Natural History, Bangkok, Thailand. One female paratype each will be deposited in the Acarology Collection at the Ohio State University, Columbus, USA, and in the Arachnida Collection of ARC-Plant Protection Research Institute, Pretoria, South Africa.

Etymology. The specific epithet "corticicola" (Latin, living in bark) refers to the microhabitat of a new species.

Distribution. Thailand (Bangkok; Pang-Nga Prov.).

Differential diagnosis. Adult females of *Anoplocheylus corticicola* **n. sp.** are closely similar to *A. brevisetosus* Ueckermann & Khanjani, 2004 from South Africa (Ueckermann & Khanjani 2004) in having slender trichobothrium *sci*, seta *vi* situated far apart from its pair, i.e. *vi*–*vi* is about 2 times of length of *vi*, and relatively short opisthosomal setae. However, the new species may be distinguished from the latter by lacking a solenidion on tarsus III (vs. present); having relatively longer setae *c2* and *e1*, i.e. more than 2 times of length of neotrichous setae (vs. shorter; subequal or slightly longer than neotrichous setae); and having different leg setation, e.g. genua I–IV of 7-5-5-5 (vs. 7-4-4-4), tibiae I–IV of 11(φ)-5-6-6 (vs. 10(φ)-5-5-5).

Anoplocheylus aegypticus Baker & Atyeo, 1964

(Figs 14–17)

Anoplocheylus aegypticus Baker & Atyeo, 1964: 267; Van Dis and Uckermann 1991: 113; Uckermann and Khanjani 2004: 63; Gerson 1967: 368.

Material examined. One female: THAILAND, Samut Songkhram Prov., Ban Bang Khantaek, 25 Mar 2003, M. Fuangarworn coll., ex litter under coconut, field no. MF2003-33. One female, 2 larvae, 2 protonymphs, 2 deutonymphs: Samut Songkhram Prov., Ban Bang Khantaek, 25 Mar 2003, M. Fuangarworn coll., ex *Tamarindus* litter, field no. 2003-41. Fourteen females, 3 larvae, 5 protonymphs, 6 deutonymphs, with previous data but 4 Aug 2003 and field no. 2003-82. One female with previous data but 23 Jun 2002. One female, 1 deutonymph: Kanchanaburi Prov., Nong Bua Sub-dist., 9 Sep 2001, M. Fuangarworn coll., ex litter of *Cassia* sp. Two protonymphs, 1 deutonymph: Nan Prov., Lai Nan Sub-dist., 17 May 2004, M. Fuangarworn coll., ex litter in grassland. One female: Pang Nga Prov., Thai Mueang Sub-dist., Khao Lampi-Hart Thai Mueang National Park, 8°29'38"N, 98°13'39"E, 7 Jan 2008, M. Fuangarworn coll., ex soil and leaf-litter in a coastal *Melaleuca* forest, field no. MF2008-1. Two females, with previous data but 12 Mar 2007; 3 females with previous data but 15 May 2007 and field no. MF2007-28; 2 females and 2 larvae with previous data but 8 Jul 2007. Five females: Chonburi Prov., Sattahip Dist., Samaesan Island, Looklom beach, 12°35'6.18"N, 100°56'49.07"E, 23 Nov 2013, M. Fuangarworn coll., ex litter and sand in grassland, field no. MF2013-54; 2 female, with previous data but 19 Mar 2011 and field no. MF2011-52; 2 females, 3 larvae, with previous data but 31 May 2013 and field no. MF2013-27; 2 females, with previous data but 21 Jul 2012 and field no. MF2012-49. One female: Chonburi Prov., Sattahip Dist., Kham Island, 12°34'34.97"N, 100°56'6.22"E, 23 Nov 2013, M. Fuangarworn coll., ex leave litter on rocks near beach, field no. MF2013-54. All specimens deposited in the Acarology Collection at the Chulalongkorn University Museum of Natural History, Bangkok, Thailand.

Distribution. Egypt (Baker and Atyeo 1964); Israel (Gerson 1967); Thailand (**New record**): Samut Songkram, Chonburi, Pang-Nga, and Nan Prov.

Remark. Adult females from Thailand agree well with the original description of *A. aegypticus* by Baker and Atyeo (1964) and re-description by Uckermann and Khanjani (2004). Our specimens differ only in the number of setae on tarsus I (19 vs. 18 in Thai specimens), tarsus II (8, in their text, vs. 7; in fact, Uckermann and Khanjani (2004) illustrated 7), and coxa I (4 vs. 5; *1e* absent in the former). However, we consider these differences as intraspecific variations.

Supplement description. Adult measurements of Thai specimens (females, *n* = 5): body length 655 (620–680), width 220 (215–225), leg I 285 (275–290), leg II 176 (170–180), leg III 226 (220–235), leg IV 256 (250–260), *vi* 25, *ve* 33 (30–35), *sci* 64 (55–70), *sce* 101 (100–105), *c1* 24 (20–25), *c2* 107 (100–110), *d1* 25, *e1* 80 (75–90), *f1* 24 (20–25), *h1* 48 (45–50), *h2* 24 (20–25), *ps1* 31 (30–35), *ps2* 42 (40–45), neotrichous setae 15–20 long.

The gonopore of *A. aegypticus* (Fig. 17), similar to that of *A. corticicola*, covered by membranous posterior extension of triangular bifid, but surface not smooth. With instead longitudinal striation that continued from anterior integument (Fig. 17A, C). Sclerotized seminal receptacle of *A. aegypticus* bilobed in cross section, and its dorsal tube (cf. Figure 5B of *A. corticicola*) less sclerotized. Ovipositor, when protruded, (Fig. 17D) is simple, tubular in form, relatively short, and lacking neither lobes nor eugenital setae (males of *A. aegypticus* were not found in this study).

Ontogeny. Larva (Figs 14A–C, 15A–C) and nymphs (Figs 14D–G, 15D–E) of *A. aegypticus* are similar to adult in species-specific characters, i.e. simple trichobothrium *sci*, long setae *c2* and *e2*, paired *vi* close to each other. Measurements: larva, body length (*n*=3) 331 (325–340), body width 143 (140–150); protonymph (*n*=3), 427 (425–430), 168 (165–170); deutonymph (*n*=3), 525 (515–535), 200 (195–205); tritonymph not available. Ontogeny of *A. egypticus* generally similar to *A. corticicola*, except noted as follows—most of them relating to addition of neotrichous setae. On dorsal opisthosoma anterior to setal row *c*, 3 pairs (vs. 4 in *A. corticicola*) of neotrichous setae added in deutonymph (Fig. 14F), and 2 more pairs added (vs. not added) in adult (Fig. 16A); between setal rows *d* and *e*, no setae added in deutonymph, but 1 pair added in adult (vs. 1 pair added each stage); between setal rows *e* and *f*, neotrichous setae absent in adult (vs. 1 pair added in adult). Relative length of principle opisthosomal setae: larva, *vi* 18 (15–20), *ve* 16, *sci* 57 (55–60), *sce* 56, *c1* 18 (15–20), *c2* 68 (65–70), *d1* 19, *e1* 48 (45–50), *f1* 18, *h1* 36, *h2* 43 (40–45), *ps1* 21; protonymph, *vi* 18(15–20), *ve* 21, *sci* 50 (45–50), *sce* 62 (60–65), *c1* 19 (15–20), *c2* 90, *d1* 21, *e1* 53(50–55), *f1* 21, *h1* 31, *h2* 19(15–20), *ps1* 22, *ps2* 26; deutonymph, *vi* 21, *ve* 19 (15–20), *sci* 58 (55–60), *sce* 87 (85–90), *c1* 21, *c2* 96 (95–100), *d1* 23 (20–25), *e1* 67 (60–70), *f1* 22, *h1* 37, *h2* 44 (40–45), *ps1* 29, *ps2* 36.

Legs (Figs 15, 16D–H) lengths: larva, leg I 140 (135–140), leg II 93 (90–100), leg III 153 (150–160); protonymph, leg I 191 (190–195), leg II 115, leg III 158, leg IV 160; deutonymph, leg I 210, leg II 138 (135–140), leg III 190, leg IV 200. Developtment of leg setation as follows.—Trochanters: larva, 0-0-1; protonymph, 1-1-2-0; deutonymph, 1-1-2-1; adult, 1-1-2-1.—Femora[telo+basifemora]: larva, 5-4-3; protonymph, 8[5+3]-4[3+1]-3[3+0]-0; deutonymph, 11[6 + 5]-4[3+1]-5[3+2]-3[3+0]; adult, 12[6 + 6]-6[3+3)]-6[3+3]-5[3+ 2].—Genua: larva, 5-3-3; protonymph, 5-3-3-0; deutonymph, 7-5-4-4; adult, 7-5-4-4.—Tibiae: larva, 6+φ-5-5; protonymph, 6+φ-5-5-2; deutonymph, 8+φ-5-5-5; adult, 9+φ-5-5-5.—Tarsi: larva, 13+ω-9/7-7; protonymph, 17+ω-9/7-7-6; deutonymph, 18+ω-9/7-9-9; adult, 18-9/7-9-9. Additions of setae during ontogeny are presented in Table 2. Setae transformed to euphathidia in protonymph: *ft'*, *ft''*, *pl'* on tarsus I; deutonymph: *a'*, *a''* on tarsi I, *l'*, *l''* on tibia I; adult: *d* on tibia I, *ft''* on tarsus II. Seta *d* on telofemora I, III, IV very long, reaching beyond respective genu.

2G-4 Discussion

1. Notation of dorsal opisthosomal setae. Adults of pseudocheylids have varying levels of neotrichy on the idiosoma —weak in *Anoplocheylus* to strong in *Pseudocheylus* —such that the principle transverse rows of setae are obscured and applying Grandjean's (1939) notation, modified by Kethley (1990), to theses setae is somewhat difficult. However, this may be possible by tracking their ontogenetic change or by close examination of these setae, even if only adults are known, since the fundamental (larval) setae (i.e. *c1*, *c2*, *d1*, *e1*, *f1*, *h1-2*, *ps1-2*) may be distinguished from neotrichous ones by having slightly larger alveoli, being longer, slightly thicker and by their positions relative to cupules and striation pattern. Khaustov and Tolstikov (2015) studied the immature stages of their new species, *A. brasiliensis*, and first successfully designated Kethley (1990)'s notation to it.

2. Setal row ps. Known larva of *Anoplocheylus* has one pair of setae in row *ps*: *ps1*; then in protonymph, 1 pair added ventrally to *ps1* (Fig. 11C). Khaustov and Tolstikov (2015) considered these protonymphal setae as *ad*, implying that the protonymph adds anamorphically segment *AD*. Alternatively, we designated this pair as *ps2* since they are well aligned in row with *ps1* and Pseudocheylidae were reported lacking anamorphic addition of segment *AD* (Kethley 1982; Walter *et al.* 2009).

3. Setal coupling on tarsus I. If the homologies of leg setae in Khaustov and Tolstikov (2015) and in this study are correct, then they are minute setae *(a)* that couple with larger eupathidia *(tc)*, respectively, on the larval tarsus I of *Anoplocheylus*. These couplings disassociate in the protonymph and *(a)* become relatively longer (Fig. 10A, G). This phenomenon—coupled in larva and then disassociated in protonymph—is also illustrated in *Pseudocheylus americanus* (Ewing) by Skvarla *et al.* (2013) and may present throughout the family Pseudocheylidae. Moreover, a similar phenomenon also occurs in many taxa of Raphignathoidea (Swift 2001) but, they are setae *(tc)* and eupathidial *(p)* that form clusters.

4. Palp tarsus and tibia. Although greatly reduced in size, the palptarsus of *Anoplocheylus* can be differentiated from the tibia by a faint suture within which setae encircled are interpreted as tarsal ones, as pointed out by Skvarla *et al*. (2013) for *Pseudocheylus americanus* (Ewing). But in the two *Anoplocheylus* species in this study, there are 8 tarsal setae in the larva and then 9 in the protonymph (seta *9*, added; Figure 11D–E). Seta *7* (= *l'Ti* in Khaustov and Tolstikov 2015) may be easily misinterpreted as a tibial seta since it is located on a more lateral (adaxial) face and is difficult to observe in dorsoventral view. Therefore, the tibia has one slender seta on its abaxial face other than the claw and 2 subterminal spurs.

5. Genital region. Developmentally, known protonymphs and deutonymphs of Pseudocheylidae lack a genital opening or progenital chamber (van Dis and Ueckermann 1991; Ueckermann and Khanjani 2004; Skvarla *et al*. 2013; Khaustov and Tolstikov 2015). This seems to be correlated with the absence of genital papillae; hence, both absences are similar to those in Eleutherengone (Walter *et al*. 2009). In the tritonymph—if present (Van Dis and Ueckermann 1991; Skvarla *et al*. 2013; but see Remark 6) —and adult, the genital opening is well developed as an ovipore and a gonopore (Figs 5, 17). The gonopore of *Anoplocheylus* has been overlooked possibly due to the thinness and membranous nature of the cuticle in this region and the triangular bifid extension, in ventral view, may give the impression of genital valves of the genital opening but in fact it separates from the ovipore (Fig. 17B). The latter is well characterized by convoluted striations of the integument. Skvarla *et al*. (2013) illustrated the gonopore of *Pseudocheylus americanus* (Ewing) as a simple slit-like opening, situated shortly anterior to the ovipore.

Interestingly, *Anoplocheylus* has a sclerotized seminal receptacle (Figs 5, 17; *sr*) and at least there are 2 forms: globular (as in *A. corticicola*) or bilobed (as in *A. aegypticus*). Those in *Pseudocheylus americanus* (Ewing) have a more elongate tube leading to the seminal receptacle (Skvarla *et al*. 2013; their Figures 7e, 8). Based on the structures of female gonopore and male genitalia, pseudocheylids may have a direct sperm transfer, but their mating behaviour needs further study.

6. Developmental stages. The pharate females of *A. corticicola* obtained (with a weakly sclerotized seminal receptacle and a well developed ovipore) within the exuviae of female deutonymphs (Fig. 13B) clearly suggest that the female directly develops from the deutonymph, hence the tritonymph is absent in this species. But it is inconclusive for the developmental sequence of the male, since no pharate males were collected. We postulate the dimorphic deutonymph (Fig. 13A) to be a male deutonymph, based on the position of the genital opening which is more anterior than in the female deutonymph (Figs 12B, 13B). So there are two possible developmental sequences of the male: either developing directly from this male deutonymph or via one more stage, a tritonymph which was not collected. We also did not find a tritonymph of *A. aeypticus* in this study; but, as mentioned earlier, the existence of this stage remains to be proven in this species. Normal four post-larval developments were reported in *A. tellustrus* Van Dis and Ueckermann and *Pseudocheylus americanus* (Ewing) (Van Dis and Ueckermann 1991; Skvarla *et al*. 2013). Thus, the life cycle of *Anoplocheylus* may vary in the presence or absence of the tritonymphal stage. Further study on the developmental stages of Pseudocheylidae is still needed.

Table 1. Ontogeny of leg setae and solenidia in *Anoplocheylus corticicola* n. sp.[1]

	Trochanter	[Telo-]+[Basi-] Femur	Genu	Tibia	Tarsus
Leg I					
La	-	*d, l', l", v', bv"*	*d, l', l", v', v"*	*d, k, l', l", v', v", φ*	*ft', ft", tc'ζ, tc"ζ, a', a", u', u", pl', pl", s, pv', pv", ω*
Pn	*v'*	[*d, l', l", v'*; *v"* added]+[*bv"*; *d1, v1'* added]	-	-	*p'ζ, p"ζ, l', l"*
Dn	-	[*li"*]+[*d2, d3, l1', v2', v1"*]	*d1, l1'*	*d1, l1', v1'*	*d, v', v"*
Ad	-	[-]+[*v3', v2"*]	-	*v2', v1"*	*l1"*
Leg II					
La	-	*d, l', l", bv"*	*d, l", v'*	*d, l', l", v', v"*	*ft", tc', tc", p'ζ, p"ζ, u', u", pv', pv", ω*
Pn	*v'*	[*d, l', l"*]+[*bv"*]	-	-	-
Dn	-	[-]+[*d1, l1'*]	*l', v"*	-	-
Ad	-	[*v"*]+ [*v1"*]	-	-	-
Leg III					
La	*v'*	*d, l', l"*	*d, l", v'*	*d, l', l", v', v"*	*ft", tc', tc", u', u", pv', pv"*
Pn	*l'*	[*d, l', l"*]+[-]	-	-	-
Dn	-	[-]+[*d1, l1'*]	*l'*	-	*p', p"*
Ad	-	[-]+[*v'*]	*v"*	*v1'*	*v'*
Leg IV					
Pn	-	-	-	*d, v'*	*ft", tc", u', u", pv', pv"*
Dn	*v'*	[*d, l', l"*]+[-]	*d, l', l", v'*	*l', l", v"*	*tc', p', p"*
Ad	-	[-]+ [*d1, v'*]	*v"*	*v1'*	*v'*

[1] Unless otherwise indicated, setae and solenidia are first added at the indicated instar (La, Pn, Dn, Ad = larva, protonymph, deutonymph, adult, respectively) and remain present in subsequent instars; dash indicates no addition; brackets indicate segmental subdivision; ζ denotes eupathidia.

Table 2. Ontogeny of leg setae and solenidia in *Anoplocheylus aegypticus* Baker & Atyeo, 1964 (see note of Table 1 for explanation).

	Trochanter	[Telo-]+[Basi-] Femur	Genu	Tibia	Tarsus
Leg I					
La	-	*d, l′, l″, v′, bv″*	*d, l′, l″, v′, v″*	*d, k, l′, l″, v′, v″, φ*	*ft′, ft″, tc′ζ, tc″ζ, a′, a″, u′, u″, pl′, pl″, s, pv′, pv″, ω*
Pn	*v′*	[*d, l′, l″, v′*; *v″* added]+[*bv″*; *d1, v1′* added]	-	-	*p′ζ, p″ζ, l′, l″*
Dn	-	[*li″*]+[*d2, l1′*]	*d1, l1′*	*d1, v1′*	*d*
Ad [1]	-	[-]+[*v1″*]	-	*l1′*	-
Leg II					
La	-	*d, l′, l″, bv″*	*d, l″, v*	*d, l′, l″, v′, v″*	*ft″, tc′, tc″, p′ζ, p″ζ, u′, u″, pv′, pv″, ω*
Pn	*v′*	[*d, l′, l″*]+[*bv″*]	-	-	-[2]
Dn	-	[-]+[-]	*l′, v″*	-	-
Ad	-	[-]+ [*d1, l1′*]	-	-	-
Leg III					
La	*v′*	*d, l′, l″*	*d, l″, v′*	*d, l′, l″, v′, v″*	*ft″, tc′, tc″, u′, u″, pv′, pv″*
Pn	*l′*	[*d, l′, l″*]+[-]	-	-	-
Dn	-	[-]+[*d1, l1′*]	*l′*	-	*p′, p″*
Ad	-	[-]+[*v′*]	-	-	-
Leg IV					
Pn	-	-	-	*d, v′*	*ft″, tc″, u′, u″, pv′, pv″*
Dn	*v′*	[*d, l′, l″*]+[-]	*d, l′, l″, v′*	*l′, l″, v″*	*tc′, p′, p″*
Ad	-	[-]+ [*d1, v′*]	-	-	-

[1]Tritonymphs not known, thus setae added in adults may tritonymphal.
[2]On tarsus II, larval setae *p′ζ* and *p″ζ* may present or absent throughout ontogeny; if present, they may becoming lost in Pn.

Figure 1. *Anoplocheylus corticicola* **n. sp.**, female (compressed), (A) dorsal view, (B) ventral view, legs omitted, gnathosoma partial drawn, cuticle lateral to anal opening split, (C) dorsal opisthosomal setae, denoted. Scale bars, A–B 100 µm, C 10 µm.

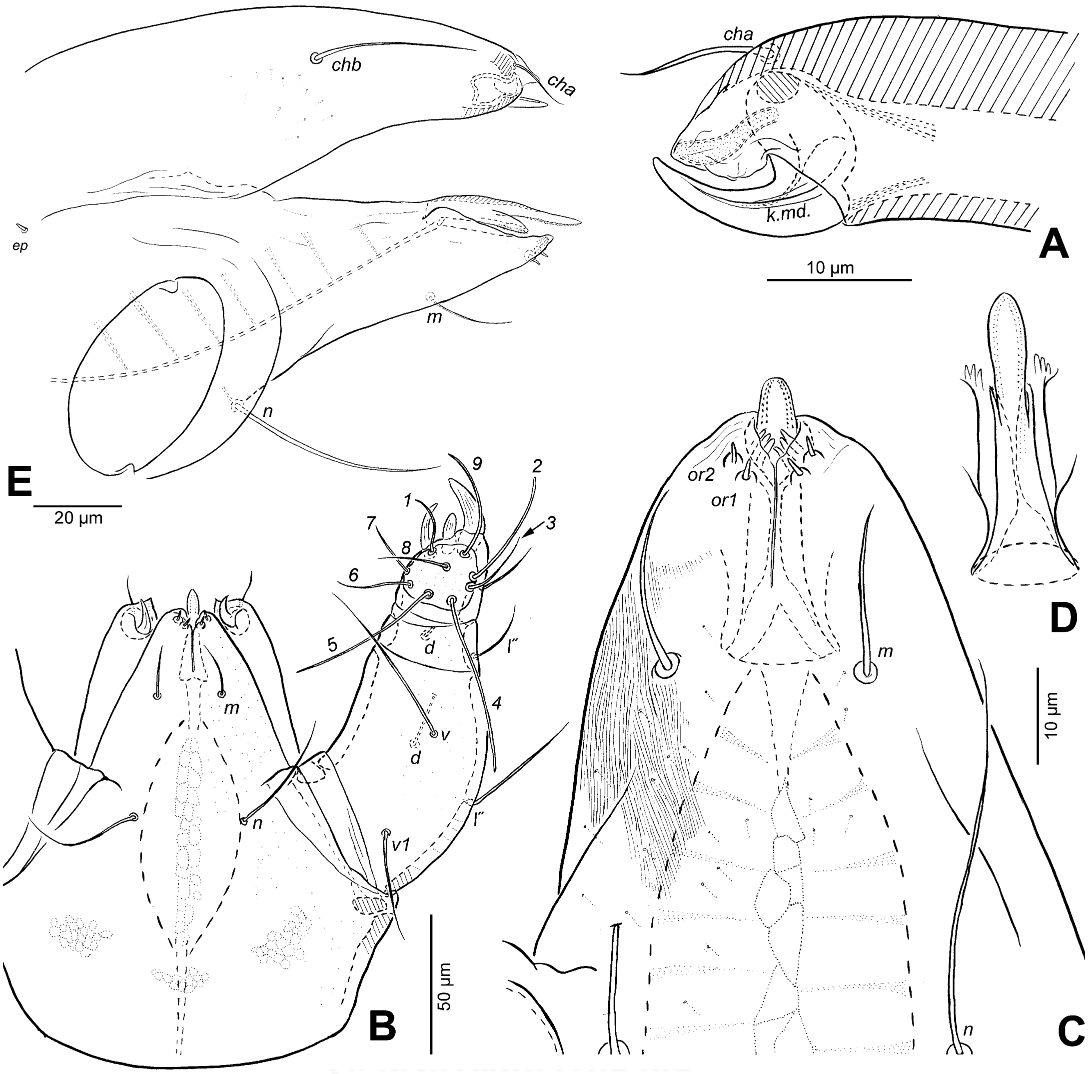

Figure 2. *Anoplocheylus corticicola* **n. sp.**, female, (A) chelicera, distal adaxial view, (B) gnathosoma, ventral view, (C) subcapitulum, ventral view, (D) labrum, dorsal view, lateral lips partial drawn, (E) gnathosoma, lateral view, chelicera slightly rotated, palp omitted. Scale bars, A 10 µm, B 50 µm, C–D 10 µm, E 20 µm.

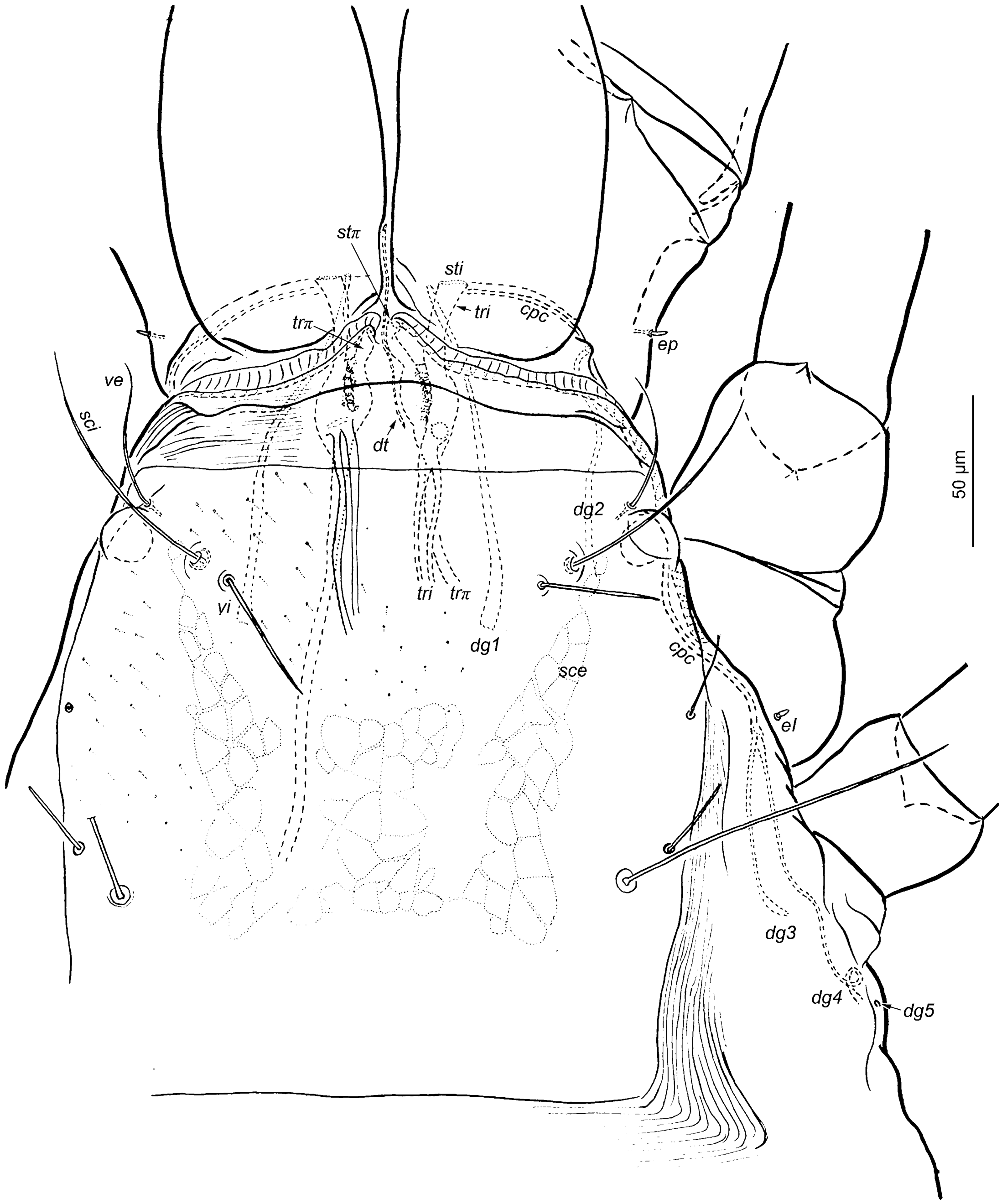

Figure 3. *Anoplocheylus corticicola* **n. sp.**, female, propodosoma, dorsal view, left *tri* drawn intact, peritreme and gland ducts on left side not shown. Scale bar 50 µm.

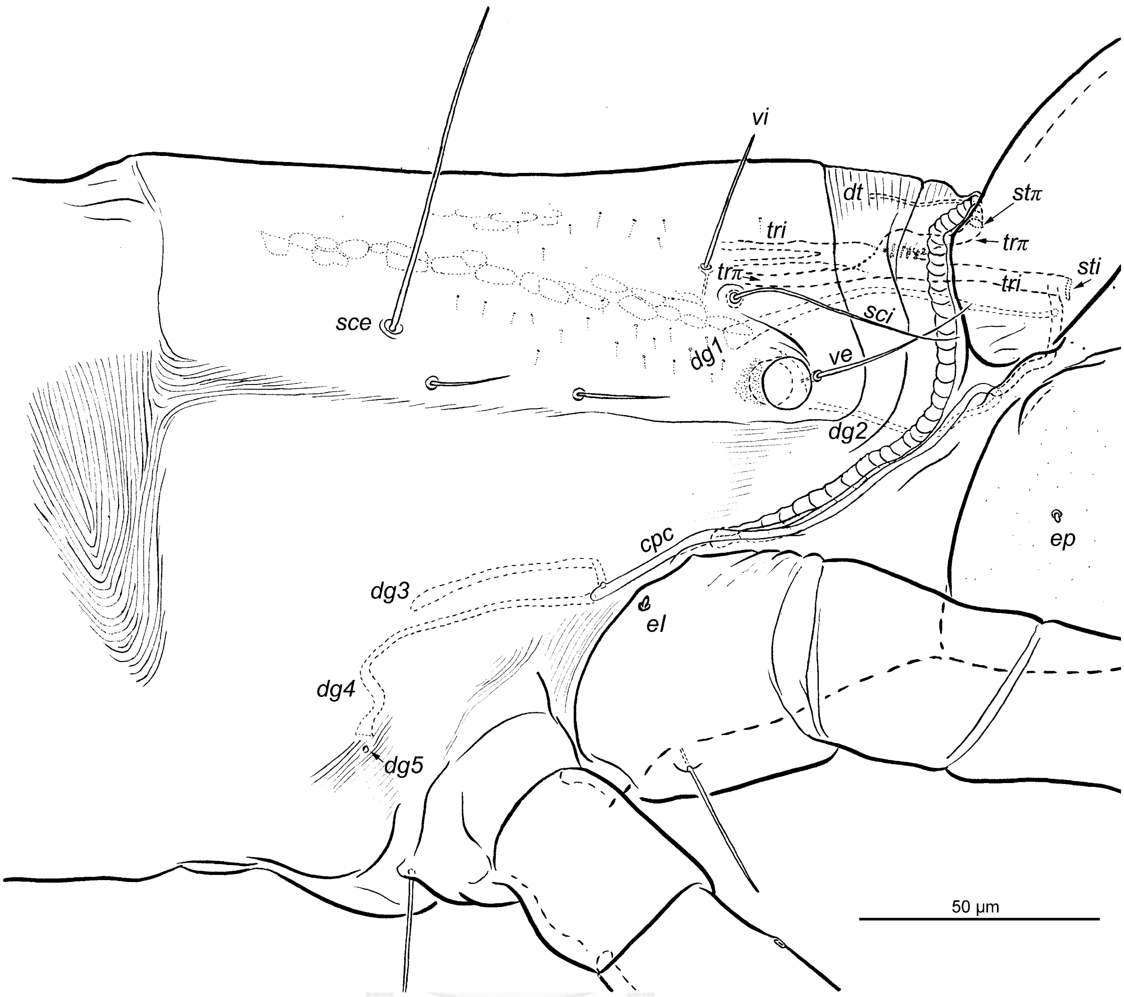

Figure 4. *Anoplocheylus corticicola* **n. sp.**, female, propodosoma, lateral view. Scale bar 50 µm.

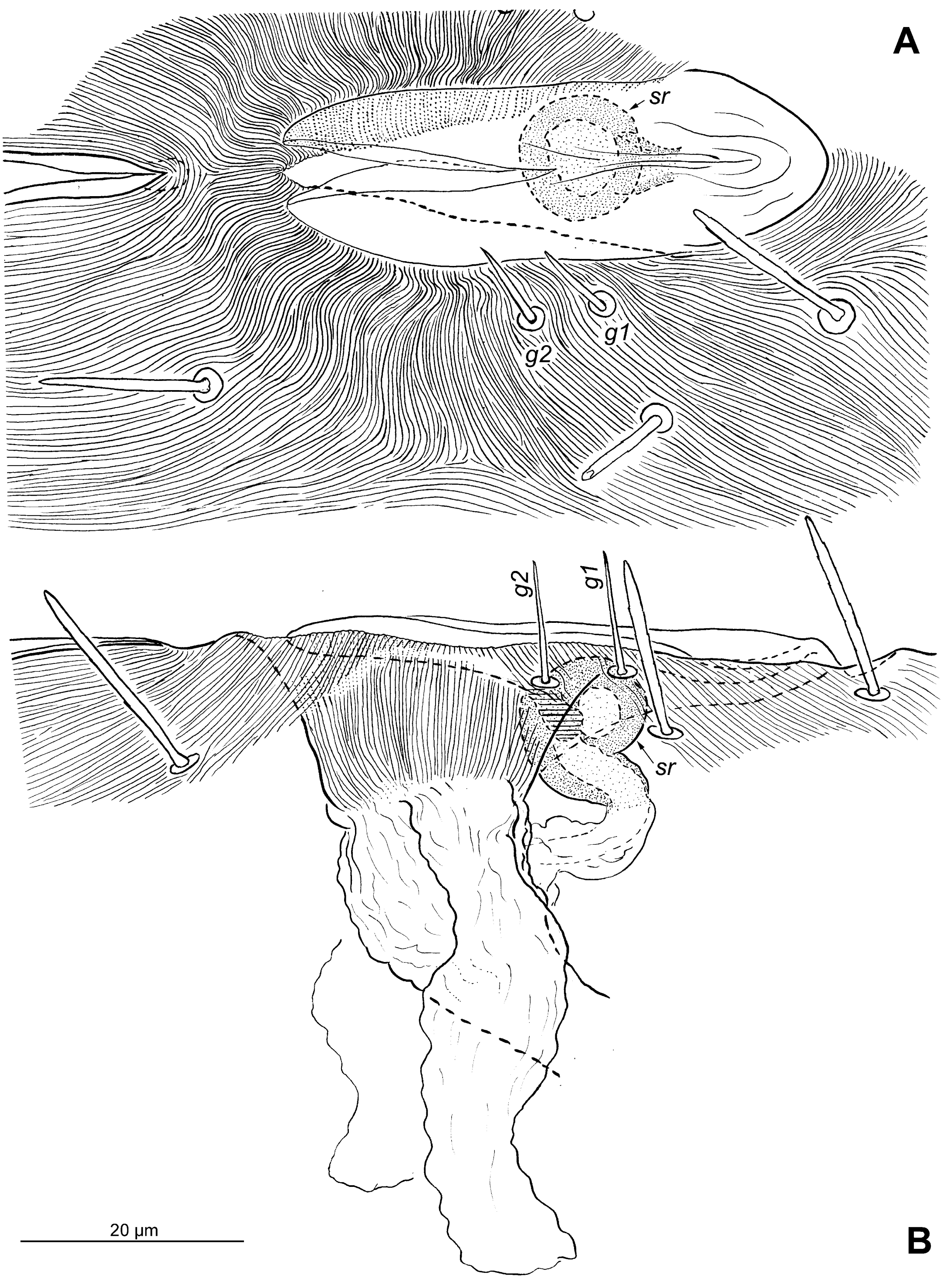

Figure 5. *Anoplocheylus corticicola* **n. sp.**, female, (A) genital region, ventral view, anterior to right, (B) same, lateral view, internal structures drawn intact, *sr*, seminal receptacle drawn in cross section. Scale bars, A–B 20 μm.

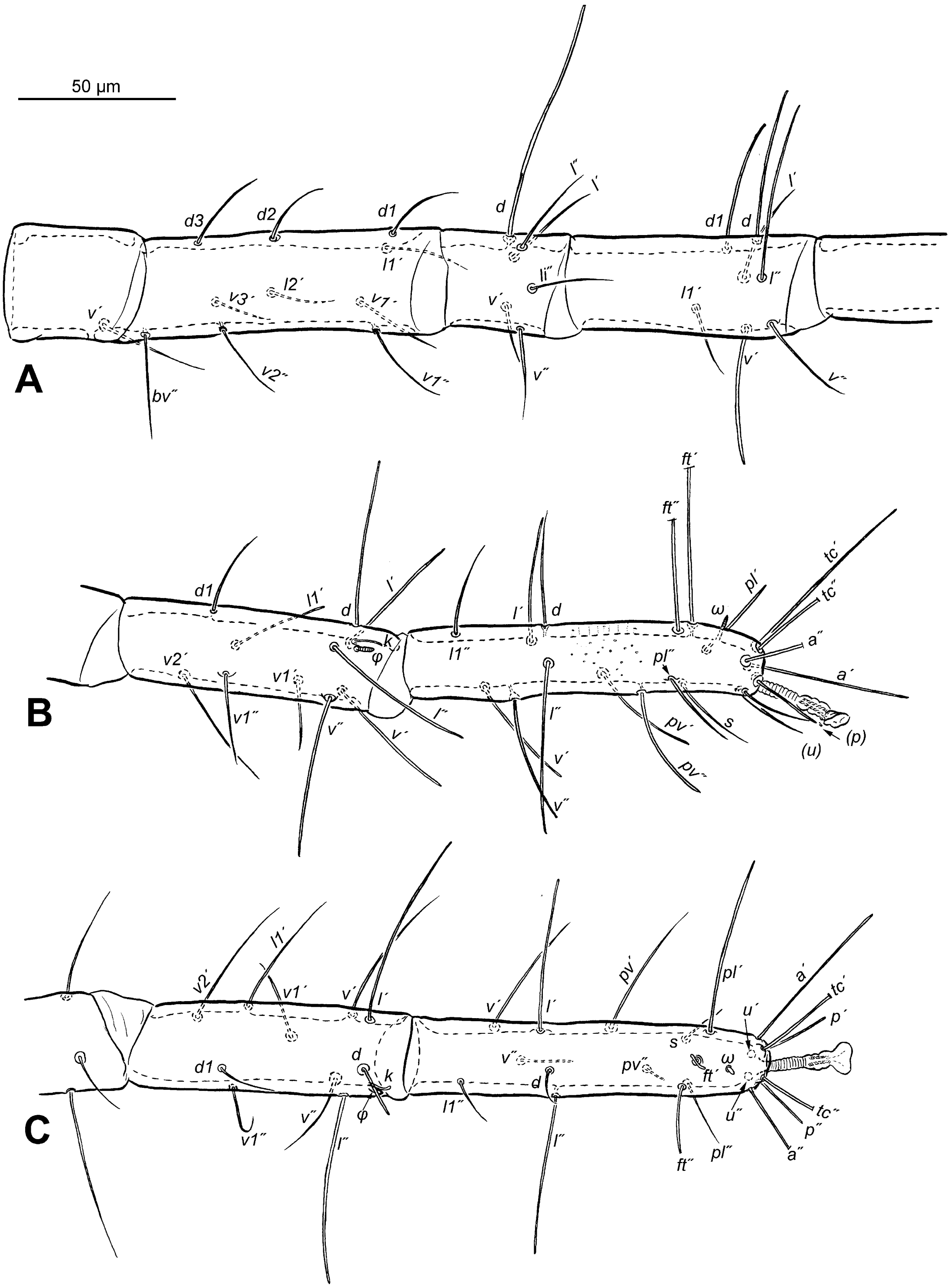

Figure 6. *Anoplocheylus corticicola* **n. sp.**, female, (A) leg I, abaxial view from trochanter to base of tibia, (B) same, from tibia to tarsus, (C) same as B, dorsal view. Scale bar 50 µm.

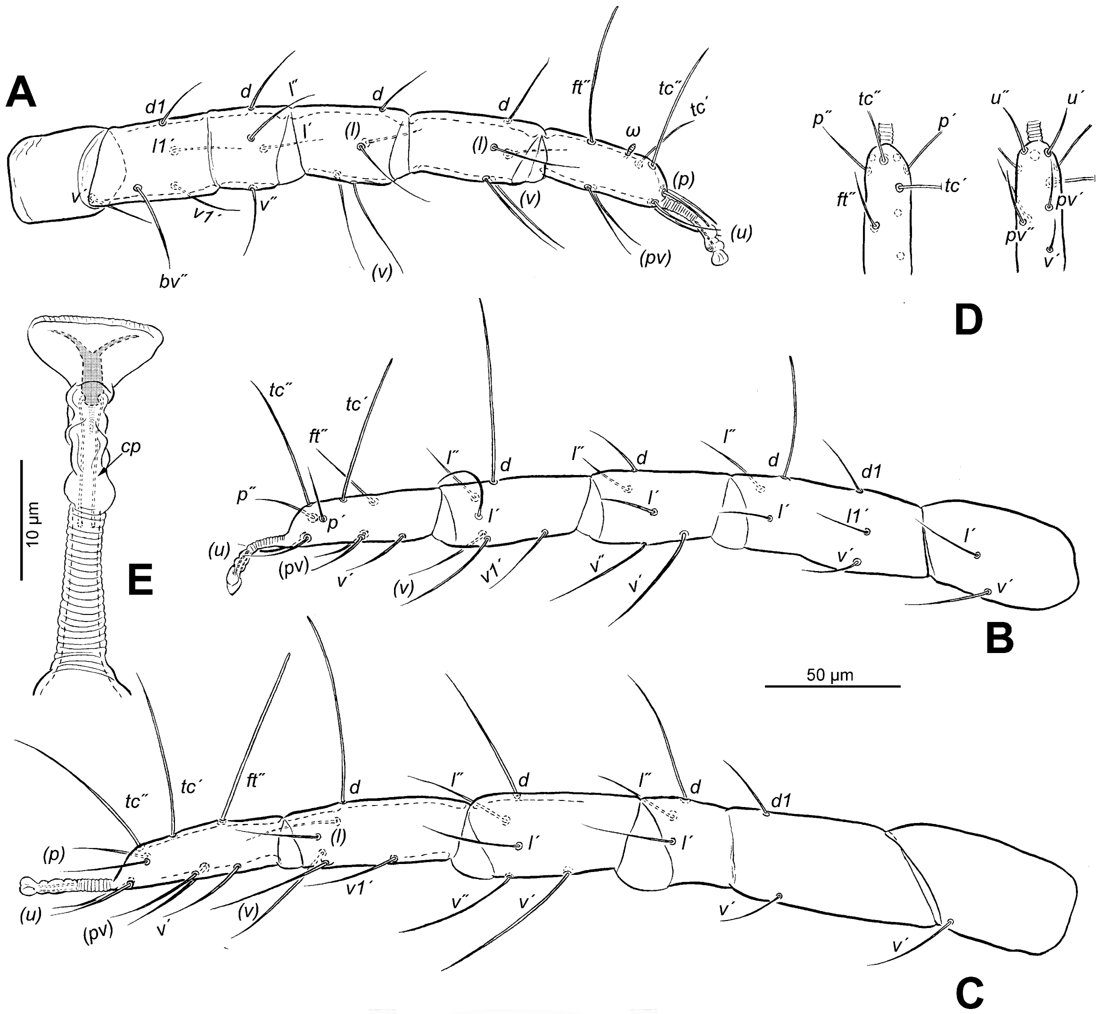

Figure 7. *Anoplocheylus corticicola* **n. sp.**, female, (A) leg II, abaxial view, (B) leg III, abaxial view, (C) leg IV, abaxial view, (D) tarsus III, dorsal (left) and ventral (right) view, (E) pretarsus IV, dorsal view, *cp*, condylophore. Scale bars, A–D 50 µm, E 10 µm.

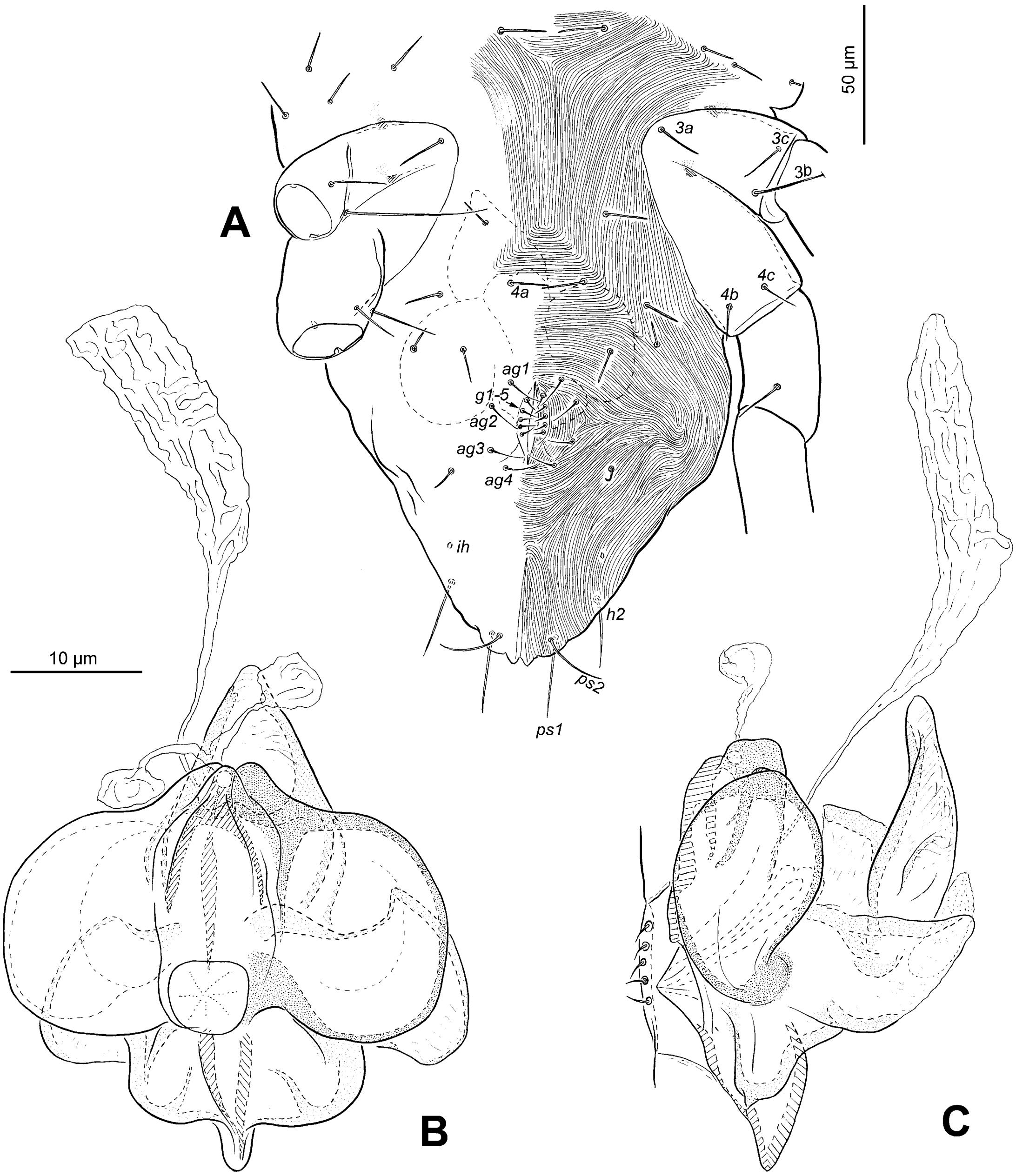

Figure 8. *Anoplocheylus corticicola* **n. sp.**, male, (A) hysterosoma, ventral view, legs omitted, left coxae III–IV slightly distorted, genitalia obliquely displaced due to integument split above left coxa III, (B) genitalia, oblique ventral view, anterior to top, (C) same, lateral view, shown in place with genital opening and setae, differences in hatching and stripping highlight thickness of different structures. Scale bars, A 50 µm, B–C 10 µm.

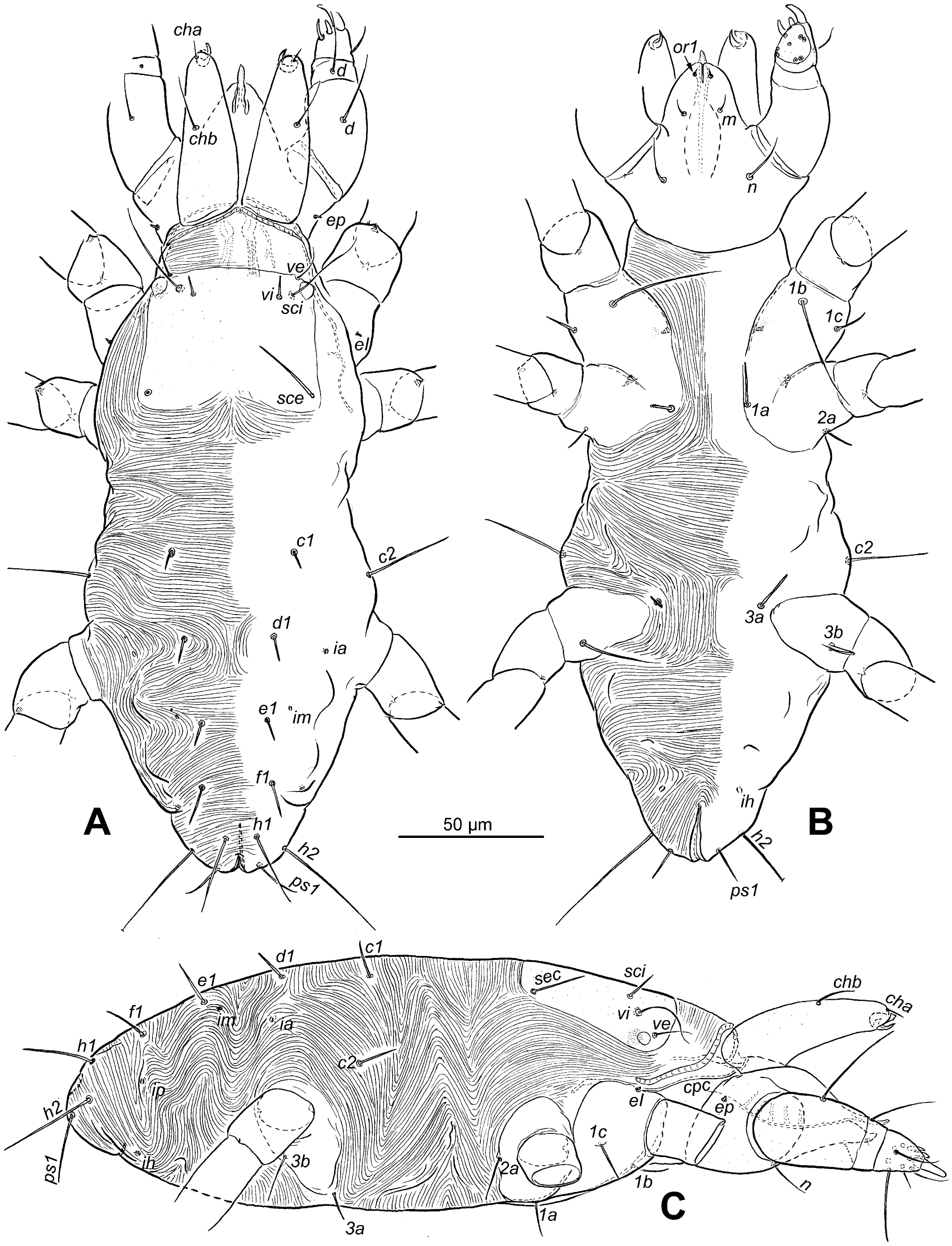

Figure 9. *Anoplocheylus corticicola* **n. sp.**, larva, (A) dorsal view, (B) ventral view, (C) lateral view, legs omitted. Scale bar 50 μm.

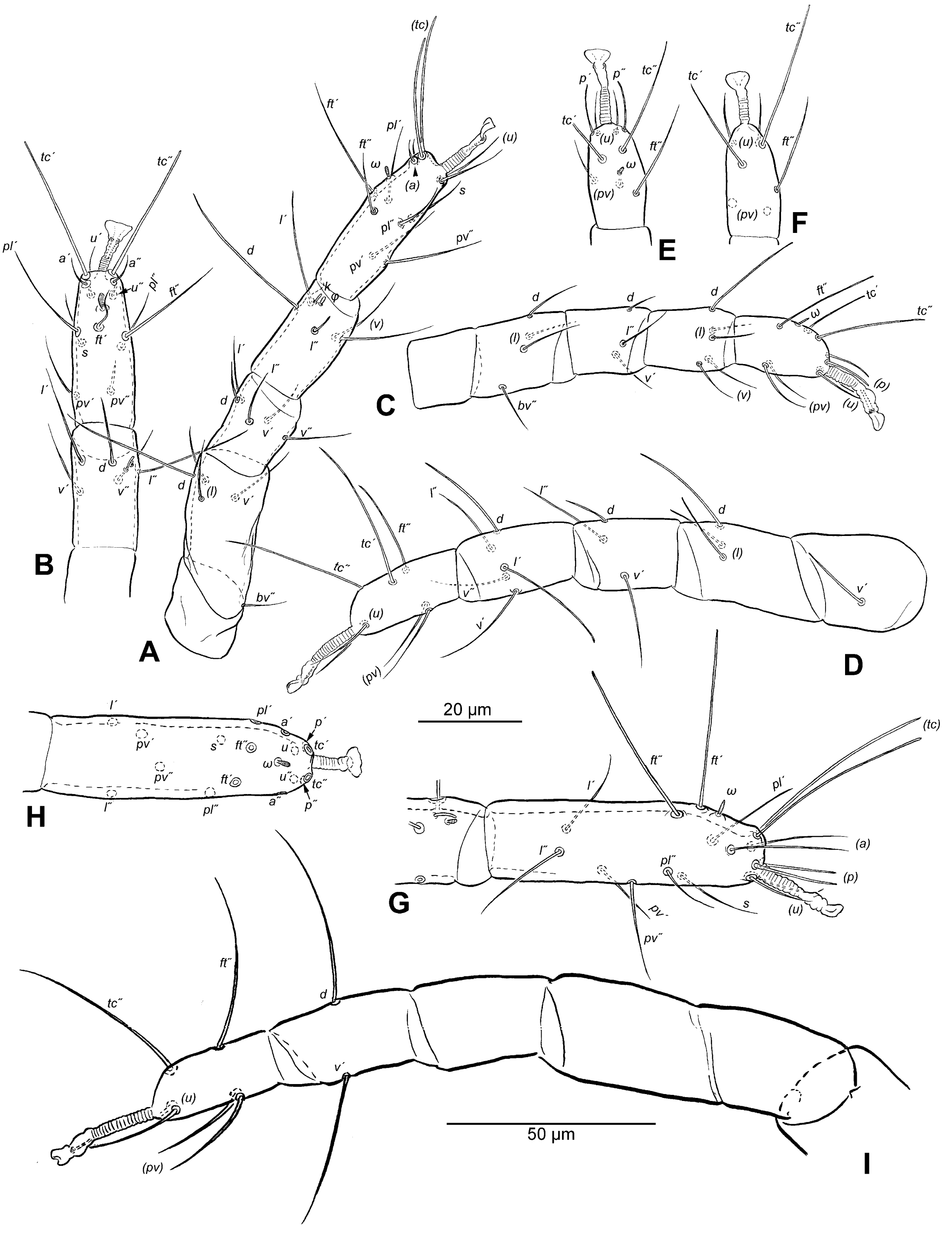

Figure 10. *Anoplocheylus corticicola* **n. sp.**, immatures, (A) larval leg I, abaxial view, (B) larval tibia and tarsus I, dorsal view, (C) larval leg II, abaxial view, (D) larval leg III, abaxial view, (E) larval tarsus II, dorsal view, (F) larval leg III, dorsal view, (G) protonymphal tarsus I, abaxial view, (H) same, dorsal view, only setal bases shown, (I) protonymphal leg IV, abaxial view. Scale bars, A–G 20 µm, I 50 µm.

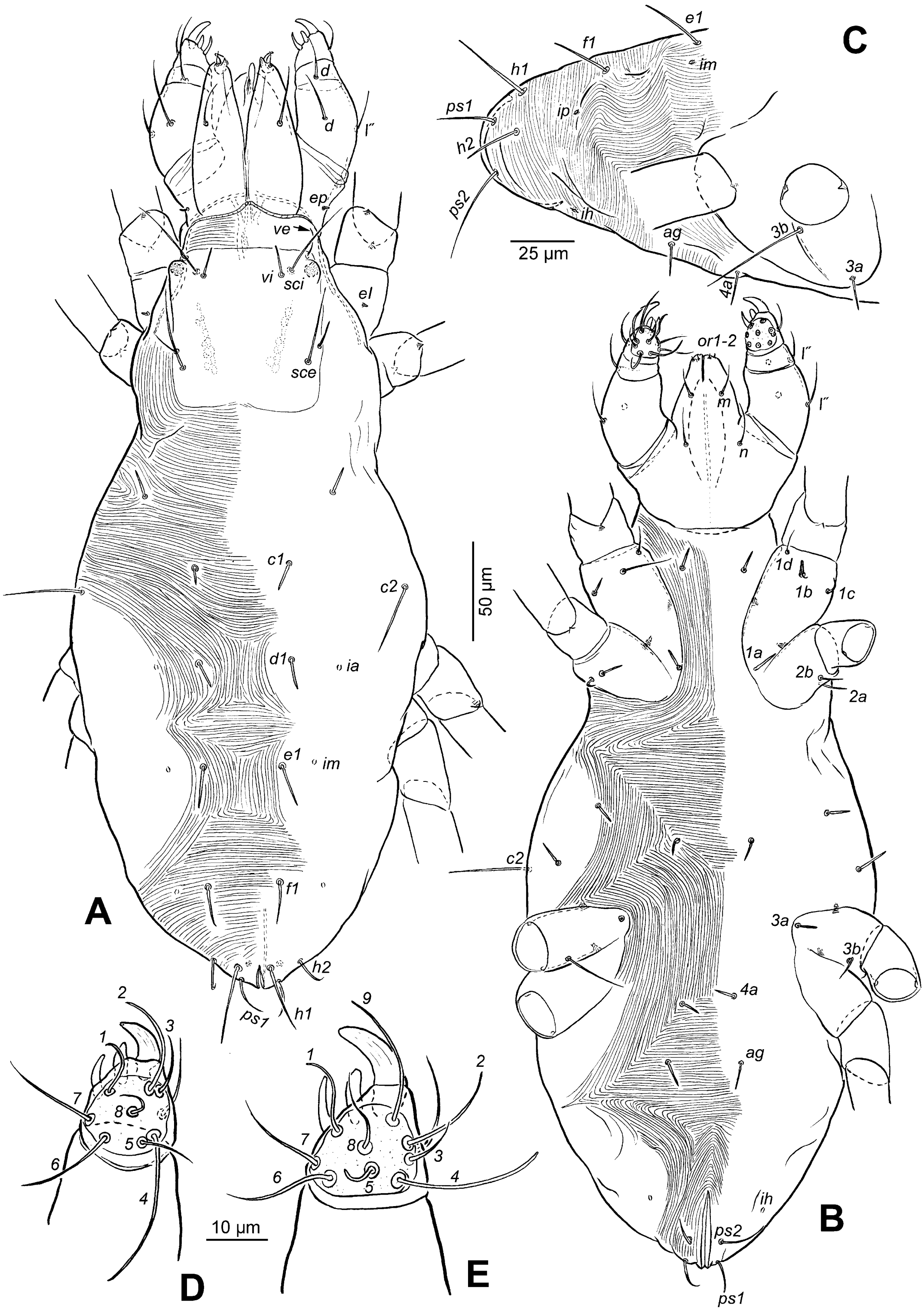

Figure 11. *Anoplocheylus corticicola* **n. sp.**, immatures, (A) protonymph, dorsal view, (B) same, ventral view, (C) hysterosoma of protonymph, lateral view, (D) and (E) palp tibiotarsus of larva and protonymph, respecitively, ventro-adaxial view. Scale bars, A–B 50 µm, C 25 µm, D–E 10 µm.

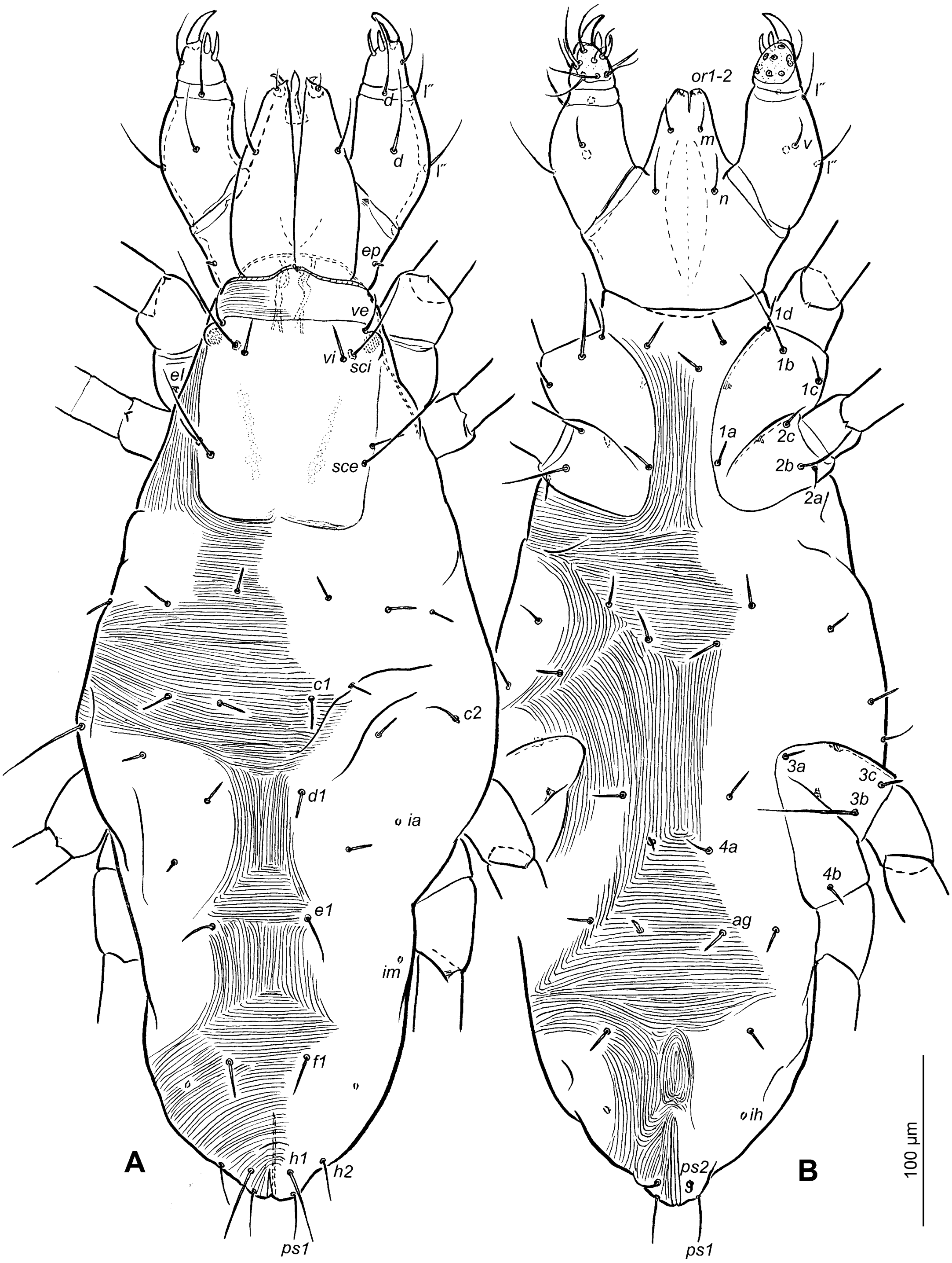

Figure 12. *Anoplocheylus corticicola* **n. sp.**, deutonymph, (A) dorsal view, (B) ventral view, legs omitted. Scale bar 100 µm.

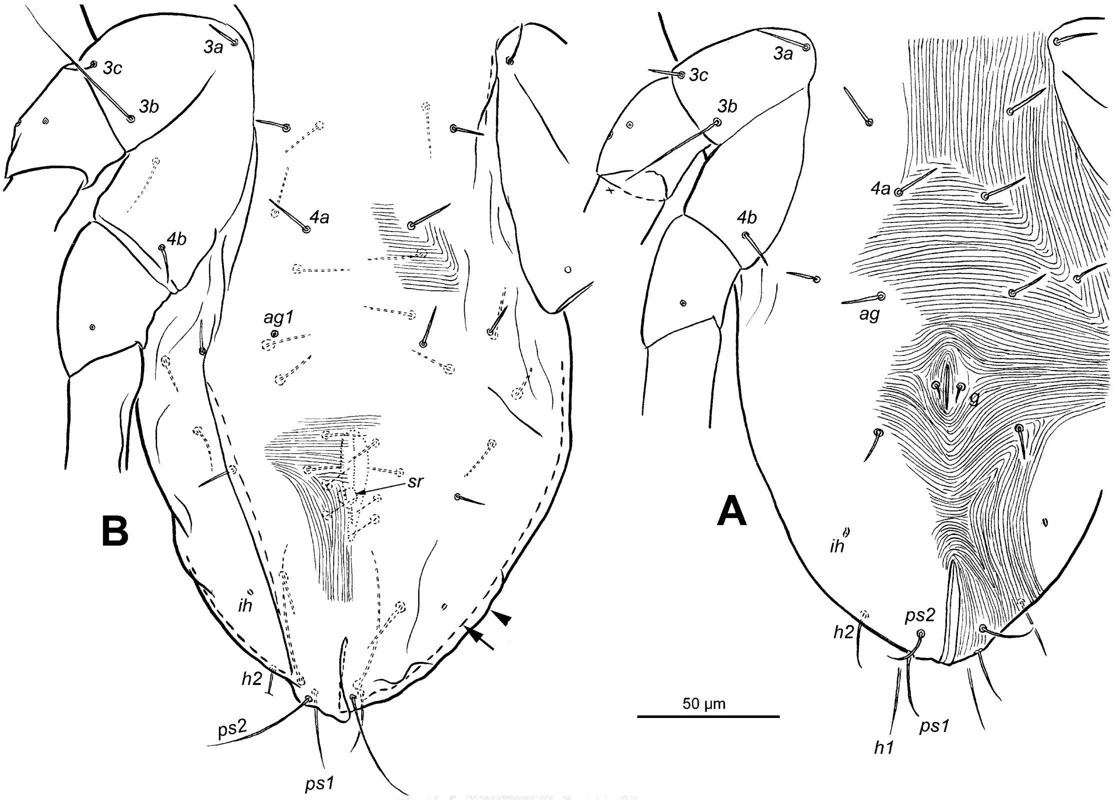

Figure 13. *Anoplocheylus corticicola* **n. sp.**, deutonymph, (A) male deutonymph, ventral view of hysterosoma, (B) female deutonymph (exuviae, arrow head) with pharate female inside (arrowed and drawn by broken lines), *sr*, seminal receptacle. Scale bar 50 µm.

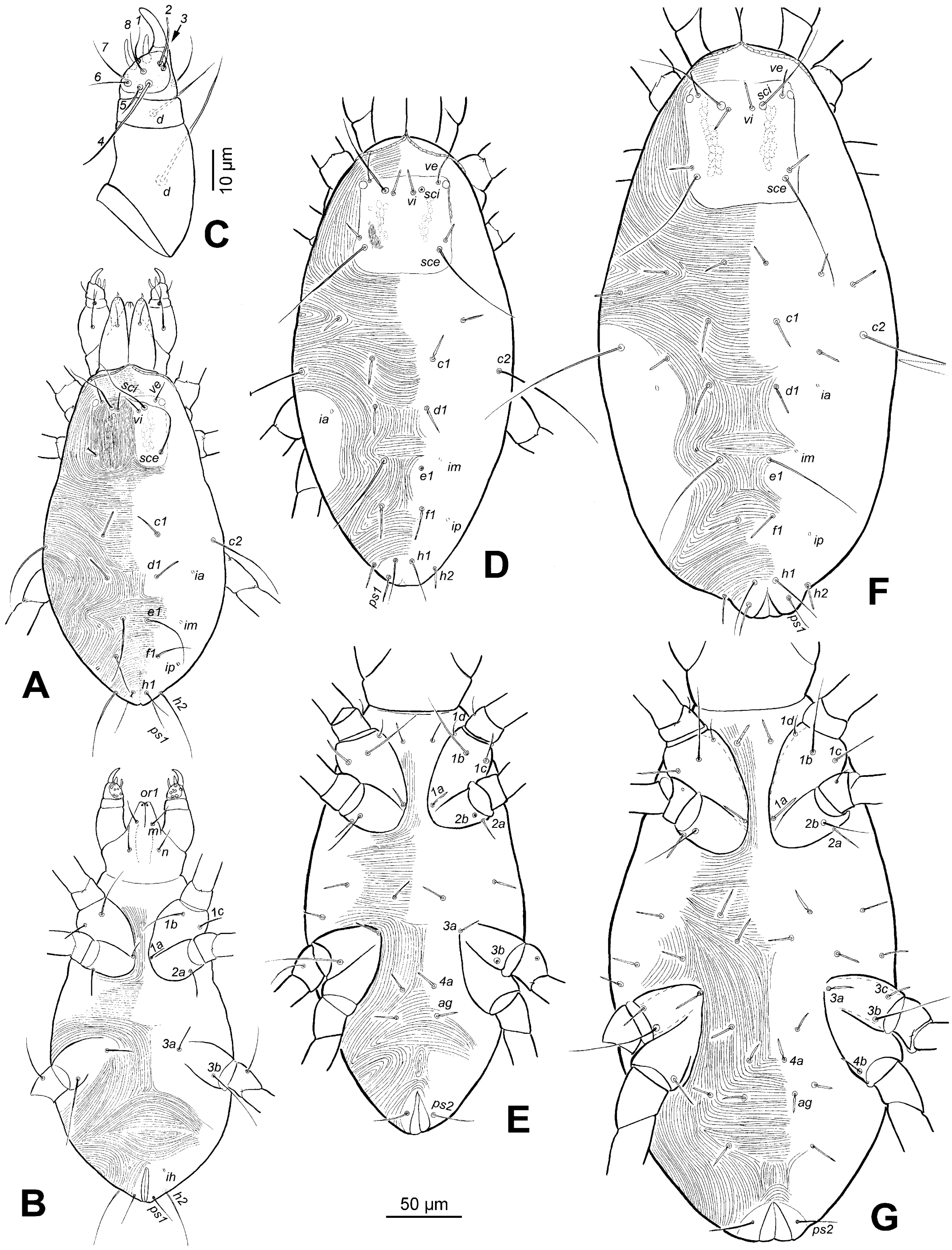

Figure 14. *Anoplocheylus aegypticus* Baker & Atyeo, 1964, immatures (compressed), (A) larva, dorsal view, (B) same, ventral view, (C) palp of larva, ventral view, (D) protonymph, dorsal view of idiosoma, (E) same, ventral view, (F) deutonymph, dorsal view of idiosoma, (G) same, ventral view; legs omitted. Scale bars, A–B and D–G 50 µm, C 10 µm.

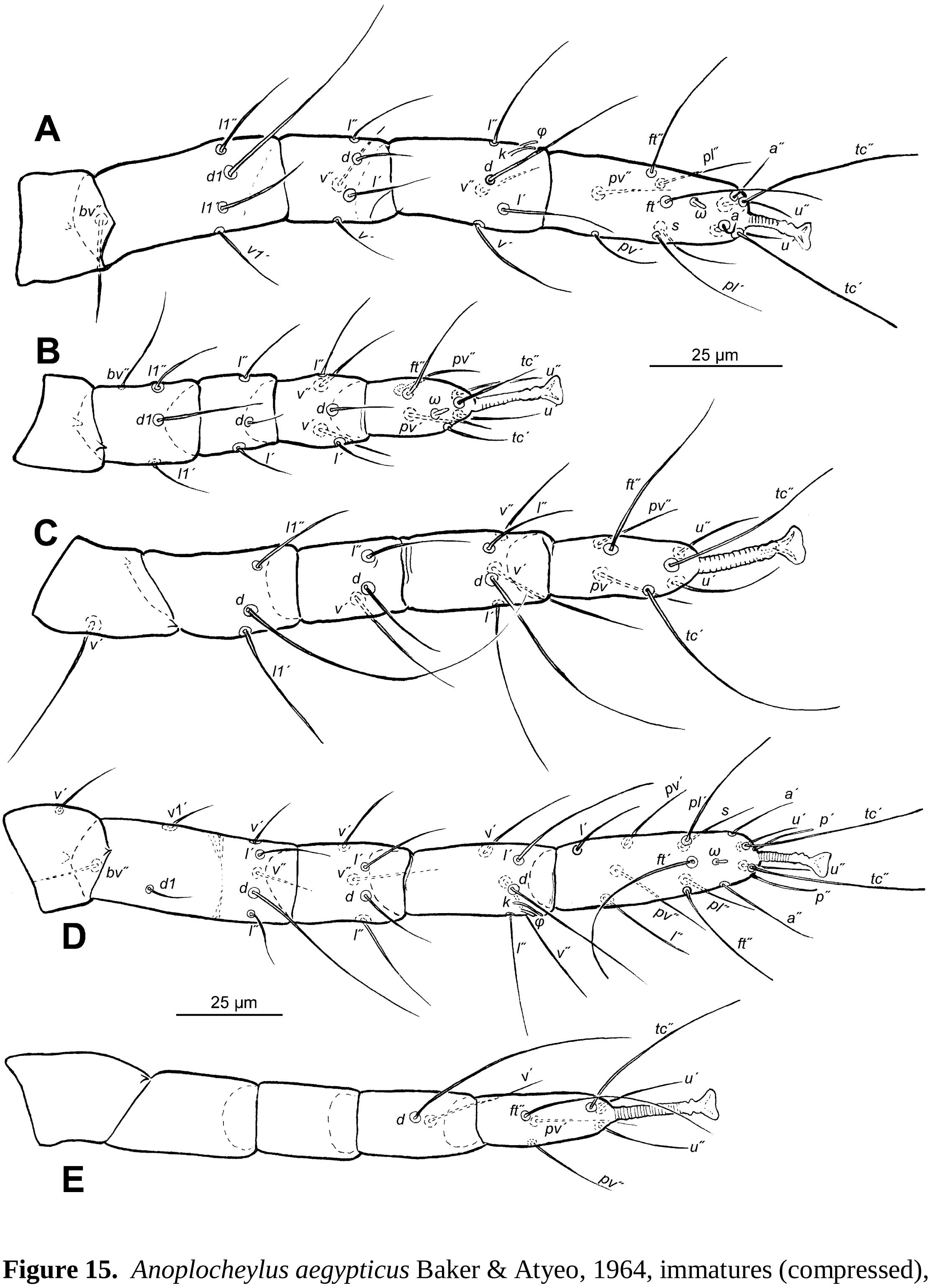

Figure 15. *Anoplocheylus aegypticus* Baker & Atyeo, 1964, immatures (compressed), (A)–(C) leg I–III of larva, respectively, (D) and (E) leg I and IV of protonymph, respectively, all in dorsal view. Scale bars, A–C 25 µm, D–E 25 µm.

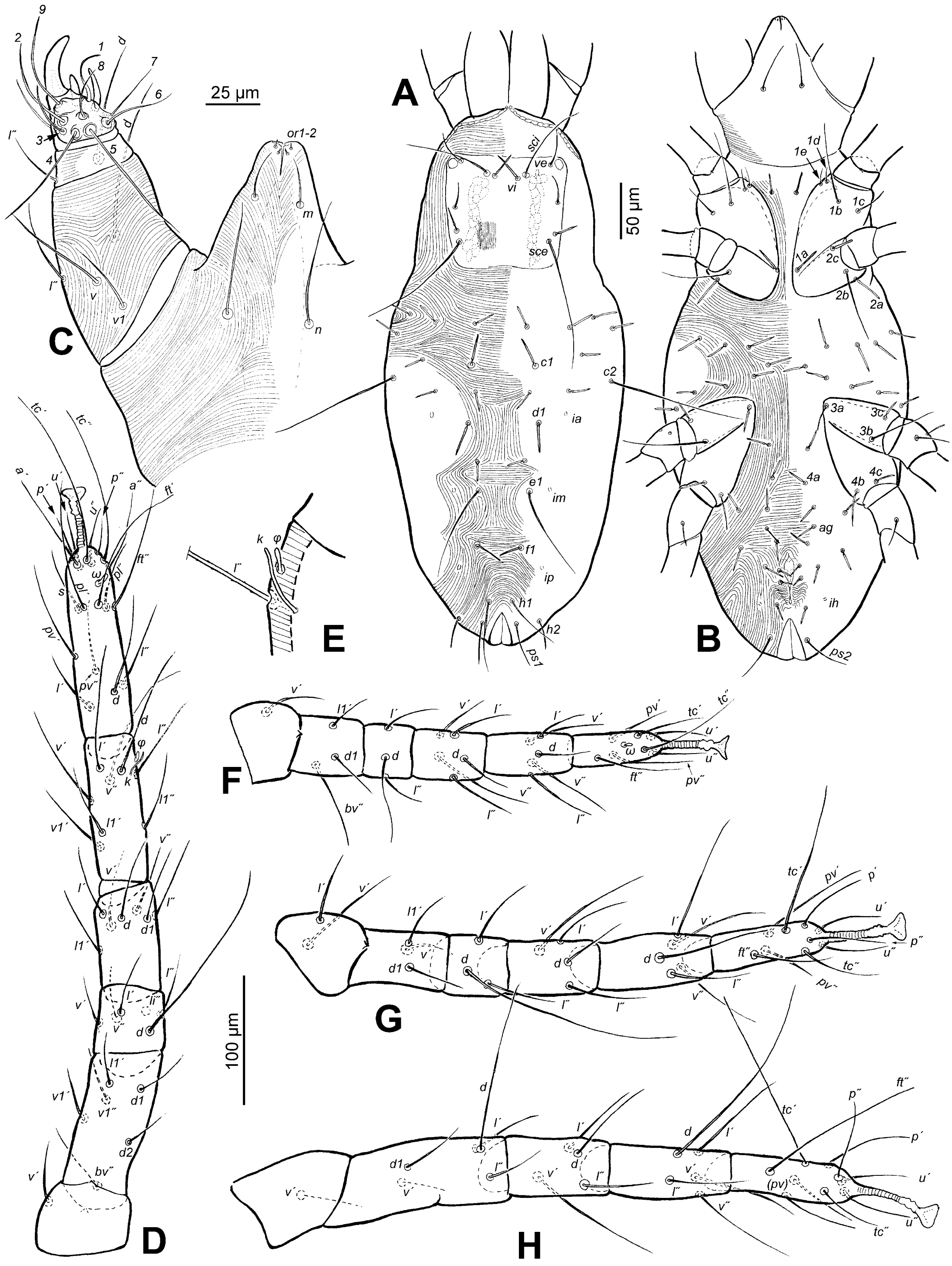

Figure 16. *Anoplocheylus aegypticus* Baker & Atyeo, 1964, female (compressed), (A) dorsal view, (B) ventral view, legs omitted and gnathosoma partial drawn, (C) subcapitulum and palp, ventral view, (D) leg I, dorsal view, (E) seta *k* and solenidion *φ* on tibia I, dorsal view, (F)–(H) leg II–IV, respectively, dorsal view. Scale bars, A–B 50 µm, C 25 µm, D and F–H 100 µm, E not in scale.

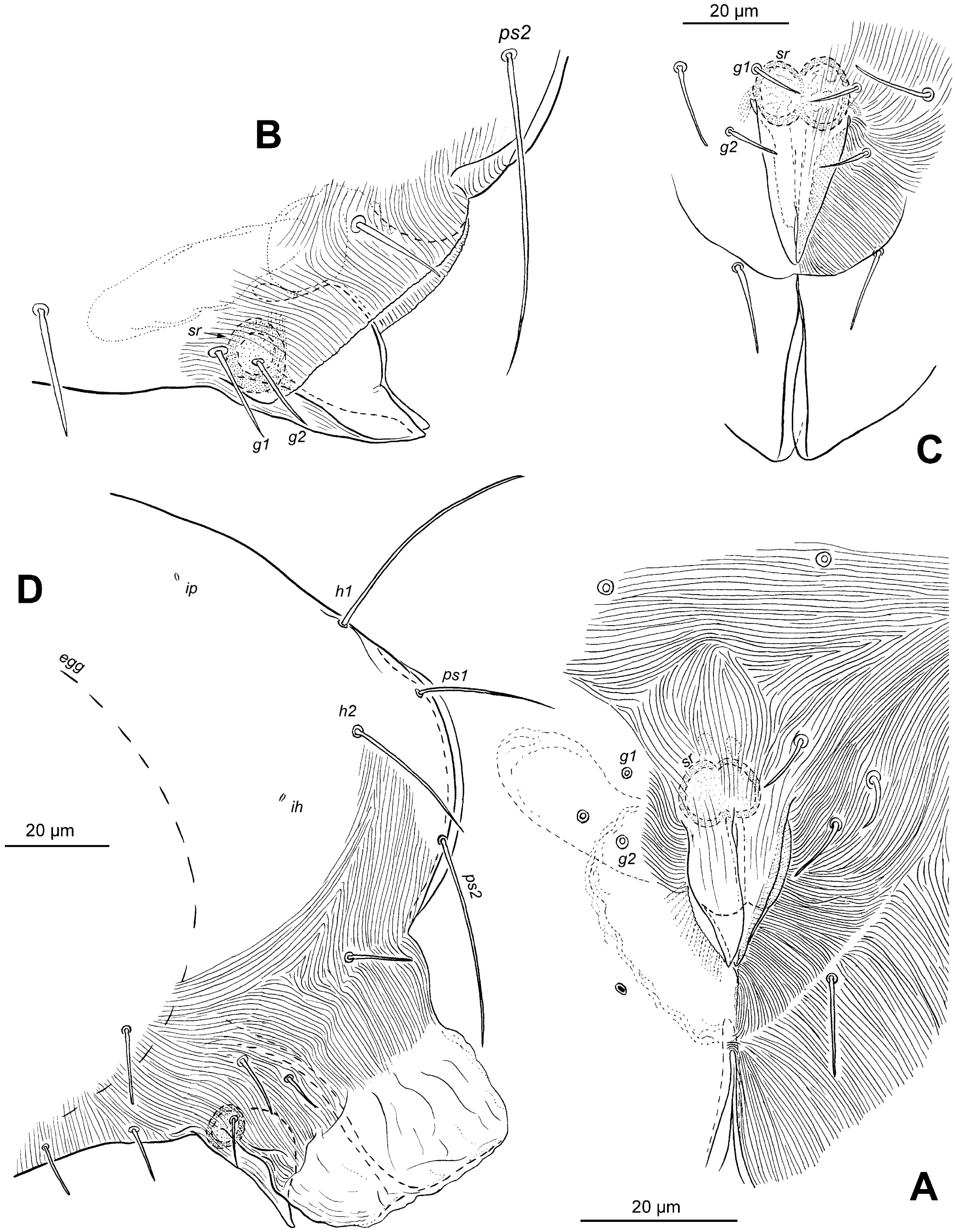

Figure 17. *Anoplocheylus aegypticus* Baker & Atyeo, 1964, female, (A) genital region, ventral view, retracted ovipositor transparently shown on left, (B) same, lateral view of A, (C) genital region of another specimen, ventral view, showing variation of seminal receptacle, (D) posterior hysterosoma of specimen with protruding ovipositor, lateral view. Scale bars, A–B 20 µm, C 20 µm, D, 20 µm.

CHAPTER 2H

A NEW SPECIES OF THE GENUS *STIGMOCHEYLUS* (ACARI: STIGMOCHEYLIDAE) FROM THAILAND*

2H-1 Abstract

Stigmocheylus bochkovi n. sp., a new species of the family Stigmocheylidae (Acari: Prostigmata), is described and illustrated from Thailand based on adult, deutonymph and tritonymph specimens. The new species is the first representative of the family recorded in the Oriental region. Key to species of *Stigmocheylus* is provided.
Keywords.—Acari, Prostigmata, Anystina, *Stigmocheylus*, soil mites, new species, Thailand

2H-2 Introduction

The monogeneric family Stigmocheylidae is characterized by having the soft and elongate body, palps with a tibial claw, one pair of prodorsal trochobothria, elongated legs I which are about twice as long as legs II-IV, the pretarsi I with two smooth claws while pretarsi II-IV are linear with tenet hairs (Bochkov 2008; Walter *et al*. 2009). Stigmocheylids are presumably predators and found in soil habitats, especially at deep soil strata (60-75 cm of depth has been reported). However, their biology and ecology are poorly known. Bochkov (2008) based on the collection data, suggested that their life cycle includes larva, protonymph, tritonynph and adult (prelarva may be present). Collectively, the family has worldwide distribution with the representatives sparsely reported from Italy (Berlese 1910), Egypt (Soliman & Zaher 1975), North America (Kethley 1990), and Australia (Norton & Kinnear 1999). Bochkov (2008) reviewed the systematics of this family and firstly proposed setal homologies of the appendages and the diagnosis of the family. To date only four species

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* This chapter is a manuscript in preparation for submission as:
Fuangarworn, M. A new species of the genus *Stigmocheylus* (Acari: Stigmocheylidae) from Thailand.

have been described in a single genus, *Stigmocheylus*: *S. brevisetus* Berlese, 1910, a type species from Italy, *S. pilosus* (Soliman & Zaher, 1975) from Egypt, *S. americanus* Bochkov, 2008 and *S. oberon* Bochkov, 2008, both from USA (New Mexico).

In this paper, a new species from Thailand is described as *Stigmocheylus bochkovi* **n. sp.** based on specimens collected from sandy soils in the coastal grassland habitat and river bank. It represents the first stigmocheylid species recorded from the Oriental region. Key to species of *Stigmocheylus* is also given.

2H-3 Materials and methods

Samples of soil and litter were collected into plastic bags and brought back to the laboratory for extraction of mites using Tullgren funnels. The water washing technique (Kethley 1991) was also applied to the soil samples in the field (see *Material examined* for collection data). The specimens were sorted under stereomicroscope. Mites were prepared on permanent slides using Hoyer's solution as a medium (Walter and Krantz, 2009). Drawings were made with the aid of a *camera lucida* attached to the phase contrast microscope. Measurements are in micrometers and given as mean followed by ranges (if relevant). In description, the terminology follows Kethley (1990) and Bochkov (2008); generic or familial diagnosis and description can be found in Bochkov (2008) and are not repeated in the species description.

2H-4 Taxonomic results

Family Stigmocheylidae Kethley, 1990

Genus *Stigmocheylus* Berlese, 1910

***Stigmocheylus bochkovi* n. sp.**

(Figs 1-4)

Diagnosis. *Stigmocheylus* with following combinations of characters states: body 300-330 long, 85 wide, peritremes non-segmented, seta *c3* absent, *ad4* present, seta *g2* absent, basifemur I with 3 setae (*l"* absent), telofemur III with 4 setae (*v* present), telofemur IV with 3 setae (*l'* absent).

Description. *Female.* Body length (from cheliceral bases to posterior end of idiosoma, n = 2) 315 (300-330), body width (at level of setal row *c*) 85. *Gnathosoma*

(Figs 1-2). typical of the family, subcapitulum 132.5 (125-140) long, 117.5 (110-125) wide, subcapitular seta *m* 17.5 (15-20) long, *m-m* 30 long, seta *n* 50 long, *or1* and *or2* about 5 long. Palp as illustrated in Fig. 2A-B, about 150 long, palp femur 75 long. Chelicerae 122.5 (115-130) long, *cha* about 30 long, *chb* about 35 long. Peritremes (Fig. 1B) unsegmented, 25.5 (45-60) long, distally alveolae. Seta *ep* peglike.

Idiosoma (Figs 1A-B). Prodorsal shield subrectangular, about 125 long, and 60 wide, surface smooth; muscle scars evident at center and near posterior margin of shield; *vi* 22.5 (20-25) long, *vi-vi* 5, trichobothrium *sci* 42.5 (40-45) long, clavate on distal half, *sci-sci* 42.5 (40-45), *ve* 22.5 (20-25) long, *ve-ve* 57.5 (55-60), *sce* 50 long, *se-se* 102.5 (100-105). Hysterosoma with 16 pairs of setae (*c1*, *c1*, *d1*, *e1*, *f1*, *h1*, *h2*, *h3*, *ps1*, *ps2*, *ps3*, *ad1*, *ad2*, *ad3*, *ad4*). All filiform with minute barbs, measurements as follows: *c1* 45 (40-50), *c2* 60, *d1* 50, *e1* 50, *f1* 60, *h1* 70, *h2* 65 (60-70), *h3* 70, *ps1* 65 (60-70), *ps2* 70 (65-75), *ps3* 55, *ad1* 55, *ad2* 70, *ad3* 40, *ad4* 17.5 (15-20), *c1-c1* 45 (40-50), *d1-d1* 40, *e1-e1* 62.5 (55-70), *f1-f1* 67.5 (60-75), *h1-h1* 65 (60-70). Lyrifissures *ia*, *im*, *ip* and *ih* at normal position.

Ventrally, genital opening about 70 long, with one pair of genital setae (seta *g2* absent), *g1* about 10 long; *ag1* 30 long, *ag1-ag1* 40, *ag2* 25 (20-30), *ag3* 22.5 (20-25) long. Coxal plates smooth; coxae I-IV setation 5(*a1*, *1b*, *1c*, *1d*, *1e*)-4(*2a*, *2b*, *2c*, *2d*)-3(*3a*, *3b*, *3c*)-3(*4a*, *4b*, *4c*), all filiform, their relative length similar to its congeners.

Legs. Leg I 350, leg II 190 (185-200), leg III 183.3 (175-200), leg IV 256.6 (250-265). Legs I-IV setation (solenidion in bracket): trochnters 1-1-1-1, basifemora 4-2-1-1, telofemora 5-3-4-3, genua 9-5-5-5, tibiae 10(1)-5(1)-4(1)-6, and tarsi I 24(2)-11(1)-11-10. Homolologies of leg setae illustrated in Figure 3.

Protonymph (Figs 4A, C). Body length (n = 1) 365, body width 140; with coxae I-IV setation 4-3-3-0, one pair of aggenital setae (*ag1*), one pair of genital setae. Setae *ps3* absent.

Deutonymph (Figs 4B, D). Body length (n = 2) 465 (460-470), body width 135 (130-140); with coxae I-IV setation 5-4-3-1, two pair of aggenital setae (*ag1-2*), one pair of genital setae. Setae *ps3* present.

Male and other immature stages. Unknown.

Material examined. Holotype: female, THAILAND, Chonburi Province, Sattahip district, Samaesan Island, Luk-lom beach, ~ 12°35'6"N, 100°56'48"E, ex. soil at depth of 0-10 cm in coastal grassland (*Spinifex littoreus* Merr.), 24 Jul 2010, coll. M. Fuangarworn (Field no. MF2010-51). Five paratypes (1 female, 3 duetonymph, 1 protonymph) with same data as holotype. *Other materials*: 3 females, Ayutthaya Province, Tha Ruea Dist, Salaloy Sub-dist., Pasak river bank, (14°31'48.84"N, 100°42'5.38"E), ex. sandy soil at 20–30 cm (water washing), 3 May 2014, coll. M. Fuangarworn (Field no. 2014-27). Two females, as previous data but on 19 Aug 2013. All materials deposited in the Acari collection at Chulalongkorn University Museum of Natural History, Bangkok, Thailand.

Etymology. The new species is name for A. Bochkov in recognition of his contribution to the study of the family Stigmocheylidae.

2H-5 Discussion

The new species is most similar to *Stigmocheylus oberon* Bochkov, 2008 (from USA) in having the non-segmented peritremes, not having a hysterosomal seta *c3* and genital seta *g2*. However, it can be distinguished from *Stigmocheylus oberon* by the presence of seta *ad4* (vs absence), coxa II with 4 setae, *2a* present (vs 3 setae, *2a* absent), basifemur I with 3 setae, *l”* absent (vs 4 setae, *l”* present), telofemur III with 4 setae, *v* present (vs 3 setae, *v* absent), and telofemur IV with 3 setae, *l’* absent (vs 4 setae, *l’* present).

Key to species of *Stigmocheylus* Berlese (female), modified from Bochkov (2008)

1. peritremes not segmented ………………………………………………………… 2
- peritremes segmented ………………………….... *S. pilosus* (Soliman & Zaher, 1975)
2. Body length 500 µm or more; setae *c3* absent ………………………………….... 3
- Body length less than 400 µm; setae *c3* present …..... *S. brevisetosus* Berlese, 1910
3. Setae *g2* absent; coxa IV with 3 setae …………………….…………………..….. 4
- Setae *g2* present; coxa IV with 2 setae ……………….... *S. americanus* Bochkov, 2008
4. Coxa II with 3 setae; setae *ad4* absent ………………….….. *S. oberon* Bochkov, 2008
- Coxa II with 4 setae; setae *ad4* present ………………………….. *S. bochkovi* **n. sp.**

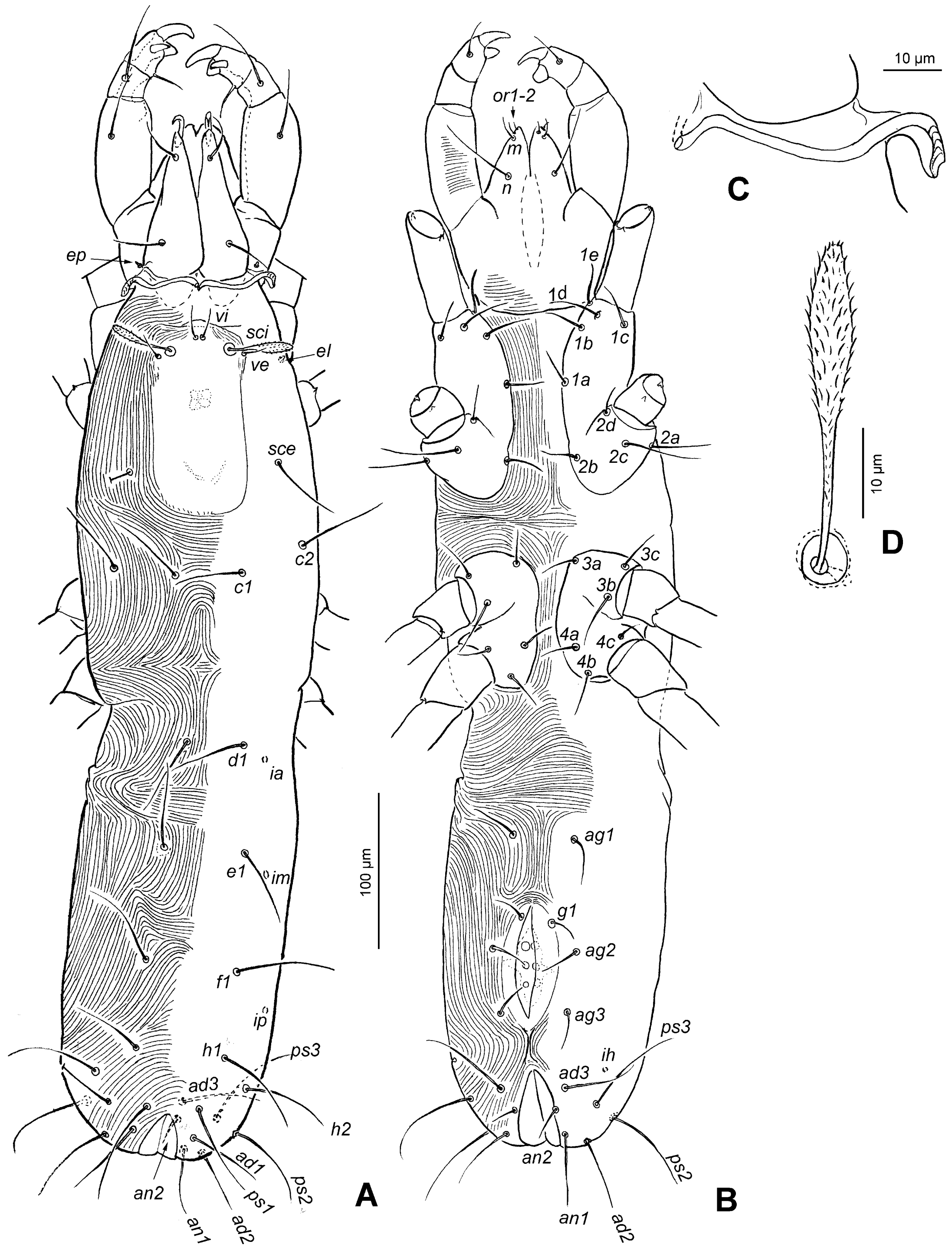

Figure 1. *Stigmocheylus bochkovi* n. sp., female: (A) dorsal view, (B) ventral view, (C) right peritreme, dorsal view, (D) trichobothrium *sci*. Scale bars: A, B 100 µm, C, D. 10 µm.

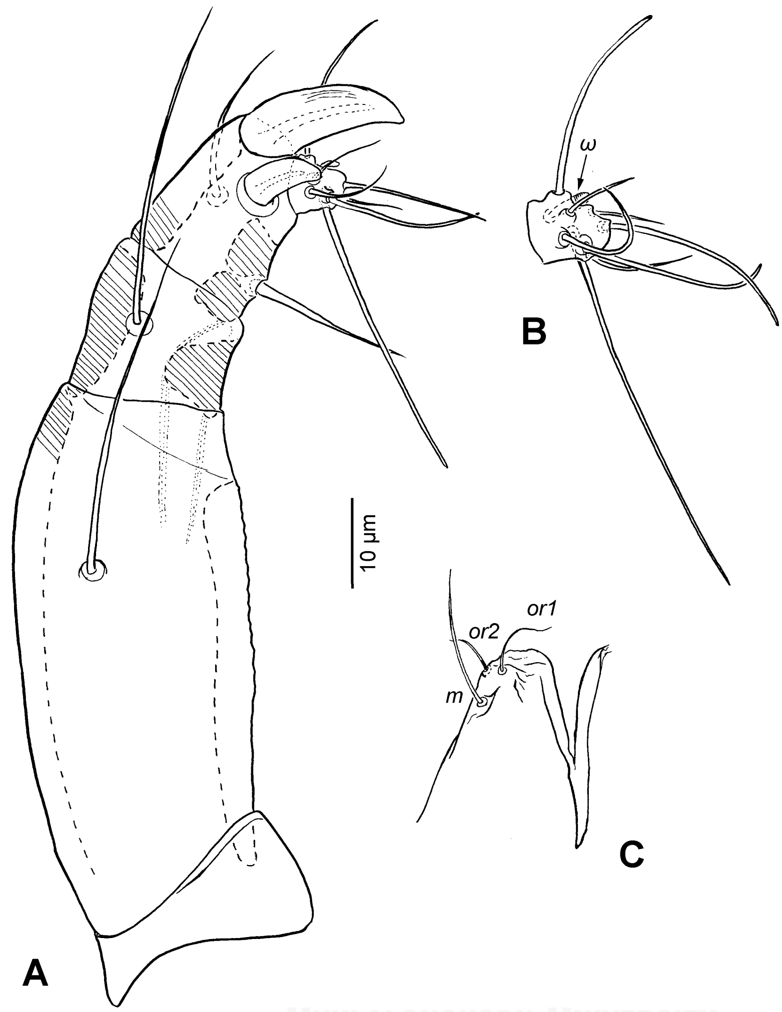

Figure 2. *Stigmocheylus bochkovi* n. sp., female: (A) palp, adaxial view, (B) palp tarus, adaxial view, (C) lateral lips, ventral view. Scale bar: 10 µm.

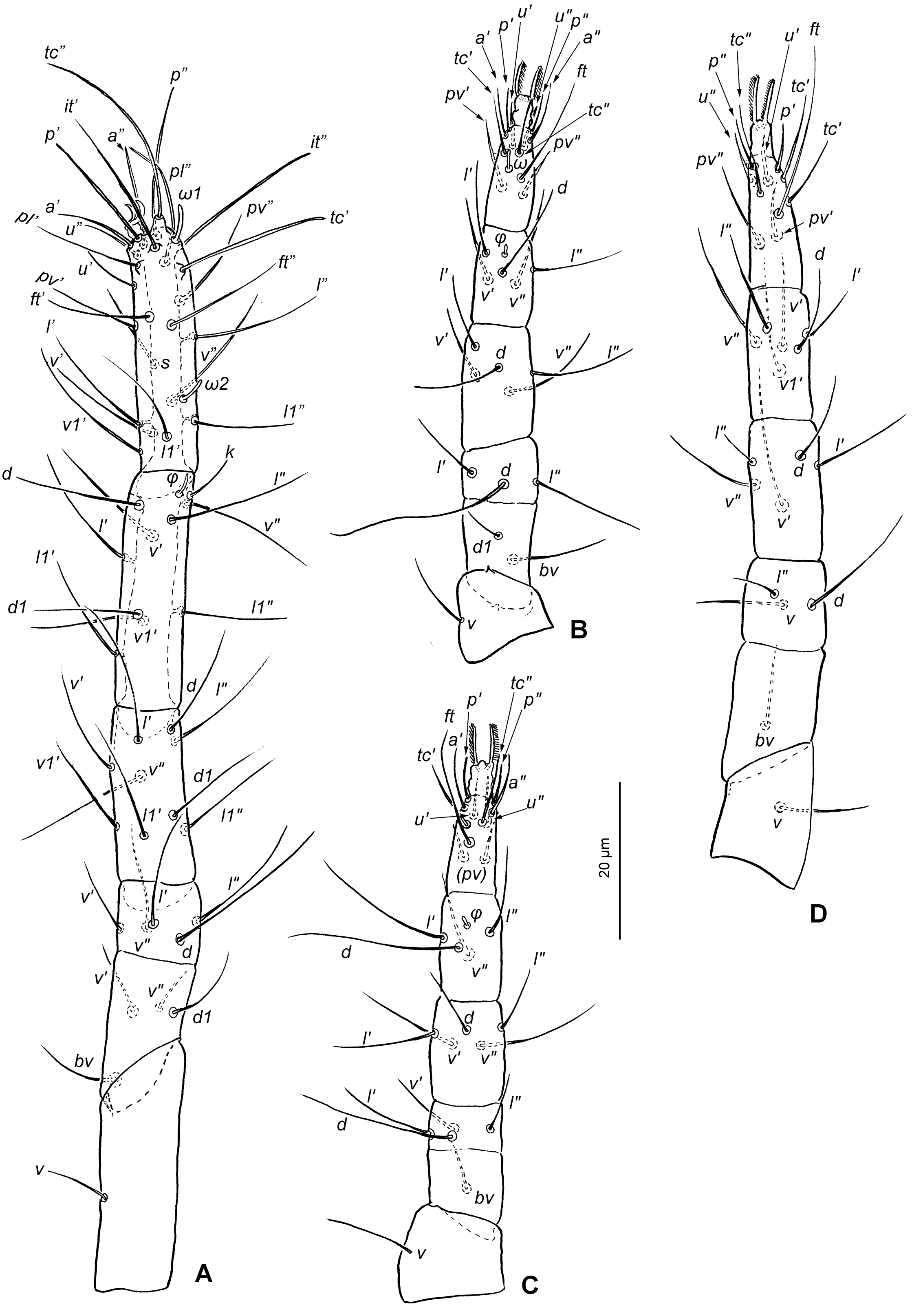

Figure 3. *Stigmocheylus bochkovi* n. sp., female: (A) leg I, (B) leg II, (C) leg III, (D) leg IV, all in dorsal view. Scale bar: 20 µm.

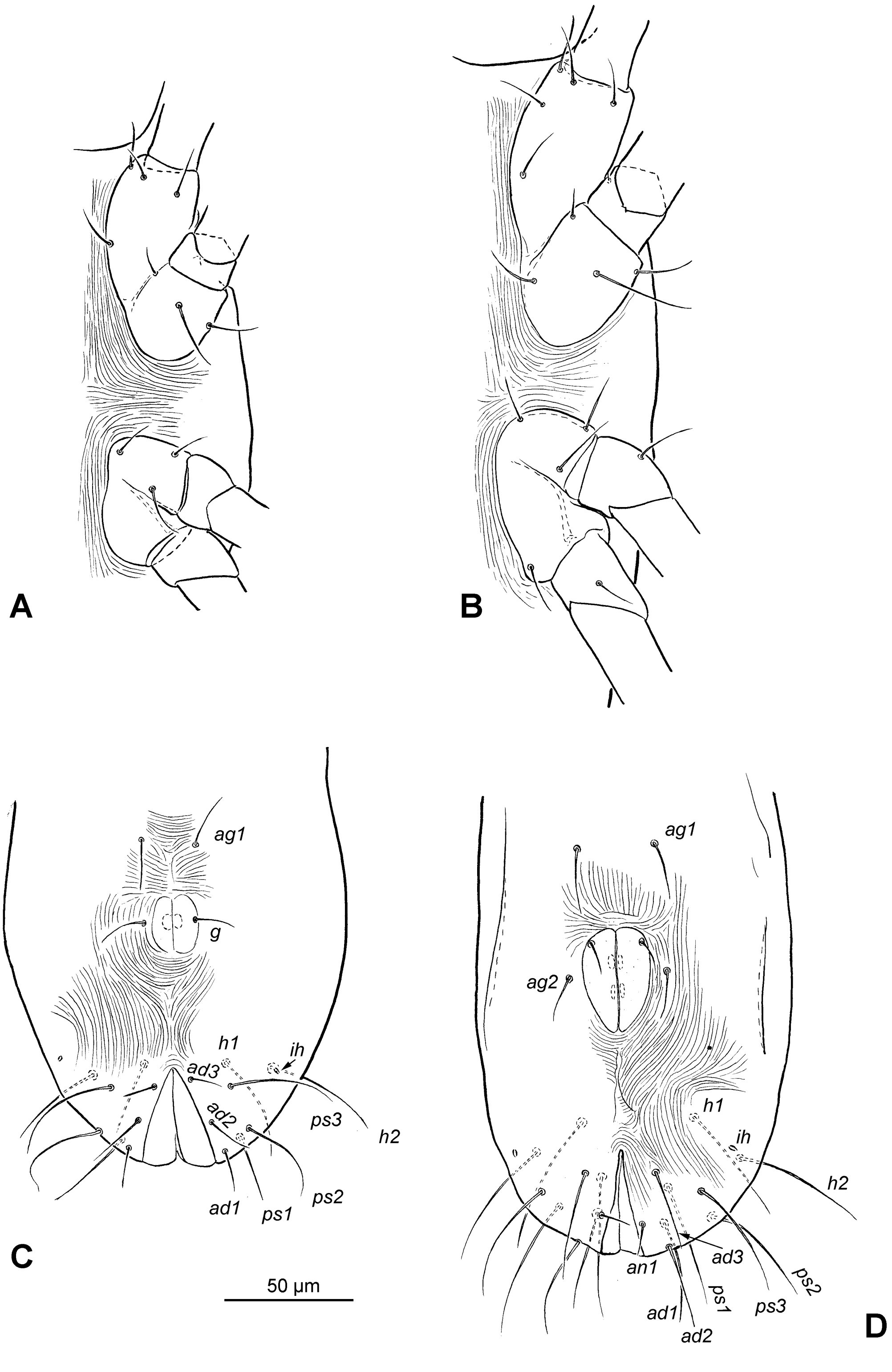

Figure 4. *Stigmocheylus bochkovi* n. sp., immatures: (A) lateral half of epimeral region of protonymph, (B) same of deutonymph, (C) opisthogaster of protonymph, (D) same of deutonymph. Scale bar: 50 µm.

CHAPTER 2I

AUSTROTENERIFFIA SUNTHORNI N. SP. (ACARI, PROSTIGMATA, TENERIFFIIDAE) FROM THAILAND*

2I-1 Abstract

Austroteneriffia sunthorni **n. sp.**, the first representative of the family Teneriffiidae (Acari, Prostigmata) from Thailand, is described and illustrated. The new species occurs in both the coastal zone, where they were collected from rocks, bark in beaches, and inland parts of the country, where they were collected from rocks, soil and litter in deciduous forests. *Austroteneriffia yunnanensis* (Luo *et al.*, 1997) **n. comb.**, transferred from *Neoteneriffiola*, is proposed. Key to known species of *Austrotenerffia* and a checklist of world species of Teneriffiidae are given.

Keywords**.**—Teneriffiidae, Prostigmata, new species, soil mites, Thailand

2I-2 Introduction

Members of the family Teneriffidae (Acari, Prostigmata) are predatory mites of medium to large size (body length about 700-1200 μm) with red, yellow, or brown in colour. They typically possess the rosette pattern at the base of the posterior prodorsal trichobothria and have elongated legs of which tarsi III-IV are subdivided (Walter *et al.* 2009). Teneriffids are usually collected from the coastal habitats (Walter *et al*. 2009) but some species have recorded from agricultural areas (Khanjani *et al.* 2011), in caves (Bernardi *et al.* 2012), from the undersides of rocks in deserts (Judson 1994) and on mountains at high altitude exceeding 1000 m (Irk 1939; Schmölzer 2002). Some species have been collected from trees (Luo *et al.* 1997; Walter & Proctor 1999).

The family Teneriffiidae currently comprises 27 species (see checklist of species below) for which a satisfactory generic classification has yet to be proposed.

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* This chapter is a manuscript in preparation for submission as:
Fuangarworn, M. *Austroteneriffia sunthorni* n. sp. (Acari, Prostigmata, Teneriffiidae) from Thailand.

When it was proposed, Teneriffiidae contained 2 genera: *Teneriffia* Thor and *Parateneriffia* Thor (Thor 1911). Then 5 genera were monotypically proposed, *Neoteneriffiola* Hirst, *Heteroteneriffia* Hirst, *Austroteneriffia* Womersley, *Mesoteneriffia* Irk and *Mesoteneriffiola* Schmölzer, by Hirst (1924, 1925), Womersley (1935), Irk (1939) and Schmölzer (1956), respectively. Until, 1976, McDaniel *et al.* (1976) reviewed the family Teneriffiidae and recognized only 2 genera, *Teneriffia* and *Parateneriffia*. They treated other genera as synonyms of the two (*Heteroteneriffia* was a synonym of *Teneriffia*; *Neoteneriffiola*, *Heteroteneriffia*, *Austroteneriffia*, *Mesoteneriffia* were synonyms of *Parateneriffia*; they over looked *Mesoteneriffiola*). Subsequent to Mcdaniel *et al*.'s (1976) work, two new genera were added, namely *Sinoteneriffia* Yin *et al*. and *Himalterneriffia* Schmölzer, by Yin *et al.* (1994) and Schmölzer (2002), respectively. However, the generic concepts of most teneriffiid genera are not well established, and usually relied on few characters, and based on the type species whose original descriptions are inadequate by modern requirements, hence their validity needs reevaluation. Judson (1994) argued that the synonymies made by Mcdaniel *et al*. (1976) seem premature. He resurrected the genus *Neoteneriffiola*, pending the clarification of *Parateneriffia* (by studying its sutaible neotype). He (Judson 1995) then also resurrected the genus *Austroteneriffia*, by reexamining the type specimens of the type species, *A. hirsti* Womersley, 1935, and gave the emended diagnosis of *Austroteneriffia*. As a result, *Austroteneriffia* is best known teneriffid genus, now including 10 species known from Iran, Japan, Australia, and Tadzhikistan.

In this paper, we describe a new species of *Austroteneriffia*, *A. sunthorni* **n. sp.**, from Thailand. This is also the first record of the family Teneriffiidae in this country. Key to known species of *Austrotenerffia* is given along with a checklist of world species of Teneriffiidae.

2I-3 Materials and methods

Mites were collected by hand or extracted from soil and leaf litter samples using Tullgren funnels for seven days (Walter & Krantz 2009) and stored in 70% ethanol (see *Material examined* for collection data). The specimens were cleared in 80% lactic acid and incubated at 50 ºC overnight. The specimens were observed while specimens were in a temporary cavity slide (with lactic acid as the medium) or on permanent slides using Hoyer's solution (Walter & Krantz 2009) under a bright-field compound microscope and a phase contrast microscope. Drawings were made with the aid of a *camera lucida* attached to a microscope. An eyepiece micrometer calibrated with a stage micrometer was used for measurements which are given in micrometers (µm). The terminology generally follows that of Grandjean's system overviewed by Kethley (1990) for idiosomal chaetotaxy, and by Judson (1995) for leg chaetotaxy.

2I-4 Taxonomic results

Family Teneriffiidae Thor, 1911

Genus *Austroteneriffiia* Womersley, 1935

***Austroteneriffia sunthorni* n. sp.**

(Figs 1-3)

Diagnosis. With characters of the genus *Austroteneriffia* (cf. Judson 1995) and a combination of following characters: female with body length 1080–1102, palpal oncophysis present, prodorsal shield with distinct pores, seta *c2* long reaching the level of setal row *e*, setation of trochanters 1-2-2-2, basifemora 5-6-5-5, telofemora 5-5-5-5, genua 7(1)-7(1)-6(1)-6(1), genual solenidion situated distal to the middle of the segment, ovipositor with grass-shaped seta (*eug 2*).

Description. *Female*. Body length (including gnathosoma, n = 3) 1071 (1080-1102), width 570 (550-600). Peritremes (Fig. 1A) typical, with about 30 rows of elongate alveoli. *Gnathosoma*. Typical for genus (cf. Judson 1995); chelicerae 208.3 (200-215) long, *cha* 40 (30-45) long *chb* 58 (50-75) long; palp not distinctive, similar to that of *A. hirsti*, palpfemur about 100 long, palpal oncophysis about 20 long. Subcapitulum 220 (210-225) long, 250 (225-275) wide, seta *n* about 40 long, *m* about 65 long; *or1-2* about 10-15 long, thickened and truncated with strong longitudinal ridges; supracoxal seta *ep* short rod-like.

Idiosoma. In dorsal view (Fig. 1A), naso broad, slightly projecting; prodorsal shield, smooth, about 318 (310-330) long, with distinct pores; trichobothrium *vi* with short barbs similar to normal setae, trichobothrium *sci* with well developed cilia, its bothridium rosette with about 20 vesicles; setal length: *vi* 89.2 (85-95), *ve* 110, *sci* 140, *sce* 155 (140-160), distributed as illustrated. Anterior pair of lateral eyes subequal to posterior pair. Hysterosomal setae with microsclerites; *c2* long, posteriorly reaching setal row *e*; setal length: *c1* 79.2 (70-80), *c2* 268.3 (250-280), *d1* 115 (100-125), *e1* 108.3 (100-115), *f1* 132.5 (125-140) *h1* 118.3 (100-130), *h2* 87.5 (75-100), *ps1* 59.16 (55-65), *ps2* 55.8 (50-60), *ps3* 52.5 (50-55); lyrifissures *ia*, *im*, *ip*, *ih* normal. In ventral view, coxal setation 4-3-4-3 (excluding *4a* on membrane); with 5 pairs of aggenital setae, about 30-50 long; genital valves with 6 pairs of genital setae, smooth, about 20-25 long; progenital chamber with normal 3 pairs of genital papillae and associated setae *k1-3* (Fig. 1D); ovipositor (Fig. 1E) with 4 pairs of eugenital setae (*eug1-4*), *eug 1* and *3* with minute subapical tooth, *eug 4* forked, *eug 3* grass-shaped (with 5-7 branches).

Legs. Leg I-IV setation (tibial famulus *k*, trichobothrium included; solenidia in parenthesis): trochanters 1-2-2-2, basifemora 5-6-5-5, telofemora 5-5-5-5, genua 7(1)-7(1)-6(1)-6(1), tibiae 15(1)-14(1)-4(1)-14(1), tarsi 27(2)-27(1)-16+7-16+6; pretarsi normal. Solenidion σ on genua I-IV located distal to middle of segment and lateral to seta *d* (Fig. 2); seta *k* absent on genu I. Lengths of leg segments (trochanter, TR; basifemur, BF; telofemur, TB; genu, GE; tibia, TI; tarsi, TA):

I – TR 100(90-110), BF 100, TF 80(75-90), GE 83.3(75-92), TI 128.3(125-130), TA 166.6(160-175);

II – TR 100, BF 91.7(75-100), TF 71.6(65-75), GE 90(80-100), TI 131.7(130-135), TA 146.7(140-150);

III – TR 108.3(100-115), BF 95(85-100), TF 90, GE 91.7(85-100), TI 146.7(140-150), TA 230(210-250);

IV – TR 133.3(125-150), BF 100(75-125), TF 106.6(100-110), GE 110(105-115), TI 181.67(175-190), TA 285(275-330).

Male. Body length (including gnathosoma, n = 1) 980, width 555. Similar to female except for having genitalia (Fig. 3). Genitalia with 10 eugenital setae: most setae similar to those in *A. hirsti* (cf. Judson 1995) except seta *6* with multi- branches and seta *8* with two rami.

Material examined. Holotype (female): THAILAND, Kanchanaburi Prov., Thong Pha Phoom Dist., Hui Kayeng Sub-dist, Huai Pakkok and Pong Pu Ron areas (14°39'1.71"N, 98°31'25.72"E), ex. moss on logs (hand collecting), coll. M. Fuangarworn (fiels no. MF2014-32), 9 May 2014. Paratypes (7 females) with same data as holotype. *Other material examined*: 3 females, 1 male, Chiang Mai Prov., Doi Saket Dist., Mae Pong Sub-dist., Huai Hong Krai, Nature trail, ex. forest floor (hand collecting), coll. M. Fuangarworn, 9 March 2008. One female, 1 male, Chonburi Prov., Sattahip Dist., Chuang Island (12°31'46.28"N, 100°57'20.07"E), ex. soil and litter under Tamarind tree near beach, coll. M. Fuangarworn (field no. MF2010-17), 20 March 2010. Five females, Chonburi Prov., Sattahip Dist., Kham Island (12°34'34.97"N, 100°56'6.22"E), ex. accumulated leaf litter on rock near beach (hand collecting), coll. M. Fuangarworn (field no. MF2013-31), 1 June 2013. Three females, 3 males, Kanchanaburi Prov., Sai Yok Dist., Ban Khao Wang Khamen, (14°24'47.86"N, 98°51'44.69"E), ex. soil and litter, coll. M. Fuangarworn (field no. MF2010-4), 20 February 2010. Two females, Kanchanaburi Prov., Sai Yok Dist., Ban Khao Wang Khamen, near Tham (cave) Manaopee (14°21'08"N, 98°56'17"E), ex. forest floor (hand collecting), coll. M. Fuangarworn, 22 April 2014. Five females, 5 males, Kanchanaburi Prov., Sai Yok Dist., Ban Khao Wang Khamen, near Tham (cave) Pra (14°24'35.77"N, 98°51'11.85"E), ex. on stones and forest floor (hand collecting), coll. M. Fuangarworn (field no. MF2013-6), 23 April 2013. Five females, 5 males, Kanchanaburi Prov., Sai Yok Dist., Ban Khao Wang Khamen, (14°24'47.86"N, 98°51'44.69"E), ex. on rock outcrops and forest floor (hand collecting), coll. M. Fuangarworn (field no. MF2013-7), 23 April 2013. Three females, Kanchanaburi Prov., Sai Yok Dist., Ban Khao Wang Khamen, near Tham (cave) Thepnimit (14°24'7.38"N, 98°52'17.54"E), ex. forest floor (hand collecting), coll. M. Fuangarworn (field no. MF2013-9), 23 April 2013. Five females, Krabi Prov., Ko Lanta Dist., Ko Rok (7°12'37.74"N, 99°3'55.45"E), ex. rhizomes of epiphytes on rocks near beach, coll. M. Fuangarworn (field no. MF2013-17), 3 May 2013. One female, 1 male, Pang Nga Prov., Thai Mueang Dist., Thai Mueang Beach (8°29'43.06"N, 98°13'23.17"E), ex. bark of *Casuarina* near beach, coll. M. Fuangarworn, April 2008. Two females, 3 males, Saraburi Prov., Kaeng Khoi Dist., Chulalongkorn University Forest Reserve (14°31'33.53"N, 101° 1'40.79"E), ex. forest floor (hand collecting), coll. M. Fuangarworn, 3 January 2012. Three females, Satun Prov., La Ngoo Dist., small island east of Tarutao Island (6°38'33.02"N, 91°41'39.17"E), ex. bark of unknown tree in beach, coll. M. Fuangarworn (field no. MF2010-17), 7 April 2008. Two females, Tak Prov., Sam Ngao Dist.,, Bhumibol Dam (17°14'46.87"N, 98°59'45.66"E), ex. litter under logs and forest floor (hand collecting), coll. M. Fuangarworn (field no. MF2008-6), 9 March 2008. All materials deposited in the Acarology Collection at the Chulalongkorn University Museum of Natural History, Bangkok, Thailand.

Etymology. Named after the senior author's father.

Distribution. Thailand (Provincial records: Chiang Mai, Chonburi, Kanchanaburi, Krabi, Pang Nga, Saraburi, Satun, Tak).

2I-5 Discussion

The new species is most similar to *Austroteneriffiia hirsti* Womersley, 1935 from Australia in having the telofemoral setation of 5-5-5-5, one solenidion on genu IV, and all genual solenidia positioned distally to the middle of the segment. However, female of the new species differs from that of *A. hirsti* in having six setae on basifemur I (vs. 5), 14 setae on tibia IV (vs. 13), the ovipositor with grass-shaped eugenital setae (*eug 2*) (vs. with short barbs). Male genitalia of the new species also differs from that of *A. hirsti* in that setae *6* is strongly multi-branched (vs. setiform) and seta *8* has 2 rami (vs. 1). Comparisons of leg setations of all *Austroteneriffiia* species are given in Table 2.

Based on the collection data, *Austroteneriffia sunthorni* **n. sp.**, has a wide distribution in Thailand. It occurs in both the seashore habitat, where it was collected from rocks and bark in the beaches, and in the inland parts of the country, where it was collected from rocks, soil and litter in deciduous forests. This species is abundance during dry season (per. obs.).

A new combination, *Austroteneriffia yunnanensis* (Luo *et al.*, 1997) **n. comb.**, is proposed as it is clear from the original description of *Neoteneriffiola yunnanensis* Luo *et al*., 1997 that it belongs to the genus *Austroteneriffia* (diagnosis given by Judson 1995).

Key to species of *Austrotenerifiia* (modified from Judson (1995) and based on original descriptions and redescriptions)

1. Palpal oncophysis absent …………………………………………………….... 2
- Palpal oncophysis present …………………………………………………….. 4

2. Prodorsal sclerite well defined …………………………………………………... 3
- Prodorsal sclerite poorly define …………………..... *A. littorina* Shiba & Furukawa
3. Basifemur I with 4 setae, telofemur III-IV with formula 3-4 ……………................
……………………………………………….. *A. kamalii* Ueckermann & Khanjani
- Basifemur I with 5 setae, telofemur III-IV with formula 4-3 ……………………....
…………………………………………………….. *A. zamaniani* Khanjani *et al.*
4. Genua IV with a solenidion …………………………………………………..... 5
- Genua IV without a solenidion …………………………………………….... 7
5. Basifemur III-IV with 5 setae; telofemur III-IV with 5 setae; famulus *k* absent on genu I …………………………………………………………………….... 6
- Basifemur III-IV with formula 3(or 4)-2; telofemur III-IV with 4 setae; famulus *k* present on genu I ………………………………………………….. *A. leei* Judson
6. Basifemur II with 5 setae; tibia IV with 13 setae, tarsi I-II with formula 26(2)-26(2); eugenital seta *2* on ovipositor with few barbs ………………... *A. hirsti* Womersley
- Basifemur II with 6 setae; tibia IV with 14 setae, tarsi I-II with formula 27(2)-27(2); eugenital seta *2* on ovipositor grass-shaped …………………..... *A. sunthorni* **n. sp.**
7. Trochanter formula 1-2-2-2 8
- Trochanter formula 1-3-2-2 ..... (*A. japonica* Ehara) or 1-2-2-3... (*A. shiraziensis* Khanjani *et al*.)
8. Basifemur III-IV with 5 setae 9
- Basifemur III-IV with less than 5 setae (with formulas 4-3 or 4-4) 10
9. Genual formula 7-8-6-6; tibial formula 15-15-15-15; subcapitular seta *n* smooth .... *A. yunnanensis* (Luo *et al*.) **n. comb.**
- Genual formula 8-8-8-8; tibial formula 14-13-13-13; subcapitular seta *n* barbed ….. …………………………………………………….. *A. tadjikistanica* (Wainstein)
10. Basifemur III-IV with formula 4-3; telofemur with formula 5-5 .... *A. hojoensis* (Shiba & Furukawa)
- Basifemur III-IV with formula 4-4; telofemur with formula 4-4 …………………………..………………..... *A. khorramabadiensis* Khanjani *et al*.

Table 1. Checklist of world species of Teneriffiidae. *Note*. Synonymies made by McDaniel *et al.* (1976) were rejected pending for the study of the suitable type materials, e.g. holotype, paratype or neotype.

1) *Teneriffia* Thor, 1911

- *T. quadripapillata* Thor, 1911 (Spain)
- *T. mexicana* Mcdaniel *et al*., 1976 (Mexico)

2) *Parateneriffia* Thor, 1911

- *P. bipectinata* Thor, 1911 (Paraguay)

3) *Neoteneriffiola* Hirst, 1924

- *N. luxoriensis* Hirst, 1924 (Egypt)
- *N. uta* Tibbetts 1958 (USA)
- *N. coineaui* Judson, 1994 (Namibia)
- *N. xelophila* Bernardi *et al*., 2012 (Brazil)

4) *Heteroteneriffia* Hirst, 1925

- *H. marina* Hirst, 1925 (Malaysia)
- *H. tokiokai* Ehara, 1965 (Japan)
- *H. mortoni* Luxton, 1992 (China)

5) *Mesoteneriffia* Irk, 1935

- *M. steinboecki* Irk, 1935 (Germany)

6) *Mesoteneriffiola* Schmölzer, 1956

- *M. alpina* Schmölzer, 1956 (Germany?)

7) *Himalteneriffia* Schmölzer, 2002

- *H. riccabonai* Schmölzer, 2002 (India)

8) *Sioteneriffia* Yin *et al*., 1994

- *S. nuda* Yin *et al*., 1994 (China)
- *S. kunmingensis* Luo *et al*., 1996 (China)

9) *Austroteneriffia* Womersley, 1935

- *A. hirsti* Womersley, 1935 (Australia)
- *A. littorina* Shiba & Furukawa, 1975 (Japan)
- *A. leei* Judson, 1995 (Australia)
- *A. tadjikistanica* (Wainstein, 1969) (Tadjikistan)
- *A. kamalii* Ueckermann & Khanjani, 2002 (Iran)
- *A. shiraziensis* Khanjani *et al*., 2013 (Iran)
- *A. yunnanensis* (Luo *et al*., 1997) **n. comb.** (China)
- *A. zamaniani* Khanjani *et al*., 2011 (Iran)
- *A. hojoensis* (Shiba & Furukawa, 1975) (Japan)
- *A. japonica* (Ehara, 1965) (Japan)
- *A. khorramabadiensis* Khanjani *et al*., 2014 (Iran)
- *A. sunthorni* **n. sp.** (Thailand)

Table 2. Leg setal formulas of 12 species in *Austroteneriffia*; tibial famulus *k* and trichobotrium on tarsi III-IV included; solenidial formulas in square brackets.

	Sex	Trochanter	Basifemur	Telefemur	Genu	Tibia	Tarsi I-II and basitarsi III-IV	Telotarsi III-IV
A. hirsti Womersley, 1935	M, F	1-2-2-2	5-5-5-5	5-5-5-5	7-7-6-6 [1-1-1-1]	15-14-14-13 [1-1-1-1]	26-26-16-16 [2-2-1-1]	7-7/8
A. hojoensis (Shiba & Furukawa, 1975)	F	1-2-2-2	5-6-4-3	5-5-5-5	7-7-6-6 [1-1-1-0]	15-14-13-14 [1-1-1-1]	26-26-16-15 [2-2-1-1]	7-6
A. japonica (Ehara, 1965)	M	1-3-2-2	5-6-4-3/4/5	5-5-5-5	7-7-6-6 [1-1-0-0]	15-13/14-13/14-12/13/14 [1-1-1-1]	26/27-27/28-15/16-13/14/15 [2-2-1-1]	7-6/7
A. kamalii Ueckermann, & Khanjani, 2002	M, F	1-2-2-2	4-4-3-3	4-3-3-4	7-5$_F$/6$_M$-5-4/5 [1$_F$/0$_M$-1-1-0]	13-10$_F$/9$_M$-9-9 [1-1-1-1]	25$_F$/26$_M$-21-18$_F$/17$_M$-18/19 [2-2-1$_F$/0$_M$-1]	Not separately counted
A. khorramabadiensis Khanjani *et al.*, 2014	F, M	1-2-2-2	5-6-4-4	5-5-4-4	8-7-7-7 [1-1-1-0]	13-12-12-12 [1-1-1-3$_F$/1$_M$]	27-27-18-16 [3-3$_F$/2$_M$-0-2]	8-8
A. leei Judson, 1995	M, F	1-2-2-2	4-5-3/4-2	4/5-3/4-4-4	7/8-6-5-4 [1-1-1-1]	12/13-9/10/11-9/10-9/10 [1-1-1-1]	26/17-27/28-13/14-14/15 [2-2-1-1]	7-8
A. littorina (Shiba & Furukawa, 1975)	M, F	1-2-2-2	4-5-3-2	5-5-4-4	7-7-6-5 [1-1-1-0]	13-13-12-12 1-1-1-1]	?-?-16-15 [?-?-?-?]	7-6
A. shiraziensis Khanjani *et al.*, 2013	F, M	1-2-2-3	5-6-4-4$_F$/3$_M$	5-5-4-4	7-7-6-6 [1-1-1-0]	13-12-12-12 [1-1-1-3$_{F\&M}$/2$_M$]	27-27-16-16 [3-3-2-2]	9-8
A. tadjikistanica Wainstein, 1969		1-2-2-2	5-6-5-5	5-5-5-5	8-8-8-8 (incl. solenidia?)	14-13-13-13 (incl. solenidia)	29-28-15-15 (incl. solenidia)	7-6
A. sunthorni **n. sp.**	F, M	1-2-2-2	5-6-5-5	5-5-5-5	7-7-6-6 [1-1-1-1]	15-14-14-14 [1-1-1-1]	27-27-16-16 [2-2-1-1]	7-6
A. yunnanensis (Luo *et al.*, 1997)	M	1-2-2-2	5-6-5-5	5-5-5-5	7-8-6-6 [0-0-0-0]?	15-15-15-15	26-25-16-15	7-6
A. zamaniani Khanjani *et al.*, 2011	F	1-2-2-2	5-4-3-3	4-3-4-3	7-5-5-5 [1-1-1-0]	12-9-9-9 [1-1-1-1]	21-19-9-10 [1-1-1-1]	7-6

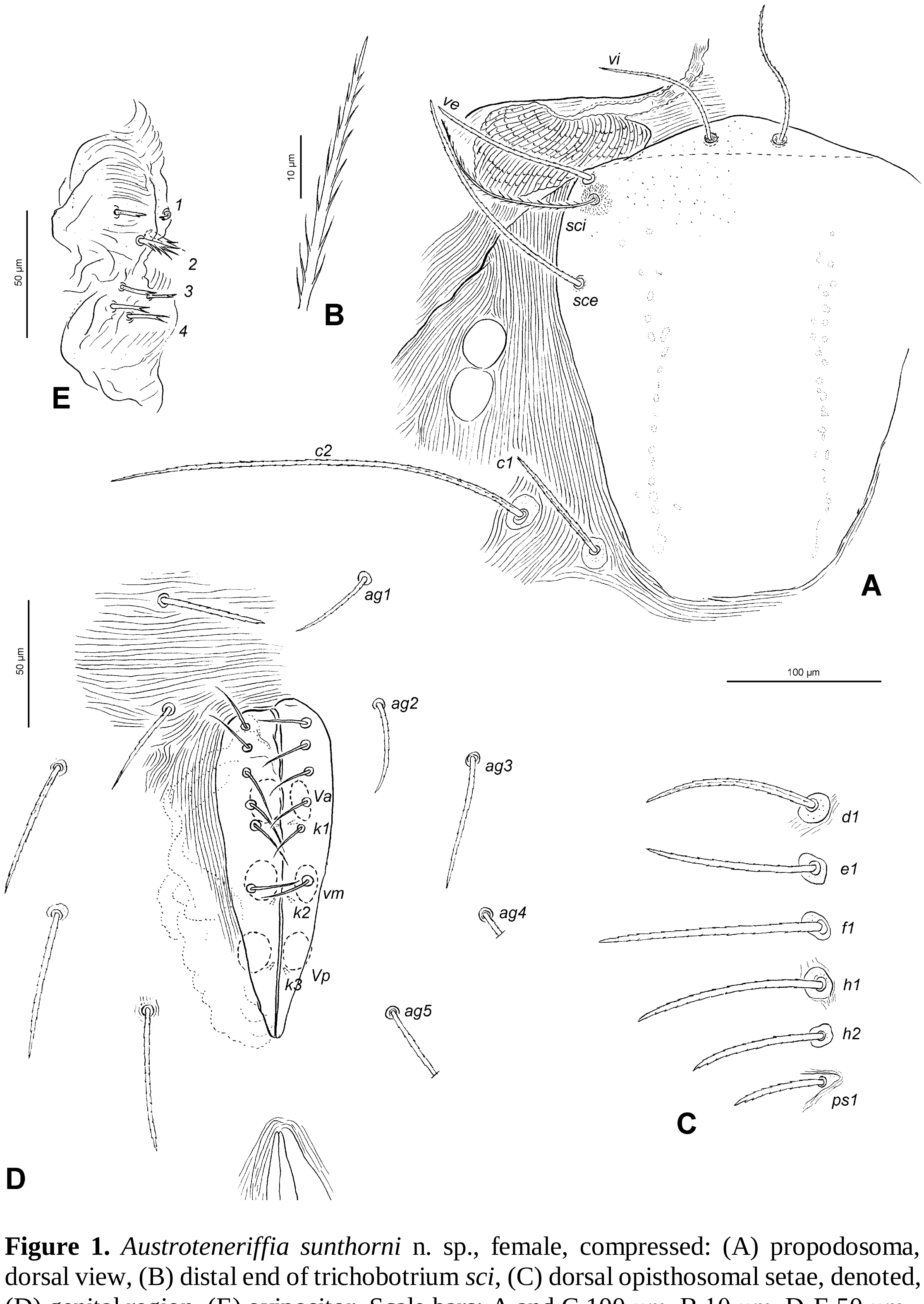

Figure 1. *Austroteneriffia sunthorni* n. sp., female, compressed: (A) propodosoma, dorsal view, (B) distal end of trichobotrium *sci*, (C) dorsal opisthosomal setae, denoted, (D) genital region, (E) ovipositor. Scale bars: A and C 100 µm, B 10 µm, D-E 50 µm.

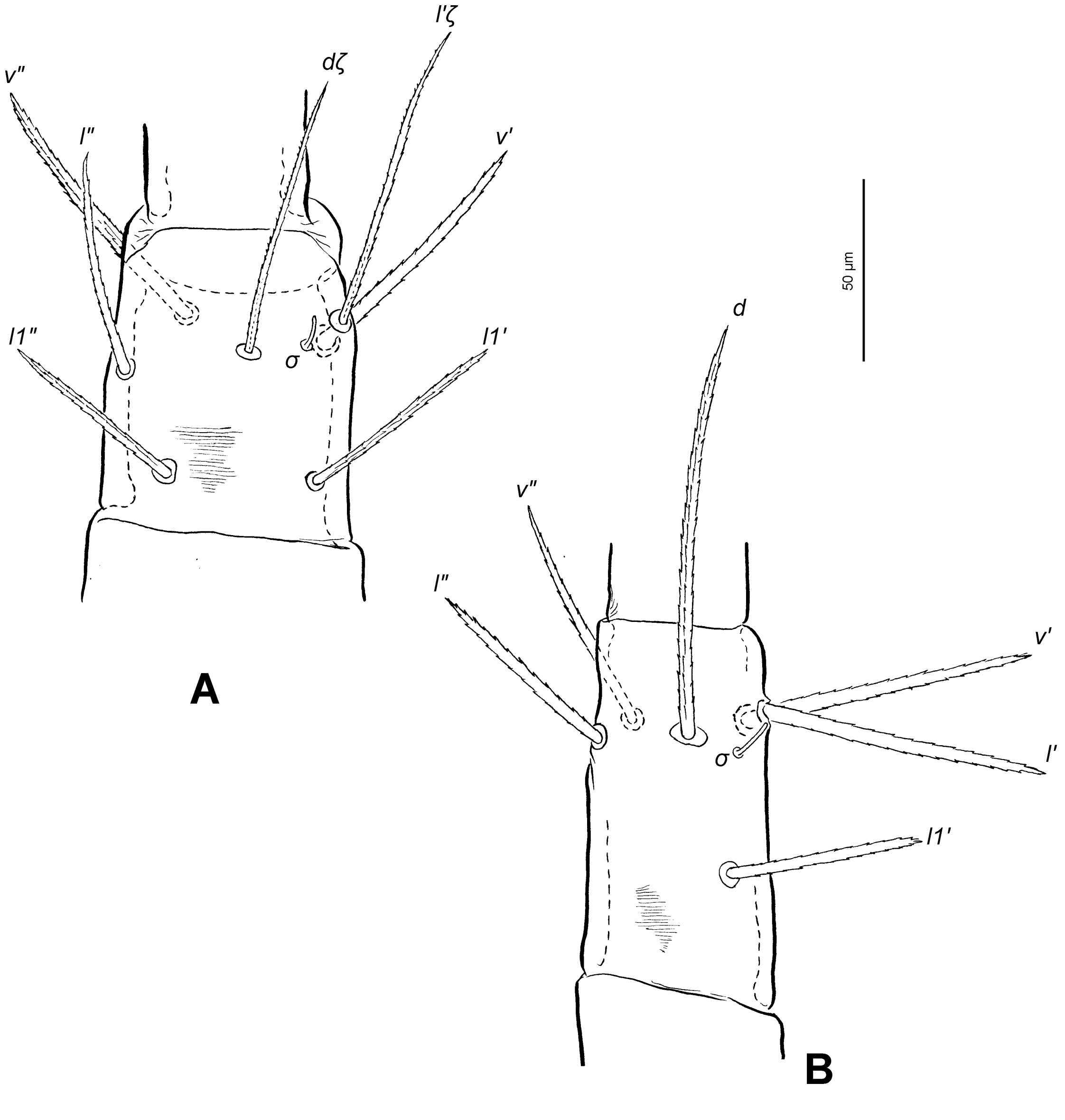

Figure 2. *Austroteneriffia sunthorni* n. sp., female: (A) genu I, dorsal view, (B) genu IV, dorsal view. Scale bar: 50 µm.

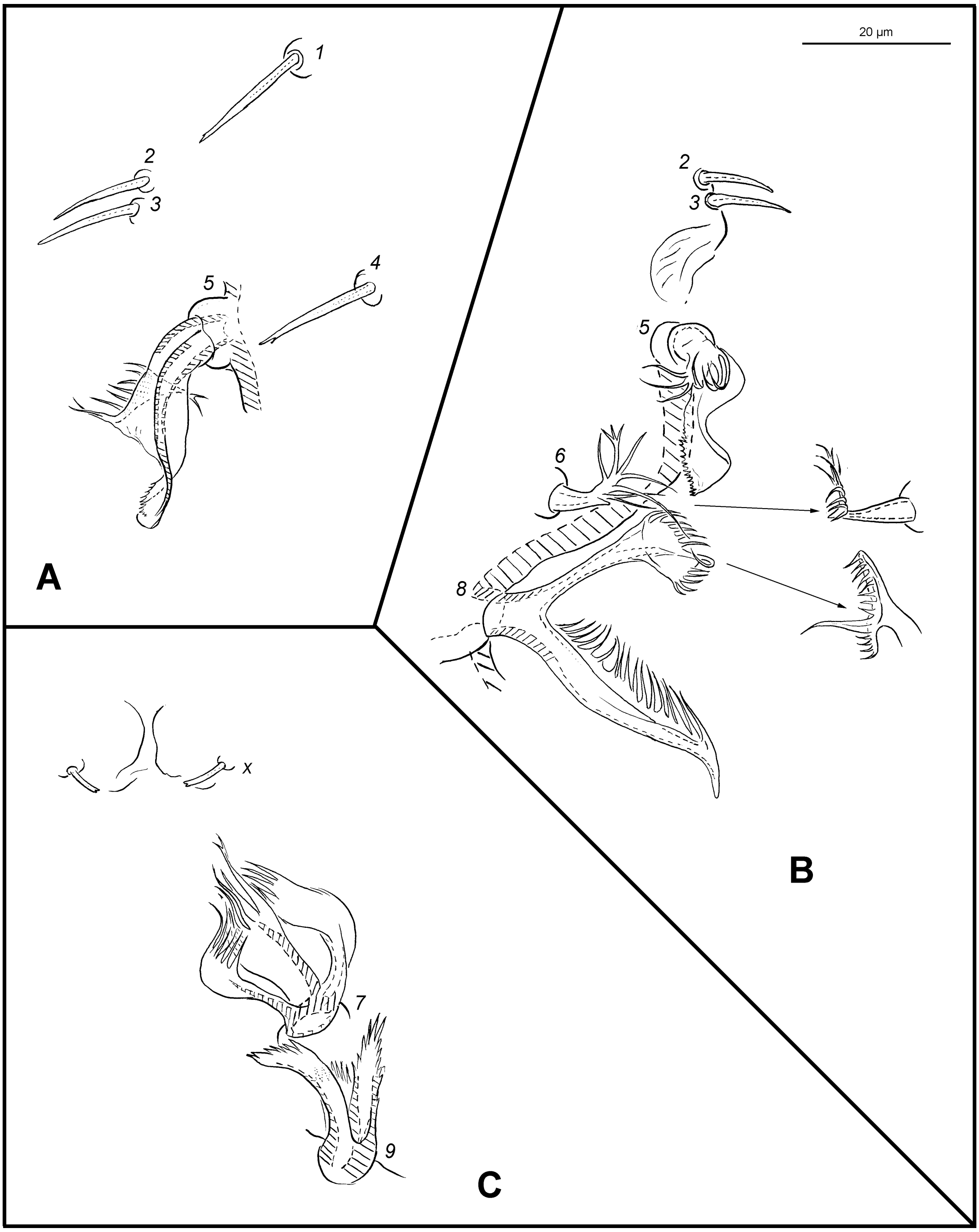

Figure 3. *Austroteneriffia sunthorni* n. sp., male: (A) eugenital setae *1-5*, drawn in place, later view, (B) setae *2, 3, 5, 6* and *8*, drawn in place, ventral view, inserts showing seta *6* and anterior ramus of seta *8* in lateral view, (C) setae *7, 9* and *x*, drawn in place, ventral view. Scale bar: 20 µm.

CHAPTER 3

A PHYLOGENETICS ANALYSIS OF THE ANYSTAEN FAMILIES (TROMBIDIFORMES, ANYSTINA, ANYSTAE) BASED ON MORPHOLOGICAL CHARACTERS

3.1 Abstract

Mites in the hyporder Anystae currently comprises 10 families and 5 superfamilies. The phylogenetic analysis including representatives from all anystaen families was conducted for the first time, based on morphological characters, to assess the higher-level (interfamilial) relationships within the Anystae. The results show incongruence with the previous studies concerning relationships within this group. All families are recovered as a monophyletic group but deeper relationships are ambiguous, due to changes in parameters (i.e., additivity), but additivity increases clade support. Anystae was retrieved as para- or polyphyletic group in all analyses, and the family Pseudocheylidae is often a sister group to the Eleutherengona. The superfamilial groupings (Anystoidea and Paratydeoidea) in the classification by Walter *et al.* (2009) are not monophyletic. Chulacaridae dose also not belong to the superfamily Anystoidea as previous thought (Fuangarworn *et al.* 2016) but is recovered as a sister taxon of Paratydeidae + ((Stigmocheylidae + Pomerantziidae) + (Pseudocheylidae + Eleutherengona)) in the preferred tree.

3.2 Introduction

Mites of the order Acariformes have long been recognized as a natural group by most acarologists (O'Connor 1982; Miranov & Bochkov 2009), however, the relationships among the higher taxa within the Acariformes have been the subject of much controversy. The higher-level phylogeny of the Acariformes was recently reviewed by Miranov and Bochkov (2009). Within its subgroup Prostigmata, one of the main unresolved problems is the phylogeny of the hyporder Anystae Krantz, 1978 and its members. The higher-level relationship within the Prostigmata in phylogenetic (cladistics) context was firstly proposed by Lindquist (1976) but not enough to illustrate the relationships of all anystaen families. Lindquist's hypothesis was later modified by Krantz (1978) and Kethley (1982) in the form of classifications, in which Anystae comprises 9 families (in parenthesis) grouped in 5 superfamilies: Anystoidea (Adamystidae, Anystidae, Teneriffiidae, Pseudocheylidae); Caeculoidea (Caeculidae); Paratydeoidea (Paratydeidae, Stigmocheylidae); Pomorantzioidae (Pomerantziidae) and Pterygosomatoidea (Pterygosomatidae).

Later, Kethley (in Norton *et al.* 1993) presented the phylogentic tree of the Prostigmata but did not provide any discussion of the characters used. According to his tree (Fig. 1), five families previously placed in the Anystae—Pseudocheylidae, Paratydeidae, Stigmocheylidae, Pomerantziidae, Pterygosomatidae—belonged to the non-anystaen clade, Eleutherengona, and the relationships within Anystae (Anystina) were as follow: (Adamytidae ((Anystidae–Parasitegona) + (Teneriffiidae–Caeculidae)). Lindquist (1996) also presented the phylogeny of the Prostigmata which similar to Kethley's hypothesis in many aspects, except the early branching patterns (Fig. 2).

The most recent classification of Anystae was proposed by Walter *et al.* (2009) and Zhang *et al.* (2011) who recognize 8 families and 5 superfamilies: Caeculoidea (Caeculidae), Adamystoidea (Adamystidae), Anystoidea (Anystidae, Teneriffiidae, and Pseudocheylidae), Paratydeoidea (Paratydeidae, Stigmocheylidae) and Pomerantzioidea (Pomerantziidae), note that Pterygosomatidae had been removed. Recently, Pepato and Klimov (2015), based on the molecular analysis, suggested that the Anystidae is not monophyletic and elevated one of the two anystid subfamilies, Erythracarinae, to familial rank. One additional family, Chulacaridae, was also described in this study (Chapter 2C; Fuangarworn *et al.* 2016) bringing anystaen families to total number of 10.

There is no special study devoted to the phylogeny of Anystae. Several morphology-based studies included only selected families in their analyses. Welbourn (1991) studied the phylogeny of the Parasitegona—a group with highly specialized life cycle and considered as a sister group of Anystae—and used the family Anystidae as an outgroup. Otto (2000) investigated the cladistic relationships of the anystid subfamily Erythracarinae, and suggested a close relationship between this subfamily and Teneriffiidae. Bochkov *et al.* (2008) analyzed the systematic position of the non-anystaen family Myobiidae and used anystaen families Anystidae, Pomerantziidae and Paratydeidae as the outgroups. The molecular phylogenetic studies of mites have been increased in a recent decade, but only Söller *et al.* (2001), Pepato *et al.* (2010), Dabert *et al.* (2010) and Pepato and Klimov (2015) included selected representatives from Anystae in their analyses. Therefore, the phylogenetic relationships within Anystae remain mysterious. Although the existing hypothesis on the classifications the hyporder Anystae was not been originally proposed cladistically, we can treat them as such and test it using a cladistic method.

This study aims to assess the higher-level relationship within the hypoder Anystae, particularly at the interfamilial level. The specific goals are to test the current classification of Walter *et al.* (2009) and to determine systematic position of the recent new family, Chulacaridae.

3.3 Materials and methods

Taxon sampling

The detailed analysis of all anystaen species is beyond the scope of this study. Only selected members of the anystaens are sampled from each family, primarily based on the cladogram by Lindquist (Fig. 2) and the recent classification of the Anystae by Walter *et al.* (2009). They are species in the type genus except for Paratydeidae and Teneriffiidae, whose neither specimens nor sufficient descriptions of any species (including type species) of type genera are available. Additional terminal taxa are species of another genera of respective family found in Thailand. In addition, based on the cladogram by Kethey (Fig. 1) who showed that some Anystaen families are allied to Eleutherengona, the selected members of Eleutherengona are also included to test Kethley's hypothesis. These Eleutherengona taxa and characters are extracted from Bochkov *et al.* (2008). Two species in the infraorder Eupodina are selected as the outgroups. The Parasitegona (or Parasitegonae) is excluded from the analysis. This highly speciose group is generally accepted as monophyletic in having alternative parasitic larval stage and free living post-larval stage although its relative position, as a group, is still unclear. Their bodies and appendages are extremely hypertricous such that several characters are obscured and coding of most characters is questionable. In total, there are 33 ingroup and 2 outgroup species (Table 1).

Morphological characters

A total of 119 morphological characters were defined. Of these, 104 characters are based on adult females, 2 on males, and 4 on the immature stages. They were coded either by observations of the slide-mounted specimens housed in the Acarology collection of the Chulalongkorn University Museum of Natural History, or from the literatures (Table 1). Seventy-nine characters are binary and 40 are multistate. The lists of the characters and the data matrix are given in the Appendix 1 and 2, respectively.

Phylogenetic analysis

Since several characters, especially the number of setae on the given structures, exhibit varying states in logically sequences and may be considered as evolutionary progression, the following 19 characters were treated as ordered (additive): 7, 11, 17, 21, 23, 31, 35, 36, 37, 38, 39, 40, 41, 61, 62, 63, 64, 65, and 66. The parsimonious analyses were performed using TNT (Goloboff *et al.* 2008) both in equally weighting and implied weighting schemes. In the implied weighting analysis, the concavity constant (k) were varyingly set (1-10, 12, 15, and 20) to test the sensitivity or robustness of the trees. All analyses were conducted using the 'Traditional search' algorithms (with the following search strategies after holding 10000 trees in memory: 500 repetitions of random stepwise addition of taxa, holding 10 trees per replicate and performing the TBR swapping algorithm). Clade support was assessed using Jackknife values, as implemented in TNT. The consistency index (CI) and retention index (RI) were calculated in TNT using the macro script 'CharStats.run' (v. 1.3) made by Peterson L. Lopes (Universidade do Sau Paulo, Brasil), presented in Appendix 3. The separate analyses with all characters treated as unordered (non-additive) were also performed, in both equally weighting and implied weighting schemes, to assess the effect of exclusion of the hypotheses of evolutionary directions or additivity. Synapomophy lists generated using TNT are given in Appendices 4 and 5.

3.4 Results

Ordered and equally weighted analysis (OE)

The analysis with 19 characters treated as ordered and equally weighted (OE) resulted 12 most parsimonious trees (MPTs) with length of 439 steps; the strict consensus tree (L= 429; CI = 0.39; RI = 0.73) is present in Fig. 3. The monophyletic groups of each anystaen families were highly support but their deeper relationships were not fully resolved. Two major monophyletic clades were retrieved (with relative low support): the first clade (clade A) retrieved as Tenerriffiidae + (Adamystidae + (Erythracaridae + Anystidae), and the second clade (clade B) comprising Raphignathina, Heterostigmata and Pseudocheylidae (Fig. 3)

Ordered and Implied weighted analysis (OI)

The analyses with 19 characters treated as ordered and using implied weighting scheme (OI) resulted a single most parsimonious tree from each concavity (*k*) values. The statistical data of this tree are presented in Table 2. The trees recovered were topologically stable from *k* = 5-20 (Table 3). These trees are topologically similar to 1 of 12 MPTs from OE analysis and it is the tree from the analysis with *k* = 5 that is chosen as a preferred tree (Fig. 4) since it has highest average node support among these *k* values (Table 2); this tree is used as a working hypothesis of the relationships to be discussed below. Compared to the strict consensus tree from OE analysis, the 'OI' tree branched into two major clades, the first clade contains the clade A (node 57) which was consistently retrieved with moderately support and it is now sister to the family Caeculidae (although with relatively low support). In the second major clade, the clade B (node 39) was also consistently retrieved with moderately support and its sub-clades were resolved as Pseudocheylidae + (Heterostigmata + Raphignathina). The families Pomeranziidae and Stigmocheylidae formed a monophyletic group (with relatively low support) and are sister to the clade B (with relatively low support). They are successively sister to the families Paratydeidae and Chulacaridae (with relatively low support). Interestingly, the internal relationships within Heterostigmata + Raphignathina (togather known as Eleutherengona) is similar to that of Bochkov *et al.* (2008).

Unordered and equally weighted analysis (UE)

When all characters were treated as unordered (non additive), and equally weighted, the analysis resulted a single MPT (length = 429, CI = 0.43, RI = 0.73) which is presented in Fig. 5. The overall topology of this tree is remarkably different from those in OE and OI analyses. However, consistently retrieved was the Eleutherengona clade (Heterostigmata + Raphignathina; although the internal relationship within Raphignathina are different). The families Pomerantziidae, Stgimocheylidae and Pseudocheylidae formed a monophyletic group (with relatively low support) which is sister to the Eleutherengona. This group is then successively sister to the remaining anystaen families (Fig. 5) with relatively low support.

Unordered and implied weighting analysis (UI)

The unordered and implied analyses yielded a single MPT from each concavity values (Table 2). The trees recovered are topologically stable from k = 3-20 (Table 4). The tree recovered from the analysis with k = 5 is presented in Fig. 6. Most relationships are consistent to the tree from the UE analysis but four families namely Stigmocheylidae, Paratydeidae, Pomerantziidae, and Pseudocheylidae change their relative positions. Note that the family Pseudocheylidae is now sister to the Eleutherengona (with moderate support), hence similar to the results from the OE and OI analyses (Figs 3, 4).

3.5 Discussion

Effect of additivity and monophyly of Anystae

The monophyly of each anystaen families is highly support, but their deep relationships are not stable primarily due to the additivity (of 19 characters in ‘ordered’ analysis), especially the relative positions of Caeculidae, Teneriffiidae Adamystidae Anystidae and Erythracaridae, in the clade A (Fig. 4 compared to Fig 6), and three other anystaen families namely Paratydeidae, Stigmocheylidae, and pomerantziidae, in the clade sister to the clade A (Fig. 4, compared to Fig. 6). Only the families Pseudocheylidae and Chulacaridae survive from changes of the parameter of additivity. Pseudocheylidae is a sister group to the Eleutherengona (forming the clade B, with moderately support) by sharing two unique characters [i.e. the absence of genital papillae (#58-1), and genital opening delayed in protonymph (118-1)] and two homoplasctic characters [i.e. palptarsus strongly reduced or apparently diffused into tibia (19-2), and larva without Claparede's organ (115-1)]. Chulacaridae is topologically basal to Paratydeidae + ((Pomerantziidae+Stigmocheylidae) + clade B) (Figs 4 and 6); with relative low support, they share three homoplastic characters [i.e. palptarsus reduced or small but distinct (19-1), four pairs of aggenital setae (62-3), and tasus II with 1 solenidion (99-1)]. Clearly in all analyses, Anystae was retrieved as paraphyletic.

The higher relationship within the Eleutherengona (i.e. between Heterostigmata and Raphignathina) is highly stable, not sensitive to the parameter changes, i.e. additivity and weighting schemes. This is congruent with the mostly accepted current classification (Walter *et al.* 2009, Zhang *et al.* 2011) and the cladistic analysis by Bochkov *et al.* (2008). The relationships within Raphignathina are affected by additivity but not weighting schemes (equal or implied weighting), however, our (ordered) analysis with additivity results the same relationships as studied by Bochkov *et al.* (2008) although they used a different data set.

Comparisons with previous hypotheses

Compared with Kethley's (1993) cladogram (Fig. 1), our analyses recovered the similar positions of only three families, namely Pseudocheylidae, Stigmocheylidae and Pomerantziidae in that they allied to taxa among Eleutherengona, although the specific topologies are different (Fig. 1 vs. 4). As mentioned above, Kethley's (1993) cladogram lacks character arguments, thus it limits further discussion.

Compared with the classification by Walter *et al.* (2009), our analyses did not support the monophyly of any (non-monobasic) superfamilial groupings in their classification. The superfamily Paratydeoidea which, according to Walter *et al.* (2009), includes Paratydeidae and Stgimocheylidae by sharing an elongated body form is retrieved as a paraphyletic group with respect to the family Pomerantziidae (Fig. 4). In our analysis, Pomerantziidae is a sister group to the Stigmocheylidae (although with relatively low support) by sharing three homoplasctic characters [i.e. coxa II with 4 setae (64-3), empodium II absent (86-1), and empodium III-IV absent (88-1)]. The superfamily Anystoidea, which includes Anystidae, Teneriffiidae, Pseudocheylidae in Walter *et al*. (2009), is para- or polyphyletic in our analysis (Fig. 4). Pseudocheylidae is sister to Eleutherengona as mentioned above.

Anystidae is a sister group to the Erythracaridae, formerly treated as one of the two subfamilies of Anystidae (Pepato & Klimov 2005), and successively to Adamystidae, and Teneriffiidae, with moderately or highly support. They (node 57) share six homoplasctic characters [i.e. coxa II with 3 setae (64-2), pretarsal claws II pectinate (81-2), pretarsal claws III-IV pectinate (83-2) solenidion on genu II present (91-0), solenidion on genu IV present (93-1), and Claparede's organs in larva located laterally (117-1)]. The previous groupings have rather been based on overall similarity, and Walter *et al*. (2009) themselves aware that their classification is tentative. However, the result from our OI analysis is not consistent with the molecular analysis by Pepato and Klimov (2015) whose results retrieved Anystidae (=Anystinae) and Erythracaridae (=Erytracarinae) as a non-sister clade.

Position of Chulacaridae

The position of Chulacaridae in the present analyses is not support the previous hypothesis that this family is closely related to Teneriffiidae (Fuangarworn *et al.* 2016). The two families were thought to uniquely share the presence of the thick and truncated adoral setae (Character 9-1), and the presence of 'cheliceral stylet' (character 4-1) but these characters are now proven to be independently derived in the present analysis. In the OI and UI analyses, Chualcaridae was retrived as a sister group of clade 41 (Figs 4 and 6), sharing three homoplastic characters [i.e. palptarsus reduced or small but distinct (19-1), four pairs of aggenital setae (62-3), and tasus II with 1 solenidion (99-1)]. Although with relative low support, establishment of the new family seem justified, something which also emphasizes its distinctiveness (Chapter 2C).

3.6 Conclusion

This is the first study to include all anystaen families in a morphological-based phylogenetic analysis. The results show incongruence with the previous studies concerning relationships within the hyporder Anystae (both in forms of classifications and published cladograms). All families are recovered as a monophyletic group but deeper relationships are ambiguous, due to changes in parameters (i.e additivity), but additivity increases clade support. Anystae was retrieved as para- or polyphyletic group in all analyses, and the family Pseudocheylidae is often a sister group to the Eleutherengona. The superfamilial groupings (Anystoidea and Paratydeoidea) in the classification by Walter *et al.* (2009) are not monophyletic. Chulacaridae does also not belong to the superfamily Anystoidea as previous thought (Chapter 2C; Fuangarworn *et al.* 2016) but is recovered as a sister taxon of Paratydeida + ((Stigmocheylidae + Pomerantziidae) + (Pseudocheylidae+Eleutherengona)) in the preferred tree (Fig. 4). In term of classification, however, it would be premature to propose any classificatory or nomenclatural changes for mites in the hyporder Anystae. It should be noted that this work is intended as a preliminary hypothesis to be tested in the more comprehensive analysis in a future by the inclusion of additional morphological characters (including that of juvenile stages), additional exemplar species, and other sources of data (e.g., molecular characters).

Table 1. List of taxa, their representatives and data source used in the cladistic analyses.

Taxa	Representatives	Sources
Outgroup		
Eupodina Eupodidae Penthaleidae	 *Caleupodes reticulatus* Baker *Halotydeus desctructor* (Tucker)	 Baker (1987) Baker (1995)
Ingroup		
Anystae Adamystidae	 *Adamystis thailandensis* Fuangarworn & Lekprayoon *Saxidromus caribeus* P.-Vagas & Truera	 Fuangarworn & Lekprayoon (2010) Palacios-Vagas & Truera (1995)
Anystidae	*Anystis siamensis* n. sp. *Walzia chamrasae* n. sp.	This study This study
Caeculidae	*Caeculus echinipes* Dufour *Neocaeculus orientalis* n. sp.	Coineau (1974a) This study
Chulacaridae (monogeneric)	*Chulacarus elegan* n. g. et n. sp.	This study
Erythracaridae	*Erythracarus nasutus* Otto *Tarsotomus ottoi* n. sp. *Lacteoscithys kanchanaburiensis* n. sp. *Tarsolarkus praeceps* Pogrebnyak	This study This study This study Pogrebnyak (2010)
Paratydeidae	*Waltydeus tauricus* Kuznetsov *Tanytydeus kakadu* Seeman & Walter	Kuznetsov (1973) Seeman & Walter (2000)
Pomerantziidae	*Pomerantzia philipina* Bochkov & Walter *Apomerantzia pasak* n. sp.	Bochkov & Walter (2007) This study
Pseudocheylidae	*Pseudocheylus americanus* (Ewing) *Anoplocheylus corticicola* n. sp.	Skavarla *et al.* (2013) This study
Stigmocheylidae (monogeneric)	*Stigmocheylus bochkovi* n. sp.	This study
Teneriffiidae	*Neoteneriffiola coineaui* Judson *Austroteneriffia sunthorni* n. sp.	Judson (1994) This study
Eleutherengona Tarsocheylidae Heterocheylidae Pygmephorus Hirstiellidae Tuckerellidae Myobiidae Syringophilidae Cheyletidea Calligonellidae Raphignathidae	 *Tarsocheylus paradoxus* *Heterocheylus proximus* *Pygmephorus punctulatus* *Hirstiella* sp. *Tuckerella knorri* *Archemyobia philander* *Cryptomyobia baranovae* *Syringophilus bipectinatus* *Eucheyletia asiatica* *Cheyletiella parasitivorax* *Storchia robusta* *Raphignathus collegiatus* *Neognathus* sp.	Bochkov *et al.* (2008)

Table 2. Summary of statistical different among most parsimonious trees (MPTs) obtained by 28 regimes of analyses (equal weighting (EW) and implied weighting (IW) with 13 values for concavity constant (*k*), and with 19 characters ordered (additive, see text) or unordered (non-additive) which respectively presented) of 20 species of Anystae, including 13 species of Eleutherengona. CI, consistency index, RI, retention index, AH, adjusted homoplasy or best score (TBR), Av J, average jackknife value.

Analyses	MPTs	Length	CI	RI	AH	Av J
EW	12/1	473/429	0.397/0.438	0.726/0.733	-	61.500/50.548
IW k = 1	1/1	481/466	0.391/0.422	0.719/0.714	71.913/57.421	57.906/47.031
IW k = 2	1/1	474/443	0.397/0.424	0.726/0.718	55.934/45.226	62.781/51.313
IW k = 3	1/1	474/433	0.397/0.434	0.726/0.729	46.126/37.509	62.212/52.781
IW k = 4	1/1	474/433	0.397/0.434	0.726/0.729	39.385/32.057	64.094/53.969
IW k = 5	1/1	473/431	0.397/0.436	0.726/0.731	34.426/28.069	63.063/51.000
IW k = 6	1/1	473/431	0.397/0.436	0.726/0.731	30.597/24.997	62.906/53.875
IW k = 7	1/1	473/431	0.397/0.436	0.726/0.731	27.554/22.555	62.156/53.938
IW k = 8	1/1	473/431	0.397/0.436	0.726/0.731	25.073/20.563	61.938/53.594
IW k = 9	1/1	473/431	0.397/0.436	0.726/0.731	23.009/18.904	61.563/53.469
IW k = 10	1/1	473/431	0.397/0.436	0.726/0.731	21.263/17.499	61.344/53.844
IW k = 12	1/1	473/431	0.397/0.436	0.726/0.731	18.470/15.246	60.594/53.531
IW k = 15	1/1	473/431	0.397/0.436	0.726/0.731	15.438/12.791	60.188/53.531
IW k = 20	1/1	473/430	0.397/0.437	0.726/0.732	12.131/10.098	60.094/52.625

Table 3. Sensitivity of the relationships among anystaen families recovered from 14 regimes of parsimonious analyses with 19 characters treated as ordered (additive). [1]

Clades	Analyses													
	EW	IW with different *k* values												
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**15**	**20**
ORDERED														
Raphignathina	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Heterostigmata	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Raphignathina + Heterostigmata (= Eleutherengona, ELE)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ELE+Psu	+	+	+	+	+	+	+	+	+	+	+	+	+	+
(ELE+Psu)+Pom	-	+	-	-	-	-	-	-	-	-	-	-	-	-
((ELE+Psu)+Pom)+ Sti	-	+	-	-	-	-	-	-	-	-	-	-	-	-
((ELE+Psu)+Pom)+ Sti)+Par	-	+	-	-	-	-	-	-	-	-	-	-	-	-
(ELE+Psu)+Sti	-	+	+	+	+	-	-	-	-	-	-	-	-	-
((ELE+Psu)+Sti)+Pom	-	-	+	+	+	-	-	-	-	-	-	-	-	-
(Sti+Pom)	-	-	-	-	-	+	+	+	+	+	+	+	+	+
(ELE+Psu)+(Sti+Pom)	-	-	-	-	-	+	+	+	+	+	+	+	+	+
((ELE+Psu)+(Sti+Pom))+Par	-	-	-	-	-	+	+	+	+	+	+	+	+	+
((((ELE+Psu)+(Sti+Pom))+Par)+Chu	-	-	-	-	-	+	+	+	+	+	+	+	+	+
Par+Chu	-	-	+	+	+	-	-	-	-	-	-	-	-	-
(Any+Ery)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
(Any+Ery)+Ada	+	+	+	+	+	+	+	+	+	+	+	+	+	+
((Any+Ery)+Ada)+Ten	+	-	+	+	+	+	+	+	+	+	+	+	+	+
(Ten+Cae)	-	+	-	-	-	-	-	-	-	-	-	-	-	-
((Any+Ery)+Ada)+(Ten+Cae)	-	+	-	-	-	-	-	-	-	-	-	-	-	-
(((Any+Ery)+Ada)+(Ten+Cae))+Chu	-	+	-	-	-	-	-	-	-	-	-	-	-	-
(((Any+Ery)+Ada)+Ten)+Cae….1	-	-	+	+	+	+	+	+	+	+	+	+	+	+
1 + (Par+Chu)	-	-	+	+	+	-	-	-	-	-	-	-	-	-

Note. [1]EW= equal weighting, strict consensus tree, IW = implied weighting; + = clade retrieved; - clade not retrieved; ? = unresolved. Clades within Heterostigmata and Raphignatha not assessed further. Abbreviations of family name: Cae (Caeculidae), Aam (Adamystidae), Any (Anystidae), Ten (Teneriffiidae), Psu (Pseudocheylidae), Par (Paratydeidae), Sti (Stigmocheylidae), Pom (Pomerantziidae), Ery (Erythracaridae), Chu (Chulacaridae). Same sheded columns depict the same topologies of the trees. Clades in bold consistently retrieved both in ‘ordered’ and ‘unordered’ analyses.

Table 4. Sensitivity of the relationships among aystaen families recovered from 14 regimes of parsimonious analyses with all characters treated as unordered (non-additive). [1]

Clades	Analyses													
	EW	IW with different *k* values												
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**15**	**20**
UNORDERED														
Raphignathina	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Heterostigmata	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Raphignathina + Heterostigmata (= Eleutherengona, ELE)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ELE+Psu	-	+	+	+	+	+	+	+	+	+	+	+	+	+
(ELE+Psu)+Sti	-	+	+	-	-	-	-	-	-	-	-	-	-	-
((ELE+Psu)+Sti)+Pom…1	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Stig+Pom	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Psu+(Stig+Pom)	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Par+Pom	-	-	-	+	+	+	+	+	+	+	+	+	+	+
(ELE+Psu)+ (Par+Pom)	-	-	-	+	+	+	+	+	+	+	+	+	+	+
((ELE+Psu)+ (Par+Pom))+Stig	-	-	-	+	+	+	+	+	+	+	+	+	+	+
(((ELE+Psu)+ (Par+Pom))+Stig)+Chu+[*]	-	-	-	+	+	+	+	+	+	+	+	+	+	+
ElE+(Psu+(Stig+Pom))	+	-	-	-	-	-	-	-	-	-	-	-	-	-
(ElE+(Psu+(Stig+Pom)))+Par	+	-	-	-	-	-	-	-	-	-	-	-	-	-
((ElE+(Psu+(Stig+Pom)))+Par)+Chu+[*]	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Adam+Ten	-	+	+	-	-	-	-	-	-	-	-	-	-	-
(Adam+Ten)+Ery	-	+	+	-	-	-	-	-	-	-	-	-	-	-
((Adam+Ten)+Ery)+Chu	-	+	+	-	-	-	-	-	-	-	-	-	-	-
(((Adam+Ten)+Ery)+Chu)+Par	-	+	+	-	-	-	-	-	-	-	-	-	-	-
((((Adam+Ten)+Ery)+Chu)+Par)+Cae..2	-	+	+	-	-	-	-	-	-	-	-	-	-	-
(1+2)+Any	-	+	+	-	-	-	-	-	-	-	-	-	-	-

[1] See Note in Table 3.

[*] Successively sister to Cae, Ery, Ten, Adam, Anys (Figs 5-6).

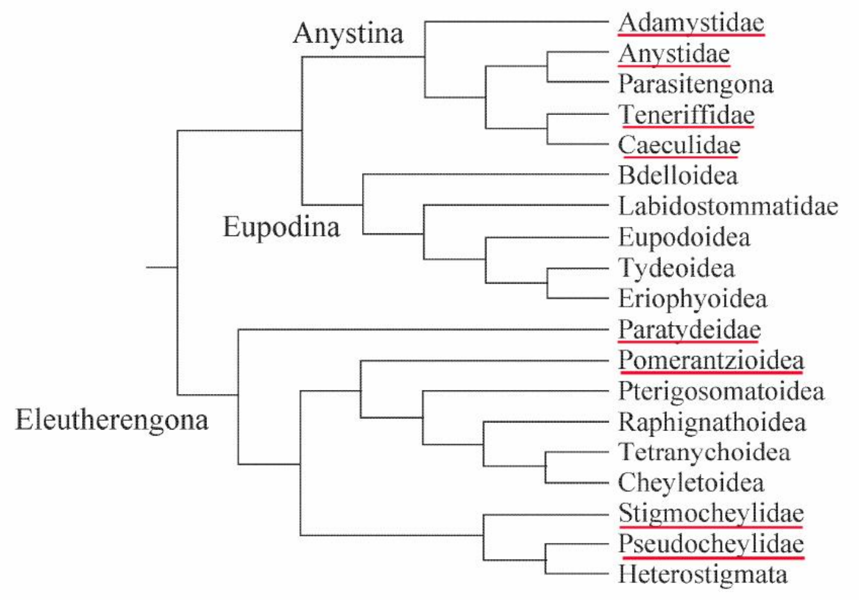

Figure 1. Phylogeny of the infraorder Prostigmata according to Kethkey (in Norton *et al*. 1993).

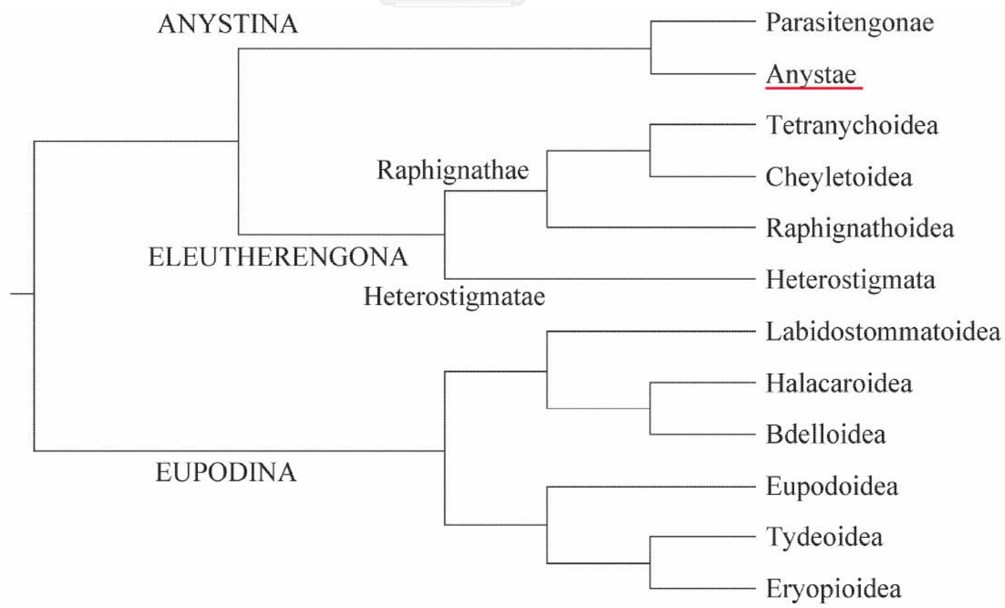

Figure 2. Phylogeny of the infraorder Prostigmata according to Lindquist (1996).

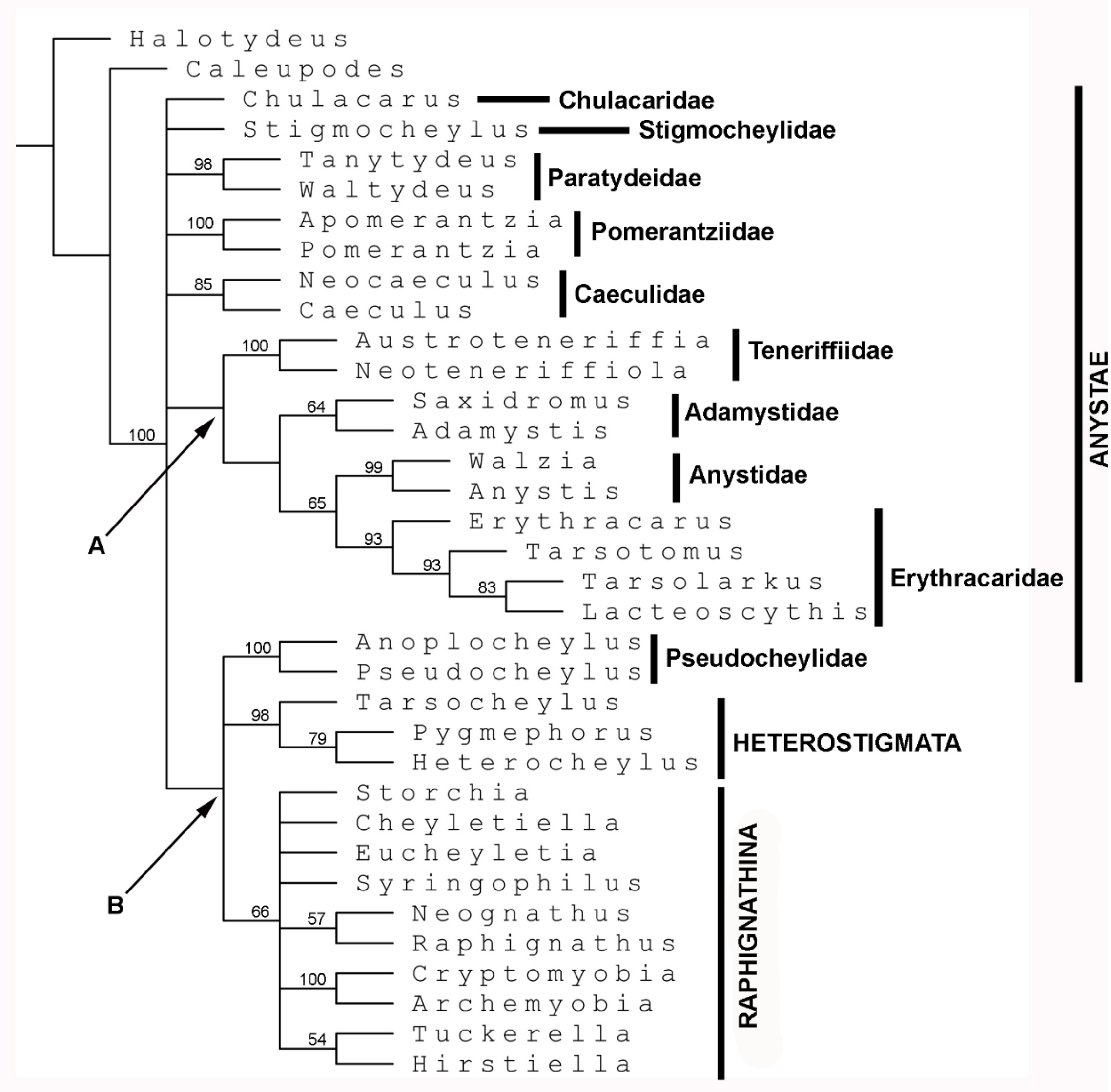

Figure 3. Strict consensus tree of 12 most parsimonious trees from the analysis with 19 characters treated as ordered (additive), under equal weighting regime. Jackknife support values are mapped for nodes with greater than 50 % support.

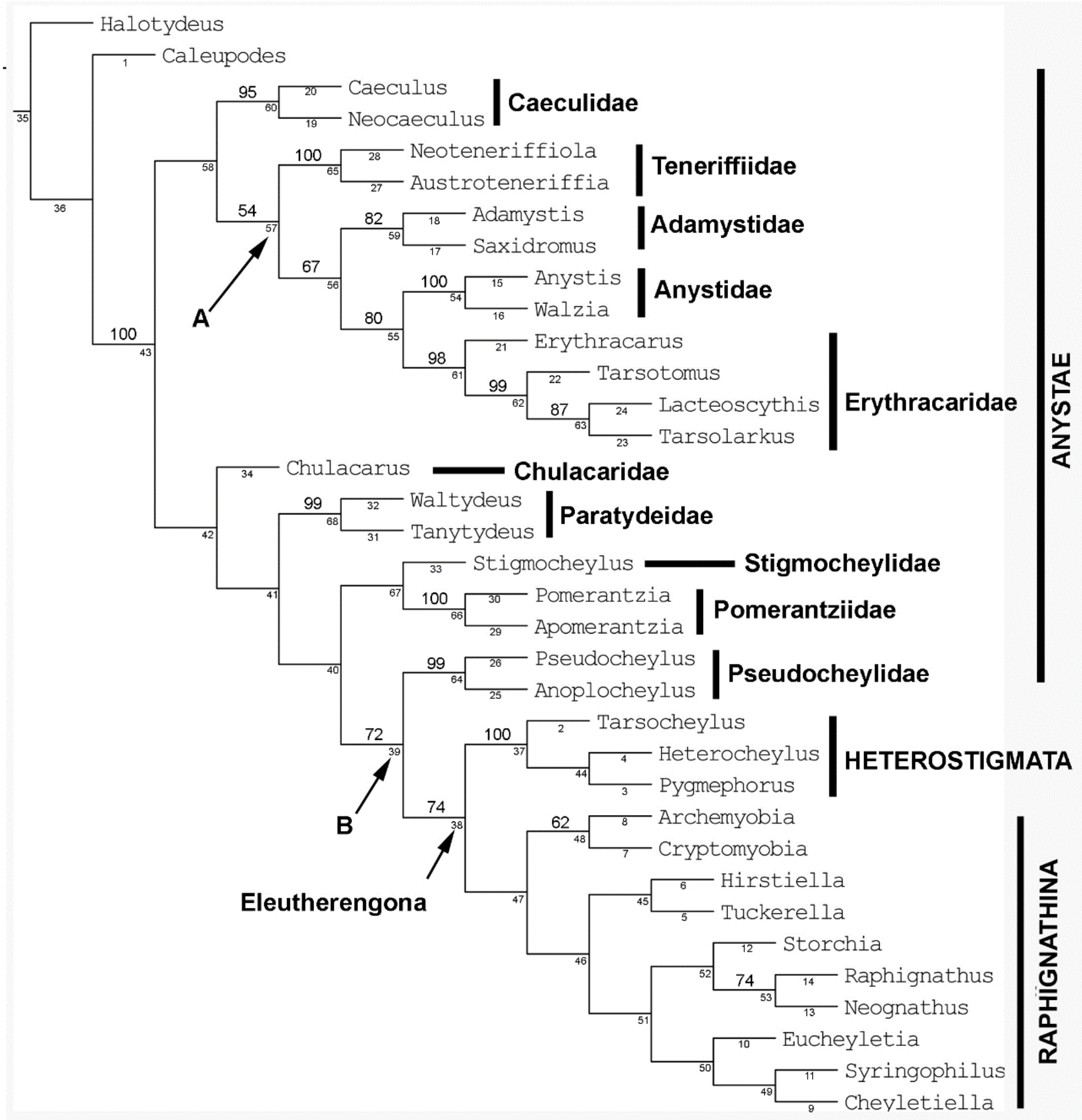

Figure 4. Tree from the analysis with 19 characters treated as ordered (additive), under the implied weighting regime at the constant of concavity $k = 5$. Jackknife support values on branches are mapped for nodes with greater than 50 % support. Numbers under branches indicate node labeling.

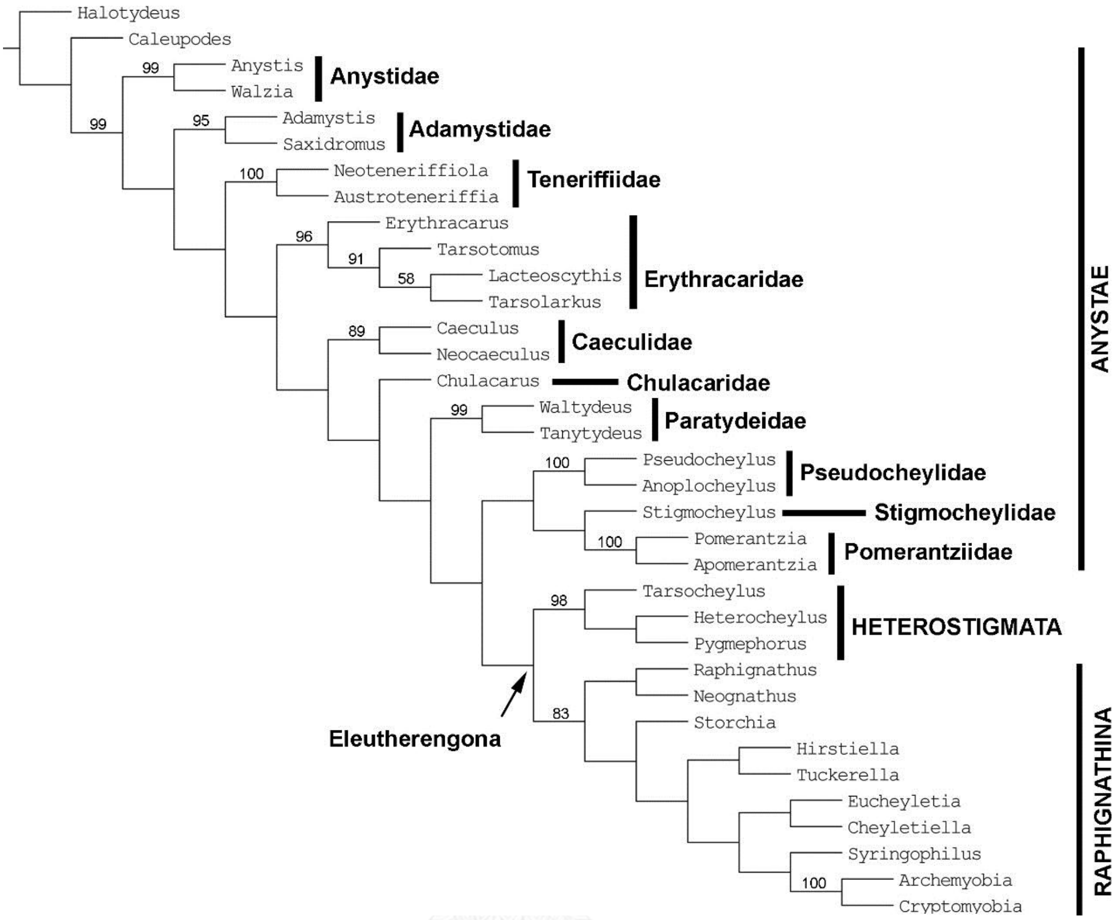

Figure 5. A single most parsimonious trees from the analysis with all characters treated as unordered (non-additive), under equal weighting regime. Jackknife support values are mapped for nodes with greater than 50 % support.

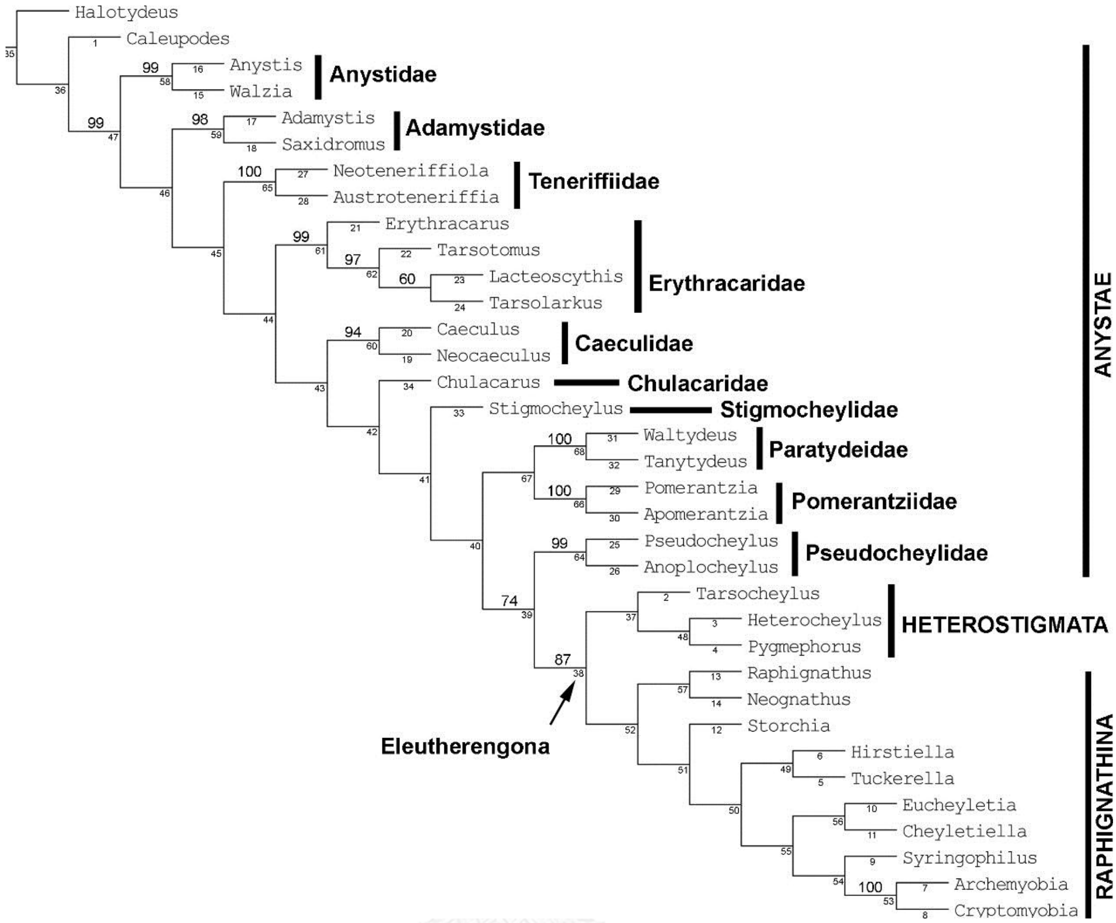

Figure 6. Tree from the analysis with all characters treated as unordered (non-additive), under the implied weighting regime at the constant of concavity $k = 5$. Jackknife support values on branches are mapped for nodes with greater than 50 % support. Numbers under branches indicate node labeling.

CHAPTER 4

GENERAL DISCUSSION AND CONCLUSION

Species in the hyporder Anystea (*sensu* Zhang *et al*. 2011) are predatory mites usually found in soil and litter, on rocks, tree bark, and lower vegetation of rather dried and exposed habitats; some members (Pomerantziidae and Stigmocheylidae) were collected from deep soil strata (Walter *et al*. 2009). Prior to this thesis, only one known anystaen species was previously documented from Thailand, namely *Adamystis thailandensis* Fuangarworn & Lekprayoon, 2010 (family Adamystidae). This study had made an important contribution to systematics of the Anystae in Thailand by increasing the known species diversity of anystaen mites to 18 species, classified into 10 families and 15 genera (Table 1). Of these, 12 species are new to science and 5 species are new records for the Thai fauna, thus extending their range of distribution; and a new genus, *Chulacarus*, and new family, Chulacaridae, are proposed (Chapter 2C). The new taxa are described and illustrated while the re-descriptions or supplementary descriptions are given for the previously known species.

Complete descriptions of the acarine life cycles are relatively scarce. This thesis also made a significant contribution to our knowledge on the ontongeny of the Anystae by examination of the detailed morphology on the complete immature stages of 4 anystaen species, in the families Caeculidae (Chapter 2B), Paratydeidae (Chapter 2E) and Pseudocheylidae (Chapter 2G). Unfortunately, the complete immature stages were not obtained for other families studied (i.e., only partial life stages were collected). However, these morphological studies will hopefully serve as a basis for the interpretation of setal homology, particularly on the body and appendages—which usually require the knowledge about the ontogenetic transformations—among the members of the Anystae and its larger grouping, the Trombidiformes.

In term of distributions, five species namely *Erythracarus nasutus* Otto (Erythracaridae), *Neocaeculus orientalis* n. sp. (Caeculidae), *Anoplocheylus aegypticus* Baker & Atyeo (Pseudocheylidae), *Austroteneriffia sunthorni* n. sp. (Teneriffiidae) and *Tanytydeus* cf. *egypticus* (Soliman) (Paratydeidae) had been recorded in the most biogeographic divisions of Thailand (Table 1) and are interpreted as the common anystaen species in Thailand. However, other species shown unclear pattern of the distributions (i.e. they occur disjuctinctly across Thailand's biogeographic divisions or occur in one location). Further collection efforts should yield additional specimens, hence additional distributional data, or even additional species.

Chapter 3 presents the first morphological-based phylogenetic analysis to include all representatives from every anystaen family. The analysis indicated the possible inconsistencies between the current classification schemes and evolutionary history of these mites. The Anystae was retrieved as a non-monophyletic group. Howeverer, all families are recovered as a monophyletic group but deeper relationships are ambiguous, due to changes in parameters (i.e additivity, but additivity increases clade support). The family Pseudocheylidae is often a sister group to the Eleutherengona. The superfamilial groupings (Anystoidea and Paratydeoidea) in the classification by Walter *et al.* (2009) are not monophyletic. Chulacaridae dose also not belong to the superfamily Anystoidea as previous thought (Chapter2C; Fuangarworn *et al.* 2016) but is recovered as a sister taxon of Paratydeida + ((Stigmocheylidae + Pomerantziidae) + (Pseudocheylidae+Eleutherengona)) in the preferred tree (Chapter 3, Fig. 4). In term of classification, however, it would be premature to propose any classificatory or nomenclatural changes for mites in the hyporder Anystae. It should be noted that this work is intended as a preliminary hypothesis to be tested in the more comprehensive analysis in a future by the inclusion of additional morphological characters (including that of juvenile stages), additional exemplar species, and other sources of data (e.g., molecular characters).

Table 1. Diversity of anytaen mites in Thailand.

Taxa	Distribution[1]						Substrate types
	N	NE	C	W	SE	S	
Family Adamystidae							
Genus *Adamystis*							
1) *Adamystis thailandensis* Fuangarworn & Lekprayoon, 2010			+			+	soil and litter
Family Anystidae							
Genus *Anystis*							
2) *Anystis siamensis* n. sp.	+						soil and litter
Genus *Walzia*							
3) *Walzia chamrasae* n. sp.			+		+		Soil and litter, vegetation
4) *Walzia monosetosa* n. sp.			+				Soil and litter, Tree bark
Family Caeculidae							
Genus *Neocaeculus*							
5) *Neocaeculus orientalis* n. sp.	+	+	+	+	+	+	soil and litter, moss
Family Chulacaridae n. fam.							
Genus *Chulacarus* n. gen.							
6) *Chulacarus elegan* n. sp.		+		+			soil and litter
Family Erythracaridae							
Genus *Erythracarus*							
7) *Erythracarus nasutus* Otto, 1999	+	+	+	+	+	+	soil and litter
Genus *Lactyoscythis*							
8) *Lactyoscythis kanchanaburiensis* n. sp.				+			soil and litter
Genus *Tarsolarkus*							
9) *Tarsolarkus pilosus* n. sp.				+			soil and litter
Genus *Tarsotomus*							
10) *Tarsotomus ottoi* n. sp.			+	+			
Family Paratydeidae							
Genus *Tanytydeus*							
11) *Tanytydeus kakadu* Seeman & Walter, 1999						+	soil and litter
12) *Tanytydeus* cf. *egypticus* (Soliman, 1975)	+	+		+	+	+	soil and litter
Family Pomerantziidae							
Genus *Apomerantzia*							
13) *Apomerantzia pasak* n. sp.			+				deep soil
Genus *Pomerantzia*							
14) *Pomerantzia philippina* Bochkov & Walter, 2007					+		deep soil
Family Pseudocheylidae							
Genus *Anoplocheylus*							
15) *Anoplocheylus aegypticus* Baker & Atyeo, 1946	+		+	+	+		soil and litter
16) *Anoplocheylus corticicola* n. sp.			+			+	tree bark

[1]The biogeographical divisions of Thailand follows Kloss (1915) and Rattanarithikul *et al.* (2005). N = North, NE = Northeast (Khorat Plateau), C = Central Valley, W = Western Mountains, SE = Southeast, and S = South (Peninsular).

Table 1. continued.

Taxa	Distribution[1]						Substrate types
	N	NE	C	W	SE	S	
Family Stigmocheylidae							
Genus *Stigmocheylus*							
17) *Stigmocheylus bochkovi* n.sp.			+		+		deep soil
Family Teneriffiidae							
Genus *Austroteneriffia*							
18) *Austroteneriffia sunthorni* n. sp.	+		+	+	+	+	soil and litter, moss

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APPENDICES

APPENDIX 1:

Characters and character states used for the cladistic analysis

Appendix 1. Characters and character states used for the cladistic analysis (note that character number begin as ‘0’)

0. Cheliceral bases: 0 = separate; 1 = adnate or fused to form stylophore.
1. Chelicerae: 0 = not fused with subcapitulum; 1 = fused.
2. Cheliceral digits: 0 = chelate, fixed digit well develop; 1 = fixed digit reduced or absent, movable digit hook-like; 2 = fixed digit reduced or absent, movable digit stylet-like.
3. Cheliceral appendix on lateral face: 0 = absent; 1 = present.
4. Cheliceral stylet-like process in the position of (reduced) fixed digit: 0 = absent; 1 present.
5. Cheliceral setae: 0 = absent; 1 = present
6. Number of cheliceral setae, when present: 0 = one; 1 = two; 2 = more than two; ? = absent.
7. Ventral lip: 0 = absent; 1 = present.
8. Adoral setae *or1-2*: 0 = present; 1 = absent.
9. Adoral setae *or1-2*: 0 = setiform; 1 = thickened and truncated; 2 = spine-like inserted without alveolus; 3 = absent.
10. Lacinae on lateral lips: 0 = absent; 1 = present.
11. Number of subcapitular setae: 0 = one; 1 = two; 2 = more than two setae.
12. Palpal supracoxal setae *ep*: 0 = present; 1 = absent.
13. Palpal trochanter: 0 = present; 1 = reduced or absent.
14. Palpal femur and genu: 0 = fused; 1 = separated.
15. Palpal tibial claw: 0 = absent; 1 = present.
16. Palpal tibial accessory claw: 0 = absent; 1 = present.
17. Palpal tibial accessory claw(s): 0 = one; 1 = two; ? = absent.
18. Position of palpal tarsus: 0 = terminal; 1 = subterminal (‘thumb-tarsus’).
19. Palpal tarsus: 0 = well develop, subequal or longer than tibia; 1 = reduced or small but distinct; 2 = strongly reduced or apparently diffused into tibia.
20. Setae on palpal femur: 0 = present; 1 = absent
21. Number of setae on palpal femur, when present: 0 = one; 1 = two; 2 = three or more; ? = absent.

22. Setae on palpal genu: 0 = present; 1 = absent.
23. Number of setae on palpal genu, when present: 0 = one; 1 = two; 2 = three or more; ? = absent.
24. Solenidion on palpal tarsus: 0 = present; 1 = absent.
25. Position of stigmata: 0 = open at bases of chelicerae; 1 = open on anterior corner of propodosoma.
26. Peritremes: 0 = absent; 1 = present.
27. Naso: 0 = present; 1 = reduced or absent.
28. Prodorsal shield: 0 = absent; 1 = present.
29. Dorsal hysterosomal shield: 0 = absent; 1 = with 5 shields, C, D, E, F, and H; 2 = with four shields, C, D, E+F, and H; 3 = two shields, C+DEF; 4 = one shield, E+F+H; 5 = one shield, D+E+F; 6 = 3 shields, C+D+E, F, and H (Caeucilidae); 7 = two shields, D and E+F+H+PS (Saxidrominae—*c1-2* on prodorsal shield); 8 = all fused with prodorsal shield (holonotal present).
30. *vi*: 0 = present; 1 = absent.
31. Type of setae *vi,* when present: 0 = normal; 1 = trichobothrial; ? = absent.
32. Setae *sci*: 0 = trichobothrial; 1 = normal.
33. Bothridial rosette on prodorsum: 0 = absent; 1 = present.
34. Neotrichous setae on prodorsal shield: 0 = absent; 1 = present.
35. Number of neotrichous setae on prodorsal shield, when present: 0 = 1 = few (one to two pairs); 1 = numerous; ? = absent.
36. Hysterosomal setae in segment C: 0 = holotrichous (only *c1-2*); 1 = oligotrichous, *c3* present; 2 = hypertrichous, more than three pairs.
37. Hysterosomal setae in segment D: 0 = holotrichous (only *d1*); 1 = oligotrichous, *d*2 present; 2 = hypertrichous, more than two pairs.
38. Hysterosomal setae in segment E: 0 = holotrichous (only *e1*); 1 = oligotrichous, *e2* present; 2 = hypertrichous, more than two.
39. Hysterosomal setae in segment F: 0 = only *f1* present; 1 = setae *f1-2* present; 2 = hypertrichous, more than two.
40. Hysterosomal setae in segment H: 0 = only *h1* present; 1 = setae *h1-2* present; 2 = oligotrichous, *h*3 present; 3 = hypertrichous, more than three

41. Hysterosomal setae in segment PS: 0 = holotrichous (only *ps1-2*); 1 = oligotrichous, *ps*3 present; 2 = hypertrichous, 4-5 setae.
42. Anamorphic addition of segment AD: 0 = present; 1 = absent.
43. Anamorphic addition of segment AN: 0 = absent; 1 = present.
44. Cupule posterior of lateral eyes: 0 = absent; 1 = present.
45. Cupule *ia*: 0 = present; 1 = absent.
46. Cupule *im*: 0 = present; 1 = absent.
47. Cupule *ip*: 0 = present; 1 = absent.
48. Cupule *ih*: 0 = present; 1 = absent.
49. Lyrifissure *ia* displaced in setal row C: 0 = no, 1 = yes.
50. Coxa I-II and coxa III-IV: 0 = widely separate; 1 = adjacent; 2 = with equal distance of all coxae.
51. Coxisternal plate I-II of females: 0 = medially separated; 1 = fused.
52. Sternal plates between coxisternal plates I and II of female: 0 = absent; 1 = present (may fused to coxisternal plates).
53. Unpaired median ventral plate: 0 = absent; 1 = present (may fused to coxisternal plates).
54. Paired lateroventral plates: 0 = absent; 1 = present.
55. Position of female anal opening: 0 = ventral or terminal; 1 = dorsal.
56. Female anal and genital opening: 0 = distinctly separated; 1 = covered with common fold or completely fused.
57. Aggenital plates: 0 = absent; 1 = present.
58. Genital papillae: 0 = present; 1 = absent.
59. Genital-papillae associated setae *k* : 0 = absent; 1 = present.
60. Genital setae: 0 = present; 1 = absent.
61. Number of genital setae, when present: 0 = more than seven (hypertrichous); 1 = five to seven; 2 = four; 3 = one or two; ? = absent.
62. Aggenital setae: 0 = one; 1 = two; 2 = three; 3 = four; 4 = five, 5 = more than five or hypertrichous.
63. Coxal setae on coxal I: 0 = two; 1 = three; 2 = four; 3 = five; 4 = six; 5 = more than six (hypertrichous).

64. Coxal setae on coxal II: 0 = one; 1 = two; 2 = three; 3 = four; 4 = five; 5 = six or more (hypertrichous).
65. Coxal setae on coxal III: 0 = one; 1 = two; 2 = three; 3 = four; 4 = five to seven; 5 = hypertrichous.
66. Coxal setae on coxal IV: 0 = one; 1 = two; 2 = three; 3 = four; 4 = five to seven; 5 = hypertrichous.
67. Supracoxal setae of leg I: 0 = present; 1 = absent.
68. Supracoxal setae of leg II: 0 = absent; 1 = present.
69. Femur I: 0 = divided; 1 = entire.
70. Femur II: 0 = divided; 1 = entire.
71. Femur III: 0 = divided; 1 = entire.
72. Femur IV: 0 = divided; 1 = entire.
73. Tarsus I: 0 = entire; 1 = divided into multisubsegments.
74. Tarsus II: 0 = entire; 1 = divided into multisubsegments.
75. Tarsus III: 0 = entire; 1 = divided into two subsegments; 2 = divided into multisubsegments.
76. Tarsus IV: 0 = entire; 1 = divided into two subsegments; 2 = divided into multisubsegments.
77. Tarsi I-IV terminating as annuli: 0 = no; 1 = yes.
78. Pretasal claws leg I: 0 = present; 1 = absent.
79. Pretasal claws leg I: 0 = rayed; 1 = smooth; 2 = pectinate; 3 = with tenant-hairs; ? = absent.
80. Pretarsal claws leg II: 0 = present; 1 = absent.
81. Pretarsal claws leg II: 0 = rayed; 1 = smooth; 2 = pectinate; 3 = linear with basal tooth and setules; 4 = with tenant-hairs; ? = absent.
82. Pretarsal claws leg II-IV: 0 = present; 1 = absent.
83. Pretarsal claws leg II-IV: 0 = rayed; 1 = smooth; 2 = pectinate; 3 = linear with basal tooth and setules; 4 = with tenant-hairs; ? = absent.
84. Empodium on leg I: 0 = present; 1 = absent.
85. Empodium on leg I: 0 = pad-like, setulate on ventral face, 1 = pad-like, smooth; 2 = with tenent-hairs; 3 = claw-like, smooth; 4 = claw-like and pectinate, 5 = brush-like; ? = absent.

86. Empodium on leg II: 0 = present; 1 = absent.
87. Empodium on leg II: 0 = pad-like, setulate on ventral face, 1 = pad-like, smooth; 2 = with tenent-hairs; 3 = claw-like, smooth; 4 = claw-like and pectinate, 5 = brush-like;? = absent.
88. Empodium on leg III-IV: 0 = present; 1 = absent.
89. Empodium on leg III-IV: 0 = pad-like, setulate on ventral face, 1 = pad-like, smooth; 2 = with tenent-hairs; 3 = claw-like, smooth; 4 = claw-like and pectinate, 5 = brush-like; ? = absent.
90. Solenidion σ on genu I: 0 = present; 1 = absent.
91. Solenidion σ on genu II: 0 = present; 1 = absent.
92. Solenidion σ on genu III: 0 = absent; 1 = present.
93. Solenidion σ on genu IV: 0 = absent; 1 = present.
94. Solenidion φ on tibia I: 0 = present; 1 = absent.
95. Solenidion φ on tibia II: 0 = present; 1 = absent.
96. Solenidion φ on tibia III: 0 = present; 1 = absent.
97. Solenidion φ on tibia IV: 0 = present; 1 = absent.
98. Solenidion ω on tarsus I: 0 = one to three; 1 = more than three.
99. Solenidion ω on tarsus II: 0 = two or three; 1 = one; 2 = more than three.
100. Solenidion ω on tarsus III: 0 = absent; 1 = present.
101. Solenidion ω on tarsus IV: 0 = absent; 1 = present.
102. Orientation of tibia solenidia: 0 = erect; 1 = appressed (rhagidial organs); 2 = in integumental sink; 3 = bump or pitted.
103. Famulus ε on tarsus I: 0 = present; 1 = absent.
104. Famulus ε on tarsus II: 0 = present; 1 = absent.
105. Famulus k on tibia I: 0 = absent; 1 = present.
106. Famulus k on tibia II: 0 = absent; 1 = present.
107. Trichobothrium on tarsus I: 0 = absent; 1 = present.
108. Trichobothrium on tarsus II: 0 = absent; 1 = present.
109. Trichobothrium on tarsus III: 0 = absent; 1 = present.
110. Trichobothrium on tarsus IV: 0 = absent; 1 = present.
111. Brush-like setae at bases of claws: 0 = absent; 1 = present.
112. Ovipositor: 0 = with eugenital setae; 1 = without eugenital setae.

113. Male eugenital setae: 0 = present; 1 = absent.
114. Male with aedeagus: 0 = yes; 1 = no.
115. Claparede's organs in larva: 0 = present; 1 = absent.
116. Claparede's organs in larva, when present: 0 = with protecting scale; 1 without proctecting scale; ? = Claparede's organs absent.
117. Claparede's organs in larva, when present: 0 = situated ventrally; 1 = situated laterally; ? = Claparede's organs absent
118. Genital opening delayed (absent) in protonymph: 0 = no; 1 = yes.

APPENDIX 2:

Data matrix

Appendix 2. Data matrix comprising 33 anytean and elutherengonan species as the in-group and two eupodinan species as the out-group. ? = unknown or inapplicable.

	0										1										2
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Halotydeus destructor	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	?	0	0	0
Caleupodes reticulatus	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	?	0	0	0
Tarsocheylus paradoxus	1	0	1	0	0	1	1	0	0	0	0	1	0	0	0	1	1	1	?	2	0
Heterocheylus proximus	1	0	1	0	0	1	1	0	0	0	0	1	1	0	0	1	1	0	?	2	0
Pygmephorus punctulatus	1	1	2	0	0	1	1	0	1	?	0	0	0	1	0	1	0	?	1	2	0
Hirstiella sp.	0	0	1	0	0	0	?	0	1	?	0	0	0	0	1	1	0	?	1	1	0
Tuckerella knorri	1	0	2	0	0	0	?	0	0	0	0	0	0	0	1	1	0	?	1	1	1
Archemyobia philander	1	1	2	0	0	1	0	0	0	0	0	1	1	1	0	0	0	?	?	2	0
Cryptomyobia baranovae	1	1	2	0	0	1	0	0	0	0	0	1	1	1	0	0	0	?	?	2	0
Syringophilus bipectinatus	1	1	2	0	0	0	?	0	0	0	0	0	0	0	1	0	0	?	?	2	0
Eucheyletia asiatica	1	1	2	0	0	0	?	0	0	0	0	0	0	0	1	1	0	?	1	1	0
Cheyletiella parasitivorax	1	1	2	0	0	0	?	0	0	0	0	0	0	0	1	1	0	?	1	1	0
Storchia robusta	0	0	2	0	0	0	?	0	0	0	0	1	0	0	1	1	0	?	1	1	0
Raphignathus collegiatus	1	0	2	0	0	0	?	0	0	0	0	1	0	0	1	1	0	?	0	0	0
Neognathus sp.	1	0	2	0	0	0	?	0	0	0	0	1	0	0	1	1	0	?	1	1	0
Anystis siamensis	0	0	1	0	0	1	1	0	0	0	1	2	0	0	0	1	1	1	0	0	0
Walzia chamrasae	0	0	1	0	0	1	1	0	0	0	1	2	0	0	0	1	1	1	0	0	0
Adamystis thailandensis	0	0	1	1	0	1	1	1	0	0	1	1	0	0	0	0	0	?	0	0	0
Saxidromus caribeus	0	0	0	1	0	1	2	1	0	0	1	1	0	0	0	0	0	?	0	0	0
Caeulus echinipes	0	0	1	0	0	1	0	0	0	0	1	1	0	0	1	1	1	0	1	0	0
Neocaeculus orientalis	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	1	1	0	1	0	0
Erythracarus nasutus	0	0	1	0	0	1	1	1	0	0	1	1	0	0	1	1	1	0	1	0	0
Tarsotomus ottoi	0	0	1	0	0	1	1	0	0	0	1	1	0	0	1	1	1	0	1	0	0
Lacteoscithys kanchanabur.	0	0	1	0	0	1	1	0	0	0	1	1	0	0	1	1	1	0	1	0	0
Tarsolarkus praeceps	0	0	1	0	0	1	1	0	0	0	1	1	0	0	1	1	1	0	1	0	0
Pseudocheylus americanus	0	0	1	0	0	1	1	0	0	0	1	1	0	0	1	1	1	1	1	2	0
Anoplocheylus corticicola	0	0	1	0	0	1	1	0	0	0	1	1	0	0	1	1	1	1	1	2	0
Neoteneriffiola coineaui	0	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	1	1	1	0	0
Austroteneriffia sunthorni	0	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	1	1	1	0	0
Pomerantzia philippina	0	0	1	0	0	1	0	0	0	2	0	0	0	0	1	1	1	0	1	1	0
Apomerantzia pasak	0	0	1	0	0	1	0	0	0	2	0	0	0	0	1	1	1	0	1	1	0
Waltydeus tauricus	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	?	0	1	0
Tanytydeus kakadu	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	?	0	1	0
Stigmocheylus bochkovi	0	0	1	0	0	1	1	0	0	0	0	1	0	0	1	1	1	0	1	1	0
Chulacarus elegan	0	0	1	0	1	1	1	1	0	1	0	1	0	0	0	1	1	0	1	1	0

Appendix 2. continued.

										3										4
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Halotydeus destructor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	0	0	1	1
Caleupodes reticulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	0	0	1	1
Tarsocheylus paradoxus	0	0	0	0	1	0	1	1	2	0	0	0	0	0	?	0	0	0	0	1
Heterocheylus proximus	0	0	0	0	1	0	1	1	2	0	0	0	0	0	?	0	0	0	0	1
Pygmephorus punctulatus	0	0	0	0	1	0	1	1	2	0	0	0	0	0	?	0	0	0	0	1
Hirstiella sp.	0	0	0	0	0	1	1	1	0	0	0	1	0	0	?	1	1	1	1	1
Tuckerella knorri	?	0	0	0	0	1	1	1	3	0	0	1	0	0	?	2	2	2	2	3
Archemyobia philander	0	1	?	1	0	1	1	1	0	0	0	1	0	0	?	0	1	1	1	1
Cryptomyobia baranovae	0	1	?	1	0	1	1	1	0	0	0	1	0	0	?	0	1	1	1	1
Syringophilus bipectinatus	2	0	1	0	0	1	1	1	5	0	0	1	0	0	?	0	1	0	0	1
Eucheyletia asiatica	2	0	1	0	0	1	1	1	0	0	0	1	0	1	1	0	1	1	1	1
Cheyletiella parasitivorax	2	0	1	0	0	1	1	1	5	0	0	1	0	0	?	0	1	1	1	1
Storchia robusta	2	0	1	0	0	0	1	1	0	0	0	1	0	0	?	0	1	1	1	1
Raphignathus collegiatus	2	0	1	0	0	1	1	1	4	0	0	1	0	0	?	0	0	0	0	1
Neognathus sp.	2	0	1	0	0	1	1	1	0	0	0	1	0	0	?	0	0	0	0	1
Anystis siamensis	2	0	2	0	0	1	0	1	0	0	1	0	0	0	?	0	0	0	1	3
Walzia chamrasae	2	0	1	0	0	1	0	0	0	0	1	0	0	0	?	0	0	0	1	3
Adamystis thailandensis	0	0	0	0	0	1	0	1	8	0	1	0	0	0	?	0	0	0	0	1
Saxidromus caribeus	0	0	0	0	0	1	0	1	7	0	1	0	0	0	?	0	1	1	0	1
Caeulus echinipes	1	0	0	0	0	1	0	1	6	0	1	0	0	1	0	2	2	2	2	3
Neocaeculus orientalis	2	0	0	0	0	1	0	1	6	1	?	0	0	1	0	0	1	0	2	3
Erythracarus nasutus	0	0	0	0	0	1	0	0	0	0	1	0	0	0	?	0	0	0	0	1
Tarsotomus ottoi	0	0	1	0	0	1	1	1	0	0	1	0	0	0	?	0	1	2	2	3
Lacteoscithys kanchanabur.	0	0	0	0	0	1	1	1	0	0	1	0	0	0	?	2	2	2	2	3
Tarsolarkus praeceps	0	0	0	0	0	1	1	1	0	0	1	0	0	1	1	2	2	2	2	3
Pseudocheylus americanus	2	0	1	1	0	1	1	1	0	0	0	0	0	1	1	2	2	2	2	3
Anoplocheylus corticicola	2	0	1	1	0	1	1	1	0	0	0	0	0	1	0	2	2	2	0	0
Neoteneriffiola coineaui	0	0	0	0	0	1	0	1	0	0	1	0	1	0	?	0	0	0	0	1
Austroteneriffia sunthorni	0	0	0	0	0	1	0	1	0	0	1	0	1	0	?	0	0	0	0	1
Pomerantzia philippina	0	0	0	0	0	1	1	1	1	1	?	1	0	0	?	0	0	0	1	1
Apomerantzia pasak	0	0	0	0	0	1	1	1	1	1	?	1	0	0	?	0	0	0	1	1
Waltydeus tauricus	0	0	0	0	0	1	1	1	0	1	?	0	0	0	?	0	0	0	1	1
Tanytydeus kakadu	0	0	0	0	0	1	1	1	0	1	?	0	0	0	?	0	0	0	1	1
Stigmocheylus bochkovi	0	0	0	0	0	1	0	1	0	0	0	0	0	0	?	0	0	0	0	2
Chulacarus elegan	0	0	0	0	0	1	0	1	0	0	1	0	0	0	?	0	0	0	0	1

Appendix 2. continued.

										5										6
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Halotydeus destructor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caleupodes reticulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tarsocheylus paradoxus	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0
Heterocheylus proximus	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0
Pygmephorus punctulatus	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	0	1
Hirstiella sp.	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1
Tuckerella knorri	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Archemyobia philander	1	1	0	0	1	1	1	1	0	2	-	0	0	0	1	1	0	1	0	0
Cryptomyobia baranovae	1	1	0	0	1	1	1	1	0	2	-	0	0	0	1	1	0	1	0	0
Syringophilus bipectinatus	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	0
Eucheyletia asiatica	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Cheyletiella parasitivorax	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Storchia robusta	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0
Raphignathus collegiatus	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
Neognathus sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Anystis siamensis	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Walzia chamrasae	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Adamystis thailandensis	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0
Saxidromus caribeus	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Caeulus echinipes	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	?	0
Neocaeculus orientalis	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Erythracarus nasutus	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Tarsotomus ottoi	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Lacteoscithys kanchanabur	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	?	0
Tarsolarkus praeceps	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	?	0
Pseudocheylus americanus	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Anoplocheylus corticicola	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Neoteneriffiola coineaui	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Austroteneriffia sunthorni	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Pomerantzia philippina	1	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0
Apomerantzia pasak	1	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0
Waltydeus tauricus	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Tanytydeus kakadu	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Stigmocheylus bochkovi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chulacarus elegan	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Appendix 2. continued.

										7										8
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Halotydeus destructor	0	5	1	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caleupodes reticulatus	1	4	1	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tarsocheylus paradoxus	2	1	2	2	3	3	1	0	1	1	1	1	0	0	0	0	0	0	1	0
Heterocheylus proximus	3	0	0	1	0	0	1	0	1	1	1	1	0	0	0	0	0	1	?	1
Pygmephorus punctulatus	?	0	2	2	1	1	1	0	1	1	1	1	0	0	0	0	0	0	1	0
Hirstiella sp.	?	2	0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	3	0
Tuckerella knorri	2	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	3	0
Archemyobia philander	4	2	1	3	2	2	?	0	1	1	1	1	0	0	0	0	0	0	1	0
Cryptomyobia baranovae	3	2	2	3	2	2	?	0	1	1	1	1	0	0	0	0	0	0	1	0
Syringophilus bipectinatus	3	2	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	0
Eucheyletia asiatica	3	2	1	0	2	2	0	0	1	1	1	1	0	0	0	0	0	0	1	0
Cheyletiella parasitivorax	3	3	1	0	2	2	0	0	1	1	1	1	0	0	0	0	0	0	1	0
Storchia robusta	3	1	1	1	2	2	0	0	1	1	1	1	0	0	0	0	0	0	1	0
Raphignathus collegiatus	2	2	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	0
Neognathus sp.	3	5	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	0
Anystis siamensis	0	5	5	5	4	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Walzia chamrasae	0	3	5	5	4	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Adamystis thailandensis	1	2	1	4	3	4	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Saxidromus caribeus	1	5	3	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Caeulus echinipes	1	5	4	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Neocaeculus orientalis	1	5	3	0	1	1	0	0	0	1	1	1	0	0	0	0	0	0	1	0
Erythracarus nasutus	0	5	5	5	5	5	0	0	0	0	0	0	1	1	2	2	0	0	2	0
Tarsotomus ottoi	0	5	5	5	5	5	0	0	0	0	0	0	1	1	2	2	0	0	2	0
Lacteoscithys kanchanabur	0	5	5	5	5	5	0	0	0	0	0	0	1	1	2	2	0	0	2	0
Tarsolarkus praeceps	0	5	5	5	5	5	0	0	0	0	0	0	1	1	2	2	0	0	2	0
Pseudocheylus americanus	2	5	1	2	2	2	0	0	0	0	0	0	0	0	0	0	1	1	?	0
Anoplocheylus corticicola	3	5	3	2	2	2	0	0	0	0	0	0	0	0	0	0	1	1	?	1
Neoteneriffiola coineaui	1	3	2	2	3	3	0	0	0	0	0	0	0	0	1	1	0	0	2	0
Austroteneriffia sunthorni	1	3	2	2	3	3	0	0	0	0	0	0	0	0	1	1	0	0	2	0
Pomerantzia philippina	3	3	2	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Apomerantzia pasak	2	3	3	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Waltydeus tauricus	1	3	2	2	2	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0
Tanytydeus kakadu	1	3	2	2	2	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0
Stigmocheylus bochkovi	3	2	3	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Chulacarus elegan	1	2	2	1	2	1	0	0	1	1	1	1	0	0	0	0	0	0	2	0

Appendix 2. continued.

										9										10
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
Halotydeus destructor	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Caleupodes reticulatus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0
Tarsocheylus paradoxus	1	0	1	1	?	0	1	0	1	1	1	0	0	0	0	0	0	0	1	0
Heterocheylus proximus	?	1	?	1	?	0	1	0	1	1	1	0	0	0	0	1	0	0	1	0
Pygmephorus punctulatus	1	0	1	1	?	0	1	0	1	1	1	0	0	0	0	0	0	0	1	0
Hirstiella sp.	4	0	4	1	?	1	?	1	?	0	1	0	0	1	1	1	1	0	1	1
Tuckerella knorri	4	0	4	0	2	0	2	0	2	1	1	0	0	0	1	1	1	0	1	0
Archemyobia philander	1	0	1	1	?	1	?	1	?	0	0	0	0	1	1	1	1	0	1	0
Cryptomyobia baranovae	1	0	1	1	?	1	?	1	?	0	0	0	0	1	1	1	1	0	1	0
Syringophilus bipectinatus	1	0	1	0	2	0	2	0	2	0	1	0	0	0	1	1	1	0	1	0
Eucheyletia asiatica	1	0	1	0	2	0	2	0	2	0	1	0	0	0	1	1	1	0	1	0
Cheyletiella parasitivorax	1	0	1	0	2	0	2	0	2	0	1	0	0	1	1	1	1	0	1	0
Storchia robusta	1	0	1	0	2	0	2	0	2	0	1	0	0	0	0	0	0	0	1	1
Raphignathus collegiatus	1	0	1	0	2	0	2	0	2	0	0	0	0	0	0	0	0	0	1	1
Neognathus sp.	1	0	1	0	2	0	2	0	2	0	1	0	0	0	0	0	0	0	1	1
Anystis siamensis	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0
Walzia chamrasae	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0
Adamystis thailandensis	2	0	2	0	3	0	3	0	3	0	0	0	1	0	0	0	0	0	0	0
Saxidromus caribeus	2	0	2	0	3	0	3	0	3	0	0	1	1	0	0	0	0	0	0	0
Caeulus echinipes	1	0	1	0	3	0	3	0	3	1	1	0	0	0	0	0	0	0	0	0
Neocaeculus orientalis	1	0	1	1	6	1	?	1	?	1	1	0	0	0	0	0	0	0	0	0
Erythracarus nasutus	2	0	2	0	4	0	4	0	4	1	1	0	0	0	0	0	1	0	0	0
Tarsotomus ottoi	2	0	2	0	?	1	?	0	4	1	1	0	0	0	0	0	1	0	0	0
Lacteoscithys kanchanabu	2	0	2	0	4	0	4	0	4	1	1	0	0	0	0	0	1	0	0	0
Tarsolarkus praeceps	2	0	2	0	5	0	5	0	5	1	1	0	0	0	0	0	1	0	0	0
Pseudocheylus americanus	1	0	1	0	1	0	1	0	1	1	1	0	0	?	1	1	1	0	1	0
Anoplocheylus corticicola	?	1	?	0	1	0	1	0	1	1	1	0	0	0	1	1	1	0	1	0
Neoteneriffiola coineaui	2	0	2	1	?	1	?	0	3	0	0	1	1	0	0	0	0	0	1	1
Austroteneriffia sunthorni	2	0	2	1	?	1	?	0	3	0	0	1	1	0	0	0	0	0	0	1
Pomerantzia philippina	1	0	1	1	?	1	?	1	?	0	1	0	0	0	0	0	0	1	0	0
Apomerantzia pasak	1	0	1	1	?	1	?	1	?	0	1	0	0	0	0	0	0	1	2	0
Waltydeus tauricus	1	0	1	0	3	0	3	0	3	0	0	0	0	0	0	0	1	0	1	0
Tanytydeus kakadu	1	0	1	0	3	0	3	0	3	0	0	0	0	0	0	0	1	0	1	0
Stigmocheylus bochkovi	3	0	3	1	?	1	?	1	?	1	1	0	0	0	0	0	1	0	1	0
Chulacarus elegan	1	0	1	1	?	0	3	0	3	1	1	0	0	0	0	0	0	0	1	0

Appendix 2. continued.

										11								
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8
Halotydeus destructor	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caleupodes reticulatus	0	1	0	0	0	0	0	0	0	0	0	0	?	?	0	?	?	?
Tarsocheylus paradoxus	0	0	1	1	1	0	0	0	0	0	0	1	1	0	1	?	?	1
Heterocheylus proximus	0	0	1	1	1	0	0	0	0	0	0	1	1	0	1	?	?	1
Pygmephorus punctulatus	0	0	1	1	1	0	0	0	0	0	0	1	1	0	1	?	?	1
Hirstiella sp.	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	?	?	1
Tuckerella knorri	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	?	?	1
Archemyobia philander	0	0	1	1	1	1	0	0	0	0	0	1	1	0	1	?	?	1
Cryptomyobia baranovae	0	0	1	1	1	1	0	0	0	0	0	1	1	0	1	?	?	1
Syringophilus bipectinatus	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	?	?	1
Eucheyletia asiatica	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	?	?	1
Cheyletiella parasitivorax	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	?	?	1
Storchia robusta	1	0	1	1	0	0	0	0	0	0	0	1	1	0	1	?	?	1
Raphignathus collegiatus	1	0	1	1	0	0	0	0	0	0	0	1	1	0	1	?	?	1
Neognathus sp.	1	0	1	1	0	0	0	0	0	0	0	1	1	0	1	?	?	1
Anystis siamensis	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	1	1	0
Walzia chamrasae	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	1	1	0
Adamystis thailandensis	0	0	0	0	1	0	0	0	0	0	0	1	0	1	?	?	?	0
Saxidromus caribeus	0	0	0	0	1	0	0	0	0	0	0	?	0	1	0	?	?	0
Caeulus echinipes	0	2	0	0	1	0	1	1	1	1	0	?	?	1	0	1	0	0
Neocaeculus orientalis	0	2	0	0	1	0	0	0	1	1	0	0	0	1	0	1	0	0
Erythracarus nasutus	0	1	0	0	?	0	0	0	0	0	0	0	0	1	1	?	?	0
Tarsotomus ottoi	0	2	0	0	1	0	0	0	0	0	0	0	0	1	?	?	?	0
Lacteoscithys kanchanabu	0	2	0	0	1	0	0	0	0	0	0	0	0	?	?	?	?	0
Tarsolarkus praeceps	0	2	0	0	1	0	0	0	0	0	0	0	0	1	?	?	?	0
Pseudocheylus americanus	0	0	1	1	1	0	0	0	0	0	0	0	1	1	1	?	?	1
Anoplocheylus corticicola	0	0	1	1	1	0	0	0	0	0	0	1	1	1	1	?	?	1
Neoteneriffiola coineaui	1	0	1	1	1	0	0	0	1	1	0	1	0	1	?	?	?	?
Austroteneriffia sunthorni	1	0	1	1	1	0	0	0	1	1	0	0	0	1	0	1	1	0
Pomerantzia philippina	0	0	0	1	1	0	0	0	0	0	0	0	?	?	0	0	0	0
Apomerantzia pasak	0	0	0	1	1	0	0	0	0	0	0	0	?	?	?	?	?	0
Waltydeus tauricus	0	0	1	0	1	0	0	0	0	0	0	1	0	?	0	0	0	0
Tanytydeus kakadu	0	3	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0
Stigmocheylus bochkovi	0	0	1	1	1	0	0	0	0	0	0	1	?	?	?	?	?	0
Chulacarus elegan	0	0	0	0	0	0	0	0	0	0	0	0	?	?	0	0	0	0

APPENDIX 3:

Consistency indiced (CI) and Retention indices (RI)

Appendix 3. Consistency indiced (CI) and Retention indices (RI) of each character in the analyses with 19 characters treated as ordered and all characters treated unordered, under equal weigths (EW), and implied weights (IW, *k*= 5)

Char	CI				RI			
	Ordered		Unordered		Ordered		Unordered	
	EW	IW	EW	IW	EW	IW	EW	IW
0	0.33	0.33	0.33	0.33	0.80	0.80	0.80	0.80
1	0.50	0.33	0.50	0.50	0.80	0.60	0.80	0.80
2	0.40	0.40	0.40	0.40	0.73	0.73	0.73	0.73
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
5	1.00	1.00	0.50	0.50	1.00	1.00	0.86	0.86
6	0.50	0.33	0.33	0.33	0.78	0.56	0.56	0.56
7	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
8	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
10	0.33	0.33	0.25	0.25	0.87	0.87	0.80	0.80
11	0.40	0.40	0.40	0.40	0.63	0.63	0.63	0.63
12	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
13	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
14	0.17	0.17	0.17	0.17	0.64	0.64	0.64	0.64
15	0.25	0.20	0.25	0.25	0.63	0.50	0.63	0.63
16	0.25	0.20	0.20	0.20	0.81	0.75	0.75	0.75
17	0.25	0.25	0.33	0.33	0.50	0.50	0.67	0.67
18	0.25	0.20	0.33	0.33	0.63	0.50	0.75	0.75
19	0.40	0.40	0.40	0.40	0.83	0.83	0.83	0.83
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
21	0.25	0.25	0.29	0.29	0.71	0.71	0.50	0.50
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
23	0.40	0.40	0.33	0.33	0.70	0.70	0.56	0.56
24	0.50	0.50	0.50	0.50	0.67	0.67	0.67	0.67
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
26	0.33	0.33	0.33	0.33	0.60	0.60	0.60	0.60
27	0.33	0.33	0.33	0.33	0.83	0.83	0.83	0.83
28	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
29	1.00	1.00	0.89	0.89	1.00	1.00	0.80	0.80
30	0.50	0.33	0.33	0.33	0.75	0.50	0.50	0.50
31	1.00	0.50	0.50	0.50	1.00	0.91	0.91	0.91
32	0.50	0.50	0.50	0.50	0.91	0.91	0.91	0.91
33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
34	0.25	0.25	0.25	0.25	0.40	0.40	0.40	0.40
35	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
36	0.25	0.25	0.40	0.40	0.45	0.45	0.40	0.40
37	0.22	0.20	0.25	0.25	0.65	0.60	0.57	0.57
38	0.20	0.18	0.29	0.29	0.58	0.53	0.58	0.58
39	0.17	0.15	0.22	0.22	0.47	0.42	0.63	0.63
40	0.25	0.25	0.43	0.43	0.47	0.47	0.50	0.50

Char	CI				RI			
	Ordered		Unordered		Ordered		Unordered	
	EW	IW	EW	IW	EW	IW	EW	IW
41	0.33	0.33	0.33	0.33	0.50	0.50	0.50	0.50
42	0.33	0.33	0.33	0.33	0.87	0.87	0.87	0.87
43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
44	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
45	0.33	0.25	0.33	0.33	0.75	0.63	0.75	0.75
46	0.25	0.20	0.25	0.25	0.50	0.33	0.50	0.50
47	0.33	0.25	0.33	0.33	0.60	0.40	0.60	0.60
48	0.50	0.33	0.50	0.50	0.67	0.33	0.67	0.67
49	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	0.67	0.67	0.50	0.50	0.92	0.92	0.85	0.85
51	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
52	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
55	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
56	0.50	0.33	0.50	0.50	0.86	0.71	0.86	0.86
57	0.25	0.25	0.25	0.25	0.57	0.57	0.57	0.57
58	1.00	1.00	0.50	0.50	1.00	1.00	0.93	0.93
59	0.33	0.25	0.33	0.33	0.75	0.63	0.75	0.75
60	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00
61	0.33	0.33	0.33	0.33	0.81	0.81	0.68	0.68
62	0.23	0.22	0.36	0.36	0.59	0.56	0.50	0.50
63	0.29	0.29	0.38	0.38	0.67	0.67	0.56	0.56
64	0.38	0.38	0.42	0.42	0.81	0.81	0.68	0.68
65	0.38	0.36	0.38	0.38	0.73	0.70	0.56	0.56
66	0.38	0.36	0.42	0.42	0.75	0.72	0.63	0.63
67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
68	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
69	0.50	0.50	0.50	0.50	0.92	0.92	0.92	0.92
70	0.33	0.25	0.33	0.33	0.88	0.81	0.88	0.88
71	0.33	0.25	0.33	0.33	0.88	0.81	0.88	0.88
72	0.33	0.33	0.33	0.33	0.86	0.86	0.86	0.86
73	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
74	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
76	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
78	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
79	0.75	0.60	0.75	0.75	0.92	0.83	0.92	0.92
80	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00
81	0.80	0.80	1.00	1.00	0.91	0.91	1.00	1.00
82	0.50	0.50	0.50	0.50	0.00	0.00	0.00	0.00
83	0.80	0.80	1.00	1.00	0.91	0.91	1.00	1.00
84	0.14	0.13	0.13	0.13	0.54	0.46	0.46	0.46
85	0.83	0.83	0.83	0.83	0.89	0.89	0.89	0.89

Char	CI				RI			
	Ordered		Unordered		Ordered		Unordered	
	EW	IW	EW	IW	EW	IW	EW	IW
86	0.17	0.17	0.17	0.17	0.44	0.44	0.44	0.44
87	0.83	0.83	0.83	0.83	0.92	0.92	0.92	0.92
88	0.25	0.25	0.25	0.25	0.50	0.50	0.50	0.50
89	0.83	0.83	0.83	0.83	0.93	0.93	0.93	0.93
90	0.20	0.14	0.20	0.20	0.69	0.54	0.69	0.69
91	0.20	0.17	0.20	0.20	0.64	0.55	0.64	0.64
92	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
93	0.33	0.33	0.50	0.50	0.67	0.67	0.83	0.83
94	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
95	0.50	0.33	0.50	0.50	0.88	0.75	0.88	0.88
96	0.25	0.20	0.25	0.25	0.70	0.60	0.70	0.70
97	0.20	0.17	0.14	0.14	0.73	0.67	0.60	0.60
98	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
99	0.67	0.50	0.50	0.50	0.92	0.85	0.85	0.85
100	0.33	0.33	0.25	0.25	0.60	0.60	0.40	0.40
101	0.50	0.50	0.33	0.33	0.75	0.75	0.50	0.50
102	0.75	0.75	0.75	0.75	0.80	0.80	0.80	0.80
103	0.50	0.33	0.33	0.33	0.93	0.86	0.86	0.86
104	0.50	0.50	0.50	0.50	0.92	0.92	0.92	0.92
105	0.33	0.33	0.25	0.25	0.80	0.80	0.70	0.70
106	0.50	0.50	0.50	0.50	0.67	0.67	0.67	0.67
107	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
108	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
109	0.50	0.50	0.50	0.50	0.67	0.67	0.67	0.67
110	0.50	0.50	0.50	0.50	0.67	0.67	0.67	0.67
111	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
112	0.25	0.20	0.20	0.20	0.77	0.69	0.69	0.69
113	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
114	0.50	0.50	0.50	0.50	0.92	0.92	0.92	0.92
115	0.50	0.50	0.33	0.33	0.91	0.91	0.82	0.82
116	1.00	1.00	0.50	0.50	1.00	1.00	0.75	0.75
117	1.00	1.00	0.50	0.50	1.00	1.00	0.50	0.50
118	1.00	1.00	0.50	0.50	1.00	1.00	0.93	0.93

APPENDIX 4:

Synapomorphy list of the ‘OI’ analysis

Appendix 4. Synapomorphy list of the 'OI' analysis

List of synapomorphies for the tree reconstructed from the analysis with 19 characters treated as ordered (additive), under implied weighting regime (*k*=5). '-->' denotes character transformations from ancestral to derived states.

Halotydeus :
No autapomorphies
Caleupodes :
Char. 96: 0 --> 1
Char. 97: 0 --> 1
Tarsocheylus :
Char. 61: 3 --> 2
Char. 65: 2 --> 3
Char. 66: 2 --> 3
Heterocheylus :
Char. 12: 0 --> 1
Char. 41: 1 --> 0
Char. 63: 2 --> 0
Char. 64: 2 --> 1
Char. 65: 1 --> 0
Char. 66: 1 --> 0
Char. 78: 0 --> 1
Char. 80: 0 --> 1
Char. 82: 0 --> 1
Pygmephorus :
Char. 1: 0 --> 1
Char. 2: 1 --> 2
Char. 8: 0 --> 1
Char. 11: 1 --> 0
Char. 13: 0 --> 1
Char. 16: 1 --> 0
Char. 56: 0 --> 1
Char. 60: 0 --> 1
Hirstiella :
Char. 0: 1 --> 0
Char. 2: 2 --> 1
Char. 8: 0 --> 1
Char. 46: 0 --> 1
Char. 60: 0 --> 1
Char. 63: 1 --> 0
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Char. 94: 0 --> 1
Char. 100: 0 --> 1
Tuckerella :
Char. 20: 0 --> 1
Char. 29: 0 --> 3
Char. 36: 1 --> 2
Char. 37: 1 --> 2
Char. 38: 1 --> 2
Char. 39: 1 --> 2
Char. 40: 1 --> 3
Char. 45: 1 --> 0
Char. 62: 2 --> 1
Char. 90: 0 --> 1
Archemyobia :
No autapomorphies
Cryptomyobia :
No autapomorphies
Syringophilus :
Char. 15: 1 --> 0
Char. 19: 1 --> 2
Char. 38: 1 --> 0
Char. 39: 1 --> 0
Char. 41: 1 --> 0
Char. 46: 0 --> 1
Char. 47: 0 --> 1
Char. 48: 0 --> 1
Char. 65: 2 --> 1
Char. 66: 2 --> 1
Eucheyletia :
Char. 34: 0 --> 1
Cheyletiella :
Char. 62: 2 --> 3
Char. 94: 0 --> 1
Storchia :
Char. 0: 1 --> 0
Char. 26: 1 --> 0
Char. 46: 0 --> 1
Char. 47: 0 --> 1
Char. 48: 0 --> 1
Char. 62: 2 --> 1
Raphignathus :
Char. 18: 1 --> 0
Char. 19: 1 --> 0
Char. 29: 0 --> 4
Char. 50: 0 --> 1
Char. 61: 3 --> 2
Char. 91: 1 --> 0
Neognathus :
Char. 62: 2 --> 5
Char. 64: 1 --> 0
Anystis :
Char. 23: 1 --> 2
Walzia :
Char. 28: 1 --> 0
Char. 62: 45 --> 3
Adamystis :
Char. 57: 0 --> 1
Char. 62: 45 --> 2
Char. 63: 23 --> 1
Saxidromus :
Char. 2: 1 --> 0
Char. 6: 1 --> 2
Char. 37: 0 --> 1
Char. 38: 0 --> 1
Char. 92: 0 --> 1
Caeculus :
Char. 14: 0 --> 1
Char. 36: 0 --> 2
Char. 37: 1 --> 2
Char. 38: 0 --> 2
Char. 63: 3 --> 4
Char. 107: 0 --> 1
Char. 108: 0 --> 1
Neocaeculus :
Char. 21: 1 --> 2
Char. 30: 0 --> 1
Char. 64: 1 --> 0
Char. 65: 23 --> 1
Char. 66: 23 --> 1
Char. 70: 0 --> 1
Char. 71: 0 --> 1
Char. 72: 0 --> 1
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Erythracarus :
Char. 7: 0 --> 1

Char. 28: 1 --> 0
Tarsotomus :
Char. 23: 0 --> 1
Char. 84: 0 --> 1
Char. 86: 0 --> 1
Lacteoscythis :
No autapomorphies
Tarsolarkus :
Char. 34: 0 --> 1
Char. 85: 4 --> 5
Char. 87: 4 --> 5
Char. 89: 4 --> 5
Pseudocheylus :
Char. 39: 1 --> 2
Char. 40: 1 --> 3
Char. 41: 1 --> 2
Char. 61: 3 --> 2
Char. 63: 2 --> 1
Char. 112: 1 --> 0
Anoplocheylus :
Char. 35: 1 --> 0
Char. 39: 1 --> 0
Char. 40: 1 --> 0
Char. 63: 2 --> 3
Char. 80: 0 --> 1
Char. 82: 0 --> 1
Neoteneriffiola :
Char. 99: 0 --> 1
Char. 112: 0 --> 1
Austroteneriffia :
No autapomorphies
Pomerantzia :
Char. 66: 2 --> 3
Apomerantzia :
Char. 61: 3 --> 2
Waltydeus :
No autapomorphies
Tanytydeus :
Char. 102: 0 --> 3
Stigmocheylus :
Char. 27: 1 --> 0
Char. 39: 1 --> 0
Char. 40: 1 --> 2
Char. 62: 3 --> 2
Char. 81: 1 --> 3
Char. 83: 1 --> 3
Chulacarus :
Char. 4: 0 --> 1
Char. 7: 0 --> 1
Char. 9: 0 --> 1
Char. 39: 1 --> 0
Char. 62: 3 --> 2
Char. 69: 0 --> 1
Char. 72: 0 --> 1
Node 36 :
No synapomorphies
Node 37 :
Char. 25: 0 --> 1
Char. 26: 1 --> 0
Char. 29: 0 --> 2
Char. 39: 1 --> 0
Char. 52: 0 --> 1
Char. 53: 0 --> 1
Char. 57: 0 --> 1
Char. 62: 2 --> 1
Char. 67: 0 --> 1
Char. 97: 1 --> 0
Node 38 :
Char. 0: 0 --> 1
Char. 62: 3 --> 2
Char. 69: 0 --> 1
Char. 72: 0 --> 1
Char. 114: 1 --> 0
Node 39 :
Char. 19: 1 --> 2
Char. 58: 0 --> 1
Char. 115: 0 --> 1
Char. 118: 0 --> 1
Node 40 :
Char. 61: 1 --> 3
Node 41 :
Char. 27: 0 --> 1
Char. 64: 1 --> 2
Char. 97: 0 --> 1
Char. 103: 0 --> 1
Char. 104: 0 --> 1
Char. 112: 0 --> 1
Node 42 :
Char. 19: 0 --> 1
Char. 62: 45 --> 3
Char. 99: 0 --> 1
Node 43 :
Char. 2: 0 --> 1
Char. 15: 0 --> 1
Char. 16: 0 --> 1
Char. 18: 0 --> 1
Char. 26: 0 --> 1
Char. 28: 0 --> 1
Char. 41: 0 --> 1
Char. 63: 1 --> 2
Char. 64: 0 --> 1
Char. 79: 0 --> 12
Char. 81: 0 --> 1
Char. 83: 0 --> 1
Char. 85: 0 --> 3
Char. 87: 0 --> 3
Char. 89: 0 --> 3
Char. 102: 1 --> 0
Node 44 :
Char. 51: 0 --> 1
Char. 62: 1 --> 0
Char. 65: 2 --> 1
Char. 66: 2 --> 1
Node 45 :
Char. 36: 0 --> 1
Char. 65: 2 --> 1
Char. 66: 2 --> 1
Char. 79: 1 --> 3
Char. 81: 1 --> 4
Char. 83: 1 --> 4
Node 46 :
Char. 5: 1 --> 0
Char. 19: 2 --> 1
Char. 64: 2 --> 1
Char. 105: 1 --> 0
Node 47 :
Char. 2: 1 --> 2
Char. 16: 1 --> 0
Char. 32: 0 --> 1
Char. 45: 0 --> 1
Char. 56: 0 --> 1
Node 48 :
Char. 1: 0 --> 1
Char. 12: 0 --> 1
Char. 13: 0 --> 1
Char. 15: 1 --> 0
Char. 22: 0 --> 1
Char. 24: 0 --> 1
Char. 46: 0 --> 1
Char. 47: 0 --> 1
Char. 48: 0 --> 1

Char. 50: 0 --> 2
Char. 55: 0 --> 1
Char. 64: 2 --> 3
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Char. 91: 1 --> 0
Char. 94: 0 --> 1
Char. 106: 0 --> 1
Node 49 :
Char. 29: 0 --> 5
Node 50 :
Char. 1: 0 --> 1
Char. 64: 1 --> 0
Node 51 :
Char. 21: 0 --> 2
Char. 23: 0 --> 1
Node 52 :
Char. 56: 1 --> 0
Char. 95: 1 --> 0
Char. 96: 1 --> 0
Char. 97: 1 --> 0
Char. 100: 0 --> 1
Char. 101: 0 --> 1
Node 53 :
Char. 37: 1 --> 0
Char. 38: 1 --> 0
Char. 39: 1 --> 0
Char. 45: 1 --> 0
Char. 65: 2 --> 1
Char. 66: 2 --> 1
Node 54 :
Char. 11: 1 --> 2
Char. 21: 0 --> 2
Char. 23: 0 --> 1
Char. 59: 1 --> 0
Char. 68: 0 --> 1
Char. 79: 2 --> 0
Char. 81: 2 --> 0
Char. 83: 2 --> 0
Char. 106: 0 --> 1
Char. 111: 0 --> 1
Node 55 :
Char. 61: 1 --> 0
Char. 63: 23 --> 5
Char. 64: 4 --> 5
Char. 97: 0 --> 1
Node 56 :
Char. 64: 2 --> 4
Char. 66: 3 --> 4
Node 57 :
Char. 64: 1 --> 2
Char. 81: 1 --> 2
Char. 83: 1 --> 2
Char. 91: 1 --> 0
Char. 93: 0 --> 1
Char. 117: 0 --> 1
Node 58 :
Char. 10: 0 --> 1
Char. 50: 0 --> 1
Char. 116: 0 --> 1
Node 59 :
Char. 3: 0 --> 1
Char. 7: 0 --> 1
Char. 15: 1 --> 0
Char. 16: 1 --> 0
Char. 43: 0 --> 1
Char. 44: 0 --> 1
Node 60 :
Char. 21: 0 --> 1
Char. 29: 0 --> 6
Char. 34: 0 --> 1
Char. 35: 1 --> 0
Char. 37: 0 --> 1
Char. 39: 1 --> 2
Char. 40: 1 --> 3
Char. 57: 0 --> 1
Char. 102: 0 --> 2
Node 61 :
Char. 14: 0 --> 1
Char. 65: 4 --> 5
Char. 66: 4 --> 5
Char. 73: 0 --> 1
Char. 74: 0 --> 1
Char. 75: 0 --> 2
Char. 76: 0 --> 2
Char. 90: 0 --> 1
Char. 91: 0 --> 1
Char. 93: 1 --> 0
Node 62 :
Char. 27: 0 --> 1
Char. 37: 0 --> 1
Char. 38: 0 --> 2
Char. 39: 01 --> 2
Char. 102: 0 --> 2
Node 63 :
Char. 36: 0 --> 2
Char. 37: 1 --> 2
Node 64 :
Char. 10: 0 --> 1
Char. 21: 0 --> 2
Char. 23: 0 --> 1
Char. 24: 0 --> 1
Char. 34: 0 --> 1
Char. 36: 0 --> 2
Char. 37: 01 --> 2
Char. 38: 01 --> 2
Char. 62: 3 --> 5
Char. 77: 0 --> 1
Char. 78: 0 --> 1
Node 65 :
Char. 4: 0 --> 1
Char. 9: 0 --> 1
Char. 14: 0 --> 1
Char. 33: 0 --> 1
Char. 42: 0 --> 1
Char. 62: 45 --> 3
Char. 75: 0 --> 1
Char. 76: 0 --> 1
Char. 86: 0 --> 1
Char. 92: 0 --> 1
Char. 100: 0 --> 1
Char. 101: 0 --> 1
Char. 103: 0 --> 1
Char. 104: 0 --> 1
Node 66 :
Char. 9: 0 --> 2
Char. 11: 1 --> 0
Char. 29: 0 --> 1
Char. 30: 0 --> 1
Char. 32: 0 --> 1
Char. 45: 0 --> 1
Char. 46: 0 --> 1
Char. 47: 0 --> 1
Char. 54: 0 --> 1
Char. 57: 0 --> 1
Char. 65: 2 --> 3
Char. 97: 1 --> 0
Char. 98: 0 --> 1
Char. 103: 1 --> 0
Char. 112: 1 --> 0
Node 67 :

Char. 64: 2 --> 3
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Node 68 :
Char. 10: 0 --> 1
Char. 15: 1 --> 0
Char. 16: 1 --> 0
Char. 18: 1 --> 0
Char. 30: 0 --> 1
Char. 49: 0 --> 1
Char. 91: 1 --> 0

APPENDIX 5:

Synapomorphy list of the 'UI' analysis

Appendix 5. Synapomorphy list of the 'UI' analysis

List of synapomorphies for the tree reconstructed from the analysis with all characters treated as unordered (non-additive), under implied weighting regime (*k*=5). '-->' denotes character transformations from ancestral to derived states.

Halotydeus :
No autapomorphies
Caleupodes :
Char. 62: 5 --> 4
Char. 91: 0 --> 1
Char. 93: 1 --> 0
Char. 96: 0 --> 1
Tarsocheylus :
Char. 61: 3 --> 2
Heterocheylus :
Char. 12: 0 --> 1
Char. 41: 1 --> 0
Char. 63: 2 --> 0
Char. 64: 2 --> 1
Char. 78: 0 --> 1
Char. 80: 0 --> 1
Char. 82: 0 --> 1
Char. 96: 0 --> 1
Pygmephorus :
Char. 1: 0 --> 1
Char. 2: 1 --> 2
Char. 8: 0 --> 1
Char. 11: 1 --> 0
Char. 13: 0 --> 1
Char. 16: 1 --> 0
Char. 56: 0 --> 1
Char. 60: 0 --> 1
Hirstiella :
Char. 0: 1 --> 0
Char. 2: 2 --> 1
Char. 8: 0 --> 1
Char. 60: 0 --> 1
Char. 63: 1 --> 0
Char. 84: 0 --> 1
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Char. 94: 0 --> 1
Tuckerella :
Char. 20: 0 --> 1
Char. 29: 0 --> 3
Char. 37: 1 --> 2
Char. 38: 1 --> 2
Char. 39: 1 --> 2
Char. 40: 1 --> 3
Char. 45: 1 --> 0
Char. 62: 2 --> 1
Char. 90: 0 --> 1
Archemyobia :
No autapomorphies
Cryptomyobia :
Char. 63: 1 --> 2
Syringophilus :
Char. 29: 0 --> 5
Char. 38: 1 --> 0
Char. 39: 1 --> 0
Char. 41: 1 --> 0
Eucheyletia :
Char. 34: 0 --> 1
Cheyletiella :
Char. 29: 0 --> 5
Char. 62: 2 --> 3
Char. 94: 0 --> 1
Storchia :
Char. 0: 1 --> 0
Char. 26: 1 --> 0
Char. 47: 0 --> 1
Char. 48: 0 --> 1
Char. 62: 2 --> 1
Raphignathus :
Char. 18: 1 --> 0
Char. 19: 1 --> 0
Char. 29: 0 --> 4
Char. 50: 0 --> 1
Char. 61: 3 --> 2
Char. 91: 1 --> 0
Neognathus :
Char. 62: 2 --> 5
Char. 64: 1 --> 0
Anystis :
No autapomorphies
Walzia :
Char. 62: 5 --> 3
Adamystis :
Char. 57: 0 --> 1
Char. 62: 5 --> 2
Saxidromus :
Char. 2: 1 --> 0
Char. 6: 1 --> 2
Char. 37: 0 --> 1
Char. 38: 0 --> 1
Char. 63: 1 --> 3
Char. 65: 3 --> 4
Char. 92: 0 --> 1
Caeculus :
Char. 36: 0 --> 2
Char. 38: 0 --> 2
Char. 107: 0 --> 1
Char. 108: 0 --> 1
Neocaeculus :
Char. 14: 1 --> 0
Char. 30: 0 --> 1
Char. 64: 1 --> 0
Char. 65: 3 --> 1
Char. 70: 0 --> 1
Char. 71: 0 --> 1
Char. 72: 0 --> 1
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Erythracarus :
Char. 7: 0 --> 1
Char. 28: 1 --> 0
Tarsotomus :
Char. 23: 0 --> 1
Char. 86: 0 --> 1
Lacteoscythis :
No autapomorphies
Tarsolarkus :
Char. 34: 0 --> 1
Char. 85: 4 --> 5
Char. 87: 4 --> 5

Char. 89: 4 --> 5
Pseudocheylus :
Char. 39: 0 --> 2
Char. 41: 1 --> 2
Char. 61: 3 --> 2
Char. 112: 1 --> 0
Anoplocheylus :
Char. 35: 1 --> 0
Char. 80: 0 --> 1
Char. 82: 0 --> 1
Neoteneriffiola :
Char. 99: 0 --> 1
Char. 112: 0 --> 1
Austroteneriffia :
No autapomorphies
Pomerantzia :
No autapomorphies
Apomerantzia :
Char. 61: 3 --> 2
Char. 63: 2 --> 3
Waltydeus :
No autapomorphies
Tanytydeus :
Char. 102: 0 --> 3
Stigmocheylus :
Char. 40: 1 --> 2
Char. 63: 2 --> 3
Char. 81: 1 --> 3
Char. 83: 1 --> 3
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Chulacarus :
Char. 4: 0 --> 1
Char. 7: 0 --> 1
Char. 9: 0 --> 1
Char. 14: 1 --> 0
Char. 69: 0 --> 1
Char. 70: 0 --> 1
Char. 71: 0 --> 1
Char. 72: 0 --> 1
Char. 105: 1 --> 0
Node 36 :
No synapomorphies
Node 37 :
Char. 14: 1 --> 0
Char. 25: 0 --> 1
Char. 26: 1 --> 0
Char. 29: 0 --> 2
Char. 52: 0 --> 1
Char. 53: 0 --> 1
Char. 57: 0 --> 1
Char. 67: 0 --> 1
Node 38 :
Char. 0: 0 --> 1
Char. 69: 0 --> 1
Char. 70: 0 --> 1
Char. 71: 0 --> 1
Char. 72: 0 --> 1
Char. 114: 1 --> 0
Node 39 :
Char. 58: 0 --> 1
Char. 87: 3 --> 1
Char. 89: 3 --> 1
Char. 113: 0 --> 1
Char. 115: 0 --> 1
Char. 118: 0 --> 1
Node 40 :
Char. 27: 0 --> 1
Node 41 :
Char. 31: 1 --> 0
Char. 61: 1 --> 3
Char. 103: 0 --> 1
Char. 104: 0 --> 1
Char. 112: 0 --> 1
Node 42 :
Char. 10: 1 --> 0
Char. 19: 0 --> 1
Char. 50: 1 --> 0
Char. 62: 5 --> 2
Char. 65: 3 --> 2
Char. 99: 0 --> 1
Char. 116: 1 --> 0
Node 43 :
Char. 64: 5 --> 1
Char. 81: 2 --> 1
Char. 83: 2 --> 1
Node 44 :
Char. 17: 1 --> 0
Char. 90: 0 --> 1
Char. 91: 0 --> 1
Char. 93: 1 --> 0
Node 45 :
Char. 14: 0 --> 1
Char. 18: 0 --> 1
Char. 63: 1 --> 2
Node 46 :
Char. 39: 1 --> 0
Char. 59: 0 --> 1
Char. 79: 0 --> 2
Char. 81: 0 --> 2
Char. 83: 0 --> 2
Node 47 :
Char. 2: 0 --> 1
Char. 6: 0 --> 1
Char. 10: 0 --> 1
Char. 26: 0 --> 1
Char. 31: 0 --> 1
Char. 50: 0 --> 1
Char. 64: 0 --> 5
Char. 66: 2 --> 4
Char. 102: 1 --> 0
Char. 105: 0 --> 1
Node 48 :
Char. 51: 0 --> 1
Node 49 :
Char. 23: 1 --> 0
Char. 79: 1 --> 3
Char. 81: 1 --> 4
Char. 83: 1 --> 4
Node 50 :
Char. 11: 1 --> 0
Char. 56: 0 --> 1
Char. 95: 0 --> 1
Char. 96: 0 --> 1
Char. 97: 0 --> 1
Node 51 :
Char. 37: 0 --> 1
Char. 38: 0 --> 1
Char. 39: 0 --> 1
Char. 45: 0 --> 1
Node 52 :
Char. 2: 1 --> 2
Char. 5: 1 --> 0
Char. 16: 1 --> 0
Char. 32: 0 --> 1
Char. 64: 2 --> 1
Char. 87: 1 --> 2
Char. 89: 1 --> 2
Char. 90: 1 --> 0
Char. 105: 1 --> 0
Node 53 :

Char. 5: 0 --> 1
Char. 11: 0 --> 1
Char. 12: 0 --> 1
Char. 13: 0 --> 1
Char. 14: 1 --> 0
Char. 21: 2 --> 0
Char. 22: 0 --> 1
Char. 24: 0 --> 1
Char. 50: 0 --> 2
Char. 55: 0 --> 1
Char. 64: 0 --> 3
Char. 84: 0 --> 1
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Char. 91: 1 --> 0
Char. 94: 0 --> 1
Char. 105: 0 --> 1
Char. 106: 0 --> 1
Node 54 :
Char. 15: 1 --> 0
Char. 19: 1 --> 2
Char. 47: 0 --> 1
Char. 48: 0 --> 1
Node 55 :
Char. 1: 0 --> 1
Char. 64: 1 --> 0
Node 56 :
No synapomorphies
Node 57 :
No synapomorphies
Node 58 :
Char. 11: 1 --> 2
Char. 21: 0 --> 2
Char. 40: 1 --> 3
Char. 63: 1 --> 5
Char. 65: 3 --> 4
Char. 68: 0 --> 1
Char. 106: 0 --> 1
Char. 111: 0 --> 1
Node 59 :
Char. 3: 0 --> 1
Char. 7: 0 --> 1
Char. 43: 0 --> 1
Char. 44: 0 --> 1
Char. 64: 5 --> 4
Node 60 :
Char. 6: 1 --> 0
Char. 29: 0 --> 6
Char. 34: 0 --> 1
Char. 35: 1 --> 0
Char. 39: 0 --> 2
Char. 40: 1 --> 3
Char. 57: 0 --> 1
Char. 102: 0 --> 2
Char. 109: 0 --> 1
Char. 110: 0 --> 1
Node 61 :
Char. 61: 1 --> 0
Char. 63: 2 --> 5
Char. 65: 3 --> 5
Char. 73: 0 --> 1
Char. 74: 0 --> 1
Char. 75: 0 --> 2
Char. 76: 0 --> 2
Char. 85: 3 --> 4
Char. 87: 3 --> 4
Char. 89: 3 --> 4
Char. 97: 0 --> 1
Node 62 :
Char. 27: 0 --> 1
Char. 38: 0 --> 2
Char. 39: 0 --> 2
Char. 40: 1 --> 3
Char. 41: 1 --> 2
Char. 102: 0 --> 2
Node 63 :
Char. 36: 0 --> 2
Node 64 :
Char. 10: 0 --> 1
Char. 24: 0 --> 1
Char. 34: 0 --> 1
Char. 36: 0 --> 2
Char. 37: 0 --> 2
Char. 38: 0 --> 2
Char. 62: 2 --> 5
Char. 77: 0 --> 1
Char. 78: 0 --> 1
Char. 95: 0 --> 1
Char. 96: 0 --> 1
Node 65 :
Char. 4: 0 --> 1
Char. 9: 0 --> 1
Char. 33: 0 --> 1
Char. 42: 0 --> 1
Char. 62: 5 --> 3
Char. 64: 5 --> 2
Char. 75: 0 --> 1
Char. 76: 0 --> 1
Char. 86: 0 --> 1
Char. 92: 0 --> 1
Char. 100: 0 --> 1
Char. 101: 0 --> 1
Char. 103: 0 --> 1
Char. 104: 0 --> 1
Char. 109: 0 --> 1
Char. 110: 0 --> 1
Node 66 :
Char. 9: 0 --> 2
Char. 11: 1 --> 0
Char. 29: 0 --> 1
Char. 32: 0 --> 1
Char. 45: 0 --> 1
Char. 46: 0 --> 1
Char. 47: 0 --> 1
Char. 54: 0 --> 1
Char. 57: 0 --> 1
Char. 65: 2 --> 3
Char. 86: 0 --> 1
Char. 88: 0 --> 1
Char. 98: 0 --> 1
Char. 103: 1 --> 0
Char. 112: 1 --> 0
Node 67 :
Char. 6: 1 --> 0
Char. 30: 0 --> 1
Char. 39: 0 --> 1
Char. 62: 2 --> 3
Char. 90: 1 --> 0
Node 68 :
Char. 10: 0 --> 1
Char. 14: 1 --> 0
Char. 15: 1 --> 0
Char. 16: 1 --> 0
Char. 18: 1 --> 0
Char. 49: 0 --> 1
Char. 59: 0 --> 1
Char. 61: 3 --> 1
Char. 70: 0 --> 1
Char. 71: 0 --> 1
Char. 91: 1 --> 0

VITA

Mr. Marut Fuangarworn was born on 23 August 1978. He finished secondary school in 1996 from Tharua 'Nittayanukul' School, Phra Nakhon Si Ayutthaya province, and completed Bachelor's degree (Biology) in 2000 and Master's degree (Zoology) in 2003 from Chulalongkorn University, and had been awarded the Development and Promotion of Science and Technology Talent Project of Thailand (DPST) Scholarship during 1997-2003. He was employed as a teaching Assistant (2002-2003), research Assistant (2004-2005), and a lecture (2005-present) at the Department of Biology, Faculty of Science, Chulalongkorn University. Mr. Marut Fuangarworn received a Ph.D. in Zoology from the same institute in 2016.