

New fossil findings of the mayfly genera *Balticobaetisca* Staniczek & Bechly, 2002 (Ephemeroptera: Baetiscidae) and *Borinquena* Traver, 1938 (Leptophlebiidae: Atalophlebiinae)

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The well preserved male imago of a new species, *Balticobaetisca stuttgartia* sp. nov., is described and illustrated from Baltic amber (Eocene). The new species is the second representative of the previously monotypic fossil genus *Balticobaetisca* Staniczek & Bechly, 2002, so far only known from the species *B. velteni* Staniczek & Bechly, 2002 from Baltic amber (Eocene). Simultaneously, the second record of the fossil species *Borinquena parva* Staniczek, 2003 from Dominican amber (Miocene) is presented. Complementary descriptions and illustrations of the studied specimens are given, and distinguishing characters and taxonomical data are discussed.

Keywords: *Balticobaetisca*; Baetiscidae; *Borinquena*; Eocene; Ephemeroptera; Leptophlebiidae; Miocene

Introduction

Staniczek and Bechly (2002) described a monotypic genus *Balticobaetisca*, the first fossil representative of the Baetiscidae from the Baltic amber (Eocene), a family with its recent distribution constrained to North America. *Balticobaetisca velteni* Staniczek and Bechly, 2002 was described from a female imago. Characters distinguishing this fossil species among extant Baetiscidae, and biogeographic and phylogenetical implications were also presented. A second fossil representative of the family Baetiscidae, namely *Protobaetisca bechlyi* Staniczek, 2007, was described from the Crato fossil beds of Brazil on the basis of a well preserved larva (Staniczek 2007, p. 182).

Staniczek (2003) published a wide contribution dealing with fossil mayflies of Atalophlebiinae Peters, 1980 (Ephemeroptera: Leptophlebiidae) from Dominican amber. Within this contribution, three new species of *Borinquena* Traver, 1938: *B. maculata* Staniczek, 2003, *B. parva* and *B. (?) caeciliana* Staniczek, 2003 were described. The diagnosis of *Borinquena* was redefined and the rank of this taxon was re-erected to the generic level. Also, relations between recent and fossil species of

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Borinquena and some species of the tribe *Hagenulini* were dealt with, and the taxonomic position of *B. (?) caeciliana* was discussed.

The aim of this paper is (1) to describe the new species *Balticobaetisca stuttgartia* sp. nov., and to present diagnostic characters distinguishing it from other fossil and extant representatives of the Baetiscidae; (2) to add new characters to the description of *B. parva* from Dominican amber and to discuss some distinguishing features and taxonomical data.

Materials and methods

Two pieces of amber containing inclusions of Ephemeroptera were made accessible to us, thanks to the kindness of Dr David Grimaldi from the American Museum of Natural History, NY, Dr Wolfgang Weitschat from the Geologisch-Paläontologisches Institut und Museum, Hamburg, and Mr. Jouzas Veilandas. The first one, Eocene Baltic amber, contained a male imago of the fossil genus *Balticobaetisca* Staniczek & Bechly, 2002 (family Baetiscidae Edmunds & Traver, 1954). The second, Dominican amber (Oligocene-Miocene), along with numerous dipterans of the Limoniidae and Sciaridae, comprised a well-preserved mayfly, undoubtedly belonging to *Borinquena parva* Staniczek, 2003 (family Leptophlebiidae Banks, 1900). Both specimens are described in this contribution.

The drawings were made by means of binocular microscope (Leica WILD M3Z) with camera lucida (WILD 308700), or directly from the camera pictures. Photographs were made in the Leica MZ FL III microscope with photo camera Leica DC 200. The morphological terminology follows Kluge (1994, 2004).

Taxonomy

Balticobaetisca stuttgartia sp. nov. (Baetiscidae) (Figures 1–5)

Material examined. Holotype: male imago in Baltic amber (Eocene), with well preserved body, visible from dorsal and partially from ventral side; housed in the Staatliches Museum für Naturkunde Stuttgart (Germany), SMNS BB-2394 (ex. coll. S. Urbonas, Klaipeda, Lithuania).

Diagnosis

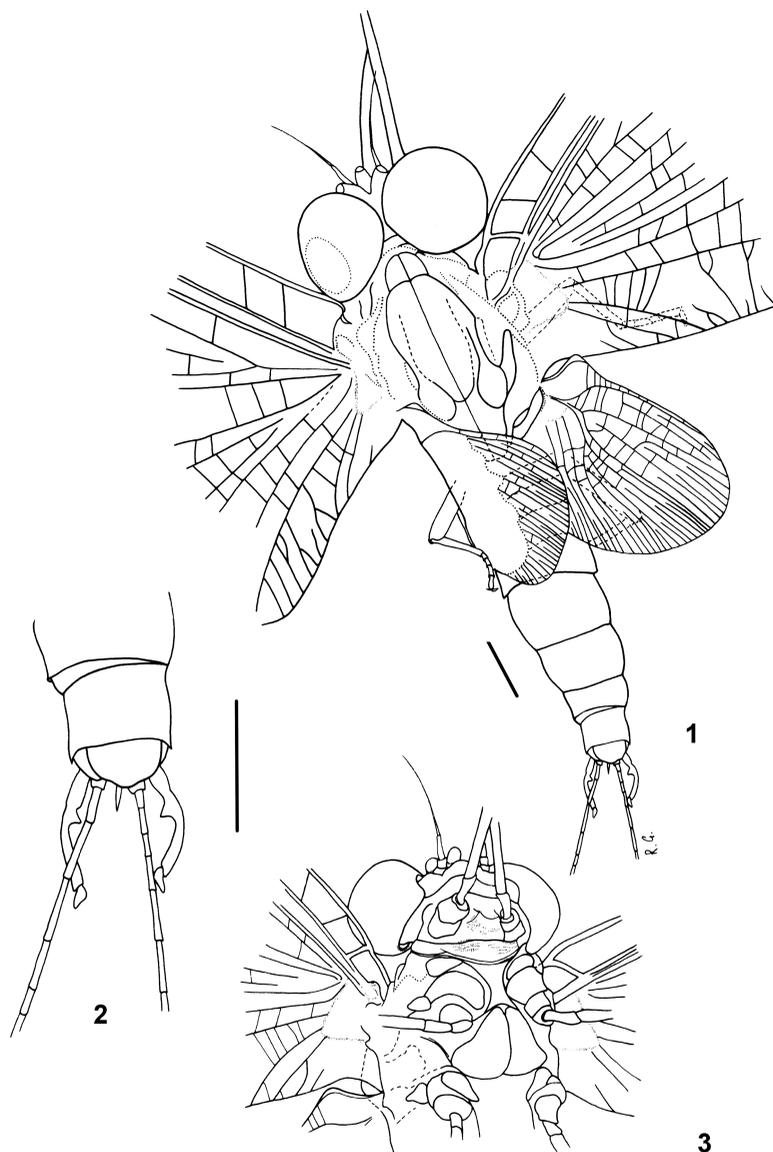
Male imago

B. stuttgartia sp. nov. can be distinguished from other representative of the genus *Balticobaetisca*, viz. *B. velteni* by a more prominent costal projection of the hind wings, and from extant species of *Baetisca* s. str., by an abdominal tergum VI without mid-dorsal transverse evaluation; first segment of forceps with distinct triangular projection on inner margin, and penis lobes clearly separated, tapered apically lobes, blunt at the tip.

Description

Male imago (Figures 1–5, measurements Table 1)

General body colour pale. Eyes large, almost contiguous dorsally, without any bands. Eyes indistinctly separated into two portions, ocelli well developed (Figures 1, 4 and 5).



Figures 1–3. *Balticobaetisca stuttgartia* sp. nov., male imago (holotype). (1) Body, dorsal view; (2) genitalia, dorsal view; (3) head and thorax, ventral view (without scale). Scale bars = 1 mm.

Prothorax reduced, almost covered by posterior part of eyes. Median part of prosternum with strong bispinate projection between bases of forelegs. Mesonotum slightly distorted due to embedding. Mesonotum massive with elongated medioscutum. Mesonotal suture distinct, almost transverse, medially stretched backwards. Furcasternal protuberances of mesosternum contiguous, without median impression (Figures 1, 3–5). Metanotum reduced.

Forewings hyaline, transparent, with slightly scalloped posterior margin. Hind wings nearly round. Costal projection well visible, distinctly prominent, apically blunt (Figures 1, 3). Wing venation occasionally poorly visible due to wings



Figures 4–5. *Balticobaetisca stuttgartia* sp. nov., male imago (holotype). (4) Body, dorsal view; (5) head and thorax, ventral view. Without scale.

imposition, but with typical baetiscid venation (Pescador and Berner 1981, p. 167, figures 2a, b; Staniczek and Bechly 2002, p. 8, figures 4, 6; Kluge 2004, p. 69, figures 17 A–C).

Forelegs nearly long as body. The segment ratio of forelegs to that of tibia: femora – 1.27; tibiae – 1.00; tarsus 1 – 0.71; tarsus 2 – 0.51; tarsus 3 – 0.46; tarsus 4 – 0.40; tarsus 5 – 0.32 (see the same for *Baetisca* s. l. in Pescador and Berner 1981,

Table 1. Morphometrics of male imago (holotype) of *Balticobaetisca stuttgartia* sp. nov. from Baltic amber (Eocene).

Characters	(mm)
Length of body	9.75
Length of right foreleg	8.30
Length of femur	2.25
Length of tibia	1.80
Length of tarsus	4.25
Segment I	1.25
Segment II	0.90
Segment III	0.85
Segment IV	0.70
Segment V	0.55
Length of left foreleg	8.20
Length of femur	2.20
Length of tibia	1.70
Length of tarsus	4.30
Segment I	1.25
Segment II	0.90
Segment III	0.85
Segment IV	0.70
Segment V	0.60
Length of right middle leg	3.03
Length of femur	1.15
Length of tibia	0.75
Length of tarsus	1.13
Segment I	0.25
Segment II	0.20
Segment III	0.20
Segment IV	0.18
Segment V	0.30
Length of left middle leg	2.98
Length of femur	1.13
Length of tibia	0.75
Length of tarsus	1.10
Segment I	0.25
Segment II	0.20
Segment III	0.20
Segment IV	0.15
Segment V	0.30
Length of right hind leg	3.50
Length of femur	1.40
Length of tibia	0.75
Length of tarsus	1.35
Segment I	0.30
Segment II	0.25
Segment III	0.25
Segment IV	0.20
Segment V	0.35
Length of left hind leg	3.49
Length of femur	1.35
Length of tibia	0.78
Length of tarsus	1.36
Segment I	0.30
Segment II	0.25

(continued)

Table 1. (Continued).

Characters	(mm)
Segment III	0.23
Segment IV	0.23
Segment V	0.35
Length of right forewing	11.75
Length of left forewing	11.60
Length of right hind wing	3.60
Length of left hind wing	3.55
Hind/Fore wings length ratio	0.31
Length of cerci	8.15

p. 167). Patella-tibial suture vestigial, present on middle and hind legs. Tarsi of all legs five-segmented. First tarsal segment of middle and hind leg fused with tibia, distinctly longer than second tarsomere. Tarsi of forelegs with similar, blunt claws, mid and hind legs dissimilar, with one hooked and one blunt claw.

Abdomen short and massive, distinctly tapered distally. Segments II–V relatively short, segments VI–VII enlarged and robust. Segment VI the largest. Tergum VI without middorsal transverse evaluation (Figure 1). Cerci well preserved, slightly shorter than body. Paracercus very short, non-segmented.

Forceps well preserved, two-segmented: segment 1 with distinct triangular projection on inner margin; distal segment short (Figures 1 and 2). Details of penis structure poorly visible from all sides, but we can confirm the presence of apically clearly separated and tapered penis lobes, blunt at the tip.

Etymology

The species epithet is a noun in apposition. It is named after the statue of Stuttgartia that symbolises the city of Stuttgart, where the holotype is housed in the Staatliches Museum für Naturkunde Stuttgart.

Relationships

B. stuttgartia sp. nov. beyond any doubts belongs to the genus *Balticobaetisca* within the family Baetiscidae by the combination of following features: (1) prosternum with prominent bispinate projection between legs bases (apomorphy of Baetiscidae); (2) forewing with full enlistment of branches and intercalaries between RS and CuP (see Kluge 2004, p. 68, figure 17B) (plesiomorphy of Baetiscidae); (3) nearly round hind wings (apomorphy of Baetiscidae); (4) structure of the legs, especially of tarsal claw (plesiomorphy of Baetiscidae); (5) tergum VI of abdomen without mid-dorsal transverse evaluation (plesiomorphy of *Balticobaetisca*); (6) rudimentary, non-segmented paracercus (apomorphy of Baetiscidae) (see Staniczek and Bechly 2002; Kluge 2004, pp. 68–69, figure 17).

The comparison of the new species with the previously described representative of the genus *Balticobaetisca* (i.e. *B. velteni*, described by a single female imago) is rather difficult, since the only available specimen of *B. stuttgartia* sp. nov. is a male imago. The possibility exists that the specimen described by us might belong to the species *B. velteni*, which has also been recorded in Eocene Baltic amber. However, to

confirm or reject this suggestion will only be possible if further evidence on the genus *Balticobaetisca* is available. At present we attribute the male described in this paper to a new species, *B. stuttgartia* sp. nov., which can be distinguished from *B. velteni* by a distinct and more prominent costal projection of the hind wings (compare with the figures in Staniczek and Bechly (2002)).

The new fossil species can be easily distinguished from all extant species of *Baetisca* s. l. by following distinguishing characters: (1) abdominal tergum VI without mid-dorsal transverse evaluation; (2) first segment of forceps with distinct triangular projection on inner margin; (3) penis lobes clearly separated and apically tapered, blunt at tip. When this list is supplemented with (4) even posterior sternal margin IX of female *B. velteni* (Staniczek and Bechly 2002, pp. 7–8, figure 10; Kluge 2004, p. 69), the genus *Balticobaetisca* is readily separated from all extant taxa of the family Baetiscidae.

Moreover, the male imago of *B. stuttgartia* sp. nov. markedly differs from the subgenus *Fascioculus* Pescador and Berner, 1981 (single species: *Baetisca* (*Fascioculus*) *escambiensis* Berner, 1955) by the lack of vertical bands of the eyes. From some representatives of *Baetisca* s. str. (namely, *B. becki* Schneider & Berner, 1963, *B. bernerii* Tarter & Kirchner, 1978, *B. carolina* Traver, 1931 and *B. rogersi* Berner, 1940) *B. stuttgartia* can be separated by hyaline fore and hind wings (Berner 1955; Pescador and Berner 1981; Staniczek and Bechly 2002).

***Borinquena parva* Staniczek, 2003 (Leptophlebiidae: Atalophlebiinae) (Figures 6–10)**

Borinquena parva Staniczek, 2003: 9, figures 13–19, 24c.

Material examined. Male imago Dr-6-110 in Dominican amber (Oligocene-Miocene, 15–45 Ma), housed in the American Museum of Natural History (New York City, USA). In the same piece of amber also imagines of Diptera: Limoniidae and Sciaridea are preserved.

Diagnosis (complementary to that of Staniczek 2003)

This fossil species markedly differs from three extant Puerto Rican and Cuban species of *Borinquena* by: (1) different size of body and wings, and contiguous medially eyes (in contrast to all extant species); (2) hind wing with well-developed costal projection and large distal part (in contrast to *B. carmencita* and *B. sexta*), and with two longitudinal veins (in contrast to *B. sexta* and *B. contradicens*); (3) styliiger plate well developed, widened apically, with distinct median incision on posterior margin (in contrast to all extant species); (4) penis lobes elongate, arranged widely apart, not narrowed apically, only slightly convergent in distal part, without subapical spines (in contrast to all extant species). *B. parva* can be easily separated from other fossil representative of the genus *Borinquena*, viz. *B. maculata* by the lack of subapical spines of penis lobes, not clouded cross veins of forewings and by the presence of cross veins in costal field of forewings.

Complementary description

Male imago (Figure 6)

Measurements: length of body – 4.73 mm; length of forewing – 4.38 mm; length of hind wing – 0.36 mm; maximum length of cerci – 10.5 mm; length of terminal

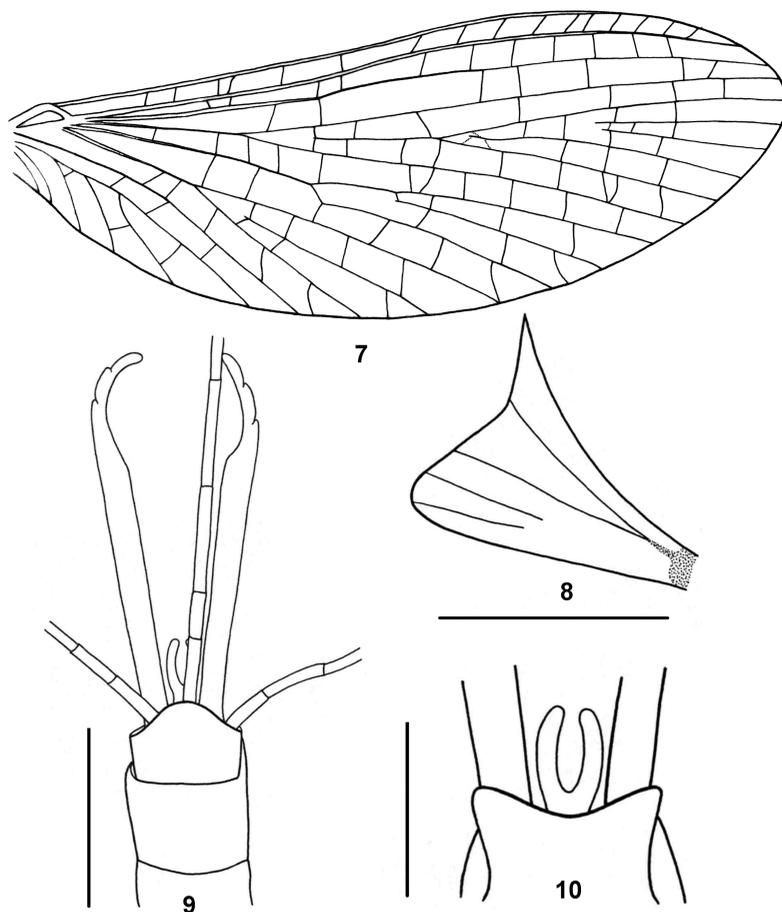


Figure 6. *Borinquena parva* Staniczek, 2003, male imago, American Museum of Natural History, New York City, USA, Dr-6-110. Body, dorsal view. Scale bars = 1 mm.

filament – 13.3 mm (same measurements are given in original description of Staniczek 2003).

General colour of body yellow to brown. Head light brownish. Eyes contiguous medially. Upper portion of eyes low with square facets, brownish; lower portion slightly darker, distinctly brown. Antennae brown.

Prothorax brownish. Mesonotum the darkest, dark brown with antelateroparapsidal suture distinctly brownish anteriorly. General characters of dorsal surface of mesothorax similar to those described in Atalophlebiinae and especially in *Hagenulini* Kluge, 1994 (see Tsui and Peters 1972; Kluge 1994); details of structure of ventral side of mesothorax poorly visible. Lateral and ventral surface of mesothorax brown. Metathorax generally brownish with slightly darker membranous pleural areas.



Figures 7–10. *Borinquena parva* Staniczek, 2003, male imago, American Museum of Natural History, New York City, USA, Dr-6-110. (7) Left forewing, dorsal view (without scale); (8) genitalia, dorsal view; (9) penis lobes, ventral view; (10) hind left wing, dorsal view. Scale bars: 8 = 0.5 mm, 9–10 = 0.25 mm.

Forewing translucent with brownish longitudinal and yellowish cross veins. Vein *MA* fork asymmetrical and vein *MP* fork symmetrical; *ICu* basally attached to vein *CuP* (characteristic for *Borinquena*) (Figures 6 and 7). Cross veins of forewing not surrounded with dark clouds. Hind wing translucent, small. Costal projection acute, long and well developed. Distal part of hind wing relatively large, well developed. Two longitudinal veins present (Figure 8).

Legs unicolourous, light brown. Patella-tibial suture distinct in all legs. Tarsi four-segmented. Claws dissimilar with one being hooked and another blunt.

Abdominal terga of light colour, generally yellowish-brown. Terga I–II with distinct reddish maculation. Terga VIII–X, and partly tergum VII brown. Sterna slightly paler than terga.

Styler plate well developed, widened apically, with distinct median incision on posterior margin (Figure 10). Forceps brownish, three-segmented, with very long

first segment (Figures 6 and 9). Inner margin of segment I of forceps with numerous short hairs. Last two segments of forceps very short. Penis lobes light brown, elongate, rounded and not narrowed apically, arranged widely apart, only slightly convergent in distal part. Subapical spines absent (Figures 9 and 10). Details of ventral part of styliger plate and surface of penis lobes hard visible. Caudal filaments light brown, fully preserved.

Remarks

Traver (1938) designated the genus *Borinquena* (Leptophlebiidae: Atalophlebiinae) for two extant species described from Puerto Rico, viz. *B. carmencita* Traver, 1938 and *B. contradicens* Traver, 1938. Peters (1971, p. 27) described *B. traverae* Peters, 1971 from Dominica and attributed it to a separate subgenus *Australophlebia* Peters, 1971 characterised by lack of hind wings. Besides, the author noted two other undescribed species of *Australophlebia* from St. Lucia in the collections of Traver (Peters 1971, p. 25). McCafferty (1985) mentioned two undescribed recent species of *Borinquena* (*Australophlebia*) from Costa Rica. Kluge (1994), revising the Cuban species of the family Leptophlebiidae Banks, 1900, designated *Borinquena* as subgenus of the genus *Hagenulus* Eaton, 1882 and described *Hagenulus* (*Borinquena*) *sexta* Kluge, 1994 from the eastern part of the island. That detailed description included the depiction of characters and illustrations of larvae and reared subimagines and imagines. He also described two new subgenera of *Hagenulus* s. l. At the same time, *Careospina*, *Traverina* and *Borinquena* originally being described as separate genera, were designated by him as subgenera. The author also noted the problematical taxonomic status of *Australophlebia*. Hofmann and Peters (1999) synonymised *Australophlebia* with *Hagenulopsis* Ulmer, 1920. Finally, Staniczek (2003) redefined the diagnosis of *Borinquena*, re-erected it to the generic level and described three fossil species from Dominican amber (see above). Fossil records of this genus were formally presented for the first time by Staniczek (2003). Earlier, Poinar (1992) recorded the representatives of the family Leptophlebiidae in Dominican amber, namely the genera *Borinquena* and *Hagenulus* (*Careospina*).

Staniczek (2003, p. 22) analysed the morphological details of the fossil *Borinquena* species and commented on some imaginal distinguishing characters previously described by Peters (1971) and Kluge (2004). He also discussed the plesiomorphies in the genitalia of *B. parva*, i.e. penis lobes not tubular, parallel and partly fused, deprived of subapical spines (Staniczek 2003, pp. 13, 17).

The characters of the male imago that distinguish it from *B. parva* are summarised in the diagnosis.

The systematic position of some earlier described fossil taxa of Leptophlebiidae is still unclear, and records of Atalophlebiinae in fossil remains are rare. Demoulin (1968, p. 267, figure 34) described a subimaginal exuvium from Baltic amber (Eocene) and tentatively attributed it to the genus *Choroterpes* Eaton, 1881 (Leptophlebiidae). However, the author did not present convincing arguments for its placement within the Atalophlebiinae Peters, 1980. In all probability the Pliocene *Atalophlebia culleni* (Etheridge & Olliff 1890), originally described as *Ephemera culleni*, in fact belongs to the subfamily Atalophlebiinae (Hubbard and Savage 1981, p. 810).

McCafferty (1997, p. 78, figures 1–7) described the monotypic genus *Conovirihus* McCafferty, 1997 (type species *C. poinari* McCafferty, 1997) from a single specimen

from Lower Cretaceous Lebanese amber (120–135 Ma). The diagnosis of the genus was based particularly on the characters of hind wing, middle and hind legs, genitalia and partly on head characters. All illustrations and descriptions are apparently typical of leptophlebiid-like species, although it is impossible to determine exactly the systematic position of *Conovirilus*, because there are no venation characters of the forewings and no details in structure of thorax and eyes available. Peters and Peters (2000) proposed that if the genus *Conovirilus* really belongs to Atalophlebiinae, it is not close to *Atalophlebioides* lineage, as McCafferty (1997) has considered, but rather close to the *Terpides* lineage sensu Savage (1986) and Peters (1997).

The systematic position of two other genera attributed to this subfamily (*Xenophlebia* Demoulin, 1968 and *Blasturophlebia* Demoulin, 1968) is obscure (see Demoulin 1968, p. 267, figures 35a–e, 268, figures 36a–f; Hubbard and Savage 1981). Kluge (1993, p. 49) supposed *Xenophlebia* to belong to the Siphonuridae Banks, 1900 (s. l.) and *Blasturophlebia* to Leptophlebiidae or Ephemeroidea Latreille, 1870.

Thus, at present only five nominal fossil species and four genera (only *Hagenulites* is known exclusively from fossil remains) are recorded for the Atalophlebiinae (Hubbard and Savage 1981; Hubbard 1987; Poinar 1992; Staniczek 2003). Additionally, Rossi-de-Garcia (1983) described the larva of *Atalophlebia* sp. from the Ventana formation (Eocene of Argentina).

The finding of *Borinquena* in Dominican amber (15–45 Ma) is not surprising, since all modern species of this genus are known only from West Indies. The discovery of fossil taxa in Dominican amber (Poinar 1992; Staniczek 2003) indicates the existence of separate taxa of *Hagenulus* s. l. at least in early Miocene (15 Ma). Thus, the differentiation of *Hagenulini* Kluge, 1994 must have taken place earlier, probably in the early Tertiary or late Cretaceous (about 45–80 Ma). Peters (1997, p. 453) assumed the splitting of Leptophlebiinae and Atalophlebiinae took place in the early Cretaceous (about 135 Ma). The finding of *Conovirilus* in Lebanese amber corroborates this hypothesis. Representatives of Leptophlebiinae already existed in the Turonian period and in the Upper Cretaceous (92 Ma), which is confirmed by the description of *Aureophlebia sinitschenkova* Peters & Peters, 2000 from New Jersey amber (Peters and Peters 2000, p. 128, figures 1a–f).

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