

Short communication

Myanmarina diversa sp. nov (Hymenoptera, Myanmarinidae) from mid-Cretaceous Kachi amber, northern MyanmarYan Zheng^{a, c, *}, Haiyan Hu^b, Han Wang^c, Jun Chen^a, Qi Zhang^d, Haichun Zhang^c, Alexandr P. Rasnitsyn^{e, f, **}^a Institute of Geology and Paleontology, Linyi University, Shuangling Road, Linyi, 276000, China^b School of Agronomy and Environment, Weifang University of Science and Technology, Jinguang Road, Shouguang, 262700, China^c State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology and Center for Excellence in Life and Palaeoenvironment, Chinese Academy of Sciences, 39 East Beijing Road, Nanjing, 210008, China^d School of Geography and Tourism, Qufu Normal University, Rizhao, 276826, China^e Palaeontological Institute, Russian Academy of Sciences, Moscow, 117647, Russia^f Natural History Museum, London, SW7 5BD, UK

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ABSTRACT

Myanmarina as a small genus has received attention since 2017 as well as the new family Myanmarinidae of basal apocritan wasps was erected by Zhang & Rasnitsyn. *Myanmarina diversa* sp. nov is the sixth myanmarinid wasp, is described and illustrated from mid-Cretaceous Kachin amber. The new species is characterized by male antenna with 13 antennomeres and mid femur with posterior apical tooth. We also provide the comparison of characters among six *Myanmarina* species and discuss their possible biology.

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1. Introduction

Stephanoidea Leach, 1815 is considered as the most basal lineage of parasitoid wasps distributed from worldwide and occupies a critical position in the phylogeny of Hymenoptera (Rasnitsyn, 2010; Rasnitsyn and Zhang, 2010; Belokobylskij, 2019). The species of staphanoids are also treated as basal to Evanioidea and (Ceraphronomorpha + Proctotrupomorpha) + (Ichneumonomorpha + Vespomorpha) (Rasnitsyn and Zhang, 2010). To data, five families have been attributed to Stephanoidea, containing one relict family Stephanidae with more than 350 extant worldwide species and 12 extinct species from mid-Cretaceous to Eocene (Engel and Grimaldi, 2004; Engel et al., 2013; Engel and Huang, 2017; Li et al., 2018), and four extinct

families: Ephialtitidae with 89 species in 29 genera from Lower Jurassic to mid-Cretaceous rock imprints (Zhang, 1986; Rasnitsyn, 2000; Li et al., 2018; Zhang, 2020), Aptenoperissidae Rasnitsyn et al., 2017 with 8 species in one genus only known from mid-Cretaceous Kachin amber (Rasnitsyn et al., 2017; Rasnitsyn and Öhm-Kühnle, 2018; Zhang et al., 2018a,b), Myanmarinidae Zhang and Rasnitsyn, 2018, with five species in one genus only known from mid-Cretaceous Kachin amber (Li et al., 2018; Zhang et al., 2018b; Jouault et al., 2020) and Ohlhoffiidae Jouault et al., 2021 with four species in three genera from mid-Cretaceous Kachin amber and Lower Cretaceous rock imprints (Rasnitsyn and Ansoerge, 2000; Jouault et al., 2020). Considering those presently described staphanoid fossils, mostly extinct lineages are documented from the noteworthy mid-Cretaceous Kachin amber. The amazing paleodiversity of insects preserved in Kachin amber (Ross, 2019, Ross, 2021a,b), and particularly that of Hymenoptera (Zhang et al., 2018a,b; Rasnitsyn and Öhm-Kühnle, 2021), is particularly relevant to the abundance and high taxonomic and morphological diversity of staphanoids in the Kachin amber biota (Rasnitsyn and Öhm-Kühnle, 2018; Zhang et al., 2018a,b; Ross, 2021a,b).

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Myanmarinidae as endemic to Myanmar terrain in the mid-Cretaceous are a unique group of Stephanioidea, showing a set of highly specialized morphological characters, e.g. body small and elongated (vs. medium-sized or large in majority of Stephanidae and Ephialtitidae), head smooth (vs. head crowned with teeth or tubercles in Stephanidae and Ohlhoffiidae), antenna oligomeric with short scape (vs. antenna polymeric and, in Aptenoperissidae only, geniculate), wing venation deeply and originally reduced (vs. venation more complete or, in Aptenoperissidae, female wings totally lost), and tibial spur formula 1-1-1 (vs. 1-2-2 or, in Aptenoperissidae, 2-2-2). Judging from their morphology, Myanmarinidae are similar to other Stephanioidea (except Aptenoperissidae) in xylophilous way of life and particularly in being parasitoids of xylophagous insect larvae (most probably of larvae of beetles and/or siricoid and cephoid wasps). However, their adult adaptations toward the life in wood and particularly to help the enclosing adult wasp to find its way out of the wood are unique. Xylophilous wasps are commonly identifiable as such based on devices that make their body possible to cling within the wooden tunnel made by its host larva. This is necessary as a mean to give sufficient support to mandibles when the wasp chews its way out through wood. These device are usually various teeth and ridges that cling into the wall of tunnel and so render a support to mandibles at work: these teeth and ridges are easily detectable on mesosomal dorsum (primarily mesoscutum), or on head dorsum (head with a crown of teeth or with transverse ridges), or else on femora and tibiae which are appressed to mesosoma in enclosing wasp and so can help fixing the body ventrally and laterally (reviewed in discussion by Zhang et al., 2020). Myanmarinidae are unique among xylobiotic wasps to develop an original clinging mechanism involving no tooth/ridge to fix onto wooden wall of a tunnel (except sometimes for weak apical tooth on femur and/or tibia). Instead, the wasp can use its mesosoma with soft (membranous) dorsum to widen it and to fix itself with plain body surface under internal pressure, precisely like an insect larva burrowing within any solid substrate widens one part of its body to cling there and to render a support to another body part to protrude it through the substrate. Though, initial stage of this adaptation can be seen in an unrelated group of cephoid wasps Trematothoracinae (Sepulcidae) as well (cf. Kopylov et al., 2020: p. 1278).

Herein, we report and describe the discovery of one new species, *Myanmarina diversa* Zheng & Rasnitsyn sp. nov., based on a further male fossil inclusion from the mid-Cretaceous fossil assemblage of Kachin amber, which is the sixth species contributed to the Myanmarinidae.

2. Material and methods

The type specimen described herein was collected from the deposits of Hukawng Valley (26°20'N, 96°36'E), Kachin State, northern Myanmar (detailed map in Grimaldi and Ross, 2017: fig. 2), and legally acquired in 2015 (see Museum Catalogue Entry in Supplementary Material). Amber deposits of northern Myanmar had been radiometrically dated at 98.79 ± 0.62 Ma, earliest Cenomanian, based on U–Pb zircon dating of the volcanoclastic matrix (Shi et al., 2012). Although an older dating based on palaeontological data has been disputed (Mao et al., 2018; Smith and Ross, 2018), a late Albian–early Cenomanian age was recently proposed based on ammonites from the amber-bearing deposits (Yu et al., 2019).

The new myannarinids of *M. diversa* Zheng & Rasnitsyn sp. nov. is well embedded in a piece of clear yellow Kachin amber, which is almost rounded, measuring $14.85 \times 12.68 \times 3.52$ mm. This holotype specimen LYU-HY-2033 is housed in the Institute of Geology and Paleontology, Linyi University. The amber piece was polished based on the emery paper (grit sizes of 5000–1000) and rotary

polisher (Mecatech 33, France). The specimen was checked and examined using the Nikon D800 and VHX 5000 digital stereomicroscope equipment. Line drawings were composed and illustrated with Coreldraw 2019 and Adobe Photoshop CC 2019 graphics softwares. Measurements were made with Image J software. In addition, nomenclature of the wing venation follows Zhang et al. (2017) and Li et al. (2018).

3. Systematic paleontology

Order Hymenoptera Linnaeus, 1758.

Suborder Apocrita Gerstaecker, 1867.

Superfamily Stephanioidea Leach, 1815.

Family Myanmarinidae Zhang et al., 2018.

Emended diagnosis. Body size small (usually less than 4 mm), narrow, elongated and subcylindrical. Head subgobular or quadrangular, without teeth or tubercles crown on the head capsule; ocelli lost or at least not distinct; compound eye apparently large, not less than half of head in length; antenna oligomeric, with 11–13 antennomeres in male and 14 in female, not geniculate; scape much longer and broader than pedicel; flagellomeres tended to contain a high density of multiporous plate sensilla; mandible short, with short teeth; maxillary palps with 4-segmented visible; labial palp short. Mesosoma long and narrower, slenderer than head in lateral view, with pronotum short medial, long lateral, propleura elongate in distinct neck, mesonotum long, membranose except narrowly anterior, lateral and possibly posterior, scutellum ordinary, mesopleura long; metanotum short; propodeum elongate with dorsal contour straight or concave; legs long and thin, with pro- and mesofemur much longer and wider than respective tibia, metafemur shorter or as long as metatibia, all tibiae with spur formula 1-1-1, tarsi 5-segmented, claws simple, arolium small or lost. Forewing long and narrow, densely pubescent and with long setae along posterior margin; pterostigma hardly developed; venation deeply reduced, modified and only present in basal third or so, with tubular veins C + R, M + Cu, Rs&M (basal vein), strongly reclival cu-a, and 1A, distally with weak folds possibly agreeing with reduced veins of obscure identity; hind wing with only R preserved, bearing three hamuli at R apex, with membrane narrow, particularly in basal half, and with long setae along hind margin. Metasoma elongated, subcylindrical, lacking petiole; ovipositor thin, much longer than body, male genitalia external, often large, plesiomorphic.

Genera included. Type genus only.

Genus *Myanmarina* Zhang et al., 2018.

Included species: *M. kachin* Zhang and Rasnitsyn, 2018; *M. lisu* Zhang and Rasnitsyn, 2018; *M. lahu* Zhang and Rasnitsyn, 2018; *M. jeanneae* Li et al., 2018; *M. sidorchukae* Jouault et al., 2020, *Myanmarina diversa* sp. nov.

Myanmarina diversa Zheng, Zhang & Rasnitsyn sp. nov.

LSID: urn:lsid:zoobank.org:pub:32095146-6476-40AF-8712-88962094D795.

Figs. 1–2

Etymology. This new species is named from the Latin *diversus*, meaning different (because of different number of antennomeres comparing other congeners).

Holotype. Male, LYU-HY-2033, mid-Cretaceous Kachin (Burmese) amber, stored at Institute of Geology and Paleontology, Linyi University; well-preserved except for some part of right forewing and hindwing damaged and diagenetic deformation present.

Horizon and locality. Kachin amber, upper Albian to lower Cenomanian, mid-Cretaceous from near the Tanai Village, Hukawng Valley, Kachin State, northern Myanmar.

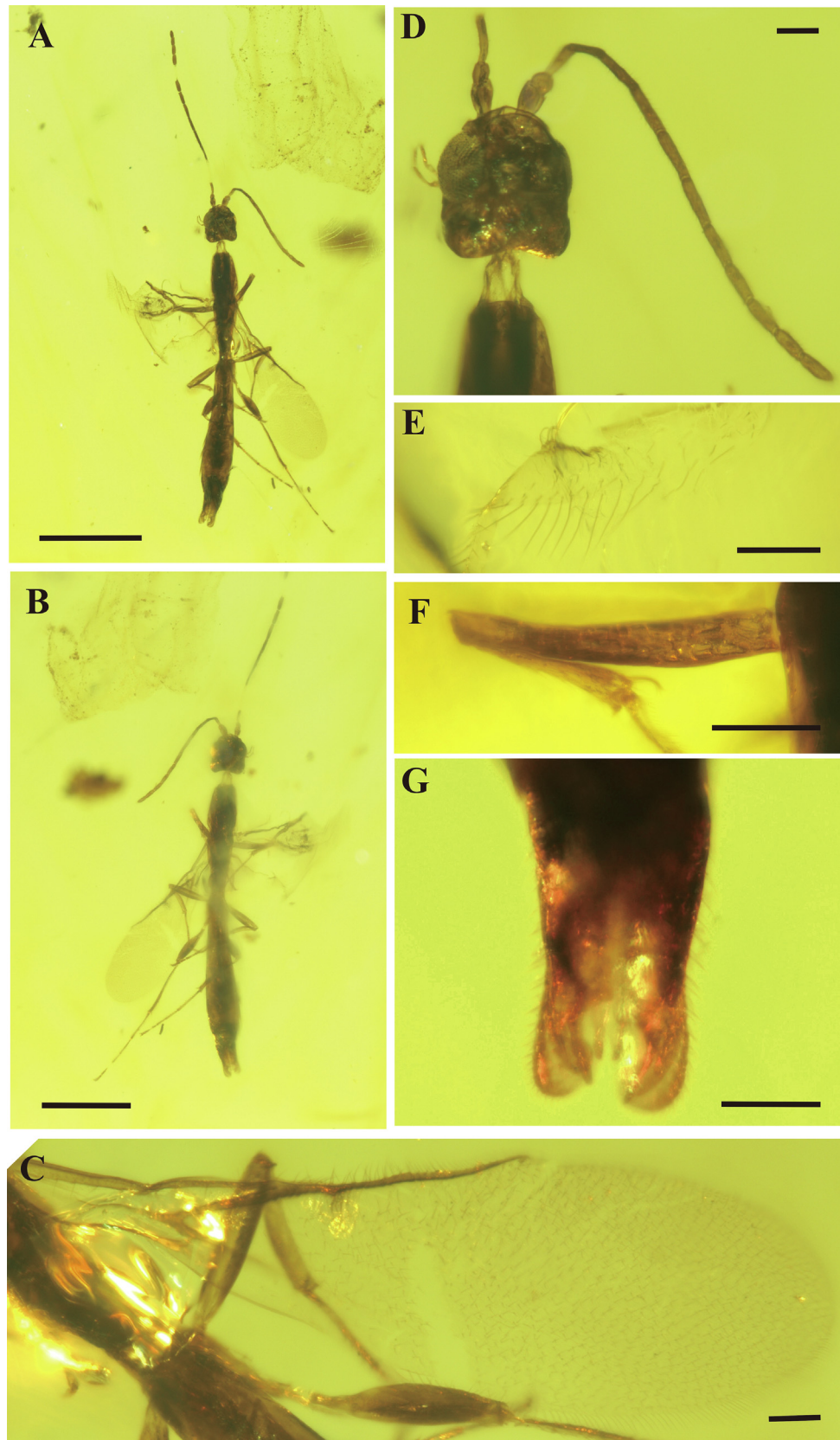


Fig. 1. Photographs of holotype of *Myanmarina diversa* Zheng & Rasnitsyn, sp. nov., holotype, LYU-HY-2033. (A), dorsal view; (B), ventral view; (C), forewing; (D), head and antenna (E), hamuli of hind wing; (F), apical tooth in metatibia; (G), male terminalia. Scale bars: A, B = 1 mm, C–G = 0.1 mm.

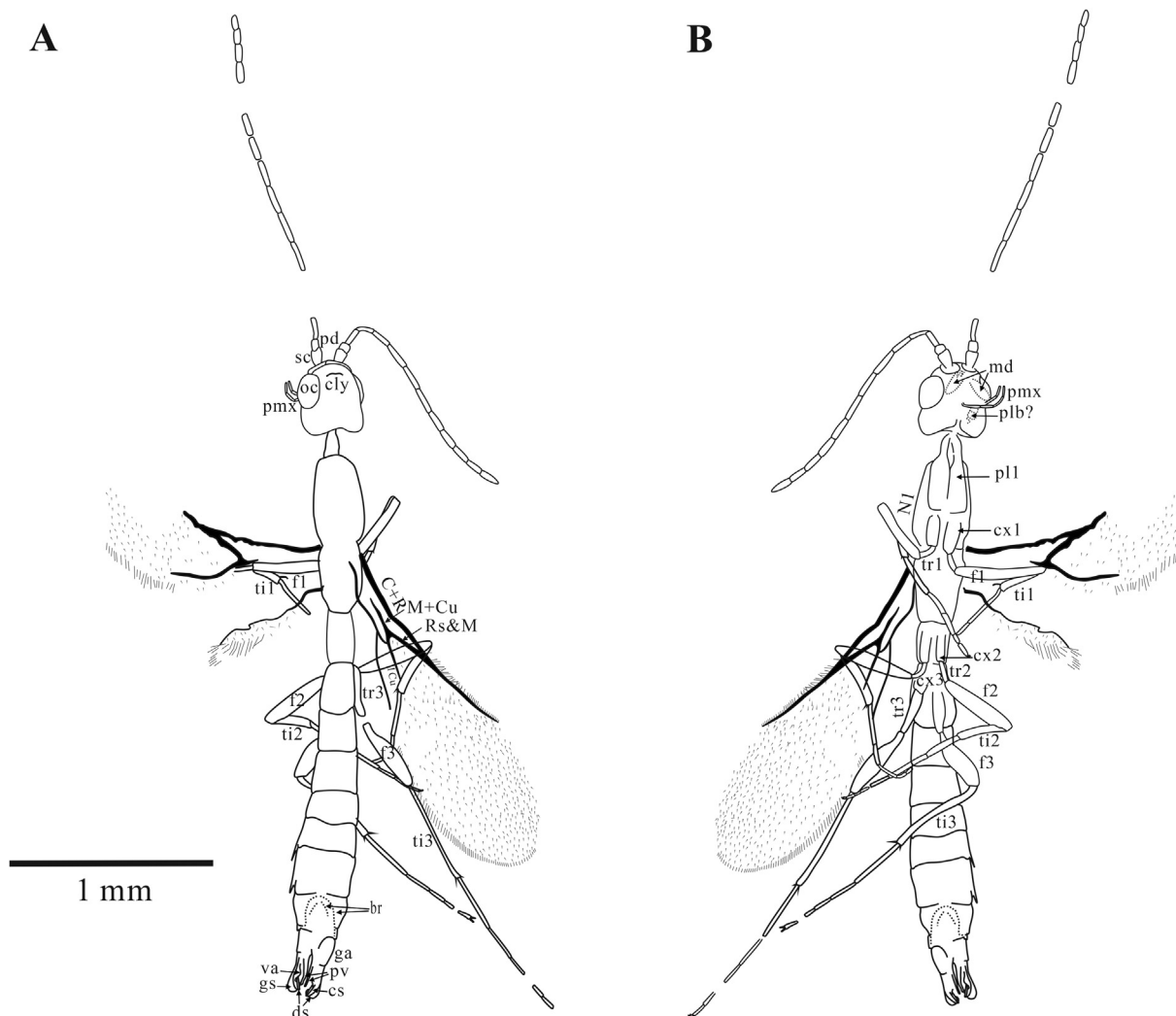


Fig. 2. Line drawings of *Myanmarina diversa* Zheng & Rasnitsyn, sp. nov., holotype, LYU-HY-2033. (A), dorsal view; (B), ventral view; Scale bar = 1 mm. Abbreviations: oc = compound eye; sc = scape; pmx = maxillary palp; md = mandible; cx₁, cx₂, cx₃ = pro-, meso- and metacoxa; tr₁, tr₂, tr₃ = pro-, meso- and metatrochanter; f₁, f₂, f₃ = pro-, meso- and metafemur; ti₁, ti₂, ti₃ = pro-, meso- and metatibia; Plb = labial palp; pl₁ = propleuron; N₁ = pronotum; ga = gonocoxa, gs = gonostylus, cs = cuspis, pv = penis valve, ds = digitus, va = volsella, br = basal ring.

Diagnosis. Head much expanded in posterior sides and longer than wide in dorsal view. Antenna with 13 antennomeres, first flagellomere not disproportionately long. Maxillary palps moderately short. Neck distinctly elongated. Mid femur and all tibiae with apical tooth, hind femur distinctly swollen, together with trochantellus much shorter than hind tibia. Male genitalia 0.75 × as long as hind tibia.

Description. Male. Specimen brown-testaceous totally, except head and mesosoma dark brown. Body small, long and thin, 3.14 mm long excluding antennae.

Head parallelsided, with posterior margin concave in middle, 0.33 mm long and 0.32 mm wide including eyes. Eye about half as long as head, approaching mandibular base. Ocelli not visible. Clypeus partly semilunar. Mandible narrowed apically, possibly with three teeth, except more wide second segment. Maxillary palps with three apical segments visible, distinctly shorter than head height. Compound eyes weakly prominent, ovoid in appearance, length 0.17 mm and width 0.10 mm and approximately half of head in length. Antenna thin, almost uniform in width except that scape and pedicel distinctly wider, 13-segmented, inserted low on head in lateral view, above level of ventral eye margin, covered with

densely setae and sensilla. Scape 0.06 mm long and 0.05 mm wide, robust, expanded apically, nearly twice as long as pedicel and slightly wider than latter. Pedicel short, 0.04 mm long and 0.04 mm wide. Flagellomeres conspicuously slender, about twice to five times longer than wide. First flagellomere length 0.09 mm and width 0.03 mm, slightly longer and wider than second one. Flagellomeres IV and V almost equal in length and width, but longer than others. Flagellomeres from VI to XI becoming gradually slightly wider and shorter toward apex. Apicalmost flagellomere short and rounded. Lengths of flagellomeres (in mm): 0.09: 0.08: 0.10: 0.13: 0.13: 0.11: 0.11: 0.10: 0.09: 0.08: 0.10. Maxillary palp thin, 4-segmented, with obviously longer than head height, with basal segment distinctly thickened, shorter than two median segments but longer than apical one.

Mesosoma much slender than head, 0.71 mm long and 0.25 mm wide. Propleura forming distinct neck. Pronotum extremely short medially and hardly visible in dorsal view. Propodeum convex, with anterior face almost as high as metanotum and posterior face higher than that former.

Forewing long, narrow (1.74 mm length, 0.53 mm width), densely pubescent and with marginal setae particularly long in distal half of

wing hind margin. Veins dramatically reduced, mainly most basal veins presented. Pterostigma absent. Vein C and R fused reaching 0.60 wing length. C + R tubular, basal much thicken and strongly curved nearly one-third distance toward basal. 1-Rs and 1-M aligned and fused as Rs&M, straight, longer than M + Cu. M + Cu lost basally and further degraded, widening toward its forking into M and Cu. 1-Cu short, nearly one-fifth length of Rs&M. cu-a aligned with 1A, meeting Cu distinctly distal of M + Cu apex. Free Cu nebulous, subparallel to posterior margin and practically fading. Legs long and slender. Fore legs with coxae large and elongate, with 0.15 mm in length and 0.07 mm in width; trochanters narrow, elongate, with almost equal width but less than half length of coxae; femur length 0.41 mm, width 0.05 mm; tibiae (ca. 0.22 mm in length, 0.03 mm in width) thin, with long curved spur (calcar); tarsi with five tarsomeres of length, respectively, 0.23 mm, 0.13 mm, 0.05 mm, 0.07 mm and 0.08 mm. Midleg measurements as follow: coxae 0.15 mm long and 0.05 mm wide; trochanter, 0.09 mm long and 0.03 wide; femur 0.35 mm long and 0.06 mm wide; tibia 0.24 mm long and 0.04 mm wide; tarsomere length 0.22 mm, 0.12 mm, 0.08 mm, 0.06 mm and 0.06 mm; apex of mesofemur with short tooth directed posteriorly. Metacoxa relatively narrow, 0.10 mm long and 0.04 mm wide; metatrochanter shorter and thicker, 0.07 mm long and 0.03 mm wide; metafemur spindle-shaped, narrowest (0.37 mm) basally, strongly swollen (0.08 mm wide medially), $0.72 \times$ as long as metatibia, metatibia (0.51 mm long, 0.02 mm wide) extremely narrow, longer than pro- and mesotibia, with long, straight apical spur. Metatarsi pentamerous, longer than pro- and mesotarsi, with metabasitarsus 0.30 mm long, shorter than remaining ones combined, second to fifth tarsomeres 0.18 mm, 0.11 mm, 0.64 mm and 0.07 mm long, respectively. All tibiae with dorsoapical tooth, all pretarsal claws with small preapical tooth. Metasoma elongated, with nine external tergita visible, 2.10 mm long and 0.28 mm maximum wide. First metasomal segment shortest and narrowest, second to eighth segments of approximately equal length, gradually widening apically, apical segment narrowing toward apex. The claspers of male genitalia wide and long, distinctly bent inward. Gonocoxa long, fused with the sternite 8 entirely. Gonostylus broaden apically. The hypopygium with narrow, elongated and hooked superior volsella. Superior volsella with narrow, elongated and inferior volsella stout, rounded. Penis valve with apex slightly flat. Digitus is prominently visible.

4. Discussion

The current researches reveal a striking and unexpected diversity of fossil insects buried in the mid-Cretaceous Kachin amber including 269 hymenopterans out of 1485 described insect species (Rasnitsyn and Öhm-Kühnle, 2018; Zhang et al., 2018a,b; Zheng et al., 2019, 2020; Rasnitsyn and Öhm-Kühnle, 2021; Ross, 2021a,b; Zheng et al., 2021a,b). Noticeably, Myanmarinidae previously possessed only five species with relatively limited morphology information from the Kachin amber.

The new species *Myanmarina diversa* sp. nov., as the sixth described myanmarinids fossil, is characterized by the following combination of male features: antenna 13-segmented (vs. 11-segmented in *M. lisu* and *K. kachin*; 12-segmented in *M. lahu*, *M. jeannineae* and *M. sidorchukae*), pedicel about half length of scape and flagellomere (pedicel equal in scape and less than $1/3 \times$ length of flagellomere in *M. lisu* and *M. jeannineae*; pedicel half length of scape and less than $1/4 \times$ as long as flagellomere in *K. kachin*, *K. lahu* and *M. sidorchukae*); maxillary palps long (vs. strongly short in *K. lahu*); mid femur apically with posterior tooth (no femoral teeth recorded in other congeners) (Zhang et al., 2017; Li et al., 2018; Jouault et al., 2020).

M. diversa sp. nov. provides an important and novel scenario of morphological features and higher diversity of myanmarinids to parasitoid hymenopterans in the Mesozoic. Particularly, it adds new features (femoral teeth) to the unusual adaptive syndrome characteristic of Myanmarinidae to fit the apocritan ground plan way of life (parasitizing xylophilous insect larvae) in their odd manner unique among adult wasps (to cling itself within wooden tunnel by simple widening of the mesosoma diameter by manipulation with internal pressure; see Introduction for details).

5. Conclusions

The *Myanmarina diversa* sp. nov. in Kachin amber from Myanmar is the sixth species reported for Myanmarinidae. This description reveals new and important morpho-species, following special features, as well as an island endemism resulting in an isolation of the West Burma plate.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cretres.2022.105311>.