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The millipede order Platydesmida (Diplopoda) in Taiwan, with descriptions of two new species

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Abstract

The diplopod order Platydesmida appears to be represented in Taiwan by two new species from one family, Andrognathidae, and two genera: *Brachycybe disticha* **sp. nov.** and *Yamasinaium latum* **sp. nov.** Descriptions of these two species are presented, also based on examination of the types of the geographically closest species of each genus: *Brachycybe nodulosa* (Verhoeff, 1935) and *Yamasinaium noduligerum* Verhoeff, 1939, both from Japan**.** The distributions of the Taiwanese species of *Brachycybe* and *Yamasinaium* are mapped and discussed.

Key words: Millipede, Andrognathidae, new species, taxonomy, key, Taiwan

Introduction

The Platydesmida is one of the smaller diplopod orders, containing only about fifteen genera from two families: Platydesmidae and Andrognathidae. Platydesmida are mainly Holarctic in distribution, occurring in North and Middle America, Japan, Korea, China, Taiwan, Southeast Asia, and the Mediterranean region. The first records of platydesmidans in Taiwan Island were published by Korsós (2004), who listed two unidentified species of Andrognathidae and provided a color picture of a specimen he referred to as "Andrognathidae sp. 1". Shelley *et al*. (2005) provisionally assigned this species to *Brachycybe* Wood, 1864, because of its general body shape. The second Taiwanese platydesmidan was referred to as "Andrognathidae sp. 2", described as slender and long-bodied (Korsós 2004). Up to now, these two unidentified species were the only records of Taiwanese Platydesmida.

Among the diplopod samples from Taiwan kept in the collections of the National Museum of Natural Science, Taichung, Taiwan (NMNS) and Department of Biological Sciences, National Sun Yat-Sen University, Kaohsiung, Taiwan (NSYSUB), two new species of Andrognathidae have been found. The present paper provides their descriptions and comparisons with type material of their geographically closest congeners.

Material and methods

Material treated here has been deposited in the collections of the National Museum of Natural Science, Taichung, Taiwan (NMNS), Department of Biological Sciences, National Sun Yat-Sen University, Kaohsiung,

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Taiwan (NSYSUB), Institute of Biology and Soil Science, Far Eastern Branch, Russian Academy of Sciences, Vladivostok, Russia (IBSS), Zoological Museum, State University of Moscow, Russia (ZMUM), and Hungarian Natural History Museum, Budapest, Hungary (HNHM), as indicated in the text.

Type material of the geographically closest congeners has also been investigated: *Bazillozonium nodulosum* Verhoeff, 1935, holotype male torso lacking both anterior and posterior body ends, as well as two micropreparations, all from the Zoologische Staatssammlung, Munich, Germany (ZSM), and *Yamasinaium noduligerum* Verhoeff, 1939, two micropreparations, ?syntype material, ZSM, and syntype male in alcohol, from the Museum für Naturkunde der Humboldt-Universität, Berlin, Germany (ZMB).

In the process of studying the material, the gonopods and some other parts were dissected from a limited number of males and mounted in glycerin as temporary micropreparations. SEM micrographs were prepared at the Centre of Collective Use "Biotechnology and Gene Engineering" of the IBSS in Vladivostok, Russia using a ZEISS EVO 40 scanning electron microscope. Mounts for SEM were made through air-drying after transfer to acetone via 96% alcohol, mounting on stubs, and coating with gold and platinum. After examination, SEM material was removed from stubs and returned to alcohol, all such samples being kept at IBSS.

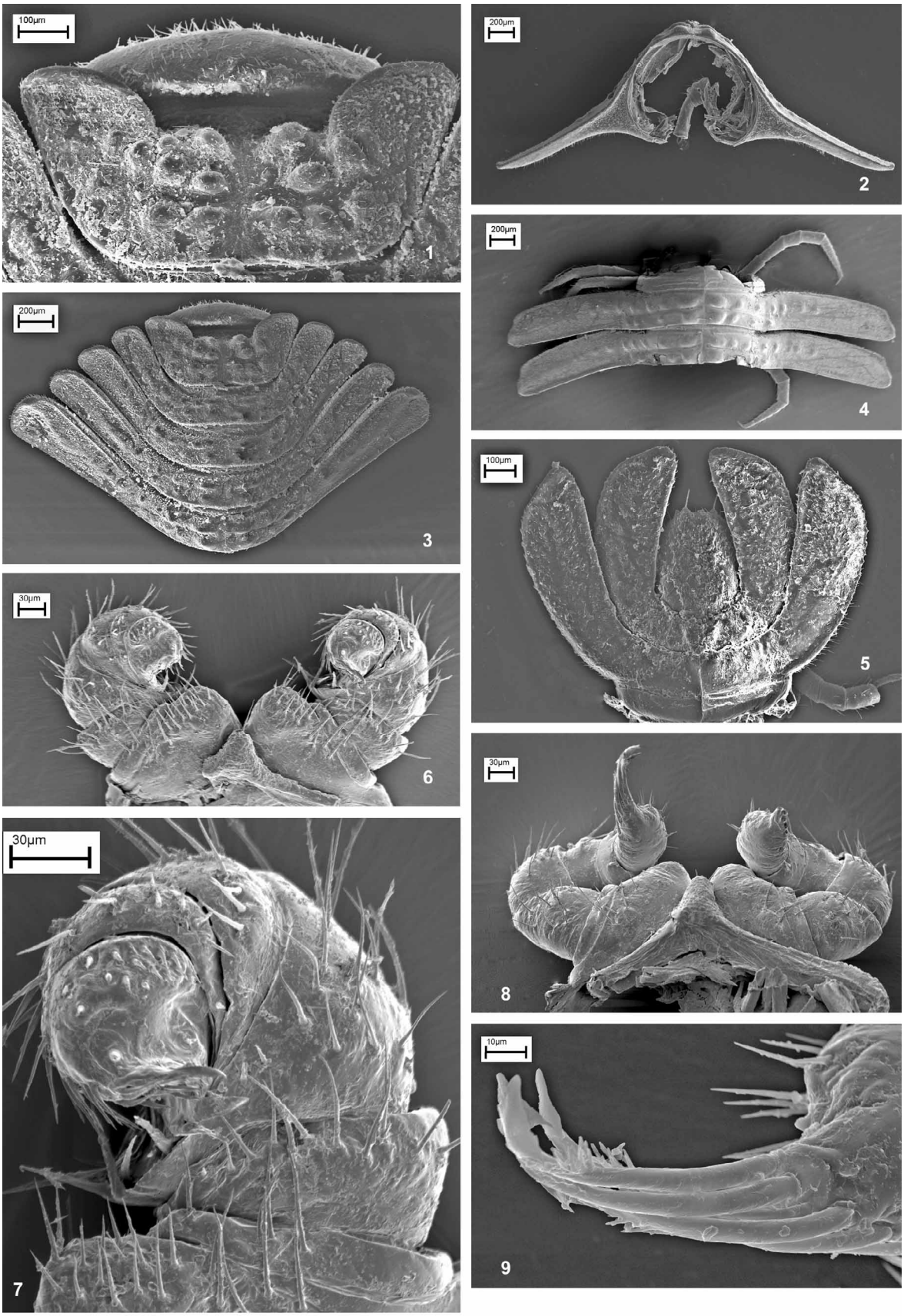
Taxonomy

***Brachycybe disticha* sp. nov.**
Figs 1–16, 18.

Material examined. *Holotype*: male (NMNS-6459-001, D-0027), Taiwan, Nantou County, Huisun timberland, 12 November 1997, leg. S. H. Wu. *Paratypes*: 5 males (one dissected for SEM: anterior and posterior body parts, midbody segment, gonopods), 4 females (IBSS), 1 male, 1 female (ZMUM), 1 male, 2 females (NSYSUB), 5 males, 11 females, 1 juvenile (NMNS-6459-002, D-0027), same locality, together with holotype, 12 November 1997, leg. S. H. Wu; 1 male (NMNS-6459-003, D-0159), same locality, 27 December 1997, leg. S. H. Wu; 2 males (NMNS-6459-004, D-0158), same locality, 8 February 1998, leg. S. H. Wu; 1 female (HNHM, No. 157), Taiwan, Nantou County, Ren-ai Township, Meifeng, 24°06' N, 121°12' E, 2300 m, 5–6 September 2003, leg. G. Csorba & Z. Korsós; 1 female (HNHM), Taiwan, Nantou County, Ren-ai Township, Wushe, western slope of Meifeng, 24°04.913' N, 121°09.434' E, 1659 m, disturbed secondary broad-leaved forest, 13 October 2009, leg. L. Dányi & E. Lazányi; 1 female (NMNS-6459-005), Taiwan, Nantou County, Shueili, Renluen biodiversity project, 1600 m a.s.l., *Cryptomeria* plantation (plot E10–2), May 2006, leg. Tunghai University Spider Research Group; 1 male, 3 females (NMNS-6459-006), Taiwan, Nantou County, Shueili, Renluen, experimental forest area, primary forest, 23°42.5' N, 120°55.3' E, 1615 m, 15 May 2008, leg. L. Dányi, Z. Korsós & E. Lazányi; 1 female (HNHM), Taiwan, Nantou County, Shueili, Renluen, experimental forest area, primary forest, 23°42.7' N, 120°56.2' E, 1901 m, 16 May 2008, leg. L. Dányi, Z. Korsós & E. Lazányi; 4 males, 2 females (HNHM), Taiwan, Pingtung County, Mutan, 8 December 1998, leg. Gy. Fábián & Z. Korsós; 3 males (NSYSUB, 0002), Taiwan, Pingtung County, Shizi Township, Neiwen, under rotten wood, 5 October 2002, leg. S. Y. Wu. *Non-type*: 1 male (NSYSUB), Taiwan, Kaohsiung County, Lioguei, Shanping Workstation, May 2004, leg. M. J. Hung.

Diagnosis. This species differs from congeners mainly by the collum showing three rows of tubercles, by distinct paranota on the collum directed anterolaterad, in the presence of six apical stylets on the posterior gonopods, in the steep lateral slopes of the dorsum and in the large, mid-dorsal tubercles forming two evident paramedian rows virtually all along the body.

Description. Male. Length mainly *ca* 8.5–15.0 mm, width *ca* 2.7–4.1 mm together with paranota, 33–47 body segments including telson. Body length of most of males 12–14 mm, width *ca* 4.0 mm, with 41 or 44 body segments. Holotype 15 mm long, 4.0 mm wide, with 47 segments including telson. Male from Kaohsiung County 20.5 mm long, 4.7 mm wide, with 53 body segments including telson, being distinguished not only by its considerably larger size, but also due to its peculiar collum (see below). Coloration in alcohol: dorsum light



FIGURES 1–9. *Brachycybe disticha* **sp. nov.**, male paratype. 1, collum, dorsal view; 2, midbody ring, cross-section; 3, anterior part of body, dorsal view, slightly skewed backwards; 4, midbody segments, dorsal view; 5, hind part of body, dorsal view; 6, anterior gonopods, front view; 7, left anterior gonopod, front view; 8, posterior gonopods, front view; 9, apex of posterior gonopod.

FIGURES 10 & 11. *Brachycybe disticha* **sp. nov.**, female paratype. 10, anterior part of body, dorsal view; 11, collum, dorsal view.

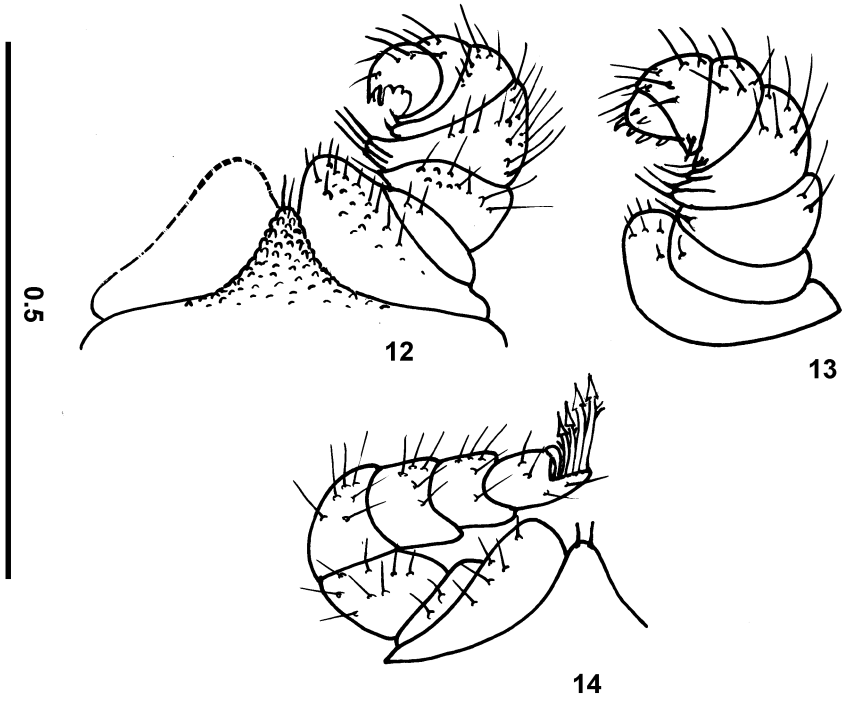
tan with paraterga growing lighter distad; ventral side of body and legs yellowish white; head yellowish or white. Coloration of younger, smaller individuals lighter to pallid.

Head moderately densely setose. Collum with distinct paranota directed anterolaterad (Fig.1). Three rows of tubercles on each side of collum: anterior row with 1–2 tubercles, middle and posterior rows with 3–4 tubercles, these varying in size with paramedian ones being larger.

Body covered with dense minute pubescence. Slopes of dorsum steep, so body in cross-section subtriangular (Fig. 2). Paranota 2–4 narrower than following ones, their lateral margins being rounded (Fig. 3). In Fig. 3, anterior body end inclined somewhat caudad, yet difference between shapes of paranota 2–4 and of following ones more drastic than shown in Fig. 3. Lateral paranotal margin of remaining segments with a small notch (Fig. 4). Midbody segments with two rows of tubercles on metazona, caudal row shorter and extending to base of paranota; anterior row longer, extending to about midlength of paranota. Paramedian tubercles considerably larger. Mid-dorsal tubercles on all segments combined forming two distinct paramedian rows extending all along body (Fig. 15). Paranota curved strongly anteriad on segments 2–5, increasingly less so on segments 6–10(11), slightly curved caudad on segment 11(12) and following segments; caudal curvature of paranota increasingly clear on 6–7 posteriormost segments in front of telson; paranota of penultimate segment produced strictly caudad and flanking telson (Fig. 5). Caudal paranotal margins entire, without notches.

Legs slender, shorter than segment width together with paranota, terminating before lateral paranotal margins. Claws normal.

Two pairs of gonopods directed anteriad. Anterior gonopods (Figs 6, 7, 12 & 13) 7-segmented, covered with long setae. Coxite broad. Podomere 2 short. Each of following podomeres (3–6) with a medial protuberance carrying strong setae. Ultimate podomere excavated centrally to accommodate stylets of posterior gonopod. Posterior gonopods (Figs 8, 9 & 14) 7-segmented, covered with sparse long setae. Coxite broad. Ultimate podomere longest, with six prominent, parallel, apical or subapical stylets of varying length. Each stylet with triangular spur subapically and group of minute batons near middle. Gonopod sterna with low papillae and two apical setae.



FIGURES 12–14. *Brachycybe disticha* **sp. nov.**, male paratype. 12, left anterior gonopod, front view; 13, right anterior gonopod, caudal view; 14, right posterior gonopod, front view. Scale in mm.

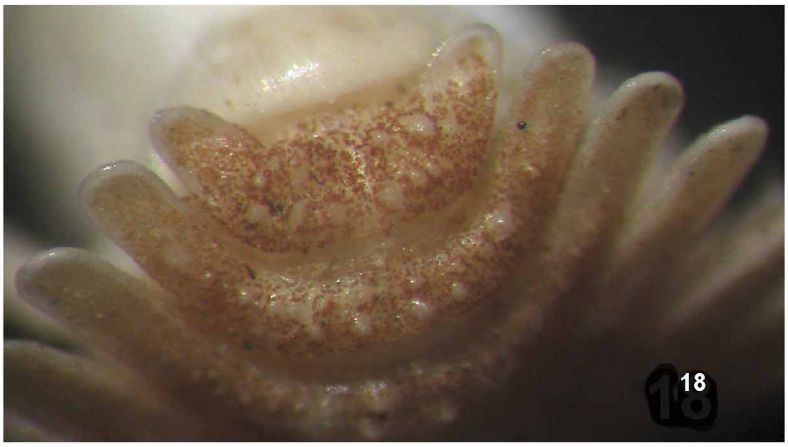
Female. Length *ca* 14–18.5 mm, width 3.9–4.8 mm together with paranota; 44–48 body segments including telson. Most of females with bodies 15–17 mm in length, *ca* 4.5 mm in width, with 44 or 47 body segments. Nonsexual characters as in male. Anterior body end and collum as in Figs 10 & 11.

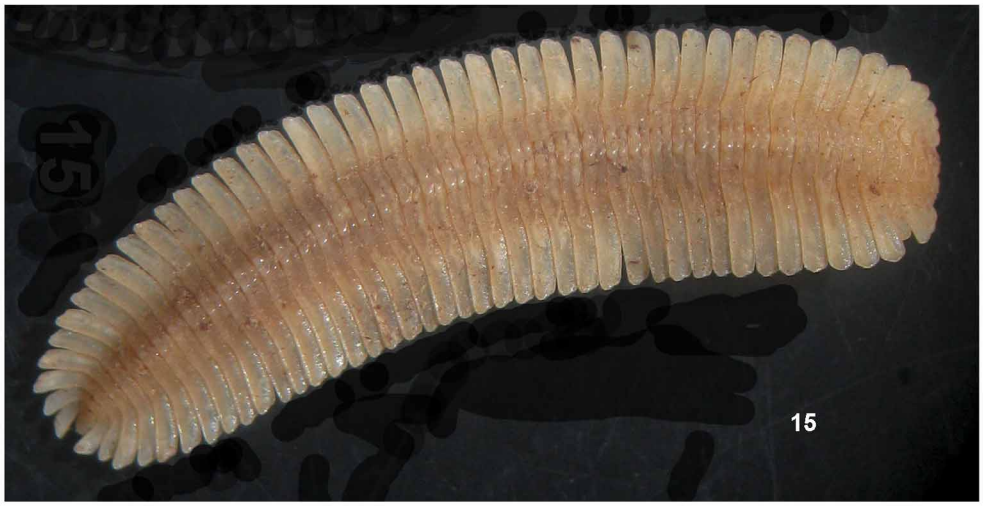
Juvenile. Length *ca* 9.0 mm, width 2.5 mm together with paranota; 29 body segments including telson.

Name. The specific epithet refers to two parallel rows of larger mid-dorsal tubercles along the axial line.

Remarks. The holotype of *Brachycybe nodulosa* (Verhoeff, 1935), the type-species of *Bazillozonium* Verhoeff, 1935, the latter genus being a junior synonym of *Brachycybe* (Gardner 1974/75), was revised for comparative purposes. *Bazillozonium nodulosum* was originally described from Beppu, Oita Prefecture, Kyushu, Japan but, according to Shelley *et al*. (2005), following Moritz & Fischer (1974) and a personal communication from S. Friedrich (ZSM), the reference to Beppu as being located near Tokyo, Honshu Island, Japan as given by Verhoeff (1935) is a mistake. Beppu in fact borders on Oita City. A side-by-side comparison of both these species revealed them to differ considerably. Thus, *B. disticha* shows the collum supporting three rows tubercles and broader anterolateral lobes (Figs 1, 11), as opposed to two rows and narrower lobes in *B. nodulosa*. In addition, in *B. disticha* the slopes of the dorsum are steep (Fig. 16), so the body in cross-section looks subtriangular (Fig. 2), whereas in *B. nodulosa* the dorsum is flatter (Fig. 17) and similar to a rounded arch in cross-section. Besides this, the paramedian mid-dorsal tubercles in *B. disticha* are much larger and placed closer to each other, thus forming two evident longitudinal rows extending all along the body (Fig. 15). In contrast, the paramedian mid-dorsal tubercles in *B. nodulosa* are smaller and more widely separated, not composing evident longitudinal rows. Furthermore, the body in *B. disticha* is broader than that of *B.*

nodulosa. This is clear from pictures (Figs 16 & 17) taken from body fragments of both these species using specimens with about the same number of segments: 47 in *B. disticha* (Fig. 16), and 50 in *B. nodulosa*, according to Verhoeff (1935) (Fig. 17).





FIGURES 15–18. *Brachycybe disticha* **sp. nov.**, male paratype (15); *Brachycybe disticha* **sp. nov.**, fragment of a male paratype (16); *Brachycybe nodulosa*, fragment of male holotype (17); *Brachycybe disticha* **sp. nov.**, collum of the male from Kaohsiung County (18). Photograph not to scale.

Both differ also in the number of apical stylets on the posterior gonopod: six in *B. disticha* versus four in *B. nodulosa*. The legs of *B. disticha* are slightly shorter than in *B. nodulosa* as well.

The male from Kaohsiung County, treated here as a non-type, is peculiar, differing from the other presumed conspecific samples of *B. disticha* from Taiwan in being 20.5 mm long, 4.7 mm wide, showing 53 body segments including the telson, and the collum rather resembling that of *B. nodulosa*, i.e. narrower anterolateral lobes and two rows of tubercles only on the right side of this tergite (Fig. 18). On the left side, the front row of tubercles is irregular, forming a group of tubercles. Yet, the front row of tubercles on the collum of the sample from Kaohsiung County appears to continue the inner edge of the collum's lobe, this being characteristic of male *B. disticha* from the other places, whereas in *B. nodulosa* the front row of tubercles on the collum is not located in continuation of the inner edge of the lobe. As regards the remaining characters, including gonopod ones, this male from Kaohsiung County fails to differ from *B. disticha.* Considering the importance of collum structure in the identification of *Brachycybe* species (Shelley *et al.* 2005), we are inclined to treat the male from Kaohsiung County as representing *B. disticha*. However, more material is required to reveal the variation range of this species.

***Yamasinaium latum* sp. nov.**
Figs 19–30.

Material examined. *Holotype*: male (NMNS-6460-001, D-0636), Taiwan, Nantou County, Huisun timberland, 01 March 1998, leg. S. H. Wu. *Paratypes*: 7 males, 5 females (NMNS-6460-002, D-0636, D-0163), 3 males, 2 females (IBSS), 1 male, 1 female (ZMUM), 1 male, 1 female (NSYSUB), same locality, together with holotype, 01 March 1998, leg. S. H. Wu; 1 male (dissected for SEM: anterior and posterior body parts, midbody segment, gonopods) (IBSS), 2 females (NMNS-6460-003, D-0052), same locality, 29 March 1998, leg. S. H. Wu; 1 male, 2 females (NSYSUB, 0001), Taiwan, Nantou County, Ren-ai Township, Huisun timberland, under rotten wood, 10 July 2007, leg. M. H. Hsu; 1 female (NMNS-6460-004, D-0698), Taiwan, Nantou County, Ren-ai Township, Meifeng, 01 April 2002, leg. S. H. Wu; 1 male (NMNS-6460-005, D-0675), same locality, 11 July 2002, leg. S. H. Wu; 1 female (HNHM), Taiwan, Nantou County, Shueili, Renluen, experimental forest area, primary forest, 23°42.5' N, 120°55.3' E, 1615 m, 15 May 2008, leg. L. Dányi, Z. Korsós & E. Lazányi; 1 male, 1 female (HNHM), Taiwan, Nantou County, Shueili, Renluen, experimental forest area, *Cryptomeria japonica* plantation, 23°43.4' N, 120°54.9' E, 1335 m, 16 May 2008, leg. L. Dányi, Z. Korsós & E. Lazányi; 1 male (HNHM), Taiwan, Nantou County, Shueili, Renluen, experimental forest area, *Cryptomeria japonica* plantation, 23°43.2' N, 120°55.1' E, 1405 m, 16 May 2008, leg. L. Dányi, Z. Korsós & E. Lazányi; 1 male, 6 females (NMNS-6460-006), 1 male, 6 females, 6 juveniles (HNHM), Taiwan, Anmashan, Tahsueh-shan Forest Recreation Area, 2900 m, 24°16.66' N, 121°01.50' E, 2 December 1998, leg. Gy. Fábián & Z. Korsós; 2 females (NMNS-6460-007), Taiwan, Taichung County, Mts Da-Hsue-san, *Cryptomeria japonica* plantation, over 2000 m, April-May 2006, leg. Tunghai University Spider Research Team; 2 males, 10 juveniles (HNHM), Taiwan, Taichung County, Mts Da-Hsue-san, logging road No. 210, *Cryptomeria* plantation, 2000 m a.s.l., 14 October 2007, leg. Z. Korsós; 2 males, 2 females (NMNS-6460-008), 2 males, 2 females (HNHM), Taiwan**,** Taichung County, Mt. Da-Hsue-san, SE slope of Shaolai Shan, 24°13.734' N, 120°58.738' E, 2003 m, primary broad-leaved forest, 24 October 2009, leg. L. Dányi & E. Lazányi.

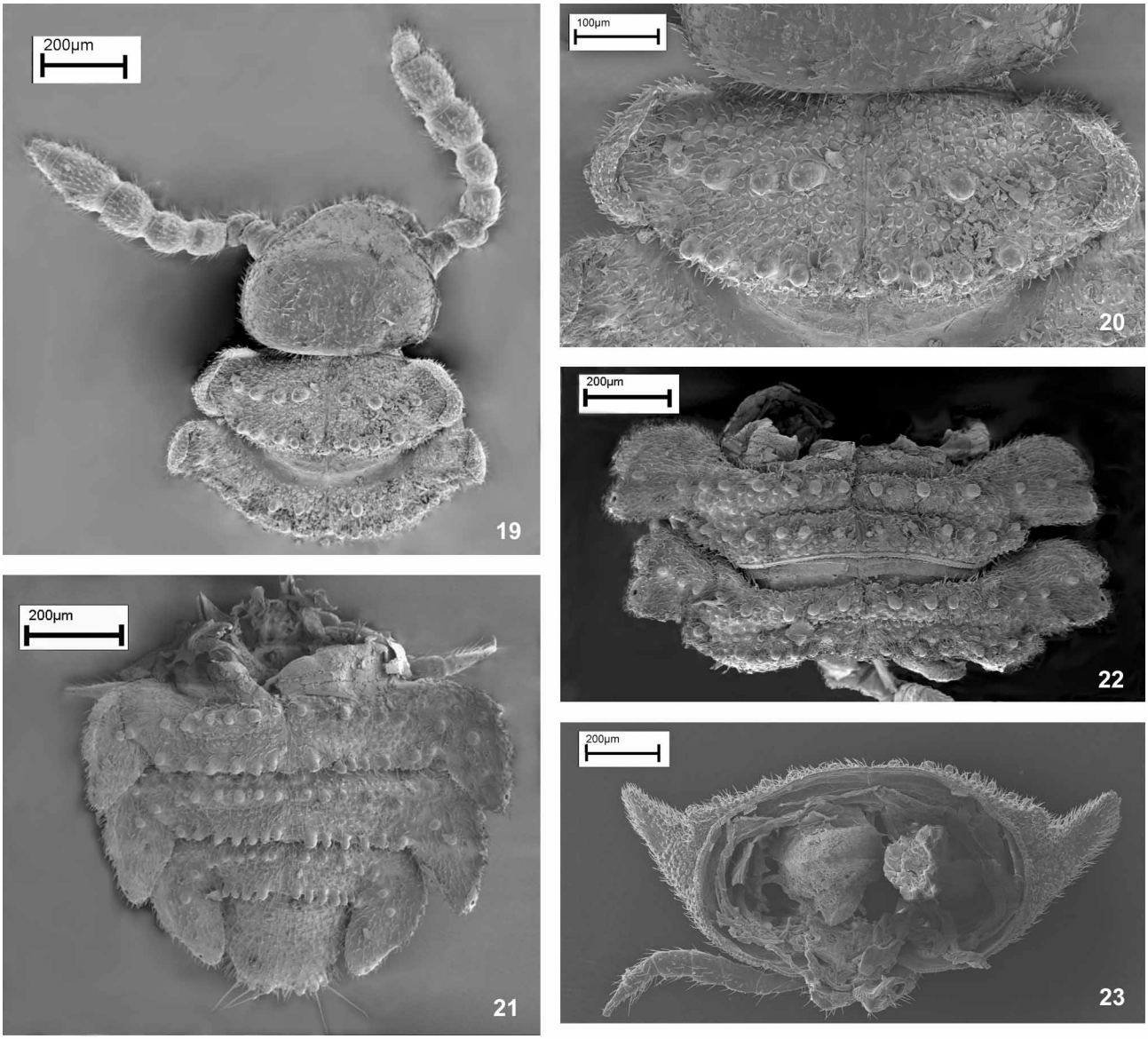
Diagnosis. This new species differs from congeners mainly by the collum being *ca* 3 times as broad as long, and broader than the head, as well as in having the body longer than in *Y. noduligerum*, but shorter than in *Y. koreanum*, in the shorter legs, and the very evident tubercles on the metaterga.

Description. Male. Length 10–21 mm, width 0.9–1.8 mm with paranota. 38–57 body segments including telson. Holotype 15 mm long, 1.1 mm wide, with 47 segments including telson. Coloration in alcohol yellow-whitish, grey-yellowish, yellow or light tan.

Head densely setose. Collum with small but distinct paranota directed anterolaterad, not covering head, latter visible in dorsal view (Figs 19 & 20). Collum much broader than head, *ca* 3 times as broad as long. Two rows of subequal tubercles on collum; each row with gap near axial suture, this gap being especially clear in

anterior row.

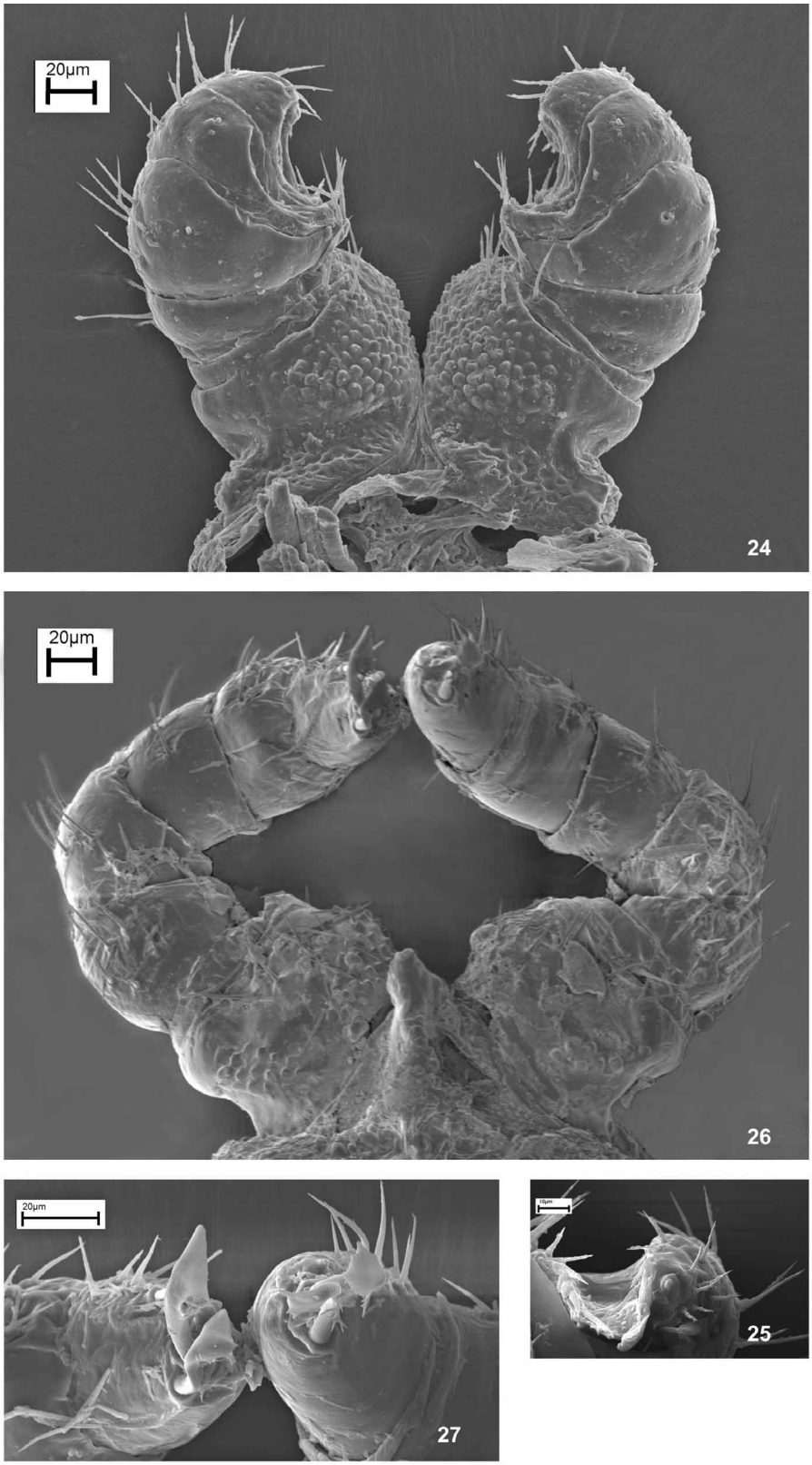
Body covered with dense minute pubescence and papillae. Papillae on pleura large. Paranota subhorizontal, not very large (Fig 30). Lateral paranotal margins on nearly all segments, except for a few fore- (1–5) and hindmost segments, with a notch. Lateral edges of segments 1–5 rounded. Paranota 2–4 narrower than following ones. Penultimate paranota extending strictly caudad and flanking telson (Fig. 21). Midbody segments (Figs 22–23) with two transverse rows of high distinct tubercles of subequal size all over body; caudal row being shorter; anterior row longer and terminating near lateral paranotal margin. Caudal paranotal margins with distinct notches starting from segment 5, anterior margins entire.



FIGURES 19–23. *Yamasinaium latum* **sp. nov.**, male paratype. 19, anterior part of body, dorsal view; 20, collum, dorsal view; 21, posterior part of body, dorsal view; 22, midbody segments, dorsal view; 23, midbody segment, cross-section.

Legs slender, somewhat shorter than segment widths together with paranota, terminating somewhat before lateral paranotal margins. Claws normal.

Two pairs of gonopods directed anteriad. Anterior gonopod (Figs 24–25, 28) 7-segmented, with groups of long setae. Coxite broad and papillate. Podomere 2 short. Each of podomeres 3–6 with median protuberance carrying strong setae. Ultimate podomere excavated centrally to accommodate stylets of posterior gonopod (Fig. 25). Posterior gonopods (Figs 26–27, 29) also 7-segmented, covered with sparse long setae. Coxite broad and papillate. Ultimate podomere longest, with two prominent, parallel, apical stylets. Each stylet with spur subapically. Gonopod sternites papillate, with two apical setae.



FIGURES 24–27. *Yamasinaium latum* **sp. nov.**, male paratype. 24, anterior gonopods, caudal view; 25, ultimate podomere of anterior gonopod with excavation for accommodating stylets of posterior gonopod; 26, posterior gonopods, front view; 27, ultimate podomeres of posterior gonopods.

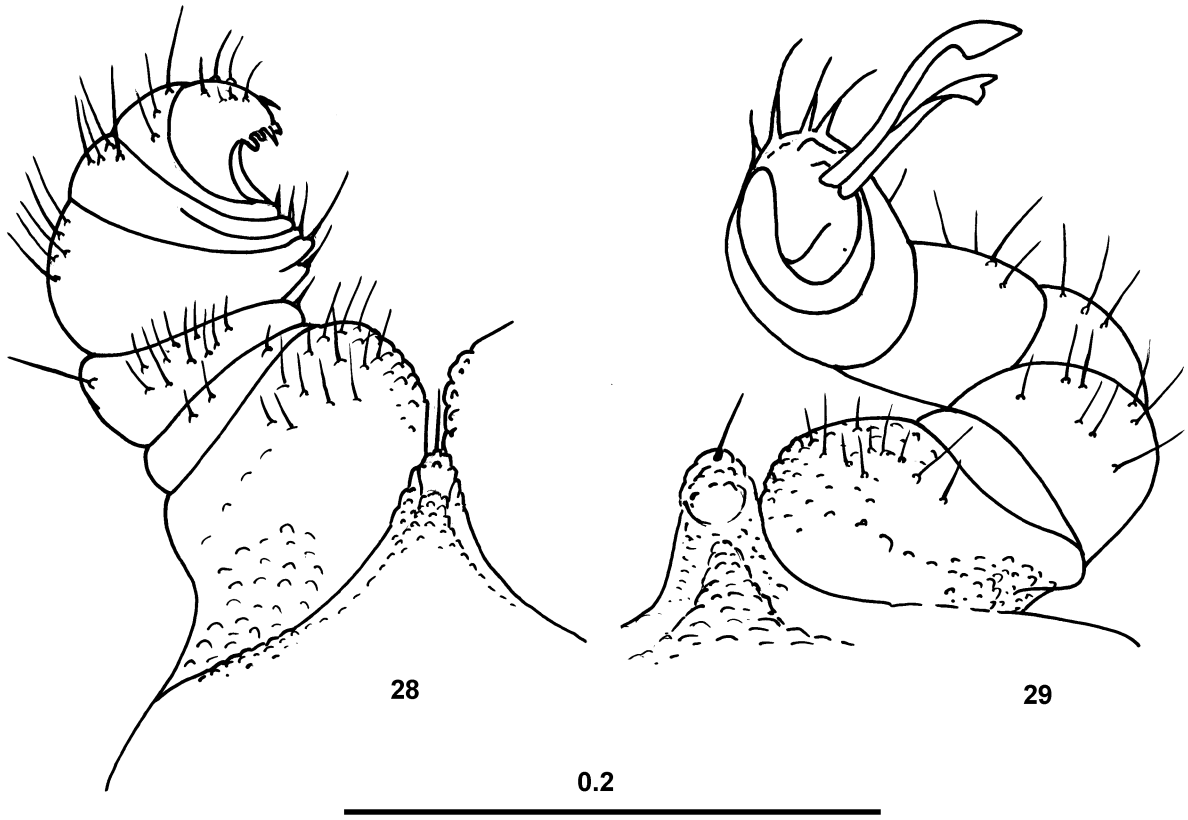
Female. Length 10–31 mm, width 1.0–2.0 mm together with paranota; 36–69 body segments including telson. Nonsexual characters as in male.

Name. The specific epithet refers to the collum being broader as compared to that in *Y. noduligerum*.

Remarks. The genus *Yamasinaium* has hitherto been known to encompass only two species: *Y. noduligerum*, the type-species described from Okinawa Island, Ryukyu Archipelago, Japan (Verhoeff 1939), and *Y. koreanum* Golovatch, 1981, discovered in Korea (Golovatch 1981).

A side-by-side comparison of the above new species with type material of *Y. noduligerum* revealed the following differences. *Y. latum* is distinguished by the collum being broader, both clearly broader than the head and about 3 times as broad as its maximum length (Figs 19 & 20). The collum of *Y. latum* supports clear-cut anterolateral lobes, while *Y. noduligerum* shows the collum subequal in width to or slightly narrower than the head, only about 2 times as broad as its maximum length, and devoid of evident anterolateral lobes. Besides this, these two species differ in body size (10–21 mm long in *Y. latum* versus 8.5–10.5 in *Y. noduligerum*) and leg length (slightly shorter, not reaching the lateral margin of the paranota in *Y. latum*, versus slightly longer, reaching the lateral margin of the paranota, in *Y. noduligerum*).

The new species differs from *Y. koreanum* mainly in the well-developed tubercles on the metaterga, the smaller body size (versus 22–28 mm long in *Y. koreanum*), the presence of a notch at the caudal paranotal margin, the less abundant tergal pilosity, and the development of subapical spurs on the stylets of the posterior gonopod.



FIGURES 28 & 29. *Yamasinaium latum* **sp. nov.**, male paratype. 28, right anterior gonopod, front view; 29, left posterior gonopod, anteroventral view. Scale in mm.

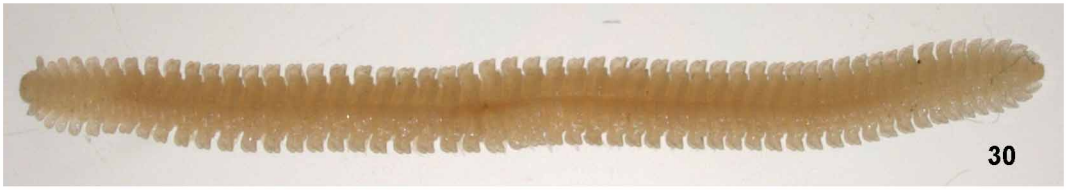
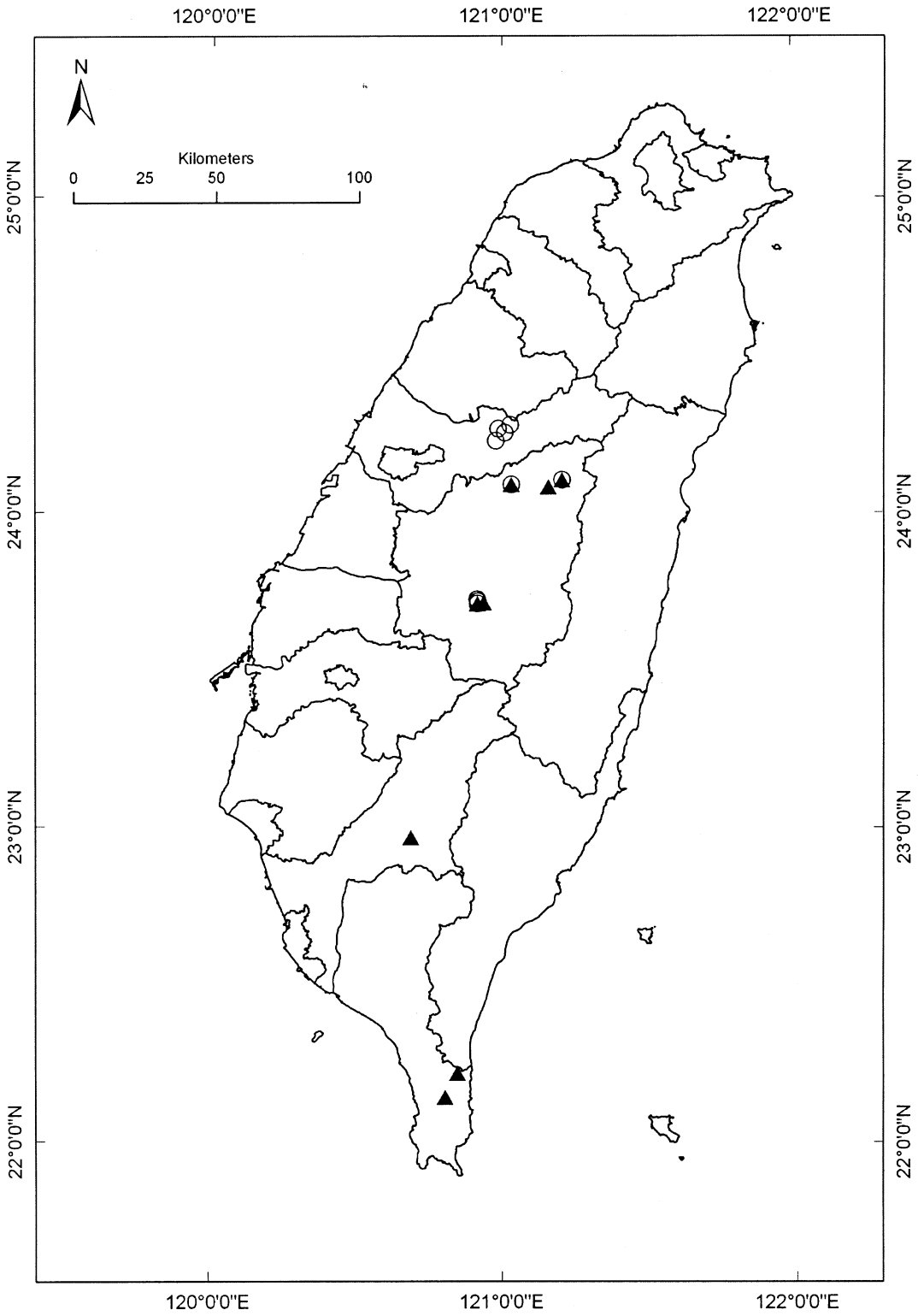


FIGURE 30. *Yamasinaium latum* **sp. nov.**, male paratype. Photograph not to scale.



MAP. Distribution of *Brachycybe disticha* **sp. nov.** and *Yamasinaium latum* **sp. nov.** in Taiwan. Borderlines show borders between the counties. Filled triangle: *Brachycybe disticha* **sp. nov.**, open circle: *Yamasinaium latum* **sp. nov.**

Conclusion

The platydesmid fauna of Taiwan appears to be poor but highly peculiar. At present, two species from two genera in one family, Andrognathidae, are known to occur on the island. One of the species belongs in the

Japanese-Korean-Taiwanese genus *Yamasinaium,* while the second is in the genus *Brachycybe,* currently known from North America, Japan, Korea, China and Taiwan. At the species level, at present the rate of endemism of the Androgнathidae on Taiwan amounts to 100 %, but this observation must be verified against the still insufficiently well studied faunas of the adjacent Ryukyus, Japan and continental China.

A similarly low-level diversity of Platydesmida at all taxonomic levels is also observed in the Korea and continental China, where the single family Androgнathidae is represented by two genera and two species, and one genus and species, respectively. In contrast, in Japan the likewise sole family Androgнathidae contains three genera and six species. This may be due to more intensive study in Japan.

Brachycybe is a genus showing a trans-Beringian distribution pattern (Shelley *et al*. 2005). It contains eight species, of which five are known from North America while the remaining three are Asian: *B. nodulosa* from Japan, *B. cooki* (Loomis, 1942) from continental China (Loomis 1942), and our *B. disticha* from Taiwan. Likewise, of all three currently described species of the East Asian genus *Yamasinaium*, *Y. koreanum* is only known from Korea, *Y. noduligerum* in Japan, and *Y. latum* in Taiwan.

The distribution of Platydesmida in Taiwan (Map) shows one of the species being relatively widespread. This is *B. disticha***,** which seems to be confined to the southern and central parts of the country. In contrast, *Y. latum* seems to be restricted to the island's central part. Of course, our map is provisional, reflecting the state of the art and the distribution of collecting efforts, but even now it is clear that both of the Taiwanese species represent the southernmost outposts in the distribution of their respective genera. This seems to be evidence of their Palaearctic roots.

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