

Two new species of *Alloscopus* from caves in Thailand, with a key to world species of the genus (Hexapoda: Collembola)

Sopark Jantarit^{1*} & Tawin Sangsiri²

Abstract. Two new cave species of the Collembola genus *Alloscopus* are described from southern Thailand: *A. whitteni* from Phang Nga province and *A. namtip* from Surat Thani province. Both species are characterised by the absence of eyes and mucronal spine, presence of PAO, two rows of smooth chaetae on manubrium and dental spines. The two new species are different by number of macrochaetae on 'A' series of head and Th.II, labial basis chaetotaxy, number of labral papillae, number of chaetae on posterior ventral tube, inter teeth of claw and trochanteral spines. They also differ in rows of smooth chaetae on tibiotarsus and lateral anal valve chaetae. Antennal morphological types were thoroughly observed for the first time in the genus, of which 13 types are recognised and homologised with recent antennal chaetal categories for *Verhoeffiella*. The complete body chaetotaxic pattern and a key to the world species of the genus are also provided.

Key words. antennal chaetotaxy, Heteromurinae, subterranean, taxonomy, southern Thailand

INTRODUCTION

The genus *Alloscopus* Börner, 1906 is widespread in the pantropical region in both edaphic and subterranean environments. It is characterised by having four antennal segments with Ant. I subdivided, and annulation of Ant. IV, head dorsal macrochaetotaxy with S0 present and S2 absent, presence of PAO and dental spines, manubrium with rows of smooth chaetae (Cipola et al., 2016; Mari Mutt, 1977, 1982, 1985). Globally, only 10 species have been described (Bellinger et al., 1996–2020, Cipola et al., 2016). In Thailand, two species have been reported: *A. tetricanthus* Börner, 1906 and *A. thailandensis* Mari Mutt, 1985, both from forests in northern Thailand (Cipola et al., 2016, Mari Mutt, 1985, Jantarit et al., 2016). Cave *Alloscopus* was first reported from Ecuador viz., *A. cf. strebeli* Winter, 1966 (Mari Mutt, 1982), although this does not appear to be a subterranean species. Deharveng & Bedos (1988) also reported *Alloscopus* from a cave in Phang Nga province of southern Thailand, but they did not give taxonomic details. Since the last species description of *A. fallax* Yoshii & Suhardjono, 1992, there has been no taxonomic progress on the group for more than two decades. Recently, a checklist and a key to species of the genus were made by Cipola et al. (2016) based on literature. In this study, we describe two

new species of *Alloscopus* from caves in southern Thailand and several morphological characters are introduced for the genus. Complete antennal chaetae on both dorsal and ventral sides are observed in detail and homologised with recent antennal chaetal categories for the Heteromurinae in *Verhoeffiella* (cf. Lukić et al., 2015, 2018). In addition, the complete body chaetotaxic pattern, a character which is often overlooked in previous studies, including macrochaetae, mesochaetae, microchaetae, S-chaetae and trichobothrium are carefully investigated and homologised. An updated key to world species of the genus is also provided.

MATERIAL AND METHODS

Specimens were collected throughout Thailand by using aspirator, funnel Berlese extraction and pitfall traps. They were stored in 95% ethanol. Specimens were mounted on slides in Marc Andre II medium after clearing in lactic acid. Morphological characters were examined using Leica DM1000 LED microscope with phase-contrast. Drawings were made using a drawing tube, and figures were improved with Illustrator CC (Adobe Inc.). Photos of the habitus were taken by a Canon EOS 6D with Canon EF 100mm f/2.8 Macro lens and optimised by Helicon Remote software. Stacking was performed under Helicon Focus 6.

Abbreviations used in the descriptions. asl, above sea level; Ant., antennal segment; Th., thoracic segment; Abd., abdominal segment; mac, macrochaeta; mes, mesochaeta; mic, microchaeta; sens or S-chaeta, 'sensillum' or 'sensory seta' of various authors; ms, very short, thick, pointed S-chaetae, tric (in text), trichobothrium; tita, tibiotarsus; psp, pseudopore.

¹Excellence Center for Biodiversity of Peninsular Thailand, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, 90110, Thailand. Email: fugthong_dajj@yahoo.com (*corresponding author)

²Department of Biology, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla, Thailand

Type material deposition. Collection of the Princess Maha Chakri Sirindhorn Natural History Museum (NHM-PSU), Faculty of Science, Prince of Songkla University (Hat Yai, Songkhla, Thailand).

Terminology. Dorsal body chaetotaxy follows Szeptycki (1979), and Zhang et al. (2019). Mac formula on tergite are marked in dotted line of Fig. 4. We use the notation of Mari Mutt (1979), Ren et al. (2018) and Soto-Adames (2008) for groups of head chaetae; and Fjellberg (1999) for the labial palp. Labial chaetae notation follows Gisin (1967), with the upper-case letter for ciliated and lower-case letter for smooth chaetae. We follow and match the notation system of Lukić et al. (2015, 2018) for antennal chaetae. The number of dorsal macrochaetae is given from head Abd.VI. Symbols representing chaetal types used in the figures are as follows: large circle = macro; cross = tric; circle with a slash = psp.

TAXONOMY

Family Entomobryidae Schäffer, 1896

Subfamily Heteromurinae sensu Zhang & Deharveng, 2015

Tribus Heteromurini Absolon & Ksenemann, 1942

Alloscopus Börner, 1906

Alloscopus whitteni, new species

(Figs. 1–4A, 5, 6)

Material examined. Holotype male on slides: sample # THA_SJ_PNA03; Thailand: Phang Nga Province: Mueang district, Tham [cave] Tapan, 8°27'17.3"S 98°31'39.5"E, 32 m asl, dark zone of cave, by aspirator, coll. S. Jantarit, 25 April 2016. Paratypes on slides: fourteen samples, 1 male, 3 females and 10 ex., by aspirator (4 specimens) and funnel Berlese extraction (10 specimens), same data as holotype.

Description. Habitus (Fig. 1). Medium size Entomobryidae. Body length (head+trunk) up to 1.7 mm (holotype 1.42 mm). Scales present on antennae I and II, on both sides of head, body, legs (coxa to femur), ventral tube and furca. Color: pale yellow to whitish in alcohol, with orange dot pigments (from light to dark) on Ant. I–II, Ant. III basally, head, body (except intersegmental membrane), legs (coxae to femur) and manubrium; presence of dark red ocular patch and PAO. Antennal length shorter than body. Body slender, not bent nor humped at level of Th. II.

Pseudopores (Figs. 2A, B, D, 3K, 4A, 5A, 6C). Present as round flat disks, smaller than mac sockets, present on various parts of body: antennae, head, tergites, coxae and manubrium. On antennae, psp located on tip of antennal segments II and III (2–3 on Ant. II and 2 on Ant. III). On head, 1+1 psp located laterally anterior to PAO. On tergites, 1+1 psp close to axis from Th. II to Abd. IV. On coxae, 1+1



Fig. 1. *Alloscopus whitteni*, new species. Habitus in alcohol with orange dot pigment variation in the population.

psp on coxa I and II, III not seen, located close to longitudinal rows of chaetae. On manubrium, 2+2 dorso-apical ones.

Antennae (Figs. 1, 2A–E). Antennae rather long, about 1.9–2.3 times longer than cephalic diagonal and 0.36–0.44 times as long as body (head + trunk) (N=6). Ant. I subdivided, Ant. III (sometimes not clearly seen) and IV annulated, except $\frac{1}{4}$ proximal part of Ant. III and tip of Ant. IV (Fig. 2). Antennal segment ratio as I(a+b):II:III:IV = 1:1.10: 1.41: 2.0 (holotype). Antennal chaetae very diversified with ordinary chaetae, S-chaetae (described below) and scales. Scales oval to rounded, of medium size, with dense cover of short spicules arranged in more or less regular longitudinal lines; numerous dorsally on Ant. Ib and Ant. II, few on Ant. Ia dorsally; absent on Ant. III and IV (Fig. 2A, C).

Sense and sens-like chaetae present on all antennal segments, of 13 morphological types in following categories (sensu Lukić et al., 2015, 2018; Fig. 2A–E):

1) Type a—ciliated mac (20–22 μ m), dorsally on Ant. Ib and II, shorter than those of head and body, number not counted (Fig. 2Ea).

2) Type b—thick ciliated mes ($\approx 15 \mu\text{m}$), on all antennal segments of both sides but dorsally on Ant. Ia. number not counted (Fig. 2Eb).

3) Type c—thin ciliated mes ($12\text{--}14 \mu\text{m}$), less ciliated than type b, on Ant. III and IV of both sides, number not counted (Fig. 2Ec).

4) Type d—pointed smooth mac ($17\text{--}25 \mu\text{m}$), ventrally on Ant. Ib (6–18), both sides of Ant. II (18–26), Ant. III (22–24) and Ant. IV (10–12) (Fig. 2Ed).

5) Type e—pointed smooth mes ($15\text{--}18 \mu\text{m}$), ventrally on Ant. Ia (4 or 5), Ib (2–5), both sides of Ant. III (9–11) and Ant. IV (15–20) (Fig. 2Ee).

6) Type f—acuminate, dark, smooth mes, thin, basally thinner than type e mes, straight and inserted perpendicular to integument ($12\text{--}14 \mu\text{m}$), ventrally on Ant. Ib (3–7), Ant. II (3–6), both side of Ant. III (18–23) and Ant. IV (75–115) (Fig. 2Ef).

7) Type g—pointed smooth mic ($5\text{--}6 \mu\text{m}$), dorsally on Ant. Ia (2 or 3), both sides of Ant. Ib (4 or 5), Ant. II (5–6) and Ant. III (3) basally (Fig. 2Eg).

8) Type h—swollen S-chaetae ($5\text{--}8 \mu\text{m}$), dorsally on Ant. III apically (5), both sides apically on Ant. Ib (3), II (3) (Fig. 2Eh).

9) Type i—thick subcylindrical S-chaetae ($5\text{--}9 \mu\text{m}$), on all antennal segments, ventrally on Ant. Ib (3–5), dorso-distally on Ant. III (1) and Ant. IV (1 or 2), never grouped as sensorial fields (sensu Lukić et al., 2015, 2018) in Thai species (Fig. 2Ei).

10) Type j—short, pointed, rather bent S-chaetae ($\approx 4 \mu\text{m}$), ventro-distally on Ant. II (1–2) and dorso-distally on Ant. III (1) (Fig. 2Ej).

11) Type k—thin, short, rather broad basally, hyaline S-chaetae ($6\text{--}7 \mu\text{m}$), ventrally on Ant. Ib (3–5), both sides of Ant. III (4 or 5) and Ant. IV (7 or 8) (Fig. 2Ek).

12) Type l—thin, long, hyaline, blunt at tip, S-chaetae ($10\text{--}14 \mu\text{m}$), both sides on Ant. Ib (6–8), Ant. II (10–12), Ant. III (25–35) and Ant. IV (50–80) (Fig. 2El).

13) Type m (new type)—acuminate, smooth mic, similar to type f but curved, hyaline and thin S-chaetae ($\approx 8 \mu\text{m}$), both sides of Ant. II (5–7), and Ant. III (3–5) (Fig. 2Em).

Ant. I subdivided into Ia and Ib. Ant. Ia always shorter than Ib. Ant. Ia dorsally with 2 basal mic (type g) and few thick ciliated chaetae (type b); ventrally with basal mic (type g) and 4 pointed smooth mes (type e). Ant. Ib dorsally densely covered with scales and ciliated chaetae (type a and b), with smooth basal mic (type g); apical row with 3 pointed smooth mic (type g), 1 swollen S-chaetae (type h), and 1 thin, long, hyaline S-chaetae (type l). Ventrally dense cover with ciliated

chaetae (type a and b) mixed with 8 types of S-chaetae (type d–i, k, l) variously interspersed. Ant. II dorsally with scales mixed with many thick ciliated chaetae (type a and b), and 10 pointed smooth mac (type d), basally with few pointed smooth mic (type g), distally with 5 S-chaetae (type l) and 1 swollen S-chaetae (type h), and 6 acuminate, smooth mic (type m). Ventrally dense cover with thick ciliated mes (type b) with 3 pointed smooth mic (type g) basally, medial to distal part mixed with 6 pointed smooth mac (type d), 2 swollen S-chaetae (type h), 1–3 short, pointed S-chaetae (type j), 6 thin, long, hyaline S-chaetae (type l), and 1 acuminate, smooth mic (type m). Ant. III without scale, chaetotaxy with tendency to form whorls of chaetae. Dorsally dense cover with many thick ciliated mes (type b and c) with pointed smooth mic (type g) basally, mixed with 7 types of S-chaetae (type d–f, h, i, k, l) variously interspersed, and at least 1 chaeta of 3 types of S-chaetae distally (type g, j, m). Ventrally dense cover with many thick ciliated mes (type b) with 2 pointed smooth mic (type g) basally, mixed with 6 types of S-chaetae (type d–f, k–m) variously interspersed. Ant. III organ with 5 sens; sens 1 (type m) longest, hyaline and acuminate; sens 4 (type i) hyaline, rather long, blunt apically; sens 5 (type j) dark, shortest; sens 2 and 3 (type h) swollen, not clearly seen in most specimens (Fig. 2A, 3L). Antennae sometimes asymmetrical, because of fusion of Ant. III and IV. Ant. III distal chaetae and Ant. IV ventrally strongly modified when Ant. III and IV fused together (Fig. 2C, D). Ant. IV annulated except in tip, without apical bulb (Fig. 2A–D), chaetotaxy with tendency to form whorls of chaetae. Dorsally dense cover with many thick ciliated mes (type b and c) mixed with 6 types of S-chaetae (type d–f, i, k, l) variously interspersed. Ventrally dense cover with many thick ciliated mes (type b and c) mixed with 5 types of S-chaetae (type d–f, k, l) variously interspersed. Pin projection on apex not seen. Subapical organite not distinctly knobbed, slightly enlarged apically, inserted dorsally near tip of Ant. IV with apical guard chaetae (Figs. 2A, 3M).

Mouthparts (Fig. 3A–G). Prelabral and labral chaetae 4/5, 5, 4, all smooth, acuminate, subequal; except chaetae of first row slightly longer than others (Fig. 3E). Four labral papillae anteriorly, conical, minute (Fig. 3E, F). Ventral complex of labrum with 2 slightly asymmetrical multi-toothed combs and a pair of thin, sinuous, unequal tubules below (Fig. 3G). Maxillary outer lobe with 1 basal chaeta, simple maxillary palp, 4 sublobal hairs, all smooth (Fig. 3C). Labial palp with 5 smooth, acuminate proximal chaetae and 5 papillae (A=0, B=5, C=0, D=4, E=5) like those described by Fjellberg (1999) for Entomobryidae, and hypostomal chaeta (H) with 2 accessorial chaetae (h1 and h2). Lateral process subcylindrical apically, not reaching apex of papilla E (Fig. 3B). Mandible asymmetrical (right with 5 and left with 4 teeth) on all examined specimens. Molar plate with 3 strong pointed basal tooth, and 3 or 4 smaller inner distal teeth (Fig. 3D). Maxilla with strong tridentate claw, 3 or 4 stout ciliated lamellae and well-developed each side, 3 or 4 sharp beaks opposite to maxilla capitulum, and thin rod, long, bent inside (Fig. 3A).

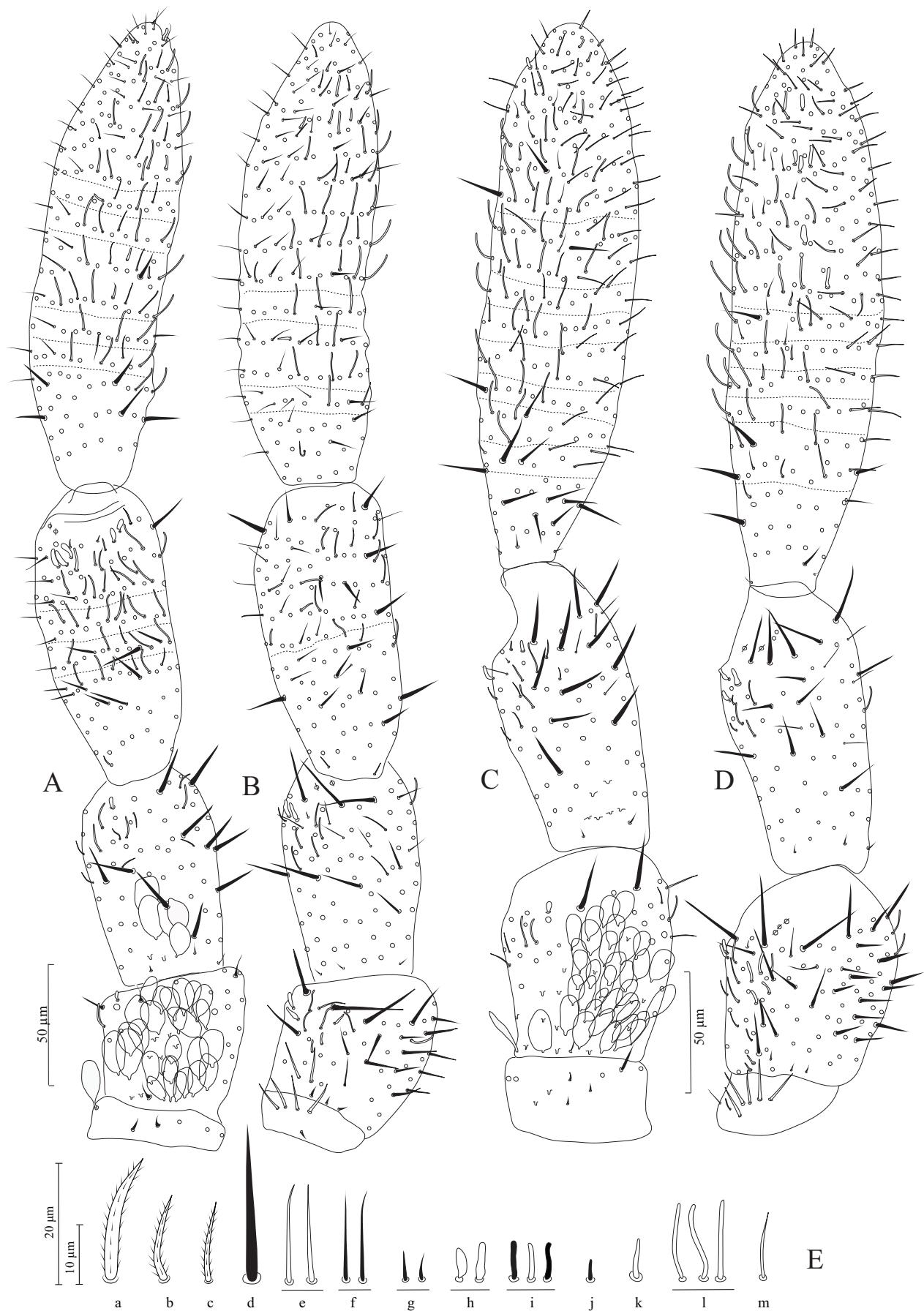


Fig. 2. *Alloscopus whitteni*, new species. A, dorsal side of normal antennal segments; B, ventral side of normal antennal segments; C, dorsal side of antennal segments when Ant. III and IV fused together; D, ventral side of antennal segments when Ant. III and IV fused together; E, antennal chaetal type; type-a to type-m (type a-c are marked as circles).

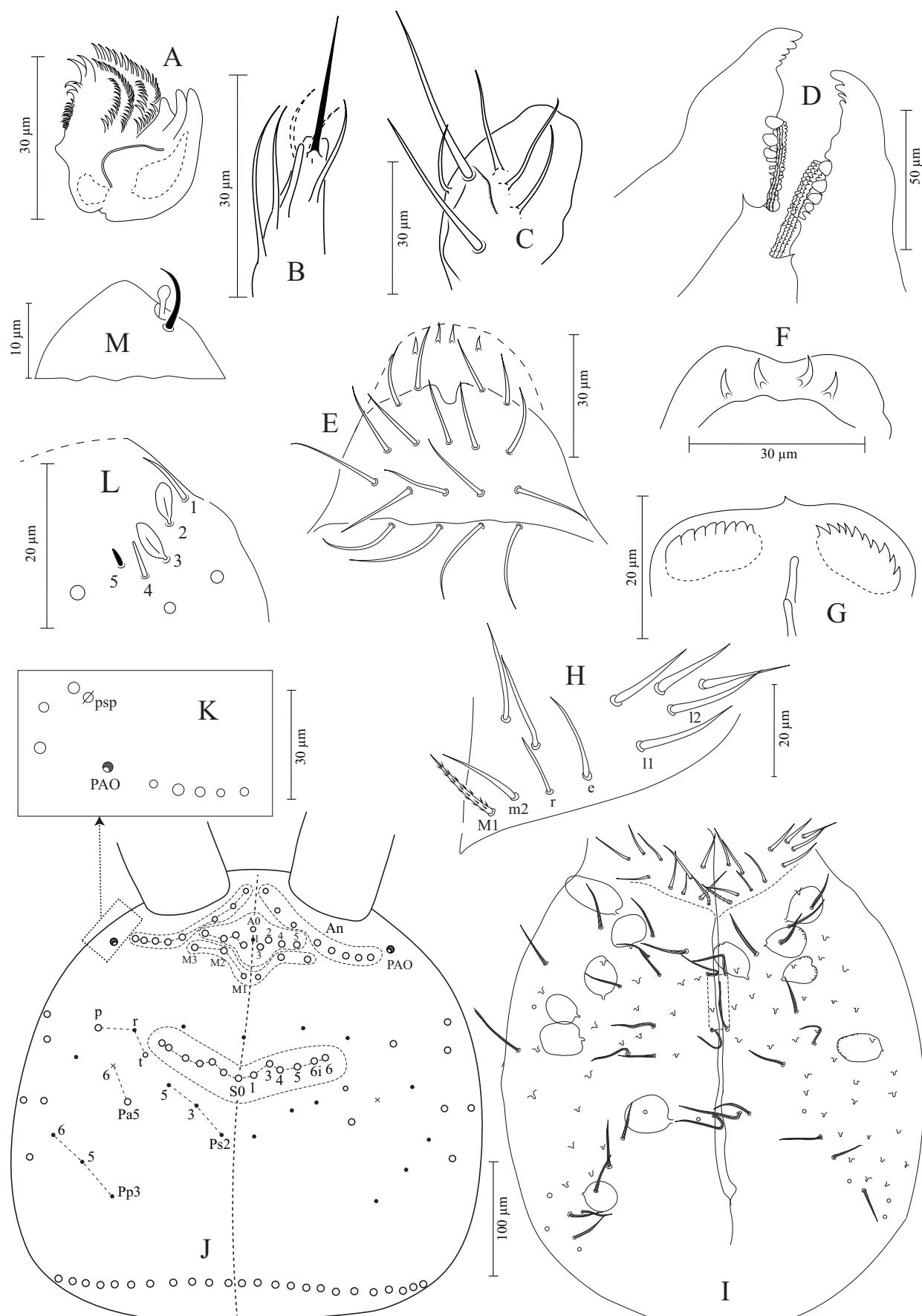


Fig. 3. *Alloscopus whitteni*, new species. A, maxilla, right side of dorsal view; B, papillae E of labial palp (left side); C, outer maxillary lobe (left side); D, mandible; E, prelabral, labral chaetae and labral papillae; F, labral papillae; G, ventral complex of labrum; H, labial basis (right side); I, head ventral chaetotaxy; J, head dorsal chaetotaxy; K, PAO and adjacent areas; L, Ant. III organ of right side; M, subapical organite with apical guard chaetae on the tip of Ant. IV.

Ventral head chaetotaxy (Fig. 3H, I). Chaetae of labial basis as $M_1m_2rel_1(l_1)$, chaetae M_1 ciliated, r shortest, chaetae M_1 , m_2 , e , l_1 and l_2 subequal, l_2 sometimes not seen. Postlabial quadrangle (PLQ) with 2+2 weakly serrated chaetae. Dense cover of scales and weakly serrated chaetae illustrated in Fig. 3I.

Dorsal head chaetotaxy (Figs. 3J, K, 4A). Dorsal cephalic chaetotaxy with stable chaetae arrangement as in Figs. 3J and 4A. Head 'An' series with 8+8 chaetae (5+5 mac and 3+3 mes for anteriomost), 'A' series with 5+5 mac (A0, A2–A5), A1 as mic; 'M' series with 3+3 mac (M1–M3), sutural mac with 7+7 mac (S0, S1, S3–6, S6i, S2 absent), between 'M' and 'S' series with 3 unnamed mic; interocular series with 3+3 chaetae (p as mac, t as mes and r as mic); postsutural area with 3+3 mic (Ps2–3 and Ps5); postoccipital anterior arae with 1+1 mac (Pa5), 1+1 short cephalic tric (Pa6) and 1+1 unnamed mic laterally; postoccipital posterior area with 3+3 mic (Pp3 and Pp5–6); head laterally with 5+5 unnamed mac. Eyes absent. PAO small, located just below antennal mac, rounded with small semicircle inside (Figs. 3J, K, 4A).

Tergites (Figs. 4A, 5F). Dorsal chaetotaxy illustrated in Fig. 4A. Formula from Th.II–Abd.V; psp formula as 1,1/1,1,1,1,0; tric formula as 0,0/0,2,3,2,0; ms formula as 1,0/1,0,1,0,0; sens formula as 2,2/1,3,3,3,3; mac formula as 11,7/3,1,3,6,5 (dotted line in Fig. 4A). Mac arrangement stable; multiplets sensu Szeptycki (1979) present only anterior on Th.II. Th. II with 5+5 anterior central mac (a5, m2, m4, m4i, m4p), 5+5 posterior mac (p1–3, p5, p2e), and 1+1 antero-lateral mac (m6p); with 7+7 mic (m1, m5, 1p2, p4, p6e, 6pi, p6). Th.III with 6+6 central mac (p1–3, p1a, a4–5) and 1+1 lateral mac (a6); 9+9 mic (a2, m1, m4–5, p4–6, p2a, m6p) and 4+4 mes (a7, m7, m6, p6i). Abd.I with 3+3 central mac (m2–4) and 8+8 mic (a1–3, a5–6, m5–6, p6). Abd.II with 1+1 central mac (m3); 12+12 chaetae (a1–3, a6–7, m3e, m5–6, p4, p6 as mic; a5 and m2 as tric). Abd.III with 1+1 central mac (m3) and 2+2 lateral mac (pm6, p6); 13+13 chaetae (a1–3, a6–7, m3e, m4, p4–5 as mic; p6 as mes; a5, m2, m5 as tric). Abd.IV with 2+2 central mac (A6, B5); 4+4 lateral mac (E1, E3, E4, Ee); with 20+20 chaetae (A2–3, A5, B2, C1, T1, T5, D1–2 as mic; C4, T3, T6–7, D3, D3p, E4p, F1–2 as mes; T2 and T4 as tric) with 1+1 unnamed mic posteriorly and 3 lateral mac; and at least 12+12 S-like chaetae. Abd. V with 3+3 central mac (p1, m2–3) and 3+3 lateral mac (m5, m5a, a6); with 11+11 chaetae (a1, a3, a5, p1p, 3pi, 3pe, 5pi as mic, p3–5, ap6 as mes). Abd. VI with at least 12 mac mixed with mes. Each anal valve with 3+3 smooth chaetae, several serrated mes mixed with mac, mic not seen (Fig. 5F).

Legs (Fig. 5A–D). Legs with ordinary ciliated chaetae of various lengths (mes to mac), smooth chaetae and scales, mic not seen. Scales covered from coxa to femur. Tita of leg III slightly longer than tita of legs I and II. Subcoxa of leg I with 3+3 mac, subcoxa of leg II with a row of 8+8 mac and subcoxa of leg III with 5–6+5–6 mac and 2+2 mes (Fig. 5A). Coxa of leg I with 1 proximal psp and 4 or 5 mac posteriorly; coxa of leg II with 5–7 mac in anterior row,

4–5 mac in posterior row and 1 proximal psp in between; coxa of leg III with 8+11 chaetae (3–5 mac) in anterior row, psp not seen (Fig. 5A). Trochanteral organ with 12–20 smooth, straight, unequal spine-like chaetae (Fig. 5B). Distal whorl of tita with 10–12 subequal ciliated chaetae, irregularly arranged, and thin, acuminate, smooth dorso-apical tenent hair (Fig. 5C, D). Tita with 2 rows of long smooth chaetae internally, tita I and II with 6–8 smooth chaetae on each row, tita III with 10–12 smooth chaetae on each row and one ciliated mac interno-proximally (Fig. 5D). Ventro-distal smooth chaeta of tita III thick, erected, pointed. Pretarsal mic minute on anterior and posterior sides (1.0–1.5 μm) (Fig. 5C, D). Ungues outer edge with proximal tooth; inner side with pair of basal teeth at about 40–44% of inner edge from basis. Unguiculus about half as long as inner edge of unguis, slightly swollen baso-internally, pointed apically, with large outer tooth (under light microscope), devoid of inner tooth (Fig. 5C, D).

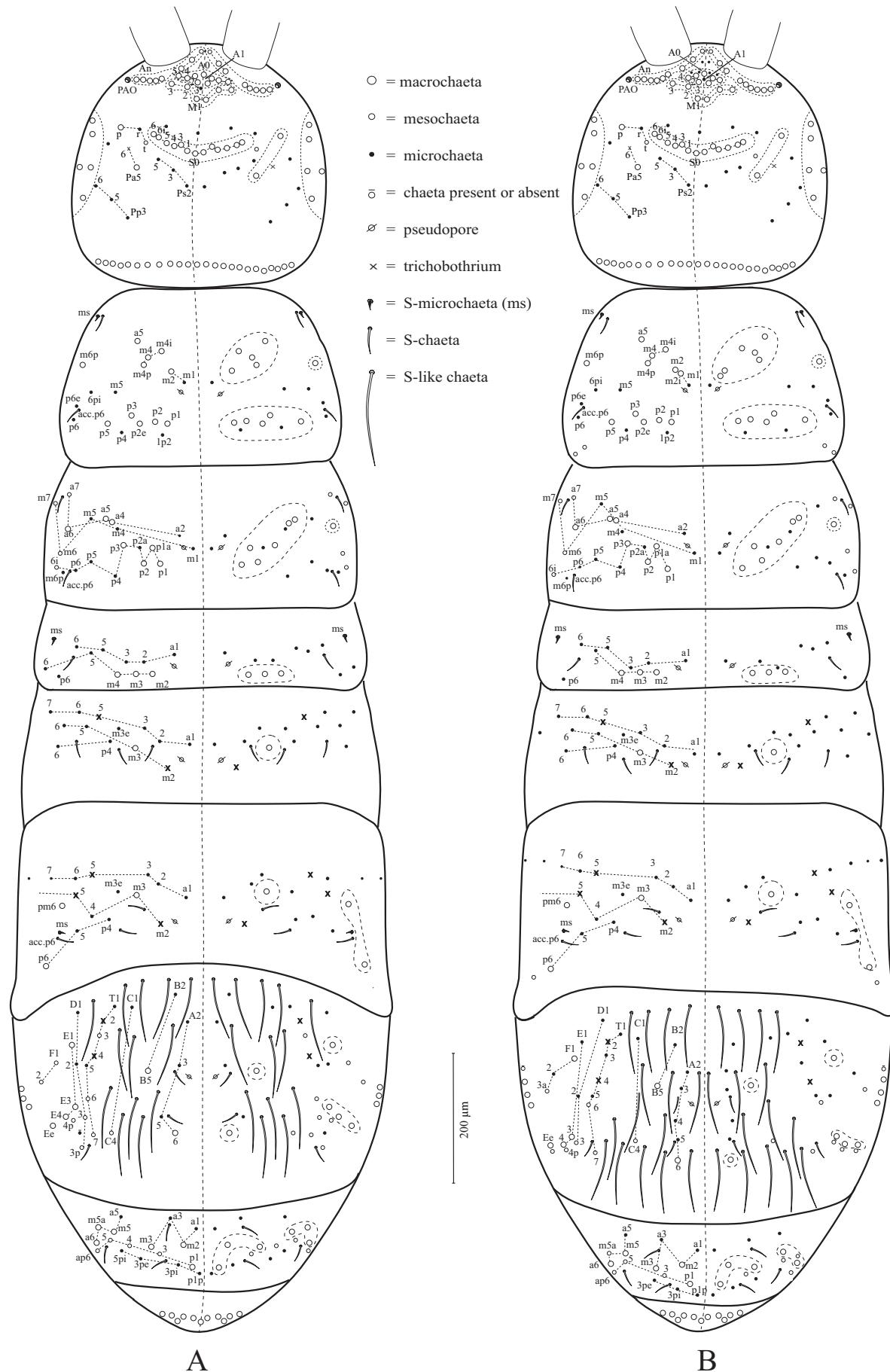
Ventral tube (Fig. 6A, B). Ventral tube about three times longer than wide; with scales both anterior and posterior sides. Anteriorly with 7–9+7–9 weakly serrated chaetae, about same size (Fig. 6B). Posteriorly with 12 smooth chaetae of different length, 1 larger proximal area, 1+1 subapical one, and 4–5+4–5 chaetae distally (Fig. 6A). Lateral flaps with 11–12+11–12 smooth chaetae (Fig. 6A).

Furcal complex (Figs. 5E, 6C–E). Tenaculum with 1 serrated chaeta and 4 large teeth of decreasing size from the basal to distal one of each ramus (Fig. 5E). Ratio of manubrium: dens: mucro = 8: 13: 1. Mucrodens 1.43–2.35 times longer than manubrium. Manubrium dorsally dense covered with ciliated mes, and row of 4 smooth chaetae on each side. Manubrial plate with 2+2 psp and 3 ciliate chaetae (Fig. 6C). Ventrally densely covered with medium size scales, chaetae not seen. Dens curved, tapering, constituted of a rather short basal part hardly annulated, long medial part annulated dorsally and short, thinner, non-annulated distal part about 4 times as long as mucro. Dens basally with 1+1 row of 4–6 finely ciliated spines internally, usually symmetrical (Fig. 6D) and 1+1 smooth chaetae latero-externally (Fig. 6C). Laterally dense covered with ciliated mes. Ventrally dense covered with medium size elongated scales mixed with ciliated mes; scales absent in distal non-annulated part. Mucro bidentate, without basal spine (Fig. 6E).

Genital plate (Fig. 6F, G). Female with 2+2 smooth mic, 1 pair on anterior and posterior lobe (Fig. 6G). Male with many acuminate, smooth circumgenital mic, not clearly seen, without modified chaetae. Spermathecal duct elongated, rather smooth (Fig. 6F).

Etymology. *Alloscopus whitteni* pays special tribute to Tony Whitten in appreciation for his enormous contributions to nature conservation, especially in threatened karstic areas and cave fauna.

Remarks. The description of *Alloscopus whitteni* given here is the first detailed description of the genus, beyond those introduced by previous studies and now used in the



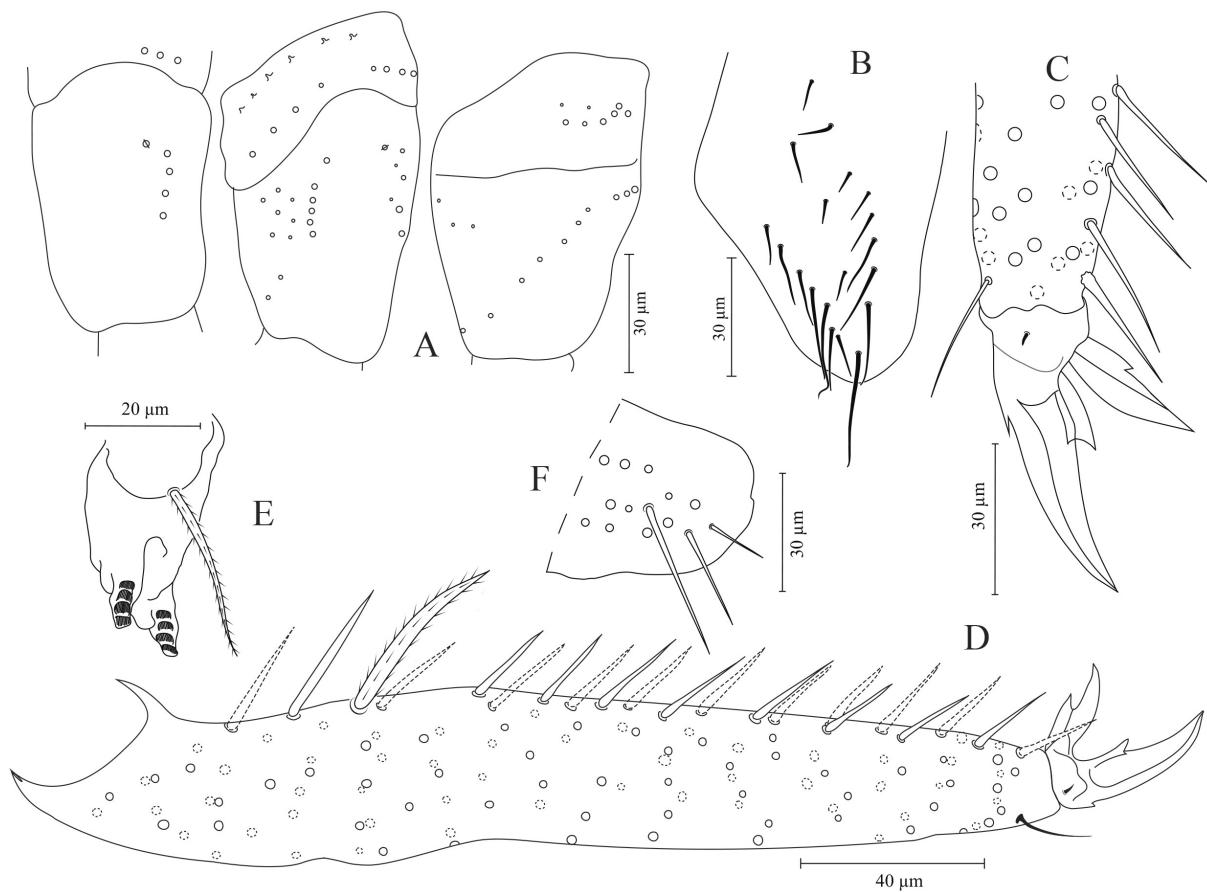


Fig. 5. *Alloscopus whitteni*, new species. A, outer chaetotaxy of coxae I–III (left side); B, trochanteral organ; C, distal part of Tita III and claw complex of anterior side; D, tibiotarsus III and claw complex of anterior side; E, tenaculum; F, lateral anal valve.

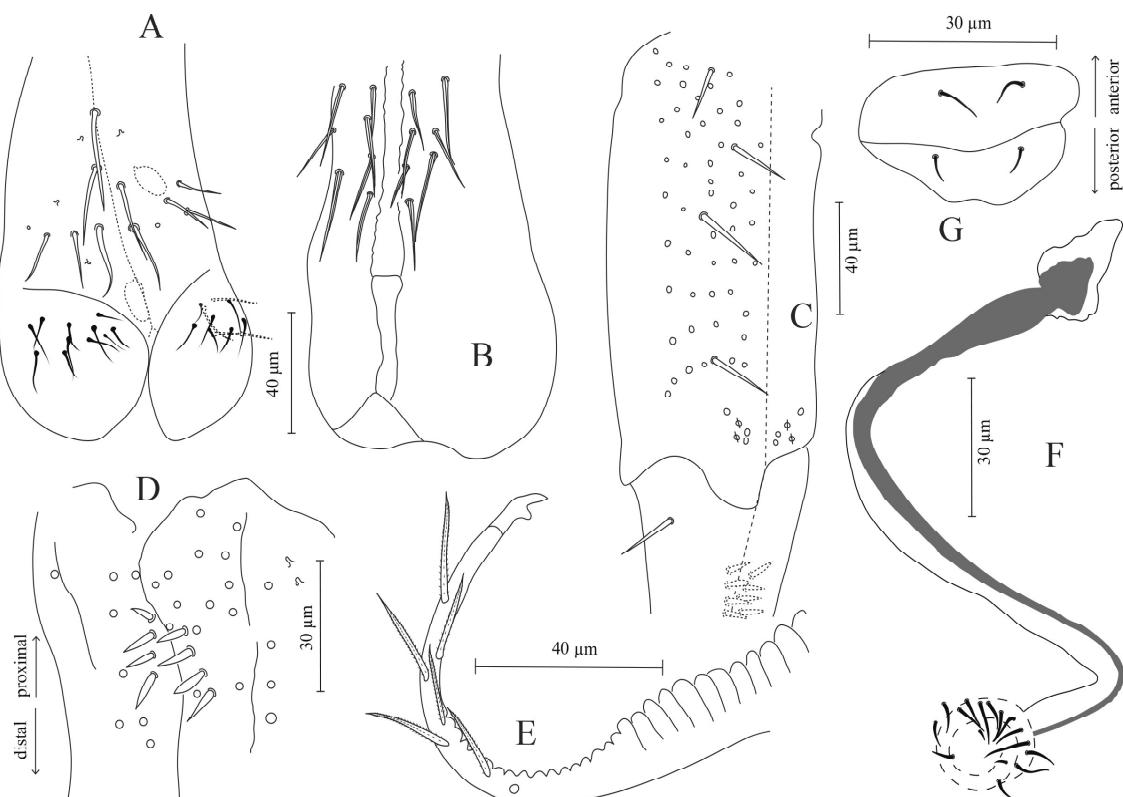


Fig. 6. *Alloscopus whitteni*, new species. A, ventral tube, posterior view; B, ventral tube, anterior view; C, manubrium and basal part of dens with rows of smooth chaetae (dorso-lateral view); D, rows of smooth spines on dens; E, distal part of dens and mucro (inner or outer side?); F, spermathecal duct and male genital plate (incomplete circumgenital mes); G, female genital plate.

Table 1. Comparison of morphological characters of five blind *Alloscopus* species, all species with 6, 3, 1 and 3 central mac on Th. III to Abd. III; ? = not given in literature description. Chaetotaxy of Th. II for *A. tetracanthus* follows Mari Mutt (1977: 244, 1982: 90) and Prabhoo (1971: 34).

Characters/species	<i>A. deharvengi</i>	<i>A. whitteni</i>	<i>A. namtip</i>	<i>A. tetracanthus</i>	<i>A. thailandensis</i>
Body length	1.4	1.7	1.6	1.6	1.7
Ant./head	?	1.5	2	2.2	?
Eye patch	absent	dark red	dark red	absent to reddish brown	dark red
Pigmentation	absent	orange dots	absent	absent	?
Pin project on Ant. IV	present	absent	absent	present	present
PAO shape	irregular	semidivided	semidivided	semidivided	oval
Chaetotaxy of head					
An	5?	8	9	?	3?
A	5 (A0, A2–A5)	5 (A0, A2–A5)	4 (A0, A2–A4)	4 (A0, A2–A4)	5 (A0, A2–A5)
M	3 (M1–M3)	3 (M1–M3)	3 (M1–M3)	3 (M1–M3)	3 (M1–M3)
S	7 (S0, S1–S6, S6i)	7 (S0, S1–S6, S6i)	7 (S0, S1–S6, S6i)	7 (S0, S1–S6, S6i)	7 (S0, S1–S6, S6i)
Labial basis	M1m2?eL1(l1)l2	M1m2rel1(l2)	M1m2rEl1(l2)	M1(m1)m2rel1l2	M1m2?el1l2
Chaetae of PLQ	smooth	weakly serrated	weakly serrated	?	smooth
Lateral process of papilla E	4	5	5	?	3
Spiniform labral papillae	4	4	2	4	2
Chaetotaxy of Th. II	12+12	10+10	11+11	9–10+9–10	12+12
central mac	6+6 (a5, m2, m2i, m4, m4p, m4i)	5+5 (a5, m2, m4, m4p, m4i)	6+6 (a5, m2, m2i, m4, m4p, m4i)	4–5+4–5 (a5, m2, m4, (m4p), m4i)	6+6 (a5, m2, m2i, m4, m4p, m4i)
posterior mac	6+6 (p1–2, p4–6, 1p)	5+5 (p1–3, p2e, p5)	5+5 (p1–3, p2e, p5)	4–5+4–5 (p1–2, (p3), p4–5)	6+6 (p1–2, p4–6, 1p)
Chaetotaxy of Abd. IV	?	6+6	6+6	?	?
central mac	2+2 (?)	2+2 (A6, B5)	2+2 (A6, B5)	2+2 (A6, B5)	2+2 (?)
lateral mac	?	4+4 (E1, E3–4, Ee)	4+4 (E1, E3–4, Ee)	?	?
Ungual inner unpaired teeth	0	0	1–2	0	1–2
Smooth chaetae on tibiotarsi	present	present	absent	present	absent
Smooth chaetae on trochanteral organ	17	12–20	25–32	15	15
Chaetae on ventral tube					
anterior face	?	7–9+7–9	9+9	8+8	?
posterior face	?	12	23	16	?
lateral flap	?	11–12+11–12	12+12	?	?
Smooth chaetae on lateral anal valves	2	3	0	2–3	0
Spines on dens	3–5	4–6	4–6	4–7	3–6
Ecology	humus and mosses	cave	cave	leaf litter, forests, tea field	leaf litter, soil, roots, tree bark
Distribution	Papua New Guinea	Thailand	Thailand	Australasia, South Asia, Pacific	Thailand
Source	Mari-Mutt, 1985; Cipola et al., 2016	This study	This study	Börner, 1906; Mari-Mutt, 1977, 1982; Prabhoo, 1971; Yoshii & Suhardjono, 1989; Cipola et al., 2016	Mari-Mutt, 1985; Cipola et al., 2016

taxonomy of Entomobryidae. Several morphological features were described especially antennal chaetae and complete body chaetotaxy that can be used as a reference for future taxonomic study. Diagnostic morphological characters of the two new species and all closely related blind species are listed in Table 1. *Alloscopus whitteni* is close to *A. deharvengi* Mari Mutt, 1985 in having two rows of smooth chaetae on tita, number of mac on 'A', 'M' and 'S' series of head, number of labral papillae, absence of ungual inner unpaired tooth, and number of dorsal smooth chaetae on manubrium. However, it differs from *A. deharvengi* by various characters: presence of dark red eye patch and orange dot pigmentation (vs. absent), absence of pin project on Ant. IV (vs. present), labial basis (M1m2rel1(l2)) (vs. M1m2?eL1(l1)l2), weakly serrated chaetae of PLQ (vs. smooth), number of lateral process of papilla E (5 vs. 4), number of mac on Th.II (10 vs. 12), number of smooth chaetae lateral anal valves (3 vs. 2), and is known from a different habitat (cave vs. humus and mosses).

Alloscopus whitteni is similar to *A. namtip*, new species, in absence of eyes, presence of small and divided PAO, two rows of smooth chaetae on manubrium, two rows of dental spines and absence of mucronal spine. However, it differs from *A. namtip* in body with orange dot pigments (vs. depigmentation), number of mac in 'An' series (8 vs. 9) and 'M' series (5 vs. 4, as A5 present) on head, central mac on Th.II (10 vs. 11) as m2i mac absent, labial basis chaetotaxy (M1m2rel1(l2) vs. M1m2rE1(l2)), number of labral papillae (4 vs. 2), number of chaetae on posterior ventral tube (12 vs. 23), number of claw inner unpaired teeth (0 vs. 1 or 2), and number of spine-like chaetae of trochanteral organ (12–20 vs. 25–32). *Alloscopus whitteni* also has two rows of smooth chaetae on all tita (vs. absent in *A. namtip*), and lateral anal valve with 3+3 smooth chaetae (vs. absent in *A. namtip*).

Alloscopus is infrequently found in caves of southern Thailand. From at least 100 sampled caves in Thai peninsula, we discovered only three caves of which two are described in this work.

Habitat. The individuals were found in soil and on the small patch of bat guano in dark zone of cave near the stream bank.

Alloscopus namtip, new species (Figs. 4B, 7A–L)

Material examined. Holotype female on slides, sample # THA_SJ_SNI09. Thailand: Surat Thani Province: Thachana district, Tham [cave] Namtip, 9°33'43.5"S 98°58'55.9"E, 195 m asl, dark zone of cave, by aspirator, coll. S. Jantarit, 28 April 2016. Paratypes on slides: twelve samples, 2 male and 10 ex., by aspirator, same data as holotype.

Description. Habitus. Medium size Entomobryidae, similar to that of *A. whitteni*, new species. Body length up to 1.6 mm

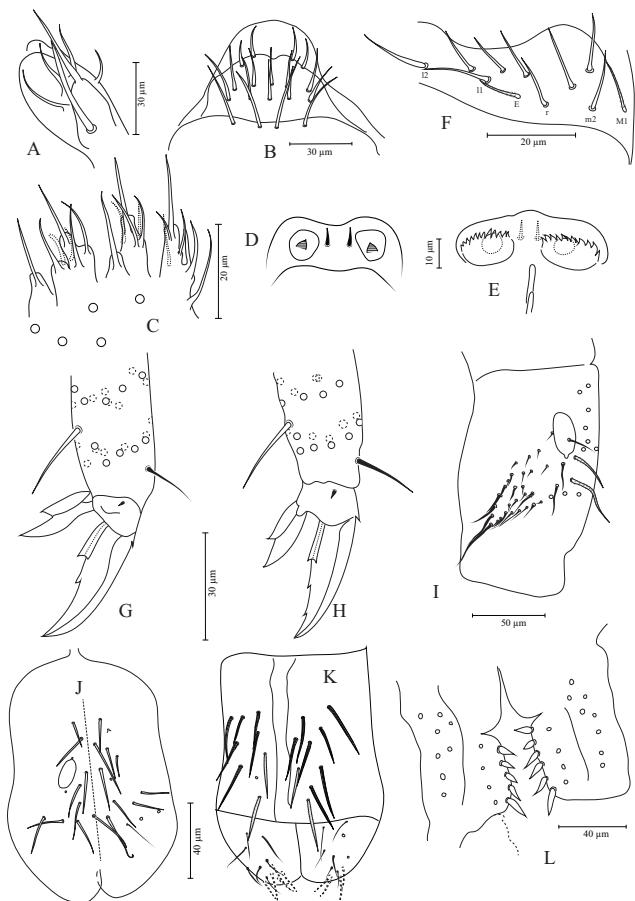


Fig. 7. *Alloscopus namtip*, new species. A, outer maxillary lobe (right side); B, prelabral and labral chaetae; C, labial palp (right side); D, labral papillae of dorsal view; E, ventral complex of labrum; F, labial basis (left side); G, H, distal part of Tita III and claw complex of anterior side; I, trochanteral organ; J, ventral tube, posterior view; K, ventral tube, anterior view; L, row of smooth spines on dens, asymmetrical arrangement.

(holotype 1.57 mm). Scales present on antennae I and II, head, body, legs (coxa to femur), ventral tube and furca. Colour: pale yellow to whitish in alcohol, without pigments; presence of dark red ocular patch and PAO. Antennal length shorter than body. Body slender, not bent nor humped at level of Th. II.

Pseudopores (Fig. 4B). Present as round flat disks, smaller than mac sockets, present on various parts of body: antennae, head, tergites, coxae and manubrium. On antennae, psp located on tip of antennal segments II and III (2 on Ant. II and 2 on Ant. III). On head, 1+1 psp located laterally anterior to PAO. On tergites, 1+1 psp close to axis from Th. II to Abd. IV. On coxae, 1+1 psp on coxa I and II, on III not seen, located close to longitudinal rows of chaetae. On manubrium, 2+2 dorso-apical ones.

Antennae. Antennae similar to that in *A. whitteni*, rather long, about 2 times longer than cephalic diagonal and 0.35 to 0.45 times as long as (head + trunk) (N=5). Ant. I subdivided, Ant. III (sometimes not clearly seen) and IV annulated, except $\frac{1}{4}$ proximal part of Ant. III and tip of Ant. IV. Antennal segment ratio as I(a+b):II:III:IV = 1: 1.20: 1.38: 2.01

(holotype). Antennal chaetae very diversified with ordinary chaetae, S-chaetae and scales. Scales oval to rounded, medium size, with dense cover of short spicules arranged in more or less regular longitudinal lines; numerous dorsally on Ant. Ib and Ant. II, few on Ant. Ia dorsally; absent on Ant. III and IV. Antennal chaetotaxic pattern similar to that of *A. whitteni*. Ant. IV without apical bulb, pin projection on apex not seen. Subapical organite with apical guard chaetae inserted dorsally near tip of Ant. IV. Antennae sometimes asymmetrical, because of fusion of Ant. III and IV, and Ant. III distal chaetae strongly modified when Ant. III and IV fused together. Thirteen antennal chaetal types and arrangement similar to that of *A. whitteni*, not repeated here.

Mouthparts (Fig. 7A–E). Prelabral and labral chaetae 4/5, 5, 4, all smooth, acuminate and subequal; except chaetae of first row slightly longer than others (Fig. 7B). Two labral papillae anteriorly, erect, minute, accompanied with 2 blunt and broad structures externally (Fig. 7D, E). Ventral complex of labrum with 2 slightly asymmetrical multi-toothed combs and pair of thin, sinuous, unequal tubules below (Fig. 7E). Maxillary outer lobe with 1 basal chaeta, simple maxillary palp, 4 sublobal hairs (Fig. 7A). Labial palp with 5 smooth and acuminate proximal chaetae and 5 papillae (A=0, B=5, C=0, D=4, E=5) like that described by Fjellberg (1999) for Entomobryidae (Fig. 7C), and hypostomal chaeta (H) with 2 accessory chaetae (h1 and h2). Lateral process subcylindrical apically, not reaching apex of papilla E (Fig. 7C). Mandible asymmetrical (right with 5 and left with 4 teeth) on all examined specimens. Molar plate with three strong pointed basal tooth, and 3 or 4 smaller inner distal teeth. Maxilla with strong tridentate claw, 3 or 4 stout ciliated lamellae and well-developed on each side, 3 or 4 sharp beaks opposite to maxilla capitulum, and thin rod, long and bent inside.

Ventral head chaetotaxy (Fig. 7F). Chaetae of labial basis as $M_1 m_2 rEl_1(l_2)$, chaetae M_1 and E ciliated, subequal, shorter than others, chaetae m_2 , r , l_1 , l_2 smooth, l_1 and l_2 longest and subequal, l_2 sometimes not seen. Postlabial quadrangle (PLQ) with 2+2 weakly serrated chaetae. Dense cover of scales and weakly serrated chaetae.

Dorsal head chaetotaxy (Fig. 4B). Dorsal cephalic chaetotaxy with stable mac chaetae arrangement as in Fig. 4B. Head 'M' series with 9+9 chaetae (6+6 mac and 3+3 mes for anteriormost), 'M' series with 4+4 mac (A0, A2–A4) mixed with 2+2 unnamed mic, A1 as mic; 'M' series with 3+3 mac (M1–M3), sutural mac with 7+7 mac (S0, S1, S3–6, S6i, S2 absent), between 'M' and 'S' series with 3 unnamed mic; interocular series with 3+3 chaetae (p as mac, t as mes and r as mic); postsutural area with 3+3 mic (Ps2–3 and Ps5); postoccipital anterior area with 1+1 mac (Pa5), 1+1 short cephalic tric (Pa6) and 1+1 unnamed mic laterally; postoccipital posterior area with 3+3 mic (Pp3 and Pp5–6); head laterally with 5+5 mac. Eyes absent. PAO small, located just below antennal mac, rounded with small semicircle inside.

Tergites (Fig. 4B). Dorsal chaetotaxy illustrated in Fig. 4B. Formula from Th.II–Abd.V; psp formula as 1,1/1,1,1,1,0; tric formula as 0,0/0,2,3,2,0; ms formula as 1,0/1,0,1,0,0; sens formula as 2,2/1,3,3,3,3; mac formula as 12,7/3,1,3,6,5 (dotted line in Fig. 4B). Mac arrangement stable; multiplets sensu Szeptycki (1979) present only anteriorly on Th.II. Th. II with 6+6 anterior central mac (a5, m2, m2i, m4, m4i, m4p), 5+5 posterior mac (p1–3, p5, p2e), and 1+1 antero-lateral mac (m6p); with 7+7 mic (m1, m5, 1p2, p4, p6e, 6pi, p6) and 2+2 unnamed postero-lateral mes. Th.III with 6+6 central mac (p1–3, pla, a4–5) and 1+1 lateral mac (a6); 9+9 mic (a2, m1, m4–5, p4–6, p2a, m6p) and 4+4 mes (a7, m7, m6, p6i). Abd.I with 3+3 central mac (m2–4) and 7+7 mic (a1–3, a5–6, m5, p6). Abd.II with 1+1 central mac (m3); 12+12 chaetae (a1–3, a6–7, m3e, m5–6, p4, p6 as mic; a5 and m2 as tric) and 1 unnamed mic laterally. Abd.III with 1+1 central mac (m3) and 2+2 lateral mac (pm6, p6); 12+12 chaetae (a1–3, a6–7, m3e, m4, p4–5 as mic; a5, m2, m5 as tric) and 2 unnamed mic antero-laterally and 1 unnamed mes postero-laterally. Abd.IV with 2+2 central mac (A6, B5); 4+4 lateral mac (F1, E3, E4, Ee); with 20+20 chaetae (A2–A5, B2, C1, T1, T3, T5, D1, D2, F2 as mic; C4, T6, T7, D3, E4p, F1, F3a as mes; T2 and T4 as tric) with 1+1 unnamed mic posteriorly and 3+3 mac and 1+1 mes laterally; and at least 15+15 S-like chaetae. Abd. V with 3+3 central mac (p1, m2–3) and 2+2 lateral mac (m5, a6); with 10+10 chaetae (a1, a3, a5, p1p, 3pi, 3pe as mic, p3, p5, m5a and ap6 as mes). Abd. VI with at least 12 mac mixed with mes. Anal valve without smooth chaetae, several serrated mes mixed with mac, mic not seen (Fig. 5F).

Legs (Fig. 7G–I). Legs with ordinary ciliated chaetae of various lengths (mes to mac), smooth chaetae, and scales, mic not seen. Scales covered from coxa to femur. Tita of leg III slightly longer than tita of legs I and II. Subcoxa of leg I with 3+3 mac, subcoxa of leg II with a row of 8+8 mac and subcoxa of leg III with 5–6+5–6 mac and 2+2 mes. Coxa of leg I with 1 proximal psp and 4 or 5 mac posteriorly; coxa of leg II with 5 or 6 mac in anterior row, 4 or 5 mac in posterior row and 1 proximal psp in between; coxa of leg III with 8+11 chaetae (3–5 mac) in anterior row, psp not seen. Trochanteral organ with 25–32 smooth, straight, unequal spine-like chaetae (Fig. 7I). Distal whorl of Tita with 10–12 subequal ciliated chaetae, irregularly arranged, and a thin, acuminate, smooth dorso-apical tenent hair (Fig. 7G–H). Tita without rows of smooth chaetae, tita III with one ciliated mac interno-proximally. Ventro-distal smooth chaeta of tita III thick, erected, pointed. Pretarsal mic minute on anterior and posterior sides (1.0–1.5 μm). Ungues outer edge with a proximal tooth; inner side with 1 or 2 inner teeth at 56% and 81%, and a pair of basal inner teeth at about 33% of inner edge from basis. Unguiculus about half as long as inner edge of unguis, slightly swollen baso-internally, pointed apically, large outer tooth (under light microscope), devoid of inner tooth (Fig. 7G, H).

Ventral tube (Fig. 7J, K). Ventral tube about 3 times longer than wide; with scales on both anterior and posterior sides. Anteriorly with 9+9 chaetae (7+7 weakly serrated and 2+2 ciliated), about same size (Fig. 7K). Posteriorly with at least

23 mes (3+3 smooth medially, others ciliated), arranged roughly asymmetrically (Fig. 7J). Lateral flaps with 12+12 smooth chaetae (Fig. 7K).

Furcal complex (Fig. 7L). Tenaculum with 1 serrated chaeta and 4 large teeth of decreasing size from basal to distal one of each ramus. Ratio of manubrium: dens: mucro = 13: 25: 1. Mucrodens about 2 times longer than manubrium. Manubrium dorsally dense covered with ciliated mes, and row of 4 smooth chaetae each side. Manubrial plate with 2+2 psp and 3 ciliate chaetae. Ventrally densely covered with medium-size scales, chaetae not seen. Dens curved, tapering, constituted of rather short basal part hardly annulated, long medial part annulated dorsally and short, thinner, non-annulated distal part about 4 times as long as mucro. Dens basally with 1+1 row of 4–6 finely ciliated spines internally, sometimes asymmetrical (Fig. 7L) and 1+1 smooth chaetae latero-externally. Laterally densely covered with ciliated mes. Ventrally dense covered with medium size elongated scales mixed with ciliated mes; scales absent in distal non-annulated part. Mucro bidentate, without basal spine.

Genital plate. Female genital plate with 2+2 mic. Male genital plate not seen.

Etymology. *Alloscopus namtip* is named for the type locality and is used as a noun in apposition.

Remarks. *Alloscopus namtip*, new species, is close to *A. thailandensis* in the absence of smooth chaetae on tita, eye patch with dark red color, number of ungual inner unpaired teeth (1 or 2), number of smooth chaetae in manubrium (4), and absence of smooth chaetae on anal valves. However, it differs from *A. thailandensis* by the combination of characters; the absence of a pin project on Ant. IV (vs. presence), number of ‘A’ series on head (4 vs. 5) as A5 absent in *A. namtip*, labial basis chaetotaxy (M1m2rEl1(l2) vs. M1m2?el1(l2)), weakly serrated chaetae on PLQ (vs. smooth), number of lateral process of papilla E (5 vs. 3), posterior mac on Th. II (5 vs. 6) as ‘p1p’ mac absent in the new species, number of spine-like chaetae on trochanteral organ (25–32 vs. 15) and occurrence in a different habitat (cave vs. leaf litter, soil, roots and tree bark). The presence of two labral papillae in *A. namtip* is also reported in *A. cf. stebeli* (see Mari Mutt, 1982: 93; fig. 43) from a cave in Ecuador, but the latter species has 3+3 eyes. The differences between the two new species are discussed above (see in *A. whitteni*).

Habitat. This species was found on ground floor with small patch of bat guano in the twilight to dark zone of the cave.

Identification key for world species of *Alloscopus*

*indicates cave dweller or reported in cave.

1. Eyes absent 2
- Eyes present 6
2. Tibiotarsi I–III with 2 rows of smooth chaetae 3
- Tibiotarsi I–III without smooth chaetae rows 5

3. Th.II with 12+12 central mac; unguis without unpaired teeth *A. deharvengi*
- Th.II with 10+10 central mac 4
4. Posterior face of ventral tube with 16 chaetae *A. tetricanthus*
- Posterior face of ventral tube with 12 chaetae *A. whitteni**
5. Th.II with 9+9 central mac *A. thailandensis*
- Th.II with 11+11 central mac *A. namtip**
6. Eyes 1+1 or 2+2. Dens base with 0+0 or 1+1 smooth chaetae 7
- Eyes 3+3. Dens base with 3+3 smooth chaetae *A. stebeli**
7. Eyes 2+2 8
- Eyes 1+1 9
8. Th II–III with 9+9 and 3+3 mac respectively. Mucronal spine absent *A. aspinosus*
- Th II–III with 8+8 and 5+5 mac respectively. Mucronal spine present *A. spinosus*
9. Postoccipital anterior area of head with Pa5 mac 10
- Postoccipital anterior area of head without Pa5 mac 11
10. Head anterior series with A5 mac and medio-ocellar series without M3 mac. Abd II with 1+1 lateral mac (m5). Trochanteral organ with up to 25 spines. Dens dorsally with a row of 5–14 spines *A. tenuicornis*
- Head anterior series without A5 mac and medio-ocellar series with M3 mac. Abd II without lateral mac. Trochanteral organ with 30–40 spines. Dens dorsally with two rows of 27–55 spines *A. multispinatus*
11. Head ‘M’ series with 1+1 mac (M1). Th II–III with 13+13 and 7+7 mac, respectively. Manubrium dorsally with 3+3 smooth chaetae *A. fallax*
- Head ‘M’ series with 2+2 mac (M1–2). Th II–III with 11+11 and 6+6 mac, respectively. Manubrium dorsally with 4+4 or 5+5 smooth chaetae *A. yosiius*

Notes. In the description of Börner (1906: 177) for *A. tetricanthus* from Java, he was not certain of the number of eyes present. He mentioned “wahrscheinlich 1+1 (unpigmentierte) omen...” meaning “probably 1 + 1 (unpigmented) ocelli”. Later on, Prabhu (1971: 33), and Mari Mutt (1982: 89) examined material from India, Micronesia, Samoa and Australia. They are in agreement that the head of *A. tetricanthus* is without eyes. Cipolla et al. (2016) mentioned again 1+1 eyes for *A. tetricanthus*, but they did not see material of this species, probably relying on the original description of Börner (1906). The redescription of *A. tetricanthus* from the type locality will be necessary to confirm the status.

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