

New Serphitidae and Gallorommatidae (Insecta: Hymenoptera: Microprocta) in the Early Cretaceous Lebanese amber

ALEXANDR P. RASNITSYN^{1, 2, *}, MOUNIR MAALOUF³, RAMY MAALOUF⁴ & DANY AZAR^{5, 6, *}

¹Palaeontological Institute, Russian Academy of Sciences, Moscow 117647, Russia

²Natural History Museum, London SW7 5BD, UK

³Mazraat Yachouh, El-Maten, Lebanon

⁴Conde de Torrecedeira 36, 5C Vigo, Pontevedra 36202, Spain

⁵Faculty of Sciences II, Earth and Life Sciences Department, Lebanese University, PO box 26110217, Fanar, Matn, Lebanon

⁶Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

 alex.rasnitsyn@gmail.com;  <https://orcid.org/0000-0002-6350-0040>

 mounirmf@hotmail.com;  <https://orcid.org/0000-0002-0265-3238>

 ramymaalouf@hotmail.com;  <https://orcid.org/0000-0002-1709-415X>

 danyazar@ul.edu.lb;  <https://orcid.org/0000-0002-4485-197X>

*Corresponding authors

Abstract

Three new serphitids (*Microserphites libanensis* **sp. nov.**, *Leptoserphites pabloi* **gen. et sp. nov.** and *Leptoserphites iriae* **gen. et sp. nov.**) and a gallorommatid (*Cretaceomma libanensis* **gen. et sp. nov.**) from two different outcrops from the lower Barremian Lebanese amber are characterised, described, illustrated and their taxonomic positions are discussed. These serphitids and gallorommatid constitute the earliest records of these Cretaceous fossil families. *Galloromma turolensis* Ortega *et al.*, 2011 is transferred to the genus *Cretaceomma* **gen. nov.**

Keywords: Serphitoidea, Lebanon, Mymarommatoidea, Microserphitinae, Supraserphitinae, fossil insects, lower Barremian

Introduction

Lebanon has a large number of Mesozoic amber outcrops: 19 from the Kimmeridgian, Upper Jurassic (Azar *et al.*, 2010b; Nohra *et al.*, 2013; Maksoud & Azar, 2020); and more than 430 from the lower Barremian (Granier *et al.*, 2016; Maksoud *et al.*, 2017), Lower Cretaceous (Maksoud & Azar, 2020). This latter number is still continuously growing, with to date 28 outcrops yielding biological inclusions (Maksoud *et al.*, 2019, 2020, 2021a, b, c).

Lebanese amber is among the most important ambers, as it documents the initial diversification of many lineages of the extant entomofauna and the disappearance of some archaic insect groups (Azar, 1997, 2007, 2012;

Azar & Nel, 1998; Poinar & Milki, 2001; Azar *et al.*, 2010a; Maksoud & Azar, 2020).

Hymenoptera are numerous and well diverse in the Lebanese amber (about 6% of biological inclusions) but still relatively underexplored with only 14 described taxa belonging to 9 different families (Archaeoserphitidae, Bethyridae, Dryinidae, Evaniidae, Maimetshidae, Scelionidae, Sclerogibbidae, Scolebythidae and Spathiopteridae) from several deposits across the country (Prentice *et al.*, 1996; Olmi, 2000; Basibuyuk *et al.*, 2002; Deans *et al.*, 2004; Nel & Azar, 2005; Engel & Grimaldi, 2006, 2007; Johnson *et al.*, 2008; Perrichot *et al.*, 2011; Azevedo & Azar, 2012; Engel, 2015; Krogmann *et al.*, 2016; Olmi *et al.*, 2020).

Serphitidae Brues, 1937 is an extinct Cretaceous family of Hymenoptera belonging to Serphitoidea, and divided into three subfamilies: Serphitinae Brues, 1937; Microserphitinae Engel, 2015 and Supraserphitinae Rasnitsyn & Öhm-Kühnle, 2019. Serphitid representatives were described from different Cretaceous ambers: El Soplao (lower Albian), San Just and Álava (upper Albian), Spain; Myanmar (lower Cenomanian); Taimyr (Cenomanian), Siberia, Russia; New Jersey (Turonian), USA; Vendée (Turonian), France; Canada (upper Campanian).

Gallorommatidae Gibson *et al.*, 2007 is an extinct Cretaceous family of microscopic Hymenoptera belonging to Mymarommatoidea. It comprises to date one described genus with five species from the ambers of Álava (upper Albian), Spain; Myanmar (lower Cenomanian); Taimyr (Cenomanian); and North-West France (Cenomanian).

Herein we describe three new serphitids [*Microserphites libanensis* **sp. nov.** (Microserphitinae Engel, 2015), *Leptoserphites pabloi* **gen. et sp. nov.**, *Leptoserphites iriae* **gen. et sp. nov.** (Supraserphitinae Rasnitsyn & Öhm-Kühnle, 2019)] and a new gallorommatid (*Cretaceomma libanensis* **gen. et sp. nov.**) from two different outcrops (Mdeirij-Hammana and Qanat Bakish outcrops) from the lower Barremian Lebanese amber. These serphitids and gallorommatid constitute the earliest records of these Cretaceous fossil families.

Material and methods

The type material of *Microserphites libanensis* **sp. nov.** and *Cretaceomma libanensis* **gen. et sp. nov.** were collected from Mdeirij-Hammana outcrop (33°48'13"N, 35°43'45"E, *elev.* 1,340 m), Caza (= District) Baabda, Central Lebanon (Azar *et al.*, 1999: fig. 1; Azar *et al.*, 2010a: fig. 2 and fig. 25; Azar *et al.*, 2011: figs 1–3; Arillo *et al.*, 2019: figs 1, 2).

The type material of *Leptoserphites libanensis* **gen. et sp. nov.** and *Leptoserphites suspectus* **gen. et sp. nov.** were collected from Baskinta, in the locality of Qanat Bakish (33°57'3"N, 35°47'24"E, *elev.* 1,488 m), Caza (= District) El-Maten, Mouhafazet (= Governorate) Mount Lebanon, in Central Lebanon (Maksoud *et al.*, 2021a: figs 1 and 2).

The amber pieces containing the inclusions were manually cut using denticulate shaving blades, and then polished with increasing grade emery papers and diatomite. The specimens were then included in a glass coffin made with cut microscopic slides and cover slips stuck together by epoxy glue and Canada balsam medium or were imbedded between two microscopic coverslips with Canada balsam medium as described in Azar *et al.* (2003). The specimens of interest were examined and photographed with a Leitz Laborlux-12 compound microscope and a Nikon SZ10 stereomicroscope, both equipped with digital cameras for photographs and camera lucida for line drawings. The figures and illustrations were processed with Helicon Focus 6, Adobe Photoshop CS6 and Adobe Illustrator CS6 software.

The type material is deposited in the Natural History Museum of the Lebanese University, Faculty of Sciences II, Fanar, Lebanon.

Systematic palaeontology

Order Hymenoptera Linnaeus, 1758

NEW SERPHITIDAE AND GALLOROMMATIDAE

Superfamily Serphitoidea Brues, 1937

Family Serphitidae Brues, 1937

Subfamily Microserphitinae Engel, 2015

Genus *Microserphites* Kozlov & Rasnitsyn, 1979

Type species. *Microserphites parvulus* Kozlov & Rasnitsyn, 1979; by original designation and monotypy.

Other species. *Microserphites soplaensis* Ortega-Blanco *et al.*, 2011; and *Microserphites libanensis* Rasnitsyn & Azar, **sp. nov.**

Microserphites libanensis Rasnitsyn & Azar, **sp. nov.**
(Figs 1, 2)

Type material. Holotype, specimen n° 1819V, Azar collection; from Mdeirij-Hammana amber outcrop; Mouhafazet Jabal Loubnan (Governorate Mount Lebanon), Caza (= District) Baabda, Central Lebanon; lower Barremian. Type material is deposited in the Natural History Museum of the Lebanese University, Faculty of Sciences II, Fanar, Lebanon.

Etymology. The specific name is derived from Lebanon in Greek, Λιβάνος = Libanos.

Diagnosis. New species differs from both its congeners in further reduced venation (all veins other than R nebulous or lost, pterostigma reduced up to a colored strip, hind wing with only R preserved and with membrane almost lost basally, and with R not reaching wing midlength) as well as in long, helmet-like head with flat eyes, in smaller size (forewing length under 0.5 mm), and from *M. soplaensis* also in flagellum much less widened apically.

Locality and horizon. Mdeirij-Hammana outcrop (33°48'13"N, 35°43'45"E, *elev.* 1,340 m), Caza (= District) Baabda, Central Lebanon, lower Barremian.

Description. Head, meso- and metasoma brownish, antennae and legs pale, petiole pale brown. Integuments mainly smooth, mesonotum between notauli rugose, propodeum carinate. Vestiture not apparent except wings with abundant longer marginal and shorter surface setae. Head dorsally long trapezoid with straight sides and deeply concave hind margin (Fig. 2A), eyes almost perfectly flat, taking most part of head sides, ocelli large, in almost equilateral triangle, with lateral ocelli close to but not touching eyes, occipital carina not apparent. Antenna 9-segmented (Fig. 2A, B), scape hardly visible, pedicel longer than wide, wider than flagellomeres except apical ones, flagellum gradually widening apicad, with flagellomeres changing from distinctly transverse basal ones to distinctly elongate apical one. Mesosoma with mesonotum strongly convex, pronotum forming wide belt on its fore declivity, posterolaterally not reaching wing base (tegula not identifiable), mesonotum with notauli very wide, not reaching rather long and transcarinate

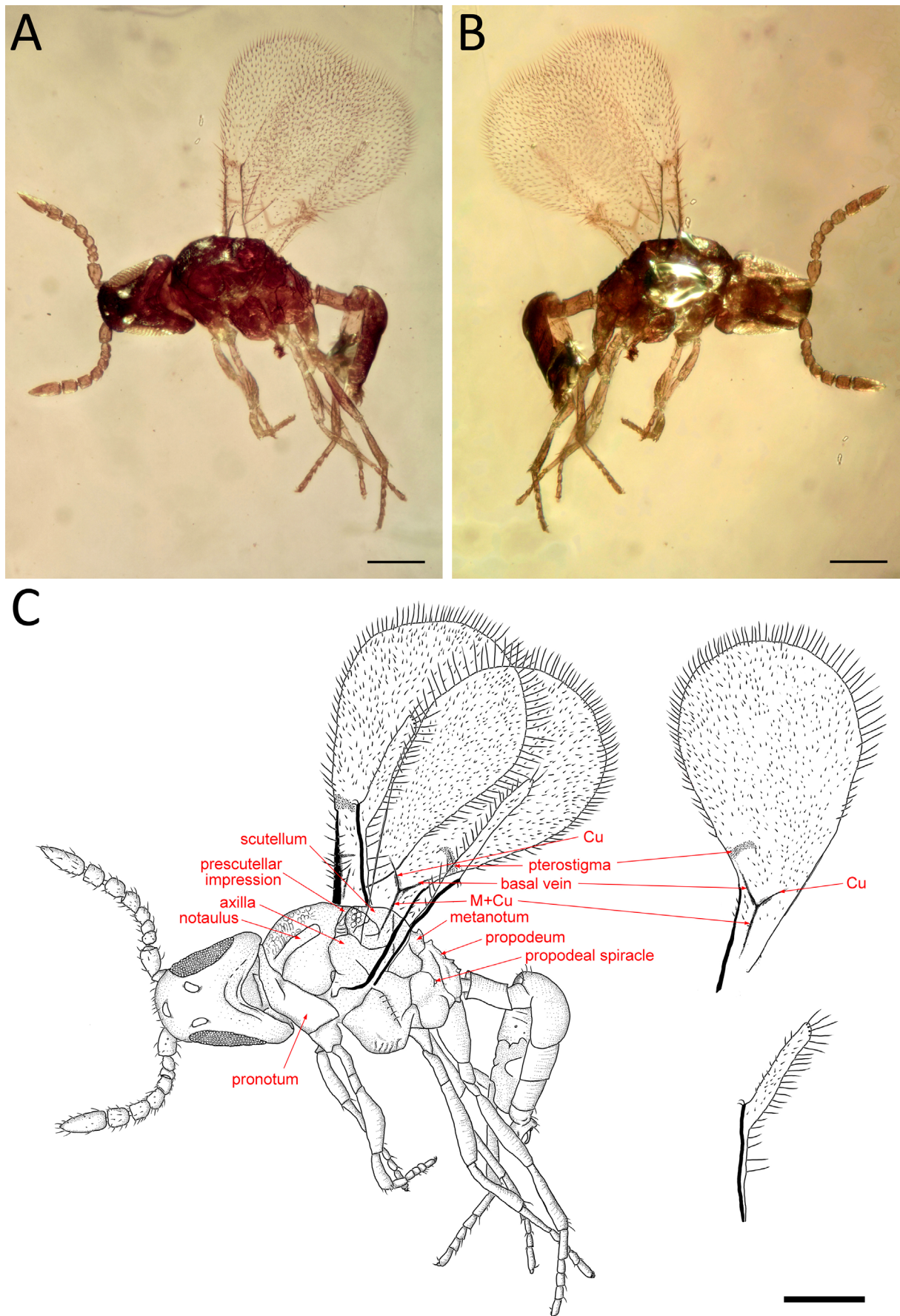


FIGURE 1. *Microserphites libanensis* Rasnitsyn & Azar, **sp. nov.**, holotype specimen n° 1819V. **A, B,** Photograph of habitus. **C,** Drawings of habitus and hind wing. Scale bars = 0.1 mm.

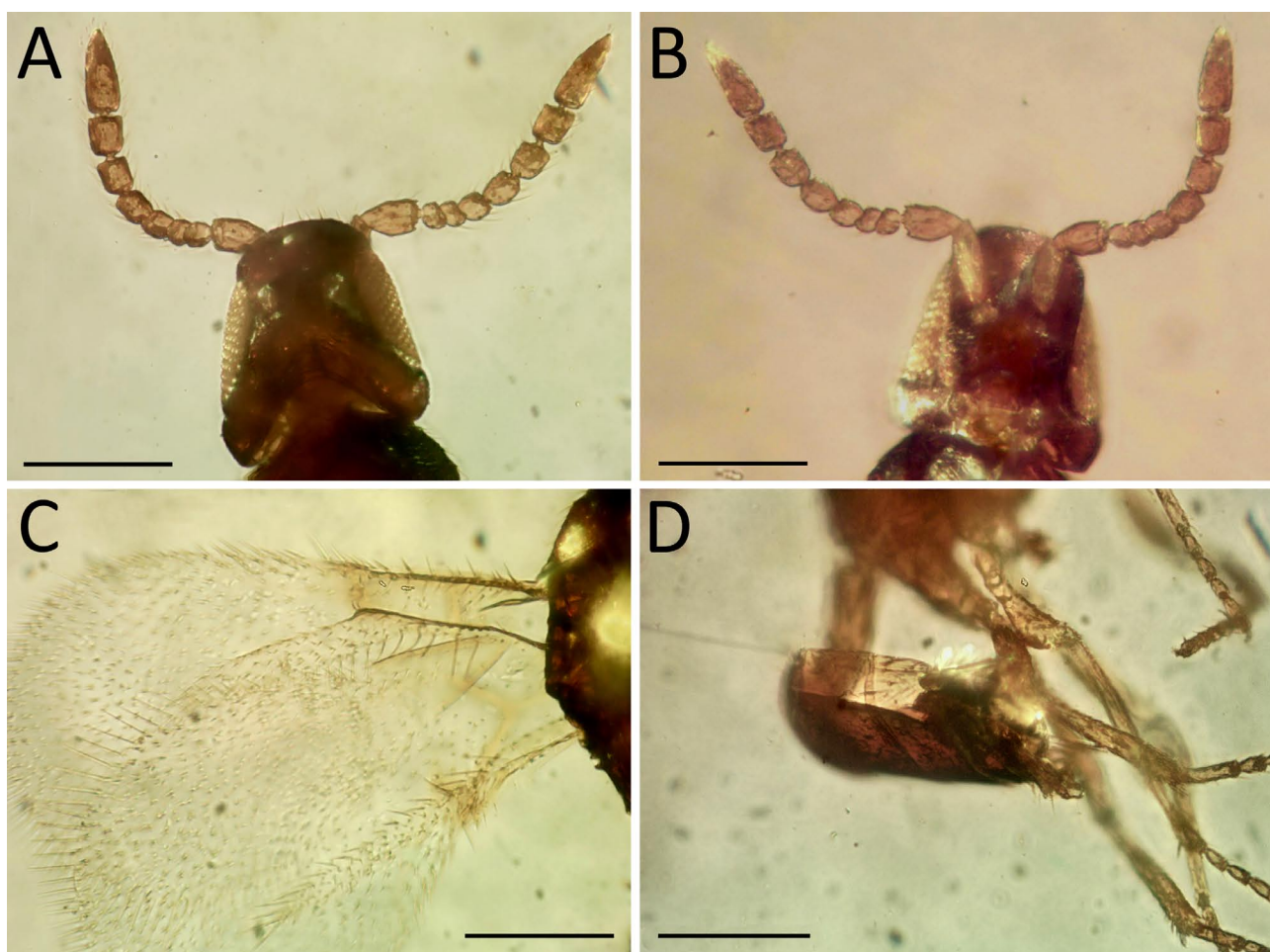


FIGURE 2. *Microserphites libanensis* Rasnitsyn & Azar, **sp. nov.**, holotype specimen n° 1819V. **A**, Photograph of head, dorsal view. **B**, Photograph of head, ventral view. **C**, Photograph of hind wing. **D**, Photograph of metasoma. Scale bars = 0.1 mm.

prescutellar fossa, mesoscutellum long with distinct posterior declivity, mesopleuron with complete oblique suture, metanotum following mesoscutellar declivity, with short medial upward tooth, propodeum short, similarly declivitous, with several short medial upward teeth (three, one apicad and two in distal third) and with oblique lateral carina. Legs weak, with coxae small, trochantelli developed, femora and tibiae narrow, femora not much longer than tibiae, tarsi not much longer than tibiae, tarsal segments all elongate, basitarsi much shorter than respective 3 middle tarsal segments but clearly longer than each of them, segment 4 scarcely shorter than segment 3, tibial spurs 1 : 1 : 2; claw simple, arolium present. Fore wing short, wide, with narrow base embracing all venation (nebulous M+Cu, basal vein [= RS&M] and Cu) except the only tubular vein R and weakly colored strip-like rudiment of pterostigma not reaching basal 0.4 of wing length; pre-radial (costal) membrane not visible. Hind wing with the only vein R present (Figs 1C, 2C), bearing 2 hamuli apical and hardly reaching wing midlength, with wing membrane very narrow before 0.4 wing length and parallel-sided with rounded apex further apical. Metasoma

with petiolar segments tubular, of subequal height, first one some twice as long as high, second subquadrate; gaster with petiolar attachment ventral (not frontal), gastral terga 2–3 subequal in length and distinctly shorter than tergum 1; form of metasomal apex and sex unknown.

Measurements. Body length 0.65 mm, fore wing 0.47 mm, hind wing 0.33 mm.

Remarks. The new species is ascribed to *Microserphites* based on pronotum not reaching wing base and much reduced wing venation (pterostigma disintegrated, no tubular veins but R, *etc.*). It is described as new because of deep differences in wing venation and head form (*cf.* Diagnosis). Worth mentioning is that this oldest member of the genus is also the most modified venationally.

Subfamily Supraserphitinae Rasnitsyn & Öhm-Kühnle, 2019

Genus *Leptoserphites* Rasnitsyn & Azar, **gen. nov.**

Type species. *Leptoserphites pabloi* **sp. nov.**; by present designation.

Other species. *Leptoserphites iriae* sp. nov.

Etymology. The genus name is from Greek λεπτός = *leptos* means thin + the genus name *Serphites*.

Diagnosis. Antenna 11–12-segmented, with no club defined. Body comparatively narrow, with mesosoma twice as long as high, forewing with only R, 2r-rs and pterostigma tubular, 2r-rs at least half as long as pterostigma high, no R and RS present as nebulous vein distal of pterostigma and 2r-rs, respectively.

Remarks. The new genus is attributed to Serphitidae and particularly to Supraserphitinae based on antenna 11–12-segmented (vs. 14-segmented in Archaeoserphitidae and less than 11-segmented in Serphitinae and Microserphitinae). It differs from the type and only supraserphitine genus *Supraserphites* Rasnitsyn & Öhm-Kühnle, 2019 in having stature narrower, basal flagellomere smallest in 12-segmented antenna (putatively fused with the next one in 11-segmented ones), forewing with RS&M nebulose (vs. tubular) and R and RS lost as colored veins distal of pterostigma and 2r-rs (vs. tubular or nebulous).

***Leptoserphites pabloi* Rasnitsyn & Azar, gen. nov.**
(Figs 3–5)

Type material. Holotype, female, specimen n° QBC-9A

(complete insect suffered from sidewise compression and partially enclosed in a bubble obscuring some body parts, particularly on head and mesosoma), Maalouf collection; from Qanat Bakish (Baskinta) amber outcrop, Mouhafazet Jabal Loubnan (Governorate Mount Lebanon), Caza (= District) El-Maten, Central Lebanon; lower Barremian. Type material is deposited in the Natural History Museum of the Lebanese University, Faculty of Sciences II, Fanar, Lebanon.

Etymology. Specific name is after Pablo Maalouf Alonso, son of one of us (RM), discoverer of the amber site.

Diagnosis. Differs from the only congener in having antenna either distinctly 12-segmented or with clear traces of two basal flagellomeres fused secondarily into one, flagellomeres shorter, propodeum smooth, pterostigma narrower, 2r-rs longer, tubular (very dark) dot at M+Cu apex developed, hind wing r-m present, long, petiolar segments shorter.

Locality and horizon. Baskinta, in the locality of Qanat Bakish (33°57'3"N, 35°47'24"E, elev. 1,488 m), Caza (= District) El-Maten, Mouhafazet (= Governorate) Mount Lebanon, in Central Lebanon; lower Barremian.

Description. Female. Colour dark fuscous as preserved, metasoma and legs slightly paler. Body with no surface sculpture and prominent vestiture discernible.

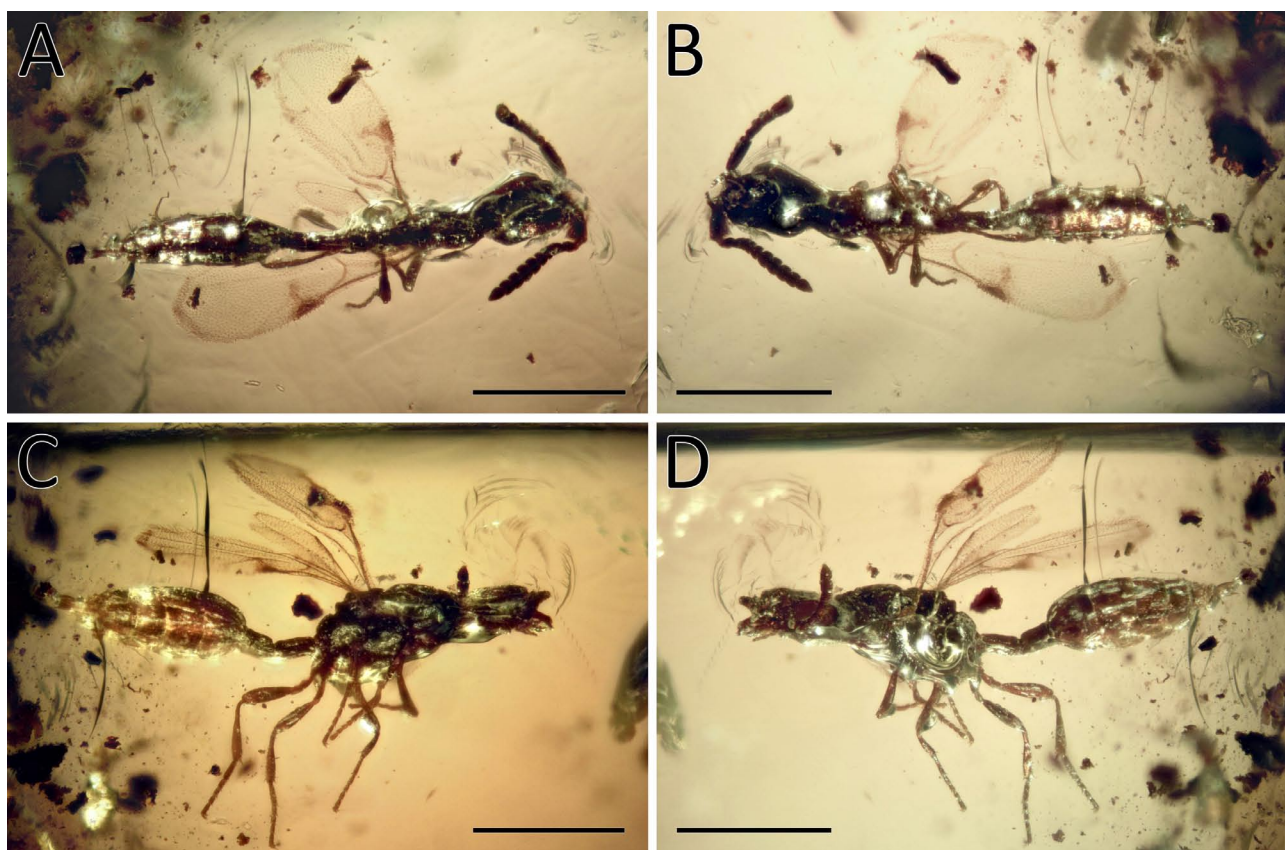


FIGURE 3. *Leptoserphites pabloi* Rasnitsyn & Azar, gen. et sp. nov., holotype specimen n° QBC-9A. Photographs of habitus. A, Dorsal view. B, Ventral view. C, D, lateral views. Scale bars = 0.5 mm.

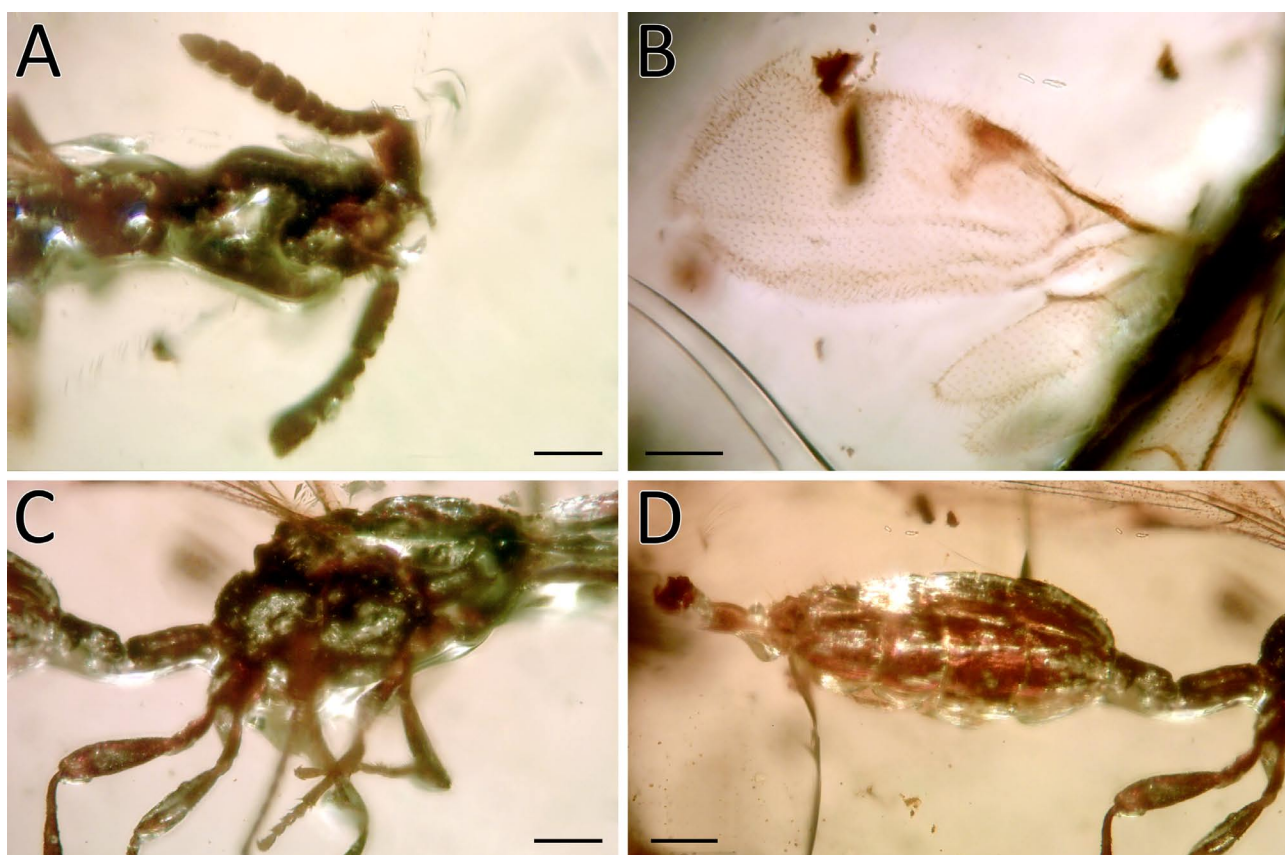


FIGURE 4. *Leptoserphites pabloi* Rasnitsyn & Azar, **gen. et sp. nov.**, holotype specimen n° QBC-9A. **A**, Photograph of head, ventral view. **B**, Photograph of wings. **C**, Photograph of thorax, lateral view. **D**, Photograph of metasoma, lateral view. Scale bars = 0.1mm.

Head elongate as preserved (possibly in part due to deformation), with eyes small, not much convex, placed near middle of head sides (Figs 4A, 5B). Antenna 12-segmented (Fig. 5A), as preserved with scape long and wide, pedicel longer than any flagellar segment, flagellum wide, slightly narrowing toward base and apex, all segments wider than long except longest apical one, basal flagellomeres particularly short (width of segments could be exaggerated by depression due to diagenetic deformation, unless antennae are naturally flattened). Distinct large subequal mandibles, right with three strong and sharp teeth (visible in an aspect difficult to illustrate) and left with two strong and sharp ones. Maxillary palpi at least 4-segmented; labial palpi apparently 3-segmented, all segments thin. Mesosoma with dorsal surface deformed and poorly visible, dorsal pronotal part apparently moderately long (longer than in other Serphitidae), in side view metascutum forming high step above wide trough of metapostnotum, propodeum short, smoothly arching toward metasomal base. Forewing (Figs 4B, 5C) with C, R behind pterostigma, RS before and behind 2r-rs (except for short section forming T together with 2r-rs) and M lost as pigmented veins or nearly so; R, pterostigma and dot at junction of M+Cu and RS&M tubular; RS&M, M+Cu and 1-Cu nebulous; pterostigma low (twice as

long as wide); 2r-rs as long as pterostigma wide, together with pterostigma enclosed in lightly pigmented area; all membrane covered with short setae (margin included). Hind wing (Figs 4B, 5D) with only R and r-m pigmented (tubular), R apex with three hamuli, r-m reaching wing hind margin (posterior wing area lost); membrane setose (much as in forewing), hind margin with fringe of long setae. Legs ordinary except that fore tibial spur (calcar) massive, strongly bent subapically and bifid, and fore basitarsus excised almost for all its length and with single row of setae along excision (so the antenna cleaning apparatus more characteristic of Mymarommatoidea than of Serphitidae); tibial spurs 1 : 1? : 1?; basitarsus shorter than tarsomeres 2–4 combined, tarsomeres 3–4 almost equal in length, elongate, claw simple, arolium about as long as claw. Metasoma with petiolar segments elongate, with no rough sculpture apparent, first segment slightly longer and narrower than second, petiolar attachment to gaster frontal, metasomal terga ratio as preserved 1 : 0.95 : 1.4 : 1.0 : 0.9 : 0.6 (gaster possibly extended longitudinally, secondarily). Ovipositor extruded (Figs 4D, 5E), stylets broken basally and bent down but not torn off, 1.5× as long as petiolar segments combined, very narrow supposed sheaths 0.25× as long as stylets, moderately wide, thin, convex transversally.

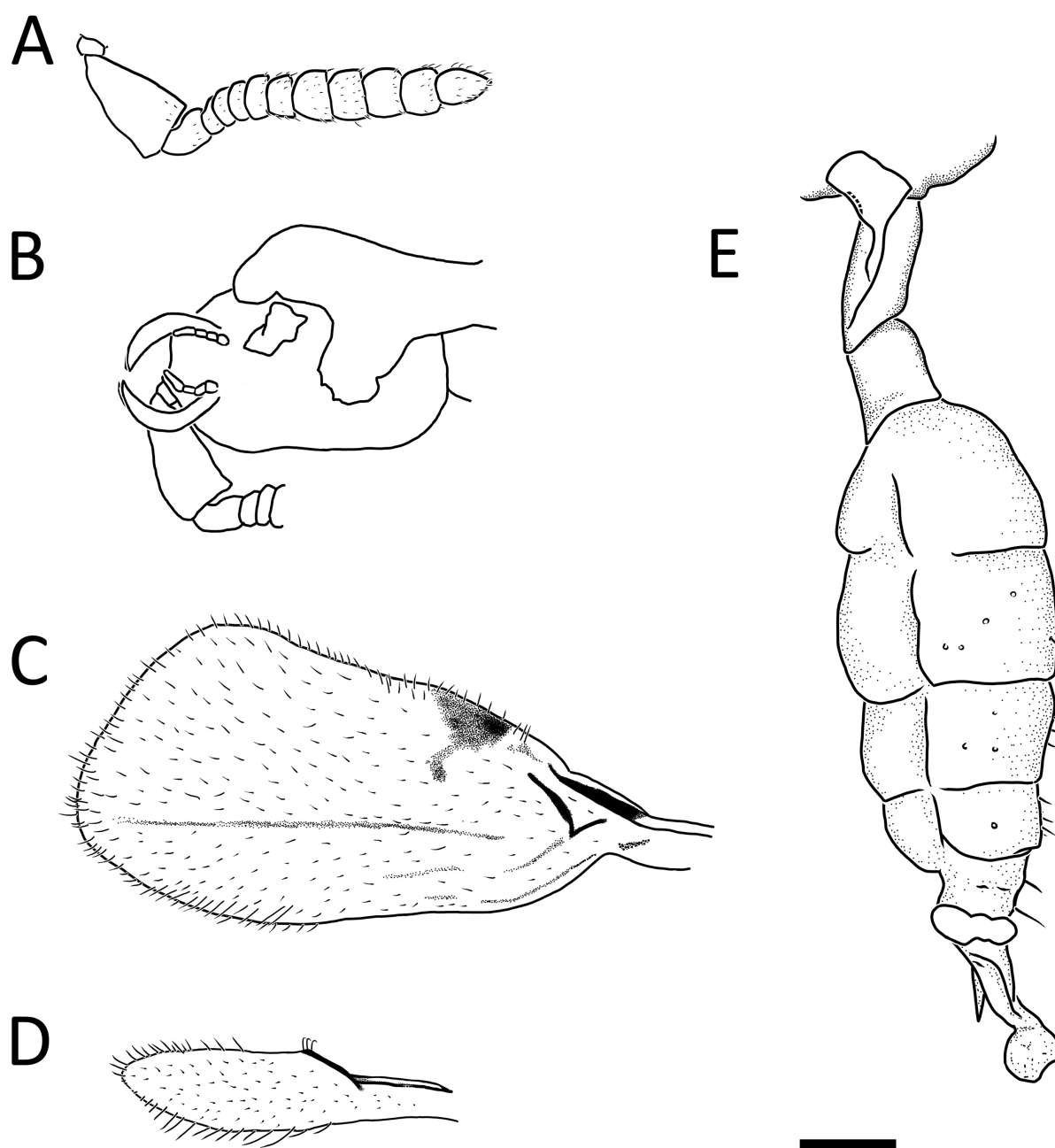


FIGURE 5. *Leptoserphites pabloi* Rasnitsyn & Azar, **gen. et sp. nov.**, holotype specimen n° QBC-9A. Drawings. **A**, Antenna. **B**, Head, ventral view. **C**, Forewing. **D**, Hind wing. **E**, Metasoma. Scale bar = 0.1 mm.

Measurements. Length of body (as preserved, up to apex of metasomal tergum 7) 1.5 mm, head 0.28 mm, mesosoma 0.49 mm, forewing 0.80 mm, metasoma 0.78 mm, petiole 1 0.13 mm, petiole 2 0.10 mm.

***Leptoserphites iriae* Rasnitsyn & Azar, sp. nov.**
(Figs 6–8)

Type material. Holotype, female, specimen n° QBC-16A (Fig. 6A–C), Maalouf collection, complete insect partially distorted postmortem (possibly diagenetically due to plactical deformation of enclosing amber under

uneven pressure of deposits); paratypes, QBC-16B (Fig. 6D) and QBC-16C (Fig. 6E, F), Maalouf collection, synincluded with holotype in the same piece of amber and still more suffered from deformation (QBC-16B is particularly poor and included mainly being synincluded and having similar wing venation). All type material is from Qanat Bakish (Baskinta) amber outcrop, Mouhafazet Jabal Loubnan (Governorate Mount Lebanon), Caza (= District) El-Maten, Central Lebanon; lower Barremian. Type material is deposited in the Natural History Museum of the Lebanese University, Faculty of Sciences II, Fanar, Lebanon.

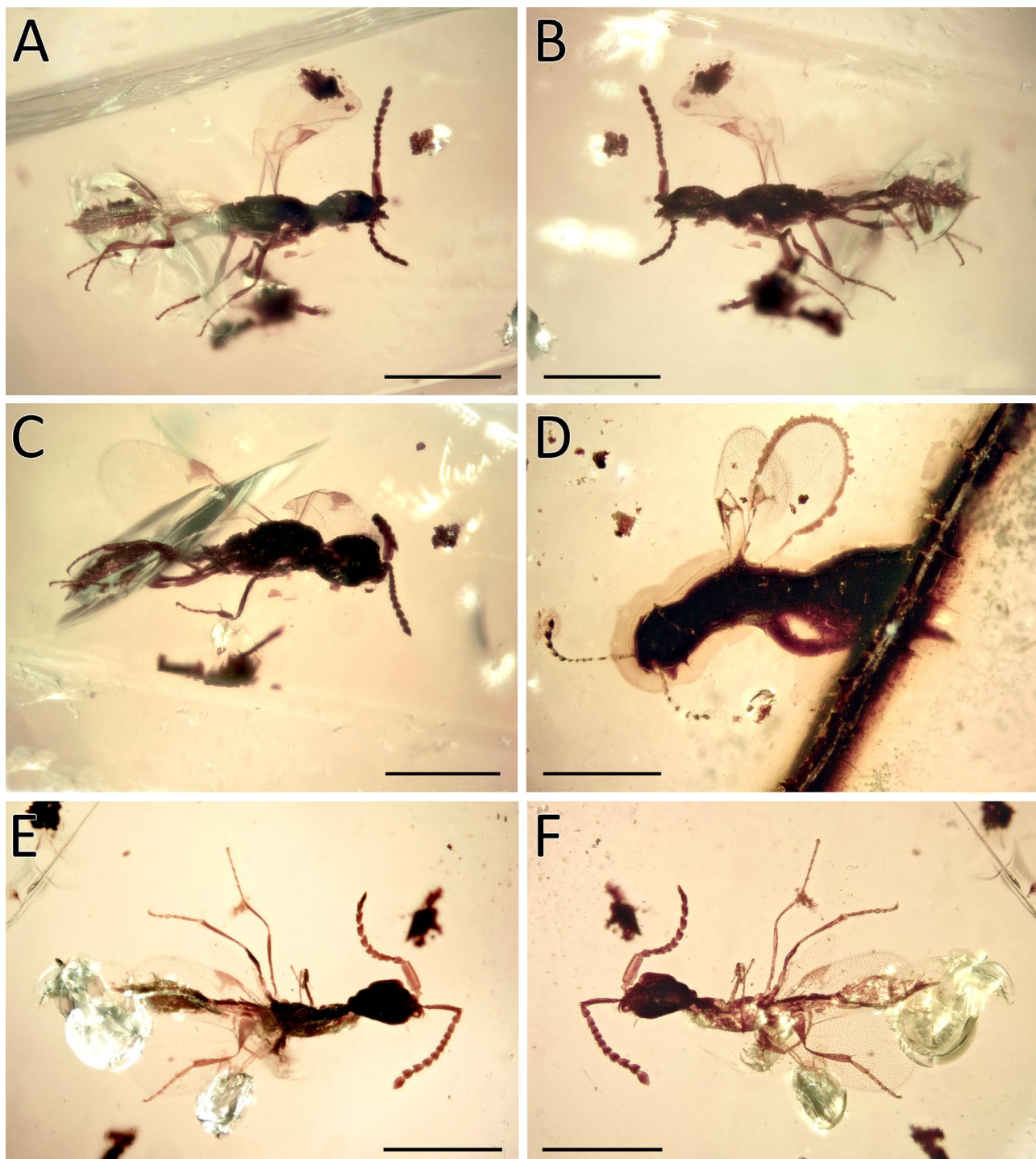


FIGURE 6. *Leptoserphites iriae* Rasnitsyn & Azar, **gen. et sp. nov.** Photographs of habitus. **A**, Dorso-lateral view of holotype specimen n° QBC-16A, head here is ventro-lateral. **B**, Ventro-lateral view of holotype specimen n° QBC-16A, head here is dorso-lateral. **C**, Lateral view of holotype, specimen n° QBC-16A, head here is dorsal. **D**, Lateral view of paratype, specimen n° QBC-16B. **E**, Lateral view of paratype, specimen n° QBC-16C. **F**, Dorsal view of paratype, specimen n° QBC-16C. Scale bars = 0.5 mm.

Etymology. Specific name is after Iria Maalouf Alonso, daughter of one of us (RM).

Diagnosis. Differs from the type species (*L. pabloi* sp. nov.) in having antenna 11-segmented with no clear traces of fusion of two basal flagellomeres into one, flagellomeres longer, propodeum transridged, pterostigma wider, 2r-rs shorter, no tubular structures present but R

and pterostigma, hind wing with no r-m, petiolar segments longer.

Locality and horizon. Baskinta, in the locality of Qanat Bakish (33°57'3"N, 35°47'24"E, elev. 1,488 m), Caza (= District) El-Maten, Mouhafazet (= Governorate) Mount Lebanon, in Central Lebanon; lower Barremian.

Description. (Based on holotype otherwise stated)



FIGURE 7. *Leptoserphites iriae* Rasnitsyn & Azar, **gen. et sp. nov.** Paratype specimen n° QBC-16C. **A**, Photograph of head, dorsal view. **B**, Photograph of metasoma, ventral view. Scale bars = 0.1 mm.

Female. Color dark fuscous, legs paler. Body with no surface sculpture and prominent vestiture discernible. Head elongate as preserved (Figs 7A, 8A, both on paratype QBC-16C) (possibly due to deformation), with eyes small, not much convex, placed before middle of head sides (more rostrally). Antenna 11-segmented [Figs 8A (paratype QBC-16C), 8D (holotype)], with scape long and wide, about as long as next three or four antennomeres combined, pedicel shorter than some apical segments, flagellum wide, somewhat flattened, slightly narrowing toward base, most segments longer than wide, basal flagellomere slightly longer than next one. Distinct subequal mandibles, right with three teeth and left with two ones. Of maxillary (Fig. 8B) and labial palps (Fig. 8C), only their elongate apical segments visible. Mesosoma with dorsal pronotal part apparently short, mesoscutellum in side view with hind part somewhat elevated, metascutum forming high step above wide trough of metapostnotum, propodeum short, gently arching toward metasomal base in side view, transridged. Forewing (Fig. 8E) with C, R behind pterostigma, RS before and behind 2r-rs (except for short section forming “T” pattern together with 2r-rs), M+Cu and M lost as pigmented veins or nearly so; R and pterostigma tubular; RS&M, 2r-rs and 1-Cu nebulous; pterostigma high (distinctly less than twice as long as wide), together with 2r-rs enclosed in lightly pigmented area; 2r-rs half as long as pterostigma wide; all membrane covered with short setae (margin included). Hind wing (Fig. 8F) with only R pigmented (tubular), R apex with three hamuli, hind margin with fringe of long setae. Legs ordinary except that fore tibial spur (calcar) straight except bent subapical with bifid apex (Fig. 8G), and fore basitarsus excised almost for all its length and with single row of setae along excision; tibial spurs 1 : 1 : 2; tibiae and tarsomeres 1–4 with stiff apical setae, mid and hind tibiae also with thick setae ventrally in distal half

or so, basitarsi shorter than or (fore basitarsus) subequal to tarsomeres 2–4 combined, tarsomeres 3–4 almost equal in length, elongate, claw simple, arolium about as long as claw. Metasoma with petiolar segments very long, with no rough sculpture apparent, first segment slightly longer (in holotype) or shorter (in QBC-16C) than second [Figs 7B, 8I (in QBC-16C), 8H (holotype)], petiolar attachment to gaster frontal. Ovipositor straight, partially external (longest visible in QBC-16C, Fig. 8I).

Measurements. Holotype: body length, 1.4 mm, head length, 0.30 mm, antenna length, 0.51 mm, mesosoma length, 0.45 mm, forewing length, 0.80 mm, width, 0.36 mm, first petiolar segment length 0.12 mm, second petiolar segment length 0.14 mm, gaster length (ovipositor excluded) 0.37 mm; paratype QBC-16C: body length, 1.4 mm, head length 0.30 mm, antenna length, 0.60 mm, mesosoma length, 0.45 mm, forewing length, 0.65 mm, width, 0.30 mm, first petiolar segment length 0.15 mm, second petiolar segment length 0.10 mm, gaster length (ovipositor excluded) 0.37 mm; paratype QBC-16B: body length, 1.4 mm, antenna (deformed) length 0.49 mm, forewing length 0.80 mm, width 0.33 mm.

Remarks. Holotype and two paratypes are incompletely preserved and so with many features obscure. Yet they are considered as conspecific based on their burial in one and the same piece of amber, their similarity in features less affected with postmortem deformation (wing venation, to an extent also antenna and legs, and, to our wonder, most measurements) and apparent absence of counter-evidence of their conspecificity.

Superfamily Mymarommatoidea Debauche, 1948

Family Gallorommatidae Gibson *et al.*, 2007

Genus *Cretaceomma* Rasnitsyn & Azar gen. nov.

Type species. *Cretaceomma libanensis* sp. nov.; by present designation.

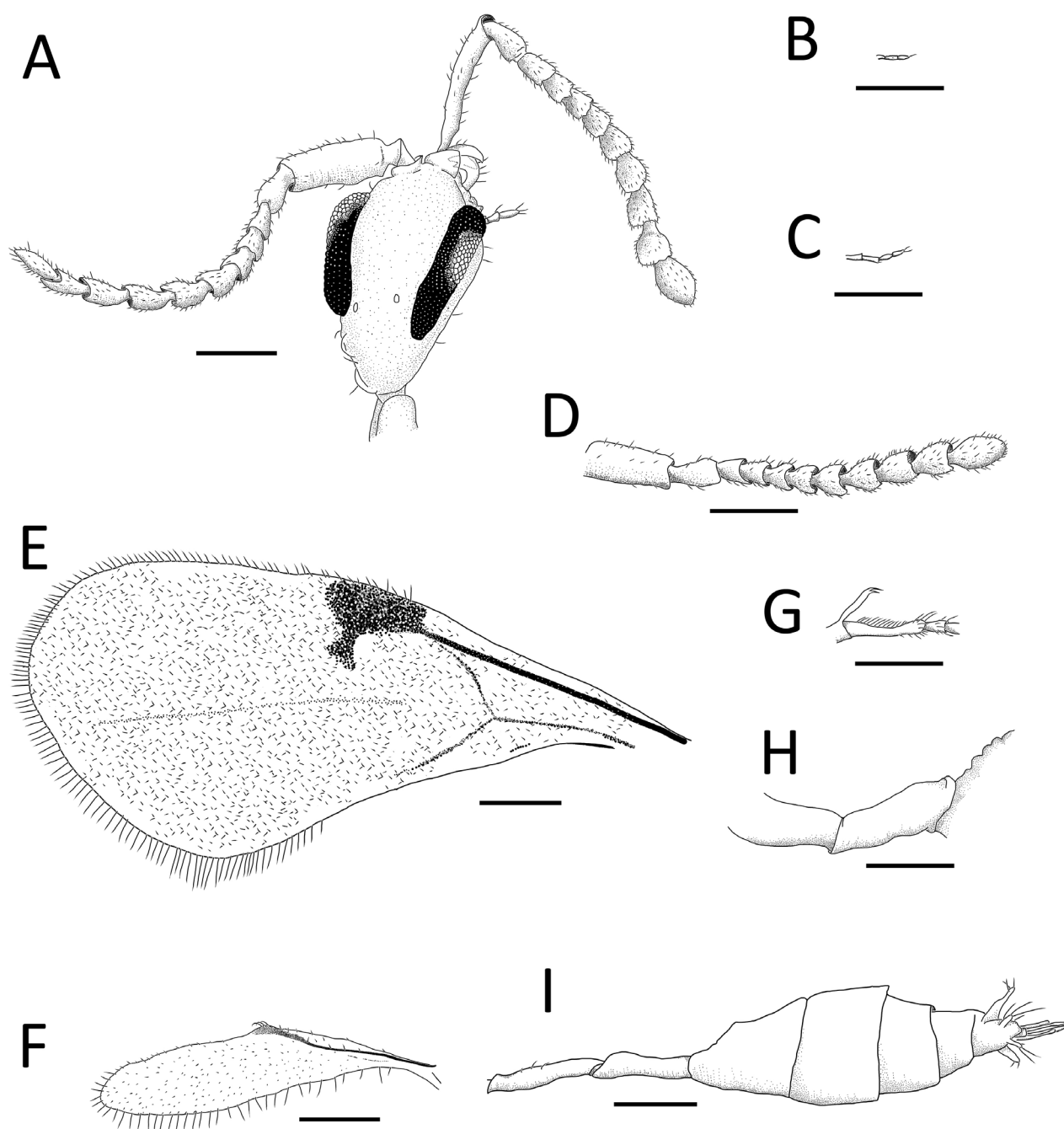


FIGURE 8. *Leptoserphites iriae* Rasnitsyn & Azar, **gen. et sp. nov.** Drawings. **A**, Head, dorsal view, paratype, specimen n° QBC-16C. **B**, Maxillary palp of holotype, specimen n° QBC-16A. **C**, Labial palp of holotype, specimen n° QBC-16A. **D**, Antenna of holotype, specimen n° QBC-16A. **E**, Forewing of holotype, specimen n° QBC-16A. **F**, Hind wing of paratype, specimen n° QBC-16C. **G**, Cleaning apparatus of holotype, specimen n° QBC-16A. **H**, Petiole of holotype, specimen n° QBC-16A. **I**, Metasoma of paratype, specimen n° QBC-16C. Scale bars = 0.1 mm.

Other species. *Galloromma turolensis* Ortega *et al.*, 2011a, transferred herein to *Cretaceomma* **gen. nov.**

Etymology. The genus name combines parts of Cretaceous and *Galloromma*.

Diagnosis. Female antenna 14-segmented with 7-segmented funicle and 5-segmented loose (movably interconnected) clava. Pronotum reaching wing base or nearly so.

Remarks. New genus differs from the type genus of the family *Galloromma* Schlüter, 1978 in more polymerous antenna (13-segmented with 4-segmented club in *Galloromma*) and pronotum apparently reaching wing bases (shortened posterolateral and far not reaching wing bases in *Galloromma*). *Galloromma turolensis* Ortega *et al.*, 2011 from the Albian San Just amber in Spain is similar to the type species in above characters and that is why it is transferred to the new genus.

***Cretaceomma libanensis* Rasnitsyn & Azar, sp. nov.**
(Figs 9, 10)

Type material. Holotype, specimen n° 1922, Azar collection, well preserved female; from Mdeirij-Hammana amber outcrop; Mouhafazet Jabal Loubnan (Governorate Mount Lebanon), Caza (= District) Baabda, Central Lebanon; lower Barremian. Type material is deposited in the Natural History Museum of the Lebanese University, Faculty of Sciences II, Fanar, Lebanon. Holotype.

Etymology. Specific name is after the country of origin.

Diagnosis. Same as for the genus and head elongate with eyes small, claval segments all elongate, probasitarsus with row of long setae, and first petiolar segment three times longer than high.

Locality and horizon. Mdeirij-Hammana outcrop (33°48'13"N, 35°43'45"E, elev. 1,340 m), Caza (= District) Baabda, Central Lebanon, lower Barremian.

Description. Colour dark, integument with weak metallic shine. Head and most of mesosoma mainly with transverse sculpture (finely distantly costulate to use terms by Harris, 1979), shining between costulae, with propodeal dorsum smooth, shining, legs and gaster dull. Prominent vestiture on antennae, legs, wings and metasomal apex.

Head some 1.5× as long as wide (Fig. 10A), eye some half as long as head, weakly convex, distant from head posterolateral end for about its length, not reaching dorsal head surface, with some 6×10 rows of ommatidia; ocelli not distinct; antennal attachments well above upper eye margin, less than their diameters apart; frons very high (possibly with clypeus which base not distinct). Antenna 14-segmented (Fig. 10B), with segment length rates (scape without radix) = 1 : 0.77 : 0.51 : 0.51 : 0.60 : 0.60 : 0.70 : 0.77 : 0.71 : 0.70 : 0.75 : 0.73 : 0.66 : 0.77 : 0.86, scape and pedicel some 1.5× as wide as funicular segments (except somewhat wide ultimate one) and some 0.7 as wide as claval segments, all segments longer than wide including claval ones; claval segments with trichoid sensilla and thicker, bent, semiprocumbent ones. Mouthparts not visible.

Mesosoma (Fig. 10C) with pronotum visible from above as narrow strip, apparently reaching wing bases, with lateral lobes longitudinally costulate, with ventral angles short, wide. Propleura not forming neck, prosternum external, both smooth. Mesonotum convex, smooth with sparse transverse costulae, lacking notauli and apparently parapsids; mesoscutellum subquadrate, with two basal foveae, metanotum half as long as mesoscutellum, entire, apparently smooth; metapostnotum weakly differentiated at propodeal base, propodeum transversely costate, evenly bent toward metasomal base. Mesopleura convex

laterally, with longitudinal impression through its entire length, apparently smooth. Forewing (Fig. 10D) stalked, with only tubular R reaching basal wing quarter only, with membrane surface not distinctly modified, densely setose except for stalk, non-stalk margin entirely setose, with no single individualized seta, with distal and posterior setae very long and deeply rooted in membrane except those less long and short rooted in basal half of hind margin, with fore margin bearing both long and short setation, short setae being basal to long ones. Hind wing short, with stalk only (no membrane), with details obscured by attached tiny segmented object of obscure nature. Legs elongate (femora slightly inflated), ordinary except that fore coxa transverse costate; femora (dorsal), tibiae and tarsi setose, each tibia with one spur, fore spur straight, bent at distal third, bifid (Fig. 10E); all tarsomeres much longer than wide, basitarsi barely or not at all as long as two next segments combined, fore basitarsus concave over all ventral surface, with row of 12 or so long setae, claw small, simple, arolium long, narrow; fore tarsomere length ratio = 1 : 0.50 : 0.51 : 0.51 : 0.63, mid one = 1 : 0.61 : 0.55 : 0.54 : 0.63.

Metasoma with narrow petiolar segments (Fig. 10F), first 2.9× as long as high, slightly narrowing to both ends, second 1.5× as long as high, slightly narrowing anterior, 0.4× as long as first, attaching to gaster from below; gaster (Fig. 10G) with first tergum slightly longer than petiolar segments combined, taking half gaster length, twice as long as second one, following terga short externally. Ovipositor scarcely visible externally, cerci with long setae.

Measurements. Body length 0.69 mm, head length 0.14 mm, antenna length 0.47 mm, mesosoma length 0.24 mm, forewing length, 0.53 mm, width, 0.18 mm, petiolar segments 1, 2, 0.16 mm and 0.10 mm, respectively.

Remarks. New species differs from the only congener *Cretaceomma turolensis* (Ortega-Blanco *et al.*, 2011a) in body longer (0.7 vs. 0.5 mm) and more elongate, with head elongate (vs. semiglobose) and eyes small (vs. taking most of head sides), claval segments all elongate (vs. quadrate to transverse), probasitarsus with row of long (vs. short) setae, and first petiolar segment three times (vs. scarcely twice) longer than high.

Discussion

With the present four new species described herein, the list of Hymenoptera described in the Lebanese amber looks as follows (updated from Maksoud & Azar, 2020):

- †Archaeoserphitidae: *Archaeoserphites melqarti* Engel, 2015; Bcharreh [Bcharré] Mountain

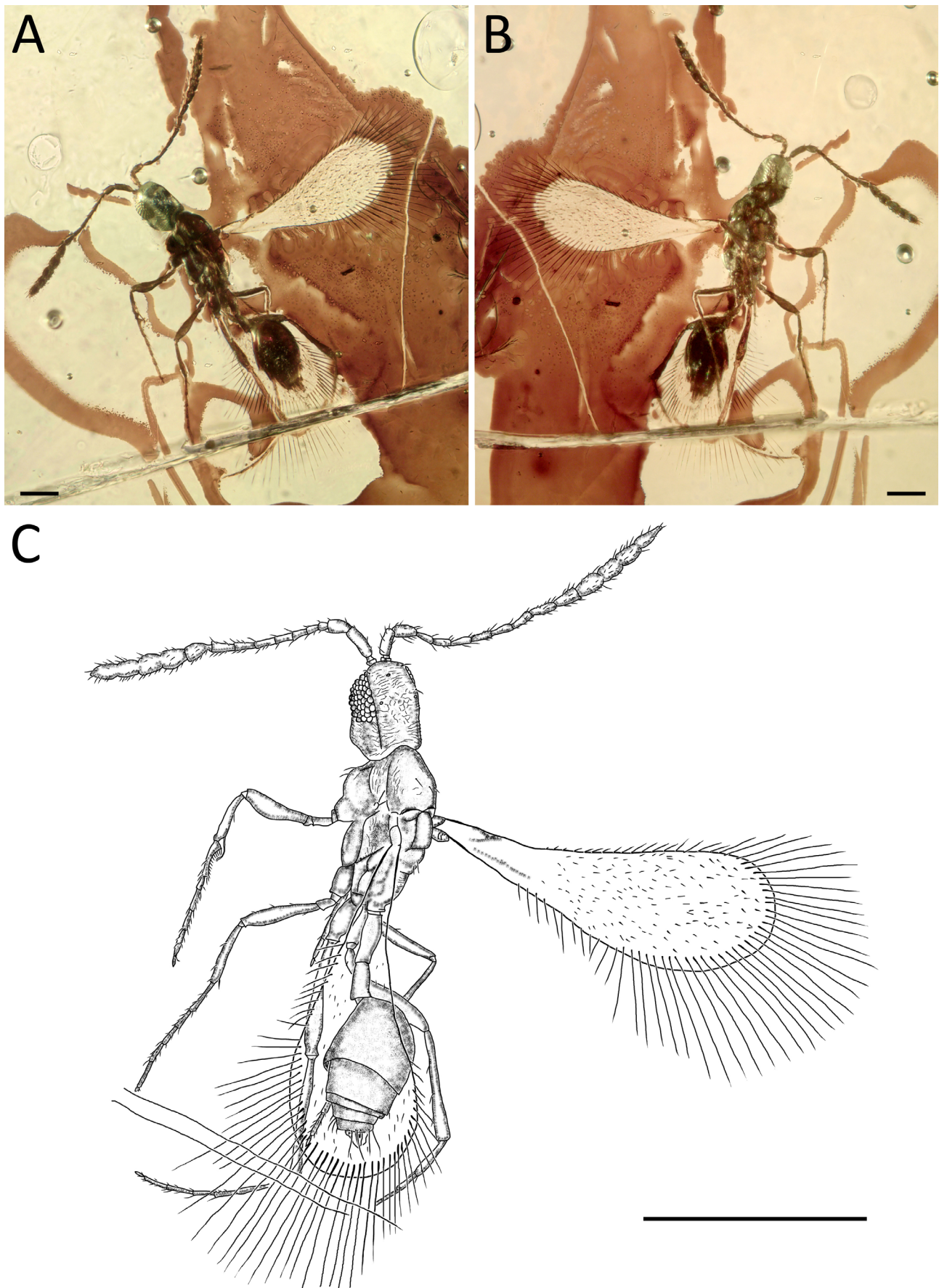


FIGURE 9. *Cretaceomma libanensis* Rasnitsyn & Azar, **gen. et sp. nov.**, holotype, specimen n° 1922, habitus. **A**, Photograph of dorso-lateral view. **B**, Photograph of ventro-lateral view. **C**, Drawing of dorsal view. Scale bars in **A**, **B** = 0.1 mm, in **C** = 0.3 mm.

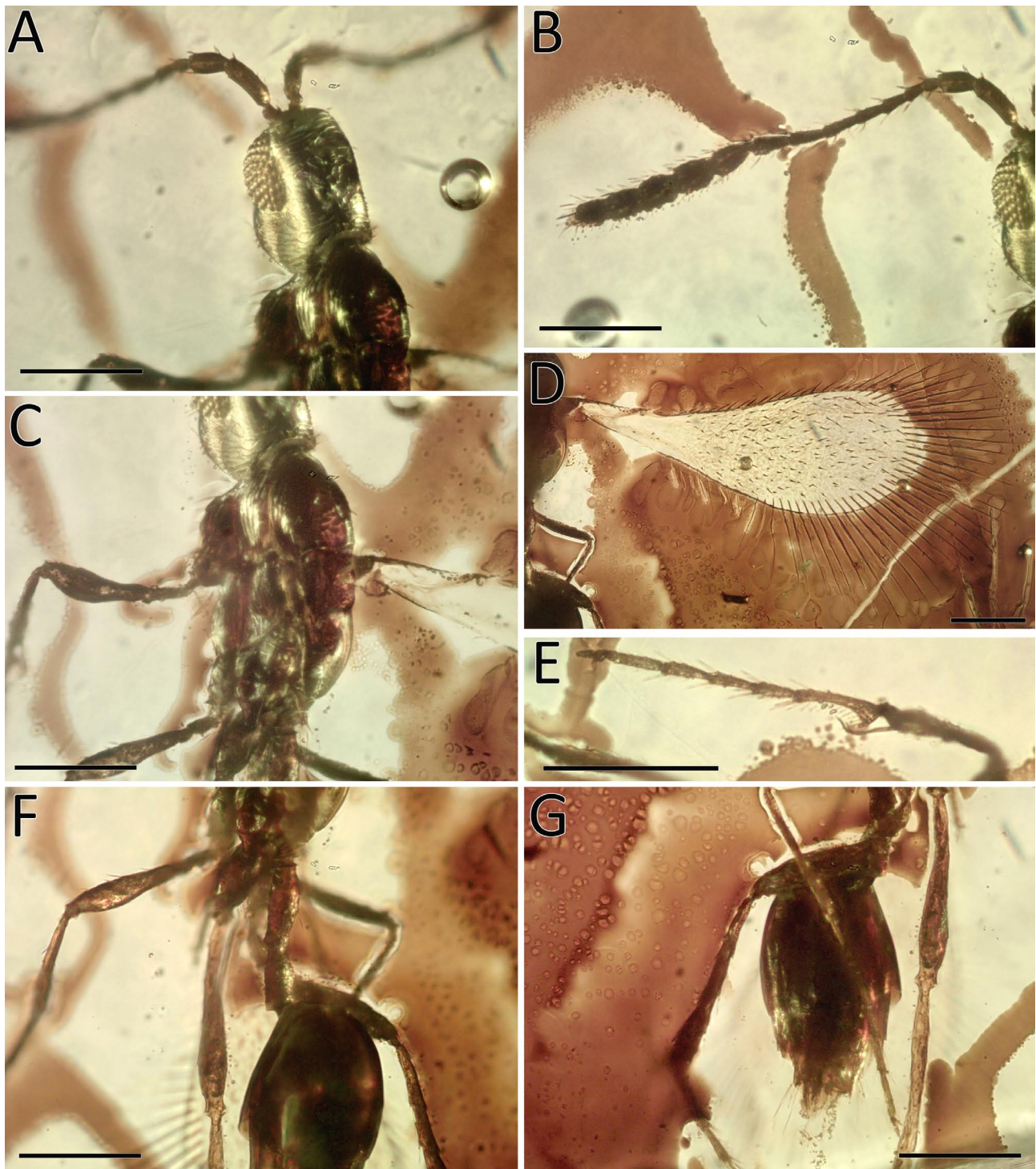


FIGURE 10. *Cretaceomma libanensis* Rasnitsyn & Azar, **gen. et sp. nov.**, holotype, specimen n° 1922, photographs. **A**, Head, dorso-lateral view. **B**, Antenna. **C**, Thorax, dorso lateral view. **D**, Forewing. **E**, Cleaning apparatus. **F**, Petiole. **G**, Gaster, ventral view. Scale bars = 0.1 mm.

- Bethyridae: *Lancepyris opertus* Azevedo & Azar, 2012; Mdeyrij-Hammana
- Dryinidae: *Archaeodryinus palaeophoenicius* (Olmí, 1999), Olmí *et al.*, 2020; Jouar Es-Souss
- Evaniidae: *Eovernevania cyrtocerca* Deans, 2004; Mdeyrij-Hammana
- *Lebanevania azari* Basibuyuk & Rasnitsyn, 2002; Jouar Es-Souss
- *Protoparevania lourothi* Deans, 2004; Mdeyrij-Hammana
- †Gallorommatidae: *Cretaceomma libanensis* **gen. et sp. nov.**; Mdeyrij-Hammana
- †Holopsenellidae; †*Holopsenella primotica* Engel, Ortega-Blanco & Azevedo, 2016; Bcharreh [Bcharré] Mountain
- †Maimetshidae: *Ahiromaimetsha najlae* Perrichot, Azar, Nel & Engel, 2011; Maknouniyyeh

- Scelionidae: *Cretaxenomerus jankotejai* Nel & Azar, 2005; Mdeyrij-Hammana
- *Proteroscelio gravatus* Johnson, Musetti & Masner, 2008; Mdeyrij-Hammana
- Sclerogibbidae: *Sclerogibbodes embioleia* Engel & Grimaldi, 2006; Bcharreh [Bcharré] Mountain
- Scolebythidae: *Libanobythus milkii* Prentice & Poinar, 1996; Jouar Es-Souss
- *Uliobythus terpsichore* Engel & Grimaldi, 2007; Mdeyrij-Hammana
- *Zapenesia libanica* Engel & Grimaldi, 2007; Mdeyrij-Hammana
- †Serphitidae: *Microserphites libanensis* **sp. nov.**; Mdeyrij-Hammana
- *Leptoserphites pabloi* **gen. et sp. nov.**; Qanat Bakish
- *Leptoserphites iriae* **gen. et sp. nov.**; Qanat Bakish
- †Spathiopteridae: *Mymaropsis baabdaensis* Krogmann, Azar, Rajaei & Nel, 2016; Mdeyrij-Hammana

The list includes 12 families, 18 genera and 19 species, all genera and species and 6 (half) families being extinct. Numerically Hymenoptera are less diversified than Diptera (20 families, 93 sp.), Hemiptera (21 families, 35 sp.) and Coleoptera (18 families, 29 sp.), which means mainly a badly underexplored Lebanese fauna of Hymenoptera. Yet it permits, in our opinion at least, to draw some generalizations at least about Bipetiolarida.

Lebanese Bipetiolarida are the oldest worldwide and therefore they are particularly important to understand early evolution of bipetiolarids. In spite of their age, the Lebanese serphitoids and mymarommatoids are not strikingly basal in comparison to their Cretaceous relatives. *Archaeoserphites* Engel, 2015 with its 14-segmented antenna is possibly the most archaic serphitoid in that respect, but its wing venation is reduced compared to those of the majority of serphitoids and particularly than that of *Supraserphites* Rasnitsyn & Öhm-Kühnle, 2019 (Engel, 2015; Rasnitsyn & Öhm-Kühnle, 2018, 2019a, 2020). Moreover, *Microserphites libanensis* **sp. nov.** is the most modified venationally and in the head form among all Serphitoidea. In Mymarommatoida, *C. libanensis* **sp. nov.** together with its Albian Spanish congener *C. tuoliensis* is basal in position within Gallorommatidae because of its 14-segmented antenna, but venationally all of them are far advanced comparing Alavarommatidae (also from the Spanish Albian, Ortega-Blanco *et al.*, 2011a). This implies that the early evolution of both Serphitoidea and Mymarommatoida took place earlier in Cretaceous.

The biogeographic aspect of Lebanese Bipetiolarida is worth discussing as well. During the Cretaceous, Lebanon was a part of the northeastern part of Gondwana (*cf.* Rasnitsyn *et al.*, 2016: fig. 1). Yet Lebanese Bipetiolarida, like Hymenoptera in general, display no particular features considered as typical Gondwanan

ones. Instead, there are genera with species coming from Lebanon and Spain (*Cretaceomma*), Lebanon, Spain and N. Siberia (*Microserphites*), Lebanon and Myanmar (*Archaeoserphites*); more such examples can be found in other Hymenoptera: *Proteroscelio* (Lebanon, Canada and Myanmar: Myanmar with its Burmese amber was an isolated island in midst of Tethys Ocean and not a part of Gondwana in mid-Cretaceous time, *cf.* Rasnitsyn & Öhm-Kühnle, 2018 and *refs.* therein), *Holopsenella* (Lebanon and Myanmar). However, this does not question the Gondwanan position of Cretaceous Lebanon, which is generally considered without serious doubts. Instead, it is explainable by a simple fact that we are aware of few Cretaceous faunas of Gondwanan Hymenoptera. Exceptions are the Early Cretaceous (Aptian?) of Koonwarra in Australia (Jell, 2004; Rasnitsyn & Öhm-Kühnle, 2019b), Early Cretaceous (Aptian) of Crato Fm. in Brazil (Ostin, 2007) and Late Cretaceous (Turonian) of Orapa in South Africa (Brothers & Rasnitsyn, 2003). However, Koonwarra deposits formed in near polar environments (Poropat *et al.*, 2018) in contrast to near equatorial ones in Lebanon, and Crato fossil assemblage is generally poor in small fossils sharply unlike Lebanese amber with absolutely predominated small insects. That is why the absence of specific similarity between Lebanese and other Cretaceous Gondwanan insects is not at all surprising. On the other hand, the presence of close relatives of Lebanese fossils in the mid-Tethyan (Myanmar) and in northern faunas (Spanish, Canadian, Siberian), this can be easily explained by overseas transfer which should be a commonplace for small creatures of air plankton size (*cf.* circumtropical distribution, including numerous ocean islands, of tiny living insects of the order Zoraptera; Mashimo *et al.*, 2019, and *refs.* therein).

Conclusion

Lebanon with its numerous Lower Cretaceous fossiliferous amber outcrops is among the richest countries in terrestrial invertebrate fossils. Lebanese amber contains many extinct families (some of them are known only from Lebanon) and the records of the oldest representatives of many modern families of terrestrial arthropods. In most cases, Lebanese inclusions constitute the “missing links” between the old fauna and the modern one. The study of Lebanese amber inclusions is to date the only one that gives a clue in determining the North-East Gondwanan biodiversity and environment of the extremely significant Lower Cretaceous period. The discovery of more biological inclusion in the Lebanese amber will undeniably outstandingly participate in understanding and increasing knowledge of the terrestrial palaeobiodiversity.

Acknowledgements

We thank Dr Taiping Gao and another anonymous reviewer for their valuable comments on an earlier version of this work. We thank Dr Neal Evenhuis for his help in polishing the English. This paper is a contribution of the activity of the laboratory “Advanced Micropalaeontology, Biodiversity and Evolution Researches” (AMBER) led by DA at the Lebanese University. DA wants to thank the Chinese Academy of Sciences for the financial support under the President’s International Fellowship Initiative (PIFI).

References

- Arillo, A., Subías, L.S., Chaves Da Rocha, G. & Azar, D. (2019) First fossil oribatid mite from Lebanese amber (Acariformes, Oribatida, Neoliodidae). *Palaeoentomology*, 2 (6), 611–617. <https://doi.org/10.11646/palaeoentomology.2.6.12>.
- Azar, D. (1997) A new method for extracting vegetal and insect fossils from the Lebanese amber. *Palaeontology*, 40, 1027–1029.
- Azar, D. (2007) Preservation and accumulation of biological inclusions in Lebanese amber and their significance. *Comptes Rendus Palevol*, 6, 151–156. <https://doi.org/10.1016/j.crpv.2006.10.004>
- Azar, D. (2012) Lebanese amber: a “Guinness Book of Records”. *Annales Universitatis Paedagogicae Cracoviensis*, 111, 44–60.
- Azar, D., Dejax, J. & Masure, E. (2011) Palynological analysis of amber-bearing clay from the Lower Cretaceous of Central Lebanon. *Acta Geologica Sinica (English Edition)*, 85 (4), 942–949. <https://doi.org/10.1111/j.1755-6724.2011.00497.x>
- Azar, D., Gèze, R. & Acra, F. (2010a) Chapter 14: Lebanese amber. In: Penney, D. (Ed.), *Biodiversity of fossils in amber from the major World deposits*. Siri Scientific Press, Manchester, pp. 271–298.
- Azar, D., Gèze, R., El-Samrani, A., Maalouly, J. & Nel, A. (2010b) Jurassic amber in Lebanon. *Acta Geologica Sinica (English Edition)*, 84, 977–983. <https://doi.org/10.1111/j.1755-6724.2010.00228.x>
- Azar, D. & Nel, A. (1998) Lebanese Lower Cretaceous amber. *Meganeura*, 2, 18–20.
- Azar, D., Nel, A., Solignac, M., Paicheler, J.-C. & Bouchet, F. (1999) New genera and species of phlebotomid and psychodid flies from the Lower Cretaceous amber of Lebanon (Insecta: Diptera: Phlebotomidae, Psychodidae). *Palaeontology*, 42 (6), 1101–1136. <https://doi.org/10.1111/1475-4983.00112>
- Azar, D., Perrichot, V., Néraudeau, D. & Nel, A. (2003) New psychodid flies from the Cretaceous ambers of Lebanon and France, with a discussion about *Eophlebotomus connectens* Cockerell, 1920 (Diptera, Psychodidae). *Annals of the American Society of America*, 96 (2), 117–127. [https://doi.org/10.1603/0013-8746\(2003\)096\[0117:NPFTCA\]2.0.CO;2](https://doi.org/10.1603/0013-8746(2003)096[0117:NPFTCA]2.0.CO;2)
- Azevedo, C.O. & Azar, D. (2012) A new fossil subfamily of Bethyridae (Hymenoptera) from the Early Cretaceous Lebanese amber and its phylogenetic position. *Zoologia*, 29 (3), 210–218. <https://doi.org/10.1590/S1984-46702012000300004>
- Basibuyuk, H.H., Rasnitsyn, A.P., Fitton, M.G. & Quicke, D.L.J. (2002) The limits of the family Evaniidae (Insecta: Hymenoptera) and a new genus from Lebanese amber. *Insect Systematic and Evolution*, 33, 23–34. <https://doi.org/10.1163/187631202X00037>
- Brothers, D.J. & Rasnitsyn, A.P. (2003) Diversity of Hymenoptera and other insects in the Late Cretaceous (Turonian) deposits at Orapa, Botswana: a preliminary review. *African Entomology*, 11 (2), 221–226.
- Brues, C.T. (1937) Superfamilies Ichneumonoidea, Serphoidea, and Chalcidoidea. *University of Toronto Studies, Geological Series*, 40, 27–44.
- Deans, A.R., Basibuyuk, H.H., Azar, D. & Nel, A. (2004) Descriptions of two new Early Cretaceous (Hauterivian) ensign wasp genera (Hymenoptera: Evaniidae) from Lebanese amber. *Cretaceous Research*, 25, 509–516. <https://doi.org/10.1016/j.cretres.2004.04.003>
- Debauche, H.R. (1948) Étude sur les Mymarommidae et les Mymaridae de la Belgique (Hymenoptera Chalcidoidea). *Mémoires du Musée Royal d’Histoire Naturelle de Belgique*, 108, 1–248, 24 pls.
- Engel, M.S. (2015) A new family of primitive serphitoid wasps in Lebanese amber (Hymenoptera: Serphitoidea). *Novitates Palaeontologicae*, 13, 1–22. <https://doi.org/10.17161/np.v0i13.5064>
- Engel, M.S. & Grimaldi, D.A. (2006) The first Cretaceous sclerogibbid wasp (Hymenoptera: Sclerogibbidae). *American Museum Novitates*, 3515, 1–7. [https://doi.org/10.1206/0003-0082\(2006\)3515\[1:TFCSWH\]2.0.CO;2](https://doi.org/10.1206/0003-0082(2006)3515[1:TFCSWH]2.0.CO;2)
- Engel, M.S. & Grimaldi, D.A. (2007) Cretaceous Scolebythidae and phylogeny of the family (Hymenoptera, Chrysidoidea). *American Museum Novitates*, 3568, p. 1–16. [https://doi.org/10.1206/0003-0082\(2007\)475\[1:CSAPOT\]2.0.CO;2](https://doi.org/10.1206/0003-0082(2007)475[1:CSAPOT]2.0.CO;2)
- Gibson, G.A.P., Read, J. & Huber, J.T. (2007) Diversity, classification and higher relationships of Mymarommatoidea (Hymenoptera). *Journal of Hymenoptera Research*, 16, 51–146.
- Granier, B., Toland, C., Gèze, R., Azar, D. & Maksoud, S. (2016) Some steps toward a new story for the Jurassic–Cretaceous transition in Mount Lebanon. *Carnets de Géologie*, 16 (8), 247–269. <https://doi.org/10.4267/2042/59924>

- Harris, R. (1979) A glossary of surface sculpturing. *Occasional Papers in Entomology*, 28, 1–31.
- Jell, P.A. (2004) Fossil insects of Australia. *Memoirs of the Queensland Museum*, 50, 1–123.
- Johnson, N.F., Musetti, L. & Masner, L. (2008) The Cretaceous Scelionid genus *Proteroscilio* Brues (Hymenoptera, Platygastroidea). *American Museum Novitates*, 3603, 1–7. [https://doi.org/10.1206/0003-0082\(2008\)3603\[1:TCSGPB\]2.0.CO;2](https://doi.org/10.1206/0003-0082(2008)3603[1:TCSGPB]2.0.CO;2)
- Kozlov, M.A. & Rasnitsyn, A.P. (1979) On the limits of the family Serphitidae (Hymenoptera, Proctotrupoidea). *Entomologicheskoe Obozrenie*, 58 (2), 402–416. [In Russian, with English summary]
- Krogmann, L., Azar, D., Rajaei, H. & Nel, A. (2016) *Mymaropsis baabdaensis* sp. n. from Lower Cretaceous Lebanese amber—the first spathiopetrygid wasp and the first female known for the family. *Comptes Rendus Palevol*, 15, 483–487. <https://doi.org/10.1016/j.crpv.2015.11.002>
- Linnaeus, C. (1758) *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. Tomus I. Editio decima, reformata. L. Salvii, Holmiae [= Stockholm], 824 pp. <https://doi.org/10.5962/bhl.title.542>
- Maksoud, S. & Azar, D. (2020) Lebanese amber: latest updates. *Palaeoentomology*, 3 (2), 125–155. <https://doi.org/10.11646/palaeoentomology.3.2.2>
- Maksoud, S., Azar, D., Granier, B. & Gèze, R. (2017) New data on the age of the Lower Cretaceous amber outcrops of Lebanon. *Palaeoworld*, 26 (2), 331–338. <https://doi.org/10.1016/j.palwor.2016.03.003>
- Maksoud, S., Maalouf, M., Maalouf, R. & Azar, D. (2021a) Baskinta and Bqaatouta: Two new early Barremian fossiliferous amber outcrops from Central Lebanon. *Palaeoentomology*, 4 (4), 367–373. <https://doi.org/10.11646/palaeoentomology.4.4.12>
- Maksoud, S., Taleb, K. & Azar, D. (2019) Four new lower Barremian amber outcrops from Northern Lebanon. *Palaeoentomology*, 2 (4), 333–339. <https://doi.org/10.11646/palaeoentomology.2.4.6>
- Maksoud, S., Taleb, K. & Azar, D. (2021b) New early Barremian fossiliferous amber outcrop from North Lebanon. *Palaeoentomology*, 4 (1), 23–26. <https://doi.org/10.11646/palaeoentomology.4.1.4>
- Maksoud, S., Zaidan, O.T. & Azar, D. (2021c) Kfar Selouan: A new early Barremian fossiliferous amber outcrop from Lebanon. *Palaeoentomology*, 4 (3), 257–265. <https://doi.org/10.11646/palaeoentomology.4.3.13>
- Maksoud, S., Ziadé, K., Gèze, R. & Azar, D. (2020) New early Barremian amber outcrops from Central Lebanon. *Palaeoentomology*, 3 (4), 415–422. <https://doi.org/10.11646/palaeoentomology.3.4.14>
- Mashimo, Y., Müller, P. & Beutel, R.G. (2019) *Zorotypus pecten*, a new species of Zoraptera (Insecta) from mid-Cretaceous Burmese amber. *Zootaxa*, 4651 (3), 565–577. <https://doi.org/10.11646/zootaxa.4651.3.9>
- Nel, A. & Azar, D. (2005) The oldest parasitic Scelionidae: Teleasinae (Hymenoptera: Platygastroidea). *Polskie Pismo Entomologiczne*, 74, 333–338.
- Nohra, Y., Azar, D., Gèze, R., Maksoud, S., El-Samrani, A. & Perrichot, V. (2013) New Jurassic outcrops from Lebanon. *Terrestrial Arthropod Reviews*, 6, 27–51. <https://doi.org/10.1163/18749836-06021056>
- Olmi, M. (2000) New fossil Dryinidae from Baltic and Lebanese amber (Hymenoptera: Chrysidoidea). *Frustula Entomologica, N.S.*, 21, 48–67.
- Olmi, M., Perkowsky, E.E., Martynova, K.V., Contarini, M., Bückle, C. & Guglielmino, A. (2020) An important intermediate step in the evolution of pincer wasps: an extraordinary new type of chela from mid-Cretaceous Burmese amber (Hymenoptera, Dryinidae). *Cretaceous Research*, 111, 104420. <https://doi.org/10.1016/j.cretres.2020.104420>
- Ortega-Blanco, J., Peñalver E., Delclòs, X. & Engel, M.S. (2011a) False fairy wasps in Early Cretaceous amber from Spain (Hymenoptera: Mymarommatoidea). *Palaeontology*, 54 (3), 511–523. <https://doi.org/10.1111/j.1475-4983.2011.01049.x>
- Ortega-Blanco, J., Delclòs, X., Peñalver, E. & Engel, M.S. (2011b) Serphitid wasps in Early Cretaceous amber from Spain (Hymenoptera: Serphitidae). *Cretaceous Research*, 32, 143–154. <https://doi.org/10.1016/j.cretres.2010.11.004>
- Ostin, T. (2007) 11.18 Hymenoptera: bees, wasps and ants. In: Martill, D.M., Bechly, G. & Loveridge, R.F. (Eds), *The Crato Fossil Beds of Brazil. Window into an ancient World*. Cambridge University Press, Cambridge etc., 657 pp.
- Perrichot, V., Ortega-Blanco, J., McKellar, R.C., Delclòs, X., Azar, D., Nel, A., Tafforeau, P. & Engel, M.S. (2011) New and revised maimetshid wasps from Cretaceous ambers (Hymenoptera, Maimetshidae). *ZooKeys*, 130, 421–453. <https://doi.org/10.3897/zookeys.130.1453>
- Poinar, G.O. & Milki, R. (2001) *Lebanese amber: the oldest insect ecosystem in fossilized resin*. Oregon State University Press, Corvallis, Oregon, 96 pp.
- Poropat, S.F., Martin, S.K., Tosolini, A.M.P., Wagstaff, B.E., Bean, L.B., Kear, B.P., Vickers-Rich, P. & Rich, T.H. (2018) Early Cretaceous polar biotas of Victoria, southeastern Australia—an overview of research to date. *Alcheringa: An Australasian Journal of Palaeontology*, 42 (2), 157–229. <https://doi.org/10.1080/03115518.2018.1453085>
- Prentice, M.A., Poinar, G.O. Jr. & Milki, R. (1996) Fossil scolybythids (Hymenoptera: Scolybythidae) from Lebanese and Dominican amber. *Proceedings of the Entomological Society of Washington*, 98, 802–811.
- Rasnitsyn, A.P., Bashkuev, A.S., Kopylov, D.S., Lukashevich, E.L., Ponomarenko, A.G., Popov, Yu.A., Rasnitsyn, D.A., Ryzhkova, O.V., Sidorchuk, E.A., Sukatsheva, I.D. & Voronskov, D.D. (2016) Sequence and scale of changes in the terrestrial biota during the Cretaceous (based on materials from fossil resins). *Cretaceous Research*, 61, 234–255. <https://doi.org/10.1016/j.cretres.2015.12.025>

- Rasnitsyn, A.P. & Öhm-Kühnle, C. (2018) Three new female *Aptenoperissus* from mid-Cretaceous Burmese amber (Hymenoptera, Stephanoidea, Aptenoperissidae): Unexpected diversity of paradoxical wasps suggests insular features of source biome. *Cretaceous Research*, 91, 168–175.
<https://doi.org/10.1016/j.cretres.2018.06.004>
- Rasnitsyn, A.P. & Öhm-Kühnle, C. (2019a) New serphitoid wasp *Supraserphites draculi* gen. et sp. nov. in Burmese amber (Hymenoptera, Serphitidae: Supraserphitinae). *Cretaceous Research*, 99, 46–50.
<https://doi.org/10.1016/j.cretres.2018.12.006>
- Rasnitsyn, A.P. & Öhm-Kühnle, C. (2019b) Revision of the Cretaceous Proctotrupomorpha (Insecta: Hymenoptera) of Australia. *Cretaceous Research*, 100, 91–96.
<https://doi.org/10.1016/j.cretres.2019.03.017>
- Rasnitsyn, A.P. & Öhm-Kühnle, C. (2020) Two new species of *Supraserphites* (Hymenoptera, Serphitidae) in Burmese amber. *Palaeoentomology*, 3 (2): 158–162.
<https://doi.org/10.11646/palaeoentomology.3.2.4>