Acta zoologica cracoviensia, **46**(suppl.– Fossil Insects): 195-204, Kraków, 15 Oct., 2003

First Eoptychopteridae (Insecta: Diptera) from the Early Cretaceous Lebanese amber

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Submitted: 15 Feb., 2002
Accepted for publication: 1 June, 2002

LUKASHEVICH E. D., AZAR D. 2003. First Eoptychopteridae (Insecta: Diptera) from the Early Cretaceous Lebanese amber. *Acta zoologica cracoviensia*, **46**(suppl.– Fossil Insects): 195-204.

Abstract. First representatives of the extinct family Eoptychopteridae (all males), belonging to *Leptychoptera dimkina* and *L. vovkina* gen. et spp. nov. (subfamily Eoptychopterinae), from the Early Cretaceous Lebanese amber are described. Many of their characters are similar to extant Ptychopteridae, among them the presence of prehalter is the most interesting. The larval mite in the feeding position is found on the abdomen of the *L. dimkina* sp. nov. holotype.

Key words: Diptera, Eoptychopteridae, Early Cretaceous, amber, Lebanon, parasitism, new genus, new species.

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I. INTRODUCTION

The Eoptychopteridae, an extinct psychodomorph family ancestral to Recent Ptychopteridae, was widespread throughout Europe and Asia in the Mesozoic. Seven genera are described from more than 20 localities in England, Germany, Kyrgyzstan, Kazakhstan, Russia (Siberia), Mongolia (LUKASHEVICH et al. 1998) and China (REN & KRZEMIŃSKI 2002). The Cretaceous record of Eoptychopteridae is poor. Fossil impressions are known from the following localities: Zhigansk (Yakutia, Russia; Lower Cretaceous Batylykh Formation), Baissa (Transbaikalia, Russia; Lower Neocomian Zaza Formation), Durlston Bay (Swanage, UK; Lower Berriasian Lulworth Formation and Upper Berriasian Durlston Formation) and Clockhouse (Capel, UK; Upper Hauterivian Lower Weald Clay) (LUKASHEVICH et al. 2001).

Up to date Eoptychopteridae were unknown as inclusions in amber, although their finds are rather common in the localities of fluvial origin or, at least, connected with river valleys (LUKASHEVICH 2000). The presence of small-sized species of Eoptychopteridae seems to be highly probable in fossil resins which often originate from riverine forests. The Lebanese amber belongs to the Middle East Lower Cretaceous amber and recently more than 70 outcrops have been discovered in Lebanon with ages extending from Late Jurassic to the Albian (AZAR et al., this volume). Only very few outcrops among the 70 known give biological inclusions. The exact ages of these latter deposits are rather difficult to define but were estimated at 125-135 million years**.** The major three outcrops of amber with biological inclusions from Jezzine (South of Lebanon), Bcharreh area (North of Lebanon) and Hammana (Central Lebanon) were recognized to be of nearly the same age, on the basis of the presence of several shared taxa in the three outcrops even if these outcrops do not correspond to the same geological facies (AZAR et al., this volume). The discovery of Eoptychopteridae in Lebanese amber with diverse arthropod fauna was expected and gave us a brilliant opportunity to compare Eoptychopteridae with Ptychopteridae on the base of non-wing characters. In this paper two new species of Eoptychopteridae are described: *Leptychoptera dimkina* sp. nov. (Figs 1-3) from Hammana (collection of Dany AZAR, provisionally deposited in the Museum d'Histore Naturelle, Paris) and *L. vovkina* sp. nov. (Fig. 4) from the Bcharreh area (collection of American Museum of Natural History, New York).

The find of mite parasitizing an eoptychopterid midge in Lebanese amber is worth to mention. The larval mite, apparently representative of Erythraeidae (determined by O. L. MAKAROVA, Institute for Problems of Ecology and Evolution, Moscow), is situated on the dorsal abdominal surface of an adult male (Figs 1, 5). It is a rare, but not unique find in Lebanese amber: mites are also found in the feeding position on several ceratopogonid midges (POINAR et al. 1994), on several chironomid midges, on a trichocerid midge (SHCHERBAKOV, AZAR, in preparation), on a limoniid (KRZEMIŃSKI, personal comm.), psychodid and a rhagionid flies. Earlier the unique parasitic association of chironomid midge and larval erythraeid mite with no present-day counterpart was described from the Canadian Cretaceous amber (Foremost Formation, Judith River Group) dated approximately at 79 million years (POINAR et al. 1997).

Venation nomenclature as in SHCHERBAKOV et al. 1995; abbreviations as in LUKASHEVICH et al. 1998.

Acknowledgments. We would like to thank Dr. D. E. SHCHERBAKOV (Paleontological Institute, Moscow), who found specimens described here in the collection of Museum d'Histoire Naturelle, Paris, for his constant support and encouragement during the course of this study. We are grateful to Dr. D. GRIMALDI for the loan of the inclusion from AMNH collection and Dr. V. A. BLAGODEROV for kind arrangment for the loan of this specimen (both American Museum of Natural History, New York).

II. SYSTEMATICS

ORDER DIPTERA LINNAEUS, 1758

Family **Eoptychopteridae** HANDLIRSCH, 1906

Subfamily Eoptychopterinae HANDLIRSCH, 1906

Genus ***Leptychoptera*** gen. nov.

Diagnosis. Small midges, wings without spots; veins Sc, R1 and Rs short, *r-m* about midlength of R4+5, four medial veins, *im* beyond M1+2 furcation.

Type species. *Leptychoptera dimkina* sp.nov., described below.

Species composition. Two species described below.

Derivation of name. From Greek leptos – small, fine, and from Recent genus *Ptychoptera*.

Description. Small midges. Body and wings pubescent. Eyes large, bare; facets of equal size. Clypeus produced; maxillary palps elongate; last palpomere goffered, as long as half of remainder; labella large; labrum small and not sclerotized (Fig. 11). Antennae 23-segmented, longer than abdomen; scape and pedicel moderately large, flagellomeres (21) bacilliform, first largest, terminal very short, remaining subequal, gradually tapering , with a whorl of few (4-5) long setae and dense, short pubescence (Figs 9, 10).

Transepimeral suture (between anepimeron and meropleurite) present (Fig. 14). Mediotergite and pleurotergite (laterotergite of some authors) have areas densely covered by hairs; episternum wide, with several setae. Prehalter large with long setae (Fig. 13).

Wings transparent, without spots, only with pale elongate pterostigma (Figs 6-8). Wings entirely covered with macrotrichia. Sc, R1 and Rs very short: Sc terminating before wing midlength, R1 terminating before 2/3 wing length (before 1/2 the distance between medial furcation and R5 apex), Rs originating beyond 1/4 wing length; *r-m* about midlength of R4+5. Four medial veins, *im* beyond M1+2 furcation.

Legs long; coxae elongate; tibial spurs (1-2-2) large and conspicuous, hairy except for acute glabrous tips; a pair of small tibial pseudospurs inserted opposite (Fig. 12, 15). Tarsomere I longer than remaining combined; tarsomeres I-IV with apical pairs of pseudospurs Tarsomere IV without basal swelling bearing tufts of setae opposed by tarsal claws (clasping organ of HENNIG 1968). Empodium and pulvilli absent; claws simple, small.

Male hypopygium compact (Figs 5, 17-19). Ninth tergite with tergal lobes. Gonocoxites separated from each other, with processes; gonostyles converging, digitiform. Hypandrium massive, with bristles. Large sperm pump (vesica of authors) present.

Comparison. The new genus is similar to *Eoptychoptera* HANDLIRSCH, 1906 in the identical pattern of medial veins, but distinct in the smaller size, shorter Sc, R1 and Rs, and lesser number of flagellomeres (21, compared to at least 28 in *E. magna*; LUKASHEVICH 1993).

Remarks. Almost each wing character of the new genus (except for shortened R1) is met in some, usually small, *Eoptychoptera* species .Sc terminating before wing midlength is known in the Lower Jurassic *E. simplex* (GEINITZ 1887) from Germany; *r-m* about R4+5 midlength – in the Lower Jurassic *E. aequdistans* LUKASHEVICH in LUKASHEVICH et al. 1998 from Kyrgyzstan and the Lower Cretaceous *E. britannica* LUKASHEVICH, CORAM & JARZEMBOWSKI 2001 from England; Rs originating distally – in several species, but not small-sized. However, the combination of the wing characters seems to be unique. The shortening of Sc and R1 is undoubtedly connected with the small size of these midges (as are possibly also: *r-m* shifted from Rs bifurcation and decreased number of flagellomeres as well), but in the small-sized *Eoptychoptera* species Rs is always longer, so pronounced shortening of R1 and Rs are considered apomorphies of the new genus.

Leptychoptera dimkina sp.nov.

Figs 1-4, 6-7, 13-18.

Diagnosis. Vein *m-cu* runs into CuA in posterior half of wing. Legs moderately long (hind tibia 0.6 times as long as wing). Ventral process of gonocoxite with several denticles directed outwards.

Type material. Holotype, specimen N 198, male without head; Hammana/Mdeirij, Caza Baada, Mouhafazit Jabal Libnen, Central Lebanon; Lower Cretaceous; collection of D. AZAR, provisionally deposited in the Museum d'istore Naturelle, Paris. Paratypes: specimens N 258, 280, both males; Hammana/Mdeirij, Caza Baada, Mouhafazit Jabal Libnen, Central Lebanon; Lower Cretaceous; collection of D. AZAR, provisionally deposited in the Museum d'Histore Naturelle, Paris.

Etymology. Arbitrary combination of letters.

Description. Prehalter large, only twice shorter than halter (Fig. 13).

Wing (Figs 6,7). Sc terminating before midwing, slightly distad of or level with CuA tip. R1 tip level with M4 tip. R2+3 subequal to R3. R4+5 fork 4-4.5 times as long as R4+5 stem. mM1+2

1

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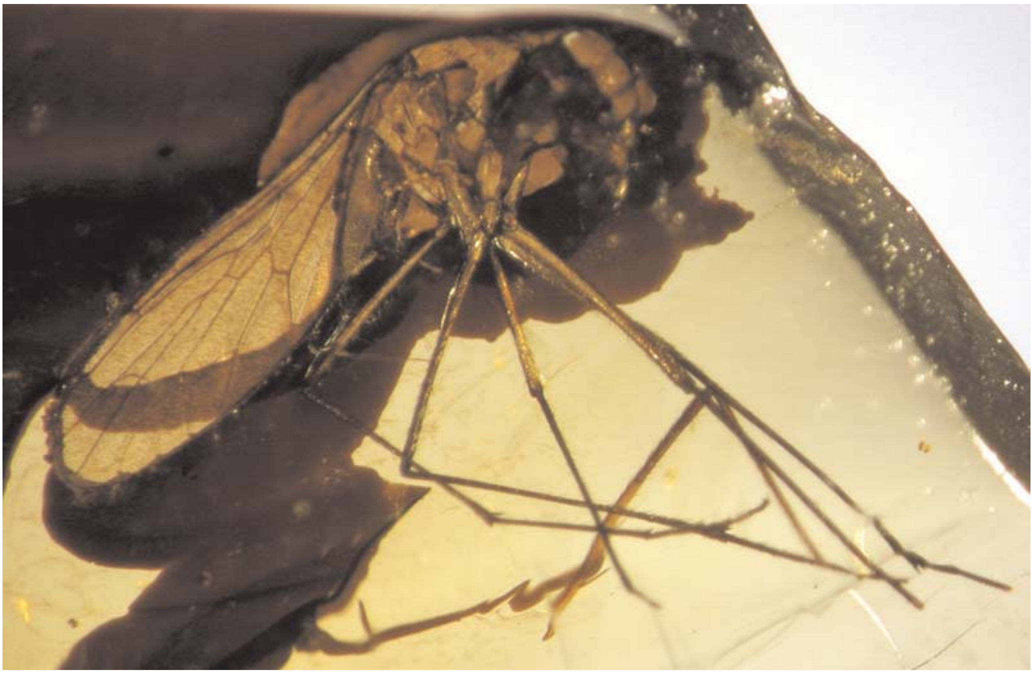

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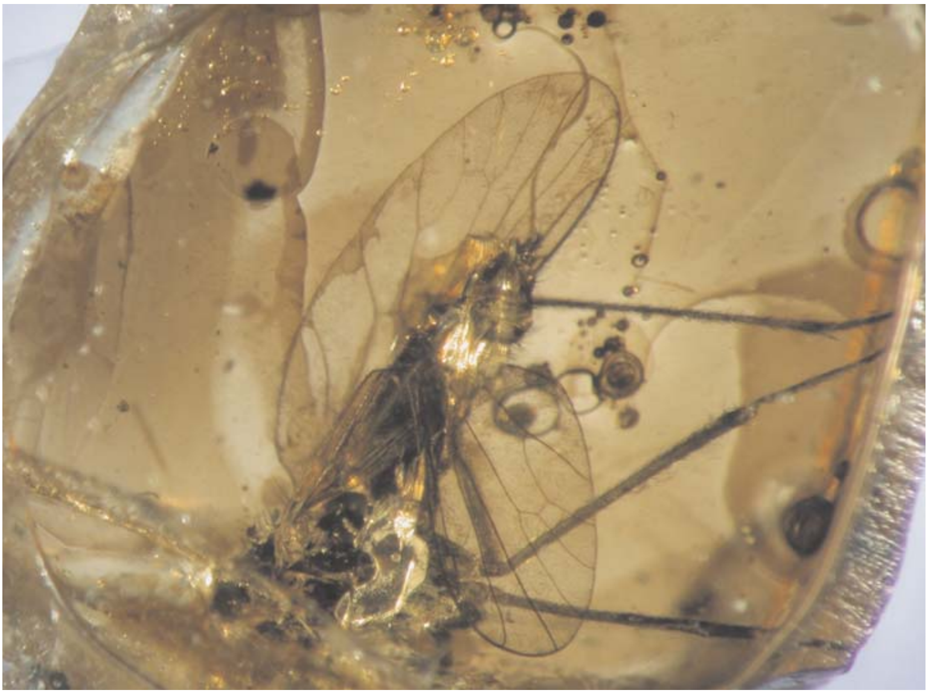
Figs 1-5. General appearance of *Leptychoptera* gen. nov. 1-4: *L. dimkina* sp. nov.: 1 – holotype N 198, 2 – same, larval mite in feeding position on abdomen (fragment magnified), 3 – paratype N 258, 4 – paratype N 280. 5 – *L. vovkina* sp. nov.: holotype AMNH Leb-250.



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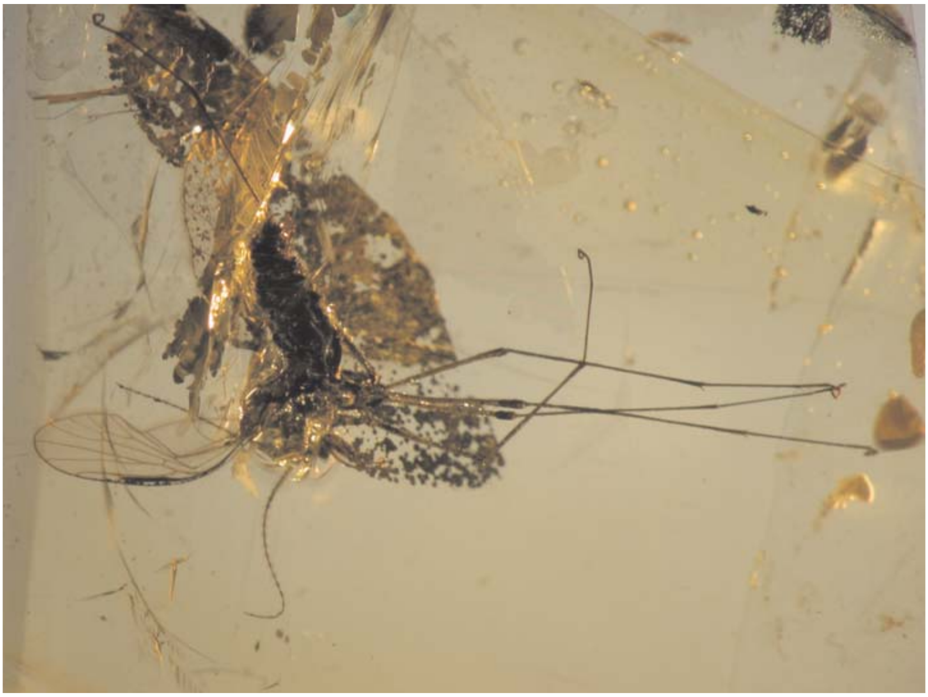

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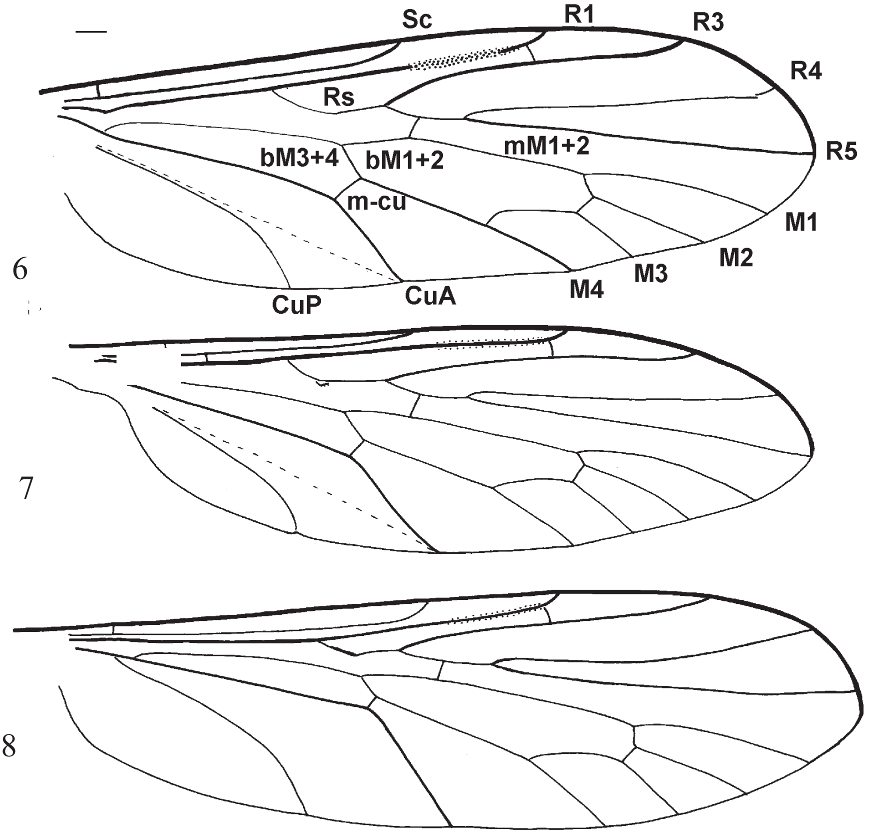


Figs 6-8. Wing venation of *Leptychoptera* gen. nov. 6, 7 – *L. dimkina* sp. nov.: 6 – holotype N 198, 7 – paratype N 258. 8 – *L. vovkina* sp. nov., holotype AMNH Leb-250. Scale bar= 0.1 mm.

2.5-2.7 times the length of bM1+2, bM3+4 subequal to *m-cu*; *m-cu* runs into CuA in posterior half of wing.

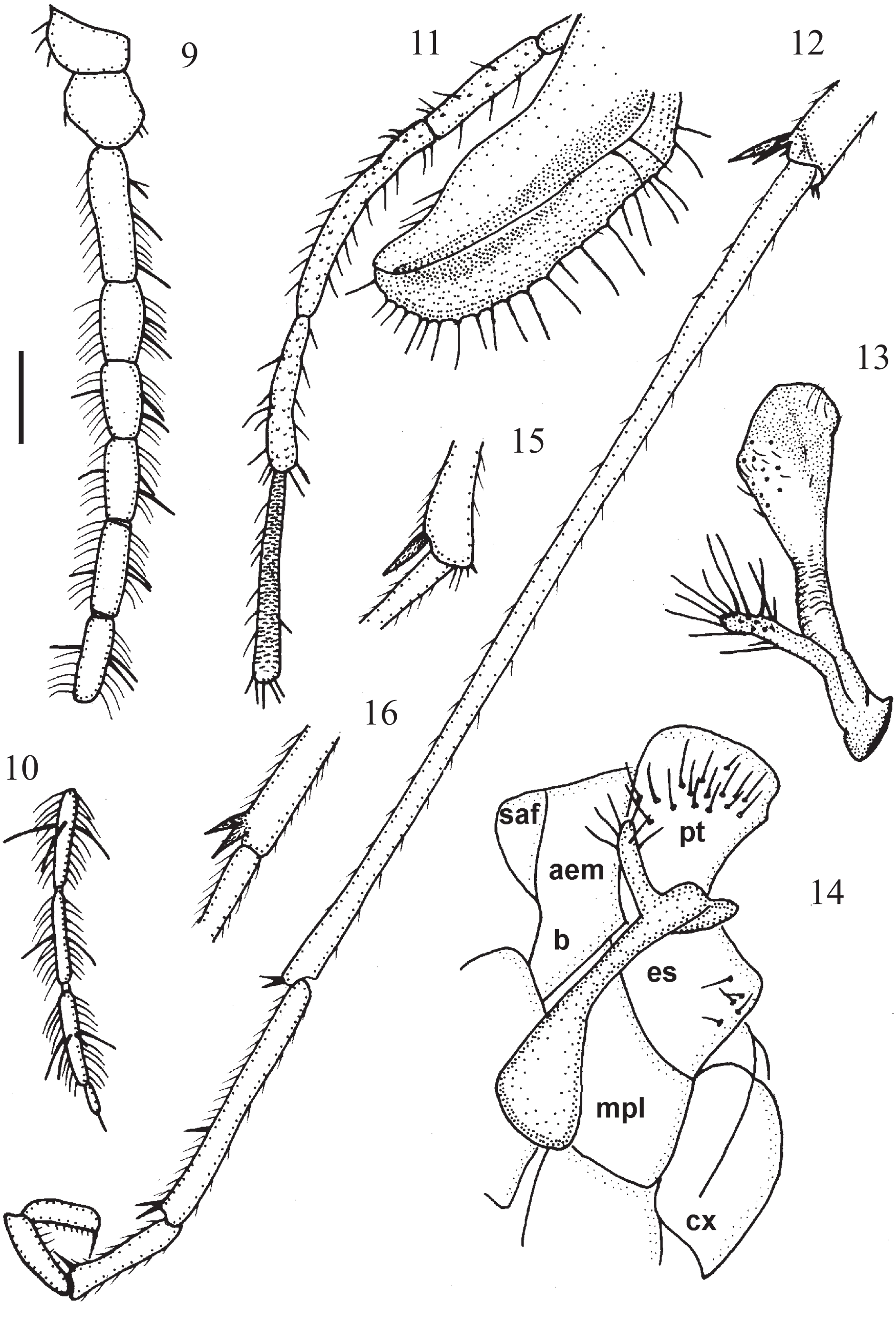
Legs moderately long (hind tibia 0.6 times as long as wing).

Male abdominal segments not modified, gradually tapering and shortening towards hypopygium, the latter not wider than segment VIII (Figs 17, 18). Ninth tergite divided, each tergal arm with small, wide submedian setose lobe. Gonocoxite roughly triangular, ventrally with short dentate process (bearing several chitinized denticles directed outwards) and dorsally with digitiform process. Gonostyles slender, digitiform, converging, each with several (7?) pairs of inner denticles, one apical spine and numerous setae.

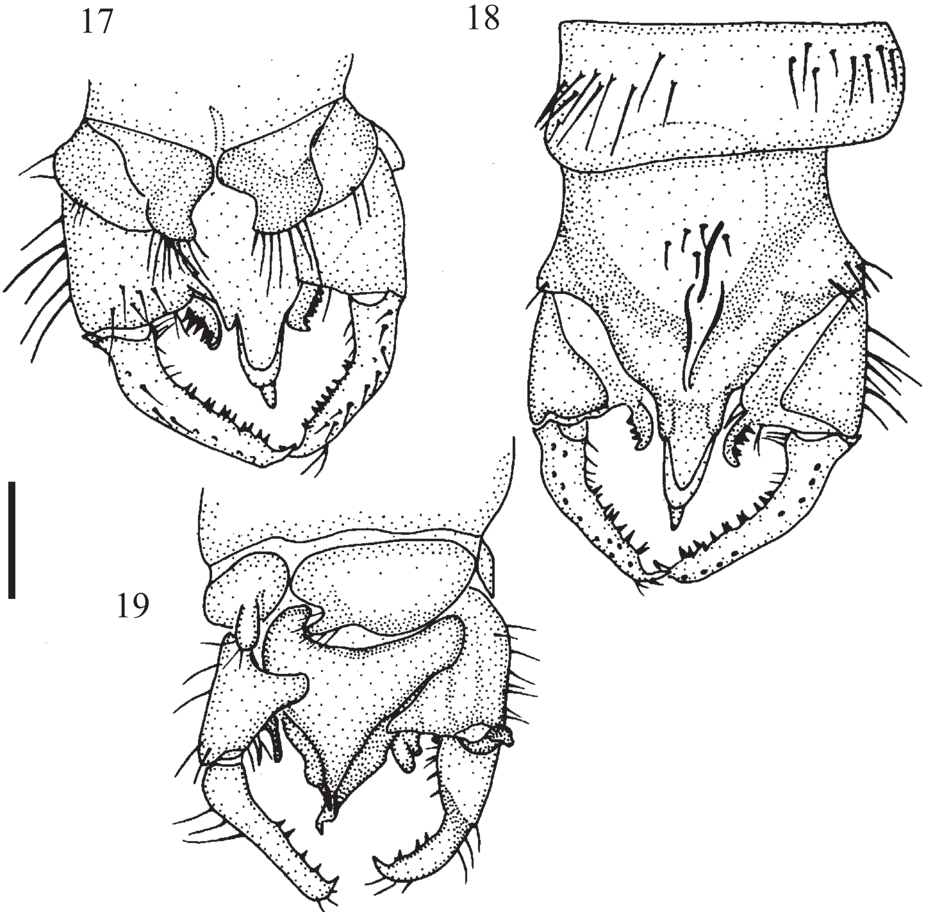
Measurements (mm). Wing length 2.4-2.6, wing width 0.7-0.8, halter 0.4, prehalter 0.2, fore leg: femur 1.0-1.05, tibia 1.0-1.3, tarsus 0.75:0.25:0.15:0.15:0.1, middle leg: femur 1.15-1.2, tibia 1.6-1.7, first tarsomere 0.8, hind leg: femur 1.2, tibia 1.5.

Remarks. In the holotype some portions of veins (base of Rs, M stem and distal portion of CuP) are desclerotized and R4 is interrupted (Fig. 6). However in both other specimens these parts are normally sclerotized, so the holotype could be teneral or aberrant.

In paratype N 258 peculiar ’knot’ near midlength of Rs marks the bend of this vein (similar ‘knot’ was recorded in *Eoptychoptera longifurcata* LUKASHEVICH, CORAM, JARZEMBOWSKI 2001: Fig. 2A).



Figs 9-16. Structures of *Leptychoptera* gen. nov. 9-12 – *L. vovkina* sp. nov. (holotype AMNH Leb-250): 9, 10 – proximal and distal portion of antennae, 11 – labelli and maxilary palp, 12 – tarsus of middle leg. Scale bar = 0.1 mm. 13-16 – *L. dimkina* sp. nov.: 13 – halter with prehalter (holotype N 198), 14 – thoracic sclerites and halter (paratype N 258), 15,16 – tibial spurs of fore and middle tibia (paratype N 258). Abbreviations: aem – anepimeron, b – transepimeral suture, cx – coxa, es – episternum, mpl – meropleurite, pt – pleurotergite, saf – subalifer.



Figs 17-19. Hypopygium of *Leptychoptera* gen. nov. Scale bar = 0.1 mm. 17, 18 – *L. dimkina* sp. nov.: dorsal and ventral view (holotype N 198). 19 – *L. vovkina* sp. nov.: dorsal view (holotype AMNH Leb-250). Scale bar = 0.1 mm.

In this specimen a fold along CuP is so deep that the anal lobe seems narrower (Fig. 7) than in the other specimens and the basal portion of CuP is not visible.

Leptychoptera vovkina sp.nov.

Figs 5, 8-12, 19.

Diagnosis. Vein *m-cu* runs into CuA in anterior half of wing. Legs very long (hind tibia nearly as long as wing). Bifid ventral process of gonocoxite without denticles (all these chracters distinguish this species fom *L. dimkina*, n. sp.).

Type material. Holotype: specimen AMNH Leb-250, male; Bcharre area, Caza Bcharreh, Mouhafazit Libnen El-Shimali, North of Lebanon; Lower Cretaceous; collection of American Museum of Natural History, New York.

Etymology. Arbitrary combination of letters.

Description. Clypeus convex, pilose. Prehalter large, only 2.5 times shorter than the halter.

Wing (Fig. 8). Sc terminating before midwing, level with CuA tip. R1 tip slightly proximad of M4 tip. R2+3 subequal to R3. R4+5 fork 3.7 times as long as R4+5 stem. mM1+2 2.6 times the length of bM1+2, bM3+4 twice longer than *m-cu*; *m-cu* runs into CuA in anterior half of wing.

Legs very long (hind tibia nearly as long as the wing).

Male hypopygium (Fig. 19) similar to that of *L. dimkina* sp. nov. but chitinized denticles on the bifid ventral processes are absent and submedian tergal lobes are narrow.

Measurements (mm). Wing length 2.7, wing width 0.8, antenna 2.25, halter 0.4, prehalter 0.15, fore leg: femur 1.3, tibia 1.5, tarsus 0.85:0.25:0.15:0.15:0.1, middle leg: femur 1.4, tibia 2.25, tarsus 1.05:0.25:0.15:0.1:0.1, hind leg: femur 1.5, tibia 2.5, first tarsomere 1.05, second tarsomere 0.25, abdomen length 1.8.

III. DISCUSSION

Detailed study of eoptychopterids from Lebanese amber has shown their amazing resemblance to Recent Ptychopteridae in many structures. The structure of the mouthparts (clypeus produced, maxillary palps elongate, labella large, labrum small and not sclerotized), antennae (scape and pedicel moderately large, first flagellomere largest, terminal very short) and legs as well as pubescence of antennae and thoracic sclerites of the new genus are very similar to those of *Ptychoptera* MEIGEN, 1803. Moreover, a prehalter (considered to be unique peculiarity of Ptychopteridae within Diptera: WOOD & BORKENT 1989) was found in *Leptychoptera* and so appears to be synapomorphous of (at least) Eoptychopterinae + Ptychopteridae.

Up to now the absence of discal cell was the only true apomorphy of Ptychopteridae when compared to Eoptychopteridae. The absence of transepimeral suture in the thorax was supposed to be the second ptychopterid apomorphy (LUKASHEVICH 1999); among eoptychopterids the suture was formerly recorded in Proptychopterininae and Eoptychopterininae, and now it is found in the third, nominate subfamily as well.

The absence of empodium (present in Ptychopteridae) as well as of basal swelling on the tarsomere IV could be characteristic of the new genus, but not of the subfamily or family as a whole, and is possibly associated with small size and advanced phyletic position of *Leptychoptera*. However, the last tarsomere was able to fold (Fig. 12) like in many Limoniidae. The so-called clasping organ of males is considered by HENNIG (1968) to be the only synapomorphy of Tanyderidae and Ptychopteridae. Its absence in Bittacomorphinae is assumed to be an apomorphy of this subfamily, connected with modification of legs; sometimes it is absent in representatives of *Ptychoptera* too, e.g. in *P. paludosa* MEIGEN, 1804 and *P. lacustris* MEIGEN, 1830 (pers. obs.). In the recent analyses of phylogenetic relationships in Diptera the capability of last tarsomere to be folded against penultimate one with clasping organ remains the only adult feature uniting Tanyderidae and Ptychopteridae (WOOD & BORKENT 1989; OOSTERBROEK & COURTNEY 1995). According to GRIFFITHS (1990), it is doubtful whether the character belongs to the ground plan of the Ptychopteridae.

In genitalic structure of *Leptychoptera* some characters have been found that seem to be plesiomorphic relative to those considered typical for Ptychopteridae, but most of them are recorded also in some ptychopterids and/or apomorphic one is known in the other eoptychopterid genera. The most important features are: abdominal segments not modified, gradually tapering and shortening, hypopygium not enlarged (not wider than preceding segments), with simple gonostyles and without lateral tergal lobes (surstyles, epandrial lobes, pseudoclaspers, projections; these terms were used by various authors) from the ninth tergite.

Unmodified abdomen with gradually tapering and shortening segments and compact hypopygium, unknown in Recent Ptychopteridae, was described also in two *Eoptychoptera* species from the Upper Jurassic of Kazakhstan (LUKASHEVICH 1993). However, elongate anterior abdominal segments, much shortened pregenital ones, and male genitalia broader than preceding segment cannot be apomorphies of Ptychopteridae, because such a condition is characteristic already of subfamily Proptychopterininae. In *Proptychopterina gracilis* LUKASHEVICH 1993 (Upper Jurassic of

Kazakhstan) and *P. yeniseica* LUKASHEVICH, 1993 (Middle Jurassic of Siberia) gonostyles (pubescent, without terminal spine, but with complex processes and chitinized denticles: LUKASHEVICH 1993, Fig. 5c) are very similar to those in recent *Ptychoptera*. The margin of the ninth tergite in *P. gracilis* is complicate, each tergal arm terminating with three tergal lobes, the mesal one being the largest and small lateral lobe setose. In *Leptychoptera* gen. nov. the subdivided tergite IX possesses two lobes with setae, but they are in middle position, so these structures do not seem to be homologous to the lateral ones. Therefore in both known cases Eoptychopteridae demonstrate the mesal tergal lobes better developed than the lateral ones.

In both subfamilies of Ptychopteridae lateral tergal lobes are present, being simple in Bittacomorphinae and, as a rule, more complex in Ptychopteridae. Usually they are comparable to gonostyles in size. However, some recent North American species of *Ptychoptera* show the ninth tergite without pronounced dominance of lateral lobes (ALEXANDER 1967, Figs 26-30), the condition not differing principally from that in Eoptychopteridae.

The structure of a hypopygium in *Crenoptychoptera antica* KALUGINA, 1985 remains uncertain. The abdominal segments are modified (first ones are longer and two pregenital several times shorter), hypandrium is doubtless enlarged, but other visible parts may represent either complex gonostyles with processes, or simple gonostyles plus simple surstyles (like in modern Bittacomorphinae). By the way, simple gonostyles, typical for Bittacomorphinae, occur also in Ptychopterinae as an exception (*P. japonica* ALEXANDER, 1913).

The new amber material had provided a 3D view of this Mesozoic group confirmed that Eoptychopteridae are very closely related to the extant Ptychopteridae and are undoubtedly ancestral for them; it had also demonstrated that very few non-wing characters distinguish these two families.

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