

ORIGINAL ARTICLE

# Two new species that are likely to represent the most basal clade of the genus *Trichadenotecnum* (Psocoptera: Psocidae)

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## Abstract

Two new *Trichadenotecnum* species, *T. corniculum* and *T. germinatum*, were described from Japan. These species were considered to compose a monophyletic group newly defined here as the *corniculum* group. Judging from morphology of male terminalia, the *corniculum* group was considered to represent the basal most clade of the genus *Trichadenotecnum*.

**Key words:** *corniculum* group, male terminalia, morphology, phylogeny, systematics.

## INTRODUCTION

The genus *Trichadenotecnum* Enderlein, 1909 is a large genus of the family Psocidae (Psocoptera), and has long been characterized by superficial similarities of forewing markings and venation. Therefore, the genus has included a heterogeneous assemblage of species (Yoshizawa 1998). Recently, Yoshizawa (2001) redefined the genus as a monophyletic group by establishing homologies of forewing markings and male terminalia, and also proposed five species groups within the genus. As shown by Yoshizawa *et al.* (2001) and Endang *et al.* (2002), redefinition and subdivision of the genus proposed by Yoshizawa (2001) has provided a strong framework for studies of the New World and Oriental species of the genus, although Yoshizawa's (2001) redefinition and subdivision of the genus was based chiefly on Japanese species.

Species of *Trichadenotecnum* share many unique structures of male terminalia, such as the clunial arm, the highly modified epiproct lobe, the hypandrial median tongue, and a unique combination of apophyses

on the posterior margin of the hypandrium. Additionally, these structures are extremely diversified within the genus, and they appear to be far more diversified than in most other psocopteran genera or even families. However, origin and transformation series of these structures remain mostly unclear. It is hoped that discovery of additional species will provide important clues to the evolution of male terminalia in *Trichadenotecnum*.

Recently, I examined some specimens possibly belonging to *Trichadenotecnum* and representing two undescribed species, which could not be assigned to the species groups proposed by Yoshizawa (2001). These species lacked the male clunial arm and the movable hypandrial median tongue, which were considered to be autapomorphies of the genus by Yoshizawa (2001). Therefore, by definition, these species might be excluded from the genus *Trichadenotecnum*. However, these species have a unique combination of forewing markings, such as opposing spots in cell r, spots in cell a, and six submarginal spots, which indicate close relationships with species of *Trichadenotecnum sensu* Yoshizawa (2001). In the following, I describe these two new species under a new species group of the genus *Trichadenotecnum*, and discuss their phylogenetic position and morphology of the male terminalia.

Methods and terminology follow Yoshizawa (2001). All specimens, including holotypes, are deposited in the Hokkaido University Insect Collection.

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## DESCRIPTION

*Trichadenotecnum corniculum* sp. nov.

*Holotype*. ♂, [Hokkaido], Site 311, Tomakomai Experimental Forest of Hokkaido University, 10.viii.2001, T. Miyake (canopy fogging).

*Paratypes*. (All paratypes were collected at Tomakomai Experimental Forest of Hokkaido University by T. Miyake using the canopy fogging method) 1♂, Site 284, 6.viii.2001; 1♂, Site 56, 10.viii.2001; 3♀, Site 152, 11.viii.2001; 1♀, Site 311, 10.viii.2001; 1♀, Site 48, 7.viii.2001; 1♂3♀, Site 51, 11.viii.2001; 1♂1♀, Site 284, 10.viii.2001.

*Male*. Head white in ground color; vertical and orbital markings brown; coronal suture black; epicranial suture black–brown; frons pale brown, with irregular paler spots; eye black, large, interocular space/eye diameter (IO/D) = 0.92; ocelli white, ocellar field black–brown marginally and white medially; gena, including antennal socket, black–brown; postclypeus with approximately 10 rows of black–brown spots at middle, fused with each other ventrally; anteclypeus black–brown. Antenna pale brown, scape and pedicel black–brown. Mouth parts brown; maxillary palpus black–brown.

Thorax: Prothorax black–brown. Mesonotum white; anterior surface of scutum pale brown; scutellum pale brown; postnotum black–brown. Metanotum black–

brown, posterior region of scutum pale brown to white. Mesopleuron and metapleuron black–brown except membranous regions white.

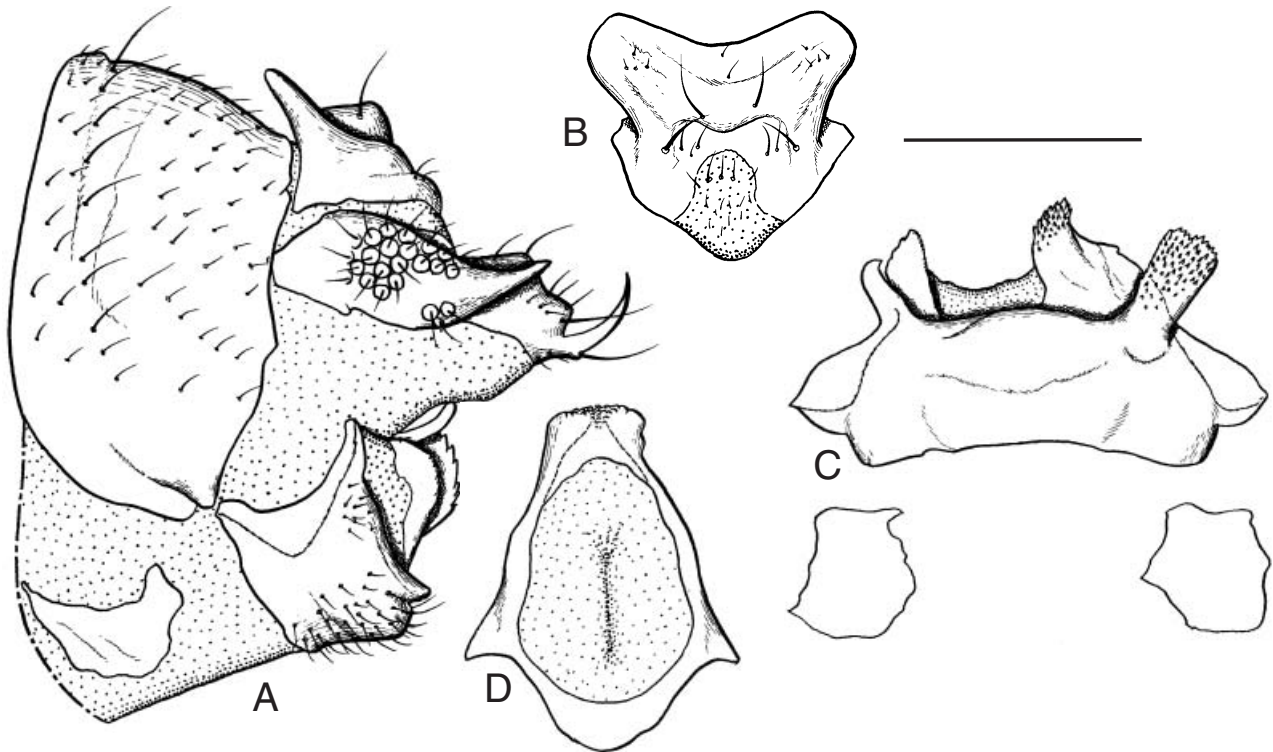
Legs black–brown.

Forewing (Fig. 1A) sparsely covered with tiny spots. Spots in cell  $a_1$  apparent. Opposing spots in cell  $r$  separated from each other. Basal band broad, broadly interrupted just beyond fork of  $M + Cu$ . Median spots rather sparse, some spots fused with each other and composing a larger marking. Distal band apparent, fragment of band in cell  $r_3$  darker. Spot on roof of cell  $m_3$  narrow. Submarginal spots apparent; spot in cell  $r_5$  much larger than others; spot in cell  $r_1$  very small, almost indistinct. Marginal clouds small but apparent. Hindwing hyaline with faint brown spots in cell  $cup$ ; veins brown.

Abdomen white in ground color, lateral surface pale brown, dorsal surface with brown transverse band on each segment. Terminalia (Fig. 2): clunial arm (Fig. 2A) hardly developed, recognized as a very slight swelling of the posterolateral margin of the clunium. Eighth sternum (Fig. 2C) with pair of circular or square sclerites. Epiproct (Fig. 2B) with median swelling bearing one pair of long setae laterally; epiproct lobe expanded dorsally, bilobed. Paraproct (Fig. 2A) with large conical process arising from distal region of trichobothrial field, apex of process extending near distal margin of paraproct; trichobothrial field divided into two or not; ven-



**Figure 1** Male forewings. (A) *Trichadenotecnum corniculum*; (B) *Trichadenotecnum germinatum*.



**Figure 2** Male terminalia of *Trichadenotecnum corniculum*. (A) Terminalia, lateral view; (B) epiproct, dorsal view; (C) hypandrium and eighth venter, ventral view; and (D) phallosome, posteroventral view. Scale line: 0.2 mm.

trolateral band very short, triangular; distal process long, directed upward. Hypandrium (Fig. 2C) asymmetrical, with widely sclerotized region dorsal to right process, its internal region strongly sclerotized and covered with denticles distally; median tongue absent; left process absent; left lobe well sclerotized, forming keel-like process, its distal margin rounded and serrated; right process strongly projected posteriorly, lamellate, covered with denticles, broadened and rounded apically. Phallosome (Fig. 2D) long, much longer than wide, narrowing distally to truncated posterodorsal end, covered with papillae medially; phallobase with well-developed lateral process, anteroventrally rounded.

Length: body (B), 2.0–2.4 mm; forewing (FW), 2.9–3.2 mm; hindwing (HW), 2.0–2.2 mm.

**Female.** Coloration and general morphology, except terminalia, almost as in male; pigmentation of head much paler; eye IO/D = 1.6.

**Genitalia (Fig. 3):** egg guide of subgenital plate (Fig. 3A) relatively broad, narrowing apically, much wider than long, apical margin rounded, with 10 setae; dorsal surface of egg guide with broad sclerites anterolaterally, separated medially from each other; posterior

margin of body of subgenital plate next to egg guide slightly projected posteriorly. Ventral valve of gonapophyses (Fig. 3B) long; dorsal valve with long distal process; posterior lobe of external valve strongly projected posteriorly. Internal plate weakly sclerotized.

Length: B, 2.8–3.0 mm; FW, 2.9–3.3 mm; HW, 2.3–2.5 mm.

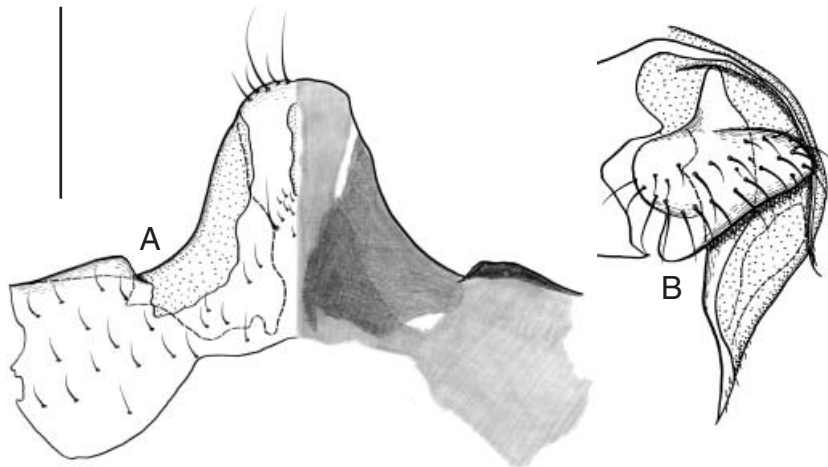
**Distribution.** Japan (Hokkaido).

**Remarks.** This new species can be distinguished from all known species of *Trichadenotecnum* by the combination of the following character states: in the male, weakly developed clunial arm, presence of conical process on trichobothrial field, and absence of hypandrial median tongue; in the female, subgenital plate with dorsal sclerite on egg guide and posterior projection next to egg guide. The species name refers to the unique conical process on the male paraprot.

***Trichadenotecnum germinatum* sp. nov.**

**Holotype.** ♂, [Honshu], Hijiriko, Geihoku-cho, Hiroshima Prefecture, 19.vii.1995, K. Yoshizawa.

**Paratypes.** 1♂, same locality as holotype, 10.vii.1994, K. Yoshizawa; 2♀, Kameyama, Geihoku-cho,



**Figure 3** Female genitalia of *Trichadenotecnum corniculum*. (A) Subgenital plate, ventral view, showing structure (left half) and coloration (right half); and (B) gonapophyses, ventral view. Scale line: 0.2 mm.

Hiroshima Prefecture, 11.vii.1994, K. Yoshizawa; 3♀, same data as holotype.

**Male.** Head white in ground color; vertical and orbital markings black–brown; coronal suture black; epicranial suture black–brown; frons with pair of triangular black–brown markings medially; eye black, large, IO/D = 0.85; ocelli white, ocellar field black–brown; gena, including antennal socket, black–brown; postclypeus with approximately 10 rows of black–brown spots at middle, fused with each other ventrally; anteclypeus black–brown. Antenna pale brown, scape and pedicel black–brown. Mouth parts brown; maxillary palpus black–brown.

**Thorax:** Prothorax black–brown. Mesonotum black–brown, medially with white longitudinal band. Metanotum black–brown, with white spot medially. Mesopleuron and metapleuron black–brown, except membranous regions white.

Legs black–brown.

**Forewing** (Fig. 1B) densely covered with tiny spots, all spots fused with neighbors. Spots in cell  $a_1$  apparent. Anterior spot of opposing spots in cell  $r$  distinct, posterior spot obscure. Basal band obscure, apparent only just below fork of  $M + Cu$  and in posterior region of cell cup. Median spots indistinct. Distal band obscure, only band in cell  $r_3$  apparent. Spot on roof of cell  $m_3$  very small. Submarginal spots distinct and relatively large in cells  $r_3$ ,  $r_5$  and  $m_2$ . Marginal clouds small but apparent. Hindwing hyaline with faint brown markings in cell cup; veins brown.

**Abdomen** white. Terminalia (Fig. 4): clunial arm (Fig. 4A) completely absent. Eighth sternum (Fig. 4C) with pair of weakly sclerotized circular plates. Epiproct

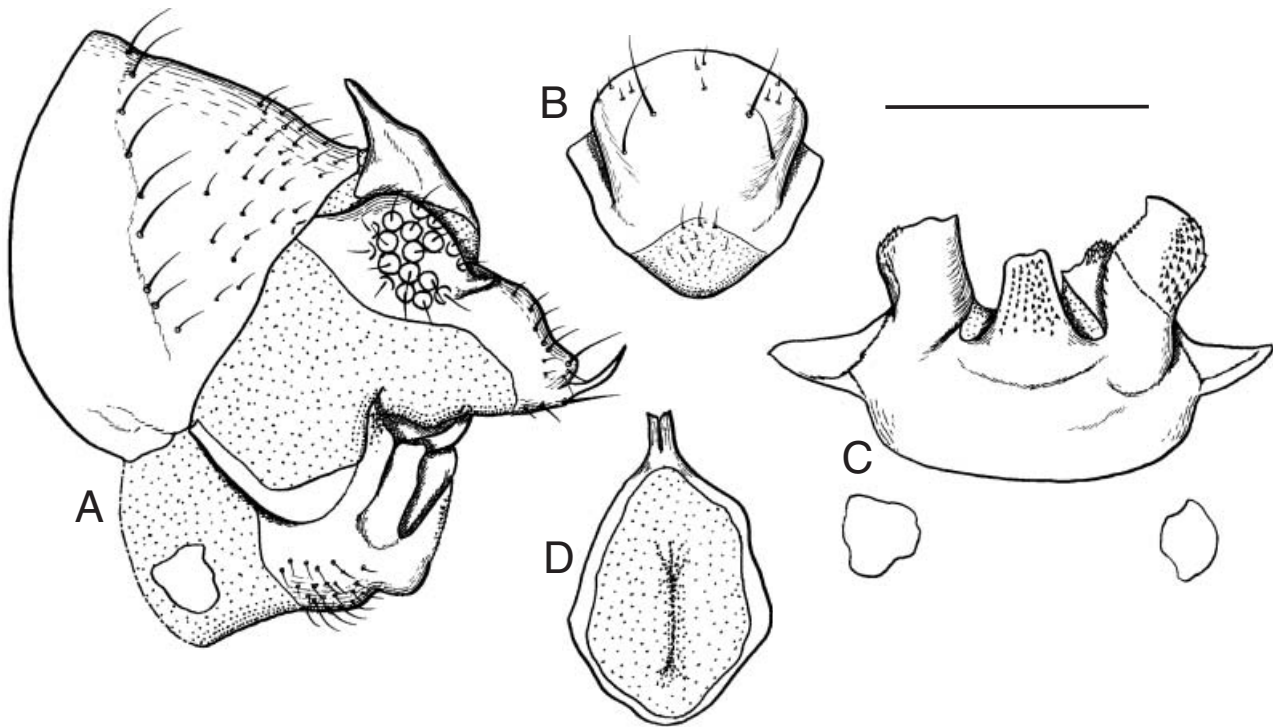
(Fig. 4B) without median swelling; epiproct lobe expanded dorsally, its dorsal margin rounded. Paraproct (Fig. 4A) with small conical process arising from distal region of trichobothrial field, process slightly longer than trichobothrium; trichobothrial field not divided; distal process long, directed upward. Hypandrium (Fig. 4C) asymmetrical, with denticulated semicircular process dorsal to right process; median tongue immovable, trapezoidal, covered with tiny denticles; left process absent; left lobe well sclerotized, internal margin forming narrow keel, dorsolateral margin serrated; right process strongly projected posteriorly, lamellate, broadened and rounded apically, external surface covered with denticles. Phallosome (Fig. 4D) rather broad, strongly tapered to nearly pointed posterodorsal apex, bifurcated apically; phallobase without lateral process, anteroventrally rounded.

Length: B, 2.2–2.3 mm; FW, 2.5–2.6 mm; HW, 2.0–2.1 mm.

**Female.** Coloration and general morphology, except terminalia, almost as in male; eye IO/D = 1.7.

**Genitalia** (Fig. 5): egg guide of subgenital plate (Fig. 5A) relatively broad, almost as wide as long, narrowing apically, apical margin nearly straight, with 10 setae; dorsal surface of egg guide with broad sclerites laterally, partly fused medially with each other; posterior margin of body of subgenital plate next to egg guide without papillae nor projection. Ventral valve of gonapophyses (Fig. 5B) long; dorsal valve with long distal process; posterior lobe of external valve strongly projected posteriorly. Internal plate weakly sclerotized.

Length: B, 2.0–2.7 mm; FW, 2.6–2.8 mm; HW, 2.1–2.3 mm.



**Figure 4** Male terminalia of *Trichadenotecnum germinatum*. (A) Terminalia, lateral view; (B) epiproct, dorsal view; (C) hypandrium and eighth venter, ventral view; and (D) phallosome, posteroventral view. Scale line: 0.2 mm.

*Distribution.* Japan (Honshu).

*Remarks.* This new species is similar to *T. corniculum* in the structures of the terminalia but can be easily distinguished from it by its smaller body size and, in the male, by its much smaller conical process on the trichobothrial field, and presence of unmovable hypandrial median tongue, and in the female by the medially fused dorsal sclerite of the egg guide. The species name refers to the relative size of the process on the male trichobothrial field, which looks somewhat like a bud of the well-developed process in *T. corniculum*.

### THE CORNICULUM SPECIES GROUP

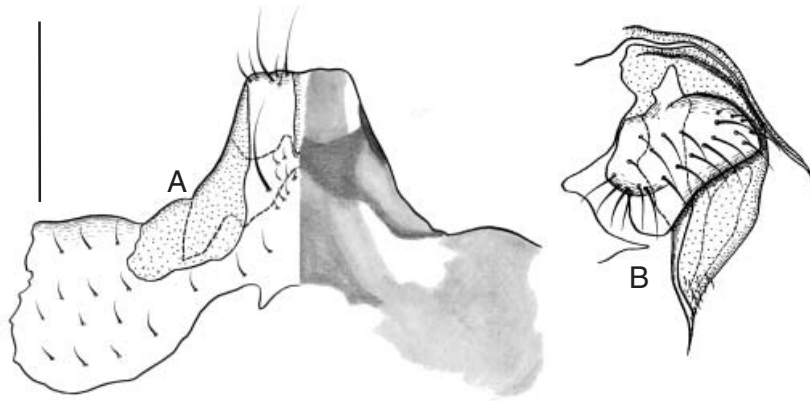
This species group is characterized by the combination of the following character states: forewing covered with minute spots; male clunial arm absent or weakly developed; male paraproct with conical process on posterior region of trichobothrial field; hypandrial median tongue immovable or absent; hypandrium with denticulated sclerite dorsal to right process; hypandrial left process absent; hypandrial right process broad, lamellate, and denticulated; parameres absent; phallosome with rounded anterior margin; ventral valve of gonapophyses long, external valve of gonapophyses with well-

developed posterior lobe. The paraproctal conical process on the posterior region of the trichobothrial field and unique combination of hypandrial processes are considered to be autapomorphies of the group.

This species group comprises so far only the two species described above. All species of *Trichadenotecnum*, including many new species recently described from China (Li 2002) and Indonesia (Endang *et al.* 2002), cannot be assigned to this species group. Species of the *corniculum* group are similar to species of the *majus* group in absence of the movable hypandrial median tongue, but species of the latter group have a well-developed clunial arm and anteriorly pointed phallosome. Configurations of the hypandrial distal apophyses also differ greatly between these two groups: the lack of the left process in the *corniculum* group is particularly notable.

### KEY TO THE JAPANESE SPECIES OF TRICHADENOTECNUM

In the key to the Japanese species of the genus provided by Yoshizawa (2001), the present species would fall into the third couplet in the male and fourth couplet in the



**Figure 5** Female genitalia of *Trichadenotecnum germinatum*. (A) Subgenital plate, ventral view, showing structure (left half) and coloration (right half); and (B) gonapophyses, ventral view. Scale line: 0.2 mm.

female, but cannot go further in both cases. The necessary modifications to Yoshizawa's (2001) key and key to the species group of Japanese *Trichadenotecnum* are presented in the following.

**Male**

- 1 Paraproct without lateral process; epiproct variable in shape . . . . . 2
  - Paraproct with lateral process; epiproct conical in shape . . . . . (*spiniserrulum* group)
- 2 Epiproct without dorsal process . . . . . 3
  - Epiproct with two or three dorsal processes directed posteriorly . . . . . (*majus* group)
- 3 Hypandrium asymmetrical, with right arm, posterior margin not deeply incised at middle . . . . . 4
  - Hypandrium asymmetrical, without right arm, posterior margin not deeply incised at middle (Figs 2C,4C) . . . . . (*corniculum* group) 17
  - Hypandrium symmetrical, without right arm, posterior margin deeply incised at middle . . . . . (*alexanderae* group)
- 4 Left process of hypandrium small, right arm weakly developed and almost straight or slightly arched . . . . . (*medium* group)
  - Left process of hypandrium well developed, right arm well developed and strongly bent . . . . . (*sexpunctatum* group)
- 17 Hypandrium without median tongue (Fig. 2C) . . . . . *T. corniculum* sp. nov.
  - Hypandrium with unmovable median tongue (Fig. 4C) . . . . . *T. germinatum* sp. nov.

**Female**

- 1 Subgenital plate without median sclerotized band . . . . . 2

- Subgenital plate with median sclerotized band . . . . . (*medium* group)
- 2 Ventral valve of gonapophyses long, extending over external valve . . . . . 3
  - Ventral valve of gonapophyses short, not reaching to external valve . . . . . 7
- 3 Subgenital plate composed of a single sclerite . . . . . 4
  - Subgenital plate composed of two separate sclerites . . . . . *T. fuscipenne* Yoshizawa, 2001 (*incertae sedis*)
- 4 Small spots of forewing restricted to median region, all six submarginal spots apparent . . . . . 5
  - Forewing extensively, but rather sparsely, clothed with small spots, all six submarginal spots apparent . . . . . (*alexanderae* group)
  - Forewing extensively, sparsely or densely, clothed with small spots, some submarginal spots obscure (Fig. 1) . . . . . (*corniculum* group) 19
- 5 Dorsal surface of subgenital plate lacking sclerites or only with sclerotized lateral margins of egg guide . . . . . (*sexpunctatum* group)
  - Dorsal surface of egg guide with pair of sclerites . . . . . (*majus* group, in part)
- 7 Subgenital plate composed of a single sclerite . . . . . (*spiniserrulum* group)
  - Subgenital plate composed of two separate sclerites . . . . . (*majus* group, in part)
- 19 Dorsal sclerites of egg guide medially separated from each other, body of subgenital plate with projection next to egg guide (Fig. 3A) . . . . . *T. corniculum* sp. nov.
  - Dorsal sclerites of egg guide partly fused at middle, body of subgenital plate without projection next to egg guide (Fig. 5A) . . . . . *T. germinatum* sp. nov.

## DISCUSSION

As discussed above, the present new species are considered to compose a monophyletic group and also share apomorphic forewing markings with the species of *Trichadenotecnum sensu* Yoshizawa, 2001 (Fig. 1). In contrast, they lack some important autapomorphies of male terminalia defining this genus (Yoshizawa 2001), notably the male clunial arm and the movable hypandrial median tongue (Figs 2A,C; 4A,C). Based on these morphological observations, the *corniculum* group is considered here to be the sister group of the genus *Trichadenotecnum sensu* Yoshizawa, 2001. Therefore, establishment of a new genus for the *corniculum* group could be justified, but I consider the inclusion of the *corniculum* group into the genus *Trichadenotecnum* to be more practical because (i) members of the *corniculum* group cannot be distinguished from *Trichadenotecnum sensu* Yoshizawa, 2001 by the female only; and (ii) monophyly of *Trichadenotecnum*, including the *corniculum* group, is well supported by the unique combination of forewing markings. Because species of the *corniculum* group lack some autapomorphies of male terminalia used by Yoshizawa (2001) to define *Trichadenotecnum*, the inclusion of these two species into *Trichadenotecnum* requires expansion of the generic concept; that is, the male clunial arm and the movable hypandrial median tongue are excluded from the generic definition. As a result, the genus *Trichadenotecnum* in the present sense is characterized by the following forewing markings (Fig. 1): spots in cell  $a_1$ ; opposing spots in cell  $r$ ; proximal band running from stigmasac through fork of  $M + Cu$  to distal third of cell  $cup$ ; submarginal row of six spots.

Within *Trichadenotecnum*, the following character states of male terminalia are unique to the *corniculum* group (Figs 2,4): absence of the clunial arm, absence of the movable hypandrial median tongue, and the anteriorly rounded and posteriorly narrowed phallosome. Most of these character states are also observed in many other genera of the tribe Ptyctini, in which *Trichadenotecnum* is classified. Therefore, these male genital character states observed in the species of the *corniculum* group probably represent the plesiomorphic condition of *Trichadenotecnum*. Among these characters, structures of the phallosome in *T. germinatum* are particularly interesting (Fig. 4D). In species other than the *corniculum* group, the anterior end of the phallosome is pointed or bears a projection, and the phallosome is usually broadened posteriorly and sometimes has paramere-like processes. In contrast, the anteriorly

rounded and posteriorly pointed phallosome in *T. germinatum* is very similar to that in *Ptycta* (Ptyctini), *Psococerastis* (Cerastopsocini), *Atrichadenotecnum* (Psocini) and *Metylophorus* (Metylophorini). Yoshizawa (2001) considered that the paramere-like structure observed in the *medium* and *sexpunctatum* groups is homologous with the paramere of other psocopterans. However, discovery of *T. germinatum* provides a completely different idea about homology of the structure; that is, absence of the paramere is considered to be the basal most condition of the phallosome in *Trichadenotecnum*, and the paramere-like structures observed in the *medium* and *sexpunctatum* groups should be regarded as secondarily derived or *de novo* structures.

As discussed above, discovery of the present new species provides an important insight into the transformation series of some characters of male terminalia in *Trichadenotecnum*. In contrast, phylogenetic relationships among species groups and transformation series of many other structures of male terminalia in *Trichadenotecnum*, particularly the hypandrial distal apophyses, are so far mostly unclear. Moreover, the structures of male terminalia show a great discontinuity among species groups. Therefore, further alpha taxonomic studies of *Trichadenotecnum* and morphology-based phylogenies are highly encouraged, because these studies could result in discovery of the ‘missing links’ between species groups, which would be most important for revealing transformation series and evolution of male terminalia in *Trichadenotecnum*.

## ACKNOWLEDGMENTS

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