

Short communication

A new wasp of Myanmarinidae (Hymenoptera: Stephanoidea) from the mid-Cretaceous Myanmar amber

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ABSTRACT

A new myanmarinid wasp, *Myanmarina jeannineae* sp. nov., is described and figured from the mid-Cretaceous Myanmar (Burmese) amber. The new species is established based on one female and two male specimens, and the following characters: antenna with 14 antennomeres in female and 12 antennomeres in males, hind femur strongly swollen in the apex, and metasoma gradually widened from the base to terminal in female. Based on the similarity of ovipositors and the phylogenetic positions of the three families of Ephialtitidae, Stephanidae and Myanmarinidae in Hymenoptera, we propose that myanmarinids are likely to be a parasitoid of wood-boring insect larvae.

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1. Introduction

Myanmarinidae Zhang & Rasnitsyn, 2018, a novel small family of parasitoid wasps, are combined with Stephanidae Leach, 1985, Ephialtitidae Handlirsch, 1906 and Aptenoperissidae Zhang & Rasnitsyn, 2018 in the superfamily Stephanoidea based on the propodeum is straight in side view lacking a posterior slope, and a real constriction is absent between the propodeum and the metasoma (Zhang et al., 2018). This interesting lineage possesses particular characters that distinguish Myanmarinidae from all other families of extant and extinct Hymenoptera. The synapomorphies of Myanmarinidae include head subgobular, without tuberculate crown on the head capsule; foreleg with femur much longer than tibia, tibia with a single, thin and arcuate spur; wing venation reduced, with two enclosed cells, 1rm and 1cua, bordered with thick veins C+R, M+Cu, A and Rs&M, all concentrated in basal one-third of wing, with distal wing plate bearing five strong, diverging folds. The fossil records of Myanmarinidae have only one

genus *Myanmarina* with three species, which were established by Zhang et al. (2018) based on five male specimens collected from Myanmar (Burmese) amber.

In this paper, we describe a new myanmarinid species based on three well-preserved specimens (one female and two males) from the mid-Cretaceous Myanmar amber and present an analysis of *Myanmarina* based on the compared morphological features from male and female species.

2. Material and methods

The amber was collected from Kachin (Hukawng Valley) of Northern Myanmar. The amber mines are located at the north end of Noiye Bum that is approximately at 26°15'N, 96°34'E, 18 km south-west of Tanai (Fig. 1) (Shi et al., 2012; Li et al., 2015, 2017a). This amber deposit previously has yielded well-preserved hymenopteran fossils (Engel et al., 2013, 2016; Li et al., 2015, 2017a; Guo et al., 2017; Rasnitsyn et al., 2017). Although the age of Myanmar amber previously was controversial (Zherikhin & Ross, 2000; Grimaldi et al., 2002; Ross et al., 2010), a recent radioisotopic date has been established at 98.79 ± 0.62 Ma (earliest

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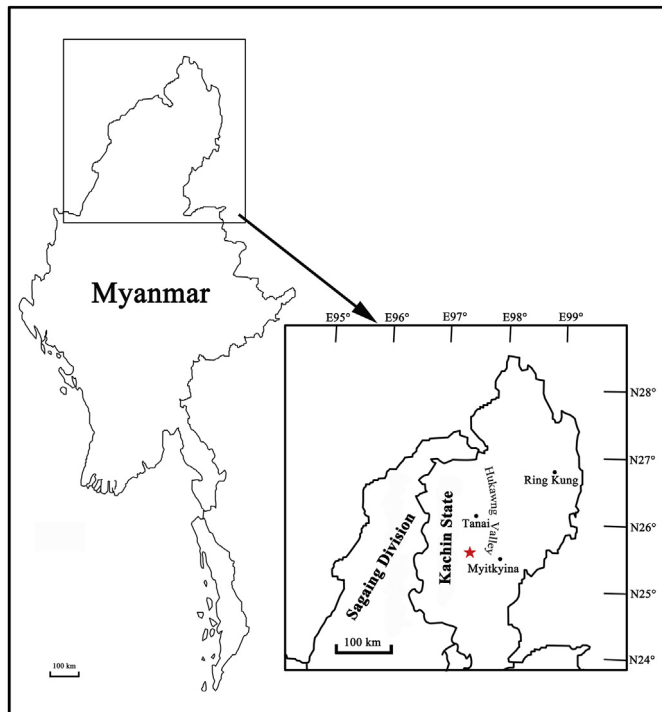


Fig. 1. Map of the amber locality near the Tanai Village in Hukawng Valley, Myanmar (Li et al., 2017a).

Cenomanian), considering other factors (e.g. radiometric dates obtained from the volcanic clasts present within the amber-bearing sediments) (Cruikshank and Ko, 2003; Shi et al., 2012). At the same time, the amber displays unquestionable traces of being redeposited (Ross, 2015, 2017) and so it is older than the source deposits. That is why it is safer to refer to its origin informally as mid-Cretaceous.

The type materials described in this paper are deposited in the Key Lab of Insect Evolution and Environmental Changes, at the College of Life Sciences, Capital Normal University, in Beijing, China (CNUB; Dong Ren, Curator). The type female specimen was examined and photographed under a Leica Z16 APO dissecting microscope with an attached JVC KY-F75U 3CCD digital camera, and photo stacking used a series of software, Cartograph 7.2.5, Archimed 6.1.4 and CombineZP. The type male specimens were examined and photographed with a Leica DFC500 digital camera attached to a Leica MZ 16.5 dissecting microscope (Leica, Wetzlar, Germany) at the Capital Normal University. The figures were prepared with Adobe Photoshop CS6 graphics software. The figures were drawn using CorelDraw 12.0 and Adobe Photoshop Creative Suite, version 5. The wing venation terminology used herein follows that of Zhang et al. (2018).

3. Systematic paleontology

Order Hymenoptera Linnaeus, 1758
 Suborder Apocrita Gerstaecker, 1867
 Superfamily Stephanioidea Leach, 1815
 Family Myanmarinidae Zhang and Rasnitsyn, 2018

Emended diagnosis. Both male and female with body small (2.3–3.2 mm in males, 3.8 mm in the only known female), narrow, elongated and subcylindrical, abundantly covered with long setae (except for metasoma and membranose mesosomal dorsum). Head subgobular, without tuberculate crown on the head capsule, with

most of vertex membranised in female, with ocelli big but apparently weakly sclerotised (looking like wide pale spots, with no cornea preserved); antenna with 11 or 12 antennomeres in male and 14 antennomeres in female, scape not elongate, flagellomeres long, more or less uniform, with multiporous plate sensilla distinct, long, moderately numerous; mandible with 2 or, possibly, 3 teeth in male and with one apical tooth visible in female; maxillary palps with 4 segments visible, short and thick basal and linear three apical; labial palp very short or lost (never visible). Mesosoma long and narrower, subcylindrical, with wings attached at about its midlength, with pronotum short medial, very long lateral, propleura elongate in distinct neck, mesonotum long, membranose except narrowly anterior, lateral and possibly posterior, with scutellum not differentiated, mesopleura long, with no details discernible; metanotum short (structure of dorsum not known); propodeum elongate with dorsal contour straight, without distinct downward bending towards metasomal articulation, sclerotised dorsal; legs with tibiae thin, each bearing one spur, tarsi 5-segmented, ordinary, claws simple, arolium small or lost; foreleg

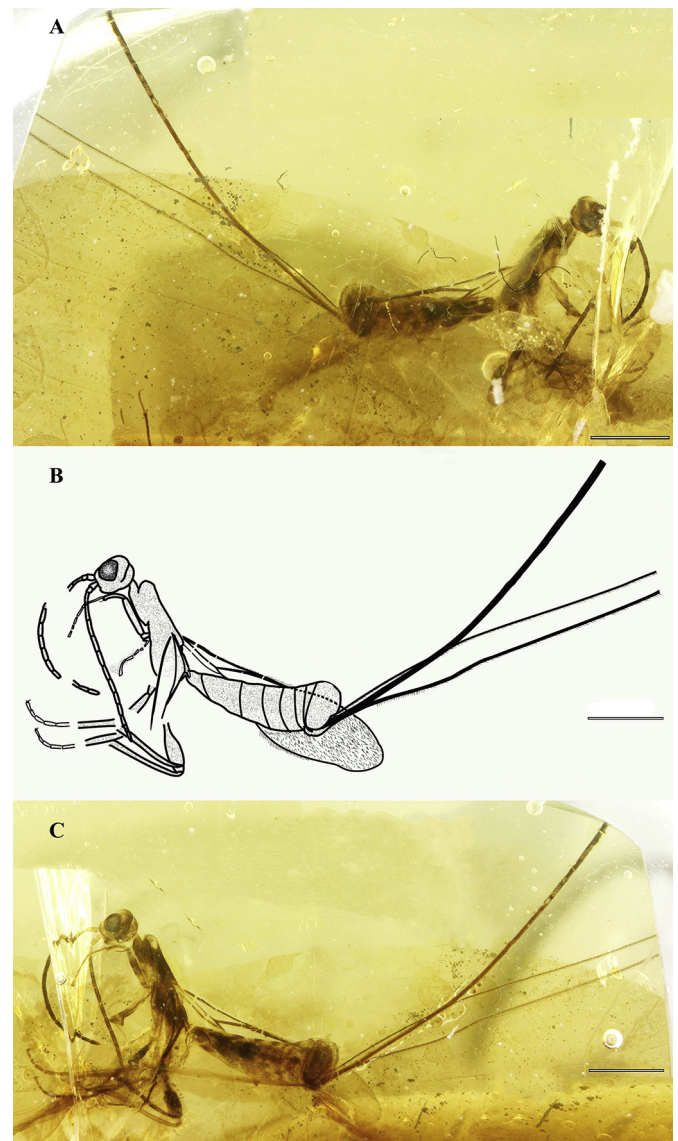


Fig. 2. *Myanmarina jeannineae* sp. nov. Photographs (A, C) and line drawing (B) of holotype. CNU-HYM-MA-2017001. Scale bars = 1 mm.

with femur much longer than tibia, tibia with spur thin, arcuate, bifid apical; female hind tibia extended dorsoapical into short spine. Wings densely pubescent with marginal setae long except short along distal anterior margin; wing venation much reduced, with only tubular veins C+R, M+Cu, 1-Rs&1-M (basal vein) and cu-a observed, C+R reaching some 0.6 wing length, nebuloase Cu reaching about wing midlength, other veins not after basal wing third; 1-Rs and 1-M forming smooth basal vein (1-Rs&1-M), M+Cu lost basal, A (probably 1-A aligned with cu-a, that is 1-A&cu-a) meeting Cu shortly distal of 1-Rs&1-M, with no signs of other veins and pterostigma, with membrane bearing 5 distinct diverging folds in distal 0.6 wing length; hind wing very narrow in basal half, somewhat widened distal, with single vein (R or C+R), with 3–4 hamuli, long setose along hind margin. Metasoma naked, parallel-sided in male and gradually widening apical in female, with no petiole, with apical tergum and sternum not fit to enclose genitalia in repose; ovipositor longer than body, with sheaths very narrow, hairy; male genitalia external, with claspers wide and often long, with no articulated gonostyle, with penis valves and volsellae inconspicuous.

Genera included. Type only

Genus *Myanmarina* Zhang and Rasnitsyn, 2018

Type species. *Myanmarina lisu* Zhang and Rasnitsyn, 2018

Diagnosis. As for family because of monotypy.

Species included. *Myanmarina lisu* Zhang and Rasnitsyn, 2018, *Myanmarina kachin* Zhang and Rasnitsyn, 2018, *Myanmarina lahu* Zhang and Rasnitsyn, 2018 and *Myanmarina jeannineae* sp. nov.

***Myanmarina jeannineae* sp. nov.**

(Figs. 2–7)

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Diagnosis. Head much longer than wide in dorsal view. Antenna with 14 antennomeres in females and 12 antennomeres in males, with the first two flagellomeres subequal in length, maxillary palp long, fore tibia much shorter than its femur, elongate dorsoapically with a curved tibia spur, hind coxa moderately long and narrow, hind femur swollen in the apex, tibiae with dorsal apical tooth in both sexes, male claspers short.

Etymology. The specific epithet of *jeannineae* is in honor of Jeannine Liang-Chi Fan Subisak for her donation of the female specimen; her

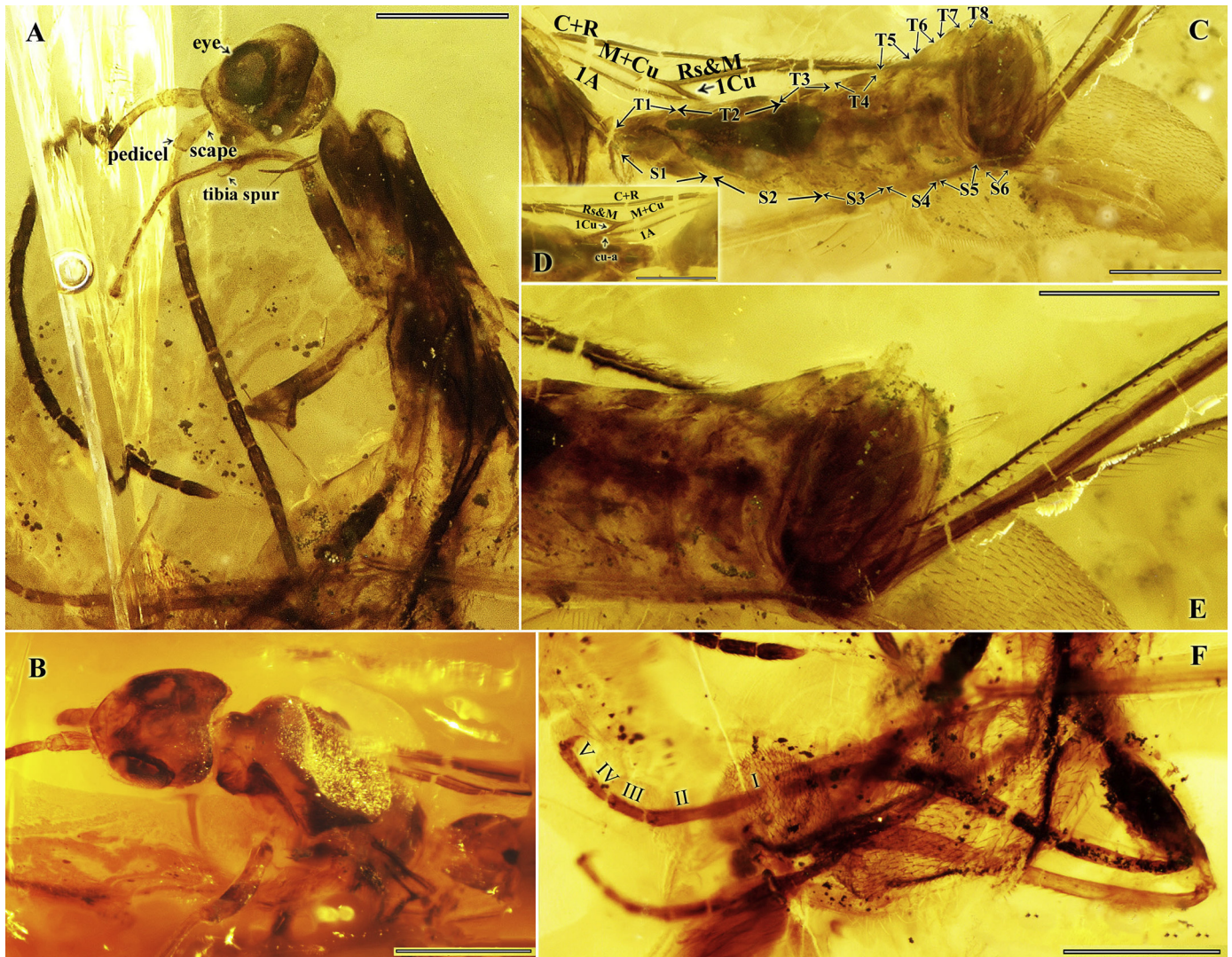


Fig. 3. *Myanmarina jeannineae* sp. nov. Photographs of holotype CNU-HYM-MA-2017001. (A) Lateral view of head and mesosoma, (B) Dorsal view of head and mesosoma, (C) Forewing and metasoma, (D) Base part of forewing, (E) Apical part of metasoma; (F) Hind legs. Scale bars = 0.5 mm.

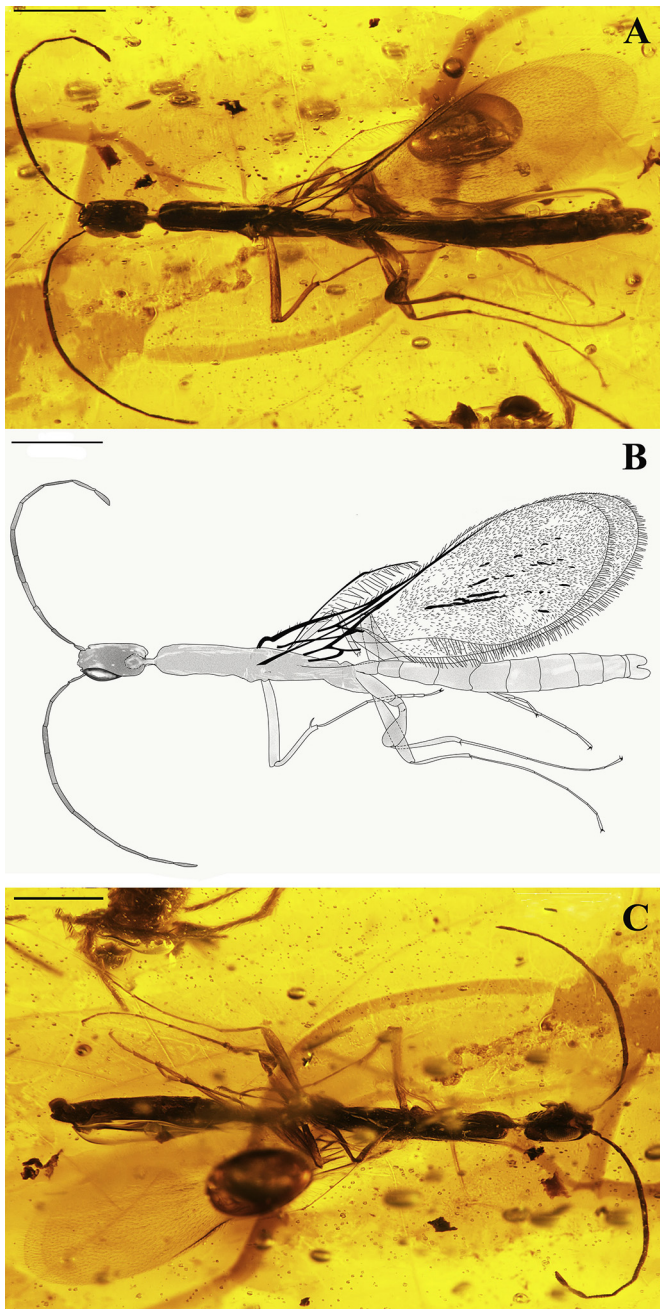


Fig. 4. *Myanmarina jeannineae* sp. nov. Photographs (A, C) and line drawing (B) of paratype (allotype). CNU-HYM-MA-2017002, male. Scale bars = 0.5 mm.

early inspiration and guidance to Dr. Shih's academic and professional careers; and her caring and dedication to her family and students of Chinese and art classes at the Columbus Academy, Columbus, Ohio.

Type material. Holotype, Female, CNU-HYM-MA-2017001 (Figs. 2 and 3), well-preserved except for some part of mid and hind legs indiscernible due to diagenesis; Paratypes (Allotype), Males, CNU-HYM-MA-2017002 (Figs. 4 and 5) and CNU-HYM-MA-2017003 (Figs. 6 and 7). Three specimens are preserved in three different pieces of amber.

Locality and horizon. Hukawng Village, Kachin State, Northern Myanmar; mid-Cretaceous.

Description. Female, CNU-HYM-MA-2017001 (Figs. 2 and 3), body length 3.8 mm (excluding ovipositor and antennae). Integument

dark reddish brown as preserved, scape, pedicel, flagellomere 1, tibiae and tarsi paler. Head subglobose with large eye, dorsum around ocelli somewhat desclerotised, ocelli conspicuously visible but lacking preserved cornea; occipital carina uncomplete below, temples much inflated (head excavate behind). Antenna with 14 antennomeres, inserted moderately low on head in lateral view, covered with densely setae; scape distinctly longer but slightly broader than pedicel; first flagellomere nearly as long as scape and pedicel combined and slightly narrower than pedicel, distinctly shorter than second one, lacking long sensilla in contrast to other ones; flagellomeres from second to seventh nearly equal in length and width; remaining flagellomeres gradually becoming shorter in length but distinctly more than twice as long as wide, apical one oval. Palps as long as flagellomeres 1–3 taken together, first visible segment short, about as long as wide, following 3 linear, thin, basal one shortest and distal longest.

Mesosoma length of 1.3 mm, subcylindrical, much slender than head in lateral view. Foreleg with femur distinctly longer and wider than tibia; tibia very short, nearly as long as first tarsomere, with spur curved, bifid apical; tarsus with five tarsomeres (I:II:III:IV:V = 0.30:0.13:0.10:0.07:0.10), basitarsomere slightly shorter than remaining tarsomeres combined, claws simple, acute, moderately bent, arolium inconspicuous. Hind femur some 2.5 times as long as wide, half as long as hind tibia, tibia slightly shorter than tarsus, with short dorsal apical tooth; hind tarsal segments ratio I:II:III:IV:V = 0.54:0.19:0.14:0.09:0.13.

Forewing long and narrower, 3.1 mm long, about 0.8 times as long as whole body; wings densely pubescent, with long marginal setae; wing venation much reduced, only several veins presented in the most basal part; C+R vein very thick, veins 1Rs and 1M aligned as Rs&M (basal vein), slightly shorter than M+Cu and formed obtuse angle with 1-Rs&1-M; 1-Cu short, nearly 1/3 length of 1-Rs&1-M; cu-a aligned with 1A, meeting Cu distinctly distal of M+Cu apex; free Cu long, nebulous, subparallel to wing hind margin, continuing into weak fold; all distal wing surface free of veins.

Metasoma length 2.0 mm, attached with its upper rim to upper rim of propodeum, with anterior face almost as high at posterior face of propodeum, with 8 terga and 6 sterna visible, with first metasomal segment gradually widened apical, second one much longer and wider than first, third to fifth segments nearly equal in width and slightly wider than second segment, sixth to eighth ones distinctly shorter than former segments. Ovipositor slim, distinctly longer than whole body length, more than 5.3 mm long.

Male, CNU-HYM-MA-2017002 (Figs. 4 and 5), body length 3.1 mm. Integument dark reddish brown as preserved, with legs more pale except hind femur. Head 0.4 mm long and 0.2 mm wide, elongate quadrangular with angles rounded and with eye large, occupying some 0.7 of head side and reaching mandibles. Antenna with 12 antennomeres, scape longer and slightly broader than pedicel; first flagellomere distinctly longer than scape and pedicel combined and nearly as wide as pedicel, near as long as the second flagellomere, the second to eighth ones nearly equal in length; remaining two ones gradually becoming shorter in length but distinctly more than twice as long as wide, apical one oval.

Mesosoma much slender in dorsal view, parallel-sided. Foreleg with femur distinctly longer and wider than tibia; tibia nearly as long as the first tarsomere, basitarsomere slightly shorter than remaining tarsomeres combined, tarsus with five tarsomeres (I:II:III:IV:V = 0.30:0.25:0.06:0.04:0.06). Mid legs and hind legs wider than forelegs; mid femur distinctly longer and wider than mid tibia, mid femur slightly shorter than first tarsomere, tarsus with five tarsomeres (I:II:III:IV:V = 0.37:0.20:0.13:0.07:0.09); hind coxa elongate, nearly as long as hind femur, hind femur thick, hind tibia

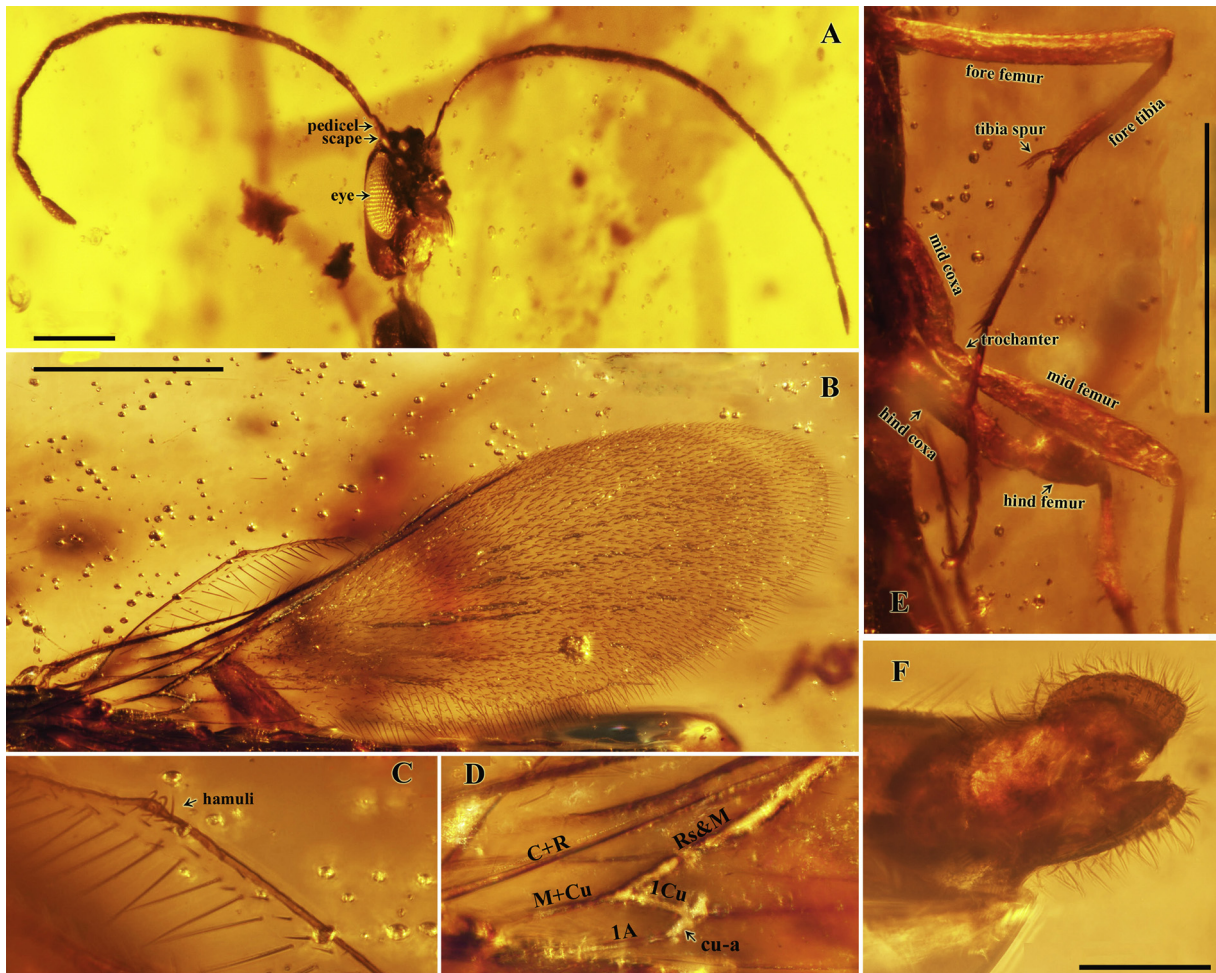


Fig. 5. *Myanmarina jeannineae* sp. nov. Photographs of paratype (allotype) CNU-HYM-MA-2017002. (A) Head, (B) Forewing, (C) Hamuli of hind wing, (D) Base part of forewing, (E) Leg structures, (F) Male terminalia. Scale bars: (A) 0.2 mm, (B, E) 0.5 mm, (F) 0.1 mm.

much narrower than hind femur, nearly as long as first tarsomere, tarsus with five tarsomeres (I:II:III:IV:V = 0.37:0.21:0.15:0.07:0.10).

Forewing 2.0 mm long, with venation similar to that of the female. Hind wing 0.7 mm long, with three distal hamuli, with only R (or C+R) present, with long hind marginal setae.

Metasoma slender, parallel-sided, attached to propodeum as in female; metasoma with 9 segments visible; the first and second metasomal segments short and narrower; the third and fourth metasomal segments distinctly wider from base to apical; the fifth to eighth segments nearly equal in width, cylindrical; the ninth segment slightly narrower than eighth. The claspers of male genitalia wide and comparatively short, plump widely rounded apical, covered with density setae, not distinctly bent downward. Short tubular penis is visible between claspers.

Male, CNU-HYM-MA-2017003 (Figs. 6 and 7), body length 3.2 mm, head 0.6 mm long and 0.4 mm wide, with other characters similar to that of the male, CNU-HYM-MA-2017002.

Mesosoma much slender in dorsal view. Legs clearly discernible, forelegs with femur about two times as long as tibia; tibia short, with one curved spur; tarsus with five tarsomeres, basitarsomere nearly as long as tibia, and distinctly shorter than remaining four tarsomeres combined, tarsus with five tarsomeres (I:II:III:IV:V = 0.37:0.21:0.13:0.11:0.12). Mid legs and hind legs much thick than fore legs, mid legs with coxa long-oval, trochanter like short cylinder, mid femur distinctly thicker than mid tibia, five tarsomeres distinctly narrower than tibia; hind coxa larger than

mid coxa, trochanter short cylinder-shaped, hind femur distinctly shorter than hind tibia, the femur with relatively swelling in apex, tarsus with five tarsomeres (I: II: III: IV: V = 0.49: 0.21: 0.17: 0.11: 0.11).

Forewing 2.7 mm long, with wing venation similar to that of the female. Hind wing 0.6 mm long, with three distal hamuli, without wing venation, only long marginal setae observed.

Metasoma gradually wider from base to apical, slightly shorter than mesosoma, with segments difficult to discern; the claspers of male genitalia visible.

Key to species of *Myanmarina*

1. Antenna with the first flagellomere very long, about 2 times as long as the second. Maxillary palp long. Male head short behind eyes (temple length less than half eye length), antenna with 11 antennomeres.....2
 Antenna with the first flagellomere short, nearly as long as the second. Maxillary palp short or long. Male with head longer behind eyes, antenna with 12 antennomeres.....3
2. Hind femur (with trochantellus) nearly as long as hind tibia, hind coxa and male claspers very long.....*Myanmarina lisu* (male)
 Hind femur at most 0.7 times as long as hind tibia, hind coxa and male claspers.....*Myanmarina kachin* (male)

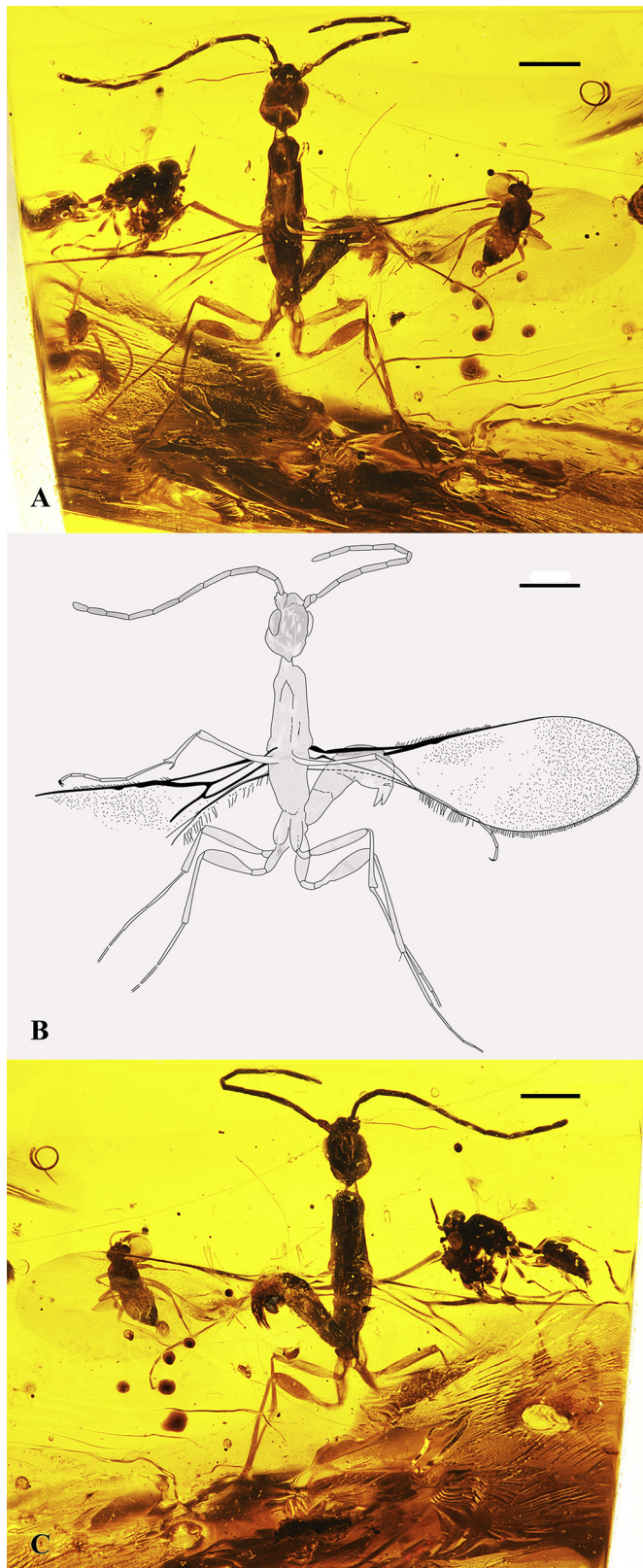


Fig. 6. *Myanmarina jeannineae* sp. nov. Photographs (A, C) and line drawing (B) of paratype (allotype). CNU-HYM-MA-2017003, male. Scale bars = 0.5 mm.

3. Maxillary palp short. Male head slightly longer than wide in dorsal view. Hind femur thin, about as long as its tibia. Tibial apex not elongate in tooth.....*Myanmarina lahu* (male)
Maxillary palp long (seen in female only). Male head much longer than wide in dorsal view. Hind femur thick, much shorter than its tibia. Tibial apex elongate in dorsal tooth.....*Myanmarina jeannineae* (female & male)

4. Discussion

All eight specimens of three previously described species which are known by males only and one new female/male species of *Myanmarina* are summarized in Table 1. The body sizes range from 2.3 to 3.2 mm for seven males and 3.8 mm for a female, and their forewing lengths range from 1.4 to 2.7 mm for males and 3.1 mm for female. The ratios of wing length/body length range from 0.56 to 0.84 for seven males and 0.82 for a female.

Some characters are considered as sexual dimorphic, such as the body size and forewing length of female distinctly longer than those of males; antenna 11 or 12 antennomeres in males, 14 antennomeres in a female (similar difference can be observed in Evanioidae, both gasteruptids and aulacids have 13 antennomeres in males and 14 antennomeres in females).

The new female holotype reveals new and important features, in part because of its previously unknown sex and in part due to its better even though not ideal preservation state of the fossil. Sexually dependent is its very long and thin ovipositor characteristic of many xylobiotic hymenopterans including the putatively closely related Ephialtitidae and Stephanidae. Li et al. (2016) have summarized the feeding habits of Parasitica, and found that the feeding habit of most hosts of parasitic wasps is phytophagous and the ephialtitids were most likely parasitoids and their hosts were xylophagous (Rasnitsyn, 1968, 1988; Li et al., 2016). Ephialtitidae are not known by the time of Burmese amber, with their latest record being the Aptian (Crato Fm., Brasil; Li et al., 2016). In contrast, Stephanidae are similar to Myanmarinidae in starting their record since the Myanmar (Burmese) amber (Engel et al., 2013; Li et al., 2017b), and since the very beginning they demonstrate various traits described by Vilhelmsen and Turrisi (2011) as xylophilous adaptation, such as long ovipositor, narrow body with a big head, the head with a tooth crown and extended on an elongated neck, and incrassate hind tibia suggestive of the vibration detector.

The new and better-preserved material described herein demonstrates further and possibly not sexually bonded xylophilous adaptations, in part absolutely unexpected. We mean particularly the widely desclerotised, membranose mesonotum in the female holotype, which found the closest parallel in Trematothoracinae, a subfamily of the basal cephoïd (stem-borer wasps) family Sepulcidae. Trematothoracinae also have mesonotum widely membranose centrally, but unlike *Myanmarina*, they retained its lateral sclerotised margins wider and furnished with transverse ridges (Rasnitsyn, 1993, figs. 25, 27, 29; Kopylov & Rasnitsyn, 2017, figs. 3,4). These transverse mesonotal ridges are equally characteristic of mesonotum in many xylophilous Hymenoptera (Vilhelmsen & Turrisi, 2011). We hypothesise that the membranous thoracic dorsum is an efficient xylophilous adaptation acting similar to other ones that help to fix the body in a tunnel and so give a reliable support to the head when it is gnawing a way out through wood. The membranous dorsum makes possible the mesosoma to widen itself as much as necessary to cling the body reliably in the tunnel. It depends on more findings of better-preserved fossils to demonstrate if this mechanism is characteristic of male *Myanmarina* as well. The currently available information indicates the male

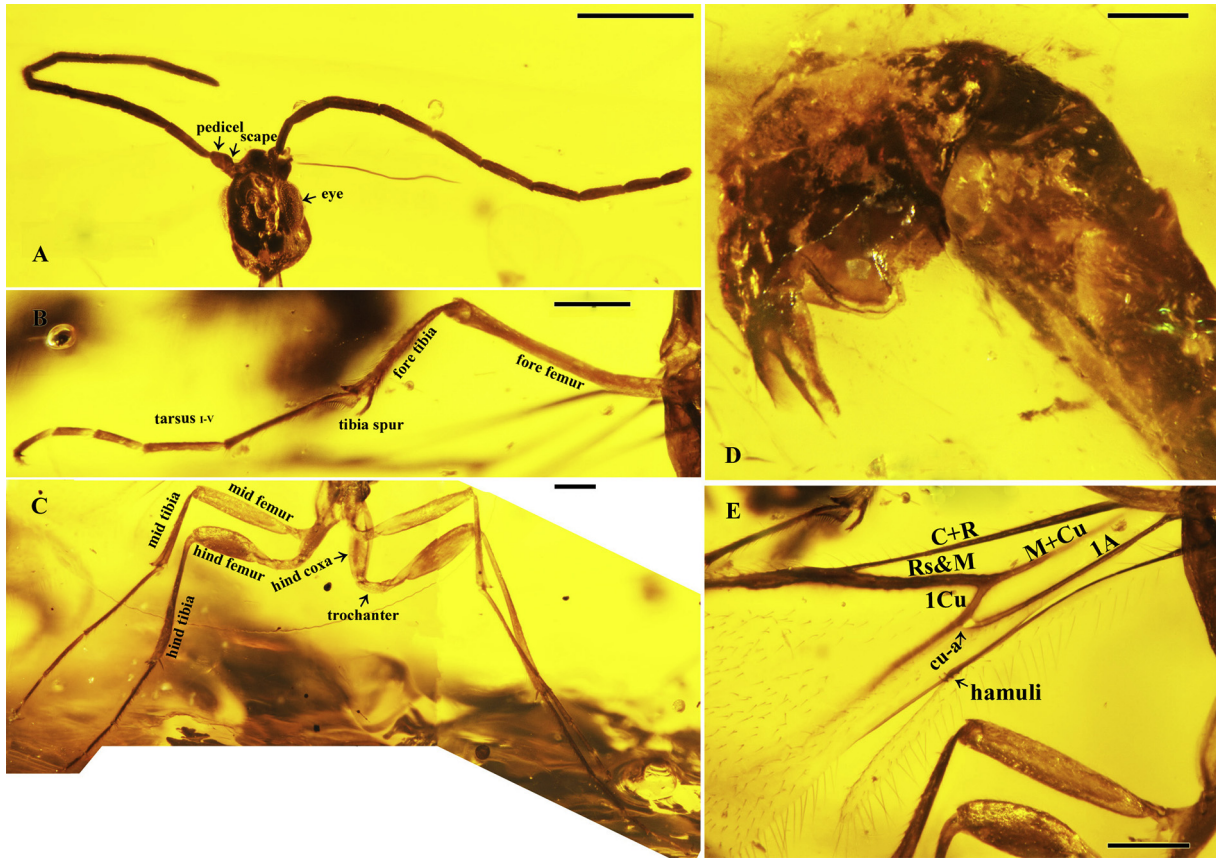


Fig. 7. *Myanmarina jeannineae* sp. nov. Photographs of paratype (allotype) CNU-HYM-MA-2017003. (A) Head and antennae, (B) Fore leg, (C) Mid and hind legs, (D) Male terminalia, (E) Base part of forewing and hamuli of hind wing. Scale bars: (A, B, C, E) 0.2 mm, (D) 0.1 mm.

Table 1
Summary of all species of *Myanmarina*.

Species/specimens ID number	Body length	Forewing length	Ratio of wing length/Body length	Antenna	Sex
<i>Myanmarina lisu</i> Zhang and Rasnitsyn, 2018					
Holotype NIGP166310	2.7 mm	1.9 mm	0.70	11 antennomeres	Male
Paratype NIGP166311	2.3 mm	1.4 mm	0.61	11 antennomeres	Male
<i>Myanmarina kachin</i> Zhang and Rasnitsyn, 2018					
Holotype NIGP166309	3.2 mm	1.8 mm	0.56	11 antennomeres	Male
<i>Myanmarina lahu</i> Zhang and Rasnitsyn, 2018					
Holotype NIGP166312	2.9 mm	1.9 mm	0.66	12 antennomeres	Male
Paratype NIGP166313	NA	NA	NA	NA	Male
<i>Myanmarina jeannineae</i> sp. nov.					
Holotype CNU-HYM-MA-2017001	3.8 mm	3.1 mm	0.82	14 antennomeres	Female
Allotype CNU-HYM-MA-2017002	3.1 mm	2.0 mm	0.65	12 antennomeres	Male
Allotype CNU-HYM-MA-2017003	3.2 mm	2.7 mm	0.84	12 antennomeres	Male

dorsum was not fully membranous but still possibly rather soft (Figs. 4A, 6C).

Another probable xylophilous adaptation is the *Myanmarina* specimens have tibia with its dorsal apex elongate in a tooth helpful in clinging body within a tunnel. This is possible because insects typically pupate with their legs appressed to the thorax, and the adult insects enclosed within a narrow tunnel cannot straighten their legs until fly out. While in the tunnel, legs are working as a functional part of the thorax. In particular, the tibial apex faces against the tunnel wall, and some *Myanmarina* with toothed tibial apex might have received an additional support while making their way out of wood. Furthermore, it is not clear whether the membranous frons of the female *Myanmarina* (and apparently not the males) is functionally related to the cling activity during chewing through wood, and if ocelli might lose their cornea in connection of that activity.

Furthermore, the highly reduced wing venation for *Myanmarina* demonstrates one more paradoxical adaptation of obscure nature which is not probably connected with the xylophilous habits. The *Myanmarina* wing has thick and heavy veins all over the basal forewing quarter or so and extending up to some 0.6 wing length only along the wing fore margin, with remaining wing disk being supported with strong folds of membrane. It is unusual that the forewing base incrassate throughout (not mainly anterior), and combined with the veinless most part of the wing. The only known analogs are some desert aculeate wasps (Bradynobaenidae: Bradynobaeninae, Chyphotinae and Apterogyninae). However, these aculeate wasps represent a distinctly different size class, and Myanmar amber hardly suggests any association with comparable desert habitats. Additionally, the above aculeate wasps have their wings more or less naked in contrast to densely and long setose

wings of *Myanmarina*, and particularly different are their hind wings which are ordinary in aculeates and narrow ribbon- or oar-like and with a single vein in *Myanmarina*. We have no suggestion what adaptation could be for such wings.

Ocelli are unusual in *Myanmarina* as well: in the female, and with a lesser certainty in males, ocelli are conspicuously visible and looking like pale spots, with no convex cornea visible. Ocelli are important in flight, and they are often strikingly large in flying nocturnal Hymenoptera. Unless the cornea is specifically degenerated due to unfavorable preservation condition, wide and flat ocellar spots are very unusual in Hymenoptera and find its analogs only in few and remote insects such as cockroaches (Vršanský, 2008).

5. Conclusions

The *Myanmarina jeannineae* sp. nov. in Myanmar (Burmese) amber is the first species documented for Myanmarinidae to have both male and female specimens. This female specimen of *Myanmarina jeannineae* sp. nov. differs significantly from all known males in body size, forewing length and the number of antennomeres, which can be considered as sexual dimorphism. Based on the similarity of ovipositor and the phylogenetic positions of these three families Ephialtidae, Stephanidae and Myanmarinidae in Hymenoptera, we propose that myanmarinids are likely to be a parasitoid of wood-boring insect larvae. Several unique or at least unusual morphological traits of *Myanmarina*, such as membranous mesonotum, cornea less big ocelli and *Apterogyna*-like forewing with highly reduced venation further highlights specific features of the mid-Cretaceous Myanmar biota.

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