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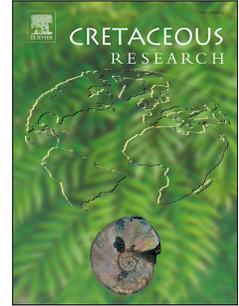
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1 Taxonomic additions to the peleciniid wasps (Hymenoptera, Peleciniidae) of the ‘mid-Cretaceous’
2 Burmese amber

3

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13

14 **ABSTRACT.**

15 A new species of peleciniid wasp, *Eopelecinus inopinatus* sp. nov., is described and figured from
16 Cenomanian Burmese amber based on a single female specimen. Additionally, the examination of a
17 new, well preserved specimen of *Zoropelecinus periosus* Guo, Shih & Ren 2016, allows to emend
18 the diagnosis of this species. These discoveries confirm that Peleciniidae were clearly highly diverse
19 during the Cretaceous. We provide a list of *Eopelecinus* species with their respective metasomal
20 ratio.

21

22 **Key words.**

23 New species, Burmese amber, *Zoropelecinus*, emended diagnosis, *Eopelecinus*

24

25 **1. Introduction.**

26 While the extant parasitoid wasp superfamily Proctotrupeoidea is modest in diversity com-
27 pared to the mega-diverse Ichneumonoidea, the former group currently comprises no less than 99
28 species during the Cretaceous (<http://fossilworks.org>). This superfamily comprises several unplaced
29 genera (viz. †*Amitchellia*, †*Hemerocynipites*, †*Paraulacus*, †*Sinocynipites*) and the families Aus-
30 troniidae, Heloridae, Jurapriidae, Mesoserphidae, Peleserphidae, Peradeniidae, Proctotrupidae,
31 Roproniidae, and Pelecinidae.

32 Pelecinidae have a fossil record dating back to the Jurassic, with four species described from
33 China and Mongolia: *Archaeopelecinus jinzhouensis* Shih, Liu & Ren 2009, *Archaeopelecinus teb-*
34 *bei* Shih, Liu & Ren 2009, *Cathaypelecinus daohugouensis* Shih, Liu & Ren 2009, *Praescopinus*
35 *excellens* Rasnitsyn 2008 (Shih et al., 2009; Rasnitsyn, 2008). The family was most diverse during
36 the Cretaceous with more than 48 described species. Following this relative diversity, the Pelecini-
37 dae gradually decreased in taxa number and currently comprise only three described species in the
38 sole extant genus *Pelecinus* Latreille 1800, distributed in North, Central, and South America (John-
39 son and Musetti, 1999). Pelecinid wasps are easily distinguishable from all other Hymenoptera in
40 having a long, thin, pluri-segmented metasoma with elongated segments (conspicuous on female
41 specimens). Females are glossy wasps and possess a very long (up to 7 cm) abdomen, used to lay
42 eggs directly on scarab larvae buried in the soil (Mason, 1984; Johnson and Musetti, 1999). Extinct
43 pelecinids are mostly documented from rock imprints or compression fossils, while six species only
44 have been described from amber. Fossil taxa are known from the Eocene Baltic amber (Brues, 1933;
45 Engel, 2002), Eocene Sakhalin amber (Kozlov, 1974; Johnson, 1998) Eocene of Montana (Green-
46 walt and Engel, 2014), Turonian New Jersey amber (Engel and Grimaldi, 2006), Cenomanian Bur-
47 mese amber (Engel et al., 2013; Guo et al., 2016a) and Cretaceous of Russia and China (Zhang and
48 Rasnitsyn 2004; Rasnitsyn, 2008; Feng et al., 2010; Shih et al., 2010; Guo et al., 2016b). Recently,
49 Engel et al. (2013) synonymized Iscopiniinae with Pelecinidae, this synonymization being accepted
50 by Guo et al. (2016a,b) and by us. With the growing number of studies on Burmese amber and re-

51 cent publications describing new families and genera (Ross, 2019), discoveries of new pelecimid
52 taxa seem inevitable.

53 In this paper, we report a new species, *Eopelecinus inopinatus* sp. nov., based on one inclu-
54 sion from the amber collection of the Geological Department and Museum (IGR) of the University
55 of Rennes, France. We also propose an emended diagnosis of *Zoropelecinus periosus* Guo et al.,
56 2016a.

57

58 **2. Material and methods.**

59 The two amber pieces containing the specimens studied herein derive from the deposits of Noiije
60 Bum in the Hukawng Valley (26° 29' N, 96° 35' E), Kachin State, northern Myanmar (see detailed
61 map in Grimaldi and Ross, 2017: fig. 2). Radiometric data established an Early Cenomanian age
62 (98.79 ± 0.62 Ma) for Kachin amber, based on zircons from volcanic clasts found within the amber-
63 bearing sediments (Shi et al., 2012). Some ammonites found in the amber-bearing bed and within
64 amber corroborates a late Albian–early Cenomanian age (Cruickshank and Ko, 2003; Yu et al.,
65 2019).

66 The holotype of *Eopelecinus inopinatus* sp. nov. is embedded in a piece of dark orange am-
67 ber. It contains a nearly complete individual with some metasomal segments missing. The new
68 *Zoropelecinus* is complete and embedded in a piece of clear yellow amber. The holotype of *Eo-*
69 *pelecinus inopinatus* sp. nov. is housed in the amber collection of the Geological Department and
70 Museum (IGR) of the University of Rennes, France, under the collection number IGR.BU-007,
71 while the new specimen of *Zoropelecinus* (Pouillon number 6) is deposited in the Musée of Colmar,
72 France. The specimens were examined with a Leica MZ APO stereomicroscope and a Nikon
73 SMZ25. Photographs were made using a Canon EOS 5D mark II mounted on a Leica MZ APO ste-
74 reomicroscope and a Nikon D800. All images are digitally stacked photomicrographic composites
75 of several individual focal planes, which were obtained using HeliconFocus 6.7 and Nikon Capture

76 NXD. The figures were composed with Adobe Illustrator CC2018 and Photoshop CC2018 soft-
77 wares.

78 Acronyms for measurements and indices are listed below:

79 HL: maximum head length measured laterally from anteriormost point of head capsule to posteri-
80 ormost point of vertex; HW: maximum head width measured at eyes level (eyes included); HH:
81 maximum head height measured at midlength; AL: antennal length; length of all antennomeres
82 combined; ED: maximum diameter of eye as measured in lateral view of head to show full surface
83 of eye; PW: pronotum width in dorsal view; ML: mesosomal length measured in lateral view from
84 anterior surface of pronotum to posterior extension of propodeum; WH: mesosoma height; in side
85 view, maximum height measured from lowermost point of mesopleuron (in front of middle coxa) to
86 dorsal edge of mesosoma; MIL: maximal length of first metasomal segment; MIH: maximal height
87 of first metasomal segment; MIIL: maximal length of second metasomal segment; MIIH: maximal
88 height of second metasomal segment; CI: cephalic index ($HH/HW \times 100$); AI: antennal index
89 ($AL/HW \times 100$); OI: ocular index ($ED/HL \times 100$).

90

91 **3. Systematic paleontology**

92 Order Hymenoptera Linnaeus, 1758

93 Suborder Apocrita Gerstaecker, 1867

94 Superfamily Proctotrupoidea Latreille, 1802

95 Family Pelecinidae Haliday, 1840

96 Genus *Zoropelecinus* Engel & Grimaldi, 2013 (in Engel et al., 2013)

97 Type species. *Zoropelecinus zigrasi* Engel & Grimaldi, 2013, other species *Zoropelecinus periosus*
98 Guo, Shih & Ren 2016.

99

100 *Zoropelecinus periosus* Guo, Shih & Ren 2016

101 Fig. 1

102 *New material.* MHNE.2019.X.1 (female, 06, coll. Jean-Marc Pouillon), deposited in the Musée of
103 Colmar, France.

104 *Locality and horizon.* Noiye Bum Hill, Hukawng Valley, Kachin State, Myanmar; lower Cenomani-
105 an, Upper Cretaceous.

106 *Remark.* This fossil is extremely similar to the holotype of *Zoropelecinus periosus*, in the body
107 shape and proportion (Fig. 1A), wing venation and even in the typical pattern of coloration of legs
108 and metasomal segments, which are basally clear and distally darkened (see Guo et al., 2016a: fig.
109 4). We can thus safely attribute this new specimen to the same species. Guo et al. (2016a: 89) had
110 some doubt about the exact number of antennomeres (indicated 14?). *Zoropelecinus zigrasi* has 14
111 antennomeres in females. Engel et al. (2013: 4) indicated the ‘combined lengths of scape and pedi-
112 cel as slightly greater than length of first flagellomere’ in this last species. Our fossil clearly shows
113 14 antennomeres (see Fig. 1B), with a scape twice as long as pedicel and a pedicel slightly shorter
114 than first flagellomere. It thus shows that *Zoropelecinus periosus* differs from *Zoropelecinus zigrasi*
115 in the antennal structure. Nevertheless, the number of antennomeres is variable among species of
116 some other peleciniid genera, thus this difference cannot support a generic separation between the
117 two species of *Zoropelecinus*.

118 We emend the diagnosis of *Zoropelecinus periosus* as follows: antenna 14-segmented with scape
119 twice as long as pedicel, short pedicel slightly shorter than first flagellomere.

120

121 Genus *Eopelecinus* Zhang et al., 2002

122 Type species: *Eopelecinus vicinus* Zhang et al. 2002. Other species: see Tab. 1.

123 *Eopelecinus inopinatus* sp. nov.

124 Figs. 2-3

125 *Material.* Holotype IGR.BU-007, nearly complete and well preserved specimen in a rectangular
126 piece of amber measuring $5 \times 4 \times 3$ mm.

127 *Locality and horizon.* Noiije Bum Hill, Hukawng Valley, Kachin State, Myanmar; lower Cenomani-
128 an, Upper Cretaceous.

129 *Etymology.* From the Latin word *inopinatus*, meaning “unexpected”. The epithet refers to the rather
130 unexpected nature of the discovery of *Eopelecinus* in Burmese amber.

131 *Diagnosis.* *Eopelecinus inopinatus* sp. nov. differs from all known *Eopelecinus* species in having a
132 unique metasomal segment ratio (for the three preserved segments): 1.0; 1.25; 0.85, the pronotal
133 and mesonotal lateral surfaces areolate; and the propodeum coarsely and regularly reticulate. It also
134 differs from other *Eopelecinus* known from compression fossil in having its relatively smaller size
135 and its 14-segmented antennae.

136 *Description.* Female; male unknown.

137 Head (Fig. 2A, D). Hypognathous, ovoid (CI: 88), wider than high, widest above mid-length in full
138 face view; mandibles dentate, oriented ventrally; eyes large, nearly oval; vertex with 3 ocelli form-
139 ing an equilateral triangle. Antennae 14-segmented (Fig. 2D), filiform; scape 0.16 mm long x 0.06
140 mm wide, pedicel 0.8 x 0.06 mm, F1 0.08 x 0.04 mm, F2 0.08 x 0.05 mm, F3 0.08 x 0.05 mm, F4
141 0.10 x 0.05 mm, F5 0.07 x 0.05 mm, F6 0.08 x 0.05 mm, F7 0.07 x 0.05 mm, F8 0.08 x 0.05 mm,
142 F9 0.08 x 0.05 mm, F10 0.08 x 0.05 mm, F11 0.07 x 0.06 mm, F12 0.14 x 0.05mm;scape narrow
143 basally, widened apically, 2.6x longer than wide, longer than the others segments; pedicel globular,
144 narrower basally, about as long as wide; first flagellomere narrower basally than pedicel apex,
145 gradually increasing in width apically, twice as long as wide; second flagellomere less than twice
146 as long as wide, gradually increasing in width apically; remaining flagellomere similar to second
147 one except tenth through apical one cylindrical slightly long than wide; apical flagellomere longer
148 than wide, rounded apically. Mesosoma (Fig. 2A, C) 0.9 mm long, rectangular, convex in lateral
149 view; pronotum extremely short; mesonotum nearly straight; notauli not clearly visible, metanotal
150 suture conspicuous; mesonotum and propodeum separated by a deep constriction; pronotum and
151 mesonotum with lateral surfaces areolate; propodeum coarsely and regularly reticulate (Fig. 3). Fore
152 and mid legs short. Hind leg with larger coxa; trochanter small; femur swollen medially; tibia nar-

153 row basally, gradually broadened apically and slightly longer than femur; basitarsomere 0.19 mm
154 long and more than twice as short as tibia; second tarsomere 0.07 mm long and more than twice as
155 short as basal tarsomere; third 0.06 mm long, slightly shorter than second; fourth 0.04 mm long,
156 shortest and half as long as third; fifth slightly clavate and sub-equal to second tarsomere. Tarsal
157 claws unarmed.

158 Fore wing 1.3 mm long, with broad costal area; pterostigma short and broadest in its apical third,
159 with posterior margin arched. Hind wing not visible.

160 Metasoma elongated and pluri-segmented (Fig. 2A, B). First metasomal segment 0.75 mm long,
161 elongated, trapezoidal and broadest slightly before its mid-length; tergite and sternite of first meta-
162 somal segment convex laterally and dorso-ventrally, slightly shorter than mesosoma and slightly
163 broader basally than apically, without conspicuous sculpture; second and third metasomal segments
164 tubiform, slender and arched medially.

165 *Color pattern.* Colors black to dark brown (as preserved in amber). Tibiae, tarsi and basal 2/3rd of
166 metasomal segments 2-3-4 (assumed) lighter than the rest of the body; apical third of metasomal
167 segments 2-3-4 (assumed) with a dorsal darker area.

168

169 *Measurements (in mm):* HL 0.4; HW 0.57; HH 0.5; AL 1.22; ED 0.25; PW 0.53; ML 0.9; WH 0.45;
170 MIL 0.75; MIH 0.34; MIIL 1; MIIH 0.12; MIIIL 0.88; MIIIH 0.12 ; CI 88; AI 214; OI 62.

171

172 **4. Discussion**

173 Although only partially preserved, *Eopelecinus inopinatus* sp. nov. possesses a fore wing
174 only with veins C and R present; the pterostigma short; the pronotum short medially; the pro-
175 podeum reticulate, and the metasoma with one basal segment wide and remaining tubular. Among
176 *Eopelecinus* species, *E. inopinatus* sp. nov. can be easily distinguished by the metasomal ratio (see
177 differential ratio for all species in tab. 1) is one of the major criteria used in the species diagnoses

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178 (Zhang et al., 2002; Zhang and Rasnitsyn, 2004; Zhang, 2005; Duan and Cheng, 2006; Liu et al.,
179 2011).

180 In addition to these data (Tabl. 1), *Eopelecinus inopinatus* sp. nov. differs from *E. giganteus*,
181 *E. mecometasomatus*, *E. mesomicrus*, *E. pusillus* and *E. laiyangicus* in its smaller size (about three
182 times as short as *E. giganteus*), different metasomal proportions, and 14-segmented antennae. It dif-
183 fers from *E. leptaleus* in its smaller head (0.4 mm vs. 1 mm) and mesosoma (0.9 mm vs. 2.5 mm),
184 and in antennae with 14 segments vs. 15-segments. *Eopelecinus inopinatus* sp. nov. differs from *E.*
185 *hodoiporus* in its metasomal proportions, a smaller size and a thinner mesosoma. It also differs from
186 *E. eucallus* in its metasomal proportions, mesonotal lateral surfaces, and propodeum coarsely and
187 regularly reticulate. *Eopelecinus inopinatus* sp. nov. differs from *E. minutus*, *E. fragilis* and *E. tu-*
188 *midus* in its larger size and higher metasomal proportions; and from *E. yuanjiawaensis*, *E. similaris*,
189 *E. shangyuanensis*, *E. vicinus*, *E. huangi*, *E. exquisitus*, *E. scorpioideus*, and *E. rudis* its smaller
190 size and metasomal proportions (Zhang et al., 2002; Zhang and Rasnitsyn, 2004; Zhang, 2005;
191 Duan and Cheng, 2006; Liu et al., 2011). *Eopelecinus inopinatus* sp. nov. only shares with *E.*
192 *mecometasomatus* Zhang 2005 a second metasomal segment longer than the first one. This charac-
193 teristic suggests a close phylogenetic relation between these two species.

194 The current fossil record of peleciniid wasps suggests an Asian origin for the family, more
195 precisely around China, and a later spreading to Europe through Central and Eastern Asia. Peleci-
196 nids are only known today in the Americas, having probably migrated from Eurasia to North Amer-
197 ica through one of the 'routes' that existed between these regions (Beringia) present from the Late
198 Cretaceous till the Paleocene, as this wasp family is present in the Eocene North America and Baltic
199 amber in the Eocene (Sanmartin et al., 2001; Shih et al., 2009; Brikiatis, 2014). Shih et al. (2010)
200 highlight this hypothesis by comparing the distribution of peleciniid wasps during geological times.
201 The recent studies of Zhang et al. (2018) and Westerweel et al. (2019) suggest an island endemism
202 for the Burmese amber biota. These new data have to be taken into consideration to explain possible
203 speciation and therefore the establishment of a unique Burmese fauna. We can assume that *Eo-*

204 *pelecinus inopinatus* sp. nov. comes from a radiation of the genus *Eopelecinus* from the Cretaceous
205 Asian terrane.

206 According to a phylogenetic analysis based on wing venation, Shih et al. (2009) proposed
207 *Allopelecinus* as the sister lineage of *Eopelecinus*. The description of *Eopelecinus inopinatus* sp.
208 nov. as the youngest representative of the genus seems to corroborate this result. *Eopelecinus inop-*
209 *inatus* sp. nov. possesses the typical wing venation of the genus and allows us to say that the re-
210 duced wing venation of the *Eopelecinus* species was maintained at least until the Cenomanian.

211

212 **5. Conclusion**

213 As aforementioned in the introduction, only six species of Pelecinidae were previously described in
214 amber (Brues, 1933; Engel and Grimaldi, 2006; Engel and Grimaldi, 2013; Guo et al., 2016a). *Eo-*
215 *pelecinus inopinatus* sp. nov. is the first record of this genus in amber, which is otherwise known as
216 imprints from n species from China and Russia. This also highlights the underestimated diversity of
217 pelecinid wasps in Burmese amber and a possible origin from Asian biota.

218

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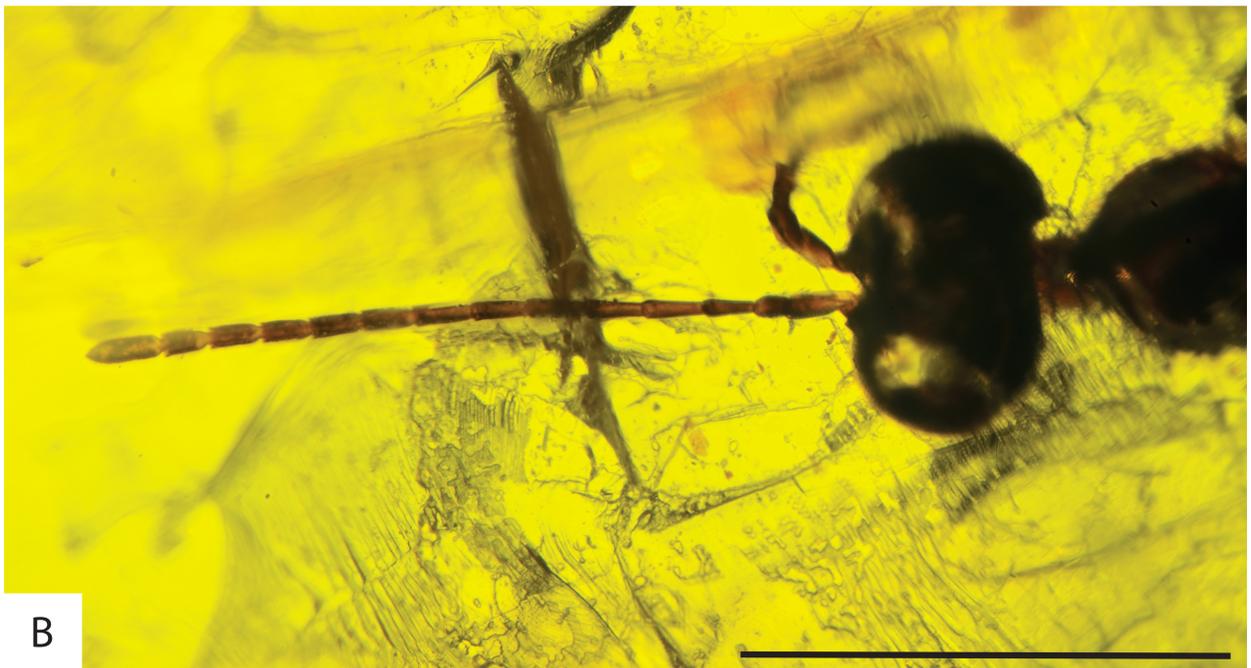
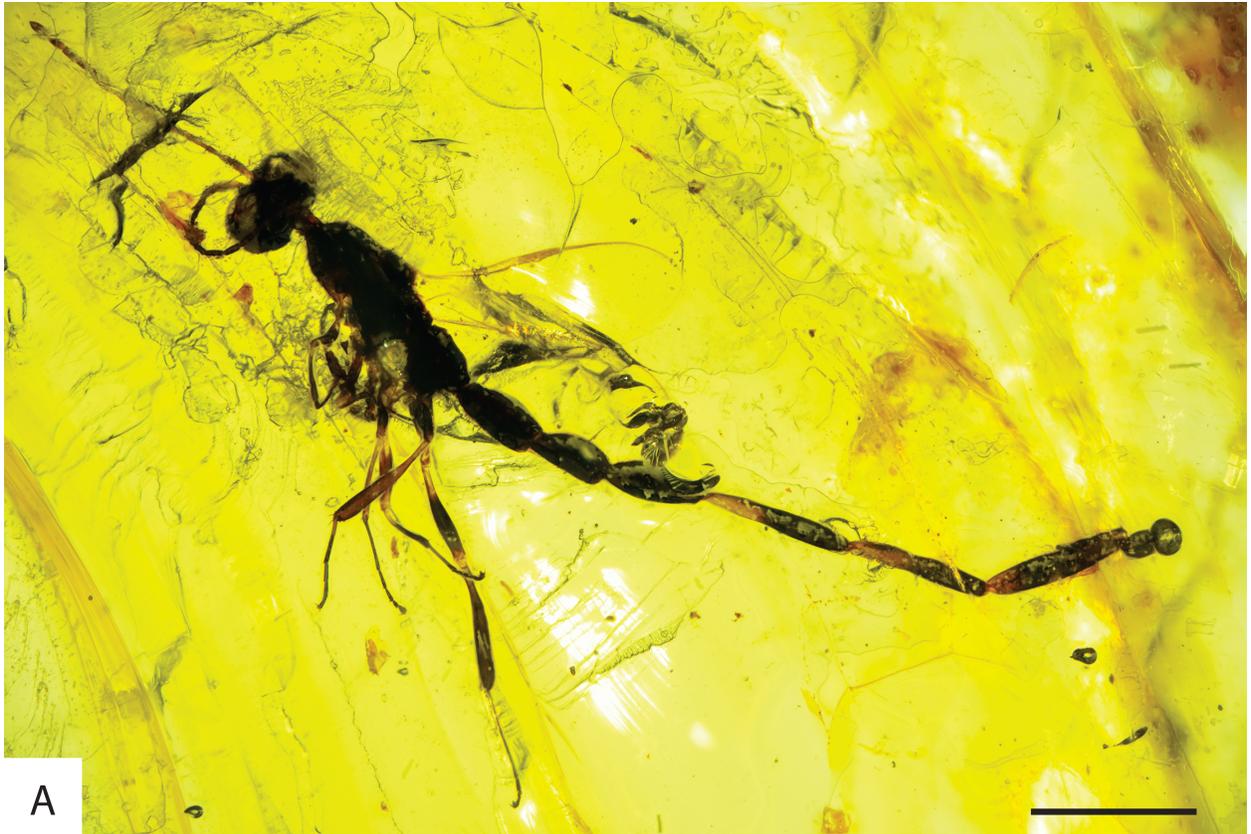
304 **Table. 1.** List of world species of *Eopelecinus* spp. with data on their metasomal ratio (X: refers to
305 incomplete data).

306 **Fig. 1.** *Zoropelecinus periosus* Guo, Shih & Ren 2016, MHNE.2019.X.1, collection J.-M. Poullion,
307 Musée de Colmar. A, habitus in lateral view. B, antenna. Scale bars: 1 mm.

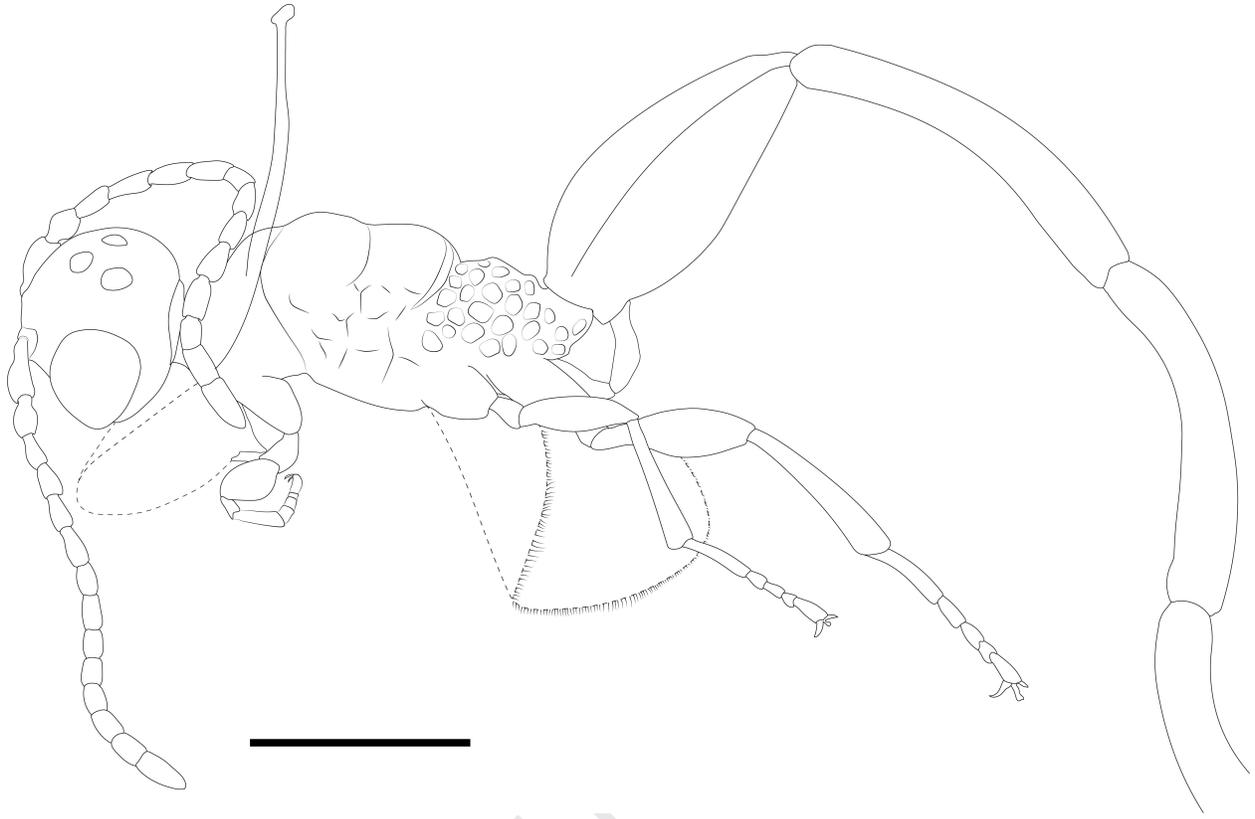
308 **Fig. 2.** *Eopelecinus inopinatus* sp. nov., holotype IGR.BU-007. A, habitus in dorso-lateral view. B,
309 detailed view of mesosoma. C, detailed view of left antenna. Scale bars: 0.5 mm.

310 **Fig. 3.** Line drawing of *Eopelecinus inopinatus* sp. nov., holotype IGR.BU-007. Habitus in lateral
311 view. Scale bars: 0.5 mm.

	Metasomal ratio	Distribution	Age	Reference
<i>Eopelecinus inopinatus</i> sp. nov.	1; 1.25; 0.85; X; X; X	Myanmar	Cenomanian, Cretaceous	This study
<i>Eopelecinus eucallus</i> Zhang 2005	1; 0.6; 0.7; 0.7; 0.6; 0.5	China	Aptian, Cretaceous	Zhang, 2005
<i>Eopelecinus exquisitus</i> Zhang & Rasnitsyn 2004	1; 1; 0.9; 0.6; 0.4; 0.4	Russia	Aptian, Cretaceous	Zhang and Rasnitsyn, 2004
<i>Eopelecinus fragilis</i> Zhang & Rasnitsyn 2004	1; 0.6; 0.6; 0.5; 0.4; 0.3	Mongolia	Valanginian, Cretaceous	Zhang and Rasnitsyn, 2004
<i>Eopelecinus giganteus</i> Zhang 2005	1; 1; 0.9; 1; 0.9; 0.3	China	Aptian, Cretaceous	Zhang, 2005
<i>Eopelecinus hodoiporus</i> Zhang 2005	1; 0.9; 0.8; 0.7; 0.6; 0.5	China	Aptian, Cretaceous	Zhang, 2005
<i>Eopelecinus huangi</i> Liu et al. 2011	1; 0.9; 1; 1; 1; 0.4	China	Aptian, Cretaceous	Liu et al., 2011
<i>Eopelecinus laiyangicus</i> Zhang 2005	1; 0.5; 0.5; 0.4; 0.4; 0.3	China	Aptian, Cretaceous	Zhang, 2005
<i>Eopelecinus leptaleus</i> Zhang 2005	1; 0.8; 0.7; 0.6; 0.4; 0.3	China	Aptian, Cretaceous	Zhang, 2005
<i>Eopelecinus mecometasomatus</i> Zhang 2005	1; 1.1; 1.1; 1; 0.9; 0.6	China	Aptian, Cretaceous	Zhang, 2005
<i>Eopelecinus mesomicrus</i> Zhang 2005	1; 0.5; 0.6; 0.4; 0.5; 0.4	China	Aptian, Cretaceous	Zhang, 2005
<i>Eopelecinus minutus</i> Zhang & Rasnitsyn 2004	1; 0.4; 0.6; 0.5; 0.5; 0.4	Mongolia	Valanginian, Cretaceous	Zhang and Rasnitsyn, 2004
<i>Eopelecinus pusillus</i> Zhang 2005	1; 0.7; 0.7; 0.4; 0.6; 0.5	China	Aptian, Cretaceous	Zhang, 2005
<i>Eopelecinus rudis</i> Zhang & Rasnitsyn 2004	NA	Russia	Aptian, Cretaceous	Zhang and Rasnitsyn, 2004
<i>Eopelecinus scorpioideus</i> Zhang & Rasnitsyn 2004	1; 0.8; 0.8; 0.5; 0.4; 0.3	Russia	Aptian, Cretaceous	Zhang and Rasnitsyn, 2004
<i>Eopelecinus shangyuanensis</i> Zhang et al. 2002	1; 0.4; X; X; X; X	China	Aptian, Cretaceous	Zhang et al., 2002
<i>Eopelecinus similaris</i> Zhang et al. 2002	1; 0.8; 0.7; 0.7; 0.6; 0.6	China	Aptian, Cretaceous	Zhang et al., 2002
<i>Eopelecinus tumidus</i> Liu et al. 2011	1; 0.45; 0.7; 0.7; 0.45; 0.45	China	Aptian, Cretaceous	Liu et al., 2011
<i>Eopelecinus vicinus</i> Zhang et al. 2002	1; 0.8; 0.7; 0.6; 0.5; 0.5	China	Aptian, Cretaceous	Zhang et al., 2002
<i>Eopelecinus yuanjiawaensis</i> Duan & Cheng 2006	1; 0.5; 1; 0.9; 0.8; X	China	Aptian, Cretaceous	Duan and Cheng, 2006







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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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