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PRELIMINARY ASSESSMENT OF THE VELVET ANT FAUNA IN NEPAL, WITH DESCRIPTION OF NEW SPECIES OF THE GENERA STRANGULOTILLA NONVEILLER AND ZEUGOMUTILLA CHEN (HYMENOPTERA: MUTILLIDAE)

By Juriya Okayasu

Abstract

Okayasu, J., 2023. Preliminary assessment of the velvet ant fauna in Nepal, with description of new species of the genera *Strangulotilla* Nonveiller and *Zeugomutilla* Chen. *Ins. matsum. n. s.* 79: 1–27, 11 figure plates.

During 1965 to 1983, Hokkaido University undertook several entomological expeditions to various parts of Nepal. Specimens are preserved in the Hokkaido University Insect Collection (SEHU), providing valuable resources for better understanding of the velvet ant fauna of this rarely explored country with only eight recorded species in seven genera. This collection included 49 velvet ant specimens. The aim of this paper is to present its outline as the first attempt to assess the potential diversity of velvet ants in this country. Two genera of the tribe Zeugomutillini Waldren, 2023, *Strangulotilla* Nonveiller, 1979 and *Zeugomutilla* Chen, 1957, are newly recorded from Nepal. Two new species, *S. dubia* (♂) and *Z. curvicarinata* (♀), are described from Chitwan, Bagmati. These new species are similar to Indian and Sri Lankan congeners but can be distinguished based on morphology. A list of Nepalese specimens in SEHU is given. This collection included 24 morphospecies in 15 genera, exceeding the known diversity by three times.

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Introduction

Velvet ants (Mutillidae and Myrmosidae) are a large group of parasitoid stinging wasps with approximately 650 species recorded in the Oriental Region (Lelej, 2005, 2007; Pagliano et al., 2020). In this region, South Asia is known for its unique but rarely explored velvet ant fauna (Lelej, 1995; Okayasu, 2022).

Nepal is located just south of the Himalayan mountains, extending approximately one third of this mountain range (Paudel et al., 2012). Although Nepal occupies only 0.1% of the global land mass, the geography of this country is disproportionately complicated, from lowlands to world's highest peak, and a variety of terrestrial ecoregions is found (Fig. 1; Dinerstein et al., 2017; Olson et al., 2001; Paudel et al., 2012; Wikramanayake et al., 2002). It is, therefore, not surprising that Nepal harbors the highest richness and endemism of terrestrial organisms in South Asia (Myers et al., 2000; Paudel et al., 2012; Roll et al., 2017; Wikramanayake et al., 2002). However, the velvet ant fauna of Nepal is largely unsampled and only eight species have been recorded in six publications (Hammer, 1962; Lelej, 2005; Lelej et al., 2007, 2023; Okayasu et al., 2021; Zhou et al., 2018).

Hokkaido University conducted entomological expeditions to Nepal in 1965, 1967, 1968, 1972, 1975, and 1983 (Kumata, 1973; Suwa, 1984; Yamane & Yamane, 1979). Many entomologists were involved in this project; a vast number of specimens representing various insect orders was collected. The material collected in the expeditions has been fruitfully discussed by expert systematists over half a century in more than 50 papers (e.g., Kimoto & Takizawa, 1972, 1973, 1981; Kumata, 1973, 1985, 1989; Miyatake, 1985; Ôhara, 1989; Okushima, 1999; Suwa, 1977, 1984, 1994; Takagi, 1975, 1977, 2019, 2020; Takizawa, 1988; Williams et al., 2010; Yamane & Yamane, 1979). Those contributions provide basic knowledge of the insect fauna of Nepal, like new species descriptions, checklists, identification keys, and illustrations.

I explored the Nepalese collection in the Hokkaido University Insect Collection and found 49 velvet ant specimens, which will provide valuable resources for better understanding of the Nepalese fauna. This paper attempts to assess the potential diversity of velvet ants in this country based on the results of the Hokkaido University expeditions. A list of the specimens and description of two new species of Zeugomutillini Waldren, 2023, tribe new to Nepal, are given.

Materials and Methods

Nepalese velvet ant specimens collected through the Hokkaido University expeditions are deposited in the Hokkaido University Insect Collection, Sapporo, Japan (SEHU). Those specimens were sorted into genera using recent keys to Old World velvet ants (Lelej, 2002, 2005; Lelej & Williams, 2023; Turrisi et al., 2015; Williams et al., 2019). Some specimens were further identified to species-level. However, this paper is limited to present new species descriptions in Zeugomutillini and a list of morphospecies, because accurate identification of South Asian species often requires reexamination of types or identified specimens. Exceptions are the following two species that were described or recorded from Nepal in previous papers (Lelej et al., 2023; Okayasu et al., 2021) based on SEHU specimens: *Eotrogaspidia adhabar* Okayasu, Lelej & Williams, 2021 and *Kurzenkotilla scrobiculata* (Hammer, 1962). Voucher specimens were so labelled and linked with the names appearing in the list below. Two female specimens of

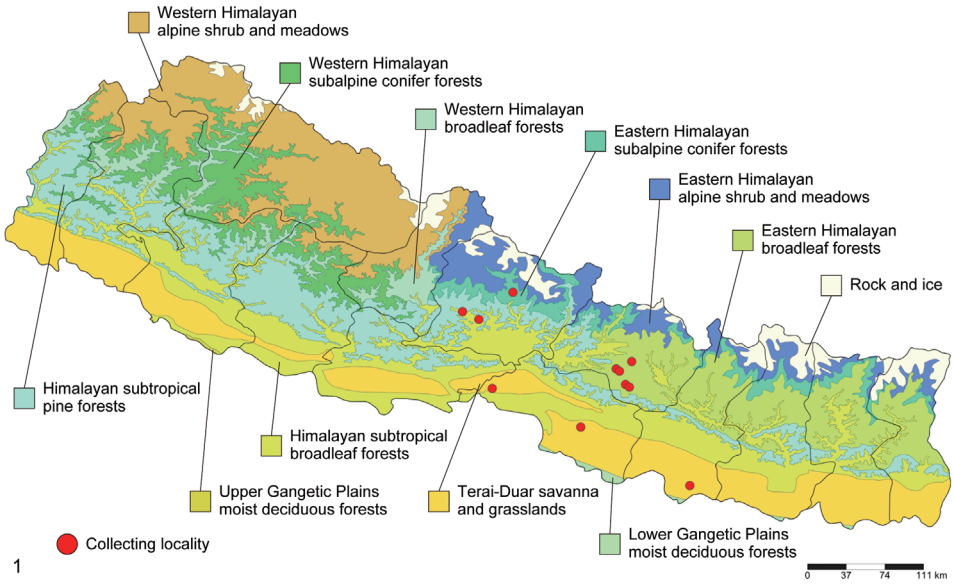


Fig. 1. The terrestrial ecoregions of Nepal and collcting localities of velvet ants of Hokkaido University expeditions.

Zeugomutilla recondita (Cameron, 1900) were examined for comparison: Udawattekele Sanctuary, Kandy District, Sri Lanka, 22.V.1973 & 4.I.1974, beating, A. Ôtake leg. [Insect Museum, National Agriculture and Food Research Organization, Tsukuba, Japan]. They were identified using the key in Lelej et al. (2017).

Morphological observation was done under a Leica M205C stereomicroscope (7.8–160× magnification). Measurement methods follow Bartholomay et al. (2019) and Okayasu (2020). Habitus photographs were taken using a Canon EOS 6D Mark II digital camera equipped with a Canon MP-E 65mm f/2.8 1–5× Macro Photo lens. External morphological features were imaged with a Canon EOS 6D Mark II attached to a Leica M205C. Focus stacking was done using Zerene Stacker (Zerene Systems LLC, Richland, WA, USA). The map figure (Fig. 1) was generated using SimpleMappr (Shorthouse, 2010); the geographic coordinates were obtained from Google Earth (Google LLC, Mountain View, CA, USA). Terminology for ecoregions follows Dinerstein et al. (2017) and Olson et al. (2001). Figures were edited with Adobe Photoshop and Adobe Illustrator software (Adobe Inc., San Jose, CA, USA). The label data of the new species were transcribed as they were and placed in quotation marks; slashes (/) separate lines on the same label. Morphological terminology mostly follows the Hymenoptera Anatomy Consortium (2023). Abbreviations are: F = flagellomere; LOD = lateral ocellus diameter; MOD = medial ocellus diameter; OD = interocellar distance between medial and lateral ocelli; OOD = ocular-ocellar distance between lateral ocellus and eye; POD = posterior ocellar distance between lateral ocelli; S = sternum; T = tergum.

Taxonomy

Tribe Zeugomutillini Waldren, 2023

This tribe was established by Waldren et al. (2023) to accommodate three genera previously included in Ctenotillini Brothers & Lelej, 2017, namely *Montanomutilla* Nonveiller, 1979 (♀), *Strangulotilla* Nonveiller, 1979 (♂♀), and *Zeugomutilla* Chen, 1957 (♂♀).

Genus *Strangulotilla* Nonveiller, 1979

This genus includes 21 species (Lelej, 2005; Lo Cascio et al., 2012; Nonveiller, 1979; Terine et al., 2021). Most species are distributed in the Afrotropical and southern Palaearctic Regions. This genus was recorded from the Oriental Region by Lelej (2005) based on the Sri Lankan species *S. krombeini* Lelej, 2005 (♂♀). Terine et al. (2021) further added *S. sureshani* Terine, Lelej & Kumar, 2021 (♂) from India.

Strangulotilla dubia, new species
(Figs 2–9)

Type material. Holotype ♂: "NEPAL: NARAYANI / Chitwan, alt. 300 m / 24–25.vii.1983 / Ent. Inst. Hokk. Univ." [SEHU].

Diagnosis. MALE. Head, pronotal dorsum, mesoscutum, and mesoscutellum with small sparse punctures (Figs 2, 4); antennal scrobe with dorsal transverse carina (Fig. 4); dorso-medial portion of occipital carina projecting posteriorly and flexed (Fig. 3); clypeus concave, lacking medial longitudinal and subventral transverse carinae (Fig. 4); notaulus reaching anterior 1/2 of mesoscutum (Fig. 2); tegula entirely punctate and setose (Fig. 2); T1–5, T6 anterior half, and S1–6 with sparse long erect white setae (Fig. 3); T6 posterior half and T7 with sparse short recumbent and sparse long erect black setae (Fig. 3); metasomal segments 3–6 not constricted (Fig. 2); S8 lacking sublateral carina (Fig. 5); digitus short broad (Fig. 8); penis valve broad, with subapical ventral tooth weakly developed (Fig. 9). FEMALE. Unknown.

Description. MALE. Body length: 8.01 mm; forewing length: 5.95 mm.

Color and setae. Frons, vertex, gena, clypeus, scape except apex, and flagellum brownish black; postgenal bridge, mandible basal 1/2 and apex, prementum, stipes, mesosoma including tegula, legs except trochanters, and metasoma dark brown; antennal rim, mandible medial 1/4, scape apex, pedicel, maxillary and labial palpi, trochanters, and protibial spur brown; wings pale brown; meso- and metatibial spurs yellowish white. Frons with sparse short recumbent white and sparse long erect dark golden setae; vertex, gena, scape mostly, pronotal dorsum, dorsal 1/2 of dorsal propodeal face, mesopleuron, femora, and tibiae with sparse short recumbent and sparse long erect white setae; postgenal bridge, mandible, pronotal neck, mesoscutellum, metascutellum, ventral 1/2 of dorsal propodeal face, T1–5, T6 anterior half, and S1–6 with sparse long erect white setae; malar space, clypeus, and propleuron with sparse long appressed white setae; scape apex and pedicel with sparse short recumbent dark golden setae; flagellum with dense erect golden microsetae; prementum, stipes, and maxillary and labial palpi with sparse short erect pale golden setae; mesoscutum with sparse long erect blackish golden setae;

Figs 2–3. *Strangulotilla dubia* Okayasu, holotype ♂. 2, Dorsal habitus. 3, lateral habitus.

Figs 4–9. *Strangulotilla dubia* Okayasu, holotype ♂. 4, Face. 5, S7–8. 6, Genitalia, dorsal view (right paramere and basiparamere removed). 7, Genitalia, ventral view. 8, Genitalia, inner view. 9, Penis valve . Arrow indicates the antero-dorsal process on the cuspis.

tegula inner margin with sparse short recumbent white setae; tegula mostly and S8 with sparse long recumbent blackish golden setae; axilla and metanotal trough with dense short appressed white setae; lateral pronotal face, metapleuron, and lateral propodeal face with sparse short appressed white setae; coxae, trochanters, and tarsi with sparse long recumbent white setae; T2 lateral portion with long white felt line; S2 lacking felt line; T6 posterior half and T7 with sparse short recumbent and sparse long erect black setae; S7 glabrous.

Structure. Head 1.54× wider than long; lateral margins weakly convergent behind

eye, postero-lateral angle rounded; vertex rounded posteriorly; POD/OOD = 0.48; OD:POD:MOD:LOD = 11:19:10:8; ocellar region slightly convex; ocelli without posterior carina; occipital carina complete, with dorso-medial portion projecting posteriorly and flexed; eye inner margin deeply emarginate; antennal scrobe dorsally with transverse carina extending nearly to eye and widely separated from antennal rim; genal carina absent; postgenal bridge flattened; hypostomal carina sharp, not projecting; clypeus concave, lacking medial longitudinal and subventral transverse carinae; dorso-medial portion of clypeus elevated into ridge; ventral portion of clypeus medially raised, forming ventral grooved space; mandible robust, narrowed to apex; mandible apex bidentate, subapical tooth smaller than apex; mandibular dorsal carina elevated, ending as subbasal rounded angle; mandible ventral margin basally widened, forming pointed triangular process; prementum flattened; scape ventrally with one sharp and one obscure longitudinal subparallel carinae, separated by 0.63× scape width; F1 cylindrical; length and width of pedicel:F1:F2 = 12:13:20:17:32:17; F2–4 similar in length; F5–10 slightly shorter than F2; F11 conical as long as F2.

Mesosoma widest at mesonotum including tegulae; head width:humeral width:pronotal width:mesonotal width:propodeal width:T2 width = 89:70:83:98:77:100; anterior margin of pronotal dorsum arcuate; anterior face of pronotum vertical; humeral angle rounded, with weak humeral carina reaching ventral 1/2 of pronotal lateral face; mesoscutum weakly convex; mesoscutal width 1.19× its length; tegula oval, 1.5× longer than wide; tegula oval, posterior margin rounded and not flexed, surpassing mesoscuto-scutellar articulation and reaching mesoscutellum; notaulus not widened posteriorly, reaching anterior 1.2 of mesoscutum, subparallel; parapsidal line obliterated; parascutal carina weakly developed, slighted raised on postero-lateral angle of mesoscutum; mesoscutellum 1.39× wider than long, slightly convex; mesopleuron divided into dorsal and ventral convexities by shallow transverse groove, ventrally without transverse precoxal ridge, longitudinal impunctate line, or precoxal swelling; dorsal propodeal face oblique, without distinct dorsum; propodeal dorso-lateral margin lacking carina; lateral margins of propodeum convergent posteriorly.

Wings well developed; distance between origin of RS on vein SC and base of stigmatic cell equal to stigmatic cell length; cell 2RS present.

Meso- and metacoxae evenly convex; metacoxa with weak complete inner longitudinal carina; tibiae without outer spines.

T1 slender, subpetiolate but not constricted posteriorly, without distinct dorsum; T1 spiracle weakly tuberculate; T2 evenly convex, 1.27× wider than long; S1 with low medial longitudinal carina on anterior 2/3, it ventral margin straight; S2 flattened with obscure anteromedial longitudinal carina; S7–8 flat without lateral carina or tubercle; S8 mostly sclerotized with posterior membranous area evenly convex posteriorly. Paramere depressed dorsally and ventrally, down-curved with posterior part flexed dorsally; paramere inner margin lacking projection; paramere ventrally face with short erect setae; ventral lobe rounded, projecting posteriorly; parapenial lobe curved ventrally, apically truncate; basiparamere slightly shorter than paramere; cuspis shape elongate, expanded ventrally on anterior 2/3 and narrowed on posterior 1/3, anteriorly with dorsal rod-like process; cuspis apex apparently surpassing posterior 1/3 of paramere; cuspis densely setose on apex, inner face, and antero-dorsal process, with large seta-filled pit on inner face; digitus 1/2× longer than cuspis, depressed, broad, densely setose on outer face; penis valve symmetrical, broad, expanded dorsally, with posterior ventral hook and small

projection anteriorly to it; endophallus membranous.

Frons, vertex, gena, postgenal bridge, scape, pronotal dorsum, propleuron, mesoscutum, tegula, metascutellum, T1–6, S1, S3–6, and S8 with small sparse punctures; clypeus, axilla, and metanotal tough with minute dense punctures; mandible outer face with small sparse and minute sparse punctures; pedicel, flagellum, prementum, stipes, and maxillary and labial palpi with dense micropunctures; mesoscutellum laterally with small dense punctures, medially with small sparse punctures; metanotal trough striate; dorsal propodeal face reticulate, anteriorly with medial elongate and sublateral semicircular cells; lateral pronotal face, mesopleuron anteriorly, and metapleuron dorsally with minute sparse punctures; mesopleuron medially with large confluent punctures; lateral propodeal face dorsally reticulate, ventrally with minute sparse punctures; S2 with large dense punctures; T7 with small dense punctures, medially with slender longitudinal smooth line; T1 lateral portion and S7 smooth.

FEMALE. Unknown.

Distribution. Nepal: Bagmati.

Etymology. The specific name *dubia*, dubious, is a Latin feminine adjective in the nominative case. It suggests that this species, together with other Oriental members, is questionably placed in *Strangulotilla* as discussed below.

Remarks. Upon description of the first Oriental species, B. Petersen pointed out the differences between *S. krombeini* and other *Strangulotilla* species from the Afrotropical Region in the shape of mandibles, clypeus, occipital carina, S8, and genitalia (Petersen in litt. to A. Lelej; Lelej, 2005: 37), casting doubt on the genus-placement of *S. krombeini*. Petersen suggested to treat this and related species from South Asia as a separate "in between" taxon of *Strangulotilla* and *Zeugomutilla*. Within *Strangulotilla*, three Oriental species, *S. krombeini*, *S. sureshani*, and *S. dubia*, are recognized by having the mandibular ventral margin with a basal triangular process (incised into a basal tooth in Afrotropical species), notaulus reaching anterior 1/2 of mesoscutum (reaching anterior margin of mesoscutum in Afrotropical species), metasomal segments 3–6 not constricted (constricted in Afrotropical species; Nonveiller, 1979: Fig. 4), S8 flat (armed with sublateral carinae in Afrotropical species; Nonveiller, 1979: Figs 6a, 6c), and penis valve broad with a weakly developed subapical ventral tooth (slender with a long sharp subapical ventral tooth in Afrotropical species; Nonveiller, 1979: Fig. 7d). They are distinguished from males of *Zeugomutilla* by having the mandibular ventral margin with a basal triangular process (basally widened and rounded in *Zeugomutilla*; Lelej et al., 2017: Fig. 12), notaulus reaching anterior 1/2 of mesoscutum (reaching anterior margin of mesoscutum in *Zeugomutilla*), S2 evenly convex (with a medial longitudinal carina in *Zeugomutilla*; Lelej et al., 2017: Figs 4, 38), S8 flat (anterior portion raised, trituberculate in *Zeugomutilla*; Lelej et al., 2017: Figs 4, 38), and penis valve broad with a weakly developed subapical ventral tooth (penis valve slender, with a long sharp subapical ventral tooth in *Zeugomutilla*; Lelej et al., 2017: Figs 9, 42). The placement of the Oriental members of *Strangulotilla* is thus tentative. Furthermore, *S. dubia* possesses an anterior rod-like process on the dorsal margin of cuspis (Fig. 8), rare trait in Mutillinae by which this new species can be separated from Afrotropical *Strangulotilla* and *Zeugomutilla* males. However, the descriptions and illustrations of *S. krombeini* and *S. sureshani* are not detailed enough to determine if this structure is present in these species. A separated genus might be eventually erected for Oriental *Strangulotilla* species after extensive morphological comparison.

Strangulotilla dubia differs from other Oriental species by having the head, pronotal dorsum, mesoscutum, and mesoscutellum with small sparse punctures (with large dense punctures in *S. krombeini* and *S. sureshani*), antennal scrobe with dorsal transverse carina (absent in *S. sureshani*), clypeus lacking medial longitudinal and subventral transverse carinae (present in *S. krombeini*), tegula entirely punctate and setose (outer portion smooth and glabrous in *S. krombeini* and *S. sureshani*), metasoma covered with sparse recumbent to erect setae (T2–7 with dense appressed golden setae in *S. sureshani*), and digitus broad (stick-like in *S. krombeini* and *S. sureshani*).

Key to males of *Strangulotilla* (modified from Nonveiller, 1979 and Terine et al., 2021)

1. Mandibular ventral margin with basal triangular process (Fig. 3); notaulus reaching anterior 1/2 of mesoscutum (Fig. 2); S8 flat (Fig. 5) 2
- Mandibular ventral margin incised, forming basal tooth; notaulus reaching anterior margin of mesoscutum; S8 with sublateral carina (Nonveiller, 1979: 6a, 6c) 4
2. Head and mesosoma dorsally with small sparse punctures (Figs 2, 4); tegula entirely punctate and setose (Fig. 2); digitus expanded (Fig. 8). Nepal ..... *S. dubia* Okayasu
- Head and mesosoma dorsally with large dense punctures (Terine et al., 2021: Figs 6, 8); tegula outer portion smooth and glabrous (Terine et al., 2021: Fig. 8); digitus stick-like 3
3. Clypeus with medial longitudinal and subventral transverse carinae; metasoma black, dorsally with sparse recumbent and suberect white setae. Sri Lanka ..... *S. krombeini* Lelej
- Clypeus with medial longitudinal depression and lacking transverse carina (Terine et al., 2021: Fig. 6); metasoma brownish black and T2–7 covered with dense appressed golden and sparse erect pale golden setae (Terine et al., 2021: Fig. 9). India ... *S. sureshani* Terine, Lelej & Kumar
4. S8 lateral margin flat, with sublateral carina apparently surpassing S8 lateral margin in lateral view (Nonveiller, 1979: Fig. 6b) 5
- S8 lateral margin elevated on anterior half, with sublateral carina partially or entirely concealed by elevation of S8 lateral margin in lateral view (Nonveiller, 1979: Figs 6d, 6e) 9
5. Mandibular subbasal inner tooth rectangular, right-angled to mandibular inner margin (Nonveiller, 1979: Fig. 6f); penis valve with posterior ventral tooth flexed outward (Nonveiller, 1979: Fig. 7a) 6
- Mandibular subbasal inner tooth narrowed apically, directed obliquely to mandibular inner margin (Nonveiller, 1979: Fig. 6g); penis valve with posterior ventral tooth straight (Nonveiller, 1979: Fig. 7e) 8
6. Tegua slender, strongly convex, entirely punctate and densely setose. Central, eastern, and western Africa ..... *S. samharica* (Magretti)
- Tegula broad, weakly convex anteriorly, with outer margin smooth and glabrous 7
7. Head black with vertex yellowish red. Namibia ..... *S. thoracosulcata damarana* (Bischoff)
- Head entirely black. Central and eastern Africa ..... *S. thoracosulcata thoracosulcata* (Magretti)
8. T2 punctures large, deep, and dense, separated by less than puncture diameter. Democratic Republic of the Congo ..... *S. kisantuana* Nonveiller
- T2 punctures small, shallow, and sparse, separated by more than puncture diameter. Republic of the Congo ..... *S. tenuipunctata* Nonveiller
9. Mesosoma red except darkened tegula; S8 lateral margin strongly elevated, entirely concealing sublateral carina in lateral view (Nonveiller, 1979: Fig. 6d). Botswana ..... *S. dayi* Nonveiller
- Body entirely black; S8 lateral margin weakly elevated, with sublateral carina partially concealed and visible in lateral view (Nonveiller, 1979: Fig. 6e). Angola ..... *S. unicolorata* Nonveiller

Genus *Zeugomutilla* Chen, 1957

This genus was recently reviewed by Lelej et al. (2017). Eight species are recognized in this genus, of which four are known from East Asia and the rest four are known from South Asia. In South Asia, this genus has been recorded from India and Sri Lanka only.

Zeugomutilla curvicarinata, new species
(Figs 10–16)

Type material. Holotype ♀: "NEPAL: NARAYANI / Chitwan, alt. 300 m / 24–25.vii.1983 / Ent. Inst. Hokk. Univ." [SEHU].

Diagnosis. FEMALE. Head black except gena dark brown (Figs 11, 14); genal carina strongly curved toward mandibular base (Fig. 15); scape dark brown (Fig. 14); propodeal dorsum armed with row of six teeth (Fig. 12); T2 with paired pale golden setal spots, separated by 1.89× spot diameter (Fig. 13); T3–4 with sparse appressed pale golden setae (Fig. 13); pygidial plate smooth (Fig. 16). MALE. Unknown.

Description. FEMALE. Body length: 5.40 mm.

Color and setae. Frons, vertex, flagellum, and T1–6 brownish black; clypeus, gena, scape, mandible apex, prementum, stipes, femora, tibiae, and S2–6 dark brown; antennal rim, postgenal bridge, pedicel, labrum, maxillary and labial palpi, and tarsi brown; mandible except apex and trochanters yellow; mesosoma, procoxa anterior 1/3, and S1 orange. Frons, vertex, pronotal anterior margin, and femora with sparse short recumbent and sparse long erect pale golden setae; gena, scape, coxae, tibiae, and tarsi with sparse long recumbent pale golden setae; clypeus, postgenal bridge, mandible, propleuron, dorsal propodeal face, trochanters, T1, T2 anterior and lateral margins, T5–6 lateral portions, and S1–6 with sparse long erect pale golden setae; pedicel, and flagellum with dense appressed pale golden microsetae; prementum, stipes, labrum, and maxillary and labial palpi with sparse short erect golden setae; pronotal collar with sparse short erect pale golden setae; thoracic dorsum, T2 disc, and T5–6 medial portions with sparse short recumbent and sparse long erect black setae; mesosomal lateral face with sparse short appressed pale golden setae; T3–4 with sparse long appressed and sparse long erect pale golden setae; T2 with a pair of small sublateral circular spots of dense appressed pale golden setae disposed in horizontal line; T2 spot diameter:distance between T2 spots:distance between T2 spot and T2 anterior margin:distance between T2 spot and T2 posterior margin = 28:53:45:48; T2 posterior margin and metasomal sterna lacking setal fringe or band.

Structure. Head 1.39× wider than long with lateral margins strongly convergent behind eye; gena wide, 1.06× eye breadth in lateral view; frons and vertex without medial carina or groove; occipital carina complete; genal carina sharp, dorsally separated from occipital carina, ventrally strongly curved reaching mandibular base; hypostomal tooth absent; hypostomal carina sharp and raised; postgenal bridge medially projecting; antennal scrobe with dorsal carina wavy, nearly straight, widely separated from inner eye margin; eye oval, slightly protruding from head capsule; minimum distance between eyes 1.40× eye height; eye height 2.60× malar distance; clypeus medially elevated with subventral transverse crenulate ridge; clypeal ventrally with lateral rounded tubercle; mandible slender, narrowed to apex; mandible apically bidentate, inner tooth smaller than

Figs 10–11. *Zeugomutilla curvicarinata* Okayasu, holotype ♀. 10, Dorsal habitus. 11, Lateral habitus.

Figs 12–16. *Zeugomutilla curvicarinata* Okayasu, holotype ♀. 12, Mesosoma, dorsal view. 13, Metasoma, dorsal view. 14, Face. 15, Gena, ventro-lateral view. 16, Pygidial plate.

apex, with small subbasal inner tooth; mandibular ventral margin straight; prementum flattened, medially with sharp longitudinal carina extending along its entire length; length and width of pedicel:F1:F2 = 10:10:17:15:13:15; F2–9 almost same in length and width; F10 as long as F1, conical and weakly depressed.

Mesosoma broadest at propodeum; lateral margins weakly crenulate, divergent posteriorly; head width:humeral width:pronotal width:mesonotal width:propodeal width:metasomal width = 93:68:73:73:80:100; dorsal thoracic length 0.86× pronotal width; anterior margin of pronotal dorsum nearly straight; pronotum laterally not projecting; pronotal lateral margin with sharp tooth; humeral carina sharp, complete, dorsally terminating as sharp tooth; scutellar scale absent; scutellar area without scales; propodeal dorsum with transverse row of six sharp tooth, longest medially; metanotal-propodeal suture obliterated; dorsal propodeal face vertical, without medial carina; propodeal lateral margin weakly dentate on dorsal half, crenulate on ventral half; mesopleural lamella short.

Procoxa with projecting lamella on antero-inner margin; metacoxa with sharp complete inner longitudinal carina; meso- and metatibiae with one row of spines; protarsus with short outer spines; protarsomere 1 apically truncate, not protruding outward.

T1 subsessile, without distinct dorsum; T2 evenly convex, dorsally flattened; dorsal T2 length 0.98× T2 width; S1 with low medial longitudinal carina on anterior 2/3, it ventral margin straight; S2 evenly convex with obscure anteromedial longitudinal carina; S6 posterior margin notched; pygidial plate slender, subconvex, lateral margins subparallel delimited by sharp longitudinal carina.

Frons and vertex with large dense punctures, separated by approximate puncture diameter, intervals distinct and smooth; gena with large confluent shallow punctures, making puncto-reticulate surface; postgenal bridge transversely rugose; clypeus medial elevated part, propleuron, procoxa, and tarsi with minute dense punctures; clypeal lateral portion, mandible, mesosomal lateral face, meso- and metacoxae, trochanters, femora, and tibiae with minute sparse punctures; scape, T1, T2 lateral margin, T3–5, and S1 with small sparse punctures; pedicel, flagellum, prementum, stipes, and labial and maxillary palpi with dense micropunctures; pronotal collar with minute sparse punctures; thoracic dorsum with large confluent punctures; dorsal propodeal face reticulate on dorso-lateral portion and with minute sparse punctures medially and ventrally; T2 disc, T6, and S3–6 with small dense punctures; S2 with large sparse punctures; pygidial plate smooth.

MALE. Unknown.

Distribution. Nepal: Bagmati.

Etymology. The specific name *curvicarinata* is the combination of a Latin prefix *curvi*, curved, and a Latin feminine adjective in the nominative case *carinata*, carinate. It refers to the curved genal carina of this new species.

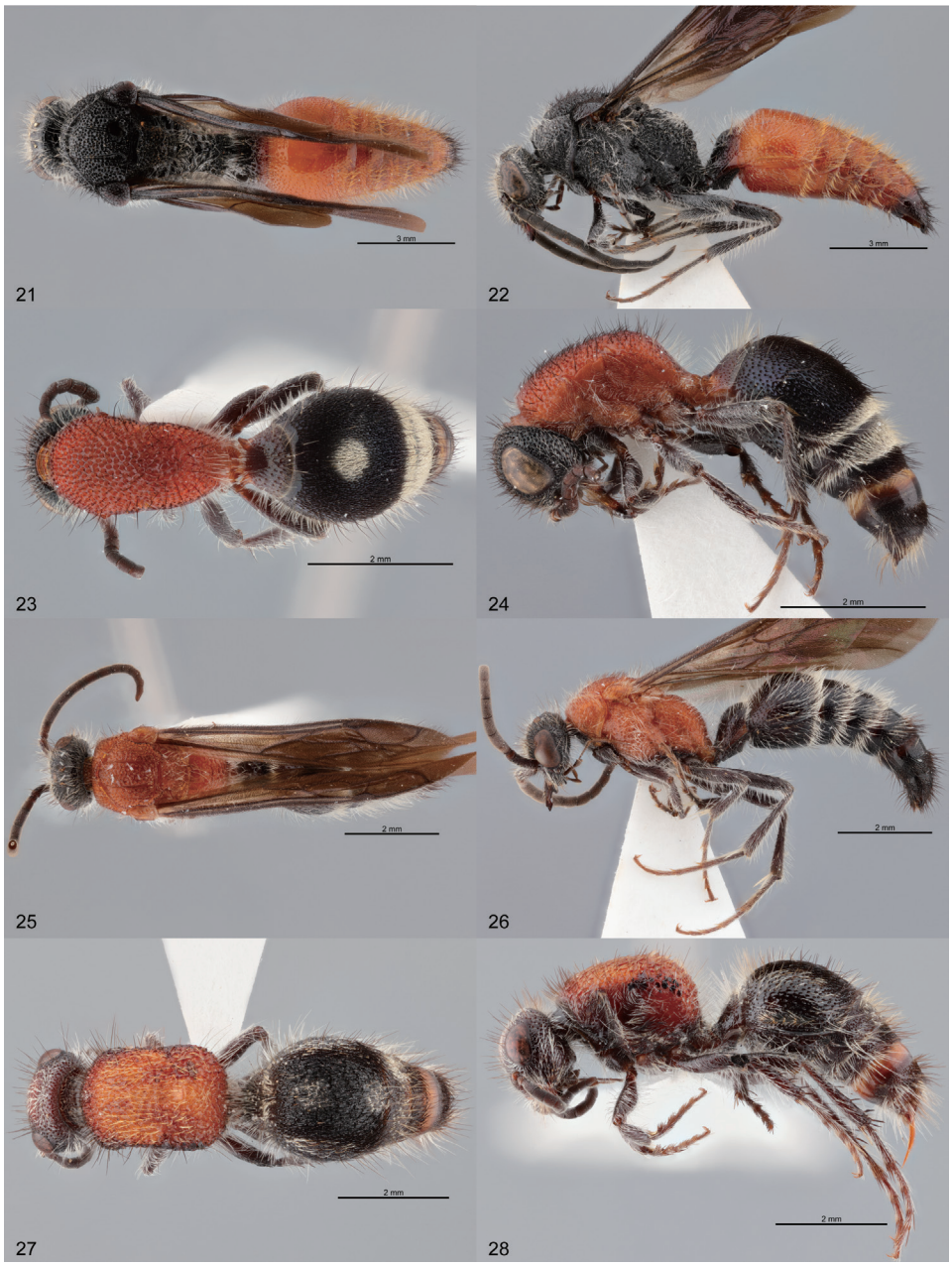
Remarks. This new species is similar to *Z. recondita* (Cameron, 1900) and *Z. spinulosa* (André, 1898) by having the T2 spots separated by more than spot diameter and pygidial plate smooth, but differs by having the head black except gena dark brown (orange to brown in *Z. recondita*; dark brown with a medial reddish spot on frons in *Z. spinulosa*), genal carina curved ventrally, extending nearly to mandibular base (straight and separated from mandibular base in *Z. recondita*), propodeal dorsum with six teeth (with eight to twelve teeth in *Z. recondita* and *Z. spinulosa*), T2 spots small, separated by 1.89× spot diameter (T2 spots separated by ~1.5× spot diameter in *Z. recondita*), and

T3–4 with sparse appressed pale golden setae (with golden setal bands in *Z. recondita*; with medial setal spots in *Z. spinulosa*).

Key to females of *Zeugomutilla* (modified from Lelej et al., 2017)

1. T2 pale setal spots large, separated by 0.25–1.0× spot diameter or spots conjugated 2
- T2 pale setal spots small, separated by 1.3–2.0× spot diameter 5
2. Head yellowish orange (Lelej et al., 2017: Figs 27, 31); T2 spots conjugated (Lelej et al., 2017: Fig. 27). India, Sri Lanka ..... *Z. horni* (André)
- Head reddish to black; T2 spots separated (Lelej et al., 2017: Figs 6, 16, 17, 28) 3
3. Body length 4.4–5.4 mm; head reddish brown to dark brown (Lelej et al., 2017: Figs 28, 32). India, Sri Lanka ..... *Z. recondita* (Cameron), part
- Body length 8.0–9.6 mm; head black (Lelej et al., 2017: Figs 1, 16) 4
4. Scape black; T2 spots larger, separated by roughly 0.25× spot diameter (Lelej et al., 2017: Figs 16, 17). China ..... *Z. pangi* Lelej
- Scape yellowish orange to brown; T2 spots smaller, separated by approximate spot diameter (Lelej et al. 2017: Fig. 6). Cambodia, China, Thailand ..... *Z. saepes* (Chen)
5. Pygidial plate longitudinally striate anteriorly, smooth posteriorly (Lelej et al., 2017: Fig. 34). India, Sri Lanka ..... *Z. bainbriggei* (Turner)
- Pygidial plate sculpture obscure, mostly smooth (Lelej et al., 2017: Fig. 35) 6
6. Frons dark brown with reddish spot; T3–4 with medial pale setal spot. India, Pakistan .... *Z. spinulosa* (André)
- Frons uniformly orange to black; T3–4 entirely covered with golden setal band or sparse pale golden setae 7
7. Head orange to brown; genal carina straight, separated from mandibular base; T2 spots larger, separated by ~1.5× spot diameter; T3–4 with golden setal band. Sri Lanka .... *Z. recondita* (Cameron), part.
- Frons and vertex black, gena dark brown (Figs 11, 14); genal carina curved ventrally, extending nearly to mandibular base (Fig. 15); T2 spots smaller, separated by 1.89× spot diameter (Fig. 13); T3–4 with sparse pale golden setae (Fig. 13). Nepal ..... *Z. curvicarinata* Okayasu

Figs 17–20. Dasylabrinae and Mutillini spp. from Nepal. 17, 18, *Dasylabris* sp., ♀. 19, 20, *Kurzenkotilla scrobiculata* (Hammer), ♀. 17, 19, Dorsal habitus. 18, 20, lateral habitus.



Figs 21–28. Smicromyrmini spp. from Nepal. 21, 22, *Promecilla* sp. 1, ♂. 23, 24, *Promecilla* sp. 2, ♀. 25, 26, *Smicromyrme* sp. 1, ♂. 27, 28, *Smicromyrme* sp. 2, ♀. 21, 23, 25, 27, Dorsal habitus. 22, 24, 26, 28, Lateral habitus.

Synoptic List of Velvet Ant Species Known from Nepal

Mutillinae: Mutillini

1. *Kurzenkotilla rufodorsata* (Cameron, 1897): Bagmati, Karnali (Lelej et al., 2023). Also known from northern India.
2. *Kurzenkotilla scrobiculata* (Hammer, 1962): Karnali, Sudurpashchim (Lelej et al., 2023). Also known from northern India.

Mutillinae: Smicromyrmini

3. *Ephutomma himalayana* Lelej & Ullah, 2007: Bagmati (Lelej et al., 2007). Also known from northeastern Pakistan.
4. *Smicromyrme nepalensis* Hammer, 1962: Bagmati (Hammer, 1962).

Mutillinae: Trogaspidiini

5. *Eotrogaspidia adhabar* Okayasu, Lelej & Williams, 2021: Madhesh (Okayasu et al., 2021). Also known from southern India.
6. *Karlissaidia sexmaculata* (Swederus, 1787): additional data unavailable (Lelej, 2005). Widespread in India and known from eastern Pakistan.
7. *Zavatilla nepalensis* Zhou & Lelej, 2018: Koshi (Zhou et al., 2018).

Mutillinae: Zeugomutillini

8. *Strangulotilla dubia* Okayasu, 2023: Bagmati (this study).
9. *Zeugomutilla curvicarinata* Okayasu, 2023: Bagmati (this study).

Odontomutillinae

10. *Yamanetilla taiwaniana* (Zavattari, 1913): additional data unavailable (Lelej, 2005). Also known from Taiwan.

List of SEHU Velvet Ant Specimens from Nepal

Overall, 49 Nepalese specimens (30♂19♀) collected from 13 localities in 20 days were found in SEHU. They represented 24 morphospecies in 15 genera of four subfamilies.

Dasylabrinae

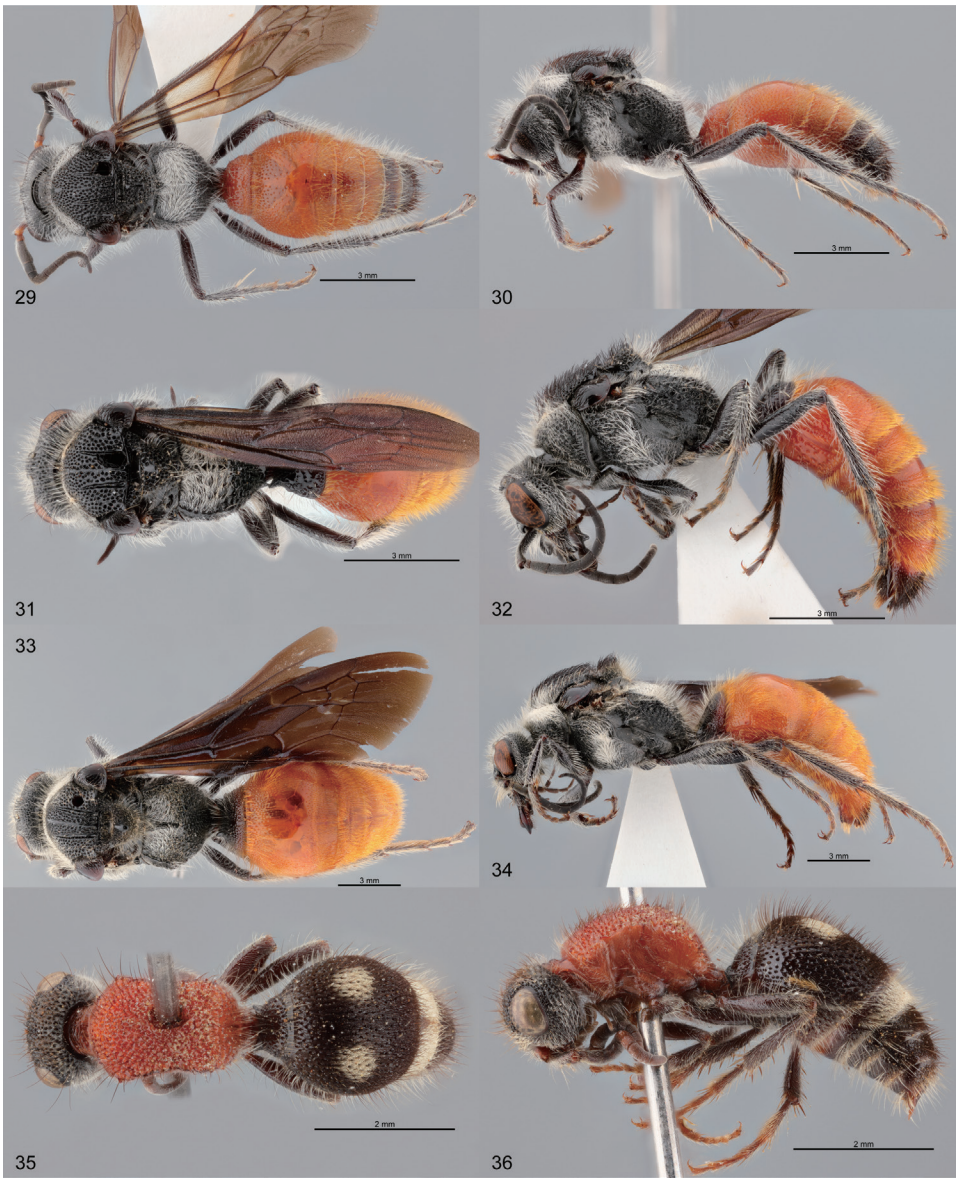
1. *Dasylabris* sp. (Figs 17, 18): Madhesh: 1♀, Adhabar, Terai Forest, 27.VI.1968, T. Kumata leg. In coloration, this species matches *D. argentipes* (Smith, 1855) known from southern India (Bingham, 1897; Lelej, 2005; Terine et al., 2015).

Mutillinae: Mutillini

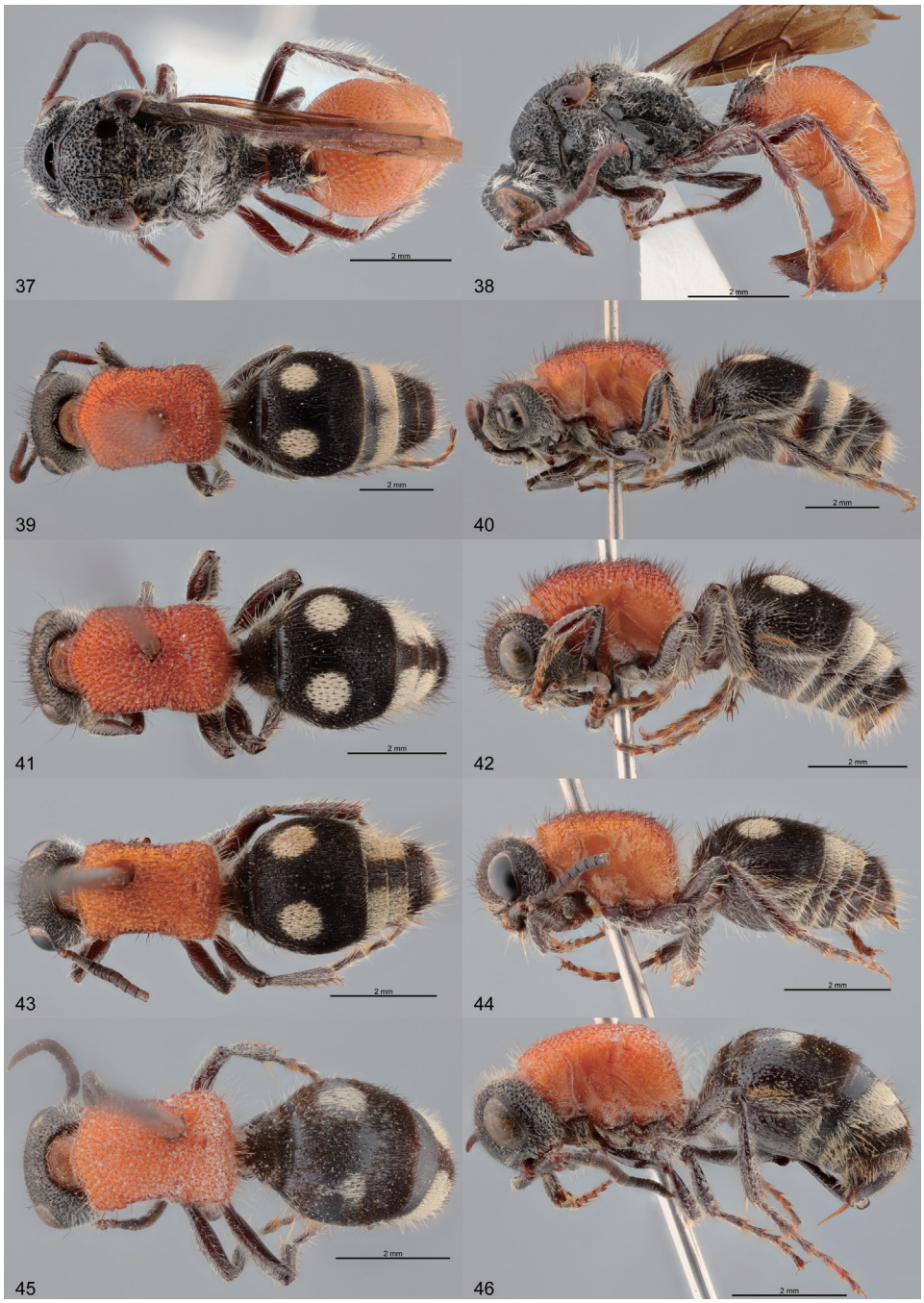
2. *Kurzenkotilla scrobiculata* (Hammer, 1962) (Figs 19, 20): 1♀, Nepal, YB, I. Yoneta leg.

Mutillinae: Smicromyrmini

3. *Promecilla* sp. 1 (Figs 21, 22): Bagmati: 1♂, Napal valley [= Nepal Valley], Godavari, 15.VI.1968, T. Kumata leg.; 1♂, same data except 11.VII.1968; 8♂, Godavari, Phulchoki, 17.VIII.1975, S. Takagi leg.; 1♂, same data except 19.VIII.1975. This species matches the description and illustrations of the male of *P. regia* (Smith, 1855) in Lelej & Williams (2023) and Nurse (1903).
4. *Promecilla* sp. 2 (Figs 23, 24): Madhesh: 1♀, Janakpur, Malipu–Suri Dhoban, 1000–1100 m



Figs 29–36. Trogaspidiini spp. from Nepal. 29, 30, *Eotrogaspidia adhabar* Okayasu et al., holotype ♂. 31, 32, *Karlissaidia* sp. 1, ♂. 33, 34, *Karlissaidia* sp. 2, ♂. 35, 36, *Petersenidia* sp., ♀. 29, 31, 33, 35, Dorsal habitus. 30, 32, 34, 36, Lateral habitus.



Figs 37–46. Trogaspidiini spp. from Nepal. 37, 38, *Radoszkowskitilla* sp., ♂. 39, 40, *Trogaspidia* sp. 1, ♀. 41, 42, *Trogaspidia* sp. 2, ♀. 43, 44, *Trogaspidia* sp. 3, ♀. 45, 46, *Trogaspidia* sp. 4, ♀. 37, 39, 41, 43, 45, Dorsal habitus. 38, 40, 42, 44, 46, Lateral habitus.

alt., 29.VIII.1983, Ent. Inst. Hokk. Univ.

5. *Smicromyrme* sp. 1 (Figs 25, 26): Bagmati: 1♂, Napal valley [= Nepal Valley], Godavari, 11.VII.1968, T. Kumata leg.
6. *Smicromyrme* sp. 2 (Figs 27, 28): Madhesh: 1♀, Adhabar, Terai Forest, 27.VI.1968, T. Kumata leg.

Mutillinae: Trogaspidiini

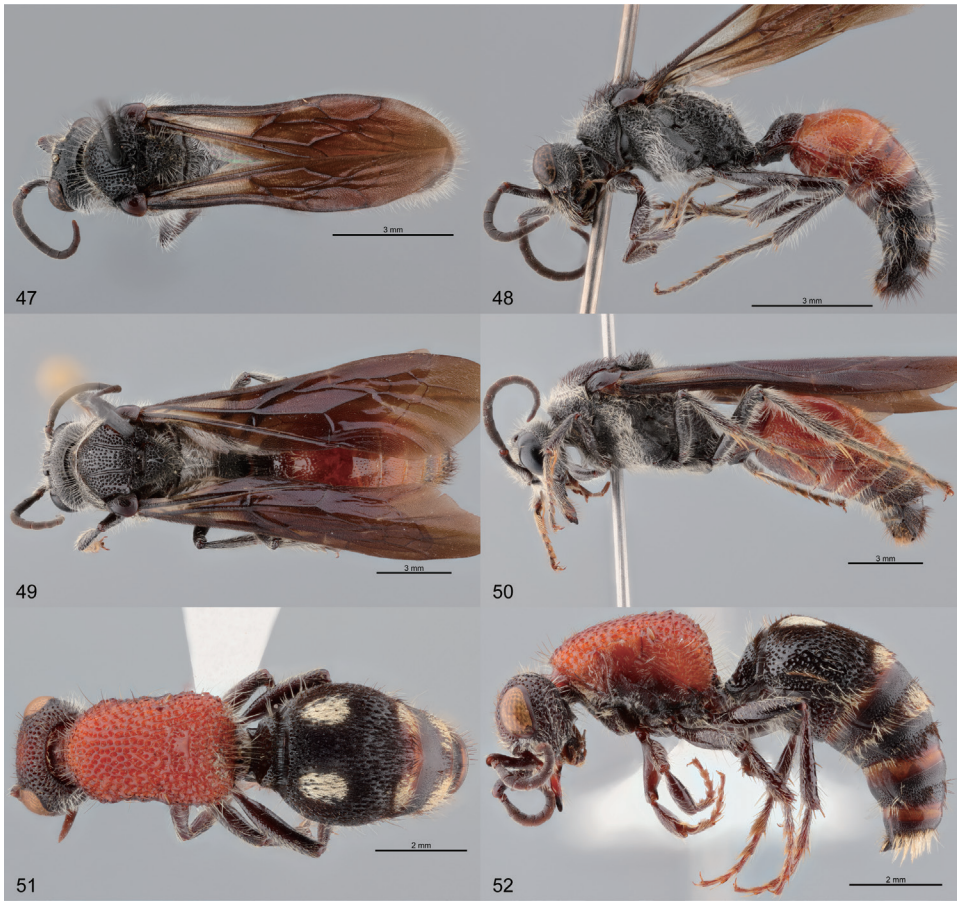
7. *Eotrogaspidia adhabar* Okayasu, Lelej & Williams, 2021 (Figs 29, 30): Madhesh: holotype ♂, Narayani, Adhabar, 21.X.1975, S. Takagi leg. This species was described based on a male from SEHU and two additional males collected in southern India (Okayasu et al., 2021).
8. *Karlissaidia* sp. 1 (Figs 31, 32): Madhesh: 1♂, Narayani, Adhabar, 21.X.1975, S. Takagi leg.
9. *Karlissaidia* sp. 2 (Figs 33, 34): Madhesh: 2♂, Adhabar, Terai Forest, 27.VI.1968, T. Kumata leg.
10. *Petersenidia* sp. (Figs 35, 36): Bagmati: 1♀, Kathmandu, Balaju, Kj-2, 23.IV.1968, T. Matsumura leg.
11. *Radoszkowskitilla* sp. (Figs 37, 38): Madhesh: 1♂, Adhabar, Terai Forest, 27.VI.1968, T. Kumata leg. According to published descriptions and keys, this species does not match any described species of the genus (Lelej, 2005, 2020).
12. *Trogaspidia* sp. 1 (Figs 39, 40): Bagmati: 1♀, Sundarijal, 22–25.X.1983, S. Takagi leg.; Madhesh: 1♀, Janakpur, Suri Dhoban–Gongar, 1100–1300 m alt., 27.VIII.1983, Ent. Inst. Hokk. Univ.
13. *Trogaspidia* sp. 2 (Figs 41, 42): Bagmati: 1♀, No. 3 West, Rupakot Tal, Pv-2, 20.V.1968, T. Matsumura leg.; Gandaki: 1♀, Marsyandi Valley, Syange–Chyamche, 1200–1400 m alt., 7.VI.1988, M. Suwa leg.; Madhesh: 1♀, No. 2 East, Namuto, Nj, 15.VII.1968, T. Matsumura leg.
14. *Trogaspidia* sp. 3 (Figs 43, 44): Bagmati: 1♀, No. 3 West, Pokhara, 21.V.1968, T. Matsumura leg.; 2♀, Narayani, Chitwan, alt. 300 m, 24–25.VII.1983, Ent. Inst. Hokk. Univ.
15. *Trogaspidia* sp. 4 (Figs 45, 46): Bagmati: 1♀, Kathmandu, MN-3, 20.II.1968, T. Kawamichi leg.
16. *Trogaspidia* sp. 5 (Figs 47, 48): Bagmati: 1♂, No. 3 West, Pokhara, Pw, 21.V.1968, T. Matsumura leg.; 1♂, Narayani, Chitwan, alt. 300 m, 24–25.VII.1983, Ent. Inst. Hokk. Univ.; Madhesh: 1♂, Janakpur, Malipu–Suri Dhoban, 1000–1100 m alt., 10.VIII.1983, Ent. Inst. Hokk. Univ.
17. *Wallacidia* sp. 1 (Figs 49, 50): Madhesh: 3♂, Adhabar, Terai Forest, 24.VI.1968, T. Kumata leg.; 1♂, same data except 15.VII.1968; 4♂, Adhabar, Terai Forest, 3000 m, 27.VI.1968, T. Kumata leg.
18. *Wallacidia* sp. 2 (Figs 51, 52): 1♀, Nepal, VI.1968, T. Kumata leg.

Mutillinae: Zeugomutillini

19. *Strangulotilla dubia* Okayasu, 2023 (Figs 2–9): Bagmati: holotype ♂, Narayani, Chitwan, 300 m alt., 24–25.VII.1983, Ent. Inst. Hokk. Univ.
20. *Zeugomutilla curvicarinata* Okayasu, 2023 (Figs 10–16): Bagmati: holotype ♀, Narayani, Chitwan, 300 m alt., 24–25.VII.1983, Ent. Inst. Hokk. Univ.

Myrmillinae

21. *Bischoffitilla* sp. 1 (Figs 53, 54): Bagmati: 1♀, Kathmandu V[alley]., Godawari, 13, 14, 17.IX.1987, H. Takizawa leg.
22. *Bischoffitilla* sp. 2 (Figs 55, 56): Bagmati: 1♀, Napal valley [= Nepal Valley], Godavari, 1450 m alt., 16.VI.1968, T. Kumata leg.



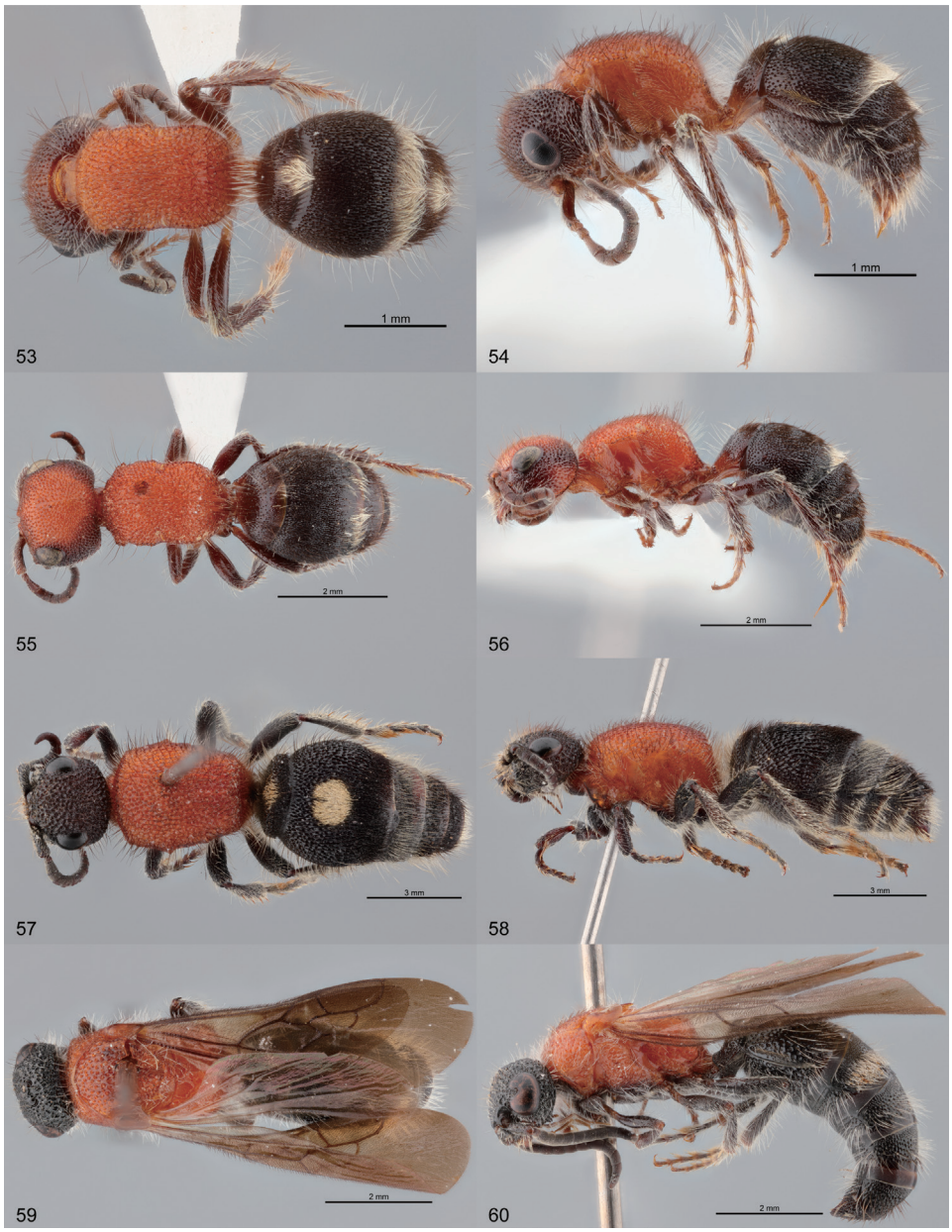
Figs 47–52. Trogaspidiini spp. from Nepal. 47, 48, *Trogaspidia* sp. 5, ♂. 49, 50, *Wallacidia* sp. 1, ♂. 51, 52, *Wallacidia* sp. 2, ♀. 47, 49, 51, Dorsal habitus. 48, 50, 52, Lateral habitus.

Odontomutillinae

23. *Odontomutilla* sp. (Figs 57, 58): Madhesh: 1♀, Adhabar, Terai Forest, 24.VI.1968, T. Kumata leg. This species does not match any described species known from the Indian subcontinent (Lelej et al., 2020).
24. *Yamanetilla* sp. (Figs 59, 60): Madhesh: 1♂, Janakpur, Malipu–Suri Dhoban, 1000–1100 m alt., 10.VIII.1983, Ent. Inst. Hokk. Univ. This species does not match *Y. taiwaniana*, the only *Yamanetilla* species known from Nepal.

Discussion

The SEHU collection included 24 morphospecies listed above, exceeding the known diversity by three times. The genera *Dasylabris* Radoszkowski, 1885 (Dasylabrinae), *Petersenidia* Lelej, 1992, *Promecilla* André, 1902, *Radoszkowskitilla* Lelej, 2005, *Strangulotilla*, *Trogaspidia* Ashmead,1899, *Wallacidia* Lelej & Brothers, 2008, *Zeugomutilla* (Mutillinae), *Bischoffitilla* Lelej, 2002 (Myrmillinae), and *Odontomutilla*



Figs 53–60. Myrmillinae and Odontomutillinae spp. from Nepal. 53, 54, *Bischoffitilla* sp. 1, ♀. 55, 56, *Bischoffitilla* sp. 2, ♀. 57, 58, *Odontomutilla* sp., ♀. 59, 60, *Yamanetilla* sp., ♂. 53, 55, 57, 59, Dorsal habitus. 54, 56, 58, 60, Lateral habitus.

Ashmead, 1899 (Odontomutillinae) are new to Nepal. Even though the SEHU specimens were collected in only a limited number of places, this fraction shows that the diversity of velvet ants in Nepal is much higher than currently documented. Additional evidence may also imply the hidden diversity of Nepalese velvet ants. First, the Himalayan region is known for the high concentration of bee species contrasting to India (Orr et al., 2021; Williams et al., 2010). Because bees are important hosts for velvet ants (Luz et al., 2016; Ronchetti & Polidori, 2020), I anticipate that the number of species per unit area in Nepal exceeds that in India, the South Asian country with more than 200 velvet ant species. Secondly, Müllerian mimicry diversity of velvet ants is likely positively correlated with the predator diversity (e.g., lizards) and habitat heterogeneity (Wilson et al., 2018). This indicates that higher morphological diversity will be found after extensive collection from wider range of Napal, since the collecting localities of Hokkaido University expeditions cover only four out of 12 ecoregions found in Nepal (Fig. 1).

The shortage of material is the major limitation of taxonomic studies dedicated to velvet ants of Nepal. Most morphospecies identified in this study are known from one or two specimens. The western and eastern parts are mostly unsampled. Given that the climate, fauna, and flora greatly vary within this country along altitude and latitude (Rawat, 2017; Williams et al., 2010), broader sampling is apparently needed.

The complex geography and species richness in Nepal provide an ideal setting to elucidate factors shaping geographical patterns of species richness and distribution (Williams et al., 2010). Previous phylogeographic studies revealed the strong connection of velvet ants and habitats, suggesting their usefulness in biogeography (Pitts et al., 2010; Wilson & Pitts, 2011; Wilson et al., 2012). It is crucial to document the local velvet ant fauna for this scarcely studied yet notable country. I hope the lists, illustrations, and descriptions in this paper will be a starting point for better understanding of Nepalese velvet ant fauna.

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