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# Synonymy of *Cryptopsocus* Li with *Trichadenotecnum* Enderlein (Insecta: Psocodea: 'Psocoptera': Psocidae) and description of three new species

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## Abstract

The genus *Cryptopsocus* Li, 2002 is synonymized with *Trichadenotecnum* Enderlein, 1909. The type species of *Cryptopsocus*, *T. cynostigmus* (Li, 2002) n. comb., is considered to be a close relative of *T. marginatum* New & Thornton, 1976. These species cannot be assigned to any species group previously established in *Trichadenotecnum* so that the *marginatum* species group is here proposed for them. Three new species belonging to this species group are described: *T. tigrinum* and *T. sharkeyi* from Thailand and *T. sabahense* from Sabah, Malaysia. The phylogenetic position of the *marginatum* group is discussed using morphological data.

**Key words:** Psocini, Trichadenotecnini, Ptyctini, new species, Thailand, Sabah

## Introduction

The monotypic genus *Cryptopsocus* was established by Li (2002) for a single species, *C. cynostigmus* Li, 2002, known only from a single male. Its superficial similarity to *Trichadenotecnum*, a diversified and widely distributed genus, was already pointed out by Li (2002), but he considered these genera as distantly related and classified them in different tribes. He assigned *Cryptopsocus* to the tribe Psocini and *Trichadenotecnum* to the Trichadenotecnini (now synonymized with Ptyctini; see Yoshizawa & Johnson, 2008). However, their differences mentioned by Li (2002) are mostly minute (roof of areola postica straight and forewing with marginal cloud in *Trichadenotecnum*; roof of areola postica slightly angulated and forewing margin clear in *Cryptopsocus*). Absence of the clunial lateral processes, the presence of which is a unique feature of *Trichadenotecnum*, is also pointed out by Li (2002) to differentiate *Cryptopsocus* from *Trichadenotecnum*. However, lack of the clunial lateral processes is quite frequent in the basal lineages or even among the more derived members of *Trichadenotecnum* (Yoshizawa, 2003; Yoshizawa *et al.*, 2008, 2014). Furthermore, Yoshizawa *et al*. (2014) pointed out that a species of *Trichadenotecnum* from Malaysia, *T. marginatum* New & Thornton, 1976, might be a close relative of *Cryptopsocus cynostigmus*. Therefore, the delimitation of these genera becomes obscure and it is highly desirable to clarify their phylogenetic relationship and taxonomic status.

Recently, we had the chance to examine specimens from Thailand and Sabah which are obviously closely related to *C. cynostigmus* and *T. marginatum*. By examination of these specimens and by morphology-based phylogenetic analysis, it became evident that *Cryptopsocus* is imbedded within *Trichadenotecnum* and thus should be synonymized with it. In this paper, we discuss the placement and status of *Cryptopsocus* and describe three new species which are close to the type species of *Cryptopsocus*.

For methods, terminologies, and abbreviations used in the paper, see Yoshizawa (2001).

## *Trichadenotecnum* Enderlein

*Trichadenotecnum* Enderlein, 1909: 329. Type species *Hemerobius sexpunctatus* Linnaeus, 1758 (by original designation).

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*Cryptopsocus* Li, 2002: 1459 (in Chinese); 1899 (in English), **n. syn.** Type species *Cryptopsocus cynostigmus* Li, 2002 (by original designation).

See Yoshizawa (2001, 2003) and Yoshizawa *et al.* (2007, 2008) for further synonymy and generic definition.

### The *marginatum* group (new species group)

**Diagnosis.** Small psocids, forewing length about 2 mm. Forewing broadly but sparsely covered with tiny spots; pterostigma pale except for maculated distal end and posterior tip; opposite spots in cell r apparent; spot in cell a apparent; basal band running from stigmasac to distal 1/3 of cell cup, with wide transparent area around first segment of M vein; distal band apparent; spot on roof of cell m3 distinct; submarginal spots apparent but sometimes indistinct in some cells; marginal cloud almost absent, only recognizable at vein ends; vein Rs forked in right angle; areola postica almost triangular (roof veins slightly angulated); distal vein of areola postica directed posteriorly. Hindwing hyaline. Male terminalia: clunium without lateral processes nor dorsal flap; epiproct lobe weakly to well developed; paraproct with weakly developed basal process; hypandrium asymmetrical, posteromedially with wide membranous region; phallosome symmetrical. Female of this group known only from *T. tigrinum*, described below, therefore variation of female characters among species unknown (see description of female genitalia of this species for a preliminary diagnosis of females of this species group).

**Remarks.** In the original description of *Cryptopsocus*, Li (2002) considered the flattened posterior margin of the phallosome to be one of the diagnostic characters of the genus (in Chinese description, p. 1459). In the English diagnosis, it is described as "phallosome acute at base and apex (p. 1900)" but, judging from the illustration (fig. 1304F), the Chinese description seems correct. However, the distal part of the phallosome is highly variable among species of this group and thus this character is unsuitable for group definition. Five species are here assigned to this species group. Based on the hypandrial structures, they can be classified into two subgroups: *T. marginatum*, *T. cynostigmus* and *T. tigrinum* by having a movable median tongue and a right corner lacking keels or processes; *T. sharkeyi* and *T. sabahense* by having an unmovable median tongue and a highly modified right corner. The group name is based on *T. marginatum*, the oldest species name within the group.

### *Trichadenotecnum marginatum* New & Thornton

*Trichadenotecnum marginatum* New & Thornton, 1976: 413.

**Distribution**. Malaysia (Peninsula).

**Remarks**. The only known specimen of this species (male holotype) has not been examined but, judging from the original description, this species is clearly close to *T. cynostigmus*, the type species of *Cryptopsocus* treated below, because of the similarity of the hypandrial structures. Diagnostic characters of this species are discussed below (see Remarks to other species of the group).

### *Trichadenotecnum cynostigmus* (Li) n. comb.

*Cryptopsocus cynostigmus* Li, 2002: 1459 (in Chinese); 1900 (in English). Note: The species name, based on the Latinized Greek noun “stigmos”, is an invariable noun in apposition.

**Distribution**. China (Hainan Is.).

**Remarks**. The only known specimen, the male holotype, of this species has not been examined but, judging from the original description and its original generic assignment (see Introduction), this species is clearly a member of the genus *Trichadenotecnum* because of the apomorphic forewing markings and some venational characters unique to this genus (Yoshizawa, 2001). Diagnostic characters of this species are discussed below (see Remarks to the other species of the group)

***Trichadenotecnum tigrinum* n. sp.**
(Figs 1A, 2)

**Holotype**. Male, THAILAND Nakhon Nayok, Khao Yai NP, Nhong ping khaokeaw, 14º23.094N 101º23.055E, 733m, Malaise trap 5–12.iii.2007, Wirat Sukho leg. T2101 (tiger7M, KY436) (will be deposited in the Queen Sirikit Botanical Gardens, Thailand).

**Paratypes** (will be deposited in the Queen Sirikit Botanical Gardens, Muséum d'histoire naturelle Geneva, and Hokkaido University). [THAILAND] 1 male, Phetchabun, Khao Kho NP, mixed deciduous forest, 16º32.546N 101º2.501E, 560m, Malaise trap 26.xii.2006–2.i.2007, Somchai Chachumnan & Saink Singiong leg. T1189; 1 male, Chaiyaphum, Tat Tone NP, by the stream, 15º58.771N 102º2.397E, 305m, Malaise trap 19–26.i.2007, Tawit Jaruphan & Orawan Budsawong leg. T1564; 2 males, Chaiyaphum, Tat Tone NP, Phu hang sing, 15º58.723N 102º2.231E, 290m, Malaise trap 5–12.i.2007, Tawit Jaruphan & Irwin Budsawong leg. T1560; 1 female, same data as for holotype (tiger7F, KY474); 1 male, same locality as for holotype, 12–19.iii.2007, Wirat Sukho leg. T2104.

**Description**. **Male**. **Head**. White in ground color; vertical markings blackish brown, each marking fused with neighbors; with pair of brown markings anterior to vertical markings next to ocellar field; orbital markings small, brown; coronal suture black; epicranial suture narrowly bordered with blackish brown band dorsally; frons with pair of pale brown markings medially and black small spots laterally; eyes black, IO/D = 1.1; ocelli white, ocellar field dark brown; gena white, medially with blackish brown marking; postclypeus with rows of blackish brown spots, rows fused to each other ventrally, dorsal margin and ventrolateral corners white; anteclypeus blackish brown. Antenna brown. Mouthparts brown.

**Thorax**. Prothorax brown. Mesonotum mostly brown, medially with white field, marking on anterior lobe bilaterally divided by narrow white stripe. Mesopleuron white, precoxal bridge and trochantin blackish brown. Metanotum brown, medially with white spot, scutellum darker. Metapleuron blackish brown except for white membranous region.

**Legs**. Coxae blackish brown; femora white, each with black spot ventrally at apical 1/3; tibiae white to pale brown; tarsi brown, second segments darker.

**Forewing** (Fig. 1A). As in group diagnosis; distal spot in cell a well developed; spot on roof of m3 apparent only in basal half; submarginal spot obscure in cell m3; roof vein of cell m3 short, about half of second section of CuA1 in length.

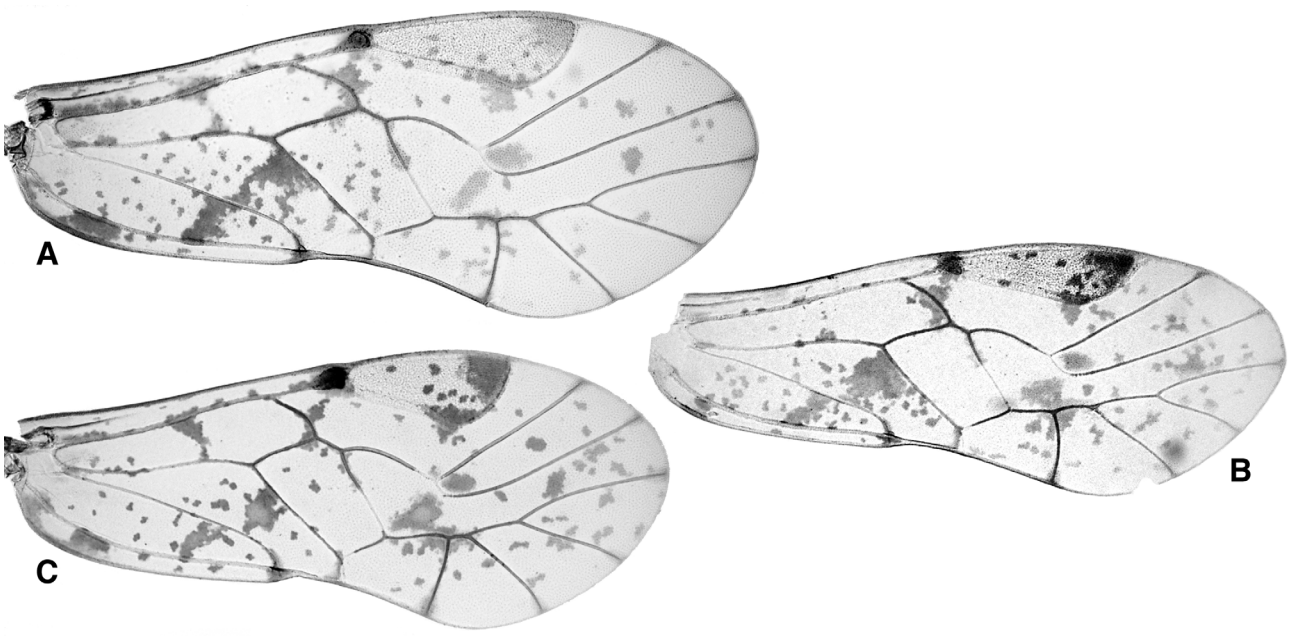



**FIGURE 1.** Forewings of new species of the *Trichadenotecnum marginatum* group. A: *T. tigrinum*, male paratype; B: *T. sharkeyi*, male holotype; C: *T. sabahense*, male holotype.

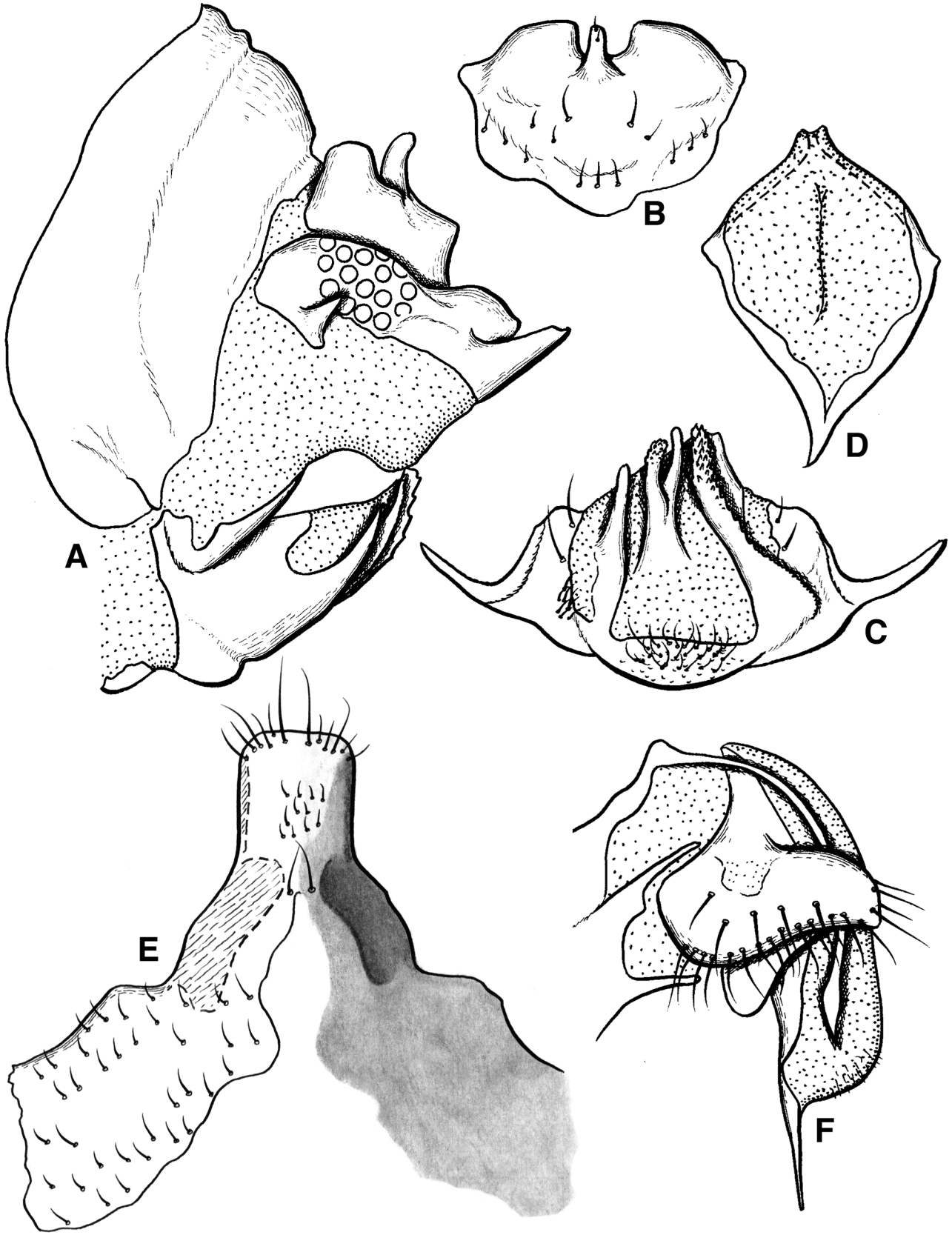



**FIGURE 2.** Male (A–D) and female (E–F) terminal structures of *Trichadenotecnum tigrinum*. A: terminalia, lateral view; B: epiproct, posterodorsal view; C: hypandrium, posteroventral view; D: phallosome, ventral view; E: subgenital plate, ventral view; F: gonapophyses, ventral view.

**Terminalia**. Eighth sternum with weak sclerite separated from hypandrium (Fig. 2A). Epiproct lobe bilobed, slightly expanded over clunium, medially with cylindrical process strongly pointed dorsally; dorsal margin smooth (Fig. 2AB). Paraproct with small basal conical process; distal process long, almost straight (Fig. 2A). Hypandrium (Fig. 2C) with broad membranous region medially, anteroventral surface weakly projecting ventrally, medially covered with papillae; left corner without significant modification; left process long and straight; median tongue well developed, movable, bifurcated distally, its left lobe covered by denticles, right lobe smooth; right process well developed, covered by denticles distally, outer margin serrated basally; right corner without significant modification. Phallosome (Fig. 2D) pointed anteriorly, posteriorly pointed and narrowly open.

**Measurements**. Body 1.4–1.7 mm, forewing 2.3–2.4 mm, hindwing 1.7–1.9 mm.

**Female**. General morphology almost as in male. IO/D = 1.2.

**Genitalia**. Subgenital plate (Fig. 2E). Egg guide broad basally, gradually narrowing to middle and parallel sided in distal half, distal margin slightly arched, dorsally with lateral sclerites at broadened base; body of subgenital plate with broad membranous region anteriorly, narrowly incising to middle of egg guide. Gonapophyses (Fig. 2F). Ventral valve long; dorsal valve with long and narrow distal process; external valve with well developed posterior lobe, anteriorly with membranous region. Spermapore plate not well sclerotized.

**Measurements**. Body 1.7 mm, forewing (from base to Rs fork) 1.4 mm (apically broken), hindwing (from base to R-M fork) 1.0 mm (distally broken).

**Distribution**. Thailand.

**Etymology**. The species epithet refers to the TIGER (Thailand Inventory Group for Entomological Research) project, through which the present material was collected.

**Remarks**. The hypandrial structure of this species is very similar to *T. cynostigmus*, but these species differ clearly in the shapes of the epiproct lobe (simple in *T. cynostigmus*, trilobed in *T. tigrinum*) and the phallosome (posterior end flattened and closed in *T. cynostigmus*, pointed and narrowly opened in *T. tigrinum*). The trilobed structure of the epiproct lobe of this species is similar to *T. marginatum* (three swellings were shown by New & Thornton, 1976: fig. 130), but these species differ in the shapes of the phallosome (posterior end wide and straight in *T. marginatum*, as in *T. cynostigmus*) and the hypandrium. *T. marginatum* clearly differs from *T. cynostigmus* by the characters of the hypandrium. The female of the *marginatum* species group is described here for the first time.

***Trichadenotecnum sharkeyi* n. sp.**
(Figs 1B, 3)

**Holotype**. Male. THAILAND, Nakhon Nayck, Khao Yai NP, entrance of Hong Pak Chee Trail, 14º27.115'N 101º21.951E 733m, Malaise trap 19-26.v.2007, Pong Sandao leg. T2270 (tiger8, KY452) (will be deposited in the Queen Sirikit Botanical Gardens, Thailand).

**Description** (note that the condition of the specimen is bad). **Male**. **Head**. White in ground color; vertical markings brown, fused and composing large marking; with pair of faint markings anterior to vertical markings; orbital markings obscure; coronal suture black; epicranial suture dark brown; frons with pair of faint markings; eye black, large, IO/D=0.6; ocelli white, ocellar field brown; gena white; postclypeus with faint brown markings ventrally; anteclypeus pale brown. Antenna brown (flagellum missing). Mouthparts brown.

**Thorax**. Prothorax brown. Mesonotum brown, anterior lobe of scutum and scutellum darker; mesopleuron white except for brown precoxal bridge and trochantin. Metanotum brown, anterior lobe of scutum pale; metapleuron brown except for white median region.

**Legs**. Coxae of all legs brown. Foreleg white, distal part of tibia and tarsus brownish. (Other legs missing.)

**Forewing** (Fig. 1B). As in group diagnosis; distal spot in cell a obscure; spot on roof of m3 obscure distally, anterointernally broadly connected to posterior spot of distal band; roof vein of cell m3 long, about equal to second section of CuA1 in length.

**Terminalia**. Eighth sternum unsclerotized (Fig. 3A). Epiproct lobe weakly developed, slightly expanded over clunium; dorsal margin covered by papillae, with posterior projection medially (Fig. 3AB). Paraproct with small basal process covered by papillae; distal process broad and short, strongly bent at tip (Fig. 3A). Hypandrium (Fig. 3C) with broad membranous region distal to median tongue, anteroventral surface smoothly curved, with pair of slight swellings; left corner without significant modification; left process short, basally fused with median tongue;

median tongue small, unmovable, covered by papillae distally, distal margin only slightly concave; right process well developed, internal margin strongly serrated; right corner highly modified, with serrated keel and outer lobes. Phallosome (Fig. 3D) pointed anteriorly, posteriorly closed and slightly bilobed, with papillar region medially.

**Measurements**. Body 1.7 mm, forewing 2.1 mm, hindwing 1.6 mm.

**Female**. Unknown.

**Distribution**. Thailand.

**Etymology**. The specific epithet is dedicated to Dr Michael Sharkey (University of Kentucky, USA), leader of the TIGER project .

**Remarks**. This species is clearly differentiated from the above-mentioned three species by the shapes of the epiproct lobe and the hypandrial processes.

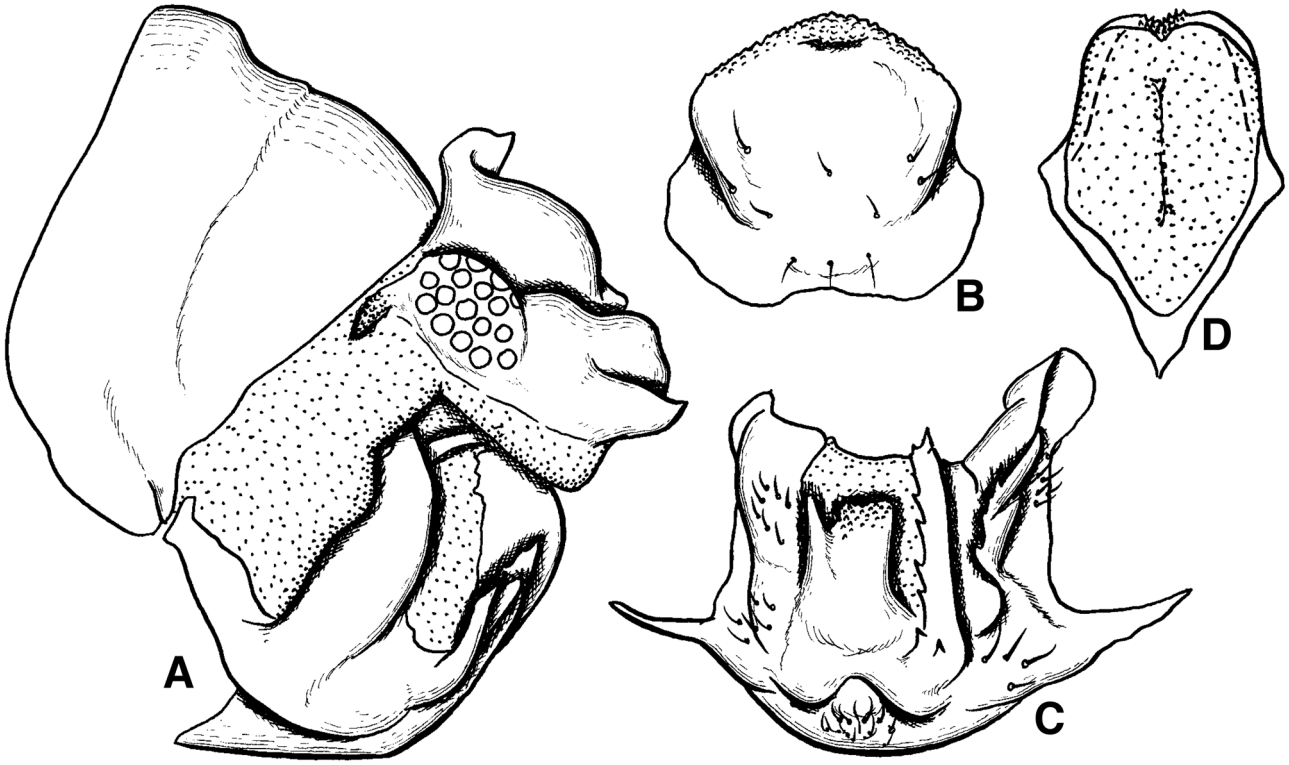



**FIGURE 3.** Male terminal structures of *Trichadenotecnum sharkeyi*. A: terminalia, lateral view; B: epiproct, posterodorsal view; C: hypandrium, posteroventral view; D: phallosome, ventral view.

***Trichadenotecnum sabahense* n. sp.**
(Figs 1C, 4)

**Holotype**. Male. MALAYSIA: SABAH (Interior Residency): Kimanis road, 16 miles from Keningau, heliport, sifting in cloud forest, 1380 m, 12.v.1982, B.Hauser leg (sabah1, KY461) (will be deposited in the Muséum d'histoire naturelle, Geneva, Switzerland).

**Description**. **Male**. **Head**. Head white in ground color; vertical markings blackish brown, each marking touching with neighbors; with pair of anterior spots anterior to vertical markings; orbital markings obscure; coronal suture blackish; epicranial suture narrowly bordered with brown band dorsally; frons with pair of brown markings medially; gena white; eye black, IO/D=1; ocelli white, ocellar field brown; postclypeus with brown spots medially; anteclypeus brown. Antenna brown, scape and pedicel darker. Mouthparts brown.

**Thorax**. Prothorax brown. Mesoscutum with large brown marking on each lobe, marking on anterior lobe darker, scutellum dark brown. Mesopleuron white except for brown precoxal bridge and trochantin. Metascutum mostly brown, medially with pale region; scutellum dark along anterior margin, pale along posterior margin. Metapleuron brown except for white membranous region.

**Legs**. Coxae of all legs dark brown. Fore legs brown except for white distal half of femur. Mid and hind legs white except for brown basal end of femur and tarsus.

**Forewing** (Fig. 1C). As in group diagnosis; distal spot in cell a apparent; spot on roof of m3 apparent, anterointernally narrowly connected to posterior spot of distal band; roof vein of cell m3 very short, about 1/3 of second section of CuA1 in length.

**Terminalia**. Eighth sternum broadly sclerotized, fused to hypandrium posteromedially (Fig. 4A). Epiproct lobe well developed, strongly expanded dorsally and over clunium; dorsal margin covered by papillae, with posterior projection medially (Fig. 4AB). Paraproct with tiny basal process covered by denticles; distal process narrow and short, strongly curved, with tiny notch at tip (Fig. 4A). Hypandrium (Fig. 4C) with broad membranous region distal to median tongue, anteroventral surface strongly projecting ventrally, with medial swelling covered with papillae; left corner with wrinkled lobe; left process absent; median tongue well developed, unmovable, covered by papillae distally, distal margin only slightly curved; right process well developed, covered by denticles; right corner highly modified, with wrinkled lobe. Phallosome (Fig. 4D) rounded anteriorly, posteriorly closed, bilobed, covered by papillae.

**Measurements**. Body 1.7 mm, forewing 2.0 mm, hindwing 1.9 mm.

**Female**. Unknown.

**Distribution**. Malaysia (Sabah).

**Etymology**. The specific epithet refers to the region of origin of the holotype.

**Remarks**. This species is very close to *T. sharkeyi*, described above, on the basis of the epiproctal and hypandrial structures, but these species differ clearly in many genital structures, including the distal structure of the phallosome (Figs 3D and 4D).

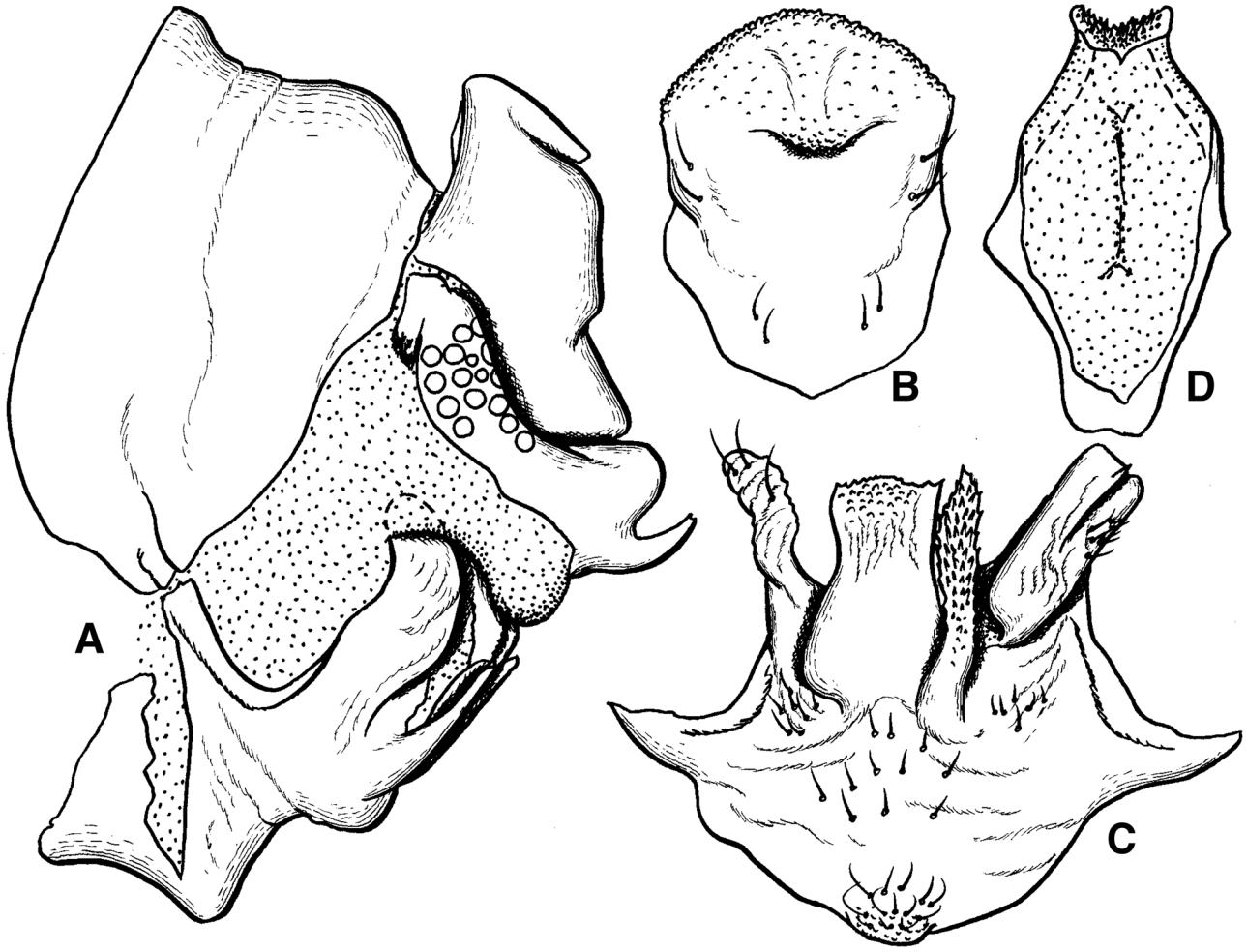



**FIGURE 4.** Male terminal structures of *Trichadenotecnum sabahense*. A: terminalia, lateral view; B: epiproct, posterodorsal view; C: hypandrium, posteroventral view; D: phallosome, ventral view.

## Phylogenetic placement

Phylogenetic placement of the *marginatum* group (= former genus *Cryptopsocus*) was tested morphologically. Morphological characters of *T. tigrinum*, for which both males and females are available, and *T. sabahense*, known only from males, were scored, and data were appended to the matrix presented in Yoshizawa (2004) and Yoshizawa *et al*. (2008). Data matrix is available from TreeBase (http://purl.org/phylo/treebase/phylows/study/TB2:S17425) or http://insect3.agr.hokudai.ac.jp/Cryptopsocus.phylog/. Maximum parsimony analysis of the data matrix (see Yoshizawa *et al*. 2008 for analytical method) yielded 488 equally parsimonious trees (Length = 144, Consistency Index = 0.403, Retention Index = 0.742). Application of successive weighting reduced the equally parsimonious trees to seven, which are included in 488 trees estimated by equally weighted analysis. Therefore, the trees estimated from successive weighting of morphological characters were preferred here. Their strict consensus tree is shown in Fig. 5. Placement of the *marginatum* group within *Trichadenotecnum* was supported by all 488 trees estimated from equal weighting analysis. Basal relationships within *Trichadenotecnum* were completely unresolved in the consensus of 488 trees but, after application of successive weighting, basal split of the *marginatum* group from the rest of *Trichadenotecnum* excluding the *corniculum* + *roesleri* groups (= Neotropical clade: see Yoshizawa *et al*., 2008) was suggested by all the trees. All species of the *marginatum* group examined here possess the paraproctal basal process, similar to that observed in the *spiniserrulum* group. Close relationship

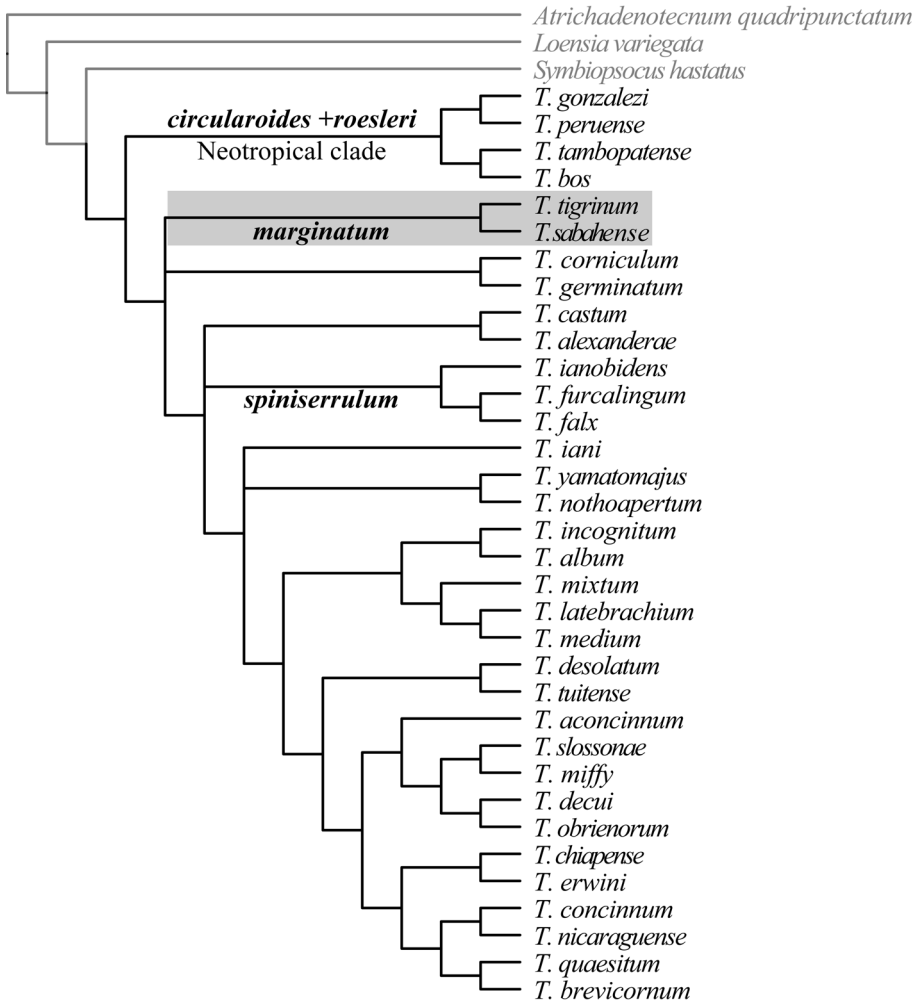



**FIGURE 5.** Phylogenetic placement of the *Trichadenotecnum marginatum* group estimated from morphological data. The figure shows strict consensus of seven trees obtained from the successive weighting analysis. Only the species group names mentioned in the discussion are labelled on the branches, and the *marginatum* group is highlighted by a gray square.

between the *marginatum* and *spiniserrulum* groups was suggested by some of 488 trees but, after application of successive weighting, these groups were placed separately. Ongoing molecular phylogenetic analyses including *T. tigrinum* and *T. sabahense* support the placement of the *marginatum* group as estimated from the successive weighting analysis of morphological data (Yoshizawa *et al*., unpublished data). The presence of the opposite spots in cell r and vein Rs forked in right or obtuse angle are shared by all *Trichadenotecnum* species including the *marginatum* group and excluding the Neotropical clade.


## Acknowledgments

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