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Bucculatrix rycki – the first fossil adult Ribbed Cocoon Maker Moth (Bucculatricidae, Lepidoptera)

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Abstract

An adult of a Ribbed Cocoon Maker Moth (Bucculatricidae) from Eocene Baltic amber is described as a new species (*Bucculatrix rycki*). This is the first description of a fossil adult of this microlepidopteran family, but previous evidence for this family comes from typical leaf mines in fossil leaves that provide evidence dating to the Upper Cretaceous. The minimal geological age for this adult specimen is here confirmed to be at least upper Eoceneand likely middle Eocene based on stratigraphic evidence. A putative host-plant range of the fossil taxon is proposed, based on host-plant records of extant species of the genus in association with paleobotanical data from Baltic amber.

Key words: Baltic amber, color preservation, Eocene, leaf mining, minimal geological age

Zusammenfassung

Ein fossiler Zwergwickler (Bucculatricidae) wird als neue Art *Bucculatrix rycki* aus dem Eozän des Baltischen Bernsteins beschrieben. Es scheint die erste Beschreibung eines fossilen Adulten dieser Familie von Mikrolepidopteren zu sein, aber es gibt Nachweise dieser Familie durch ihre typischen Minen in fossilen Blättern, die bis in die obere Kreide zurückreichen. Das minimale geologische Alter durch direkten Nachweis eines Imagos wird also mindestens für das obere Eozän und, nach stratigraphischen Daten, wahrscheinlich auch für das mittlere Eozän bestätigt. Ein mögliches Wirtspflanzenspektrum des fossilen Taxons wird diskutiert, basierend auf Wirtspflanzenspektren rezenter Arten im Vergleich zu paläobotanischen Daten für den Baltischen Bernstein.

Schlüsselwörter: Baltischer Bernstein, Blattminierer, Eozän, Farberhaltung, minimales geologisches Alter

1. Introduction

Bucculatricidae is a small family of ditrysian microlepidoptera with leaf-mining early larval stages which become external feeders in later instars (Davis & Robinson 1999; Scoble 1995). This family (superfamily Gracillarioidea) comprises 297 species in four genera (van Nieukerken et al. 2011); the majority of the species are included within its major genus, *Bucculatrix*. The spindle-shaped ribbed cocoon for pupation is typical of the species and the source of the family common name. The adults often fly in the evening during sunshine (Sterling & Parsons 2012). Their leaf-mining activities in crop plants are of some economical relevance, but host-plant damage usually is not serious. The monotypic genus *Leucoedemia*, in contrast, has a larva which lives in galls (*L. ingens*, formerly *Bucculatrix ingens*, Scoble & Scholtz 1984).

The fossil record of Bucculatricidae currently comprises only fossil leaf mines (summarized in Sohn et al. 2012). The oldest evidence comes from mines in *Platanus* leaves of the Turonian (Upper Cretaceous) of Kazakhstan (Kozlov 1988). From the Cenozoic there are only few reports on leaves with Bucculatricidae-type mines, namely on *Quercus* leaves from the late Eocene Florissant Beds (Colorado) (Opler 1982) and possibly also from the late Eocene of the White Lake Basin of British Columbia (Freeman 1965), from Middle Miocene *Quercus* leaves from Buffalo Canyon (Nevada) (Opler 1973), and from the Pliocene of Willershausen (Germany) on *Tilia* leaves (Brauckmann et al. 2001).

A first fossil Bucculatricidae adult is described here that is preserved in Eocene Baltic amber and shows color pattern preservation of wing scales, hence allowing some comparisons with extant genera.

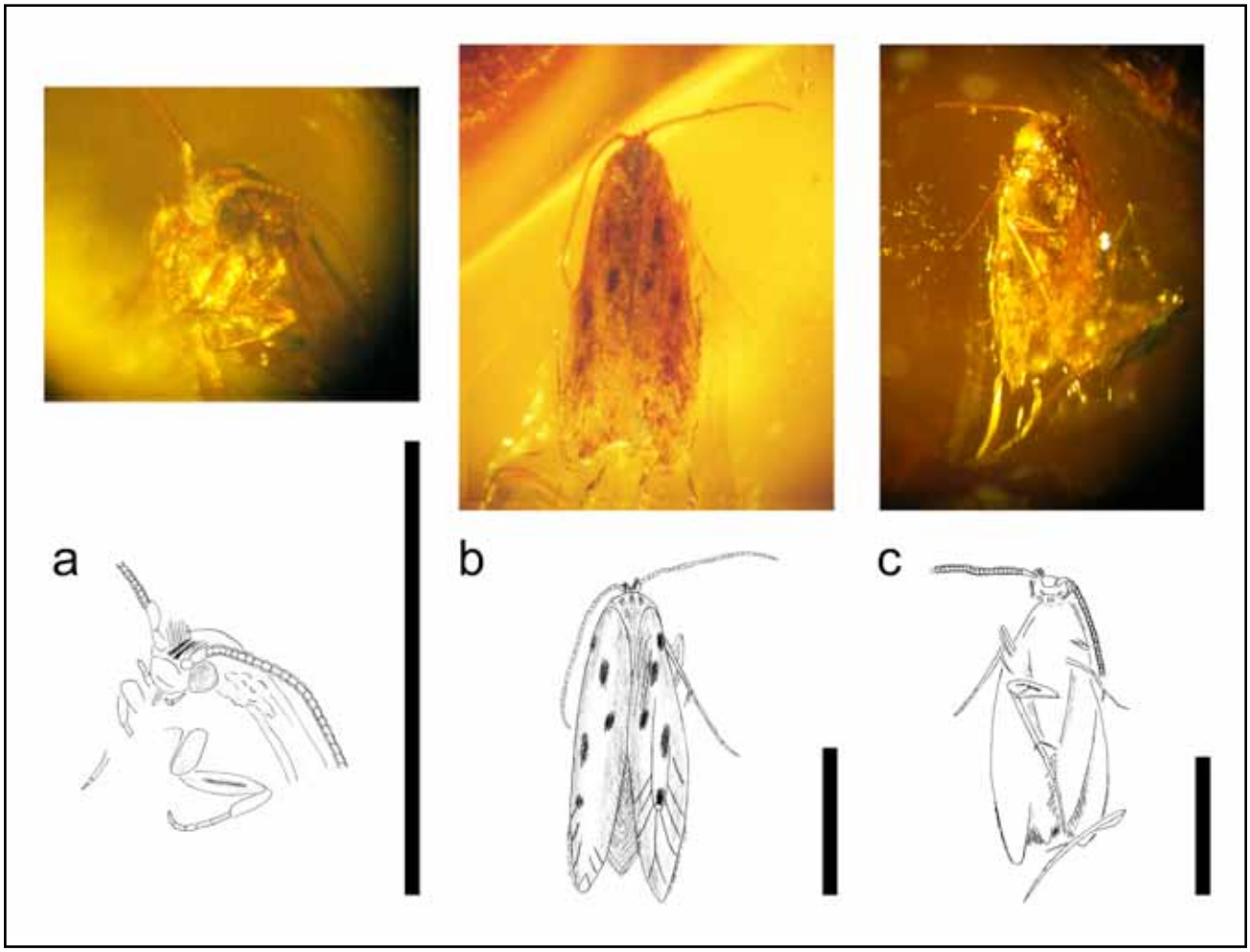

Figure 1: *Bucculatrix rycki* nov. sp. **(a)** Front view of head; **(b)** dorsal view; **(c)** ventral view. Scale bars = 1 mm.

2. Material and methods

The specimen from Baltic amber with the inclusion was made available by Walter Ludwig (Oberesslingen). The inclusion was photographed using a binocular microscope (Zeiss) and a digital camera system (Canon Model Ixus). The amber specimen was trimmed by sawing and subsequent polishing, both done in a wet state. It was treated with an acryl varnish and is kept in the author's collection with the number 5985.The specimen is kept at constant temperature in plastic containment within a metal box that excludes oxygen and light, and will be made available for researchers via the Bayerische Staatssammlung für Paläontologie und Geologie (BSPG) in Muncih, Germany.

3. Systematic paleontology

Systematics based on van Nieukerken et al. (2010).

Order Lepidoptera Linnaeus, 1758
Clade Ditrysia Börner, 1925
Superfamily Gracillarioidea Stainton, 1854
Family Bucculatricidae Fracker, 1915
Genus Bucculatrix Zeller, 1839

Species *Bucculatrix rycki* nov. sp.
Fig. 1

Holotypus: Specimen ex coll. Fischer no. 5985

Locus typicus: Amber mine of Yantarni, Russia

Stratum typicum: "Blaue Erde" (middle – upper Eocene)

Etymology: The epithet *rycki* is chosen to acknowledge the merits of Uwe Ryck with his manifold activities for the Bayerische Staatssammlung für Paläontologie und Geologie.

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Diagnosis: Total length 2.6 mm; Front wing lanceolate with acute wing tip; hindwing more narrow, length 2,25 mm, breadth 0,44 mm, four brown colour marks positioned as follows: two colored spots

along proximal part of vein A, one spot at the centre of the cell, and one at the distal end of it, distal half with individually large scales, termen with long cilia of 200 µm maximal length, distal part of costa with shorter cilia, wing apex without cilia, venation consisting of Sc, R1, R1 - R4, R4 ending before the apex, M, CuA, CuP and 1A + 2A with a basal branch; prothorax 310 µm long, 465 µm broad, with a transverse series of scales.

Legs: Length of femur plus tibia and tarsus of front legs 1.2 mm, spur formula 0-2-4, well developed epiphysis on front leg tibia close to the joint with its femur; five tarsomers present.

Antenna: Filiform, 1,05 mm long, ringed, with upwards-directed cilia organized in tiny whorls, 25 to 28 flagellomers (most distal flagellomers only partially preserved at both antennae), scape long and enlarged, antennal pedicel with a notch, antennal length little more than half the length of front wings.

Head: head slender, eyes small (75 µm in diameter), proboscis very thin and short (less than 50 µm), frons extending below eyes and limited by an upper and lower edge, vertex with two longitudinal folds, rows of hairs at antennal bases

Mouthparts: labial palps minute and directed forwards and curving upwards terminally, three-segmented, maxillary palps only present as knobs. (The ventral space between lower part of the head and the prothorax is covered by an air bubble.)

Thorax: Vestiture consists of a covering of large scales.

Abdomen: Flat, covered with scales, abdomen terminus hidden by a ring of piliform scales which renders sex determination difficult. Ventral side of the abdomen is partially hidden behind clusters of loose scales.

Differential Diagnosis: The antennal pedicel shows the characteristic notch in *Bucculatrix* (Parenti 2001: fig. 24); the frons is smooth and extends well below the eyes, and is limited by an upper and lower edge (possibly by desiccation, resulting in collapsed eye). The vertex shows two shield-like structures (pilifers?) and an enlarged scape as in *Bucculatrix* (Davis & Robinson 1999).

In comparison to the general description of Bucculatricidae given by Davis and Robinson (1999: fig. 7.7 K), there are some differences in wing venation, R4 ends before the apex, and 1A + 2A possess a basal branch.

As in *Leucoedemia*, the present taxon has three-segmented labial palpi, extant *Bucculatrix* possess reduced, one-segmented labial palpi.

Description: The micromoth with 2.6 mm length falls into the lowest size range of Baltic amber Lepidoptera, being little larger than the smaller Nepticulidae. Apart from its conspicuous size, the head is quite characteristic with its small eyes, enlarged cap-like antennal bases, with a slender form and prolonged scape. Fore legs are disarticulated or lost in this specimen. By contrast, its complete color pattern preservation of both wings is a rare exception. Some small particles of detritus are preserved as syninclusions.

4. Discussion

Identification of the Baltic amber moth inclusion as a member of Bucculatricidae is suggested primarily by its small size and habitus, but is also supported by a specific combination of characters. These characters are mainly the antennal scape with a characteristic notch, antennal eye-cap, and a strongly reduced proboscis with short galeae. However, in *Bucculatrix* the labial palps are reduced to one segment (Davis & Robinson 1999). In contrast, *Leucoedemia* has three-segmented labial palps as in this fossil. Beyond this feature, *Leucoedemia* possesses a scape that lacks a notch, the head is not tufted and the imagos are much larger, having a wingspan of 14 mm (Scoble & Scholtz 1984). The fossil is interpreted in the most parsimonious way as a member of the genus *Bucculatrix*. The three-segmented labial palps of the fossil putatively represent the primitive state, and they are not drooping as in extant *Bucculatrix* and *Leucoedemia*. It also may be possible that this species represents an undescribed genus.

This fossil adult from Baltic amber seemingly is the first direct paleontological evidence of the genus *Bucculatrix* and the family Bucculatricidae, confirming a minimal geological age of upper Eocene and more likely a middle Eocene date for both (Labandeira 2014). *Bucculatrix*-type leaf mines, however, do indicate a much earlier age of the group of Upper Cretaceous (Turonian) (Kozlov 1988). Other families of Lepidopteran leaf miners reported from Baltic amber on base of adults are Nepticulidae (Fischer 2013), Heliozelidae, Adelidae, Incurvariidae, Gracillariidae, Lyonetiidae, Elachistidae, and subgroups of Gelechiidae (Skalski 1976; Scoble 1995; Sohn et al. 2012). *Prolyonetia cockerelli* had been compared with *Bucculatrix* and *Oenophila* (Kusnezov 1941), but these are no longer placed in Lyonetiidae (Sohn et al. 2012).

The late description of a *Bucculatrix* imago seems due to two factors, their general diminutive size and their rarity, the latter possibly also caused by an under-representation of moths below 3 mm among available amber inclusions. From the author's collection of Lepidoptera from Baltic and Bitterfeld amber used for this work, the discovery of a bucculatricid specimen is an isolated finding; its frequency is only one in 650 specimens (0.15%).

Based principally on the favourable color preservation of the wings, a comparison with extant species of the genus *Bucculatrix* was performed. For extant species which are representative and somewhat similar to the fossil one (meaning largely not of uniform wing color) an association of their host.

Table 1: Selected extant species of *Bucculatrix* with similarities in wing color pattern, in association with their host plants and related plant taxa known from fossil record of Baltic amber. Data from (1) Schütze (1933), (2) Biesenbaum (2010), (3) Lepiforum (accessed March 2015), (4) UK Moths, and (5) Spahr (1993).

Extant species	Similar color pattern	Host plants	References	Plant taxa in Baltic amber	Ref.
Bucculatrix cidarella	+	*Alnus glutinosa* (Betulaceae), *Myrica gale* (Myricaceae)	(1, 2, 3, 4)	*Alnus* sp. (Betulaceae), *Myrica* sp. (Myricaceae)	(5)
Bucculatrix ulmella	+++	*Quercus* sp. (Fagaceae), *Ulmus* sp. (Ulmaceae), *Sorbus* sp. (Rosaceae)	(1, 2, 3, 4)	*Quercus* sp. (Fagaceae), *Ulmus* sp. (Ulmaceae), Rosaceae	(5)
Bucculatrix albedinella	+++	*Ulmus minor* (Ulmaceae)	(1, 2, 3, 4)	*Ulmus* sp.(Ulmaceae)	(5)
Bucculatrix bechsteinella	++	*Crataegus* sp., *Pyrus sp., Malus* sp., *Sorbus* sp. (Rosaceae), *Hippophae* sp. (Elaeagnaceae)	(1, 2, 3, 4)	Rosaceae, *Eleagnus* sp.	(5)
Bucculatrix nigricomella	+	*Potentilla* sp. (Rosaceae), *Leucanthemum vulgare* (Asteraceae)	(1, 2, 3, 4)	Rosaceae, Compositae	(5)
Bucculatrix thoracella	++	Acer sp. (Aceraceae), *Aesculus* sp. (Hippocastanaceae), *Tilia* sp. (Tiliaceae), *Carpinus* sp. (Betulaceae)	(1, 2, 3, 4)	Acer sp. (Aceraceae), *Aesculus* sp. (Hippocastanaceae), *Tilia* sp. (Tiliaceae), *Carpinus* sp. (Betulaceae)	(5)
Bucculatrix frangutella	+++	*Frangula alnus, Rhamnus cathartica* (Rhamnaceae)	(1, 2, 3, 4)	*Rhamnus* sp. (Rhamnaceae)	(5)
Bucculatrix rhamniella	+	*Rhamnus cathartica* (Rhamnaceae)	(1, 3)	*Rhamnus* sp. (Rhamnaceae)	(5)
Bucculatrix maritima	++	*Aster tripolium* (Asteraceae)	(1, 3, 4)	Compositae	(5)
Bucculatrix cristatella	+	*Achillea millefolium* (Asteraceae)	(1, 2, 3, 4)	Compositae	(5)
Bucculatrix absinthii	+	*Artemisia absinthium* (Asteraceae)	(1, 2, 3)	Compositae	(5)
Bucculatrix artemisiella	+++	*Artemisia campestris* (Asteraceae)	(1, 2, 3)	Compositae	(5)
Bucculatrix noltei	++	*Artemisia campestris* (Asteraceae)	(1, 2, 3)	Compositae	(5)
Bucculatrix gnaphaliella	+++	*Helichrysum* sp. (Asteraceae)	(1, 2, 3)	Compositae	(5)
Bucculatrix demaryella	++	*Betula* sp.,, *Corylus* sp. (Betulaceae), *Castanea sativa*(Fagaceae)	(2, 3, 4)	*Corylus* sp. (Betulaceae), *Castanea* sp. (Fagaceae)	(5)

plants was made that includes evidence for Baltic amber plant-feeding relationships (Tab. 1). By using this approach, the availability of data for extant species may have a bias towards selection of species from well-investigated boreal regions. The most similar extant species with respect to wing color pattern were (1) *Bucculatrix ulmella* and *B. albedinella* (online resource NK Moths) which infest *Quercus* oaks), *Ulmus* (elms), and *Sorbus* (mountain ashes), (2) *Bucculatrix frangutella* found on *Rhamnus* and *Frangula* (Rhamnaceae, buckthorns), and (3) *Bucculatrix artemisiella* and *B. gnaphaliella*, both of which live on *Artemisia* (wormwood) and *Helichrysum* (strawflower) (Asteraceae, composites). These

plant families are known from Baltic amber, even though they are only represented by pollen records in most cases. Among these potential plant hosts, *Quercus* remains are most abundant in Baltic amber and are represented by a large number of species, indicated by the citations listed in Spahr (1993). Its abundance as a putative host plant, however, is an obvious contrast to the rarity of Eocene *B. rycki*. If rarity is not biologically based, which seems unlikely for a leaf mining species, it may also be caused by a taphonomic bias against preservation of such inclusions (Sohn et al. 2015). The single specimen could have originated from outside the Baltic amber local forest habitat, occurring as rare arial plankton. However, the host-plants of the most similar extant species of *Bucculatrix* seem good candidates for inferring the probable host-plant of the fossil species. *Quercus* (Fagaceae), *Ulmus* (Ulmaceae), *Rhamnus* (Rhamnaceae), as well as *Artemisia* and *Helichrysum* (Asteraceae) are all dicotyledonous plants that, like most of the extant host plants of *Bucculatrix*, do not provide much information on a distinct habitat, as these plant taxa have growth forms that include trees (*Quercus*, *Ulmus*), shrubs (*Rhamnus*), and also herbs (Asteraceae).

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