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Water ferns *Azolla* spp. (Azollaceae) as new host plants for the small China-mark moth, *Cataclysta lemnata* (Linnaeus, 1758) (Lepidoptera, Crambidae, Acentropinae)

ATOUSA FARAHPOUR-HAGHANI^{1,2}, MAHDI HASSANPOUR¹, FARAMARZ ALINIA²,
GADIR NOURI-GANBALANI¹, JABRAEIL RAZMJOU¹, DAVID AGASSIZ³

1 University of Mohaghegh Ardabili, Faculty of Agriculture and Natural Resources, Department of Plant Protection, Ardabil, Iran

2 Rice Research Institute of Iran (RRII), Agricultural Research, Education and Extension Organization (AREEO), Rasht, Iran

3 Department of Life Sciences, Natural History Museum, London SW7 5BD, England

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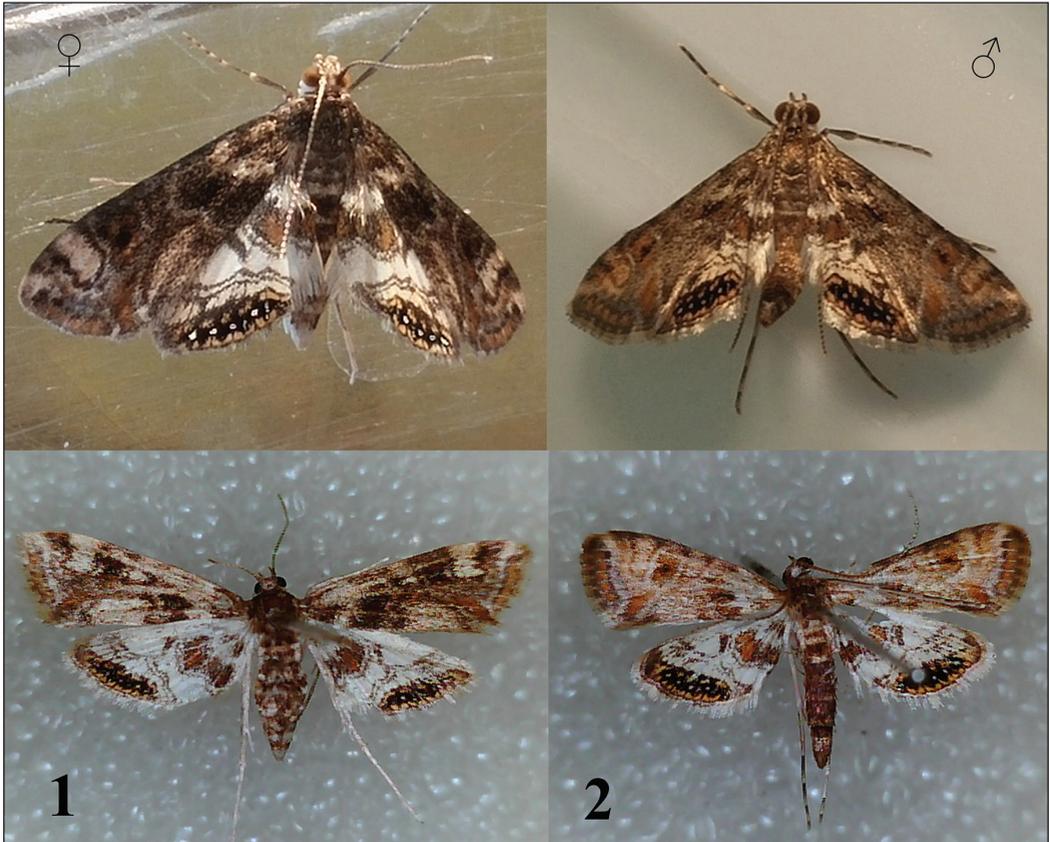
Subject Editor: Bernard Landry.

Abstract. Water ferns (*Azolla* spp., Azollaceae) are reported for the first time as host plants for the larvae of the small China-mark moth *Cataclysta lemnata* (Linnaeus) (Lepidoptera: Crambidae: Acentropinae) in rice fields and waterways of northern Iran. *Cataclysta lemnata* is a semi-aquatic species that has been recorded to feed on Lemnaceae and a few other aquatic plants. However, it has not been reported before on *Azolla* spp. Larvae use water fern as food source and shelter and, at high population density in the laboratory, they completely wiped water fern from the water surface. Feeding was confirmed after rearing more than eight continual generations of *C. lemnata* on water fern in the laboratory. Adults obtained this way are darker and have darker fuscous markings in both sexes compared with specimens previously reported and the pattern remains unchanged after several generations.

Introduction

Cataclysta lemnata (Linnaeus) is a small semi-aquatic moth belonging to the Crambidae subfamily Acentropinae. Acentropinae, previously known as Nymphulinae, are distributed worldwide and reach their highest diversity in tropical regions of South East Asia/Malaysia and in the Neotropical Region (Mey and Speidel 2008). Until 2008, a total of 50 genera and 737 described species were assigned to this subfamily and 23 new species were described from Africa in 2012 (Mey and Speidel 2008; Agassiz 2012). Nuss et al. (2016) list 745 species in 75 genera. Most of the Acentropinae species have aquatic larvae and in some species, e.g. *Parapoynx stratiotata* (Linnaeus), the larvae have gills for breathing under water (Hasenfuss 1960).

The genus *Cataclysta* was described by Hübner, 1825 with *Phalaena (Geometra) lemnata* Linnaeus, as the type species. There are 18 described species assigned to this genus (Nuss et al. 2016) and the full synonymy of *C. lemnata* is given by Speidel (2005). *Cataclysta lemnata* is sexually dimorphic (Figs 1, 2). The morphological characteristics of each sex have been described by Speidel (1984), Goater (1986), and Speidel (2005).



Figures 1–2. *Catachysta lemnata* adults. **1.** Female; **2.** Male (live specimens above and prepared specimens below).

Azolla Lamarck is a genus of aquatic ferns and small-leaved floating plants divided into two subgenera: *Euazolla*, containing five species, and *Rhizosperma* with two species (Raja *et al.* 2012). Different species of *Azolla* provide various benefits such as organic nitrogen source, soil improvement and nutrient availability, weed suppression, food source for livestock, chickens, ducks and fishes (Anonymous 1987; Ferentinos *et al.* 2002). However, some of the species, such as *Azolla filiculoides* Lamarck and *Azolla pinnata* R. Brown (e.g. Barreto *et al.* 2000) are considered as major weeds in South Africa, Europe, and New Zealand (Hill 2003; Bodle 2008; Sadeghi *et al.* 2013a).

Azolla filiculoides is native to the tropics, subtropics, and warm temperate regions of Africa, Asia, and the Americas (Costa *et al.* 2009), while *A. pinnata* is native to a large area of the tropics, subtropics, and warm temperate regions of Africa, Asia, and Australia (Sweet and Hills 1971; PIER 2007; Pemberton and Bodle 2009). Both species, and in particular *A. filiculoides*, are among the world's fastest growing aquatic macrophytes, with a doubling time in biomass of only 2–5 days (Zimmerman 1985; Taghi-Ganji *et al.* 2005).

In Iran, *A. filiculoides* is considered an alien species (JICA 2005; Delnavaz and Azimi 2009). Although the presence of another species is not yet confirmed, it seems that there is more than one *Azolla* species in some areas (Figs 3, 4). The Anzali and Amir-Kelayeh wetlands are two ecologi-



Figures 3–4. *Azolla* spp. in natural habitats that seem to represent different species. **3.** Different coloration of *Azolla* spp. in natural habitats; **4.** Different size and shape of each type.

cally important natural habitats in the north of Iran for breeding, wintering, and survival of many species of birds, fishes, and micro-organisms (Khoshechin 1993; Naddafi et al. 2005; Charkhabi and Sakizadeh 2006; Moradinasab et al. 2012). The invasion of *Azolla* into these wetlands (Delnavaz and Azimi 2009; Sadeghi et al. 2013a) is of concern because infestations reduce the quality of the water used for agriculture and humans, and simplify local aquatic food webs (Hill 1998). In addition, in rice fields with a poor drainage system this annoying weed could become problematic in transplanting rice-culturing systems because dense masses cause seedling death by covering the young seedlings and force the farmers to transplant anew.

Stenopelmus rufinusus Gyllenhal (Coleoptera: Curculionidae), a weevil native to the USA, has had a huge impact on *A. filiculoides* as a biological control agent in Africa, USA, and some other regions (Hill *et al.* 2008; Partt *et al.* 2013). However, due to the various positive and negative effects of other active herbivores on *Azolla* as biotic resistance factors and competitor species to the main biological agents, the identification of other active herbivores on *Azolla* was found to be desirable. Mechanical methods for control of water fern in Iran are impractical and there are no registered safe herbicides for aquatic ecosystems either. Therefore, control options for this obnoxious weed in Iran are limited. This situation stimulated the use of biological control as a sustainable strategy for the long-term management of *Azolla* spp. (Richerson and Grigarick 1967; McConnachie *et al.* 2003). We conducted surveys in rice fields over two years due to a lack of information on local herbivores attacking *Azolla* spp. in Iran, and the specific objective of this paper is to report the life history of *C. lemnata* attacking *Azolla* spp. in Iran.

Material and methods

Rearing: Laboratory colonies were established by collecting larvae and pupae from water fern collected in the Anzali (N 37°28'16", E 49°27'44") and Amir-Kelayeh (N37°20'35" E50°11'27") wetlands, waterways and experimental rice fields at the Rice Research Institute of Iran (RRII) (N 37°12'22.2", E 49°38'40.7", 80 m) from September to November 2014 and 2015.

Larvae and pupae were kept in transparent plastic containers (16.5 by 25 cm, diameter by height) filled with 1500 ml of water and 40 g of water fern. These containers were used for rearing in all tests. After adult emergence, the males and females were transferred to the mating containers. We used transparent plastic cups (8.5 by 11 cm, diameter by height) filled with 200 ml of water and 3 g of water fern, and covered with transparent cellophane for mating and we made small holes with a needle in the cellophane for ventilation. Two or three males with one female were released in each container to maximize the chances of fertilising eggs. Cups were changed daily until the female died. Water fern was also renewed regularly. Eggs were counted and kept in the incubator until larval emergence. First instar larvae released in rearing containers and all life stages were surveyed daily. Rearing containers were renewed every five days in order to prevent the growth of fungi and bacteria.

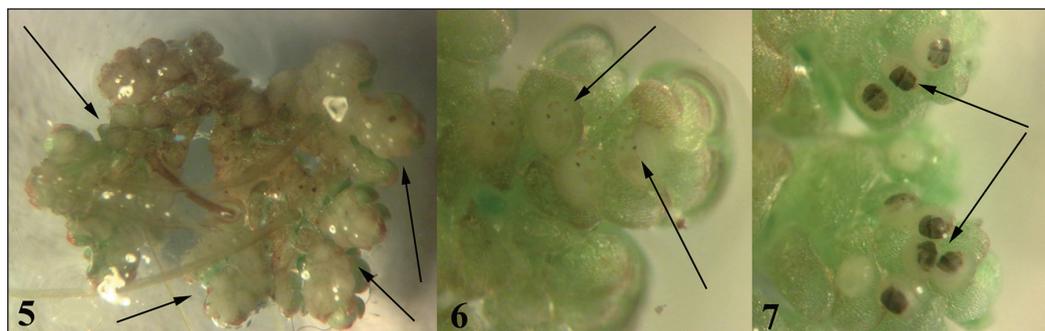
Identification: Forty adults were used for preliminary identification based on wing venation and other morphological characters. Dissection of both male and female genitalia (Figs 17–21) were made following the indications of Landry (2003) and Lee and Brown (2009). Dissections were conducted at the RRII laboratory and photographs sent to D. Agassiz in London for final determination.

Field observations: During 2014 and 2015, feeding damage observations by *C. lemnata* on water fern and other potential host plants were conducted in the waterways and experimental rice fields located at RRII.

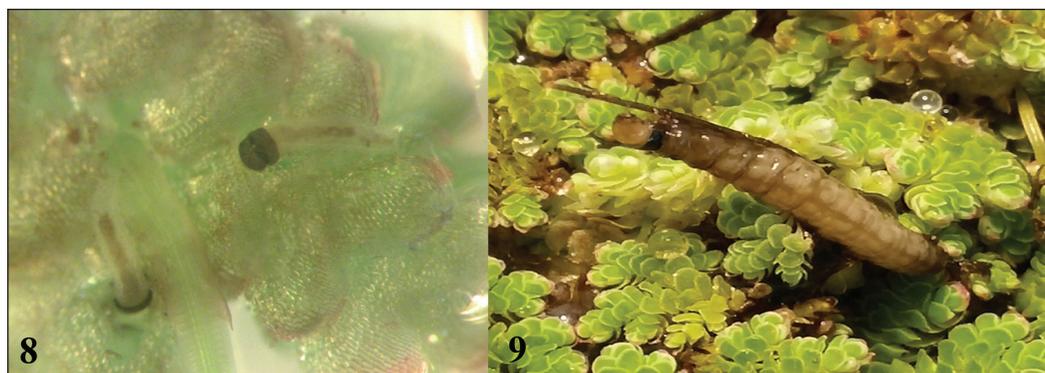
Results

Identification: Based on dissections of both male and female genitalia, the specimens were identified as *Cataclysta lemnata*.

Eggs: Less than 1 mm in diameter, globular, opaque to white (Fig. 5), with two darker spots on fertilised eggs after 24–48 hours (Fig. 6). These spots are larval eyes that become invisible as the



Figures 5–7. *Cataclysta lemnata* eggs on *Azolla*. 5. A few hours after laying; 6. After 48–72 hours; 7. A few hours before hatching.



Figures 8–9. *Cataclysta lemnata* larvae on *Azolla*. 8. First instar larva; 9. Last instar larva.

head capsule gets darker. Before hatching, the head capsule becomes completely visible (Fig. 7). The eggs are laid singly or in groups of two or more under water on fern leaves. The developmental time of the eggs at 25–27°C was 5–7 days.

Larva: Newly hatched larvae are off-white, about 1.5 mm in length, with a black head capsule (Fig. 8). By the first moulting, after 3–5 days, the body colour changes to greenish grey or black and the head capsule becomes off-white. The last instar larva is dark grey to black and 15–18 mm in length with an off-white head capsule (Fig. 9). The developmental time of 100 larvae at 23–25°C was 25–47 days.

Pupa: Pupation usually occurs in shelters made from water fern leaves and a silky cover. As in other Acentropinae, the pupa of *C. lemnata* has chimney-like stigmata on abdominal segments 2 to 4. The pupa is reddish brown and approximately 7 mm in length (Figs 10–13). The development time of 50 pupae at 25–27°C was 7 days approximately.

Adults: The wingspan is 13–18 mm in male and 18–24 mm in female. Male with head and thorax light brown. Forewing off-white; costa fuscous, subbasal area with scattering of ochreous scales and dark brown patterns, discal spot with ochreous margin, median area with scattering of ochreous scales and antemedian ochreous spot, termen with a series of fuscous spots; fringe dirty yellow and brown alternately. Hindwing white with ochreous subbasal fascia, a scattering of pale fuscous scales, and one discal spot; termen with five conjoined black terminal spots, each with one



Figures 10–13. *Catachysta lemnata* pupa. 10. Pupa; 11. Pupal shelter; 12. Inside the pupal shelter with a silky layer; 13. Pupa with chimney-like stigma.

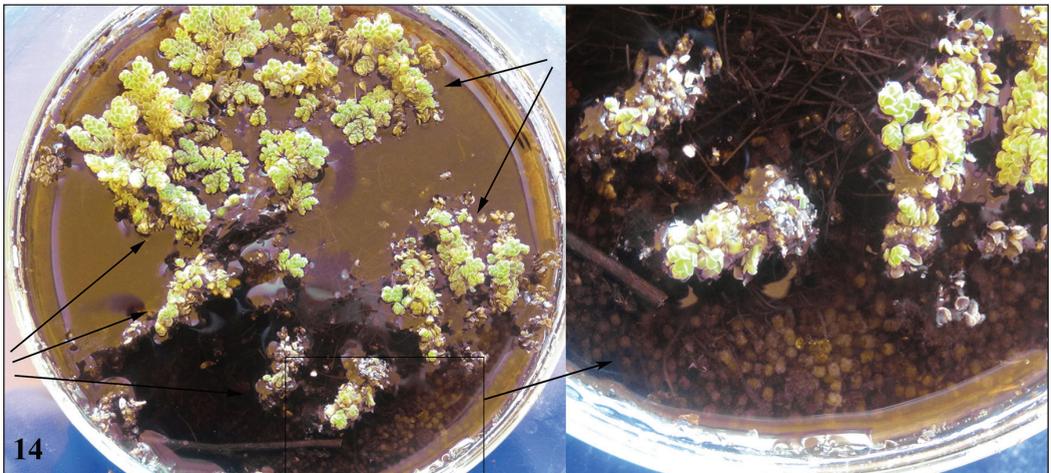


Figure 14. Evidence of *Catachysta lemnata* activity. Larval shelters on surface; magnified: frass and stems at bottom of Petri dish.

silver dot; fringe white with dark line at base (Fig. 2). Female with head and thorax brown. Forewing fuscous and fringe with obscure markings as in males; hindwing as in male, with an irregular fuscous median fascia and a white lined fringe (Fig. 1).

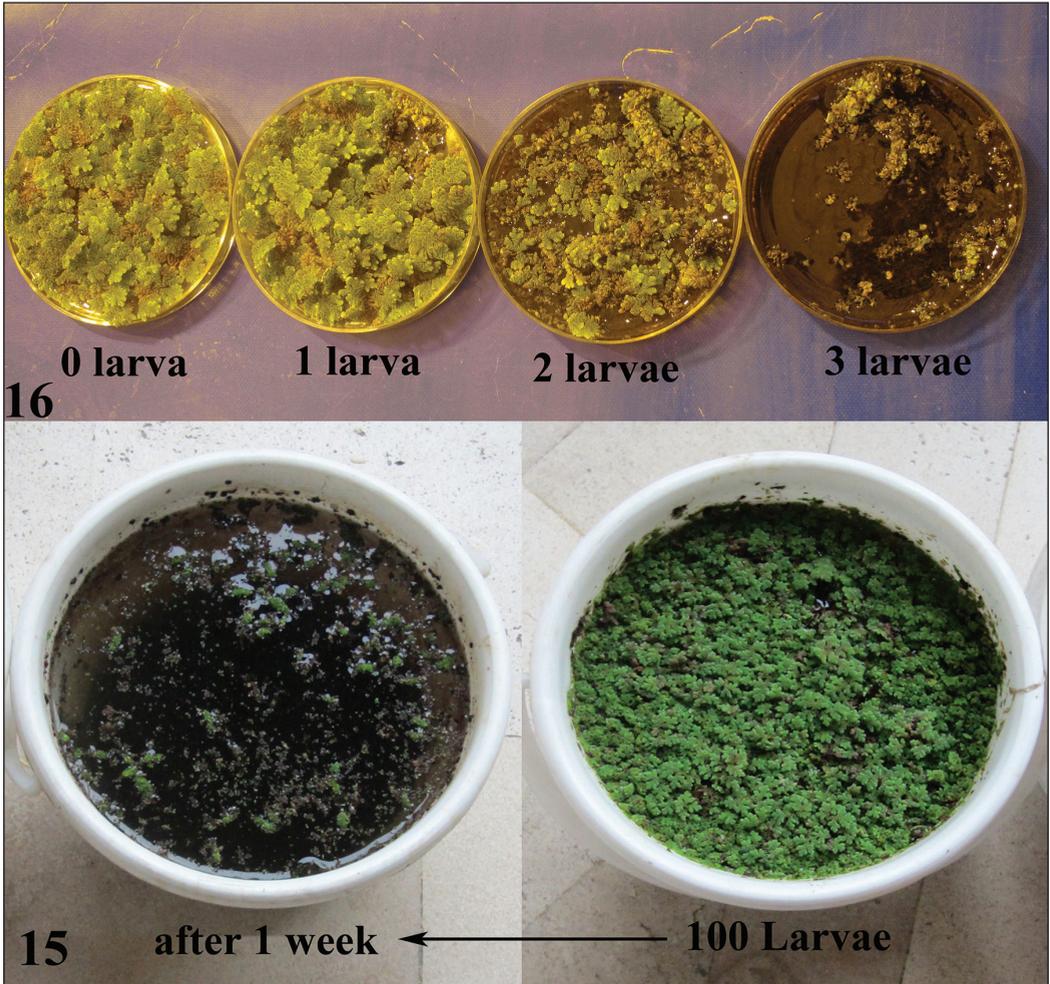
Evidence of damage on host plants: First instar larvae have been reported to be internal feeders on duckweed leaves (Chapman 1905; Wojtusiak and Wojtusiak 1960). However, on *Azolla* spp., first instar larvae feed on leaf buds, also internally. After a few days, they make shelters by attaching *Azolla* fronds to one another. The larvae remain in these shelters until pupation. They continue feeding and, as they develop, they make their shelters bigger. As the larvae get ready for pupation, they close the shelter with silk and adults emerge after almost a week. During heavy infestations in the laboratory, larvae almost wipe out water fern from the water surface and produce dregs made of cut stems and frass at the bottom of their containers (Fig. 14).

Discussion

The exotic aquatic fern, *A. filiculoides*, has invaded the Anzali Wetland. Since then, the overall ecological water quality, the habitat conditions, the numbers of migratory birds and fishes, and the aquatic plant diversity have declined in this ecosystem, particularly in the protected Selkeh wildlife refuge (Sadeghi et al. 2013a, b). In addition, the Amir-Kelayeh Wetland, which is another wildlife refuge, has become infested by this annoying weed as well (Farahpour et al. 2016). These changes are mainly related to anthropogenic activities (e.g. application of fertilizers, pesticides and herbicides in the paddy fields, and poor treatment of industrial waste in the watershed) and the invasion of *A. filiculoides* (JICA 2005; Ganjidoust et al. 2009; Sadeghi et al. 2013b). Moreover, although *Azolla* species are useful in paddy fields as an organic nitrogen source, for soil improvement, nutrient availability and weed suppression, they became problematic in fields with a poor drainage system in the northern region of Iran. At the same time, it seems that more than one species of *Azolla* invades aquatic ecosystems in Iran (Figs 3, 4) and this is another matter of concern. In order to manage *Azolla*, getting insight into biotic and abiotic factors affecting its growth in aquatic ecosystems of the north of Iran was necessary. Since 2011, some studies were conducted in the Anzali Wetland on some of the abiotic factors and the habitat requirements of *A. filiculoides* (Sadeghi et al. 2012a, b; 2013a, b). However, this weed's biotic resistance factors in Iran remained unclear.

During the present study, we investigated the activity of *C. lemnata* on *Azolla* spp. in rice fields and waterways. The first studies on *C. lemnata* suggested that this moth is a stenophagous species on Lemnaceae (Chapman 1905; Wojtusiak and Wojtusiak 1960) but it was reported later that this moth consumes various macrophytes (Vander Velde 1979, 1988; Pabis 2014). *Cataclysta lemnata* has been previously recorded from Iran (Speidel 2005), but *Azolla* spp. were never mentioned before as an element of the *C. lemnata* diet; in previous reports this species did not attack most other macrophytes beside Lemnaceae whilst the plants were fresh (Vander Velde 1979, 1988). In the rice fields and waterways of Iran, the moth is active from May until November. If the winter is mild, the larvae continue their activity slowly. They attack fresh water fern leaves and stems, but it seems that they prefer leaves to stems (Fig. 14). In the laboratory, larvae were capable of removing large parts of the floating cover of water ferns in Petri dish tests (Fig. 15) and when we increased the population density of larvae they almost wiped out the floating cover (Fig. 16).

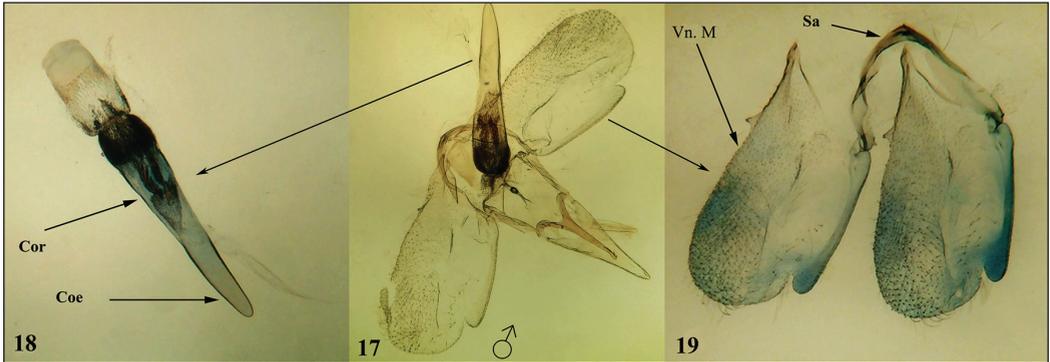
Speidel (1984, 2005) and Goater (1986) described and illustrated *C. lemnata* with a wingspan of 18–19 mm in the male and 22–24 mm in the female. The characteristics of the Iranian specimens are very similar to those mentioned in Speidel (1984, 2005) and Goater (1986), except that the Iranian specimens differ in the colouration of the head and thorax, the ochreous markings of the



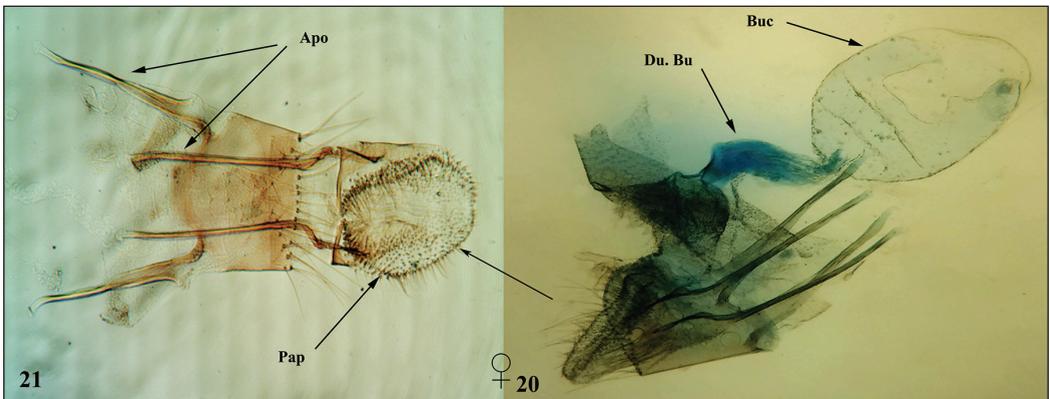
Figs 15–16. *Catachysta lemnata* effects on water fern in the laboratory tests. **15.** Petri dish test with different population density; **16.** Larvae consuming the floating layer during a week of artificial infestation with high-density larval population in laboratory.

forewing, and the ochreous subbasal fascia of the hind wing. These differences are visible in both sexes, but they are more prominent in males.

The explanation for these external differences is unclear. Dissections of genitalia (Figs 17–21) showed that our specimens do not differ in that respect from those of other populations of *C. lemnata* occurring outside of Iran. It is possible that some of the differences among populations are due to phenotypic plasticity. There are many environmental conditions (e.g. temperature, diet, parasitism, etc.), that induce phenotypic plasticity in insects. For example, woolly bear caterpillars (*Grammia incorrupta* Edwards; Lepidoptera, Erebidae, Arctiinae) that were parasitized by *Exorista mella* Walker (Diptera, Tachinidae) ingest more of the plant toxins called pyrrolizidine alkaloids to confer increased resistance against parasitoids (Singer *et al.* 2009). *Chilo suppressalis* (Walker) (Crambidae, Crambinae) that feed on water-oat differ in adult body size and mating time compared with those that feed on



Figures 17–19. *Catachysta lemnata* male genitalia slides. **17.** Ventral view with phallus; **18.** Phallus; **19.** Valva; **Cor** – cornuti; **Coe** – coecum; **Vn. M** – ventral margin; **Sa** – sacculus)



Figures 20–21. *Catachysta lemnata* female genitalia. **20.** Lateral view; **21.** Last segments of the abdomen. **Buc** – bursa copulatrix; **Du. Bu** – ductus bursae; **Apo** – apophyses; **Pap** – papillae.

rice (Takasaki et al. 1969; Ishiguro et al. 2006). Perhaps the different colouration of *C. lemnata* feeding on *Azolla* spp. in Iran represents phenotypic plasticity related to a different diet. Nevertheless, we reared larvae on both *Azolla* spp. and *Lemna minor* as main host plants separately and imagines from both diets were phenotypically the same. Since this type of colouration is permanent among generations, it is possible that these specimens represent a new biotype of *C. lemnata* or perhaps even a new subspecies. However, we do not have any molecular or other evidence to test this hypothesis yet.

Our study is the first to record *Azolla* sp. as a host plant for *C. lemnata*. However, there are 12 other recorded Pyraloidea that feed on *Azolla* spp.: *Elophila enixalis* Swinhoe, *E. nigrabalis* Caradja, *E. responsalis* Walker, *E. turbata* Butler, *E. melagynalis* Agassiz, *E. manilensis* Hampson (Mochida et al. 1985, 1987), *E. africalis* Hampson (Roberts et al. 1998) and *Synclita oblitalis* Walker (Habeck 1991) in Acentropinae, *Ephestiopsis vishnu* Roesler and Koppers (Mochida et al. 1985, 1987) and *Cryptoblabe gnidiella* Millière (Sasmal and Kulshreshtha 1984) in Phycitinae, and *Samea multiplicalis* Guenée (Knopf 1976) and *Diasemiopsis ramburialis* Duponchel (Farahpour et al. 2016) in Spilomelinae.

Although we briefly studied the biology of *C. lemnata* as a probable biotic resistance factor for water fern, many other important biological aspects such as population growth parameters and host preference in the natural habitat remain unclear. We could not find any specific parasitoid or predator for this moth although there are several generalist predators and parasitoids active in the rice fields (Shepard *et al.* 1987; Ooi and Shepard 1994) that could affect *C. lemnata* populations. However, some of the imagines in our colonies had a wing growth abnormality that seems to be genetic in origin. These imagines have distorted wings and were unable to fly properly, but they could mate as well as other imagines and produce fertile eggs. We did not use statistical or molecular methods for this study, but the number of eggs produced by these imagines was lower than for normal imagines. This abnormality appeared after at least four to five continual generations in the laboratory and only one or two imagines showed this abnormality during a whole generation.

Conclusion

Many studies have mentioned *Azolla* spp. as a weed (Hill 2003; Bodle 2008; Delnavaz and Azimi 2009). These invasive aquatic ferns are a major concern for biologists and ecologists dealing with conservation and management of wetland ecosystems due to the threats they may pose to the rich original biological diversity. They can have important harmful and irreversible impacts on wetlands as they may change the local fauna and flora (Sax *et al.* 2005; Vander Zanden and Olden 2008). Over the last few years, this obnoxious weed has invaded many wetlands in northern Iran (JICA 2005; Delnavaz and Azimi 2009; sadeghi *et al.* 2012a, b; 2013a, b). Due to the invasiveness of *Azolla* spp., many native macrophytes such as duckweed have been eradicated in these valuable habitats (Sadeghi *et al.* 2012a). *Cataglyphis lemnata* is an aquatic moth that was originally reported to feed on duckweeds and a few of other macrophytes. However, probably because of the eradication of its main host plant in many aquatic ecosystems of the northern region of Iran, this moth attacks exotic *Azolla* spp. water ferns and chooses them as new host plants. The effect of this moth on water fern as a biotic resistance factor is not clear yet and despite a rich fauna of aquatic and semi-aquatic insects, other biotic resistance factors of water fern in Iran are still poorly known. We have started our surveys on water fern biotic resistance factors in the rice fields and wetlands in the north of Iran in 2013 and this is the second report of our results. More studies are under way to uncover important facts on the biotic resistance factors of this annoying weed in northern regions of Iran.

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***Borkhausenia crimnodes* Meyrick, 1912 (Lepidoptera, Oecophoridae), a southern hemisphere species resident in Portugal**

MARTIN F. V. CORLEY^{1,2}, SÓNIA FERREIRA²,
ALEXANDER L. LVOVSKY³, JORGE ROSETE⁴

1 Corresponding author: Pucketty Farm Cottage, Faringdon, Oxfordshire SN7 8JP, U.K.; martin.corley@btinternet.com

2 CIBIO-InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto, Campus Agrário de Vairão, P-4485-61 Vairão, Portugal; hiporame@gmail.com

3 Zoological Institute, Russian Academy of Sciences, 1 Universitetskaya Emb., St Petersburg, Russia; Alexander.Lvovsky@zin.ru

4 Urbanização Lourisol, Rua Manuel Cerqueira Nobrega, Lote 16, 2. frente, P-3105-165 Louriçal, Pombal, Portugal; roseteprof@gmail.com

<http://zoobank.org/AA2BD4BF-933D-4F87-8B4B-3D04380E8DD0>

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Abstract. *Borkhausenia crimnodes* Meyrick, 1912, a species described from Argentina, has been found resident in Beira Litoral, Portugal, constituting its first records in Europe. *Borkhausenia intumescens* Meyrick, 1921, described from South Africa, is shown to be synonymous with *B. crimnodes*, described from Argentina. COI barcode sequencing has shown that a Portuguese specimen has 100% similarity with specimens collected in South Africa. The origin of the Portuguese population remains unclear but it is likely to be connected with timber importation for the paper industry. Male and female genitalia of *B. crimnodes* type and the Portuguese specimens are illustrated and described.

Introduction

Nine specimens of an oecophorid moth have been taken by Jorge Rosete on separate occasions from five different localities in central Portugal between July 2012 and July 2016. The first specimen, a female which appeared to belong to Oecophoridae, was examined in 2013 by Martin Corley. The following year, dissection of a male evidently belonging to the same species confirmed the family placement but could not be recognised as any known European member of that family. The possibility that it was an adventive from another continent was considered more likely than that it was a native of Portugal.

Central Portugal is dominated in many areas by plantations of eucalyptus. This, together with the fact that there are more Oecophoridae species in Australia than in any other continent, gave rise to the consideration that the species might have an Australian origin. Other Australian Oecophori-

dae have arrived in Europe as adventives, such as *Tachystola acroxantha* (Meyrick, 1885) (Clutterbuck 1910; Agassiz 1971) and *Barea asbolaea* (Meyrick, 1883) (Oakes *et al.* 2010). Therefore, the first attempts to identify the Portuguese moths followed this avenue. At the suggestion of Martin Honey, photographs of the female genitalia and the moth were sent to E. D. Edwards at Canberra, who suggested it might be the previously unknown female of one of the undescribed species of the genus *Oncomerista* Common, 2000, since the female of the only described species, *O. ochrophaea* (Meyrick, 1883) has a signum consisting of radiating spines. In 2013, after a male had been found, it became clear that the Portuguese species did not belong to *Oncomerista*. Furthermore, a search of the three volumes on Australian Oecophoridae (Common 1994, 1997, 2000) did not produce any plausible candidate for the Portuguese species.

In 2016, a DNA sample was taken for barcoding. This gave a 100% match on BOLD with three unidentified specimens that had been captured in South Africa. This new information opened up new possibilities. Images of the moth and the genitalia of both sexes were sent to Alexander Lvovsky (Russia), who has a wide knowledge of Old World Oecophoridae. He was able to determine that the Portuguese specimens belong to *Borkhausenia intumescens* Meyrick, 1921, described from Port Elizabeth in South Africa. At the suggestion of AL, MFVC studied the type of the Argentinian *B. crimnodes* Meyrick, 1912 at BMNH. From this it became evident that *Borkhausenia intumescens* is a junior synonym of *B. crimnodes*.

Material and methods

Nine specimens of *B. crimnodes* have so far been captured in Beira Litoral, Portugal by JR (Table 1, Fig. 1), specimens were always seen singly. In addition, the following museum material has been examined:

Borkhausenia crimnodes Meyrick, 1912. Holotype: Argentina: Parana. R. '06 [1906] J.F.G. Clarke male gen. prep. 4765. (BMNH), seen by MFVC.

Borkhausenia intumescens Meyrick, 1921. Two specimens. Lectotype in DNMNH, seen by AL, labelled 'Borkhausenia intumescens M. Type No. 774' 'Port Elizabeth, Fitz Simons 25.12.16, Coll. Janse' '24 81' 'G 8241'. Second specimen in BMNH, South Africa: Cape Province, Port Elizabeth, probably a paratype, but not labelled as such, seen by MFVC.

Table 1. *Borkhausenia crimnodes* specimens captured in Portugal. For each we list the Municipality, locality, the UTM coordinates, date of collection, genitalia preparation code when applicable and collection where the specimens are deposited.

Municipality	Locality	UTM	Date	Gen. prep.	Collection
Pombal	Louriçal	29TNE2228	27.vii.2012	§ Corley gen. prep. 4109	J. Rosete
Pombal	Louriçal	29TNE2228	18.x.2013		M. Corley
Pombal	Louriçal	29TNE2228	14.ix.2014		J. Rosete
Pombal	Louriçal	29TNE2228	21.ix.2014		J. Rosete
Pombal	Louriçal	29TNE2228	8.vii.2016		J. Rosete
Pombal	Louriçal: Casais do Porto	29TNE2329	11.vi.2015		J. Rosete
Pombal	Carriço: Mata do Urso, Lagoa de São José	29TNE1128	17.viii.2012		J. Rosete
Ansião	2 km east of Ansião	29TNE5019	13.iv.2014	§ Corley gen. prep. 4172	J. Rosete
Soure	Paúl da Madriz	29TNE3142	15.vii.2016		J. Rosete

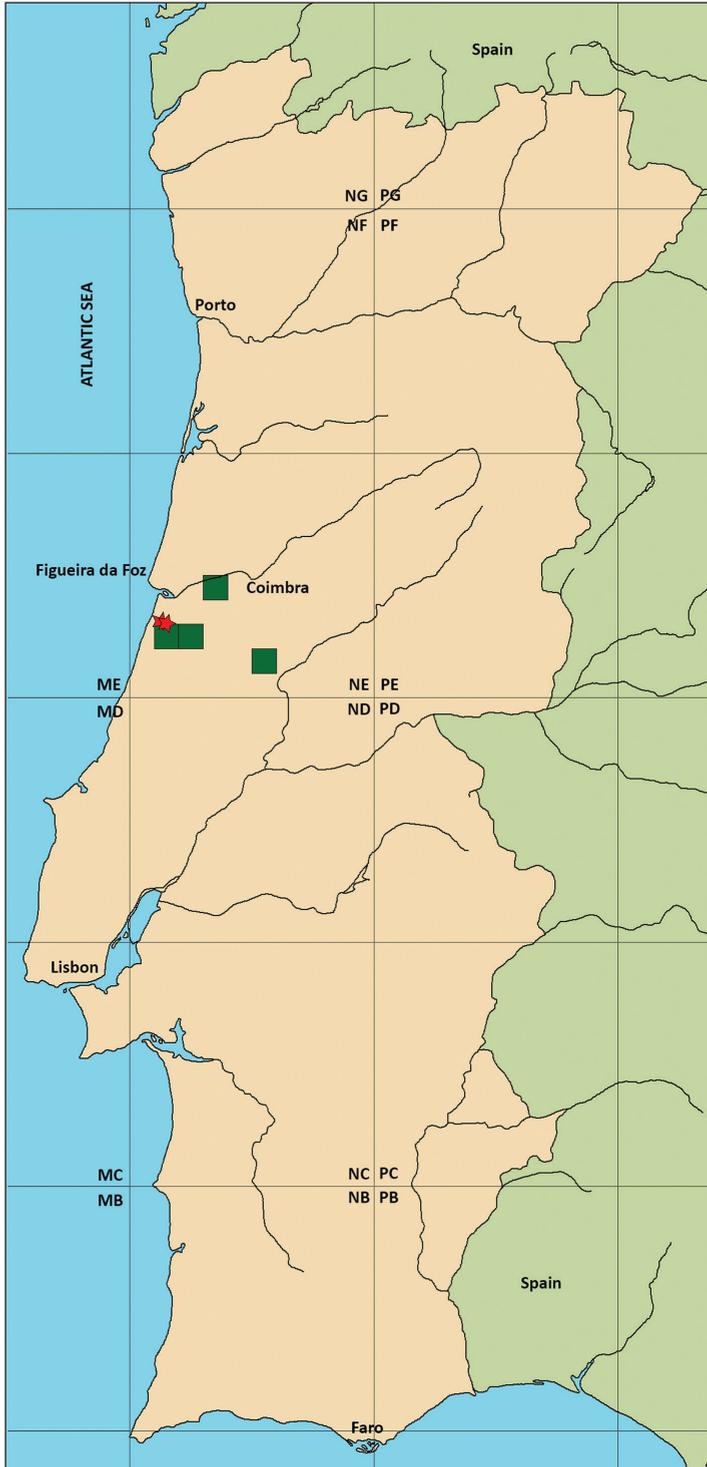


Figure 1. Distribution of *B. crinnodes* in Portugal (green squares). Red stars indicate the location of paper mills.

DNA extraction and sequencing

Genomic DNA was extracted from leg tissue (Table 1) using EasySpin Genomic DNA Tissue Kit (Citomed) following manufacturer's protocol. The cytochrome c oxidase I (COI) barcoding fragment was amplified as two overlapping fragments, using two sets of primers. For the first fragment, primers LepF (Hebert *et al.* 2004) and MlepR (Hajibabaei *et al.*, 2006) were used, while primers LepR (Hebert *et al.* 2004) and MlepF (Hajibabaei *et al.* 2006) were used to amplify the second fragment.

Both PCR reactions had 10 µL of final volume, containing 5 µL of Multiplex PCR Master Mix (QIAGEN), 0.4µM of each primer, and 1-2µL of DNA. PCR amplification was carried out on a T100 Thermal Cycler (BioRad) using the following conditions: initial denaturation at 95 °C for 15 min; 5 cycles at 95 °C for 30 s, 47 °C for 45 s, 72 °C for 45 s; then 40 cycles at 95 °C for 30 s, 51 °C for 45 s, 72 °C for 45 s; and a final elongation step at 60 °C for 10 min. The barcodes were sequenced in an Illumina Miseq platform, following the approach described by Shokralla *et al.* (2015).

We used OBITools (<https://git.metabarcoding.org/obitools/obitools>) for general sequence processing. Geneious v.6.1.5 (<http://www.geneious.com/>) was used for final sequence assembly. The sequence obtained was blasted against GenBank and BOLD databases. The average divergence (uncorrected p-distance) between the sequence of Portuguese specimen and *Borkhausenia* sp. COI sequences available in GenBank and BOLD was calculated in MEGA v.5.2.1 (Tamura *et al.* 2011).

Abbreviations

BMNH Natural History Museum, London

DNMNH Ditsong National Museum of Natural History, Pretoria, formerly Transvaal Museum.

Results

Borkhausenia crimnodes Meyrick, 1912, *Trans. ent. Soc. Lond.* 1911: 695.

Figs 2–3

Type locality. Argentina, Paraná.

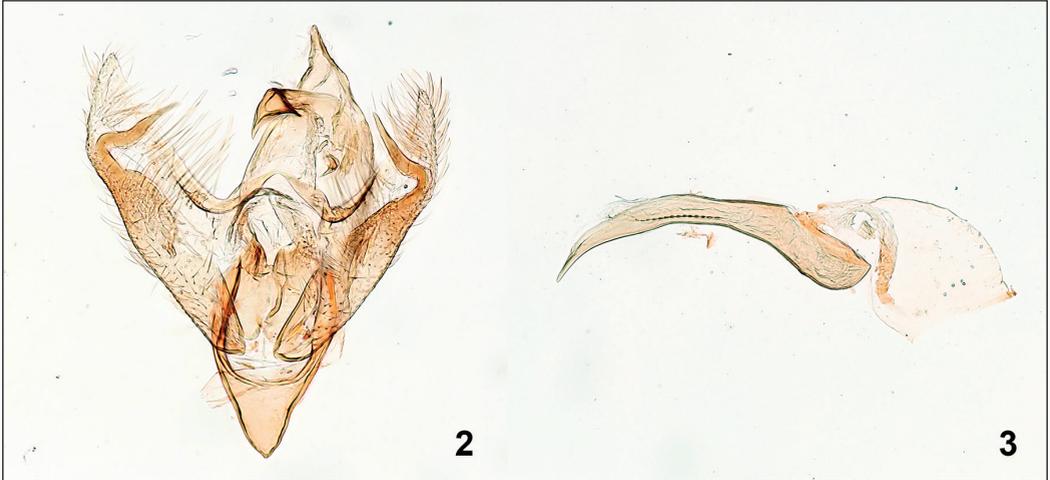
Borkhausenia intumescens Meyrick, 1921, *Ann. Transvaal Mus.* 8: 99. *syn. nov.*

Figs 4–6

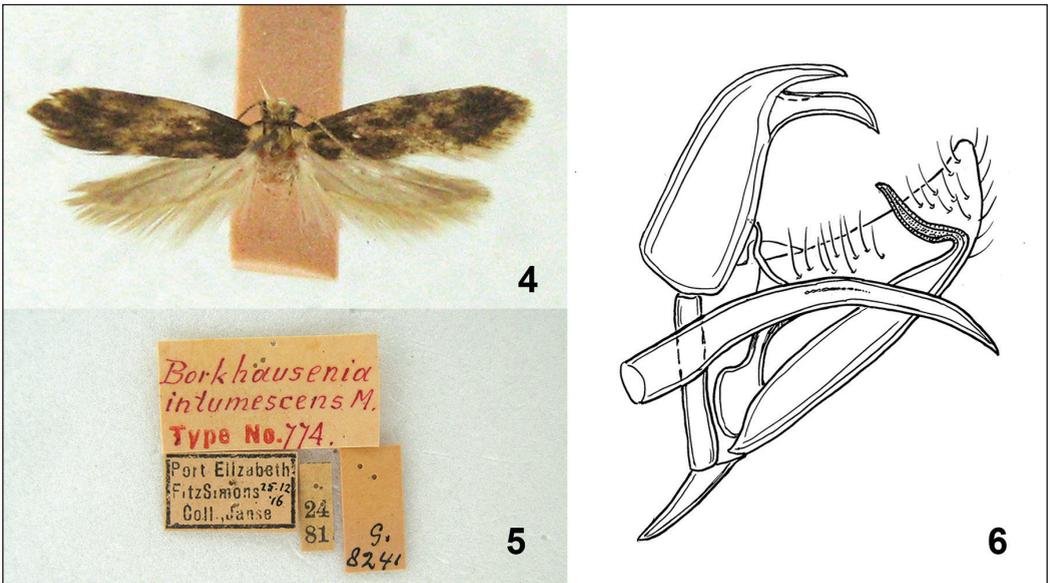
Type locality. South Africa, Port Elizabeth. Justification for the synonymy is elaborated in the section Synonymy below.

Redescription. Meyrick (1912, 1921) described *B. crimnodes* and *B. intumescens* separately. The redescription below is based on Portuguese specimens, but is equally applicable to the two Meyrick types. Male and female genitalia have not been described or documented previously (Figs 2–3, 6–10).

Habitus. Male and female similar (Figs 11–12). Wing length 4.4–6.0 mm; wingspan 9–13 mm. Head cream-coloured. Antenna buff, with light brown bands, scape with a pecten-like row of elongated scales. Ocellus absent. Proboscis present. Labial palp upcurved, creamy white, segment 3

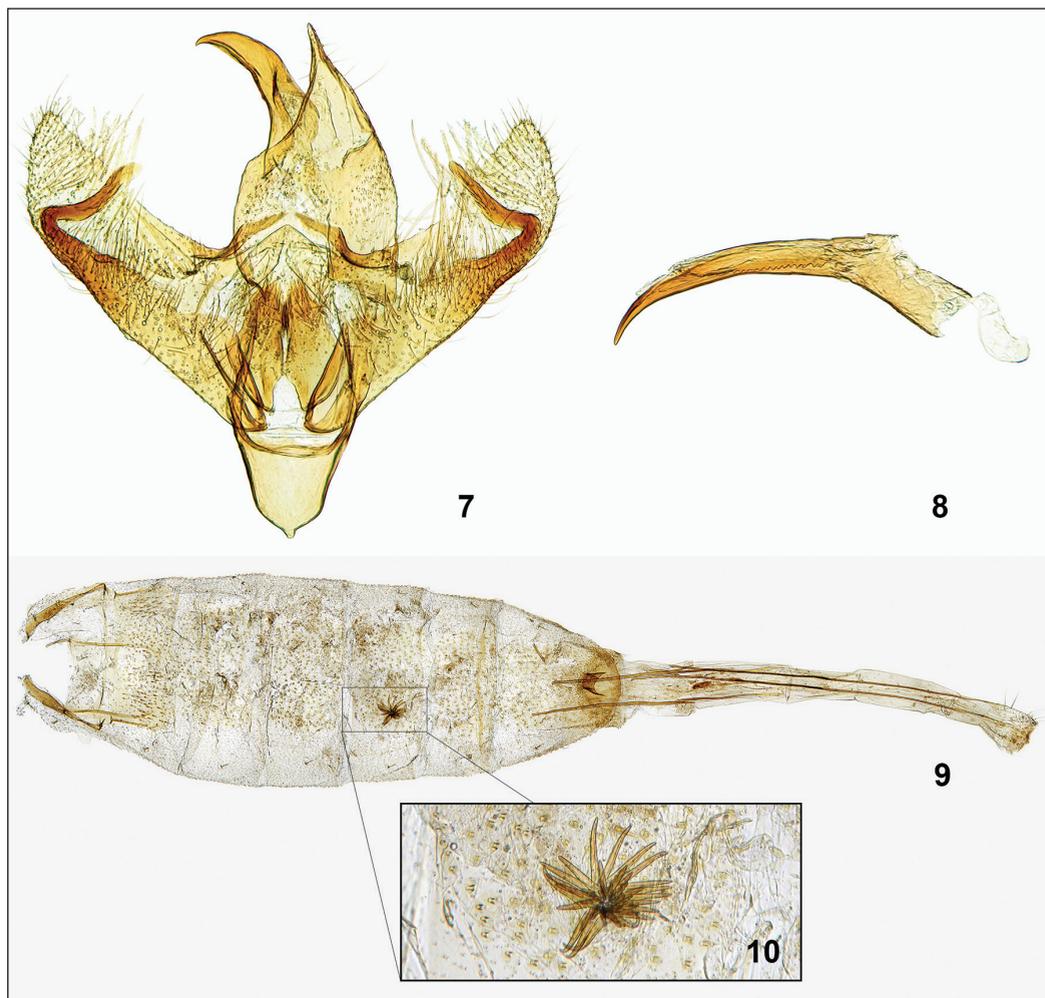


Figures 2–3. Male genitalia of *Borkhausenia crinnodes* Meyrick, 1912, Argentina, Paraná (BMNH). 2. Genitalia without phallus; 3. Phallus.



Figures 4–6. *Borkhausenia intumescens* Meyrick, 1921, South Africa, Port Elizabeth. 4. Lectotype male (DNMNH); 5. Labels of lectotype; 6. Male genitalia of lectotype (left valva omitted), A. Lvovsky del.

shorter than segment 2, with fuscous base and apex. Thorax creamy ochreous. Forewing elongate, narrow, creamy ochreous with extensive fuscous patches, sometimes mixed creamy ochreous, one patch at base extending to one-third on costa, and to three-fifths on dorsum with irregular outer margin, one in terminal quarter of wing and a small elongate patch along costa at middle; usually three dark fuscous round spots in mid-line, the first and third usually touching the basal and terminal dark patches respectively, the middle spot nearer the costa than the other two, a slightly



Figures 7–10. Genitalia of Portuguese specimens. **7.** Male genitalia, without phallus (Portugal, Ansião); **8.** Phallus (extreme base missing); **9.** Female genitalia (Portugal, Lourical); **10.** Signum enlarged.

elongated plical spot is sometimes visible within basal fuscous patch; cilia creamy ochreous. Hindwings light grey. Abdomen ochreous buff.

Venation. Forewing with R4 and R5 stalked; R5 to costa near apex; Cu1 and Cu2 separately from the cell. Hindwing with Rs and M1 separately from the cell; M3 and Cu1 from one point; Cu1 and Cu2 separately from the cell.

Male genitalia (Figs 2–3, 6–8). Uncus narrowed to pointed apex. Gnathos sclerotised, narrowed to pointed apex, extending beyond uncus. Valva with narrow processes at the base of costa forming hemitransstilla; sclerotised process at the distal end of sacculus strongly elbowed at base, with a slight outwards curve in middle, distal part crossing costa of valva perpendicularly. Juxta lobes broad, slightly tapering to hairy apex. Saccus triangular to trapeziform. Phallus slightly curved, cornutus saw-like, two-fifths length of phallus.



Figures 11–12. Male Portuguese specimens: **11.** Lourical, Pombal, Coimbra; **12.** Paul de Madriz, Soure, Coimbra.

Female genitalia (Figs 9–10). Ovipositor long and narrow. Small antrum sclerotised. Ductus bursae short. Signum flower-like with sclerotised narrow petals.

Variation (Figs 11–12). Some Portuguese specimens have the forewing ground colour more golden ochreous than whitish ochreous. The precise shape of the basal and apical fuscous patches is somewhat variable; the middle dark fuscous spot may be weakly developed.

Synonymy

The male genitalia illustrated in this paper (Figs 2–3, 6–8) appear to show small differences, particularly in the shape of the saccus, and possibly in the cornutus. Other differences between the dissected genitalia of the Portuguese specimens and the type of *B. crinnodes* are artefacts due to differences in the way the genitalia are presented in the preparation. This affects the shape of the valva and the gnathos, mainly because the cover slip of the Clarke preparation of the Argentinian type is less pressed down. The preparation of the type of *B. intumescens* was seen by AL a number of years ago and a drawing of part of it made at the time, which is reproduced here (Fig. 6). It does not show the whole of the saccus and the juxta is obscured by the phallus.

In spite of these differences there are very good reasons for considering the Portuguese specimens and the types of *B. intumescens* and *B. crinnodes* to belong to a single species. The moths are of similar size and have the same habitus (Figs 4, 11, 12). In the male genitalia, the shape of the process at the end of the sacculus, which is very distinct from other species, is similar in the specimens analysed (Figs 2, 6, 7). Differences in the cornutus are explained by the position in which this lies within the phallus; in the Portuguese specimen (Fig. 8) it appears in lateral view where it resembles a saw, while in the other two figures (3 and 6) it is seen edge on and only the points of the teeth are clearly evident. The saccus is clearly broader in the Portuguese preparation than in that of *B. crinnodes* type, but not too much significance can be placed on this character, which sometimes shows some variation in other gelechioid moths. Finally, the Portuguese moth barcoded is 100% identical to three specimens (details below under Molecular analysis) from South Africa which are illustrated in BOLD and have the same habitus as the Portuguese specimens, *B. intumescens* and *B. crinnodes*. We are fully convinced that *B. intumescens*, *B. crinnodes*, and the Portuguese specimens belong to a single species, *B. crinnodes*, of which *B. intumescens* is a junior synonym.

Table 2. Mean (below diagonal) and standard deviation (above diagonal) sequence divergence (uncorrected p-distances) of 658 bp fragment of cytochrome c oxidase I (COI) among pairs of species of *Borkhausenia* with sequences available on BOLD and GenBank.

	<i>B. crimnodes</i>	<i>B. catochopis</i>	<i>B. fuscescens</i>	<i>B. luridicomella</i>	<i>B. minutella</i>
<i>B. crimnodes</i>		1.3%	1.3%	1.3%	1.2%
<i>B. catochopis</i>	13.8%		1.4%	1.3%	1.3%
<i>B. fuscescens</i>	13.2%	15.4%		1.3%	1.1%
<i>B. luridicomella</i>	13.0%	14.1%	13.0%		1.2%
<i>B. minutella</i>	12.2%	13.1%	10.9%	12.2%	

Bionomics

The larval food of *B. crimnodes* is unknown, but is likely to be some sort of dry plant matter or debris, perhaps affected by mould or other fungi. Three specimens were taken from inside the building where JR lives, adjacent to garages. The prevalence of the species in this building is unexplained. One was taken beneath a street light, one from a porch light and three were taken at 160-watt blended mercury vapour light. Individuals have been captured in April, June, July, August, September and October, suggesting that the species is multivoltine in Portugal.

Molecular analysis

The BLAST search in BOLD (Ratnasingham and Hebert 2007) with the 658 bp COI sequence obtained from a Portuguese specimen (Specimen code – INV03258; GenBank Accession number KY053459) yielded 3 records with 100% similarity score. The three corresponding specimens, coded as CCDB-22957-E10, CCDB-22957-E11 and CCDB-22957-F10, are deposited at the National Museum of Natural History, Smithsonian Institution and were collected in Eastern Cape – South Africa. None of the specimens has identification at family level or below. No other *Borkhausenia* species has been listed in 99 first results from the search in the COI Full Database despite the existence of 25 published records. *Borkhausenia* species pairs exhibited high levels of genetic divergence in the COI dataset analysed (uncorrected p-distance ranges 10.9–15.4) (Table 2).

Discussion

At the time of the description of *Borkhausenia crimnodes*, before the use of genitalia characters as a taxonomic tool had become routine practise, many genera of Microlepidoptera were understood in a much wider sense than is now the case. *Borkhausenia* is an example of a genus that once included large numbers of species. More than 268 species were described as *Borkhausenia* species (Bisby *et al.* 2011), but the majority are now considered to belong in other genera, sometimes even in other families. In Common (1994, 1997, 2000) all of the approximately 40 *Borkhausenia* species described from Australia were placed in other genera. Due to lack of revisionary work elsewhere it is not currently possible to be sure how many species remain in the genus. The morphological and genetic distinctness of *B. crimnodes* raises the question of whether it should still be placed in *Borkhausenia*. Comparison of male and female genitalia with those of other European *Borkhausenia* species [*B. fuscescens* (Haworth, 1828), *B. minutella* (Linnaeus, 1758) (type species), *B. luridicomella* (Herrich-Schäffer, 1856), *B. nefrax* Hodges, 1974] has been made. The following

characters are shared by *B. crimnodes* and the European species: gnathos longer than uncus, transtilla interrupted in the middle, sacculus ending in a process that partially crosses the valva, a single cornutus in the phallus (male), and the long telescopic ovipositor (female). One distinct feature of *B. crimnodes* that is not shared by the European species is the presence of a signum, which is furthermore of a form that is unusual in the family. Likewise, the cornutus is quite different from the cornuti in the European *Borkhausenina* species. The male genitalia characters (gnathos longer than uncus, divided transtilla and distal process of sacculus crossing the valva) do not of themselves indicate close relationship between these species, particularly as the last two characters can be found in other families of Gelechioidea.

Querying of the BOLD database for *Borkhausenina* species indicates that the few species which have barcode available on BOLD and GenBank (n=5) are not closely related to one another, exhibiting more than 10% divergence between analysed species. Possibly the genus *Borkhausenina*, from which many species have already been removed, is still polyphyletic and its taxonomy certainly requires further research. In the absence of a world revision of this and related genera, we retain *B. crimnodes* in *Borkhausenina*.

B. crimnodes was described from Paraná in the province of Entre Rios, Argentina. Paraná is by the Paraná River, about 250 kilometres inland from Buenos Aires. *B. intumescens* was described from Port Elizabeth, Eastern Cape, South Africa. It is also present inland in the mountains. Those *Borkhausenina* species with known larvae feed on plant detritus, so this is likely to be the case also with *B. crimnodes*. Species with this larval behaviour are readily transported by human trade across considerable distances and resulting adults can readily find suitable food sources for oviposition. Examples include several species of *Blastobasis* originally from Madeira and now well established in the British Isles (Agassiz 1996) and *B. decolorella* (Wollaston, 1858) in continental Portugal (Corley 2015).

Since *B. crimnodes* is so far recorded from nowhere else in Europe, it would appear to have been accidentally introduced into Portugal, perhaps from South Africa or Argentina, although the possibility that it might be established elsewhere in the world cannot be ruled out. With species that are readily transported long distances by human agency, it can be difficult to establish the true country of origin. While it is puzzling that the known Portuguese sites are in Beira Litoral, remote from the main ports or airports of Lisboa and Porto, there is a smaller port at Figueira da Foz that might have provided a means of entry for *Borkhausenina crimnodes*. It is known that two paper mills in the region import timber from South America through Figueira da Foz port.

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The biology and preimaginal morphology of Italian endemic species *Isturgia sparsaria* (Hübner, 1809) (Lepidoptera, Geometridae)

HOSSEIN RAJAEI¹, MICHAEL LEIPNITZ², SIEGFRIED ORTNER³

¹ Staatliches Museum für Naturkunde Stuttgart, Rosenstein, 1, 70191-Stuttgart, Germany; hossein.rajaei@smns-bw.de (corresponding author)

² Bodoweg-8, 70327-Stuttgart, Germany; mc.leipnitz@web.de

³ Rettenbachwaldstr. 8/1, A 4820 Bad Ischl, Austria; s.ortner@eduhi.at

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Abstract. The geometrid species *Isturgia sparsaria* (Hübner, 1809) is restricted to Italy and its biology is unknown. Recently, several individuals of this species have been successfully reared in captivity. Experiments with various potential host plants are reported. The larva was reared successfully on *Genista tinctoria* L. and *Ulex europaeus* L. (both from family Fabaceae). Adult insects, as well as ovum, larva, and pupa are illustrated and/or briefly described.

Introduction

Genus *Isturgia* Hübner, 1823, with around 60 species, is mainly distributed in the Palaearctic, Afrotropical and Oriental Regions, and in Australia (Skou and Sihvonen 2015). Of these, 16 *Isturgia* species occur in Europe (Flamigni et al. 2007; Skou and Sihvonen 2015). In this genus, the biology and early stages of the Italian species *Isturgia sparsaria* (Hübner, 1809) (as well as of *I. punctistrigaria* (Christoph, 1897) and *I. messapiaria* (Sohn-Rethel, 1929)) were unknown (see Prout 1915; Wehrli 1940; Flamigni et al. 2007; Leraut 2009; Skou and Sihvonen 2015).

Isturgia sparsaria (Figs 1, 2) is a medium-sized geometrid moth (wingspan 24–28 mm). Wing colour pale straw, sprinkled with brown, with three brown lines, antemedial angled at costa, obsolescent medial, and postmedial; hindwing with postmedial line (see Flamigni et al. 2007 and Skou and Sihvonen 2015 for further morphological descriptions and diagnostic characters). It is an Adriato-Mediterranean species (corology after Hausmann 2001) endemic to Italy, in most of the Apennine mountain chain, Liguria, and Piedmonte (Skou and Sihvonen 2015).

Material and methods

On 7 June 2016, the third author collected a female specimen of *Isturgia sparsaria* in central Italy (Prov. Frosinone, ca. 1 km NW of Acuto, altitude 770 m, 13°09'57.97"E, 41°48'00.11"N).

A single female was attracted to a black light. It laid a total of 71 eggs in a small plastic box, with the bottom covered by toilet paper. Each egg was laid separately. During his holidays in Sardinia, the second author received the eggs from the third author in a plastic box. They were placed in a refrigerator (2°C) for five days to retard their development until he reached home and

could start his experiments. Most of the eggs were then kept in the refrigerator (2°C), but three were allowed to hatch at room temperature (22°C) in order to conduct experiments on host-plant preferences before allowing the remainder to hatch.

The tiny first instar larvae were housed in a small Polyethylene box (7.0×4.5×3.0 cm). They were offered a variety of food plants to see which plants were being accepted (this examination took eight days). Then, the larvae were transferred to the food plant. The first instar larva could always be recognised by the bigger head capsule in comparison with the body. After second–third ecdysis, the breeding was continued successfully in a cage (12×12×25 cm), which was covered with a screen-printing mesh, with the food plant in a small jar of water.

Results and discussion

Food plants and preimaginal stages. The second author successfully reared the larvae, after many experiments on food preferences (see below).

Food plant. Nearly all species of *Isturgia* feed on species of Fabaceae (Scoble and Krüger 2002; Flamigni *et al.* 2007; Skou and Sihvonen 2015). Based on this knowledge, the larvae were offered a wide variety of Fabaceae in our experiments, as well as species in other families (e.g. *Lonicera* sp.; *Artemisia* sp.; *Prunus* sp.) (see Table 1 for the complete list of all tested plants listed by family).

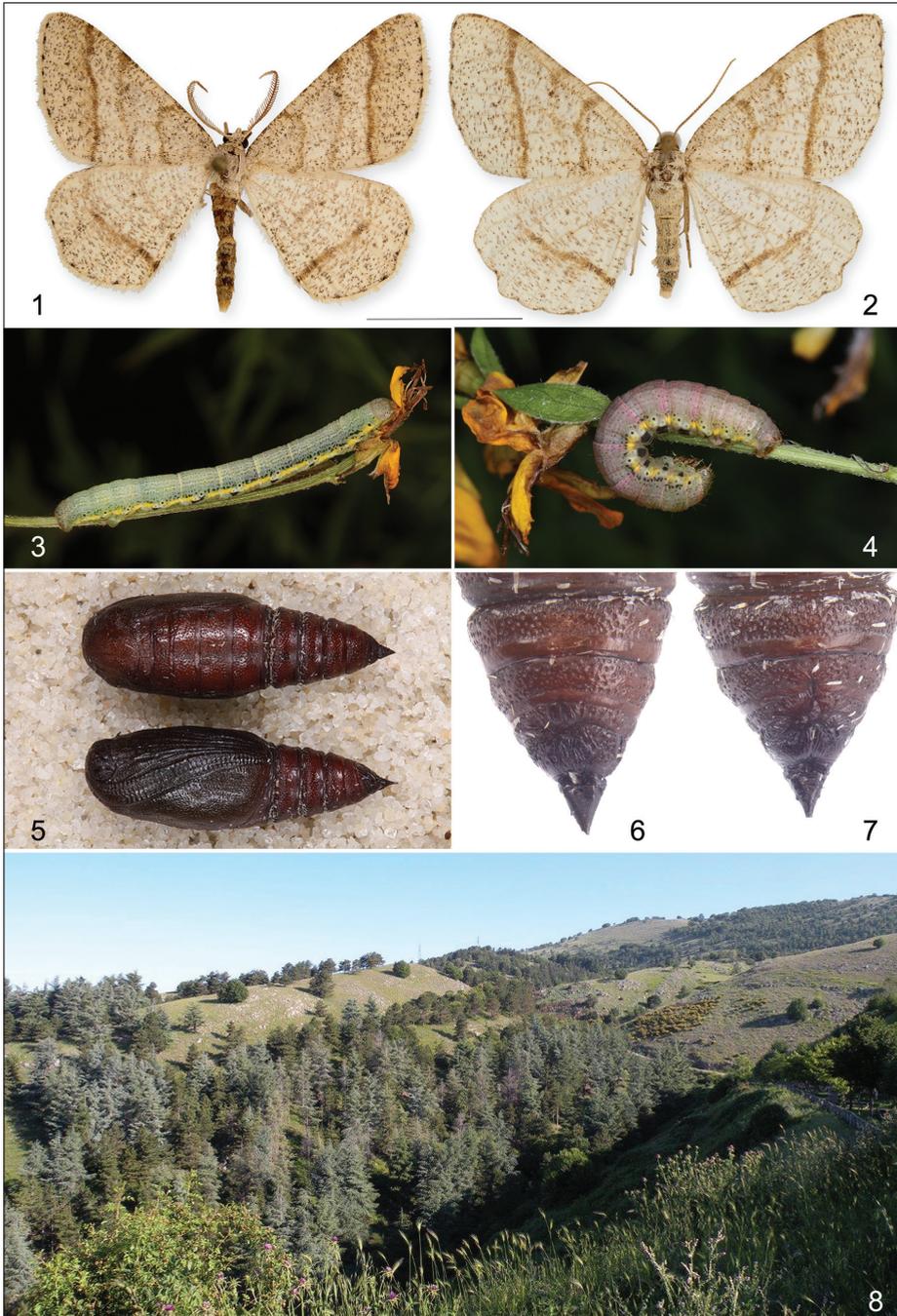
Preimaginal stages

Ovum. Elliptical, length about 0.75 mm, breadth about 0.45 mm. Freshly laid eggs dark grey-green, becoming violet-brown after two or three days. The eggs were attached dorso-ventrally to the substrate.

Larva. The first and second instar larva (L1 and L2) are more or less grey-green, without any characteristic colour pattern. The colour pattern appears gradually from L3 towards L5 (see below). The fifth instar (L5) (Fig. 3) is 35–45 mm long (n=6). Larval ground colour light turkey-green with scattered tiny dark dots; dorsal line is slightly darker, bordered on each side with a thin dark line; sub-dorsal and dorso-lateral lines slightly lighter than background, bordered by thin dark lines; lateral black spots, with higher concentration towards head capsule, form a disconnected black line, which becomes blurred in abdominal region; sub-lateral line yellow, ventrally with characteristic black spots, which are clearly visible on segments A3, A4, A5, and A6. Spiracles dark brown. Head white to light straw-coloured, with tiny dots. After 30–35 days and shortly before pupation, the fully-grown larva stops feeding and its ground colour changes to light pink or red-brown (Fig. 4).

Pupa. In total six larvae completed their development to the pupal stage. Pupa 10–11 mm long, fairly scabrous, red-brown in colour; wing case dark-green directly after pupation, gradually becoming dark-brown; punctures visible on 1st–8th abdominal segment (Fig. 5). Pre-pupal phase lasts four to six days in the soil, under laboratory conditions, and no cocoon was formed.

Results of this study indicate that the larvae feed largely on flowers or young soft leaves of *Genista tinctoria* and flowers or young soft spines of *Ulex europaeus* in captivity. It is likely that the hostplant of *Isturgia sparsaria* in the wild is also a species of Fabaceae. In the locality where the specimens were collected, *Spartium junceum* (Fabaceae) is quite common and is regarded as a potential hostplant of *I. sparsaria* in the wild, but this suggestion needs further study. According to



Figures 1–8. 1–6. *Isturgia sparsaria*. 1. Male (Italy, Marche, Bolognola, 1100 m, Valle Fargno, 2.viii.2010, leg. Teobaldelli, in coll. M. Leipnitz). 2. Female (Italy, Abruzzo, Majella, 450 m, Fara S. Martino, Valle del Fossato, 26.vi.2009, leg. N. Zahm, in coll. M. Leipnitz). 3. Fifth instar larva (L5). 4. Pre-pupal stage. 5. Pupa. 6–7. Pupal cremaster of male (6) and female (7). 8. Habitat of *Isturgia sparsaria*, where female specimen was collected: Acuto (Italy, Prov. Frosinone, altitude 770 m). Scale-bar for Figs 1, 2: 1 cm.

Table 1. *Isturgia sparsaria* (Hübner, 1809): larval reactions to plants (listed by family) offered under captive conditions (botanic nomenclature according to The Euro+Med Plant Base: <http://www.emplantbase.org/home.html>).

Family: Plant species	Larval reaction
Fabaceae: <i>Lathyrus pratensis</i> L. - <i>Ononis spinosa</i> subsp. <i>procurrens</i> (Wallr.) Briq. (= <i>Ononis repens</i> L.) - <i>Cytisus scoparius</i> (L.) Link (= <i>Sarothamnus scoparius</i> (L.) W. D. J. Koch) - <i>Chamaecytisus purpureus</i> (Scop.) Link - <i>Genista sagittalis</i> L. (= <i>Genistella sagittalis</i> (L.) Gams) - <i>Medicago sativa</i> L. - <i>Trifolium campestre</i> Schreb. - <i>Dorycnium pentaphyllum</i> subsp. <i>germanicum</i> (Gremli) Gams (= <i>Dorycnium germanicum</i> (Gremli) Rikli) - <i>Lotus corniculatus</i> L. - <i>Astragalus alpinus</i> L. - <i>Securigera varia</i> (L.) Lassen (= <i>Coronilla varia</i> L.) - <i>Vicia sepium</i> L. - <i>Vicia sativa</i> subsp. <i>nigra</i> (L.) Ehrh. (= <i>Vicia angustifolia</i> L.) - <i>Vicia cracca</i> L.	Rejected
Fabaceae: <i>Genista tinctoria</i> L.	Accepted (Flowers, young soft leaves)
Fabaceae: <i>Ulex europaeus</i> L.	Accepted (Flowers and young soft spines)
Salicaceae: <i>Salix purpurea</i> L.	Rejected
Fagaceae: <i>Quercus robur</i> L.	Rejected
Rosaceae: <i>Prunus spinosa</i> L.	Rejected
Apiaceae: <i>Bupleurum falcatum</i> L.	Rejected
Lamiaceae: <i>Thymus vulgaris</i> L.	Rejected
Caprifoliaceae: <i>Lonicera tatarica</i> L.	Rejected
Compositae: <i>Artemisia alba</i> Turra (= <i>A. camphorata</i> Vill.)	Rejected

Flamigni *et al.* (2007), *I. sparsaria* reaches also higher altitudes (1300 m and 1600 m in the central and southern Apennines, respectively), where *S. junceum* does not occur. However, *Genista tinctoria* is widespread throughout the Apennine regions from sea level up to 1800 m.

It is also quite possible that the larvae of this species are polyphagous on other plants which occur in its habitat. In captivity, the larvae accepted two different genera of Fabaceae, but further field studies are necessary to confirm how host specific the larvae of this species are in the wild.

As the adult specimens of *Isturgia sparsaria* were observed on an oak, *Quercus* sp. (Worm-Hansen 1935), this tree was suggested as a potential hostplant (Flamigni *et al.* 2007). In our experiments, the larvae rejected *Quercus robur* and this tree is definitely not one of the hostplants.

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Pseudobankesia keersmaekersi sp. n., a new species from Greece (Lepidoptera, Psychidae, Taleporiinae)

WILFRIED R. ARNSCHEID¹, HANS HENDERICKX²

¹ Im Ostholz 58, D-44879 Bochum, Germany; reisseronia@gmx.de

² Hemelrijkstraat 4, B-2400 Mol, Belgium; deceased November 8, 2016

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Abstract. *Pseudobankesia keersmaekersi* sp. n. (Lepidoptera, Psychidae, Taleporiinae) is described from Greece and compared with its likely close relatives *Pseudobankesia arahova* Stengel, 1990 and *Pseudobankesia darwinii* Stengel, 1990. The new species is well characterized by its remarkably coloured forewings and wing-pattern and the unusually large larval cases.

Samenvatting. *Pseudobankesia keersmaekersi* sp. n. (Lepidoptera, Psychidae, Taleporiinae) wordt van Griekenland beschreven. Ze wordt vergeleken met de wellicht erg nauw aanverwante soorten *Pseudobankesia arahova* Stengel, 1990, en *Pseudobankesia darwinii* Stengel, 1990. De nieuwe soort wordt gekenmerkt door de opvallende kleur en tekening van de voorvleugel, bovendien hebben de larven buitengewoon grote larvenkokers.

Zusammenfassung. *Pseudobankesia keersmaekersi* sp. n. (Lepidoptera, Psychidae, Taleporiinae) wird aus Griechenland beschrieben und mit den vermutlich nächstverwandten *Pseudobankesia arahova* Stengel, 1990, und *Pseudobankesia darwinii* Stengel, 1990, verglichen. Die neue Art ist gekennzeichnet durch die auffällige Farbe der Vorderflügel und ihre Flügelzeichnung sowie durch die ungewöhnlich großen Säcke der Larven.

Introduction

The genus *Pseudobankesia* Meier, 1963 (Lepidoptera, Psychidae, Taleporiinae) contains 15 species in the Palearctic Region. Fourteen of them are distributed from Portugal eastwards to Cyprus (Sobczyk 2012; Arnscheid and Weidlich in press). Most species inhabit rocks and walls in mountainous areas where they occur up to 2500 m in the Alps. Eight species have been described from south-eastern Europe: *P. macedoniella* (Rebel, 1920) from Macedonia; *P. kresnensis* Weidlich, 2014 from Bulgaria; *P. arahova* Stengel, 1990, *P. darwinii* Stengel, 1990, and *P. lichenaria* Weidlich, 2016 from Greek mainland and Peloponnes; *P. hauseriella* Henderickx, 1998 from Crete; and *P. aphroditeae* Weidlich & Henderickx, 2002 from Cyprus. *P. dioszeghyi* (Rebel, 1935), which is known only from the holotype, has been described from Romania. After examination of the holotype (deposited at the Hungarian National History Museum Budapest, Hungary) in 2014, WA came to the conclusion that it is more than questionable that this specimen belongs to *Pseudobankesia*.

During his expeditions to Greece, HH discovered along with other psychids a lot of cases with larvae of a remarkable *Taleporiinae* species from which he reared one male and several females. The flight period of this species is in the second half of November through December. The larval cases were all found under lava rocks, never on walls or on the exposed surface of stones.

Comparing this material with the likely closely related taxa, as well as a subsequent analysis of the adult morphology including the male genitalia structures, supported the recognition of a new species, which is herewith introduced to science as *Pseudobankesia keersmaekersi* sp. n.

Pseudobankesia was separated from the related *Bankesia* Tutt, 1899 by Meier (1963) based on differences in the antennae of both sexes and in the male genitalia. The male genitalia of *Pseudobankesia* resemble those of *Taleporia* Hübner, 1825, which were illustrated by de Freina and Witt (1984), but the cases of *Taleporia* and *Pseudobankesia* are very different, and therefore these taxa are not congeneric as considered by de Freina and Witt (1984).

Material and methods

Figures 1a, b, c, and d were made with a Canon 5D mark III and MP-E 65 macro lens, with soft flash illumination. Figures 1a and 1b were stacked by using Zerene Stacker software. Figures 2a and 2b were taken from preparations in Euparal with an Olympus stereo microscope using a Pentax digital camera and stacked by CombineZP Stacker software. Figures 3a and b were made with an Olympus E1 digital camera and 35 mm macro objective.

We used DNA barcodes (a region of 658 base pairs of the mitochondrial cytochrome c oxidase I, also known as COI) from seven *Pseudobankesia* species (one represented by two specimens) and two *Bankesia* species (one also represented by two specimens) as a tool to help us better understand the taxonomy of *Pseudobankesia*. DNA sequencing of the DNA barcode was carried out at the Biodiversity Institute of Ontario, University of Guelph in 2015 and 2016 and it followed standard methods (Wilson 2012). The sequences are freely available in the online BOLD database (<http://www.boldsystems.org/>; Ratnasingham and Hebert 2007), as well as the images of the specimens. The specimens information can be found in Table 1. As an outgroup we used a specimen of *Dahlia mannii*, another species of Psychidae. The neighbour-joining tree, based on the Kimura 2 parameter (K2P) model of nucleotide substitution (Kimura 1980) as recommended in the barcoding protocol (Ratnasingham and Hebert 2007, 2013) was obtained using MEGA 5 (Tamura et al. 2011). The intra- and interspecific distances are based on this analysis (Table 1).

Systematics

Pseudobankesia keersmaekersi Arnscheid & Henderickx, sp. n.

<http://zoobank.org/7B7BF8DE-1FE6-40CC-BA35-0BD6676FFEB5>

Material. Holotype ♂: Methana, Greece, 550 m, e.l. 6.xii.2012, leg. Henderickx.

Paratypes: 18 ♀ Methana, Greece, N 37.611348, E 23.365761, 550 m, e.l. Nov.- Dec. 2012 and 2014, leg. Henderickx.

The holotype and two paratypes will be deposited in the “Staatliches Museum für Naturkunde Karlsruhe” (SMNK), Germany. The other paratypes are deposited in the private collections of WA and M. Weidlich (Neißemünde, Germany).

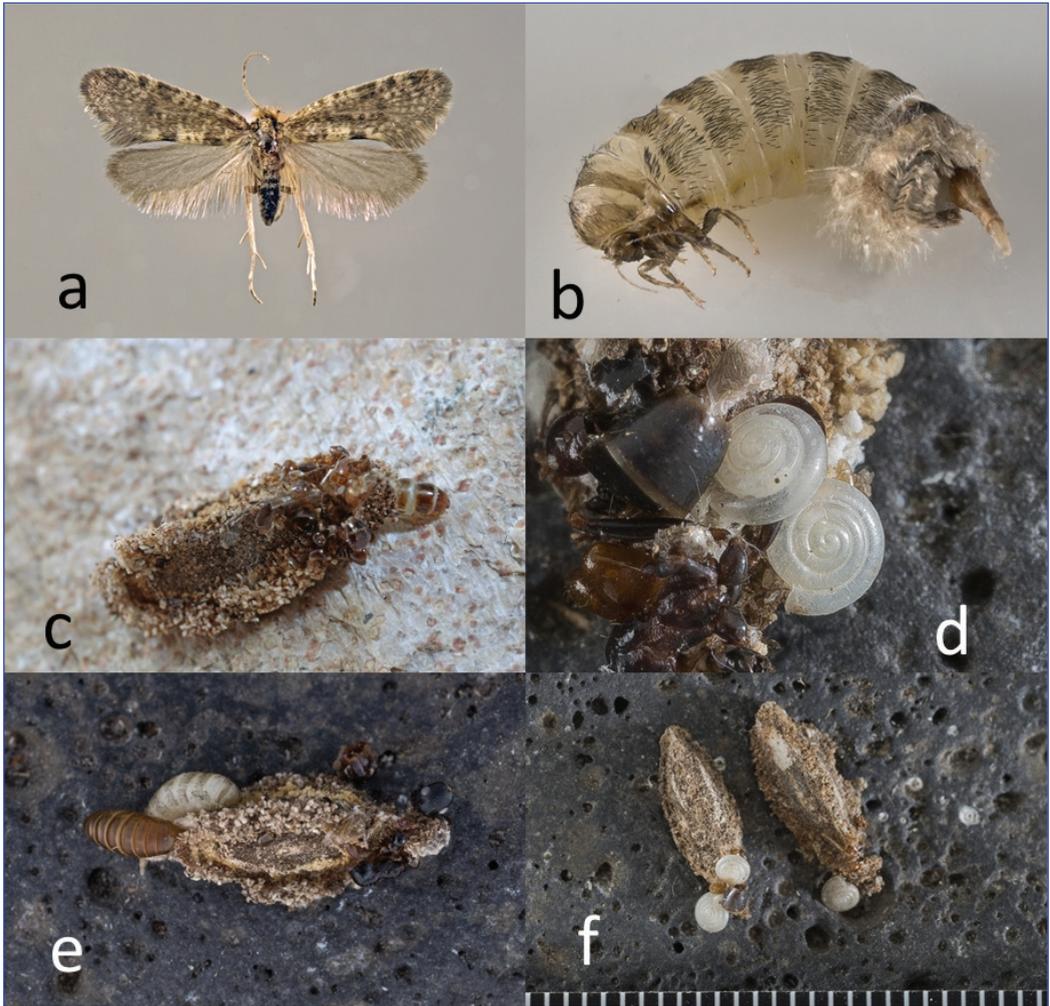


Figure 1. *Pseudobankesia keersmaekersi* sp.n. **a.** ♂ holotype; **b.** ♀ paratype; **c.** ♀ larval case; **d.** detail of case decoration with insect debris and land molluscs; **e.** ♀ on larval case; **f.** larval case decoration with land mollusks.

Etymology. We gratefully dedicate this nice new species to Jan Keersmaekers, Mol (Belgium), who joined HH on the Greek expeditions and helped collect the cases with his son Tom.

Male (Fig. 1a). Wingspan 11 mm. Head appearing hairy, frons and vertex with rough yellowish brown scales of variable length; external ocelli present; labial palp reduced to 3 segments; antenna thread-like with 26 segments; regularly short ciliated. Forewing length 5 mm; ground colour yellowish grey, basally and postdiscally with 2 broad interrupted brownish bands; at inner margin two distinct spots of ground colour; submarginally the veins with darker brownish scales forming a distinct reticulate pattern; costal margin with a series of dark brownish spots. Scales moderately broad, with 3–4 dentations (class 5 after Sauter 1956); fringe scales long, light greyish, becoming distinctly longer at the last third of inner margin; narrow, with 3–4 dentations. Hindwings uniform

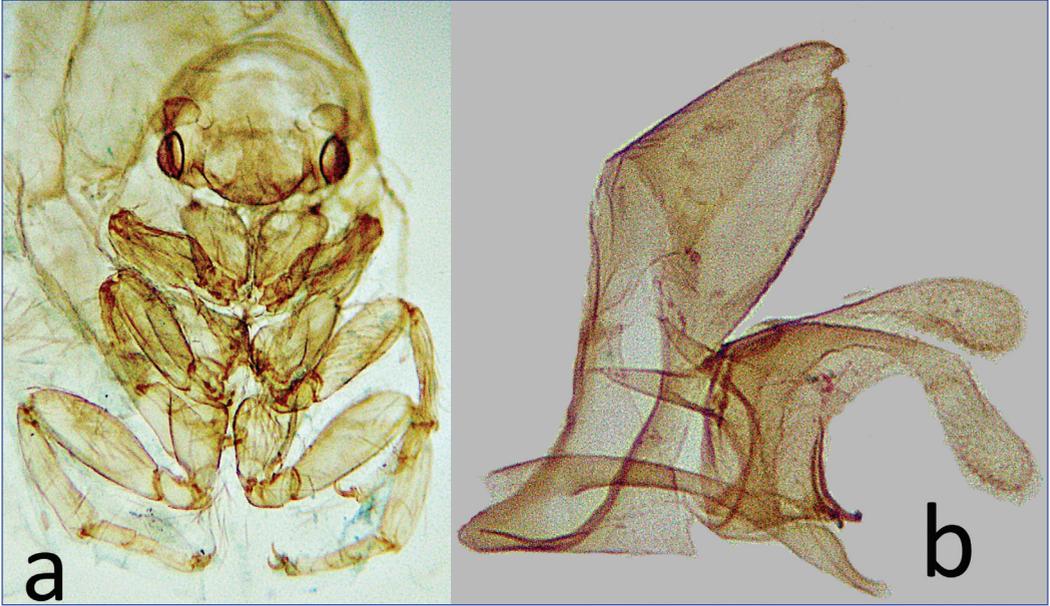


Figure 2. a. *Pseudobankesia keersmaekersi* sp.n. paratype female, head and legs after maceration in 20% KOH; b. male genitalia of *Pseudobankesia keersmaekersi* sp. n., holotype.

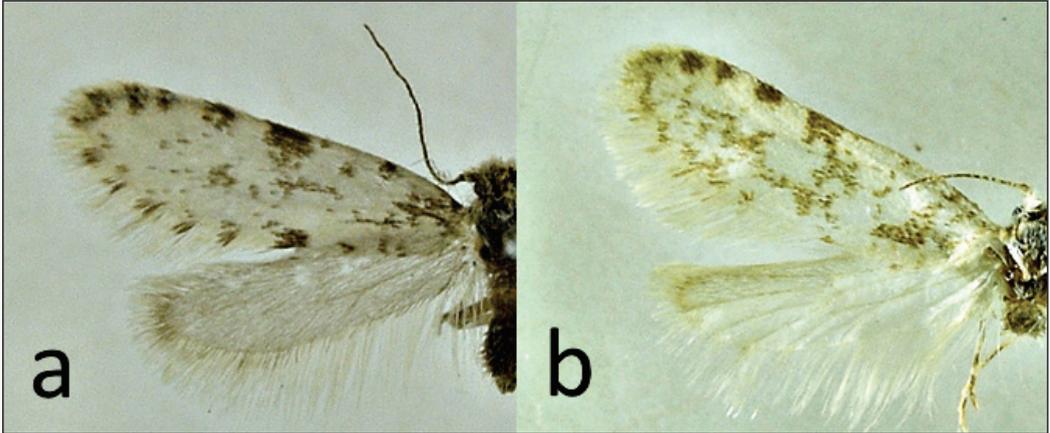


Figure 3. a. *Pseudobankesia arahova* Stengel, 1990, ♂, Greece, Sterea Ellas, Parnassos Mts., e.l. 22.v.2002, leg. Weidlich (coll. M. Weidlich); b. *Pseudobankesia darwinii* Stengel, 1990, ♂, holotype, Greece, Peloponnese, Mt. Helmos, e.l. 8.vi.1989, leg. Stengel (coll. Museum Witt Munich).

dark greyish, slightly glossy, scales narrow (class 2 after Sauter 1956). Venation hardly visible under magnification, with 10 veins from discal cell; accessory cell present, intercalary cell absent. Forelegs with tibial epiphysis, midlegs with one pair of apical tibial spurs, and hindlegs with medial and apical tibial spurs.

Male genitalia (Fig. 2b) typical for *Pseudobankesia* (Fig. 3), resembling the likely most-closely related genus, *Taleporia*. Tegumen conical, flat, indented distally, and with two downward-directed

Table 1. Distance matrix showing the intra- and interspecific distance between *Pseudobankesia* and *Bankesia* species based on the neighbour-joining analysis of the DNA barcode.

	PHLAG435-12_Pseudobankesia_vernella	PHLAG436-12_Pseudobankesia_vernella	POESE188-16_Pseudobankesia_keersmaekersi	PHLAB577-10_Pseudobankesia_alpestrella	TISY494-12_Pseudobankesia_casaella	PHLAH322-12_Pseudobankesia_lichenaria	TIPSY496-12_Bankesia_montanella	LEEU045_11_Bankesia_conspurcatella	TYPY007-08_Bankesia_conspurcatella	PHLAH323-12_Pseudobankesia_aphroditae	LEAT014-13_Pseudobankesia_kresnensis	POESE110_Dahlica_mannii
PHLAG435-12 Pseudobankesia_vernella Piedmont_Italy												
PHLAG436-12 Pseudobankesia_vernella Piedmont_Italy	0.02											
POESE188-16 Pseudobankesia_keersmaekersi sp.n. Greece	0.12	0.12										
PHLAB577-10 Pseudobankesia_alpestrella Italy	0.05	0.04	0.14									
TIPSY494-12 Pseudobankesia_casaella Spain	0.04	0.05	0.13	0.05								
PHLAH322-12 Pseudobankesia_lichenaria Greece	0.04	0.04	0.11	0.06	0.04							
TIPSY496-12 Bankesia_montanella France_Corse	0.15	0.14	0.17	0.15	0.14	0.14						
LEEU045-11 Bankesia_conspurcatella Denmark	0.15	0.16	0.14	0.16	0.15	0.14	0.12					
TIPSY007-08 Bankesia_conspurcatella England	0.14	0.15	0.14	0.16	0.15	0.14	0.12	0.00				
PHLAH323-12 Pseudobankesia_aphroditae Cyprus	0.12	0.13	0.08	0.14	0.12	0.12	0.16	0.13	0.13			
LEAT014-13 Pseudobankesia_kresnensis Bulgaria	0.13	0.12	0.07	0.13	0.13	0.12	0.17	0.13	0.13	0.09		
POESE110-16 Dahlica_mannii Slovakia (outgroup)	0.22	0.20	0.24	0.21	0.21	0.19	0.22	0.23	0.23	0.24	0.26	

lobe-shaped sharp pointed appendages; clasper of sacculus short, broad, and with a distinctly pointed process distally; saccus often very short, but also medium-sized and pointed in other species; valva folded distally, extending beyond distal end of tegumen, more slender than in *Taleporia*, covered with hair and short spines. Phallus short and thin, curved, with setae in the distal half. Genital index (phallus length / valva length) 1.02 (n = 1).

Female (Fig. 1b). Wingless. Length 5.5–6.0 mm (excluding ovipositor), body segments creamy yellowish. Dorsally head and thorax brownish and sclerotized; each segment covered with fields of blackish hair; ventrally less sclerotized. Eyes black, very small; antenna with 13–15 segments. Anal hair-tuft undulated, yellowish grey. Legs with 2–3 tarsal segments, spur of third tibia absent or very short.

Female genitalia with antrum and antevaginal plate distinctly sclerotized, two pairs of long apophyses, lateral plates triangular, pointed, postvaginal plate indistinct.

Case. Male length 9 mm, width 3 mm, female length 9–12 mm, width 4–5 mm, distinctly triangular in cross section. Light greyish brown, sparsely covered with plant debris and sand (Fig. 1c–f). The edges of the often broad cases are mostly ornamented/accentuated with organic material, the larval opening with larger invertebrate parts (i.e. ant debris and small land molluscs). It is especially remarkable that several specimens used minute juvenile snails of the family Zonitidae to decorate the cases at the larval opening.

Based on the differentiation in the DNA barcode, *P. keersmaekersi* is well separated from the other species in the genus (Fig. 4). The nearest species is *P. kresnensis* Weidlich (2016a), with a distance of 7%.

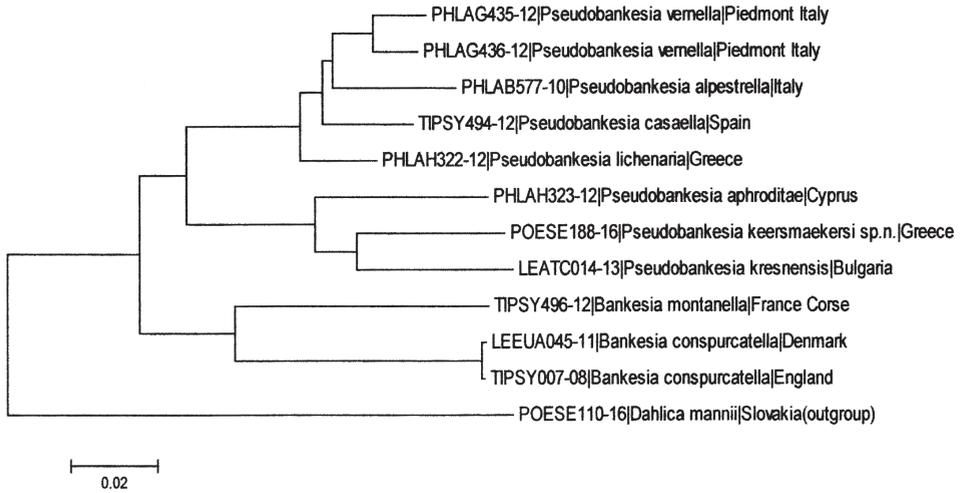


Figure 4. Neighbour-joining barcode tree showing the clustering of seven *Pseudobankesia* and two *Bankesia* species with another psychid species *Dahlicha mannii* as the outgroup (scale bar = 2%).

The distances to the next closest species of the genus are 8% to *P. aphroditae* Weidlich & Hendericks (2002), 11% to *P. lichenaria* Weidlich (2016), 12% to *P. vernella* (Constant, 1899) and 14% to *P. alpestrella* (Heinemann, 1870) (Table 1). No genetic data are available for *P. arahova* Stengel (1990) and *P. darwinii* Stengel (1990). In the future, sampling of *Pseudobankesia* species should be increased to include more specimens per species, as well as other species in the genus.

Placement of the new species in *Pseudobankesia* is based on the regular ciliation of the antennae of the male. Those of the probably most-closely related genus *Bankesia* have brushes of long hairs basally on both sides of each segment. On the other hand, females of *P. keersmaekersi* sp. n. have long antennae with 13–15 segments, while those of *Bankesia* species have short antennae with only 3–6 segments. The male genitalia of *Bankesia* are very different from those of *Pseudobankesia*. They are flat in general appearance and the tegumen is narrow, conical, and slightly indented, while the genitalia of *Pseudobankesia* are much higher in lateral view and the tegumen is more or less triangular. The valvae are long and slender, much more slender than in *Pseudobankesia* and like them protrude considerably beyond the distal end of the tegumen. The clasper of sacculus is sharply extended, thorn-shaped, curved inwardly, while that of *Pseudobankesia* is short and broad with a distinctly pointed process distally. The phallus is very thin, two-thirds length of valva, almost straight and not curved as in *Pseudobankesia*, in which it is tubular and slightly enlarged caudally with setae in the distal half. Further, as far as we know, the genus *Bankesia* is distributed only in western and south-western Europe and the presence of a *Bankesia* species in Greece seems unlikely. However, recently *Bankesia cephalonica* Weidlich, 2016b, was described from an Ionian island, Kefalonia.

P. keersmaekersi is one of the larger *Pseudobankesia* species (wingspan 11 mm). The male (holotype) is distinctly characterized by its remarkable colouration and the very special wing pattern which is unique within the whole genus. Therefore, it cannot be confused with males of other *Pseudobankesia* species (Table 2). The geographically close *Pseudobankesia* species *P. darwinii* and *P. arahova* (Fig. 2a,b) differ from *P. keersmaekersi* sp.n. in the distinctly darker colouration and the remarkable female cases, which are broader.

Table 2. A comparison of morphological characteristics of *Pseudobankesia* species from south-eastern Europe.

♂	Forewing length (mm)	Scales (classes)	Colour of head scales	No. antennal segments
<i>kresnensis</i>	8.6–11	4–5	yellowish	29–30
<i>aphroditae</i>	8.5–10	4–5	brown	32–33
<i>macedoniella</i>	8.4–12	4–5	yellowish	26–28
<i>arahova</i>	9–10.2	5	whitish	26–28
<i>darwinii</i>	11.5–12	5–6	creamy white	29–31
<i>hauseriella</i>	12–12.8	4	yellowish grey	29–31
<i>keersmaekersi</i>	11	4–5	reddish brown	26
<i>lichenaria</i>	9.6–11.8	4–6	silvery grey	34–35
♀	No. antennal segments	Colour of anal hair-tuft	No. tarsal segments	Spur of third tibia
<i>kresnensis</i>	10–12	brownish golden	2–3	short
<i>aphroditae</i>	10–16	whitish grey	3–4	short
<i>macedoniella</i>	12–16	silvery grey	4–5	long, double
<i>arahova</i>	12–15	whitish	4–5	very short
<i>darwinii</i>	11	whitish	5	absent
<i>hauseriella</i>	20–23	greyish brown	5	short or absent
<i>keersmaekersi</i>	13–15	brown	2–3	absent
<i>lichenaria</i>	12	yellowish white	3–4	short, broad

Acknowledgements

The authors express their sincere gratitude to Dr. Thomas J. Witt, Munich (Germany) and Dr. Michael Weidlich, Neißemünde (Germany) for useful comments and the loan of material. We thank Dr. Nico Büsscher (Belgium) for determination of the mollusc shells. We also wish to thank Deborah Matthews (Gainesville, Florida, USA) for her critical comments and linguistic correction. Thanks to Donald R. Davis (Washington, USA) and another anonymous reviewer for critical review of the manuscript.

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Revision of the West-Mediterranean geometrid genus *Ekboarmia*, with description of a new species from Portugal (Lepidoptera, Geometridae, Ennominae)

PEDER SKOU¹, DIETER STÜNING², PASI SIHVONEN³

¹ Aamosen 1, DK-5762 Vester Skerninge, Denmark; info@apollobooks.dk

² Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, DE-53113 Bonn, Germany; d.stuening@zfmk.de

³ Pasi Sihvonen, Finnish Museum of Natural History, Zoology Unit, University of Helsinki, P.O. Box 17, FI-00014, Finland; pasi.sihvonen@helsinki.fi

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Abstract. The West-Mediterranean geometrid moth genus *Ekboarmia* Wehrli, 1943 (Lepidoptera: Geometridae, Ennominae) is revised based on morphology, life history, and DNA barcodes. It was found that wing patterns allow reliable identification of species, whereas the genitalia are rather uniform in shape and less informative, and the genetic divergence (in the COI gene) between species is considerably lower than in the Geometridae on average, ranging 1.5–3.9%. Four species are considered as valid: *E. atlanticaria* (Staudinger, 1859), with one putative subspecies in North Africa, *E. fascinataria* (Staudinger, 1900), *E. sagnesi* Dufay, 1979, and *E. miniaria* **sp. n.** from Portugal. *Boarmia atlanticaria gracilis* Albers & Warnecke, 1941 is downgraded to junior synonym of *Boarmia(?) atlanticaria atlanticaria* Staudinger, 1859, **syn. n.** *E. fascinataria* is removed from the European checklist due to lack of confirmed records. Larvae, where information exists, are external feeders on *Juniperus* needles (Cupressaceae), and adults are nocturnal, inhabiting various habitats up to 1400 metres above sea level, having apparently at least two generations per year. Adults, male and female genitalia, distribution map, and diagnostic characters are illustrated for all species. Larva and pupa of *E. atlanticaria* and larva of *E. sagnesi* are illustrated, and results of DNA barcode analysis are presented for most taxa studied.

Introduction

The concept of the geometrid genus *Ekboarmia* is based on *Boarmia atlanticaria* Staudinger, 1859, a West-Mediterranean species that occurs in the Iberian Peninsula, the Balearic Islands, Sardinia, and in North Africa. This nocturnal species is small, with the wingspan ranging 19–27 mm, and the adult is characterised by grey-brown wings and forewing postmedial line, which is slightly to strongly dentate, with a deep, z-shaped incision near the forewing costa. The larva of *E. atlanticaria* is green, a needle-mimic that matches (see Fig. 6) the branches of its foodplant *Juniperus phoenicea* (Cupressaceae) (Corley 2004; Flamigni et al. 2016). Externally, the unrelated *Menophra harterti* (Rothschild, 1912) and *Ecleora solieraria* (Rambur, 1834) are very similar to *E. atlanticaria* (see Flamigni et al. (2007) for diagnostic characters).

The genus *Ekboarmia* included for a long time two externally similar yet diagnostic species, *E. atlanticaria* and *E. fascinataria* (Staudinger, 1900), the latter occurring in North Africa from Morocco to Algeria. The few articles that deal with the genus *Ekboarmia* can be summarised as follows. Albers and Warnecke (1941) illustrated type specimens of both species as photographs and the male genitalia as line drawings. They provided new faunistic information, for instance a record of *E. atlanticaria* from Sardinia, where the species was found for the first time by Bytinski-Salz (1937), and described a new subspecies of *E. atlanticaria* from Morocco. In 1979 a new *Ekboarmia* species was described, namely *E. sagnesi* from the French Alps (Dufay 1979). It differs externally from the above-mentioned species by having more uniform pale brown ground colour and forewing postmedial line is less angled inwards near costa. At the time of description, only males were known. Twenty-six years later Colomb (2005) described the life history and illustrated the female of *E. sagnesi*, reporting that in captivity larvae of *E. sagnesi* feed on *Juniperus* as was hypothesised by Dufay (1979). Colomb (2005) also illustrated a superficial line drawing of the corpus bursae of the female genitalia, having an unusual curved structure, not reported in other *Ekboarmia* species. More recently, a new subspecies of *E. sagnesi* was described from south-east Spain, Jaén province (Expósito Hermosa 2007), on the basis of a single male. Leraut (2009, p. 185) synonymised the taxon with a note ‘general appearance and genitalia in all aspects correspond to the holotype of *sagnesi* Dufay’. The two Spanish species (*E. atlanticaria* and *E. sagnesi*) have been treated in detail by Redondo *et al.* (2007), the only Italian species (*E. atlanticaria*) by Flamigni *et al.* (2007, 2016) and the three known *Ekboarmia* species (*E. atlanticaria*, *E. sagnesi* and *E. fascinataria*) by Leraut (2009).

Between 1995 and 2011, 11 specimens of a small Geometridae, represented by both sexes, were found in Portugal, which, due to their unusual appearance could not be placed at first in any known European genus. Later the second author was able to solve this problem, through study of the large ZFMK collection. In this paper we demonstrate that these specimens belong to genus *Ekboarmia* and describe them as a species new to science, revise the entire genus, provide diagnostic characters for all taxa, and new faunistic and life history information on these moths.

Material and methods

The study is based on material housed in the following collections: Private collection of Bernd Müller, Berlin, Germany (Müller); Muséum National d’Histoire Naturelle, Paris, France (MNHN); Zoologisches Museum der Humboldt Universität, Berlin, Germany (MNHU); The Natural History Museum, London, United Kingdom (NHM); private collection of Pasi Sihvonen, Veikkola, Finland (Sihvonen); private collection of Peder Skou, Vester Skerninge, Denmark (Skou); private collection of Manfred Sommerer, München, Germany (Sommerer); private collection of Dirk Stadie, Lutherstadt Eisleben, Germany (Stadie); Stuttgart State Museum of Natural History, Stuttgart, Germany (SMNH); Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany (ZFMK); Zoologische Staatssammlung München, Germany (ZSM).

Distribution map is based on examination of authentic specimens, and was created by compiling label data from collection specimens. These data were supplemented by additional information from recent publications with precise distribution data including Spain and Portugal (Redondo *et al.* 2009) and Italy (Flamigni *et al.* 2007, 2016).

The taxa were delimited on the basis of combining data from various sources including morphology, biology and DNA barcodes, and applying the phylogenetic species concept of Nixon and Wheeler (1990). In the taxonomy section, the diagnostic characters are in bold italic font style.

The genitalia and the abdomen were prepared following methods described by Hardwick (1950). The phallus was photographed during dissection, and afterwards the vesica was everted from the same sample. The vesica was everted via the caecum that was cut open, by placing the phallus inside a hypodermic syringe (Sihvonen 2001). The wing venation slides were prepared by removing one pair of wings either by gentle downwards pressure or by lifting with fine forceps. The wings were then placed in a dish containing 99.5% ethanol and scales removed from both surfaces with delicate brushes. They were placed on a slide in a drop of ethanol, which was replaced by a drop of euparal, and placed under a coverslip. The preparations were left unstained.

For the DNA analyses, one or two legs were removed from each dried specimen and stored in an individual tube, which in most cases contained ethanol. DNA extraction, amplification, and sequencing of the barcode region of the mitochondrial cytochrome c oxidase I (COI) gene (658 base pairs) were carried out in the Canadian Centre for DNA Barcoding, Ontario, Canada, using standard high-throughput protocols (Ivanova et al. 2006; de Waard et al. 2008), which are described at CCDB (2013). Sequence divergence within and between species was calculated using the Kimura 2-parameter model (Kimura 1980) and the neighbour-joining algorithm (Saitou and Nei 1987), as implemented in BOLD (Ratnasingham and Hebert 2007; <http://www.boldsystems.org/>)

Results and discussion

The genus *Ekboarmia* is a uniform group in regard to the structure of the male and female genitalia and differences between the taxa are minute. This concerns both the external and internal genitalia structures. In the male genitalia the most variable interspecific features, and thus diagnostic in separating the taxa, are the shape of juxta, the angle at which the vesica opens, width of the uncus and the setose ridge in the medial part of valva. In the female genitalia the most variable structures are shape of the lamella antevaginalis, shape of the signum, and presence or absence of a signum.

With regard to the external characters, the group is less uniform. *E. atlanticaria* and *E. fascinataria* form a closely related yet distinguishable species pair, *E. sagnesi* has somewhat similar medial lines on wings but the overall appearance is more uniform. *E. miniaria* sp. n. is the most distinct in its small size, dark brown wing colour, the different course of the postmedial line in the male and most notably, the female is almost uniform dark brown, without markings. Such sexual dimorphism is not apparent in other *Ekboarmia* species. External differences between recognised species are conspicuous and diagnostic, allowing reliable and easy identification.

DNA barcodes were available for the majority of named taxa (Fig. 26). These proved useful and were in agreement with morphological characters. Interspecific distances were found to range from 1.5% to 3.5% in the three examined species of the genus, thus being considerably smaller than in other geometrid genera (on average within genus 10%, see Hausmann et al. 2011). Mean intraspecific variation ranged from 0.15% to 1.35% (average 0.60%). We comment on the genetic data of each species under relevant sections below. The most notable DNA barcode absence is that of *E. fascinataria* and despite extensive efforts, we have failed to get fresh material from North Africa for the genetic work. The most recent *E. fascinataria* specimens in European col-

lections, both public and private, that we managed to locate are from 1979 (in coll. Sommerer). The absence of recent material may be an artefact, and not a true indication of disappearance of *E. fascinataria*, because we simply may not have contacted the right sources. In addition, it is known that collecting activities in many areas in Algeria and Morocco are few and geographically biased to certain locations.

The larvae of the taxa whose biology is known feed exclusively on needles of *Juniper* trees. Larva of *E. atlanticaria* has been found on *Juniperus phoenicea* in Portugal (Corley 2004), Spain (Staudinger 1859), and Sardinia (Flamigni *et al.* 2016), and is perhaps monophagous on it.

To conclude, four correlating characters sets were useful in delimiting the species (not all character sets were available for all species): external features, genitalia structures (including both the external and internal genitalia), DNA barcodes, and details of life history. Three of these characters sets were available for *E. miniaria* sp. n., supporting its placement in *Ekboarmia*.

Four species are presently considered valid: *E. atlanticaria* (Staudinger, 1859), with one putative subspecies in North Africa, *E. fascinataria* (Staudinger, 1900), *E. sagnesi* Dufay, 1979, and *E. miniaria* sp. n. from Portugal.

Taxonomy

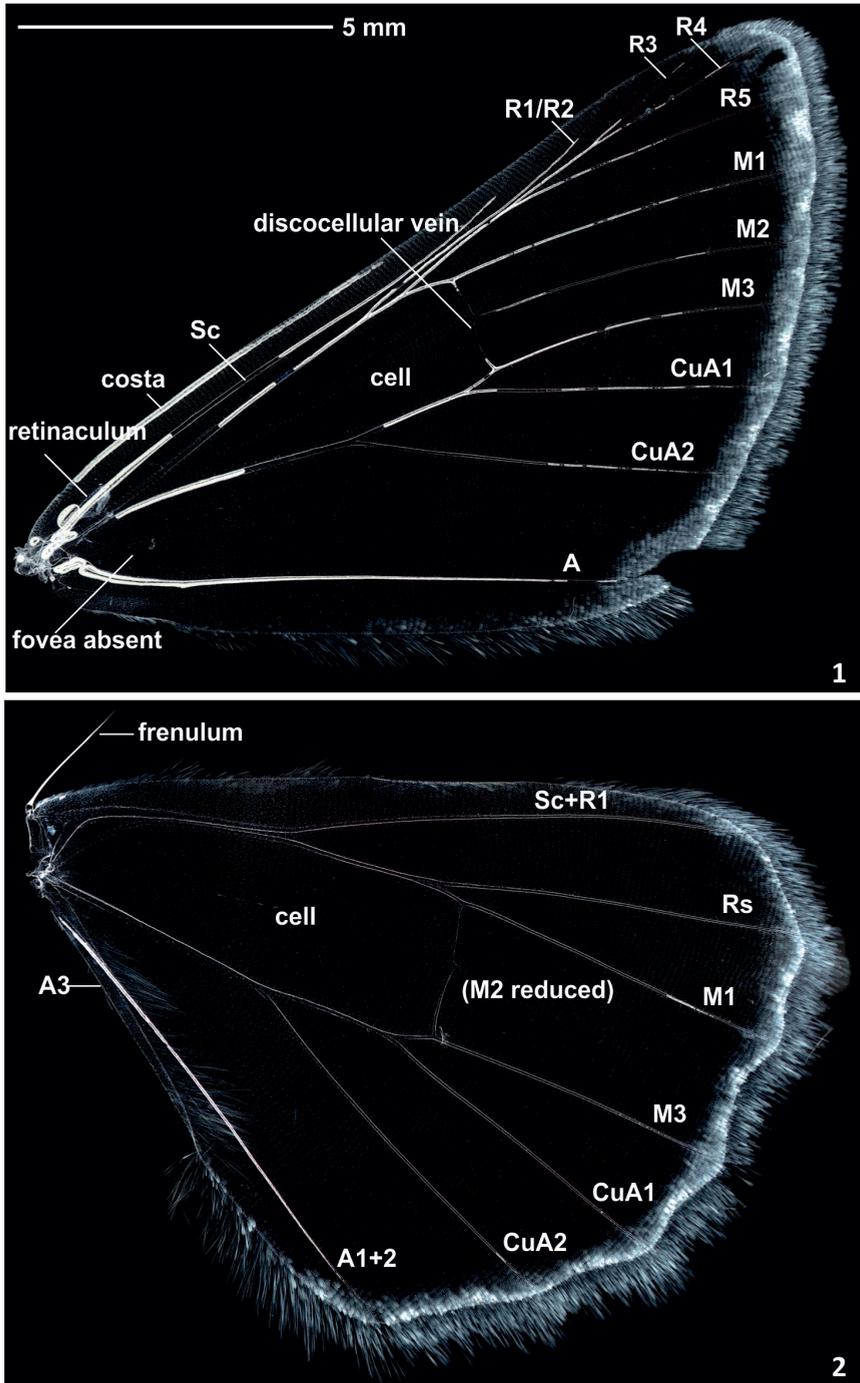
Ekboarmia Wehrli, 1943

Ekboarmia Wehrli, 1943, Gross-Schmetterlinge der Erde 4 (Supplement.): 517. Type species: *Boarmia atlanticaria* Staudinger, 1859 [replacement name].

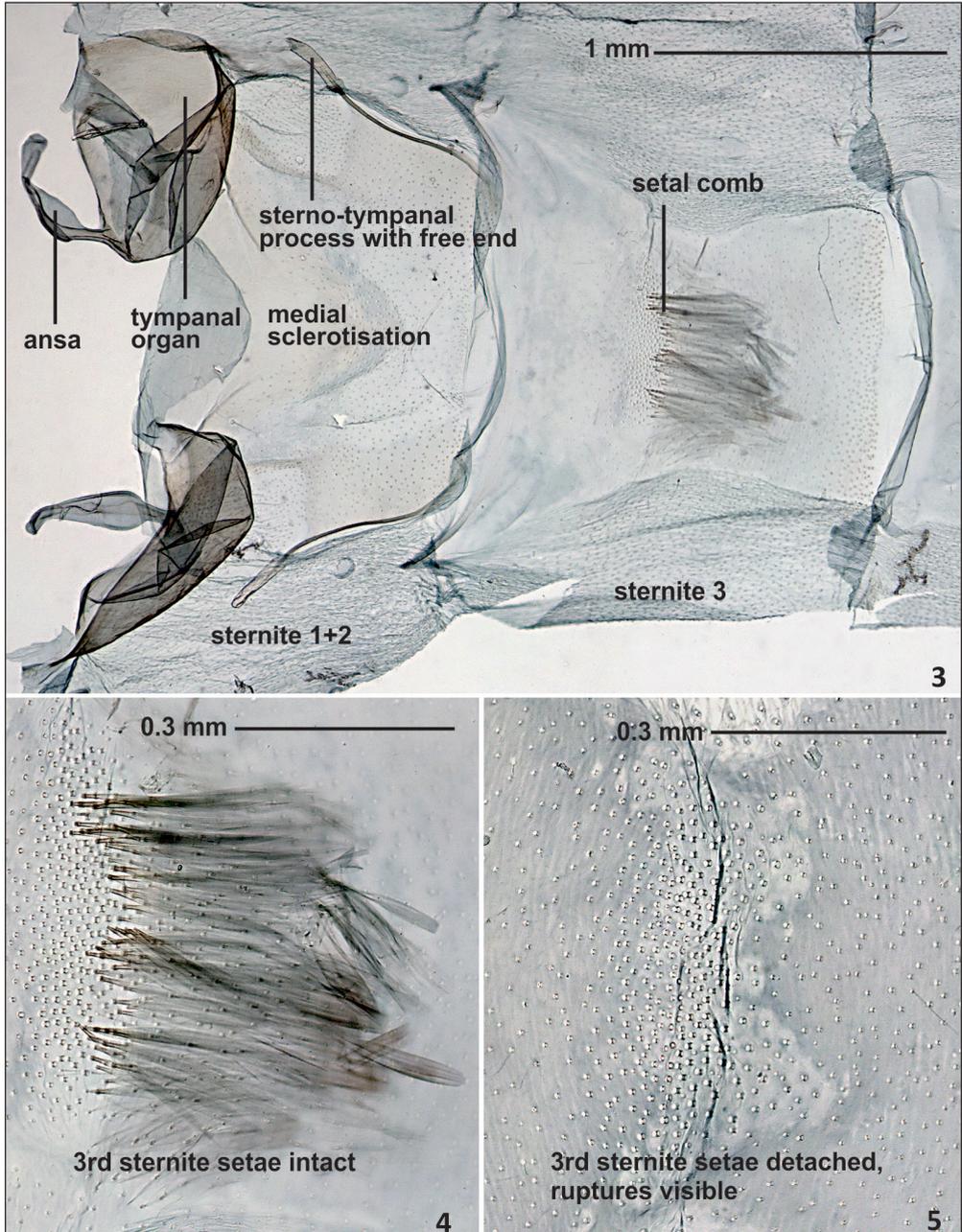
Rhoptria Gumpfenberg, 1892, Nova acta Academiae Caesareae Leopoldino-Carolinae Germanicae Naturae Curiosorum 58: 299. Type species: *Boarmia atlanticaria* Staudinger, 1859. [Junior homonym of *Rhoptria* Guenée, 1857 (Geometridae: Ennominae)].

Diversity and distribution. Four species in the West-Mediterranean area, including the French Alps, Iberian Peninsula, the Balearic Islands, Sardinia in Italy, and Morocco, Algeria, and Tunisia in North Africa (Fig. 17).

External characters and abdomen. Medium-sized, wingspan 18–29 mm. Wings grey-brown or different shades of brown, markings blackish. **Postmedial line prominent**, on forewing it is rather smooth, **dentate or even zigzag-shaped**, turning inwards near costa, outer margin bordered with whitish. Fovea absent. Venation (Figs 1–2); Sc free, R1 and R2 in forewing completely coincident, often approaching the stem of R3+R4 near its base, rarely anastomosing with it. Common stalk (stem) of R3–R5 remote from upper corner of cell (= origin of M1). R3 and R5 branching off rather basally (proximally). Hindwing with large frenulum. Veins Rs and CuA1 arising remote from upper and lower corner of cell. Space between M1 and M3 large. 3A present, weak, reaching posterior margin just behind middle. **Male antennae bipectinate** almost to the tip (5–8 apical segments unpectinated), rami narrow, dorsally unscaled, arising proximally on ventral side from rather long flagellomeres. **Female antennae filiform**. Frons flat, rather broad, smooth-scaled, palps porrect or slightly curved upwards, rough-scaled, reaching well beyond frons. Haustellum moderately developed. Chaetosemata round type, near eye margin, well developed. **Male hindtibia with weak hair pencil** (if not everted, a weak groove visible only), hindtibia of both sexes with 2+2 spurs (index of spurs 0-2-4). **Setal comb** (oval field) of minute setae **present on abdominal sternite 3** (Figs 3–5), weak sterno-tympanal process laterally on sternite 1+2, with short, free, distally rounded end.



Figures 1–2. Wing venation of *E. atlanticaria* (Staudinger, 1859) male (Portugal: Province Algarve, Salema, 19.iv.2007, slide Sihvonen 2156, coll. Skou). **1.** Forewing fovea is often present in the Boarmiini, but absent in *Ekboarmia*. **2.** Hindwing anal margin was partly folded during slide preparation, hence vein A3 appears at the margin of the wing (=dissection artefact). Veins are partly filled with air (white sections), particularly in forewing.



Figures 3–5. Male abdominal sternite A3 has a small setal comb in *Ekboarmia*, shown here in *E. sagnesi* Dufay, 1979. **3–4.** Illustrated from a specimen from Spain: Leon, Valle de Luna, 1200 m, 2.vii.2011 (slide Sihvonon 2157, coll. Skou). **5.** The setae are detached easily during preparation, revealing an oval field (specimen from France: Dept. Isère, Valle de la Romanche, 1200 m, 22.-23.vi.1999, slide Sihvonon 2095, coll. Skou). The presence of setal comb correlates with presence of sterno-tympanal processes laterally on sternite 1+2, with short, free end. Probably its function is the eversion of the hind leg hair-pencil. Species with a strongly developed hair-pencil always have a strong setal comb and a long sterno-tympanal process.



Figures 6–8. Larva, pupa and adult of *E. atlanticaria* (Staudinger, 1859). Larvae fed in captivity on *Juniperus phoenicea*. Photos by Michael Leipnitz.

Male with tergites 1 and 2 more strongly sclerotised, 8th tergite weakly triangular, posterior margin narrower, other abdominal segments membranous and without modifications. Tympanal cavities without lacinia, medium-sized.

Male genitalia. Uncus triangular, with slightly elongated tip, apex rounded. Socii absent. Gnathos arms fused ventrally, upturned, plate-shaped. *Valva evenly narrowing towards apex, costa sclerotised, apical part of valva with narrow, setose ridge. Juxta sclerotised, with two large arms, inner and/or distal margins serrate or dentate.* Saccus elongated, upturned medially. *Phallus deeply cleft distally*, with dorsal and ventral sclerotised process, latter shorter, gradually narrowing to pointed tip, dorsal one longer, spatulate, *with narrow base which is bent by everted vesica.* Cae-

cum with sclerotised band on ventral side only, dorsal side membranous. *Vesica* slightly enlarged at base, *without cornuti*.

Female genitalia. Papillae anales rather short, oval, setose. *Lamella antevaginalis sclerotised, loosely V-shaped transverse band*. Lamella postvaginalis weakly sclerotised, rounded plate. *Ductus bursae short, fluted, membranous*. Colliculum elongate, sclerotised. Corpus bursae elongated, oval, membranous, without sclerotisations. Signum stellate, of medium size, small or absent.

Biology. Probably all species feed on *Juniper* needles. Larva of *E. atlanticaria* has been recorded on (Culot 1919) and found on *Juniperus phoenicea* (Zangheri 1968; Corley 2004) and that of *E. sagnesii* has been reared on *Juniperus communis* (Colomb 2005). Moths are found in a variety of habitat types from coastal dunes to open pine forests to mountain slopes with scattered trees and bushes, from sea-level to 1400 metres.

Immature stages. Larvae of *E. sagnesii* (see Colomb 2005) and *E. atlanticaria* (see Fig. 6 and Spuler 1904) are green needle-mimics that closely match the needles of their *Juniperus* food-plants. Larvae of both species have a row of red dots dorsally, interspersed with yellow and white markings both dorsally and laterally. Pupa typical (Fig. 7), with D2 setae in the cremaster fused and elongated.

Remarks. *Ekboarmia* has recently been classified in Ennominae tribe Boarmiini (Vives Moreno 1994; Leraut 1997; Hausmann *et al.* 2011). Pupal cremaster with setae D2 fused and elongated supports this placement.

Ekboarmia atlanticaria (Staudinger, 1859)

atlanticaria atlanticaria Staudinger, 1859, Stettiner Entomologische Zeitung 20 (7–9): 218, (*Boarmia*?). Syntypes 3 ♂♂, 3 ♀♀ (MNHU), 1 ♂ (ZFMK; genitalia dissected by E. Wehrli, prep. number 5199). Spain: Andalusia, near Chiclana (examined externally, illustrated also in Albers & Warnecke (1941), plate II, figs. 9, 12 (on p. 332).

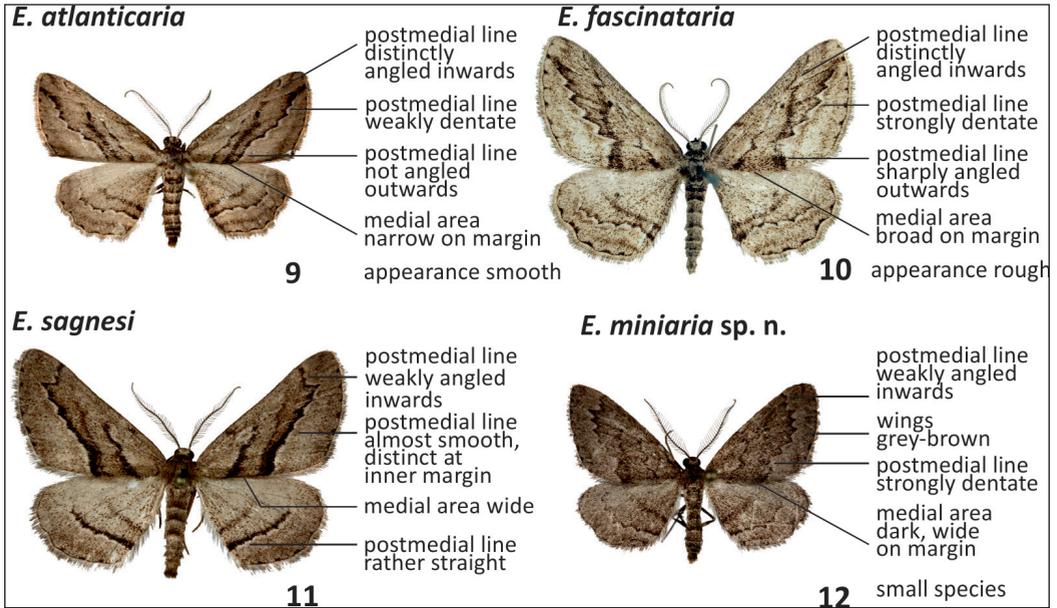
= *atlanticaria gracilis* Albers & Warnecke, 1941, Mitteilungen der Münchner Entomologische Gesellschaft 31 (1): 115, pl. 4, fig. 40, (*Boarmia*). Syntypes 4 ♂♂, 5 ♀♀ (2 syntype ♂♂ in Universität Hamburg, Centrum für Naturkunde, Germany), [Morocco]: Mehedy (examined externally, based on a photograph in the original description). Downgraded from subspecific rank of *Ekboarmia atlanticaria gracilis* (for instance Scoble 1999; Leraut 2009) to synonymy with *Boarmia*(?) *atlanticaria atlanticaria* Staudinger, 1859 (**syn. n.**), based on the absence of distinct morphological or molecular structures and adjoining distribution area. See Remarks.

atlanticaria holli Oberthür, 1909, Études de Lépidoptérologie comparée 3: 412, pl. 27, fig. 152, (*Hemerophila*). Holotype male (ZFMK), Algeria: Alger [Originally as sp.] (examined, including genitalia, dissected by E. Wehrli, prep. number 5193).

Infrasubspecific names, probably unavailable: *pallidior* Lucas, 1956 (f.).

Examined non-type material. 139 specimens (100 ♂♂, 39 ♀♀; data provided in a Suppl. material 1).

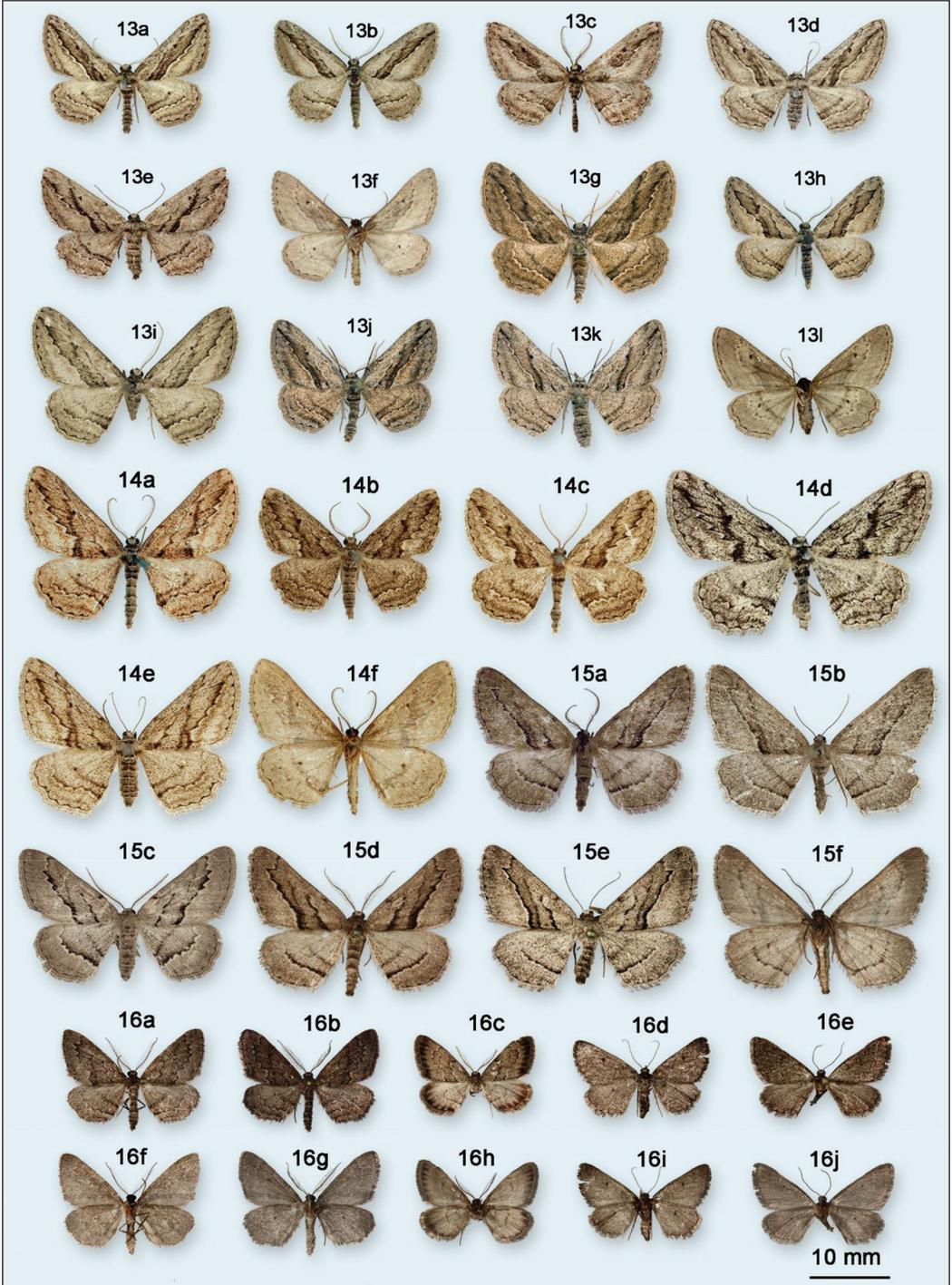
External characters and abdomen (Figs 8, 9, 13). Wingspan 19–27 mm, *medium-sized species in the genus*. Wings grey-brown, forewing medial area darker brown, *general appearance somewhat smooth, slightly glossy*. Forewing with antemedial line inclined, deeply V-shaped and acutely angled back towards base but often this part very narrow and only weakly visible. Forewing medial line narrow, often strongest and approaching postmedial line near inner margin. Forewing postmedial line dark-brown to blackish, inclined, *weakly dentate* on veins, shallowly curved



Figures 9–12. Diagnostic external characters (indicated) of *Ekboarmia* species. **9.** *E. atlanticaria* male (Staudinger, 1859), Portugal: Salema, 40 m, 19.iv.2007 (coll. Skou). **10.** *E. fascinatoria* male (Staudinger, 1900), Algeria: Hammam Righa, April 1928 (coll. ZFMK). **11.** *E. sagnesi* male Dufay, 1979, Spain: Valle de Luna, 1200 m, 2.vii.2011 (coll. Skou). **12.** *E. miniaria* male sp. n., Portugal: Grandola, Ameiras de B., 20.vi.2011 (coll. Skou).

inwards between veins, dark brown, deeply V-shaped and **angled towards base** (along vein M1) **near apex**, angled again towards apex before reaching costa. **Forewing postmedial line not angled outwards at inner margin and medial area narrow.** Dark brown to blackish streak in forewing subapical area, often appearing as an extension of postmedial line. Outer margin bordered with whitish. Subterminal line mostly present, but indistinct, dark grey or brown, more or less parallel and close to termen. Terminal line blackish, narrow, often discontinuous, stronger at vein endings. Fringes uniform grey-brown. Hindwing medial line weakly curved, strongest near inner margin, often absent towards costa. Area between medial and postmedial lines often darker than remaining wing surface. Hindwing postmedial line weakly dentate, more strongly curved outwards than medial line, outer margin whitish. Hindwing subterminal line grey or brown, diffuse. Forewing discal spots blackish, small, distinct. Hindwing discal spots smaller. Wings below grey-brown, medial lines diffuse. Postmedial line discontinuous, with blackish dentation, discal spots and terminal line blackish. Course of postmedial line differs from that of upperside, antemedial line hardly visible. Frons, collar, thorax and abdomen concolorous with wings. Antennae concolorous with wings dorsally. Morphological structure of antennae, hindtibia, tympanal organs, tergites and sternites of abdomen as mentioned in generic description.

Variation. Spring generation much larger. Wings vary from grey-brown to different shades of brown. Medial area sometimes completely suffused with dark grey or brown. Terminal line can be continuous or discontinuous. Very rarely specimens occur with stronger dentation on postmedial



line and/or a shallow incision near inner margin, producing a somewhat *fascinataria*-like appearance. We consider such specimens to fall within intraspecific variation of *atlanticaria*. The male syntype of *atlanticaria* from Andalusia in coll. ZFMK shows this feature.

Male genitalia (Fig. 18). *Uncus* narrow, elongated, apex round. Socii absent. Gnathos arms fused ventrally, upturned, plate-shaped, surface rather smooth, margin round. Valva evenly narrowing towards apex, costa sclerotised, apical part of valva with narrow, setose ridge. *Juxta* arms large, rather narrow, dentate at apex only, base solid. Saccus elongated, upturned medially. Phallus narrow, caecum very short. Longer phallus apex elongate-oval, becoming bent when vesica is everted. *Vesica* enlarged at base, everts at c. 135 degree angle, without cornuti.

Female genitalia (Fig. 22). Papillae anales slightly elongated, setose. Apophyses posteriores longer (about 1.6×) than apophyses anteriores. *Lateral arms of lamella antevaginalis* weakly sclerotised. *Lamella postvaginalis* weakly sclerotised, rounded plate with caudal, acute process. Ductus bursae very

Figures 13–16. *Ekboarmia* adults. **13a.** *E. atlanticaria* ♂, syntype, Spain: Andalusia, near Chiclana (coll. MNHU); **13b.** *E. atlanticaria* ♂, Italy: Sardinia, Teulada, 8-11.xi.1934 (coll. ZFMK); **13c.** *E. atlanticaria* ♂ Spain: Ibiza, St. Antonio, May 1983 (coll. Sihvonen); **13d.** *E. atlanticaria* ♀, syntype, Spain: Andalusia, near Chiclana (coll. MNHU); **13e.** *E. atlanticaria* ♀, Spain: Cádiz, 10 km NW of Tarifa, Punta Paloma, 30 m, 22–23.v.2006 (coll. Skou); **13f.** *E. atlanticaria* ♂, syntype, Spain: Andalusia, near Chiclana (underside of **13a**, coll. MNHU); **13g.** *E. atlanticaria* ♂, Morocco: Kenitra area, 2 km S of Medya, 22 m, 6.iv.2011 (coll. Stadie); **13h.** *E. atlanticaria* ♂, Morocco: Tanger, xii 1908 (coll. ZFMK); **13i.** *E. atlanticaria* ssp. *holli* ♂, holotype m, Algeria: Alger, 20.vii.1904 (coll. ZFMK); **13j.** *E. atlanticaria* ssp. *holli* ♂, Tunisia: Grombalia area, 2 km S of Semech, 70 m, 2.iv.2007 (e.o.) (coll. Stadie); **13k.** *E. atlanticaria* ssp. *holli* ♀, Tunisia: Grombalia area, 2 km S of Semech, 70 m, 2.iv.2007 (e.o.) (coll. Stadie); **13l.** *E. atlanticaria* ♀, syntype, Spain: Andalusia, near Chiclana (underside of **13d**, coll. MNHU). **14a.** *E. fascinataria* ♂, Algeria: Hammam Righa, April 1928 (coll. ZFMK) [illustrated in Wehrli (1939–1954) also]; **14d.** *E. fascinataria* ♂, Algeria: Hammam Righa, Juni 1928 [gen. II?] (coll. ZFMK) [illustrated in Wehrli (1939–1954) also]; **14c.** *E. fascinataria* ♂, Algeria: Hammam Righa, Juni 1928 [gen. II?] (coll. ZFMK); **14d.** *E. fascinataria* ♀, holotype, Algeria: Teniet el Had, May–June (coll. MNHU); **14e.** *E. fascinataria* ♀ Algeria: Hammam Righa, April 1928 (coll. ZFMK) [illustrated in Wehrli (1939–1954) also]; **14f.** *E. fascinataria* ♂, Algeria: Hammam Righa, April 1928 (underside of **14a**, coll. ZFMK) [illustrated in Wehrli (1939–1954) also]; **15a.** *E. sagnesi* paratype ♂, France: Hautes-Alpes, Les Fréaux, près la Grave, 1400 m, 20.vi.1979 (coll. Herbulot in ZSM); **15b.** *E. sagnesi* ♀, France: Hautes-Alpes, Usine, Romanche, 1155 m, 24.vi.2009 (coll. Tautel); **15c.** *E. sagnesi* ♂, France: Hautes-Alpes, Usine, Romanche, 1155 m, 15.viii.2009 ex larva (coll. Tautel); **15d.** *E. sagnesi* ♂, Spain: Leon, Valle de Luna, 1200 m, 2.vii.2011 (coll. Skou); **15e.** *E. sagnesi* ♀, Spain: Leon, Valle de Luna, 1200 m, 2.vii.2011 (coll. Skou); **15f.** *E. sagnesi* ♂, Spain: Leon, Valle de Luna, 1200 m, 2.vii.2011 (underside of **15d**, coll. Skou); **16a.** *E. miniaria* sp. n. holotype ♂, Portugal: Grandola, Ameiras de Baixo, 20.vi.2011 (coll. Skou); **16b.** *E. miniaria* sp. n. paratype ♂, Portugal: Grandola, Ameiras de Baixo, 20.vi.2011 (coll. Skou); **16c.** *E. miniaria* sp. n. paratype ♂, Portugal: Alentejo, Lagoa de Santo André, Nature Reserve, 16.ix-10.x.1995 (gen. II) (coll. Skou); **16d.** *E. miniaria* sp. n. paratype ♀, Portugal: Grandola, 15.vi.2009 (coll. Skou); **16e.** *E. miniaria* sp. n. paratype ♀, Portugal: Grandola, 15.vi.2009 (coll. Skou); **16f–16j** = corresponding undersides of **16a–16e**.

short, fluted, colliculum long, narrow. Corpus bursae elongated, oval, without sclerotisations. *Signum* *distinctly stellate, of medium size.*

Subspecies *holli*. The holotype is large, greyish-brown (Fig. 13i). In ZFMK is a series of distinctly smaller specimens, collected later in the year, probably a similar phenomenon of seasonal variation as for taxon *gracilis*, see Remarks. The specimens from Tunisia (Fig. 13j, k) are reared and it is therefore difficult to form a judgement upon them. DNA barcodes of Tunisian specimens are distinct from other *E. atlanticaria* specimens (see under Genetic data). No specimens from Algeria were available for DNA barcoding. Historically the subspecies has been delimited to occur in Tunisia and Algeria. We do not propose formal changes to the current classification because more research is needed.

Distribution and abundance (Fig. 17). West-Mediterranean. In Europe only in southwestern Iberian Peninsula, the Balearic Islands, and Sardinia. There is also a record of a single specimen from southern France, undoubtedly a migrant from outside the known distribution area, of which the closest is the Balearic Islands. Outside Europe, in Morocco, Algeria, and Tunisia. In Europe a somewhat local but not rare species, which can be found in limited numbers in its localities.

Phenology. Multivoltine. Recorded from early March to early November with a few additional records in late January, February, and December. Larvae have been found in February (Staudinger 1859), in March, and mid October (M. Corley, pers. comm.). Hibernation probably takes place as egg, larva, and pupa, or a combination of these. The moths are nocturnal and both sexes come readily to light.

Biology. Larva monophagous. It has been found on *Juniperus phoenicea* (Staudinger 1859; Zangheri 1968; Corley 2004).

Habitat. In a variety of habitat types where the foodplant occurs, including coastal dunes as well as non-sandy inland localities. From sea level up to 300 m; according to Redondo *et al.* (2009) up to 500 m.

Genetic data. BIN: BOLD: AAD7906 (n=11 from Morocco, Portugal and Spain including the Balearics belonging to nominal subspecies) (Fig. 26). In Tunisia (putative subsp. *holli*) with two separate, sympatrically occurring BINs (BOLD: ABZ3161, n=3) diverging by 1.0% and (BOLD: ABZ6474, n=2) and by 2.2% from the Iberian and Moroccan populations. *E. sagnesi* samples were nested within *E. atlanticaria* groups (only short sequences available for the former, see *E. sagnesi*). Distance from *E. miniaria* 3.5% and from *E. sagnesi* 1.5%.

Similar species. Forewing postmedial line weakly dentate and not angled outwards towards posterior margin in *E. atlanticaria* (strongly dentate or zigzag-shaped and sharply angled outwards towards posterior margin in *E. fascinataria*). Forewing medial area narrow at posterior margin in *E. atlanticaria* (wide in *E. fascinataria*). The not closely related *Menophra harterti* (Rothschild, 1912) has striated hindwings and forewing postmedial line is continuous, reaching wing margin below apex. The medial area of the not closely related *Ecleora solieraria* (Rambur, 1834) is not dark and hindwing postmedial line is rather straight (see Flamigni *et al.* 2007 for illustrations).

Remarks. Taxon *gracilis* from Morocco has been considered valid at subspecies level (e.g., Scoble 1999; Leraut 2009). The description of taxon *gracilis* was based on a series of nine males and females, collected in August and November, and the specimens are very small and dark greyish-brown. In our opinion type specimens belong to a summer or autumn generation, probably developed under dry conditions. Wet conditions in winter and spring yield larger specimens (see Fig. 13g). Same hypothesis has been presented by Wehrli (1943 *in* Wehrli 1939–1954). One specimen from Moroc-

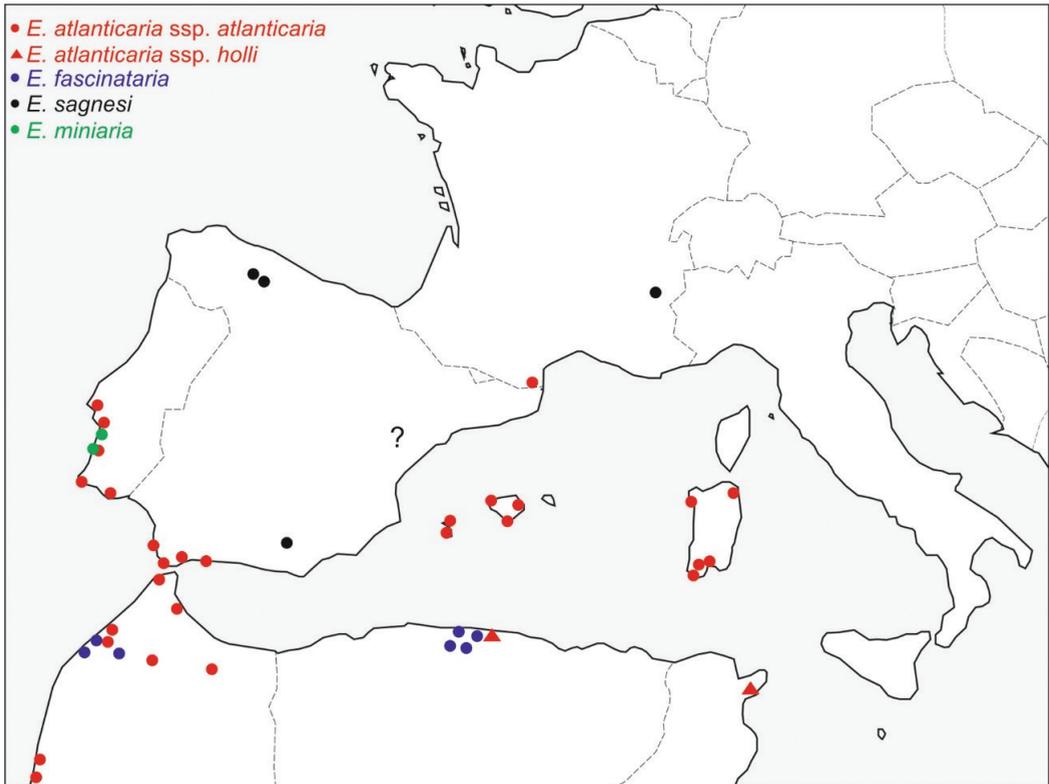


Figure 17. Confirmed records of *Ekboarmia* species. All records of *E. fascinataria* from Europe have proved to be *E. atlanticaria*, therefore this species is removed from the European fauna until a reliable record will be provided. According to current knowledge *E. fascinataria* has a scattered distribution in North Africa, but this may be an artefact of low collecting activity biased towards few sampled areas. An uncertain record of *E. sagnesii* is marked with a question mark, see text for details.

co was available for barcoding and it nested within *E. atlanticaria* subsp. *atlanticaria* specimens from the Iberian Peninsula. Due to similarity in barcodes, adjunct geographical distribution on the opposite sides of Straits of Gibraltar, and presumably seasonal variation of external appearance, we synonymize *Boarmia atlanticaria gracilis* Albers & Warnecke, 1941 with *Boarmia(?) atlanticaria atlanticaria* Staudinger, 1859.

Ekboarmia fascinataria (Staudinger, 1900)

fascinataria Staudinger, 1900, Deutsche entomologische Zeitschrift Iris 12: 395, pl. 6, fig. 3, (*Boarmia*). Holotype female (MNHU), [Algeria]: Teniet el Had (examined externally, illustrated also in Albers & Warnecke (1941), plate II, fig. 10 (on p. 332).

Examined non-type material. 65 specimens (22♂♂, 43♀♀; data provided in Suppl. material 1).

External characters and abdomen (Figs 10, 14). Generally as *E. atlanticaria* (see above), but with following differences. Wingspan 24–29 mm, **large species in the genus**. **General appearance somewhat rough.** Forewing postmedial line distinctly dentate, even zigzagged, angled sharply outwards above posterior margin and medial area wide at that margin.

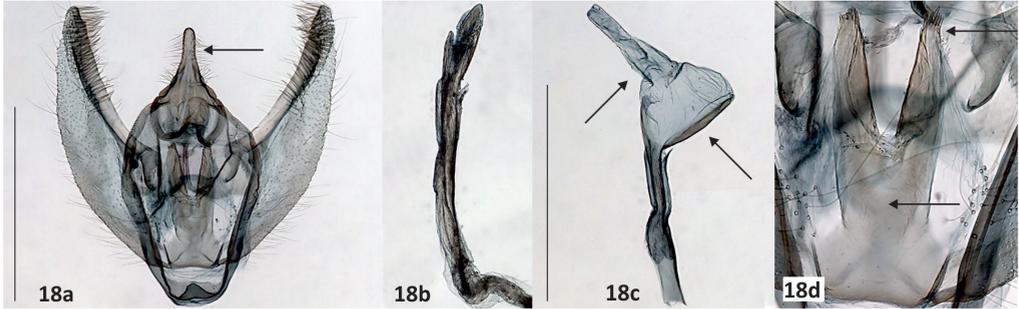
Variation. Wingspan varies quite a lot, the holotype female (collected in May/June) with 29 mm wingspan is the biggest specimen encountered so far. Specimens in the ZFMK collection, collected from March to May in Algeria, Hammam Righa are almost of the same size, while a large series from June consists of distinctly smaller specimens (figured as 1st and 2nd generation in Wehrli 1939–1954). Wing colour varies from grey-brown to grey; males of the Algerian 2nd generation are considerably darker than the females. In addition, a small number of specimens are found in which the forewing postmedial line is not distinctly angled outwards at inner margin. Such specimens, in which this character is somewhat transitional between *E. fascinataria* and *E. atlanticaria*, are nevertheless identified as *E. fascinataria*, as all other relevant characters are typical for this species.

Male genitalia (Fig. 19). Generally somewhat larger and more robust than *E. atlanticaria* (see above), but without any noticeable differences. Base of the juxta tends to be a little longer and narrower, the incision between the furca-arms narrower. The spatulate process at apex of phallus seems to be more elongated and parallel-sided (elongated-oval in *E. atlanticaria*). Large differences as recently published by Leraut (2009, fig. 96) were not observed.

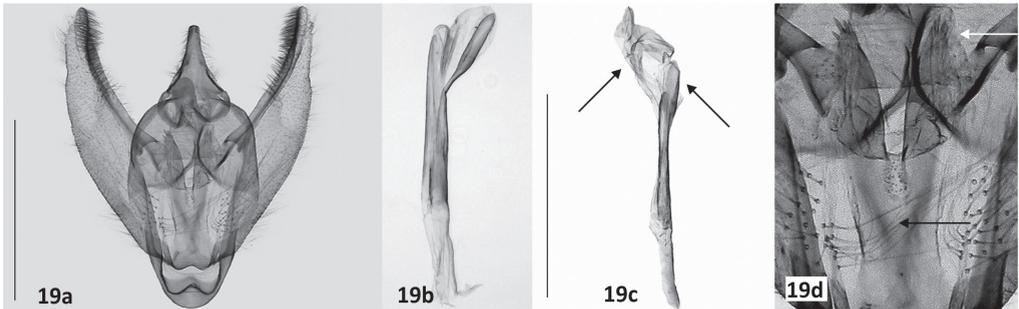
Female genitalia (Fig. 23). Generally as *E. atlanticaria* (see above), but little more robust, with slight, rather gradual differences. Apophyses anteriores and posteriores, and lamella antevaginalis are longer and stronger, lamella postvaginalis is a larger, more equally rounded plate, colliculum longer, but narrower, corpus bursae with a shallow and a more strongly rounded side. Signum a little larger, with fewer but larger marginal teeth. However, all or some of these characters may be due to variation and should be verified by study of more material.

Figures 18–21. Male genitalia of *Ekboarmia* species, diagnostic characters are indicated and explained. Scale (where shown) is 1 mm. **18a.** *E. atlanticaria* genitalia, Portugal: Prov. Algarve, Salema, 40 m, 19.iv.2007, slide PS2053 (coll. Skou); **18b.** *E. atlanticaria* phallus, Portugal: Prov. Algarve, Salema, 40 m, 19.iv.2007, slide PS2053 (coll. Skou); **18c.** *E. atlanticaria* vesica, Portugal: Prov. Algarve, Salema, 40 m, 19.iv.2007, slide PS2053 (coll. Skou); **18d.** *E. atlanticaria* juxta, Portugal: Prov. Algarve, Salema, 40 m, 19.iv.2007, slide PS2053 (coll. Skou); **19a.** *E. fascinataria* genitalia, Algeria: Hammam Righa, May 1928, slide 2307-DS (coll. ZFMK); **19b.** *E. fascinataria* phallus, Algeria: Hammam Righa, June 1928, dissection 5919-Wehrli (in glycerol), mounted on slide by Stüning in 2015 (coll. ZFMK); **19c.** *E. fascinataria* vesica, Algeria: Hammam Righa, May 1928, slide 2307-DS (coll. ZFMK); **19d.** *E. fascinataria* juxta, Algeria: Hammam Righa, May 1928, slide 2307-DS (coll. ZFMK); **20a.** *E. sagnesi* genitalia, Spain: Leon, Valle de Luna, 1200 m, 2.vii.2011, slide PS2157 (coll. Skou); **20b.** *E. sagnesi* phallus, Spain: Leon, Valle de Luna, 1200 m, 2.vii.2011, slide PS2157 (coll. Skou); **20c.** *E. sagnesi* vesica, France: Dept. Isère, Valle de la Romanche, 1200 m, 22.–23. vi.1999, slide PS2095 (coll. Skou); **20d.** *E. sagnesi* juxta, France: Dept. Isère, Valle de la Romanche, 1200 m, 22.–23. vi.1999, slide PS2095 (coll. Skou); **21a.** *E. miniaria* sp. n. genitalia, Portugal: Grandola, Ameiras de B.[aixo], 20.vi.2011, slide PS2050 (coll. Skou), holotype; **21b.** *E. miniaria* sp. n. phallus, Portugal: Grandola, Ameiras de B.[aixo], 20.vi.2011, slide PS2050 (coll. Skou), holotype; **21c.** *E. miniaria* sp. n. vesica, Portugal: Grandola, Ameiras de B.[aixo], 20.vi.2011, slide PS2050 (coll. Skou), holotype; **21d.** *E. miniaria* sp. n. juxta, Portugal: Grandola, Ameiras de B.[aixo], 20.vi.2011, slide PS2050 (coll. Skou), holotype.

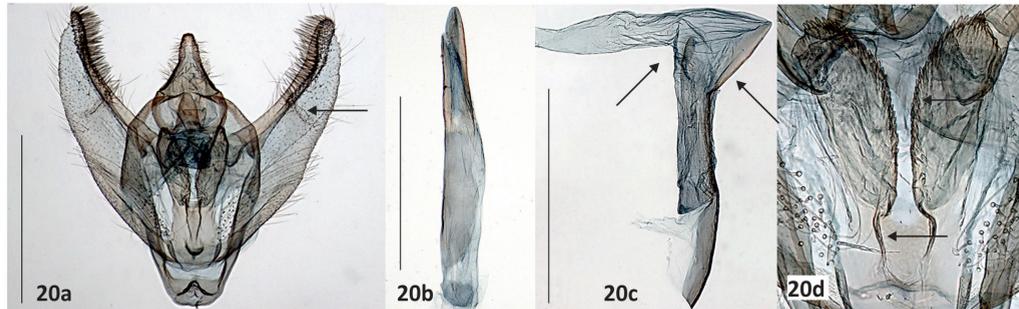
E. atlanticaria * uncus narrow * phallus apex bents when vesica is everted * vesica enlarged at base, opens at 135° angle * juxta arms dentate at apex only, base without grooves



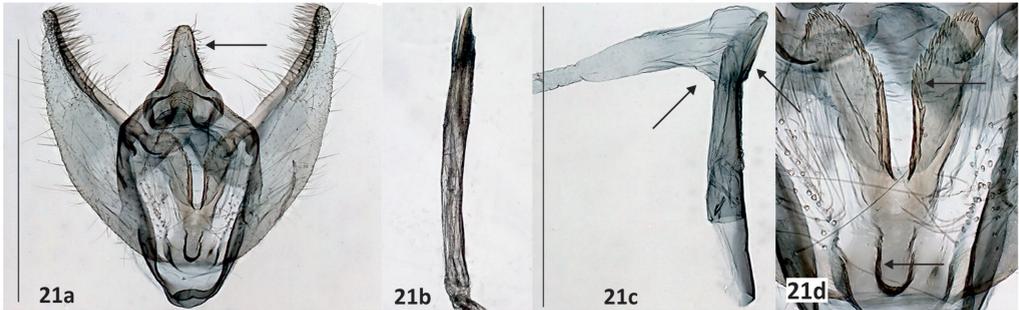
E. fascinataria * uncus narrow * phallus apex bents when vesica is everted * vesica assumably enlarged at base, opens at 135° angle * juxta arms dentate at apex only, base without grooves



E. sagnesii * setose ridge extends into medial part of valva * phallus apex bents when vesica is everted * vesica opens at 90° angle * juxta arms dentate (or smooth) along margin, base grooved



***E. miniaria* sp. n.** * uncus wide * phallus apex does not bent when vesica is everted * vesica opens at about 90° angle * juxta arms dentate along margin, base grooved



Distribution and abundance (Fig. 17). Maghrebian. In Algeria and Morocco. The abundance of the species is unknown. Apparently it is some decades since it was last collected. No confirmed records from Europe, see Remarks.

Phenology. Probably bivoltine. Only rather few and imprecise records available: February, March, April, May, June, October. Rungs (1981) gives February to June and September to November. Wehrli (1939–1954) mentions ‘several generations’ and figures specimens of a 1st and 2nd generation. Larval time and hibernation are unknown. It is unknown when the adults fly, but probably at night.

Biology. Unknown.

Habitat. Unknown.

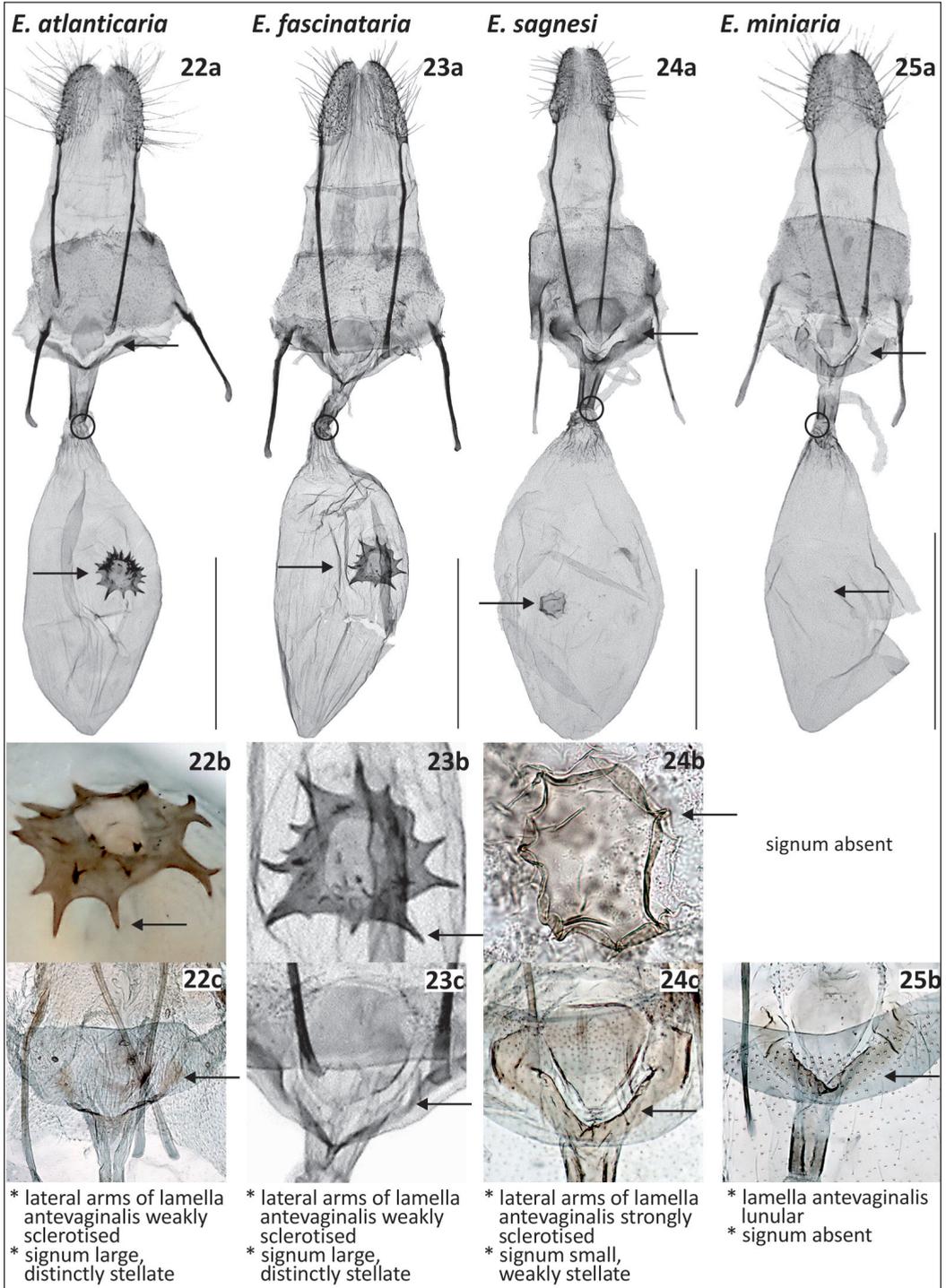
Genetic data. No data available.

Similar species. *E. atlanticaria*, see text above.

Remarks. Although the genitalia of *E. atlanticaria* and *E. fascinataria* are similar, without distinct diagnostic characters, the validity at species level is supported by distinct external appearance and perhaps sympatric occurrence in Morocco and Algeria. This is not unique, as there are examples among the Geometridae and more widely in other Lepidoptera in which external appearance is distinct but the genitalia are rather homogenous (European examples include for instance *Macaria notata* – *M. signaria*, *Isturgia limbaria* – *I. roraria*, *Isturgia sparsaria* – *I. messapiaria* (Skou and Sihvonen 2015), *Nemophora degeerella* (Kozlov *et al.* 2016)), and DNA barcodes are para- or polyphyletic (Mutanen *et al.* 2016 pinpoint numerous Geometridae examples), and yet these taxa are considered valid at species level. The currently available data do not support synonymisation of *E. atlanticaria* and *E. fascinataria*. DNA barcode and life history of *E. fascinataria* are not known at the moment. These, when available, are likely to shed more light on the taxonomy.

E. fascinataria has been recorded from France (Llauro, Department Pyrénées-Orientales by Bérard 1995) and it has been included in the French list of Lepidoptera (Leraut 1997) and in Fauna Europaea (Hausmann *et al.* 2011). In our opinion the specimen in Bérard (1995) is *E. atlanticaria* and also Leraut (2009) states in his more recent publication that the species is not yet known from Europe. Expósito Hermosa (2007, p. 270) explains the identity of a male specimen from the Island of Formentera in the Balears, recorded on 24 August, 1968. The conclusion is vague (our translation from Spanish): “male genitalia concur with the picture of *E. fascinataria* from Morocco as

Figures 22–25. Female genitalia of *Ekboarmia* species, diagnostic characters are indicated and explained. Scale (where shown) is 1 mm. **22a.** *E. atlanticaria* genitalia, Spain: Prov. Huelva, ESE Mazagon, 20 m, 21.ix.2009, slide 2309-DS (coll. ZFMK); **22b.** *E. atlanticaria* signum, Spain: Prov. Cádiz, 10 km NW of Tarifa, Punta Paloma, 30 m, 22.-23. v. 2006, slide PS2049 (coll. Skou); **22c.** *E. atlanticaria* ostium bursae and adjacent structures, Spain: Prov. Cádiz, 10 km NW of Tarifa, Punta Paloma, 30 m, 22.-23. v. 2006, slide PS2049 (coll. Skou); **23a.** *E. fascinataria* genitalia, Algeria: Hammam Righa, May 1928, slide 2310-DS (coll. ZFMK); **23b.** *E. fascinataria* signum, Algeria: Hammam Righa, May 1928, slide 2310-DS (coll. ZFMK); **23c.** *E. fascinataria* ostium bursae and adjacent structures, Algeria: Hammam Righa, May 1928, slide 2310-DS (coll. ZFMK); **24a.** *E. sagnesi* genitalia, France: Dept. Isère, Valle de la Romanche, 1155 m, 24.vi.2009, slide 2311-DS (coll. C. Tautel, Paris); **24b.** *E. sagnesi* signum, France: Dept. Isère, Valle de la Romanche, 1200 m, 22.-23.vi.1999, slide PS2096 (coll. Skou); **24c.** *E. sagnesi* ostium bursae and adjacent structures, France: Dept. Isère, Valle de la Romanche, 1200 m, 22.-23.vi.1999, slide PS2096 (coll. Skou); **25a.** *E. miniaria* sp. n. genitalia, Portugal: Grandola, 15.vi.2009, slide 2312-DS (coll. ZFMK), paratype; **25b.** *E. miniaria* sp. n. ostium bursae and adjacent structures, Portugal: Grandola, 15.vi.2009, slide PS2051 (coll. ZFMK), paratype.



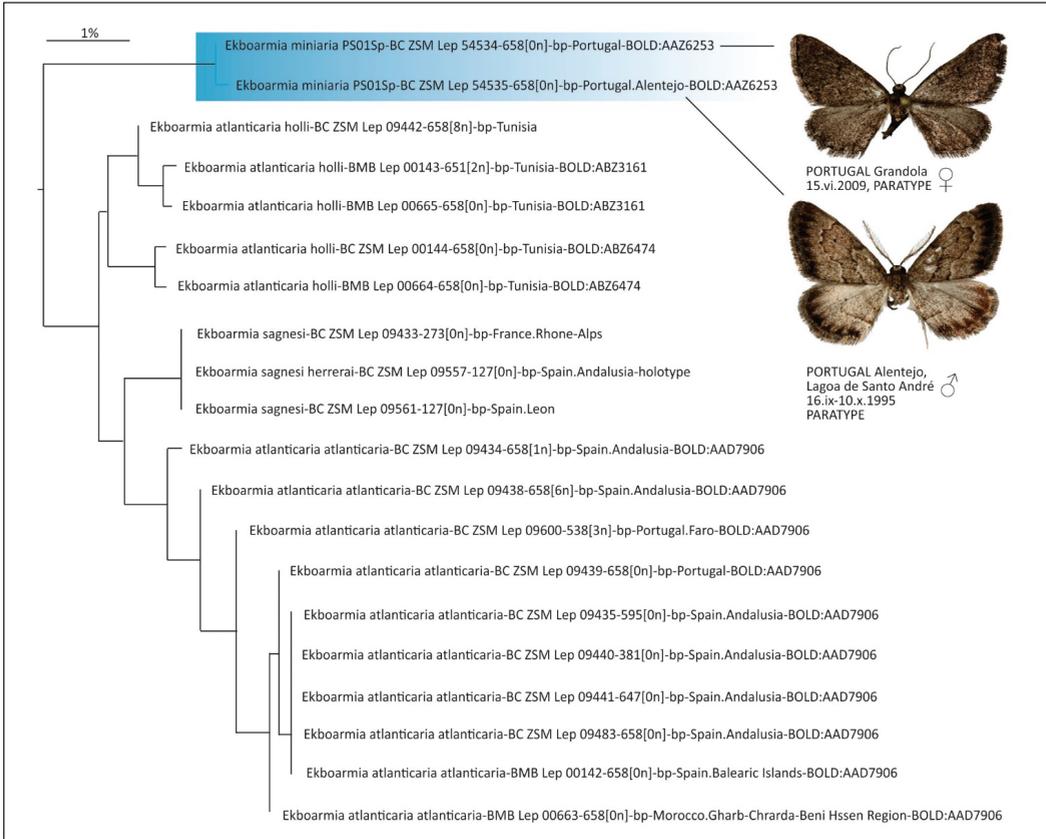


Figure 26. Neighbour-joining tree of *Ekboarmia* taxa, with the position of *E. miniaria* sp. n. from Portugal highlighted. Tree was generated under the K2P nucleotide substitution model of 20 barcode sequences as implemented on BOLD. The position of *E. sagnesi* within *E. atlantica* is likely to be an artefact, resulting from short barcode sequences. The taxonomic status of *E. atlantica* subspecies *holli* from Tunisia needs further research.

illustrated in Albers and Warnecke (1941, p. 137, fig. 1); however, characters of *E. atlantica* and *E. fascinataria* share a sufficient number of correlations and an important number of coincidences, so specimens of *E. atlantica* and *E. fascinataria* share the same identity in Spain.” Due to lack of confirmed records, we propose removal of *E. fascinataria* from the European list until there is a reliable record.

Ekboarmia sagnesi Dufay, 1979

sagnesi Dufay, 1979, Bulletin de la Société entomologique de France 84: 129, figs 1–3, (*Ekboarmia*). Holotype male (MNHN), France: Hautes-Alpes, high valley of the Romanche (examined externally, illustrated in Leraut (2009), plate 47, fig. 18, paratype male genitalia illustrated in Dufay (1979)). Paratype male (coll. Herbulot in Zoologische Staatssammlung München, Germany), France: Les Fréaux, près La Grave,, 1400 m, (H.A.) 20-VI-[19]79, C. Dufay leg (examined externally).

sagnesi herreraei Expósito Hermosa, 2007: SHILAP Revista de Lepidopterologia 35 (138): 269, fig. 1–2, (*Ekboarmia*). Holotype male (coll. A. Expósito Hermosa, Móstoles, Madrid, Spain), Spain, Andalusia: Jaén, Hornillos, Puente de Guada (genitalia examined). Junior synonym proposed by Leraut (2009), here confirmed.

Examined non-type material. 13 specimens (6♂♂, 7♀♀; data provided in a Suppl. material 1).

External characters and abdomen (Figs 11, 15). Wingspan 25–29 mm, *large species in the genus*. Wings dark grey, sometimes with chocolate-brown tinge, rather uniform in colour. Forewing antemedial line black, narrow, deeply angled inwards below costa. Medial line narrow, barely visible and rather straight, strongest near posterior (inner) margin. *Postmedial line* distinct, particularly at inner margin, black, dentate, bordered white outside, *weakly V-shaped and angled towards base subapically*, angled again towards costa. *Postmedial line not angled outwards near inner margin and medial area rather narrow*. *Hindwing medial line almost straight*, not reaching costa. Hindwing postmedial line black, weakly dentate, outer margin bordered with white, weak or absent near costa. Subterminal line absent or very faint. Terminal line faint, continuous. Fringes concolorous with wings, uniform. Discal spots weak or absent. Wings below uniform pale greyish brown, postmedial line and discal spots most visible, antemedial line of forewing absent. Course of postmedial line in forewing does not conform to upperside. Frons, collar, thorax, and abdomen concolorous with wings. Other structures as in *E. atlanticaria*, see above.

Variation. Forewing medial area concolorous with wings or darker, particularly near inner margin. Forewing postmedial line can be rather smooth or distinctly dentate.

Male genitalia (Fig. 20). Generally as *E. atlanticaria* (see above). Setose ridge extends into medial part of valva in *E. sagnesi* (medial ridge absent in other *Ekboarmia* species). Vesica opens at 90 degree angle (at 135 degree angle in *E. atlanticaria* and *E. fascinataria*). Juxta arms broader distally than basally, dentate or smooth along inner margin, always dentate distally, base with roundish lobe in *E. sagnesi* (juxta arms gradually tapered towards apex, margin dentate at apex only in *E. atlanticaria* and *E. fascinataria*, base with elongated lobe in *E. miniaria*).

Female genitalia (Fig. 24). Generally as *E. atlanticaria* (see above). Lamella antevaginalis broader. Signum small, weakly stellate in *E. sagnesi* (signum distinctly stellate in *E. atlanticaria* and *E. fascinataria*, signum absent in *E. miniaria*).

Distribution and abundance (Fig. 17). Southwest European. Only few and isolated populations are known: In Val de la Romanche, Dept. Hautes-Alpes, France, from Valle de Luna and Velilla de Rio Carrión (Javier Gaston, pers. comm.), both in Leon Province and Sierra de Cazorla, Jaén Province, Spain. The species is unknown outside Europe. An apparently extremely local species that appears as single specimens or in limited numbers.

Weiss (1920) listed *E. atlanticaria* from Spain, Sierra de Albarracín. We have not been able to trace the Weiss Collection, and since *E. atlanticaria* has not been reported since from that area, which is unlikely to contain habitats suitable for this species, Weiss's record is surely based on a misidentification. Redondo et al. (2009) mention Weiss's record from Sierra de Albarracín also, suggesting it is possibly *E. sagnesi* because potentially suitable habitats are present in the area (this record is shown as a question mark in the map). *E. sagnesi* should certainly be looked for in Sierra de Albarracín.

Phenology. Uni- or bivoltine. In Spain from early June to mid-July, in France from early May to late June and in August. Larval period and method of hibernation are unknown. The moths are nocturnal and come to light.

Biology. Larva monophagous on *Juniperus*. Reared on *Juniperus communis* (C. Tautel pers. comm., Colomb 2005), but other *Juniperus* species are possible foodplants.

Habitat. Mountain slopes with scattered trees and bushes. In France from 1150 to 1400 m, in Spain known from around 1200 to 1400 m. In Spain, Leon found on slopes with *Juniperus sabina* (Tomas Molina, pers. comm.).

Genetic data. *E. sagnesi* specimens (n=3 from France and Spain, including the holotype of taxon *herrerai*), grouped within *E. atlanticaria*, as the sister-group to *E. atlanticaria* specimens from the Iberian Peninsula, the Balearic Islands and Morocco (Fig. 26). Distances from *E. atlanticaria* 1.5% (from its Tunisian populations 2.0%) and 3.9% from *E. miniaria*. The barcodes of *E. sagnesi* were incomplete, only 127–273 bp in length, so the results must be considered tentative.

Similar species. There are no similar species in Europe. Rather uniform greyish brown colour and small angle in forewing postmedial line near costa are diagnostic.

Remarks. Colomb (2005) illustrated a superficial, hand-drawn picture of the female genitalia, which shows an unusual curved, probably sclerotised structure on the corpus bursae. We have not observed such structure in any of the *E. sagnesi* specimens examined, and the signum (which Colomb apparently did not illustrate) of *E. sagnesi* is weakly stellate, not resembling such curved structure. Second author was able, through the courtesy of Claude Tautel, to re-examine the badly damaged genitalia, preserved in a tube with glycerol pinned under the moth. Remaining sclerotised parts clearly showed the identity with *E. sagnesi*, membranous parts were largely lost, even though attempts were made to make them visible by staining. The curved, probably sclerotised structure was loosely floating around in the tube and not attached to a membrane. It probably was lying on the bursa only accidentally when the original drawing was made.

Ekboarmia miniaria sp. n.

<http://zoobank.org/455E1158-2ACE-4390-8BB6-A345174D381D>

Type-locality and type-specimen. Holotype male, pinned, with genitalia on a separate slide. Original labels: HOLOTYPE/ *Ekboarmia/ miniaria* [red rectangle label]; Portugal Grandola/ Ameiras de B.[aixo] [38°14.29'N; 8°32.42'W]/ 20.vi.2011/ A. & Z. Laštůvka lgt.; Prep. number 2050/ Pasi Sihvonen (in coll. Skou, to be deposited at Zoological Museum, University of Copenhagen, Denmark).

Paratypes 5 ♂♂ and 5 ♀♀, all with same type label: PARATYPE/ *Ekboarmia/ miniaria* [red rectangle label]. One female will be deposited at ZFMK, one male at NHM, one male at ZSM and all remaining specimens are currently in coll. Skou, to be deposited at Zoological Museum, University of Copenhagen, Denmark. Paratype label data: 4 ♂♂, 2 ♀♀: same label data as the holotype. 1 ♂: P.[ortugal] Alentejo/ Lagoa St André [Lagoa de Santo André]/ Nature Reserve [38°5.12'N; 8°46.57'W] / 16.ix-10.x.[19]95/ B. Elliott; genit. prep. m/ 496/ B. Goater. 3 ♀♀: Portugal/ Grandola/ 15.vi.2009/ A. & Z. Laštůvka lgt.

External characters and abdomen (Figs 12, 16). Wingspan males 17–19 mm (n=6), females 17–18 mm (n=5), *smallest species in the genus*. Sexual dimorphism apparent. *Male dark greyish-brown or rather blackish-brown*, medial area darker. Forewing antemedial line absent. Medial line blackish, weakly dentate, turned inwards on costa. *Postmedial line distinctly dentate*, angled inwards before costa, outer margin very narrowly bordered with whitish. Medial area dark, wide on inner margin. Subterminal line absent. Terminal line narrow, black-

ish, slightly widened at vein endings. Fringes grey-brown, unicolorous. Hindwing medial area paler, postmedial line less dentate. Forewing discal spot small, distinct, dark brown. Wings below uniform grey-brown, postmedial line weakly visible. Female almost uniform grey-brown, postmedial line weakly visible, dark brown, dentate. Forewing discal spot small, distinct, dark brown. Hindwing discal spots smaller. Wings below uniform grey-brown, discal spots minute and dark brown. Frons, collar, thorax, and abdomen concolorous with wings, irrorated with grey. Abdomen paler ventrally. Male antennae bipectinate, female antennae filiform. Hindtibia with 2+2 spurs, male hindtibia not swollen, with very small hair pencil (if not everted, a weak groove visible only). Tympanal organs medium-sized, not meeting medially, slightly smaller in female. Male 8th tergite weakly triangular, posterior margin narrower. Other sternites and tergites of both sexes unmodified.

Variation. June specimens are dark brown; the specimen taken in October is light brown, except terminal area, which is distinctly dark brown (see Figs 16c, h). It is not clear whether this specimen shows the normal appearance of the second generation or whether it is a strongly aberrant individual.

Male genitalia (Fig. 21). Generally as in *E. atlanticaria*, but smaller. Uncus wide in *E. miniaria* (similar, but a little less wide in *E. sagnesii*, narrow in *E. atlanticaria* and *E. fascinataria*). Phallus apex does not bend when vesica is everted (bends when vesica is everted in *E. atlanticaria*, *E. fascinataria* and *E. sagnesii*). Vesica opens at about 90 degree angle (at about 135 degree angle in *E. atlanticaria* and *E. fascinataria*). Juxta arms broader apically than basally, dentate along inner margin, base with elongated lobe (juxta arms tapering apically, dentate at apex only, base solid in *E. atlanticaria* and *E. fascinataria*; juxta arms broader apically, dentate (or smooth) along inner margin, base with roundish lobe in *E. sagnesii*).

Female genitalia (Fig. 25). Generally as in *E. atlanticaria*, but genitalia distinctly smaller. Lamella antevaginalis is curved, broad band in *E. miniaria* (lateral arms of lamella antevaginalis weakly sclerotised in *E. atlanticaria* and *E. fascinataria* and strongly sclerotised in *E. sagnesii*). Signum absent in *E. miniaria* (signum distinctly stellate in *E. atlanticaria* and *E. fascinataria* and weakly stellate in *E. sagnesii*).

Etymology. The species name *miniaria* (word stem based on the Latin “minima”, an adjective in the nominative singular), refers to the small size of the species. The wingspan and genitalia of both sexes are smaller than in any other *Ekboarmia* species.

Distribution and abundance (Fig. 17). Endemic to Portugal, where it is presently known from only two localities in the southern part of the country. Seven specimens were found in one night (20.vi.2011).

Phenology. Possibly bivoltine. So far, the species has been recorded in mid-June and once between 16 September and 10 October. Nothing is known about larval time and hibernation. The moths are nocturnal and come to light.

Biology. Unknown.

Habitat. Open pine forests (*Pinus pinaster*) on sandy soil with undergrowth of herbs and scattered bushes, including *Halimium atriplicifolium*, *Stauracanthus genistoides*, and *Cistus psilosepalus* among the dominant species. One of the two known localities had suffered a bushfire, probably 8–10 years earlier. Found close to sea level and at 90 m (Figs 27–29).

Similar species. There are no similar species in Europe.

Genetic data. BIN: BOLD: AAZ6253 (n=2 from Portugal) (Fig. 26). Intraspecific variation low (0.15%). Distances from *E. atlanticaria* 3.5% and from *E. sagnesii* 3.9%.



Figure 27. Habitat of *Ekboarmia miniaria* sp. n., showing the location where the first specimen was found in 1995 by Brian Elliott. Portugal: Lagoa de Santo André, 24.ix.2009. Photo by Peder Skou.



Figure 28. Habitat of *Ekboarmia miniaria* sp. n., showing the location where majority of specimens have been found. The dominant pine is *Pinus pinaster*. In the undergrowth *Halimium atriplicifolium*, *Stauracanthus genistoides* and *Cistus psilosepalus* are among the dominant species. Portugal: Grandola, Ameiras de Baixo. Photo taken on 16.vi.2009 by Zdenek Laštůvka.



Figure 29. Habitat of *Ekboarmia miniaria* sp. n., showing the location where majority of specimens have been found. The dominant pine is *Pinus pinaster*. In the undergrowth *Halimium atriplicifolium*, *Stauracanthus genistoides* and *Cistus psilosepalus* are among the dominant species. Portugal: Grandola, Ameiras de Baixo. Photo taken on 21.vi.2011 by Zdenek Laštůvka.

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Supplementary material 1

Examined non-type material.

Authors: Peder Skou, Dieter Stüning, Pasi Sihvonen

Data type: MS Excel file

Explanation note: Examined non-type material.

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Taxonomic confusion around the Peach Twig Borer, *Anarsia lineatella* Zeller, 1839, with description of a new species (Lepidoptera, Gelechiidae)

KELD GREGERSEN¹, OLE KARSHOLT²

¹ Fru Ingesvej 13, DK-4180, Denmark; Keld_gregersen@stofanet.dk

² Zoological Museum, Natural History Museum of Denmark, Universitetsparken 15, DK-2100 Copenhagen, Denmark; okarsholt@snm.ku.dk

<http://zoobank.org/B06525D1-90F4-469F-B156-F33933FD7889>

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Abstract. A new species of Gelechiidae is described as *Anarsia innoxella* sp. n., based on differences in morphology and biology. It is closely related to and has hitherto been confused with the Peach Twig Borer, *Anarsia lineatella* Zeller, 1839. Whereas larvae of the latter feed on – and are known to be a pest of – *Prunus* species (Rosaceae), the larva of *A. innoxella* feeds on *Acer* species (Sapindaceae). All known synonyms of *A. lineatella* are discussed in detail, including *Anarsia lineatella* subsp. *heratella* Amsel, 1967, from Afghanistan and *A. lineatella* subsp. *tauricella* Amsel, 1967, from Turkey. Our study has shown no evidence for changing the present taxonomic status of these two taxa. We discuss also the status of the genus *Ananarsia* Amsel, 1957. The new species *A. innoxella* is widely distributed in Europe and is often found in the same areas as *A. lineatella*, but the latter species does not occur naturally in northern Europe. *A. innoxella* seems not to be of economic importance. We propose, in line with the provisions of Article 23.9 of the International Code of Zoological Nomenclature, suppression of the priority of *Tinea pullatella* Hübner, 1796, **nomen oblitum**, over *Anarsia lineatella* Zeller, 1839, **nomen protectum**. An appendix with references on the prevailing use of the latter species is included.

Introduction

The peach twig borer, *Anarsia lineatella*, was described in 1839 by Zeller and has since been known as a pest of stone fruits of the genus *Prunus* (Rosaceae). It has for several years been assumed among specialists studying the family Gelechiidae that *Anarsia lineatella* s.l. includes hidden diversity. In Europe there are at least two widely distributed distinct species: *A. lineatella* and a closely related species feeding on *Acer* (Sapindaceae) which is described in the present paper as *A. innoxella* sp. n.

When *A. lineatella* was first reported from Denmark (Wolff 1965), the Danish State Plant Pathology Institute seriously considered removing all cultivated *Prunus* trees in the vicinity of the place it was found (Th. Thygesen, pers. comm.). The proposal was rejected for practical reasons, which was fortunate as the species reported by Wolff was misidentified, its true identity being *A. innoxella*, the larva of which feeds on *Acer* not *Prunus*.

Material and methods

Data from holotypes are cited exactly as on the labels of the specimens (Fig. 1), whereas other material is organised in a standardized way rather than verbatim, viz. alphabetic after country and province; material from the same province is listed chronologically. Abbreviations for Danish faunistic provinces follow Enghoff and Nielsen (1977).

Genitalia preparation mostly follows the technique described by Huemer and Karsholt (2010). Male genitalia were ‘unrolled’. In some cases female genitalia were left inside the abdomen to avoid distortion of characters. Photographs of adults were taken using Leica Application Suit MZ 16A, and ZERENE HELICON Stacker program was used for stacking subsequent images. Photographs of genitalia slides were taken using an Olympus SZX16 microscope with motorized focus drive attached to an Olympus E520 digital camera. All images have been edited in ADOBE Photoshop. Line-drawings have been performed by KG and edited in ADOBE Photoshop. Plates and figures are not to exact scale.

Description of genital morphology follows Kristensen (2003a, 2003b), with additions from Ponomarenko (2005) and a few other modifications.

The present study is based on material from the following collections:

BMNH	Natural History Museum, London, U.K.
ECKU	Collection of Ecology-Centre, Kiel University, Germany
KG	Collection of Keld Gregersen, Sorø, Denmark
KL	Collection of Knud Larsen, Søborg, Denmark
NHMO	Natural History Museum, University of Oslo, Norway
PF	Collection of Per Falck, Neksø, Denmark
RS	Collection of Rudi Seliger, Nordrhein-Westfalen, Germany
SMNK	Staatliches Museum für Naturkunde Karlsruhe, Germany
UJ	Collection of Urmas Jürivete, Tallinn, Estonia
TLMF	Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria
ZSM	Zoologische Staatssammlung München, Germany
ZMUC	Zoological Museum, Natural History Museum of Denmark, Copenhagen, Denmark

Results

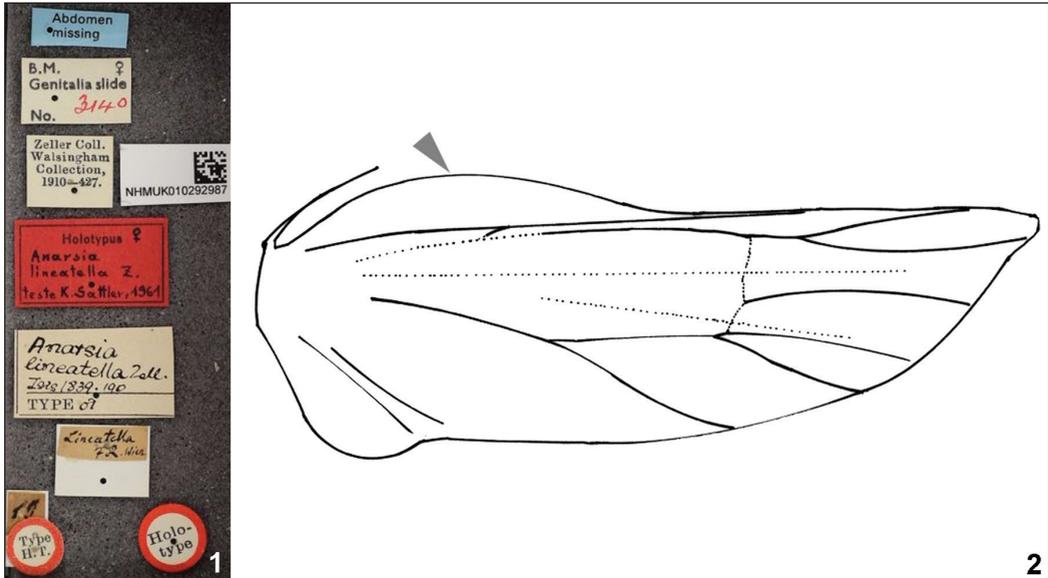
Anarsia Zeller, 1839: 190.

Type species: *Tinea spartiella* Schrank, 1802.

Ananarsia Amsel, 1959: 32.

Type species: *Anarsia lineatella* Zeller, 1839.

The genus *Anarsia* has traditionally been considered as related to certain similar genera, e.g., *Hypatima* Hübner, 1825, in the subfamily Chelariinae (see, for example, Karsholt and Riedl 1996). Due to its peculiar morphology Amsel (1977: 233–235) erected a family Anarsiidae exclusively for *Anarsia*; however, this action was not supported by other researchers (Ponomarenko 2009: 24).



Figures 1, 2. 1. *Anarsia lineatella*, holotype, labels (foto D. Lees, by courtesy of the BMNH). 2. *Anarsia innoxia* sp. n., hindwing with convex extension at proximal part of costa.

Ponomarenko (1997: 312) gave it the status of a tribe, but in a recent molecular study (Karsholt et al. 2013) *Anarsia* clustered together with *Hypatima*, *Neofaculta* Gozmány, 1955, and *Nothris* Hübner, 1825 in Chelariini of the subfamily Anacampsinæ.

Many of the morphological specializations present in some or all *Anarsia* species (e.g., androconial scales, hair pencils, shape of labial palpi and hindwings and genital structure) are probably related to courtship, i.e., dispersal of pheromones and attracting of the opposite sex. This may explain why these striking characters are not reflected more strongly in the molecular analysis (Karsholt et al. 2013), which places *Anarsia* amongst more ‘normal-looking’ genera of Gelechiidae.

Anarsia is characterized by some remarkable morphological characters: vestigial segment 3 of labial palpus in male, hindwing with distinct convex elevation at proximal part of costa (Fig. 2), and presence of secondary wing locking mechanism, the ‘frenum’ (see Ponomarenko 1997); male genitalia asymmetrical, without gnathos, and valva with specialized palmate scales (Figs 3a, 4a); in female genitalia ostium bursae with widely different ventral and dorsal sides (see Fig. 4b, os-a and os-d) with antrum tilted, hence appearing asymmetrical.

These characters are not, or only rarely, found in any other of the 500 or so genera of Gelechiidae. At present *Anarsia*, as understood here, includes about 100 species (catalogued by Ponomarenko 2009: 339 ff). It is widely distributed in Eurasia and Africa.

Anarsia s.l. is morphologically diverse. An attempt to split the genus was made by Amsel (1959), who erected the genus *Ananarsia* for *A. lineatella* and related species based on the location of the spines on the valvae of the male genitalia. However, having examined additional species, he retracted *Ananarsia* as a separate genus and synonymised it with *Anarsia* (Amsel 1967: 25).

The structures on the valvae described as spines (“Dornen”) (Amsel 1959, 1967) or processes (Ponomarenko 2009) are in fact tubes, characterized by being hollow and having a distal opening (Fig. 3b). We think that these tubes may be connected with glands and function in disseminating

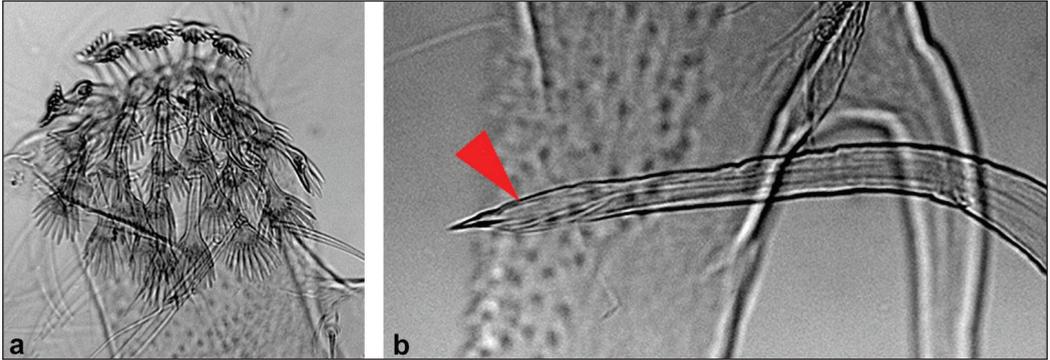


Figure 3. *Anarsia* male genitalia. **a.** Palmate scales at distal part of left valve; **b.** Tube at right valva with distal opening.

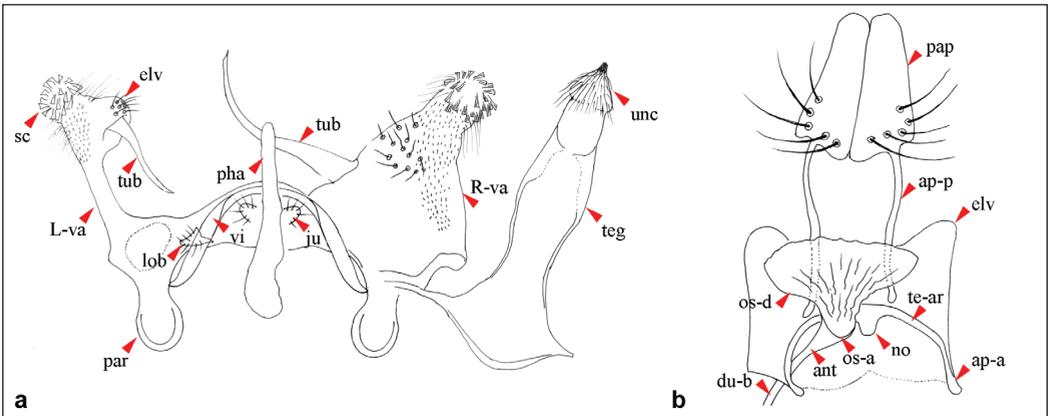


Figure 4. *Anarsia* genitalia (schematic). **a.** male, **elv**: elevation at left valva (sub-apical lobe); **ju**: juxta; **L-va**: left valva; **lob**: lobe at left side of vinculum; **par**: parategminal sclerite; **pha**: phallus; **R-va**: right valva; **sc**: scent scales (palmate); **teg**: tegumen; **tub**: tubular process; **vi**: vinculum. **b.** female genitalia (schematic); **ant**: antrum; **ap-a**: apophysis anterioris; **ap-p**: apophysis posterioris; **du-b**: ductus bursae; **elv**: elevation at segment VII; **no**: notch, **pap**: papillae analis; **os-a**: ostium bursae (anterior part); **os-d**: ostium bursae (dorsal part); **t-ar**: tergal arch.

male pheromones during courtship and mating. Ponomarenko (2005, 2008, 2009) has described tubes at the vinculum in the tribe Litini (Gelechiidae) with a similar function, naming them glandiductors.

Ponomarenko retained *Anarsia* at first as a subgenus (Ponomarenko 1989) and later (1992) as a separate genus. She restricted *Anarsia* to *A. spartiella* and related species based on characters in the genitalia: male phallus with blind base (coecum), so-called valvella reduced (see below under *A. innoxia*), female with anterior lobe at tergum and lack of sack-like structure in segment VIII (Ponomarenko 1997). Whereas *Anarsia* sensu Ponomarenko may well be monophyletic, it leaves the morphologically diverse *Anarsia* paraphyletic. Ponomarenko's view has not been followed by subsequent authors (e.g., Ueda 1997; Li and Zheng 1998; Bae et al. 2016) who kept *Anarsia* undivided; this is followed here.

***Anarsia innoxia* sp. n.**

<http://zoobank.org/F632AB41-2E16-4860-B207-47419F38972B>

Holotype. ♀, Denmark, LFM, Flintinge, 9.vii.2002, leg. K. Gregersen, gen. slide Gregersen 3462 (ZMUC).

Paratypes. **Bulgaria.** Blagoevgrad prov., 5 km E Illindentsi, 880 m, 1♂, 7.viii.2012, leg. O. Karsholt (ZMUC); Burgas prov., Strandja, Zvezdets, Kovach, 350 m, 2♂, 1♀, 16-25.vi.2014, leg. H. Roweck & N. Savenkov (ECKU); Kardzhali prov., Krumovgrad, 1♂, 9.vi.2005, leg. J. Buszko, gen. slide Karsholt 5243 (ZMUC). **Croatia.** Velebit Mt., 1 km W Brusane, 825 m, 1♂, 1♀, 27.vi.2003, leg. C. Hviid & B. Skule, gen. slide Gregersen 1621, 1622 (ZMUC). **Czech Republic.** Bohemia, Srbsko, 1♂, la. 24.v.2000, Acer campestre, leg. O. Karsholt (ZMUC). **Denmark.** B: Øster Sømarken, 1♂, 5.vii.2006 & 1♂, 5.vii.2008, leg. P. Falck; B: Sømarken, 1♀, 25.vii.2010, leg. P. Falck; B: Melsted, 1♂, 17.vii.2010 & 1♂, 18.vii.2013, leg. P. Falck; B: Grisby, 1♂, 11.vi.2011, leg. P. Falck; B: Årsdale, 1♂, 7.viii.2015, leg. P. Falck (all PF). LFM, Horreby Lyng, 1♂, 20.vii.1960, leg. H. K. Jensen, gen. slide Jensen 589 (ZMUC), 1♀, 10.vii.2010, leg. K. Gregersen, gen. slide Gregersen 3463 (KG); LFM, Maltrup Skov, 1♂, 9.vii.1971, leg. K. Schnack (ZMUC); LFM, Saksøbing, 1♀, 9.vii.1972, leg. K. Pedersen (ZMUC); LFM, Melleskoven, 1♂, 5.viii.1972, leg. G. Pallesen (ECKU), 1♂, 7.vii. 1973, G. Jørgensen, leg., gen. slide Gregersen 3361 (KG); LFM, Hanemose, 1♂, 11.vii.1975, leg. O. Karsholt (ZMUC); LFM, Frejlev Skov 1♀, 3.vii.1976, leg. O. Karsholt (ZMUC); LFM, Møns Klint, 1♂, 6.vii.1976, leg. K. Schnack, 1♂, 13.vii.1985, leg. H. Hendriksen, gen. slide Hendriksen 506, 1♂, 17.vii.1999, 1♂, 10-12.vii.2010, leg. O. Karsholt (ZMUC); LFM, Ulfshale, 1♀, 8.vii.1977, K. Schnack, gen. slide Gregersen 1629 (ZMUC); LFM, Blans Skifter, 1♂, 7.vii.1983, leg. K. Gregersen, gen. slide Gregersen 1585 (KG); LFM, Vålse Vesterskov, 1♂, 1♀, 30.vii.1984, leg. K. Gregersen (KG), 1♂, 1.vii.1993, leg. H. K. Jensen (ZMUC); LFM, Stubbekøbing, Rodemark, 1♂, 31.vii.1984, 1♂, 12.vii.1985, 1♂, 27.vii.1986, 1♂, 9.vii.1989, 1♂, 25.vi.1990, 1♂, 26.vi.1990, 1♂, 28.vi.1990, 1♂, 8.vii.1993, 1♂, 9.viii.1996, 1♂, 10.viii.1996, 1♀, 15.vii.2002, 1♂, 2.vii.2003, 1♀, 2.vii.2006, 1♀, 4.vii.2009, leg. A. Madsen (KG, ZMUC); LFM, Næsgård Landbrugsskole, 1♂, 26.vi.1989, leg. A. Madsen (ZMUC); LFM, Roden Skov, 1♀, 8.vii.1989, leg. K. Gregersen, gen. slide Gregersen 1594 (KG); LFM, Løgnor, 2♂, 30.vii.1991, 4♂, 4.vi.1992; leg. H. K. Jensen (ZMUC); LFM, Jydelejet, 1♂, 9.vii.1992, leg. H. K. Jensen (ZMUC); LFM, Korselitte Østerskov, 1♂, 19-25.vii.1992, leg. G. Jeppesen & K. Larsen (KL); LFM, Guldborg Storskov, 1♂, 8.vii.1993, leg. A. Madsen (ZMUC); LFM, Fuglsang, Skejten, 1♂, 1♀, 15.vii.1993, leg. M. Stoltze & O. Karsholt, gen. slide Hendriksen 2094 (ZMUC); LFM, Hamborgskoven, 2♂, 14.vii.1995, leg. K. Gregersen, gen. slide Gregersen 0943, 1♂, 3.vii.2010, leg. K. Gregersen (KG); LFM, Mandemarke, 1♂, 21-22.vii.1996, 1♂, 28.vii.1996, 1♂, 7-13.vii.2002, 1♀, 10-12.vii.2005, 2♂, 13-15.vii.2005, 1♂, 1-4.vii.2006, 1♀, 12-19.vii.2009, 1♂, 4♀, 10-11.vii.2010, gen. slide Karsholt 5247, 4♀, 12-13.vii.2010, 1♀, 16.vi.2010, gen. slide Karsholt 5211, 1♂, 15.vii.2010, gen. slide Karsholt 5238, 1♂, 1♀, 17.vii.2010, 2♀, 19.vii.2010, 1♂, 2♀, 3-4.vii.2011, 1♂, 27-28.vii.2012, 1♂, 4-7.vii.2013, 1♂, 8-10.vii.2013, 2♂, 11-18.vii.2013, 1♂, 3-5.vii.2014, 1♂, 9-13.viii.2015, 1♂, 22-23.vi.2016, 1♂, 1♀, 22-29.vii.2016, leg. O. Karsholt (ZMUC); LFM, Faksehule Fyr, 1♂, 9.vii.1999, leg. B. Baungaard, gen. slide Gregersen 3286 (KG); LFM, Hesnæs Havn, 1♂, 18.vii.2002, leg. K. Gregersen, gen. slide Gregersen 3079 (KG); LFM, Møns Klint syd, 1♂, 10-12.vii.2010, leg. O. Karsholt (ZMUC); LFM, Rødbyhavn, 1♀, 5.vii.2014, gen. slide Gregersen 3359; 1♀, 6.vii.2014, leg. K. Gregersen (KG). NEZ, Gentofte, Dyssegård, 1♂, 18.vii.1968, leg. C. Aastrup, gen. slide Hendriksen 762 (ZMUC); NEZ, Søborg, 2♂, 10.vii.1976, leg. K. Schnack (ZMUC); same locality but 1♀, 13.vii.2001, leg. K. Larsen & B. Martinsen (KL); NEZ, Høje Taastrup, 1♂, 11.vii.1981, J. P. Baungaard, gen. slide Gregersen 3292 (KG); NEZ, København Ø, 1♂, 24-25.vi.1992, 2♂, 26-28.vi.1992, 1♂, 10-13.vii.1995, 1♂, 24-25.vii.1996, gen. slide Hendriksen 6266,

1♀, 14-15.viii.1996, gen. slide Hendriksen 6269, 1♂, 22-23.vii.1997, gen. slide Hendriksen 6267, 1♂, 2-4.vii.1999, gen. slide Karsholt 5240, 1♂, 20-23.vii.2001, 1♀, 28-29.vii.2004, 1♀, 3-10.vii.2009, leg. O. Karsholt (ZMUC); NEZ, Kulhuse, 1♂, 1♀, 6.vii.2006, gen. slide Hendriksen 6302, 6303, 1♂, 1♀, 9.vii.2006, leg. H. Hendriksen (ZMUC). NWZ, Føllenslev, 1♂, 29.vii.2006, 1♂, 4.vii.2008, leg. E. Palm, gen. slide Gregersen 1964 (EP); NWZ, Slagelse, 1♂, 9.vii.2002 gen. slide Gregersen 1586, 1♀, 27.vii.2007, gen. slide Gregersen 3360, 1♀, 1.viii.2010, leg. K. Pedersen, gen. slide Gregersen 3090 (KG); NWZ, Røsnæs, 1♀, 12.vii.2005, leg. U. Seneca, gen. slide Gregersen 3368 (KG). SZ, Højstrup, 1♂, 9.vi.1959, leg. H. K. Jensen [1th Danish specimen]; SZ, Jungshoved, 1♂, 5.vii.1959, gen. slide Wolff 2359, 3♂, 12.vii.1964, gen. slide Wolff 3124, 1♂, 1♀, 15.vii.1964, 1♂, 18.vii.1964, 1♂, 25.vii.1964, 1♀, 28.vii.1967, 1♂, 21.vii.1969, 2♂, 24.vii.1970, 1♀, 16.vii.1972, gen. slide Gregersen 1630, 1♂, 21.vii.1972, 1♂, 29.vii.1972, 2♂, 20.vii.1975, 3♂, 10.vii.1976, 1♂, 15-18.vii.1976, 2♂, 18.vii.1976, 6♂, vii.1976, leg. N. L. Wolff; same locality but 2♂, 1.-7.vii.1981; 7♂, 1♀, 8-14.vii.1981, gen. slide Karsholt 4178; 1♂, 14.vii.-13.viii.1991, leg. O. Karsholt (ZMUC); SZ, Glænø, 1♂, 18.vii.1983, leg. H. K. Jensen (ZMUC); SZ, Præstø, 2♂, 11-14.vii.1991, 1♂, 1♀, 27.vi.-1.vii.1992; 1♀, 8-11.vii.1992, gen. slide Hendriksen 6301; 1♀, 15-27.vii.1993, leg. O. Karsholt (ZMUC); SZ, Vemmetofte, 2♂, 18.vii.2005, leg. K. Gregersen (KG); SZ, Sorø By, 1♂, 13.vii.2006, gen. slide Gregersen 1587, 1♂, 26.vi.2011, leg. K. Gregersen (KG); SZ, Sorø Sønderkov, 1♂, 30.vi.2009, leg. K. Gregersen (KG). **France.** Provence, Domain de Maura Vieille, 1♂, 5.x.2002, leg. H. Hendriksen, gen. slide Gregersen 3427 (ZMUC); Provence, Castellane, 2♂, 18.vi.2012, leg. E. Palm, gen. slide Gregersen 3344, 3350 (EP). **Germany.** Baden-Württemberg, Marback am Neckar, 1♀, 3.vii.1973, leg. L. Süßner (TLMF); Hessen, Zwergen, 1♀, 10.vi.2000, leg. H. Retzlaff (ECKU); Niedersachsen, Witzendorf, 1♂, 27.vii.2008, leg. C. Kayser, gen. slide Gregersen 1924 (KG); Northrein-Westphalen, Weserbergland, Biesterberg, Lemgo, 1♂, 1♀, 27.vi.2003, leg. H. Retzlaff (ECKU); Rheinland-Pfalz, Vulkaneifel, Gillenfeld, NSG Strohner Märchen, 1♀, 18.vi.2005, leg. R. Seliger, gen. slide Gregersen 3086 (RS); Thüringen, Bad Blankenburg, 1♀, 18.vi.1976, leg. H. Steuer, gen. slide Gregersen 3349; same data but, Muschelkalk, 1♂, 25.vi.1989 (ECKU). **Greece.** Evros, Avandas Gorge, 100 m, 1♀, 29.vi.2004, leg. B. Skule; Florina, Limni Mikra Prespa, near Karies, 1025 m, 1♂, 24.vi.2004, leg. B. Skule; Lakonia, waterfall by Nomia-Lyra, 1♀, 1.vi.1979, leg. G. Christensen & L. Gozmány; Lakonia, 7 km SW Monemvasia, 150 m, 1♂, 1♀, 17.vi.1980, 3♀♀ 2.vii.1982; 1♂, 24.vi.1980 26.vi.1981, leg. G. Christensen; Sérres, Kalócastro, 1♀, 25.vi.1997, leg. Z. Laštůvka (all ZMUC). **Hungary.** Leanyfalu, 1♀, 5-10.vii.1997, leg. B. S. Larsen (ZMUC). **Italy.** Piemonte (CN), Parco Naturale Regionale Alpi Maritime, Valdieri, 900 m, 1♀, 17.vii.1999, leg. G. Baldizzone (ZMUC). **Netherlands.** Twello, 1♀, 16.vi.2002, leg. J. Wolschrijn (ZMUC). **Norway.** Ø, Sarpsborg, Tune, Råkil, 1♂, 15.vii.2011, leg. T. J. Olsen (NHMO). **Romania.** Mehedinți, Dubova, 2♀, 10.vi.1993, leg. L. Rakosy (ZMUC); Caraș-Ceverin, 5 km NW Sasca Montană, 250 m, 1♂, 1♀, 14.vii.2005, leg. C. Hviid, B. Skule & E. Vesterhede (ZMUC). **Slovakia.** Zvolen, 1♂, la. v.1979, *Acer campestre*, gen. slide Karsholt 5242, Domaniky, 2♀, la. vi.1979, *Acer campestre*, leg. J. Patočka (ZMUC); Slovenský Kras, Zadiel, 1♀, 24.vii.1992, leg. K. Larsen (ZMUC); Sliepkovce, 1♂, 8.vi.1963, leg. K. Krušek (ECKU). **Turkey.** Edirne, Keşan, 1♀, 5.vii.1987, leg. E. Baraniak (ZMUC).

Material not included in the type series (see also below under Remarks). **Cyprus** (Southern part). N of Limasol, Moniatis, 650 m, 1♀, 23-29.vi.1997, leg. M. Fibiger, A. Madsen, D. Nilsson & P. Svendsen; Trodos Mts., Platres, 1200 m, 7♂, 4♀, 11-16.v.1999, leg. C. Hviid & B. Skule, gen. slide Gregersen 1623, 1624, 3417; same data but 2 km S. Platres, 1100 m, 6♂, 1♀, 16.v.1999 (all ZMUC). **Estonia.** Järvselja, 1♂, 6.vii.2012, leg. E. & U. Jürivete (UJ). **Greece, Crete.** Omalos, 1200 m, 1♀, 25-30.vi.2000, leg. M. Fibiger, A. Madsen, D. Nilsson & P. Svendsen, gen. slide Gregersen 3420; Crete W, Kallergi Mts., 1450-1550 m, 1♀, 28-30.vii.2001, leg. M. Fibiger, A. Madsen, D. Nilsson & P. Svendsen; Chania, N of Omalos plateau, at pass, 1150

m, 1♂, 7.vi.2004, leg. C. Hviid, B. Skule & E. Vesterhede; Omalos Plateau, 1040 m, 3♂, 15♀, 15-20.vi.2014, leg. C. Hviid, O. Karsholt, F. Vilhelmsen, gen. slides Gregersen 2♂ 3436, 3438; 2♀ 3437, 3439 (ZMUC); Omalos Plateau, road to Kaligeri, 1225 m, 4♂, 9♀, 15-20.vi.2014, leg. C. Hviid, O. Karsholt, F. Vilhelmsen (all ZMUC). **Latvia.** Daugaupils distr., Silene, 1♀, 15-19.viii.2002, leg. N. Savenkov, gen. slide Gregersen 3141; same data but, Silene, Ilgas, 3♂, 1♀, 11-15.vi.2007, gen. slide Gregersen 3085, 3347, 3395 3348; same data but Silene, Ilgas, 1♀, 24.vi.2013, gen. slide Gregersen 3396 (all ECKU). **Spain.** Alicante, Parcent, 450 m, 1♀, 14.v.2013, leg. H. Rietz (ECKU); Málaga, 14 km W Algeciras, 200 m, 1♂, 23-24.ix.1973, leg. M. & W. Glaser, gen. slide Gregersen 3422 (ZMUC); Málaga, Sierra de Marbella, El Mirandor, 1♂, 19.viii.1977, 1♂, 28.x.1983, leg. E. Traugott-Olsen, gen. slide Gregersen 3423, 3424 (ZMUC); Málaga, Camino d. Rhonda, 1♂, 23 v.1986, leg. E. Traugott-Olsen, gen. slide Gregersen 3421 (ZMUC).

Diagnosis. *Anarsia innoxiiella* is characterized by its whitish grey and blackish grey forewings, which bear black longitudinal streaks, with the streak in the middle of the wing being especially prominent. It is similar to *A. lineatella*, but that species can be distinguished by the broadly longitudinal black spot followed by white in the middle of the wing (*A. innoxiiella* has a straighter black streak here). *A. innoxiiella* shows some variation from light, variegated specimens to darker moths approaching *A. lineatella* in appearance. Several other *Anarsia* species have wing markings similar to the two species dealt with in this paper, e.g., *A. acaciae* Walsingham, 1897 (Amsel 1967: 23), but they differ in genitalia characters. Males of *A. acaciae* have a pencil of long, black hairs on the base of the hindwing costa.

The genitalia of *A. innoxiiella* are similar to those of *A. lineatella*. The male of *A. innoxiiella* can be separated from the latter by 1) the sub-triangular sub-apical lobe of the left valva being less protruding in *A. lineatella*; 2) the conic, triangular uncus being slightly more slender in *A. lineatella*; and 3) the moderately broad tegumen with weakly sinuous lateral margins.

In the female genitalia the ridges from the middle of a sclerotised arch of tergum VIII are distinct in *A. lineatella*, but absent or very weak in *A. innoxiiella*.

Description. Adult (Fig. 5a–d). Male. Wingspan 13–15 mm. Segment 2 of labial palpus with sub-rectangular scale tuft, black, mottled with whitish grey on upper and inner surface; segment 3 reduced. Antenna light grey, ringed with black. Head light grey mottled with dark grey; frons cream-white; thorax grey, laterally darker; tegula dark grey. Ground colour of forewing whitish grey; dorsally basal part overlaid with blackish grey; costa with small blackish grey spot at 1/6, and two larger spots at 1/4 and 1/3; one distinct longitudinal black spot in middle of wing; veins with black scales interrupted by white; fringe grey, speckled with light grey and with darker fringe lines. Hindwing grey with grey fringe. Female. Segment 2 of labial palpus with distinct ventral brush; segment 3 longer than 2, narrow, whitish grey with two black rings. Otherwise similar to male.

Variation. There is some variation in the amount of blackish grey scales in the forewing. The above description is based on specimens from northern Europe (mainly Denmark and north Germany). Specimens from north-eastern Europe are larger (15–16 mm) and have the forewings more uniformly covered with dark grey scales (thereby restricting the white scales) whereas the black stripes are prominent, giving the wing a striped appearance. Such (more or less) dark grey, black-striped specimens also occur as an individual form from other East European countries. Specimens from mountain localities in Crete and Cyprus are externally similar to northern European specimens.

Male genitalia (Figs 6, 10a, b). Tergum IX–X truncate, medium in breadth, lateral margins moderately sinuous; uncus regularly triangular, apex tapered with tiny, pointed, distal tip; gnathos and

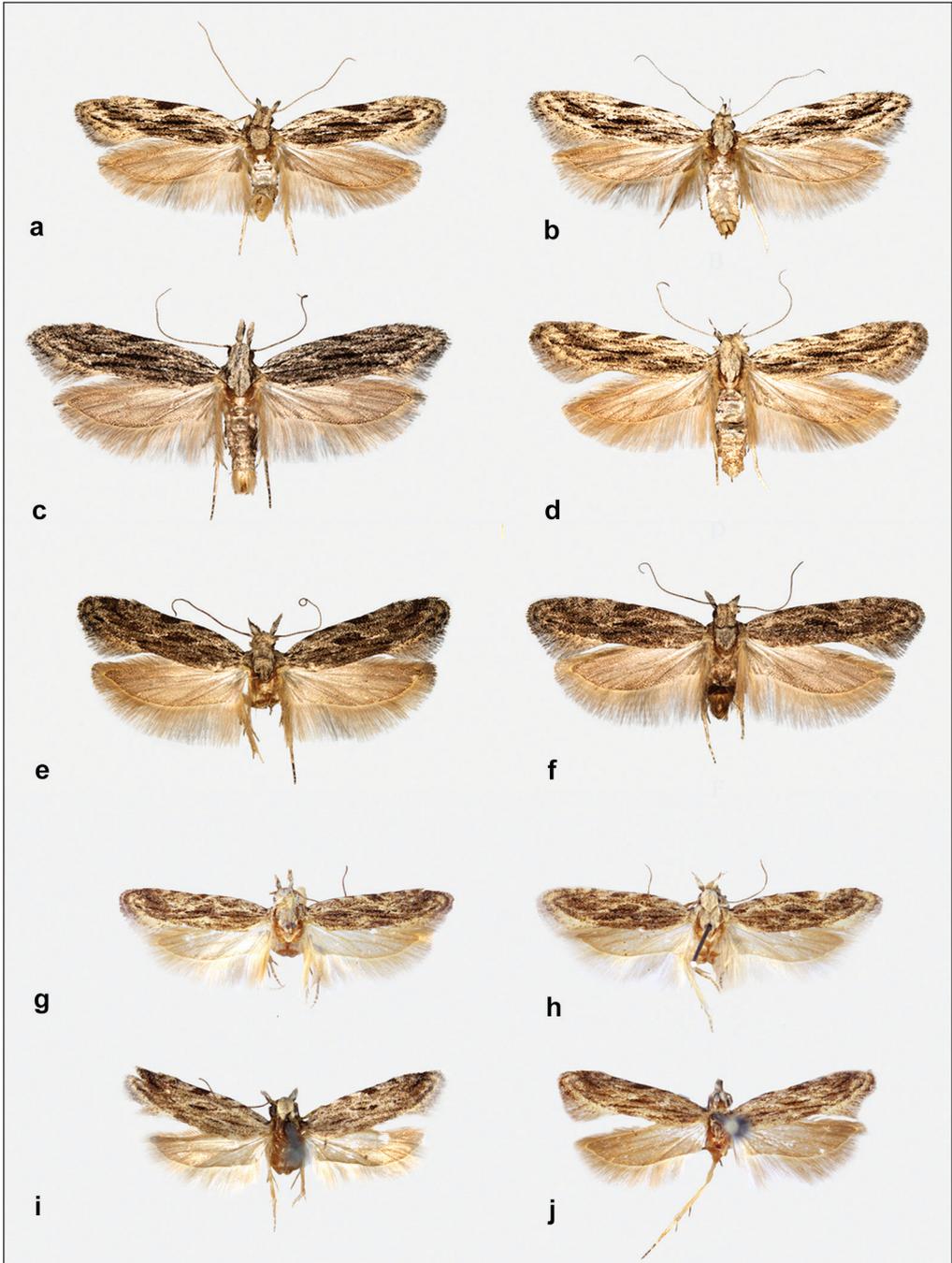


Figure 5. *Anarsia* adults. **a.** *A. innoxiiella* sp. n., Denmark (KG); **b.** *A. innoxiiella* sp. n., Holotype, Denmark (ZMUC); **c.** *A. innoxiiella* sp. n., Latvia (ECKU); **d.** *A. innoxiiella* sp. n., Germany (ECKU); **e.** *A. lineatella* Zeller, Germany (KG); **f.** *A. lineatella* Zeller, Germany (ECKU); **g.** *A. lineatella* ssp. *heratella* Amsel, Afghanistan (SMNK); **h.** *A. lineatella* ssp. *heratella* Amsel, Afghanistan (SMNK); **i.** *A. lineatella* ssp. *tauricella* Amsel, holotype, Turkey (ZSM); **j.** *A. lineatella* ssp. *tauricella* Amsel, paratype, Turkey (SMNK).

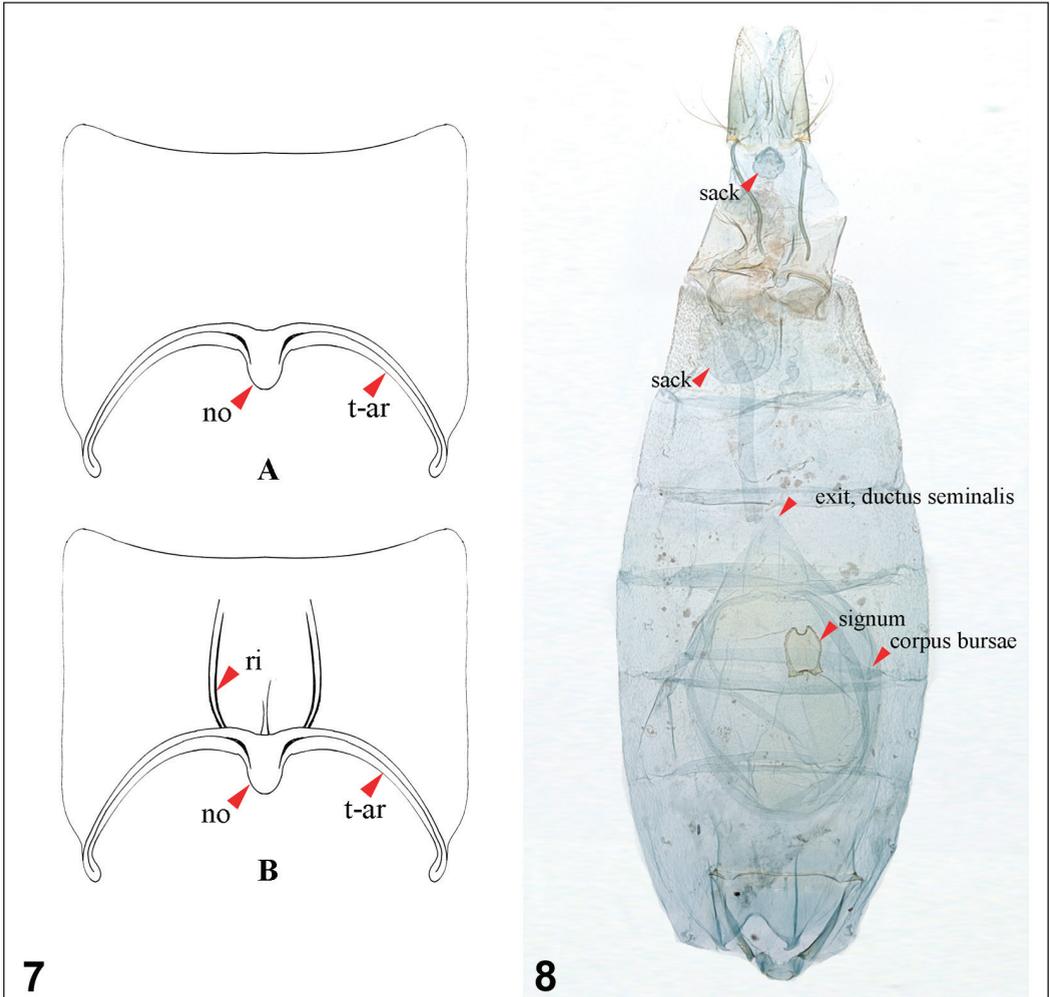


Figure 6. *Anarsia innoxia* sp. n., male genitalia, Slovakia (OK5242).

culcitula absent; parategminal sclerites almost round and lacking coremata; sternum IX strongly asymmetrical, left valva truncate, sub-apical lobe protruding, usually somewhat up-turned, bearing long slender, pointed tubular process; right valva large, broadly sub-triangular, bearing very long, pointed, moderately curved, tubular process; single small, sub-triangular, slightly setose lobe near vinculum on left side (valvella sensu Ponomarenko 2009), juxta lobes small, setose; phallus ankylosed to juxta, tubular without coecum, trunk flat, bent dorsally, apex rounded.

Female genitalia (Figs 7a, 8, 9a, b). Papillae anales elongate, apophyses posteriores moderate in length; apophyses anteriores very short; segment VIII cylindrical, evenly sclerotised, with a pair of slight, distal elevations; strongly sclerotised concave arch at anterior margin of tergum with medial notch; distal ridges from middle of tergal arch absent or faintly indicated; antrum tilted, funnel-shaped; ostium bursae with ventral part crescent-shaped, sharply defined, dorsal part wrinkled, widely extending caudad; ductus bursae slender, straight; colliculum absent; ductus seminalis arising from transition between ductus and corpus bursae; signum plate sub-rectangular, with strongly serrate margins. Sac-like formation in segment IX anterior of papillae anales and similar formation distad of segment VII.

Bionomics. The larva is dark reddish-brown with small pinacula, bearing white hairs; head and prothoracic plate small, glistening black; anal plate black (description based on photograph of larva of “*A. lineatella*” at Lepiforum 2016). It is similar to that of *A. lineatella*. It feeds between fresh leaves of *Acer campestre* L. (Lepiforum *op cit.* – as “*A. lineatella*”). Lepiforum also refers to “Ahorn” (= *Acer* L.) as host plant for this species, and it is well possible that the larva of *A. innoxia* feeds on more than one *Acer*-species. The species has also been reared from larvae



Figures 7, 8. 7. *Anarsia* female genitalia, tergite VIII (schematic). **a.** *A. innoxiiella* sp. n.; **b.** *A. lineatella*. **no:** notch; **ri:** ridges; **t-ar:** tergal arch. **8.** *A. innoxiiella* sp. n., female abdomen (KG3368).

found on *Acer campestre* in the Czech Republic and in Slovakia (see list of examined material). In Crete *A. innoxiiella* was caught in numbers in light traps placed among *Acer sempervirens* L. *A. innoxiiella* occurs in a wide range of biotopes, such as deciduous woods, hedgerows, and gardens. Univoltine. Adult from mid-June to mid-August. Larva from April to June. The species is mostly collected at light.

Distribution. *A. innoxiiella* is widespread in Europe and locally common, but in view of its previous confusion with *A. lineatella* our knowledge of its distribution is still incomplete. It is found in Scandinavia, where it was recently (2015) recorded in Norway (L. Aarvik in litt.), and is known from Denmark, southern and middle Sweden (Gustavsson 2017), and southern Finland (M. Mutanen in litt.); it is also recorded from the three Baltic countries. In addition to the countries from

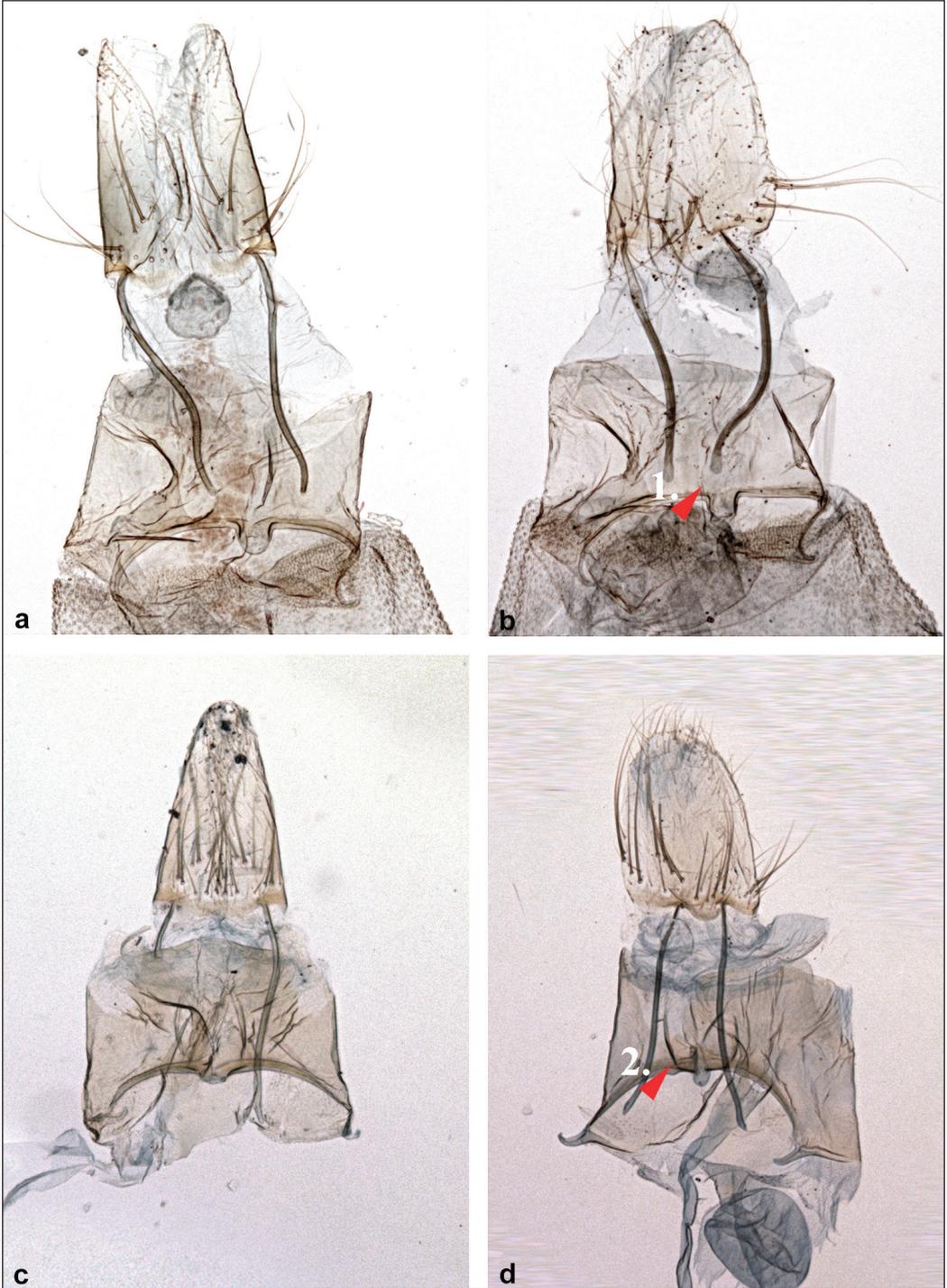


Figure 9. *Anarsia* female genitalia. **a, b.** *A. innoxia* sp. n. (KG3368, KG3360); **c, d.** *A. lineatella* (KG3335, KG3341). **1.** ridges absent; **2.** ridges present.

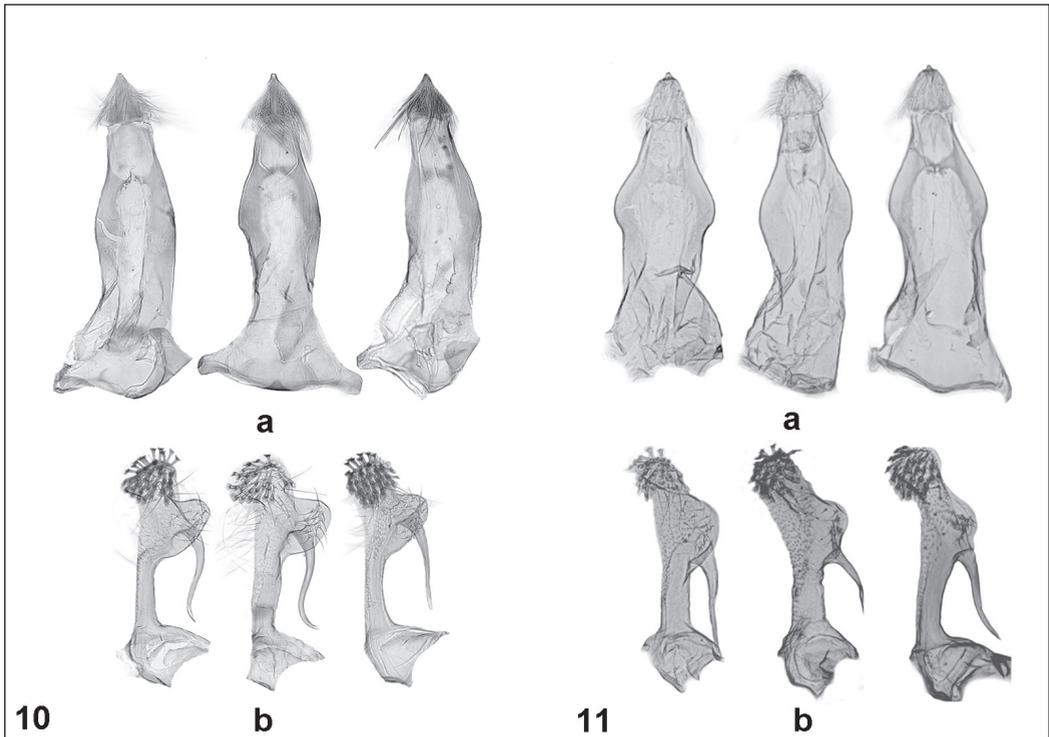


Figure 10–11. 10. *A. innoxia* sp. n.; variation of male genitalia (HH6266, HH6303, OK5040). a. tegumen; b. left valva. 11. *A. lineatella*; variation of male genitalia (KG935, KG3349, KG3365). a. tegumen; b. left valva.

where we have examined specimens we can also confirm the presence of *A. innoxia* in Austria (Lepiforum 2016), Great Britain (Lewis 2016), and Poland (T. Rynarzewski in litt.).

Etymology. The species name “*innoxia*” is a composite word formed from the Latin adjective *innoxia* = harmless, innocuous (in contrast to *A. lineatella*), and the diminutive suffix *-ella*. The name is to be treated as a noun in apposition.

Remarks. Specimens of *A. innoxia* from north-eastern Europe differ in external characters from other specimens treated here (as described above under ‘Variation’), but they have similar genitalia. It is unclear if the north-eastern form differs due to geographical isolation (thus representing a subspecies), if it is a result of the climate (i.e., short summers and/or cold winters), or if it is due to difference in the foodplant (the north-eastern population probably feeds on *Acer platanoides* L., the only native *Acer* in that area). Due to these uncertainties we have excluded such specimens from the type material – and for the same reasons we refrain from using them to describe a subspecies. Specimens with intermediate colour and wing markings occur among typical specimens further south in eastern Europe.

The few specimens examined from southern Spain are generally smaller and paler than typical *A. innoxia* and are likewise excluded from the type series. Also, specimens from mountain localities in Crete and Cyprus are – in spite being externally very similar to North European specimens – excluded from the type series due to slight differences in the genitalia.

Anarsia lineatella* Zeller, 1839Anarsia lineatella* Zeller, 1839: 190 (**nomen protectum**)*Tinea pullatella* Hübner, 1796: 63, pl. 17, fig. 118 (**nomen oblitum**)*Anarsia* ? *pruniella* Clemens, 1860: 169.*Anarsia lineatella heratella* Amsel, 1967: 20. Subspecies.*Anarsia lineatella tauricella* Amsel, 1967: 20. Subspecies.**Type material.** *A. lineatella*, holotype, ♀, with 9 labels (Fig. 1).*A. lineatella heratella*, holotype, ♂: “AFGHANISTAN Herat 970 m 5.5.1956 H. G. Amsel leg.” “Holotypus ♂ leg H. Amsel *Anarsia lineatella heratella*” | “Gen. præp. nr. 5296♂, O. Karsholt”. Paratypes. 3♀, same data as holotype but genitalia slide 5295, 5297 (LNK).*A. lineatella tauricella*, holotype, ♂: “Syr. sept. Taurus D Marasch VI 29” | “Holotypus ♂ leg. H. Amsel *Anarsia lineatella tauricella*” | “Gen. præp. nr. 5300♂, O. Karsholt” | “Coll. Osthelder” (ZSM). Paratypes. 1♀, “Syria sept. Taurus Marasch 1200 m 19.V.1928 L. Osthelder leg.” | “AlloTypus ♀ leg. H. Amsel *Anarsia lineatella tauricella*” | “Gen. præp. nr. 5301♀, O. Karsholt” | “561” (ZSM); 1♂, same data as holotype, but genitalia slide 3868 (LNK).**Other material studied.** Bulgaria (3♂, 7♀), Cyprus (1♂, 1♀), Denmark (4♀) (introduced), Germany (4♂, 10♀), Greece (4♂, 7♀), Hungary (5♂, 1♀), Israel (1♂), Libya (2♂, 1♀), Morocco (3♂, 4♀), Romania (1♂), Spain (7♂, 2♀), Spain, Canary Islands (1♀), Turkey (2♂, 1♀), Ukraine (1♂).**Diagnosis.** *Anarsia lineatella* is characterized by its fuscous grey forewing with only a little white and with indistinct black streaks; it appears darker than *A. innoxia* and has a less fractured pattern of the forewings. For separation from *A. innoxia* see under that species.The male genitalia are characterized by 1) the flatly rounded shape of the sub-apical lobe of the left valva, 2) the rather slender shape of the uncus, and 3) the comparatively broad tegumen with its distinctly sinuous margins. These characters separate *A. lineatella* from *A. innoxia*. The female genitalia differ from those of *A. innoxia* by having two or three distinct ridges articulating distad from the middle of a sclerotised arch of the tergum.**Description.** Adult (Fig. 5e, f). Male. Wingspan 11–15 mm. Segment 2 of labial palpus with sub-rectangular scale tuft, black, mottled with whitish grey on upper and inner surface; segment 3 reduced. Antenna light grey, indistinctly ringed with blackish grey. Head light grey mottled with dark grey; frons lighter; thorax and tegula dark grey. Forewing fuscous grey, mottled with some light grey; costa with five small blackish spots separated by whitish grey, the spot at 1/2 most distinct; a broadly elongate black spot in middle of wing followed by white; veins with interrupted black scales; fringe whitish grey at base, darker grey beyond black fringe line. Hindwing grey with grey fringe. Female. Segment 2 of labial palpus with a distinct ventral brush; segment 3 longer than segment 2, thin, whitish grey with broad, black ring in middle and some black at base and tip. Otherwise similar to male.**Variation.** The nominotypical subspecies is rather uniform, showing only slight variation. Segment 3 of the labial palpi in females can have more or less black. The wingspan of a series of specimens of both sexes from Morocco is smaller than average (11–12 mm), but otherwise similar to European specimens. Specimens from Afghanistan (*A. lineatella* subsp. *heratella*) are characterized by having head, thorax, and basal half of the antennae whitish. The wing markings are similar to those of typical *A. lineatella*, but the forewings are somewhat bi-coloured, having a

lighter costal third and a darker dorsal two-thirds. Specimens from southern Turkey are relatively small (about 11 mm) and generally paler grey compared with typical *A. lineatella*. Such specimens have been described as *A. lineatella* subsp. *tauricella*. See also under 'Remarks' below for these two subspecies.

Male genitalia (Figs 11a, b, 12a). Tergum IX-X truncate, rather broad, lateral margin distinctly sinuous; uncus conical, comparatively slender, with tiny distal tip; gnathos and culcitula absent; parategminal sclerites almost round, without coremata; sternum IX strongly asymmetrical, left valva truncate, sub-apical lobe flatly rounded, bearing long, slender, pointed tubular process; right valva large, broadly sub-triangular, bearing very long, pointed, moderately curved, tubular process; single small, sub-triangular, slightly setose lobe near vinculum on left side, juxta lobes small, setose; phallus ankylosed to juxta, without coecum, phallic trunk flat, bent dorsally, apex rounded.

Female genitalia (Figs 7b, 9c, d). Papillae anales elongate, apophyses posteriores moderate in length; apophyses anteriores very short; segment VIII cylindrical, evenly sclerotised, laterally slightly elevated; strongly sclerotised concave arch at anterior margin of tergum medially notched; two or three distinct ridges articulate distad from middle of arch at tergum, extended to middle of segment; antrum tilted, funnel-shaped; ostium bursae with ventral part crescent-shaped, sharply defined, dorsal part wrinkled, widely extended caudad; ductus bursae slender, straight; colliculum absent; ductus seminalis arising from transition between ductus and corpus bursae; signum sub-rectangular plate with strongly serrate margins; sac-like formation in segment IX anterior of papillae anales – and similar formation distad of segment VII.

Bionomics. The larva has (the rather small) head and prothoracic plate glistening black; the body is honey-brown or chestnut brown, with intersegmental divisions whitish; pinacula small, black, each with one whitish hair; anal plate glistening black; prolegs concolorous with body (Fischer von Röslerstamm 1842; Heckford 1992).

The species feeds on a number of Rosaceae, especially *Prunus* L. species. CABI (2016) lists *Prunus armeniaca* L., *P. domestica* L., *P. dulcis* (Mill.) D.A. Webb, *P. persica* (L.) Batsch and *P. salicina* Lind. as main host plants, and additionally *Malus domestica* Borkh. and *Pyrus communis* L. Piskunov (1990: 974) adds *Prunus cerasus* L. and *P. spinosa* L. He also lists *Diospyros* (Ebenaceae), which is an unlikely host plant of *A. lineatella*, and *Acer tataricum* L., which is probably a host plant of *A. innoxia*. According to Piskunov (1990: 974, 899, fig. 611.3) the larvae of *A. lineatella* have also been reported to consume galls of the plum gall mite (*Eriophyes phloeoptes* Nal.).

In early spring the young larva of the first brood bores into a shoot from below the pith and hollows it out causing exudation of some sap; the shoot withers and the larva moves to a new one. Larvae of the second brood bore into the pulp of the fruit, causing serious damage; the entrance hole is inconspicuous, but the fruit becomes discoloured and matures too early. The larva pupates in a light web on the ground or between leaves; from the latter most often hymenopterous parasitoids emerge (Fischer von Röslerstamm 1842: 283). *A. lineatella* is a serious pest on cultivated *Prunus* in subtropical areas of western Eurasia and North America. In Central Europe the adults fly in two generations a year, from May to July and again during August and September (Kocourek et al. 1996). Further to the south and in the western USA there are 3–4 generations a year (Damos and Savopoulou-Soultani 2008: 467).

Distribution. Widespread in Central and southern Europe and North Africa, eastwards through the Middle East and Turkey to Central Asia and China (Li and Zheng 1997: 122). *A. lineatella* has been introduced with its host plants to North America where it was present already in the

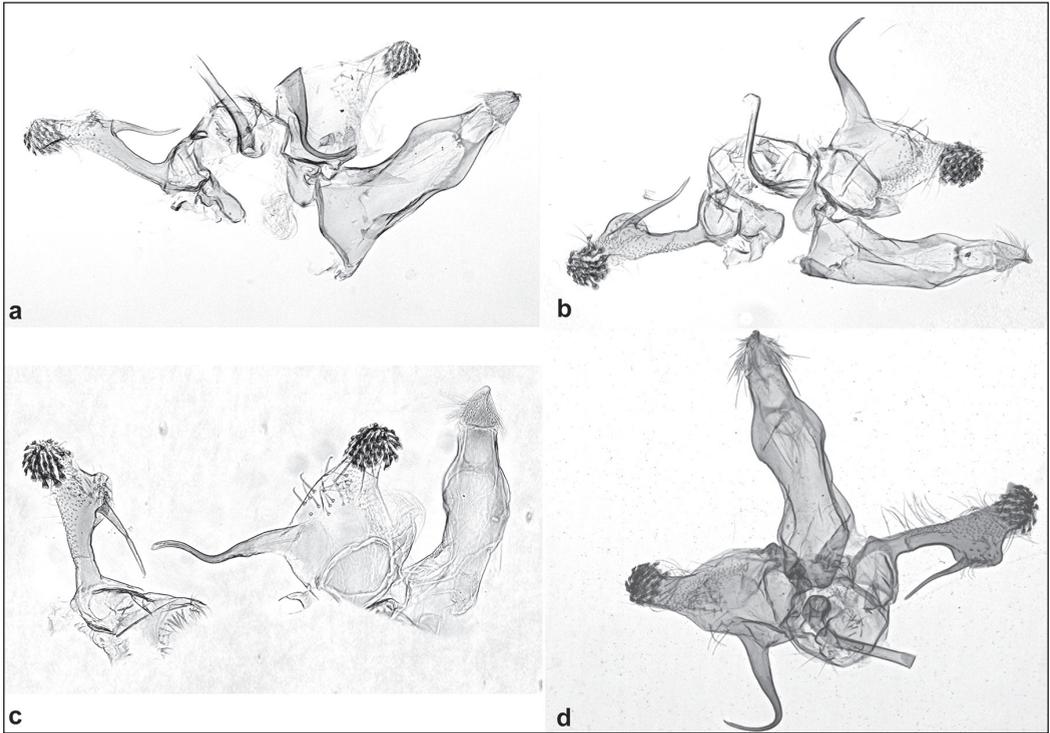


Figure 12. a. *Anarsia lineatella*, male genitalia, Morocco (KG3365); b. *Anarsia lineatella* ssp. *heratella*, male genitalia, holotype (OK5296); c. *Anarsia lineatella* ssp. *tauricella*, male genitalia, holotype (OK5300); d. *Anarsia lineatella* ssp. *tauricella*, male genitalia, paratype (Amsel 3868).

middle of the 19th century (Clemens 1860). It now occurs all over the USA and southern Canada. Records from other areas need confirmation because of confusion with similar looking species. In Europe the northernmost occurrence seems to be in northern central Germany (Niedersachsen, Nordrhein-Westfalen, and Brandenburg). Records from further north in Europe – and from other parts of the world – are either the result of introductions of fruits or – in most cases – misidentifications of *A. innoxia*.

Remarks. *Anarsia lineatella* was described from one male from Austria, Wien, in the collection of Fischer von Röslerstamm (“*Lineatella* FR”). Whereas the original description by Zeller was very short, Fischer von Röslerstamm (1842: 282–284, pls 95–96) gave a detailed and for that time very good illustrated description of adult, larva, pupa, and life history. It leaves no doubt that he was dealing with the species which is injurious to *Prunus* spp.

Tinea pullatella was described from an unstated number of specimens from Austria. The type material is probably lost. Hübner’s colour painting of *pullatella* is small, dark, and schematic, and not clearly associated with any species. Hübner (1825: 415) placed *pullatella* in his genus *Gelechia*, together with *notatella*, *rhombella*, *proximella*, and *mulinella*. The first author to deal with *pullatella* was Treitschke (1833: 95), who gave a re-description which matches *A. lineatella*. Additionally, he wrote that Geyer (1831: pl. 491) – in the continuation of Hübner’s works – figured “eine kleine, haarige, braunschwarze Raupe aus *Spartium*” (a small, hairy, blackish brown

larva on broom) (Treitschke 1835: 199, 299). The larva figured by Geyer (who misspelled its name “*pulatella*”) probably belongs to *Anarsia spartiella* (Schrank, 1802) and is a misidentification as figure 188 in the above mentioned work by Hübner does not fit *A. spartiella* or any other *Anarsia* species.

Treitschke’s interpretation of *Tinea pullatella* Hübner was not followed by his contemporaries Zeller and Fischer von Röslerstamm, who did not even discuss that species in connection with their description of *Anarsia lineatella*.

Later Herrich-Schäffer (1855: 153) wrote under *Anarsia lineatella*: “*Pullatella* H. 118 stellt diese Art ziemlich kenntlich dar” (*Pullatella* H.[übner, fig.] 188 depicts this species quite recognizably rather well”). After that time *Anarsia pullatella* was to our knowledge only used as a valid name by Mann (1861: 190, 1862: 400), who later (e.g., Mann 1866: 355) used *A. lineatella* for this species.

Tinea pullatella has been out of use for over 150 years (**nomen oblitum**), and therefore we here-with propose to conserve the name *Anarsia lineatella* (**nomen protectum**) and suppress *T. pullatella* according to the provisions of Article 23.9 (ICZN 1999). Appendix 1 lists 28 references by more than ten different authors that have used *A. lineatella* in the last 50 years.

Anarsia pruniella was described from an unstated number of specimens bred from larvae found 16th June 1860 on *Prunus* (“plum”) at Philadelphia, USA (Clemens 1860: 170).

Anarsia lineatella heratella was described from a series of 9 males and 21 females from Herat in Afghanistan, plus one further female from the Paghman Mts (also in Afghanistan), and two worn specimens from the Muk Pass in Iran. Herat is situated at an altitude of 923 m, but the two other localities are at about 3000 m altitude, and Amsel (1967: 20) referred the specimens from Iran to his subsp. *heratella* with some reservation.

We have examined the holotype and three female paratypes from Herat (see Figs 5g, h, 12b) and compared them with material from south-east Europe and the Middle East. They look admittedly different from other specimens of *Anarsia* from that region, but it has not been possible to observe any clear difference in the genitalia between the type material of subsp. *heratella* and *A. lineatella* sensu stricto. As we have no sufficient basis for changing the taxonomic status of subsp. *heratella* we retain it as a subspecies of *A. lineatella*.

In his description of *A. lineatella heratella*, Amsel (*op cit.*) refers to figures of its male and female genitalia (“Taf. 7 Fig. 9” and “Taf. 10 Fig. 26”). That reference has been copied into later literature, e.g., Ponomarenko (2009: 341), but the figures are based on German specimens and not of the Afghan subspecies.

Anarsia lineatella tauricella was described from three males and one female from Marasch (now Kahramanmaraş) in Turkey. The country of origin was given as Syria by Amsel (1967: 20), apparently because Marasch was part of Syria when the specimens were collected. We have examined the holotype and two paratypes. The three specimens are similar in external appearance (Fig. 5i, j), with the head and thorax whitish grey, mottled with dark grey, and the ground colour of the forewing light grey overlaid with darker grey. Whereas the genitalia of the allotype are similar to those of other females studied by us, the male genitalia of the two studied specimens (Fig. 12c,d) show some variation. In the holotype the lobe of the left valva is evenly convex (as in typical *A. lineatella*) whilst the paratype has a larger, somewhat rectangular lobe. A similarly shaped lobe is present in *Anarsia* specimens examined from Israel and south-easternmost Europe examined by us. We find it possible that it represents a further, undescribed species, but due to insufficient material we refrain from describing it here.

Leraut (1980: 80) listed *Lampros (Eupleuris) albilineella* Bruand d'Uzelle, 1859 as a synonym of *Anarsia lineatella*. It is, however, an unnecessary replacement name of *Isophrictis lineatellus* (Zeller, 1850).

Discussion

Taxonomy, being the science of naming, describing, and classifying organisms (Secretariat CBD 2008) is both a discipline of its own and an important support to other sciences. It is in itself of value for biodiversity to detect and describe a new species, but a lot of organisms have a more or less direct influence on human health and economy. Among the latter are the so called noxious or pest species, being harmful to crops and other cultivated plants, and numerous people are involved in pest control around the world. It is obvious that efficient pest control depends on a directed effort towards the harmful species. If the taxonomy of the species in question is confused, much effort and money may be wasted trying to control a 'harmless' species.

As mentioned above *A. innoxella* resembles *A. lineatella*, both externally and in the male and female genitalia, and therefore it has not been possible to separate the two species in the past. However, information on the differences in the host plant preference, and insight into the DNA barcodes, which differ between the two species (P. Huemer and M. Mutanen in litt.), stimulated a more detailed search for morphological differences. By comparing a large sample of moths and genitalia preparations we have discovered diagnostic characters to separate these two species; indeed, with some experience almost all specimens in good condition can be identified by external characters.

The available material of the two taxa *A. lineatella* subsp. *heratella* and *A. lineatella* subsp. *tauricella* is inadequate to provide a safe basis for a change of their status; however, based on differences in external appearance and the genitalia we are certain that neither of them is conspecific with *A. innoxella*. Further studies of DNA from fresh material may throw light on the question whether the two subspecies really belong to *A. lineatella* or represent distinct species. That also applies to specimens with a differently shaped lobe of the left valva, as found in one paratype of *A. lineatella tauricella*.

Conclusion

By studying the taxonomy and morphology of the Peach Twig Borer we can demonstrate that *Anarsia lineatella* shows cryptic diversity and beside the well-known *Prunus*-feeding pest includes a widespread and common species the larvae of which feed on *Acer*.

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Appendix

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A new LED lamp for the collection of nocturnal Lepidoptera and a spectral comparison of light-trapping lamps

GUNNAR BREHM¹

¹ *Institut für Spezielle Zoologie und Evolutionsbiologie mit Phyletischem Museum, University of Jena, Vor dem Neutor 1, 07743 Jena, Germany. email: gunnar.brehm@uni-jena.de*

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Abstract. Most nocturnal Lepidoptera can be attracted to artificial light sources, particularly to those that emit a high proportion of ultraviolet radiation. Here, I describe a newly developed LED lamp set for the use in the field that is lightweight, handy, robust, and energy efficient. The emitted electromagnetic spectrum corresponds to the peak sensitivity in most Lepidoptera eye receptors (ultraviolet, blue and green). Power LEDs with peaks at 368 nm (ultraviolet), 450 nm (blue), 530 nm (green), and 550 nm (cool white) are used. I compared the irradiance (E_v) of many commonly used light-trapping lamps at a distance of 50 cm. Between wavelengths of 300 and 1000 nm, irradiance from the new lamp was 1.43 W m⁻². The new lamp proved to be the most energy efficient, and it emitted more radiation in the range between 300 and 400 nm than any other lamp tested. Cold cathodes are the second most energy-efficient lamps. Irradiation from fluorescent actinic tubes is higher than from fluorescent blacklight-blue tubes. High-wattage incandescent lamps and self-ballasted mercury vapour lamps have highest irradiance, but they mainly emit in the long wave spectrum. The use of gauze and sheets decreases the proportion of UV radiation and increases the share of blue light, probably due to optical brighteners. Compared with sunlight, UV irradiance is low at a distance of 50 cm from the lamp, but (safety) glasses as well as keeping sufficient distance from the lamp are recommended. In field tests, the new LED lamp attracted large numbers of Lepidoptera in both the Italian Alps and in the Peruvian Andes.

Introduction

Light-trapping has long been known as an efficient method for collecting of nocturnal insects in general and Lepidoptera in particular (e.g. Taylor and French 1974; Holloway et al. 2001; Infusino et al. 2017). Early on, it was observed that moths can be attracted to the light of fire or candlelight and might even get burned – the family name Pyralidae probably relates to this observation (Emmet 1991). Light-trapping, either manual or with automatic traps, has become a standard and widespread method in ecology, taxonomy, and Lepidoptera monitoring schemes, and it is supposed to represent the only method allowing a large number of clades to be sampled quantitatively in large numbers (Holloway et al. 2001). Light sources with a high proportion of ultraviolet (UV) radiation tend to attract a greater number of individuals and more taxa (van Langevelde et al. 2011). A research focus in recent years has been to investigate the impact of modern street lighting on insects (“light pollution”: e.g. Huemer et al. 2011; van Langevelde et al. 2011; Somers-Yeates et al. 2013; Pawson and Bader 2014; van Grunsven et al. 2014; Macgregor et al. 2016), including

implications of anthropogenically driven selection on flight behaviour in urban areas (Altermatt and Ebert 2016).

A wide range of lamp and trap types for light-trapping has been used in entomological research. Although standardisation is desirable, the availability of new designs and lamps has continually led to changes in the lamp set-ups used. Depending on the requirements of research, it is (a) either more important to stress continuity and use a standard method that has been used in previous studies, or it is (b) more important to apply the most efficient and best available technology. A good example of (a) are Rothamsted traps (Williams 1948) that are operated with strong incandescent lamps with a tungsten filament. The use of this ‘old-fashioned’ technology can be justified in long-term monitoring programmes that are intended to be continued without a substantial methodological change (Southwood et al. 2003). Established methods such as the use of incandescent or high-pressure mercury vapour (MV) self-ballasted lamps also offer the advantage of long-term experience and published comparative studies on their performance (e.g., Intachat and Woïwod 1999).

The use of established light trapping methods does, however, have some disadvantages. For example, incandescent lamps have largely been abandoned in Europe because they are primarily producing long-wave radiation including a large proportion of invisible infrared radiation (Fig. 5a) that contributes relatively little to attracting insects (e.g. Cowan and Gries 2009), while the lifespan of such lamps is rather limited (Infusino et al. 2017). MV lamps emit a more favourable spectrum of radiation (Fig. 5a), but the longevity of the commonly employed self-ballasted type is similarly limited as incandescent lamps (Infusino et al. 2017). Moreover, high pressure MV lamps are being phased out due to their content of toxic mercury, which is banned by new legislations in many countries. Both types of lamps require high voltage, which means that during field work heavy and bulky generators are required. Despite containing mercury, fluorescent tubes of all types are still widely used (e.g. ‘energy-saving lamps’). For insect collectors, particularly popular types of fluorescent tubes emit large proportions of UV radiation, including actinic / blacklight (BL) tubes as well as blacklight-blue (BLB) tubes – the latter with a dark-blue filter coating that absorbs most light. More recently, cold cathodes have become available through their use as backlighting of monitors and as decorative illumination in computer cases. These vary in their wavelengths and one can therefore choose those that include the UV range. However, little seems to be known about their performance in light-trapping so far. The use of LEDs is now increasingly common in light-trapping (Green et al. 2012; Price and Baker 2016; Infusino et al. 2017). LEDs have also been employed in experimental studies because a wide range, with different radiation peaks, is available (e.g. Cowan and Gries 2009; Kadlec et al. 2016).

Although lamp emission data are sometimes provided by the manufacturers, standardized comparisons of the emission or irradiation of different lamps are rare in the entomological literature. A comparison of six light sources with an emphasis on street lighting was given by van Grunsven et al. (2016). Papers can also easily be overlooked if published in journals or in languages with limited readership, as exemplified by a paper by Steidel and Plontke (2008) that graphically shows the qualitative emission spectra of various lamps.

Here, I describe a new LED lamp design intended for use in light trapping under field conditions, including remote tropical locations. The lamp was developed with the aim to minimize weight and size and to maximize energy efficiency and longevity. The aim was to be able to power this lamp with cheap and widely available 5 V lithium batteries (‘powerbanks’), as well as the option of using 12 V batteries. Overall emission was intended to be of comparable or higher quantity

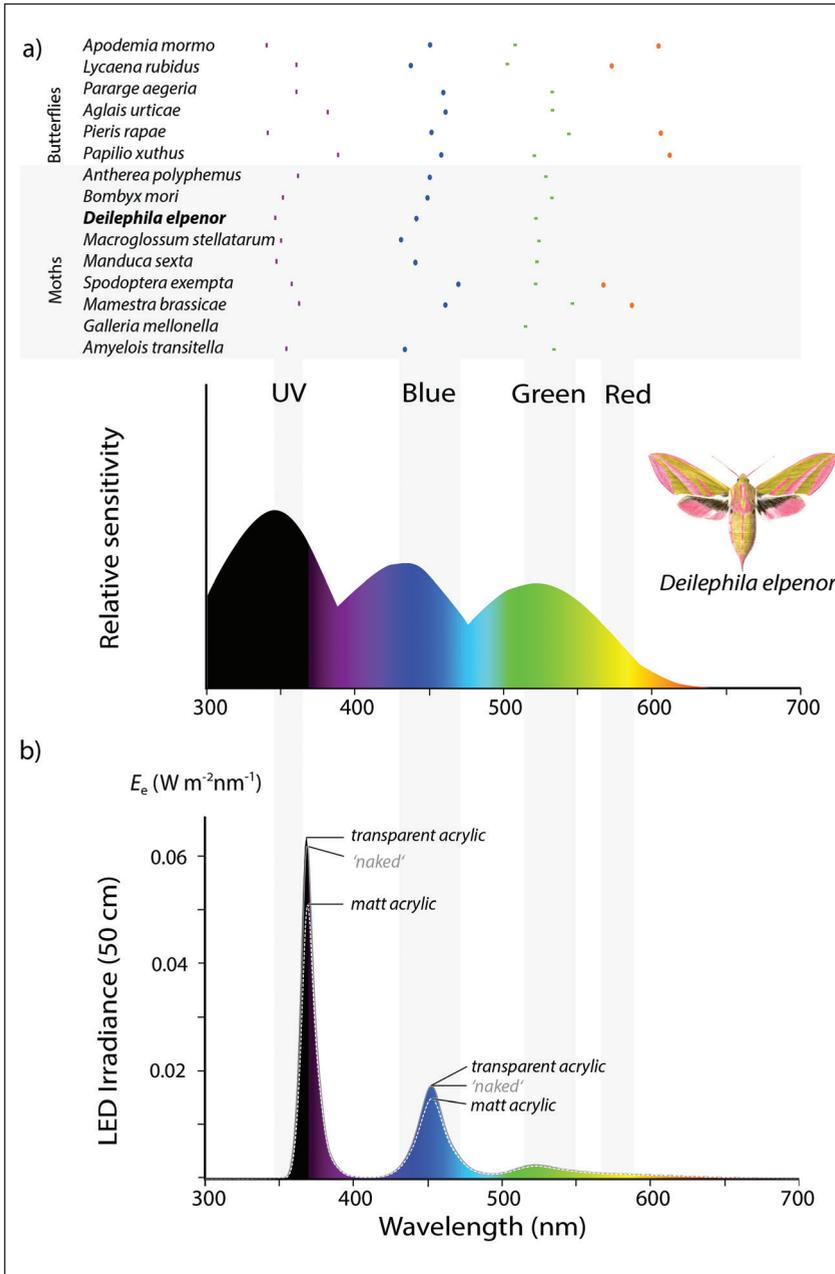


Figure 1. a. Values of maximum spectral sensitivity of Lepidoptera eyes, modified from Briscoe and Chittka (2001) and Johnsen et al. (2006), and sensitivities of the photoreceptors of the hawk moth *Deilephila elpenor* as an example, with peak absorption wavelengths of 350, 440, and 525 nm (Johnsen et al. 2006). **b.** The spectral composition of the new LED lamp (operated at 350 mA) is oriented towards the spectral sensitivity of moth eye receptors (background grey bars). A transparent acrylic cylinder has only a minimal influence on the irradiation from the lamp whereas a matt acrylic cylinder (dashed white line) slightly decreases the performance of the lamp, see also Table 1.

than fluorescent BL and BLB tubes used in many previous field studies (e.g. Brehm and Axmacher 2005), and to provide a higher output than in previously described LED-based designs (Green et al. 2012; Price and Baker 2016; White et al. 2016; Infusino et al. 2017).

The spectral composition of the lamp is orientated towards the peak sensitivity of lepidopteran eye receptors as suggested e.g. by Steidel and Plontke (2008), Mobbs (2016), and Price and Baker (2016). The available data on lepidopteran eye receptor sensitivity is still limited but includes a broad range of taxa (Briscoe and Chittka 2001, Fig. 1a). These data suggest that three types of receptors are commonly found in moths, exemplified in the hawkmoth *Deilephila elpenor* (L.) (Johnsen et al. 2006): one in the ultraviolet, one in the blue, and one in the green range (Fig. 1a). *Synanthedon myopaeformis* (Borkhausen) (Sesiidae) is sensitive both in the ultraviolet and green range (Eby et al. 2013). Further receptors can be present and are possibly even widespread, such as red receptors known from the noctuids *Spodoptera exempta* (Walker) and *Mamestra brassicae* (L.) (Fig. 1a). As an extreme case, photoreceptors of 15 distinct spectral sensitivities were found in the butterfly species *Graphium sarpedon* (L.) (Papilionidae) (Chen et al. 2016). Given the large empirical success of lamps with a high proportion of UV radiation (including MV lamps, fluorescent tubes, cold cathodes, and UV LEDs), the emission of this short wave radiation was considered to be particularly important.

The emission of the new lamp is described in detail and quantitatively compared with a range of lamps commonly used by entomologists. Measurements include transparent clear and matt protective acrylic glasses, sheets, and gauze. Lamp emissions at different distances are compared with sunlight and the roles of spectacles and sun spectacles as eye protection are discussed briefly. Finally, the new LED lamp was tested under field conditions in more than 50 sampling events in the Italian Alps and Peruvian Andes, to confirm that nocturnal Lepidoptera were indeed attracted to the lamp and opening perspectives for further research.

Material and methods

Lamp design

The outer shape of a cylinder was considered as the best choice, not least because this allows the use of the lamp within existing trap designs. Power LEDs with a maximum power consumption of 3 W were chosen because they are generally more energy efficient than Power LEDs ≤ 1 W as found for example in LED stripes (White et al. 2016; Infusino et al. 2017). On the other hand, LEDs with higher wattage (e.g., 5 or 10 W) were not considered since this would have easily surpassed the desired maximum power consumption of ca. 15 W. Irradiance from a number of different LEDs was measured (see below, Appendix 1) and those with the best performance were chosen. LEDs with different wavelengths were used in order to reflect different sensitivity peaks in moth eye receptors (Fig. 1), with an emphasis on short wave radiation (UV and blue). For the final lamp design, eight Power LEDs on star circuit boards were arranged at two levels, each separated by 90° (Fig. 2). Four UV LEDs (SSC Viosys UV CUN66A1B), two Cree XP-E2 Royal Blue LEDs, one Cree XP-E2 Green LED, and one Cree XP-L V6 Cool White LED were finally selected. LEDs were glued with a thermal adhesive on a cooling aggregate (Fischer Elektronik LAM 31005) in order to avoid overheating and to maximize LED lifespans. A small axial fan (ca. 0.15 W) on top of the aggregate additionally removes heat from the inside. Airflow is directed from the bottom to the top of the lamp, supporting air convection. Metal gauze at the bottom and the top of the lamp

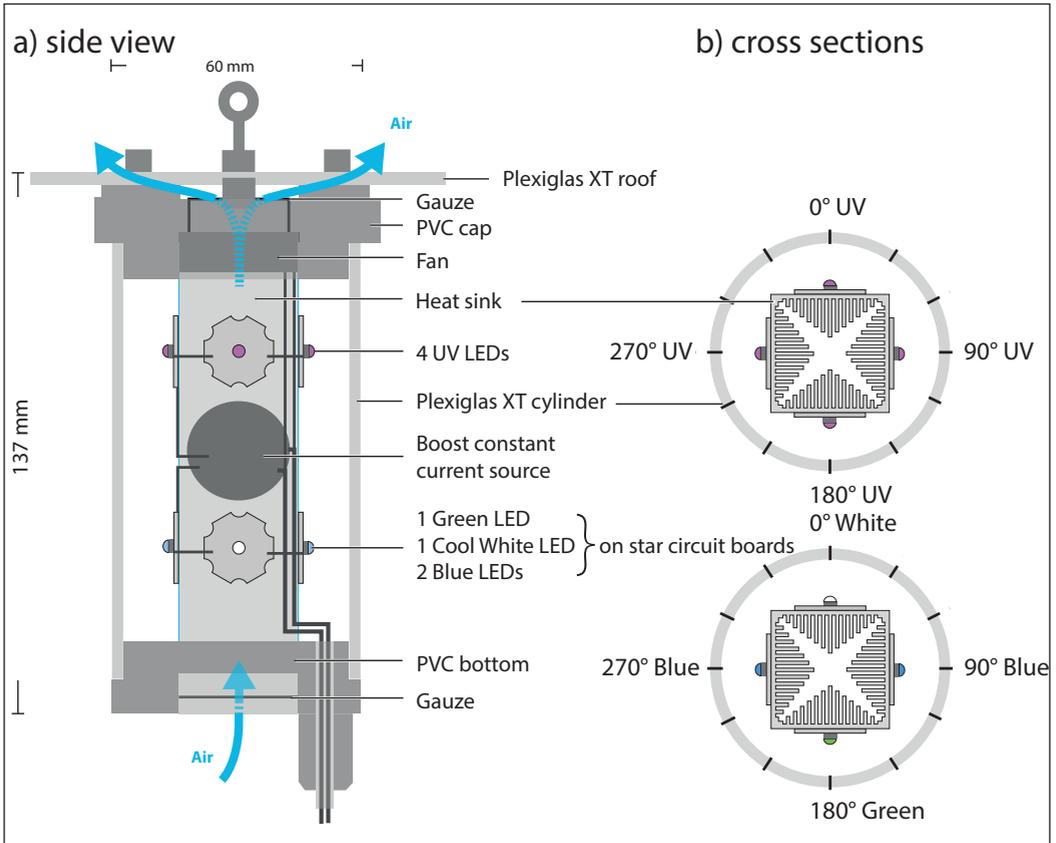


Figure 2. Design of the new LED lamp (scale 1:2). A total of 8 Power LEDs is arranged at two levels (4 UV, 2 blue, 1 green, 1 cool white).

prevents small insects and dirt from entering, and a transparent acrylic (Plexiglas® XT) roof protects the lamp from rain. The protective cylinder around the LEDs also consists of Plexiglas XT characterized by high transmission rates including for UV radiation (Fig. 1b). Alternatively, a matt Plexiglas cylinder can be used (Fig. 1b, Table 1). The bottom and top of the lamp are made of PVC. Inside is a cooling aggregate (heat sink) and outside a Plexiglas cylinder. In future models, PVC will be replaced by anodized aluminium. LEDs are connected in series to a Boost LED constant current source (pcb components Led Sensor V2 Rev.2) that allows an input current in the given design of ca. 5–12 V DC. After performance tests with different currents, the output current was set to 350 mA.

Spectral measurements

The irradiance (E_e) of different lamps was measured in a dark room with a Specbos 1211 UV broadband spectro-radiometer aligned to the centre of the lamps at a distance of 50 cm (Fig. 3). Irradiance is defined as radiant flux (or intensity) received by a surface per unit area, here expressed as $W\ m^{-2}\ nm^{-1}$ and measured at wavelengths between 300 and 1000 nm. While irradiance refers to

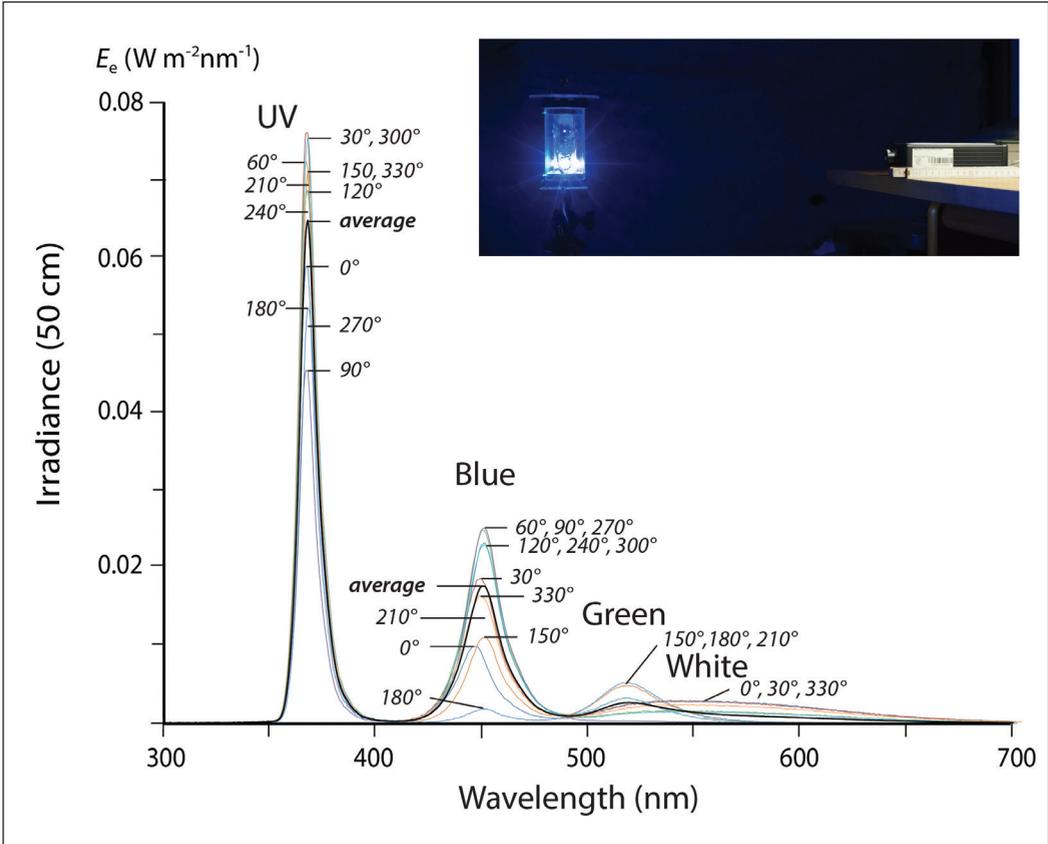


Figure 3. The irradiance of the new lamp was measured at a distance of 50 cm around its circumference at 12 points giving 30° between each. Average value: black line.

a receiving surface, the terms “radiance” and “emission” refer to the radiant source. Irradiance was calculated in total as well as separately for the spectral bands 300–400 nm, 401–650 nm, and 651–1000 nm. Because of the unequal emission patterns of the new LED lamp, irradiance was measured 12 times, at 30° angular intervals around the lamp, and the average was calculated for each wavelength (Fig. 3). Apart from the LED lamp, a number of lamps commonly used in light-trapping were also assessed (Table 1, Appendix 1). In cases where more than one lamp was measured, modest variation in the data was observed, as expected for standard industry products. For a comparison of UV irradiance of lamps and sunlight, irradiance from sunlight was measured on a sunny but hazy day on 17.iii.2016 at 10:50 in Jena, Germany (50.9° N). In addition, lamp and sunlight were filtered with regular clear glasses (Fielmann: Essilur, allyl diglycol carbonate (= CR 39) with additives, super-nonreflecting) and sun glasses (Fielmann: Rupp and Hubrach, allyl diglycol carbonate with additives, polarized, 85% grey).

The wattage of the lamps was measured with a Muker-J7 USB Multimeter QC2.0 QC3.0 and a REV Ritter ‘energy cost measuring device’ (Nr. 002580). The ratio between irradiance and watt-

Table 1. Irradiation of selected lamps and LEDs at wavelengths between 300 and 1000 nm, measured at a distance of 50 cm. A full list is provided in Appendix 1. *Italics*: Measurement of lamp within a gauze tower. Grey cells: wavelength band with highest irradiance. *Unlike other lamps in the test, the GemLight emits only into a single direction (max. 180°). ** Wattage and efficiency of the new LED lamp depend on the input voltage; Values are provided for 12 V and 5 V DC input, respectively.

Lamp	300–400 nm	401–650 nm	651–1000 nm	300–1000 nm	Effective wattage (W)	Irradiation/wattage (efficiency)
Low pressure mercury vapour						
350 nm actinic tube in acrylic glass	0.44	0.04	0.01	0.49	8	0.06
<i>in gauze tower</i>	<i>0.25</i>	<i>0.10</i>	<i>0.01</i>	<i>0.36</i>	8	--
350 BLB in acrylic glass	0.14	0.01	0.01	0.15	8	0.02
<i>in gauze tower</i>	<i>0.08</i>	<i>0.02</i>	<i>0.01</i>	<i>0.11</i>	8	--
368 nm actinic tube in acrylic glass	0.45	0.04	0.01	0.50	8	0.06
<i>in gauze tower</i>	<i>0.26</i>	<i>0.12</i>	<i>0.01</i>	<i>0.39</i>	8	--
8 W BLB in acrylic glass	0.04	0.00	0.01	0.05	4	0.01
<i>in gauze tower</i>	<i>0.02</i>	<i>0.01</i>	<i>0.01</i>	<i>0.04</i>	4	--
Revoltec cold cathodes (twin sets)						
Cold cathode UV	0.32	0.01	0.00	0.33	3.9	0.09
Cold cathode blue	0.00	0.48	0.01	0.49	3.9	0.13
Cold cathode green	0.01	0.23	0.00	0.24	6.8	0.04
Tungsten filament lamps						
160 W mercury vapour	0.57	3.316	7.09	10.98	190	0.06
<i>in gauze tower</i>	<i>0.33</i>	<i>3.010</i>	<i>6.45</i>	<i>9.79</i>	190	--
200 W incandescent	0.04	1.54	8.36	9.94	180	0.06
LED lamps						
GemLight*	0.10	0.02	0.00	0.13	--	--
400 nm Infusino et al. (2017)	0.13	0.10	0.00	0.23	8	0.03
New LED lamp**						
(350 mA) in Plexiglas cylinder	0.77	0.64	0.01	1.43	10.4 / 13.4	0.14 / 0.11
<i>without Plexiglas cylinder</i>	<i>0.77</i>	<i>0.66</i>	<i>0.01</i>	<i>1.44</i>	10.4 / 13.4	0.14 / 0.11
<i>with matt Plexiglas cylinder</i>	<i>0.64</i>	<i>0.59</i>	<i>0.01</i>	<i>1.24</i>	10.4 / 13.4	0.11 / 0.09
<i>with sheet in background</i>	<i>0.76</i>	<i>0.94</i>	<i>0.02</i>	<i>1.72</i>	10.4 / 13.4	--
<i>in gauze tower</i>	<i>0.34</i>	<i>0.71</i>	<i>0.01</i>	<i>1.06</i>	10.4 / 13.4	--

age at 50 cm between 300 and 1000 nm expresses the energy efficiency of the lamps. Temperature of LEDs was measured with an Omega hypodermic needle probe connected to an Omega HH21 thermometer.

Field work performance

A prototype, operated with an output current of 500 mA, was first tested in dry grassland near Leutra, Jena, Germany (29.vi.2016), and later in similar habitats in South Tyrol, Italy: Oberversant (2–13.vii.2016) and Innerunterstell (4.vii.2016). After the successful first field tests, a series of ten LED lamps, operated with an output current of 350 mA, became available in August 2016 and was used for a quantitative moth survey along a rain forest elevational gradient in the Cosñipata

valley (Cusco province, Peru) for more than 50 sampling events (23.viii.–4.ix.2016, 12.8868° S, 71.4012° W–13.2003° S, 71.6172° W, 520–3500 m). Detailed analyses of this sampling campaign will be published in due course, but selected photographs illustrate the attraction of Lepidoptera to the lamp.

Results

Features of the new LED lamp

Pronounced irradiation peaks from the new LED lamp occur at 368 nm (UV), at 450 nm (blue), and at 520 nm (green) (Figs 1, 3–6). The mean irradiance of wavelengths between 300 and 1000 nm at a distance of 50 cm is 1.43 W m⁻². The irradiance without the protective Plexiglas cylinder is only minimally higher (1.44 W m⁻², Fig 1b), and the irradiance with a matt Plexiglas cylinder is ca. 13% lower (1.24 W m⁻², Fig. 1b). As expected, UV irradiation is relatively constant at all angles around the lamp, whereas more pronounced spatial peaks occurred with the blue, green, and white LEDs (Fig. 3). A white sheet in the background behind the lamp increases irradiance to 1.72 W m⁻² (Fig. 4a). However, in this case irradiance is a theoretical value because a sheet can only be placed on one side of the lamp, and irradiance on the reverse of the sheet will be far lower. A gauze tower around the lamp led to a decrease of irradiance to 1.07 W m⁻² (Fig. 4a), but in-depth comparisons are hindered by increased stray light—the whole gauze tower appears illuminated (Fig. 7). Remarkable in both cases is a partial shift from UV to blue irradiation. This can also be observed when measurements with and without a surrounding gauze tower are compared for a single UV LED (Fig. 4b).

When operated with a 12 V battery, the wattage of the lamp is ca. 10.4 W. When operated with a 5 V (powerbank) battery, the wattage is ca. 13.4 W. Without an axial fan, the LEDs reach (at room temperature) temperatures of between 43 and 53° C. With an operating fan, the temperature range is 30–33° C with a 12 V battery, and 33–39° C with a 5 V battery.

Comparison of lamps

Both the self-ballasted MV and the incandescent lamp assessed surpass by far the irradiance (full range 300–1000 nm) of the new LED lamp (Fig. 5a, Table 1). However, ca. two thirds of their respective irradiation is in the long wave spectrum (> 650 nm), much of it infrared. Remarkably, irradiation from the new LED lamp in the near-UV range between 300 and 400 nm is higher (Table 1)—despite having more than tenfold lower wattage. The MV lamp shows various narrow radiation peaks reflecting the characteristic spectral lines of mercury vapour and an increasing proportion of long wave radiation due to the tungsten filament. The incandescent lamp produces a continuously increasing long wave radiation spectrum but practically no UV radiation.

None of the other lamps that were compared surpass the irradiation from the new LED lamp, neither in total nor in a single wavelength band (Fig. 5b, Table 1, Appendix 1). All tested fluorescent low-pressure mercury tubes (BL / BLB) either show peaks around 350 or 368 nm (Fig. 5b). The highest total irradiation is from 368 nm and 350 nm actinic BL tubes (0.50 and 0.49 W m⁻²nm⁻¹, respectively) whereas the 350 nm BLB tube shows a considerably lower irradiation (0.15 W m⁻²nm⁻¹). All cold cathodes show clearly visible peaks in UV, blue, and green, with irradiance sums of 0.33, 0.49, and 0.24 W m⁻²nm⁻¹, respectively.

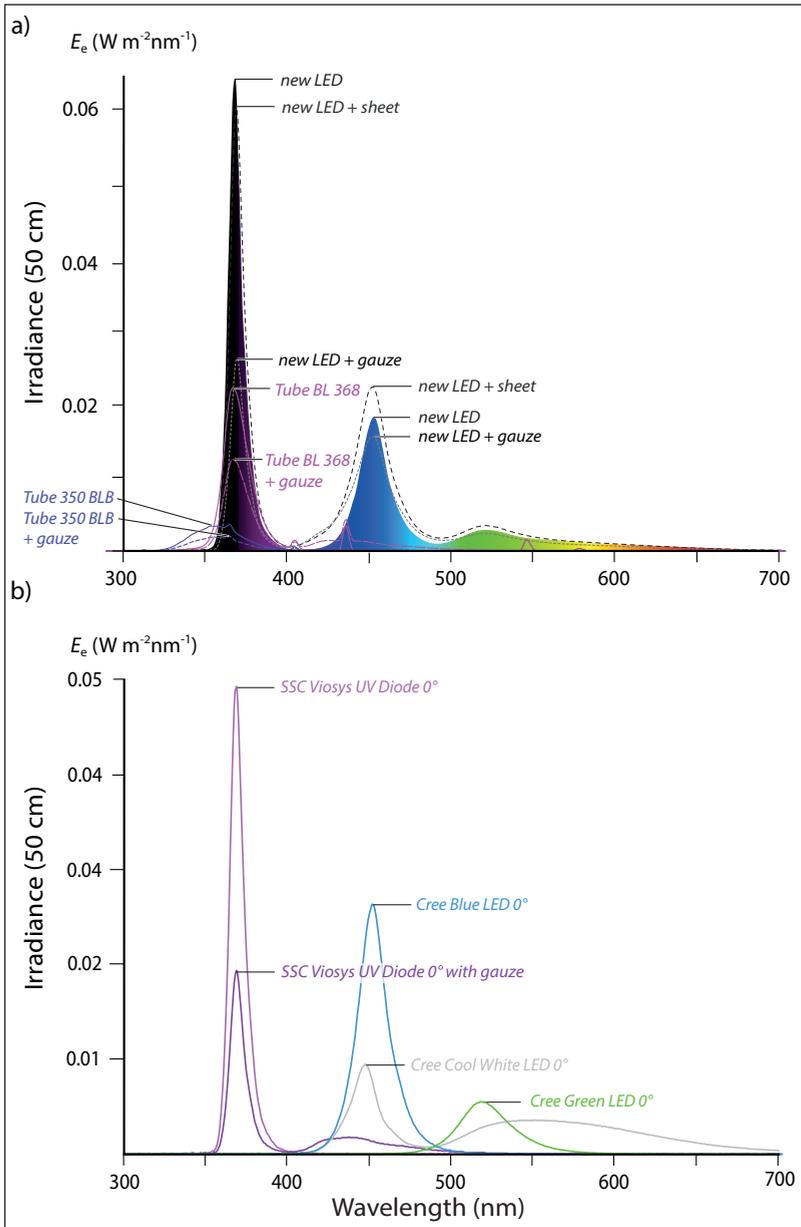


Figure 4. a. Irradiance from the four LED types used in the new LED lamp, measured at 50 cm distance and at 0° (see Fig. 3), and influence of Bioform ‘light tower’ gauze on the spectral composition of the UV LED. UV irradiance decreases significantly and a new blue peak appears at ca. 440 nm, probably due to optical brighteners applied to the textile. **b.** Influence of Bioform ‘light tower’ gauze and a white sheet on the irradiance of the new LED lamp, of a 368 nm fluorescent actinic BL tube and a 350 nm fluorescent BLB tube. In all cases, a part of the UV radiation is absorbed and re-emitted by the textile as blue light, caused by optical brighteners. Distance between measuring device and lamp: 50 cm. The tower gauze was placed between the measuring device and the lamp. The sheet was placed 15 cm behind the lamp (increased irradiation due to reflection).

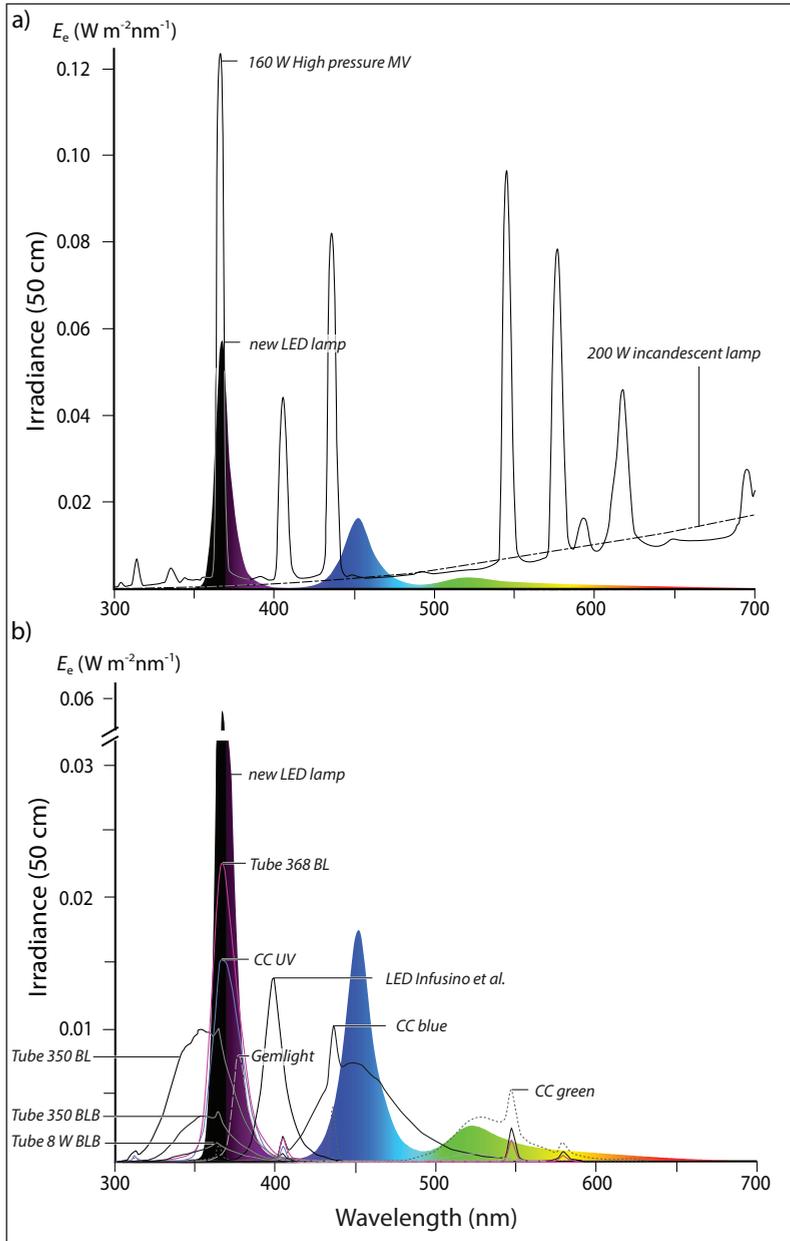


Figure 5. Irradiance from the new LED lamp (in colour), compared with irradiation from a 190 W high-pressure mercury vapour (MV) bulb with tungsten filament (black line), and a 200 W incandescent lamp with tungsten filament (dashed black line). **b.** Irradiance from the new LED lamp (in colour), as compared to irradiance from various commonly used lamps used for insect collecting. CC blue: Blue cold cathode; CC green: Green cold cathode; CC UV: ultraviolet cold cathode; tube 350: low pressure actinic mercury vapour tube with 350 nm emission peak; tube 350 BL: low pressure mercury vapour blacklight tube with 350 nm emission peak; tube 368: low pressure mercury vapour tube with 368 nm emission peak. Gem-Light: GemLight UV LED at 0°. LED Infusino et al.: 400 nm LED stripe applied by Infusino et al. (2017).

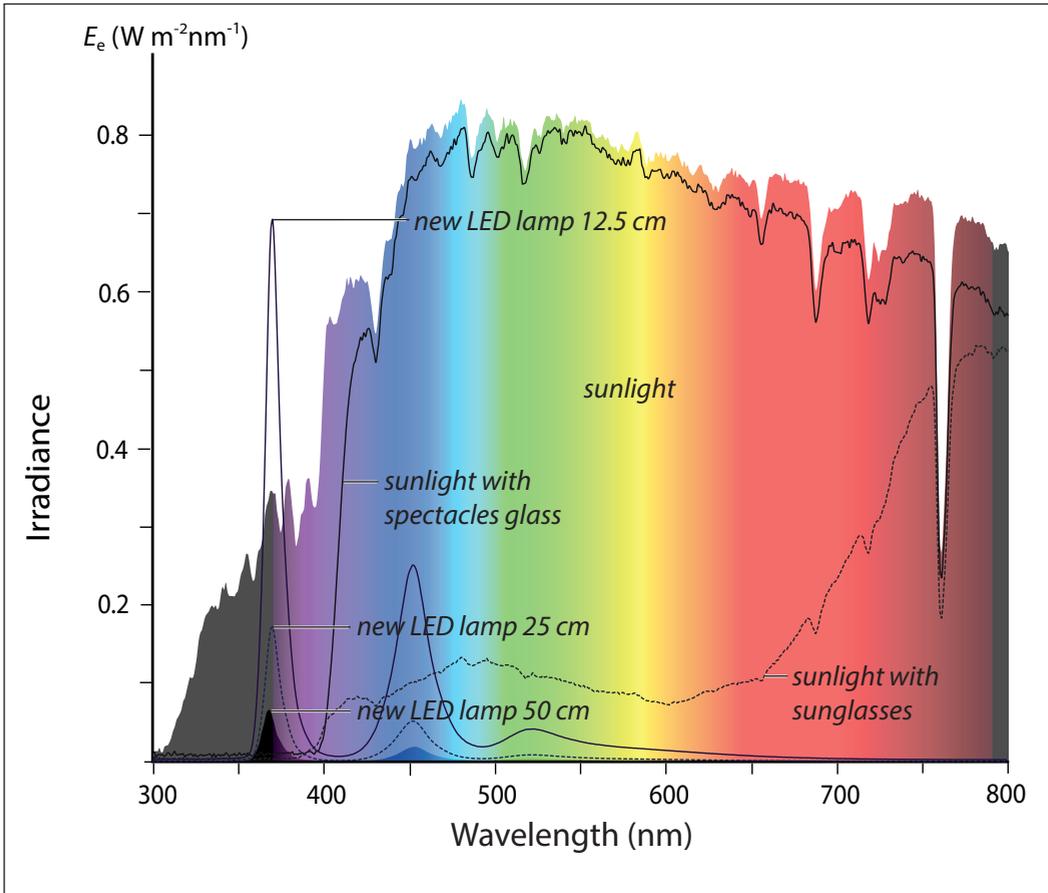


Figure 6. Irradiance from sunlight (in colour; 50.9° N, on a sunny, hazy day at 10:50h in March 2016), irradiance from sunlight with clear synthetic glasses (solid line), irradiance from sunlight with synthetic sunglasses (dashed line), and irradiance from the new LED lamp at distances of 50 cm (see all other Figs), 25 cm, and 12.5 cm. The two spectacle lens types almost completely absorb UV radiation.

Sunlight comparison and UV protection

Fig. 6 shows a comparison of the irradiance on a sunny March day in Jena with the irradiance of the new LED lamp at different distances from the measuring device. The UV irradiation from the new lamp at a distance of 50 cm (the same as in all standardized measurements) is small compared with the irradiance from the sun. However, irradiance from the LED lamp becomes higher at shorter distances. Normal spectacle glasses (allyl diglycol carbonate with additives) almost completely filter away UV radiation but allow almost full transmission of radiation > 400 nm. Sunglasses (allyl diglycol carbonate with additives) again filter UV radiation and also a large proportion of longer wavelengths.

First results from field work

Generally, the LED lamps attracted moths very well, including e.g. Geometridae, Noctuidae, Erebidae, Pyraloidea, Sphingidae, and many other taxa. Lamps were either mounted in front of a white

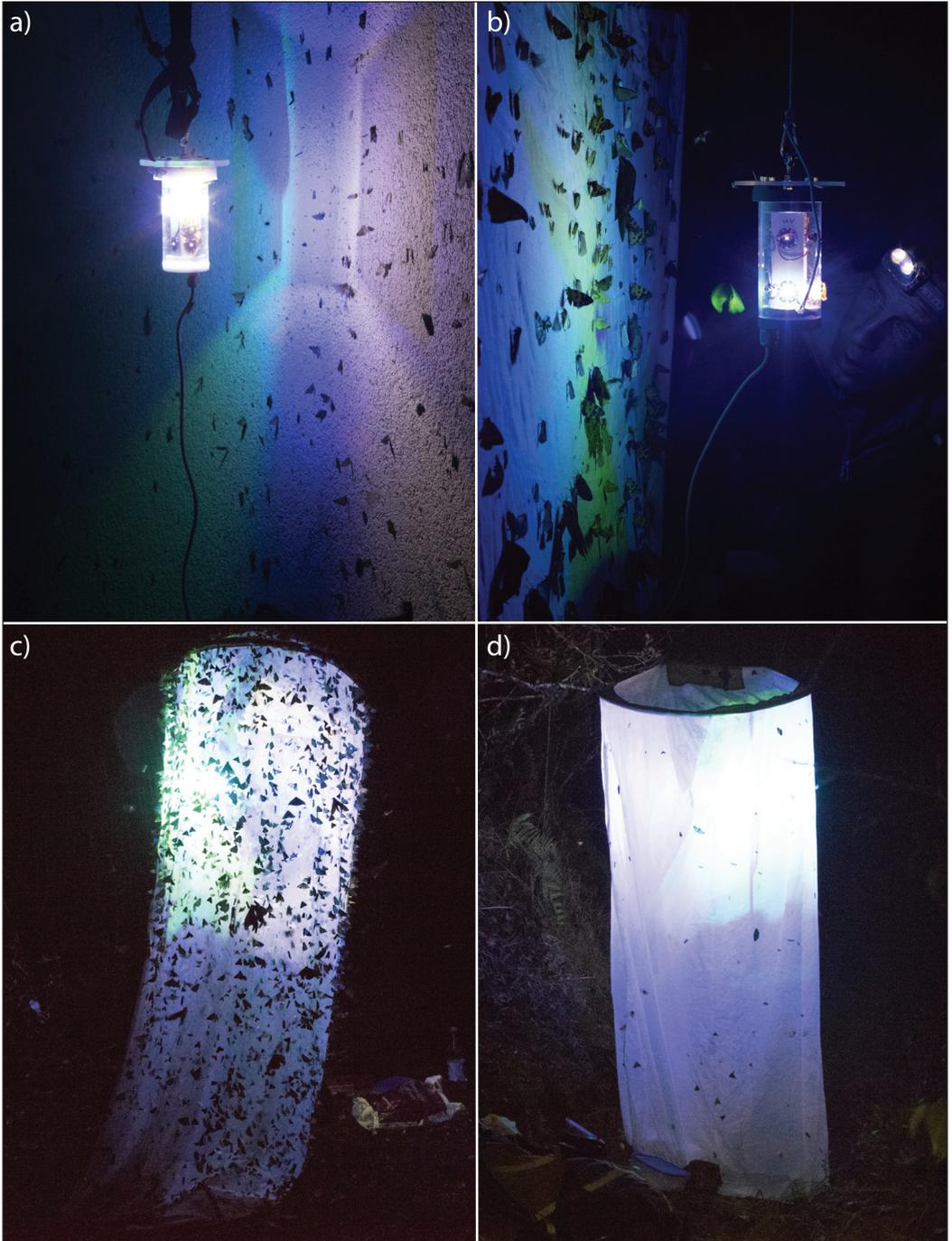


Figure 7. LED lamp used in field work. **a.** Lamp operating in front of a house wall, Obversant, South Tyrol, Italy (8.vii.2016). **b.** Lamp operating in front of a white sheet, Paradise Lodge, Cosñipata valley, Cusco Province, Peru, 1360 m (30.viii.2016). **c.** Lamp operating in a gauze tower, Cosñipata valley, Peru, 1940 m (3.ix.2016). **d.** Lamp operating in a gauze tower, near Wayqecha station, Peru, 2890 m (4.ix.2016).

house wall in South Tyrol (Fig. 7a), in front of a white sheet in Peru (Fig. 7b) or in a gauze tower in Peru (Figs 7c,d). Most individual moths along the rain forest elevational gradient in Peru were collected at low and medium elevations. The “busiest” night in Peru occurred two days after new moon (3.ix.2016) at 1940 m (Figure 7c). Geometrid moths were the most abundant moth family at this elevation, and I estimate that at least 1000 individuals were attracted within less than three hours after dusk. Only one night later, far fewer specimens (ca. 100 individuals of Geometridae) were collected in a partly clear night at 2890 m (Fig. 7d).

Discussion

The new LED lamp was constructed with the aims of being lightweight, handy, robust, and energy efficient, and these aims were clearly fulfilled. First field tests have demonstrated that the lamp is very attractive to nocturnal Lepidoptera (Fig. 7), and a detailed analysis of the samples will be published in due course. The measurements carried out concentrate on irradiance rather than on total emission of the lamp, first because the required measuring device, a two-meter diameter Ulbricht sphere, was not available in Jena. Second, the chosen approach allowed comparison of irradiance from lamps in combination with gauze and sheets, as well as with incoming sunlight. Generally, comparisons between different lamps are never simple because lamps differ in their design, in their dimensions, and in the way radiation is emitted. All of these factors could possibly influence moth behaviour, and therefore measurement results should be regarded as an approximation of potential moth attractiveness, to be supplemented by field studies and physiological measurements.

The age and the cumulative operating hours of the lamps could have an impact on their performance, but it was beyond the scope of this paper to explore this effect in detail. For example, the emission of fluorescent tubes drops with age to ca. 80% in new-generation lamps (Sylvania BL 368 nm) and to ca. 50% in old-generation tubes (e.g. Sylvania BL 350 nm) (Havells-Sylvania 2012). Decreases are also expected to occur in LEDs, accelerated by high temperatures and high currents. For this reason, LEDs in the lamp are not being operated at the maximum possible current (700 mA) but only at 350 mA, aided by an efficient cooling system. Ageing of acrylic glass and other materials possibly also influences the radiation flux.

Clearly, a cross calibration study with other lamps is desirable. Such comparative studies have regularly shown that even lamps with fundamentally different light spectra attract similar moth assemblages. For example, Geometroidea samples attracted to an incandescent and a MV lamp were surprisingly similar (Intachat and Woiwod 1999; Infusino et al. 2017; Jonason et al. 2014). On the other hand, noctuid moths were more attracted to short wave radiation than geometrid moths (Somers-Yeates et al. 2014), so certain differences in samples obtained with different methods must be expected.

An unexpected result was the appearance of a blue peak at ca. 440 nm when ‘light tower’ gauze and a white sheet were used in combination with various lamps. In all cases, a part of the UV radiation is absorbed and re-emitted by the textile as blue light, caused by commonly used optical brighteners in textile production and in washing powders. This means that supposedly ‘pure’ UV sources such as BLB tubes and UV LEDs combined with a textile also emit a certain amount of blue light. This lowers energy efficiency to some extent, but the additional blue light possibly increases the attractiveness to insects.

The lamp itself has a weight of less than 500 g, and it can be operated for five to six hours with a standard powerbank, e.g. an Easy Acc battery (5 V, 26 Ah, 400 g). Since powerbank batteries are a mass product on the market used for mobile phones etc., their prices are reasonable, they can easily be transported in carry-on baggage and recharged with mobile solar panels in remote areas. The total equipment, including the lamp, powerbank and charging device (220 V AC to 5 V DC USB charger) weighs less than 1 kg. In comparison, any equipment operated with generators is far heavier because a generator alone weighs ca. 13 kg. Equipment operated with 12 V is usually connected to (heavy) lead batteries. For example, field work in Ecuador and Costa Rica (Brehm and Axmacher 2005; Brehm 2007) was undertaken with a 15 W actinic BL tube and a 15 W BLB tube, operated with a lead battery (12 V, 7 Ah, 2 kg). Together with the charging device, the equipment weighed ca. 4 kg. The size of the new LED lamp (6 x 14 cm) is also small, so that it easily fits into travel bags and backpacks. The lamp has furthermore proven to be robust in the field. In one case, the axial fan broke when a gauze tower was blown down in a thunderstorm. However, the lamp remained fully functional without the fan, but since a working fan reduces the temperature of the LEDs (by ca. 10° C), which leads to a longer lifetime of the diodes, it is recommended that a broken fan is replaced when it is practical to do so (it takes only a few minutes).

In terms of energy efficiency, the new LED lamp outperformed every other lamp that was tested (Table 1, Appendix 1), and total irradiance between 300 and 400 nm was greater than from any other tested lamp, even including strong, self-ballasted MV bulbs. If efficiency is to be maximized, the use of 12 V batteries is recommended but from a weight-optimising point of view, 5 V powerbank batteries are the better choice. The second most energy-efficient tested lamps are cold cathodes with an input voltage of 12 V (Table 1). Their use nonetheless requires heavier batteries or a step-up converter that lowers energy efficiency. Cold cathodes (especially blue ones) are very lightweight and appear to have the best price / performance ratio.

The new LED lamp emits the desired spectrum of different wavelengths (UV, blue, and green). Half of the LEDs are UV diodes because UV is particularly attractive to moths. However, the additional diodes are expected to contribute further to the attractiveness of the lamp, and to stimulate eye receptors sensitive to longer waves. When MV lamps are compared with BL and BLB tubes, MV lamps usually attract more moth species and individuals (e.g., Jonason et al. 2014; Tikoca et al. 2016). A possible reason is that MV lamps emit not only more UV radiation, but also a much broader spectrum, than fluorescent tubes. A major advantage of LEDs is that a light mix can experimentally be assembled from a wide range of available diodes (Cowan and Gries 2009; Kadlec et al. 2016). Future studies could assess whether a maximisation of UV radiation on the one hand versus a mixture of wavelengths on the other hand, results in a higher number of attracted moth species and individuals. The new LED lamp could easily be used for such experiments, and mixtures of different LEDs could be tested. In principle, the lamp could also be modified in such a way that more diodes, e.g. 12, 16, or 20, are mounted on an extended design.

Safety considerations

Ultraviolet radiation is well known for its harmful effects on skin and eyes, being linked to accelerated ageing, various forms of skin cancer, eye cataracts etc. (O'Sullivan and Tait 2014). Protection with appropriate glasses and sunscreen is therefore strongly recommended to all lepidopterists who often work in open sunlight. The potential hazard of light-trapping lamps used by entomologists has received little consideration to date. The data presented here suggest that UV irradiance at a distance



Figure 8. First exemplar of the commercially available lamp “LepiLED”, height ca. 88 mm, diameter ca. 62 mm. Scale bar: 10 cm.

of 50 cm from the lamp is low compared with sunlight, which was relatively weak (51° N, low angle) compared to sunlight at lower latitudes, at higher angles, and at high elevations. This of course does not mean that UV lamps are generally harmless: irradiance strongly increases as distance decreases between lamp and exposed surface. As a general rule, it is certainly advisable to keep a reasonable distance from the lamp, depending on its type, and to avoid exposure of skin and eyes to the UV source at a short distance. High quality glasses (but not normal spectacle glasses) will often provide a sufficient protection, but UV transmission of glasses should individually be checked by an optician. In doubt, one can easily purchase safety-glasses which also protect from stray light. Good quality sun-glasses also protect from UV radiation, but only models with weak shading will be practicable for use at night.

Outlook

Further studies are required with regard to cross-calibration of the new LED lamp with existing lamps, including cold cathodes, which have been poorly studied so far. The lamp design is also open to experimental approaches in the field with different sets of LEDs. So far, only a small series of lamps has been available. However, a professionally manufactured model will be available for 395 € from the author (info@gunnarbrehm.de) in 2017. This model uses the same basic design as the lamp described in this paper. It weighs ca. 470 g, has a height of 88 mm and a diameter of 62 mm, the same input voltage (5–12 V) and a very similar set of LEDs (manufacturer: Nishia). Also, this model has almost identical emissions to the lamp described here. It is manufactured with anodized aluminium and borosilicate glass, and instead of a fan, it uses a passive cooling element and is totally waterproof. This model will hopefully make the LED technology available to a larger community of lepidopterists and other entomologists.

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Appendix 1

Table 2. Full list of tested lamps and LEDs with irradiance measured in different bands of wavelengths. Grey cells: LEDs used for the new LED lamp.

Type	Remarks / angle	Wattage effective (W)	Brand	Nr	300–400 nm	401–650 nm	651–1000 nm	300–1000 nm
Low pressure MV actinic tube (BL)	naked	8	Sylvania	Blacklight 368 F15W/T8/BL368	0.427	0.039	0.008	0.474
Low pressure MV actinic tube (BL)	naked in gauze tower	8	Sylvania	Blacklight 368 F15W/T8/BL368	0.256	0.090	0.007	0.353
Low pressure MV actinic tube (BL)	acrylic glass	8	Sylvania	Blacklight 368 F15W/T8/BL368	0.438	0.040	0.009	0.487
Low pressure MV actinic tube (BL)	acrylic glass in gauze tower	8	Sylvania	Blacklight 368 F15W/T8/BL368	0.251	0.098	0.008	0.357
Low pressure MV actinic tube (BL)	naked	8	Sylvania	Blacklight F15W/350 BL-T8	0.469	0.041	0.007	0.517
Low pressure MV actinic tube (BL)	naked in gauze tower	8	Sylvania	Blacklight F15W/350 BL-T8	0.264	0.126	0.008	0.398
Low pressure MV actinic tube (BL)	acrylic glass	8	Sylvania	Blacklight F15W/350 BL-T8	0.450	0.039	0.008	0.497
Low pressure MV actinic tube (BL)	acrylic glass in gauze tower	8	Sylvania	Blacklight F15W/350 BL-T8	0.256	0.124	0.008	0.388
Low pressure MV actinic tube (BL)	naked	9	Philips	PL-S 9W/12 Made in Poland	0.223	0.057	0.013	0.293
Low pressure MV actinic tube (BL)	naked in gauze tower	9	Philips	PL-S 9W/12 Made in Poland	0.109	0.063	0.012	0.184
Low pressure MV actinic tube (BL)	naked	13	Exo Terra	Repti Glo 5.0 UVB 13 W	0.053	0.492	0.054	0.599
Low pressure MV actinic tube (BL)	naked in gauze tower	13	Exo Terra	Repti Glo 5.0 UVB 13 W	0.029	0.482	0.053	0.563
Low pressure MV actinic tube (BL)	naked	12	Osram	Dulux S Blue UVA, 78 Color	0.441	0.075	0.022	0.538
Low pressure MV actinic tube (BL)	naked in gauze tower	12	Osram	Dulux S Blue UVA, 78 Color	0.247	0.137	0.016	0.401

Type	Remarks / angle	Wattage effective (W)	Brand	Nr	300–400 nm	401–650 nm	651–1000 nm	300–1000 nm
Low pressure MV actinic tube (BL)	naked	30	Kelly	Bug Killer 40W, ESL Lamp Nr. 71468	1.014	0.355	0.005	1.374
Low pressure MV actinic tube (BL)	naked in gauze tower	30	Kelly	Bug Killer 40W, ESL Lamp Nr. 71468	0.548	0.471	0.005	1.024
Low pressure MV blacklight-blue tube (BLB)	naked	8	No brand	F15 T8 BLB	0.144	0.005	0.013	0.162
Low pressure MV blacklight-blue tube (BLB)	naked in gauze tower	8	No brand	F15 T8 BLB	0.080	0.024	0.011	0.115
Low pressure MV blacklight-blue tube (BLB)	acrylic glass	8	No brand	F15 T8 BLB	0.135	0.005	0.010	0.149
Low pressure MV blacklight-blue tube (BLB)	acrylic glass in gauze tower	8	No brand	F15 T8 BLB	0.076	0.022	0.009	0.106
Low pressure MV blacklight-blue tube (BLB)	naked	8	No brand	F15 T8 BLB	0.141	0.004	0.007	0.152
Low pressure MV blacklight-blue tube (BLB)	naked in gauze tower	8	No brand	F15 T8 BLB	0.080	0.021	0.007	0.108
Low pressure MV blacklight-blue tube (BLB)	acrylic glass	8	No brand	F15 T8 BLB	0.129	0.003	0.006	0.138
Low pressure MV blacklight-blue tube (BLB)	acrylic glass in gauze tower	8	No brand	F15 T8 BLB	0.070	0.021	0.007	0.098
Low pressure MV blacklight-blue tube (BLB)	naked	19	Ommilux	Energy Saving Lamp 3U 20W E27	0.184	0.009	0.004	0.197
Low pressure MV blacklight-blue tube (BLB)	naked in gauze tower	19	Ommilux	Energy Saving Lamp 3U 20W E27	0.105	0.034	0.003	0.142
Low pressure MV blacklight-blue tube (BLB)	naked	4	no brand		0.041	0.002	0.008	0.051
Low pressure MV blacklight-blue tube (BLB)	naked in gauze tower	4	no brand		0.021	0.008	0.006	0.035
Cold cathode (twin set)	naked	3,9	Revoltec	UV RM130	0.324	0.009	0.001	0.334
Cold cathode (twin set)	naked	3,9	Revoltec	Blue RM128	0.004	0.483	0.005	0.492
Cold cathode (twin set)	naked	6,8	Revoltec	Green RM125	0.007	0.231	0.003	0.241

Type	Remarks / angle	Wattage effective (W)	Brand	Nr	300–400 nm	401–650 nm	651–1000 nm	300–1000 nm
High pressure MV lamp, self-ballasted	naked	190	Osram	HVL 160 W	0.567	3.316	7.093	10.975
High pressure MV lamp, self-ballasted	naked in gauze tower	190	Osram	HVL 160 W	0.331	3.010	6.454	9.794
High pressure MV lamp, self-ballasted	naked	190	Osram		0.694	3.132	6.330	10.156
High pressure MV lamp, self-ballasted	naked in gauze tower	190	Osram		0.348	2.443	4.879	7.671
High pressure MV BLB lamp, self-ballasted	naked	190	Omnilux	UV Lampe 160 W / E27	0.306	0.048	1.475	1.829
High pressure MV BLB lamp, self-ballasted	naked in gauze tower	190	Omnilux	UV Lampe 160 W / E27	0.211	0.113	1.466	1.789
Incandescent lamp	naked	180	no brand	200 W (E27)	0.035	1.541	8.364	9.940
LED UV + Green	naked	nA	Worldwide Butterflies	GemLight	0.104	0.024	0.000	0.129
LED UV + Green	naked in gauze tower	nA	Worldwide Butterflies	GemLight	0.055	0.035	0.000	0.090
LED UV	naked	8	no brand		0.129	0.104	0.000	0.234
LED UV	naked in gauze tower	8	no brand		0.069	0.108	0.000	0.178
LED UV	0°	at 350 mA	SSC Viosys	UV CUN66A1B	0.610	0.005	0.000	0.615
LED UV	0° gauze I	at 350 mA	SSC Viosys	UV CUN66A1B	0.274	0.099	0.000	0.373
LED UV	0° gauze II	at 350 mA	SSC Viosys	UV CUN66A1B	0.275	0.100	0.001	0.375
LED UV	30°	at 350 mA	SSC Viosys	UV CUN66A1B	0.526	0.011	0.002	0.539
LED UV	60°	at 350 mA	SSC Viosys	UV CUN66A1B	0.397	0.009	0.002	0.408
LED UV	0°	at 350 mA	Nishia	NCSU033B	0.446	0.004	0.000	0.450
LED UV	30°	at 350 mA	Nishia	NCSU033B	0.452	0.003	0.001	0.456
LED UV	60°	at 350 mA	Nishia	NCSU033B	0.218	0.002	0.000	0.220

Type	Remarks / angle	Wattage effective (W) at 350 mA	Brand	Nr	300–400 nm	401–650 nm	651–1000 nm	300–1000 nm
LED UV	90°	at 350 mA	Nishia	NCSU033B	0.000	0.000	0.000	0.000
LED UV	0° in gauze tower	at 350 mA	Nishia	NCSU033B	0.189	0.047	0.000	0.236
LED UV	0°	at 350 mA	Winger	WEPUV3-S2 Blacklight	0.137	0.252	0.001	0.391
LED UV	0° gauze I	at 350 mA	Winger	WEPUV3-S2 Blacklight	0.062	0.203	0.001	0.266
LED UV	0° gauze II	at 350 mA	Winger	WEPUV3-S2 Blacklight	0.064	0.213	0.001	0.278
LED UV	30°	at 350 mA	Winger	WEPUV3-S2 Blacklight	0.109	0.247	0.001	0.357
LED UV	60°	at 350 mA	Winger	WEPUV3-S2 Blacklight	0.096	0.225	0.001	0.322
LED UV	0°	at 350 mA	no brand		0.188	0.010	0.000	0.199
LED UV	30°	at 350 mA	no brand		0.160	0.009	0.000	0.169
LED UV	60°	at 350 mA	no brand		0.093	0.006	0.000	0.100
LED UV	90°	at 350 mA	no brand		0.002	0.000	0.000	0.003
LED Turquoise	0°	at 350 mA	Bridgelux	Turquoise	0.000	0.237	0.000	0.238
LED Turquoise	30°	at 350 mA	Bridgelux	Turquoise	0.001	0.214	0.000	0.215
LED Turquoise	60°	at 350 mA	Bridgelux	Turquoise	0.000	0.249	0.000	0.250
LED Turquoise	90°	at 350 mA	Bridgelux	Turquoise	0.000	0.029	0.000	0.029
LED Blue	0°	at 350 mA	Cree	XP-E2 Royal Blue	0.003	0.665	0.002	0.670
LED Blue	30°	at 350 mA	Cree	XP-E2 Royal Blue	0.002	0.555	0.003	0.560
LED Blue	60°	at 350 mA	Cree	XP-E2 Royal Blue	0.001	0.447	0.002	0.451
LED Blue	0°	at 350 mA	Bridgelux	Royal Blue	0.003	0.502	0.002	0.507
LED Blue	30°	at 350 mA	Bridgelux	Royal Blue	0.004	0.611	0.002	0.617
LED Blue	60°	at 350 mA	Bridgelux	Royal Blue	0.003	0.556	0.002	0.560
LED Blue	90°	at 350 mA	Bridgelux	Royal Blue	0.000	0.099	0.001	0.101
LED Blue	0° in gauze tower	at 350 mA	Bridgelux	Royal Blue	0.002	0.404	0.000	0.407
LED Blue	0°	at 350 mA	Winger	WEPRB3-S1 Royal Blue	0.002	0.483	0.002	0.487
LED Blue	0° gauze I	at 350 mA	Winger	WEPRB3-S1 Royal Blue	0.002	0.366	0.002	0.371
LED Blue	0° gauze II	at 350 mA	Winger	WEPRB3-S1 Royal Blue	0.001	0.364	0.003	0.368
LED Blue	30°	at 350 mA	Winger	WEPRB3-S1 Royal Blue	0.002	0.408	0.001	0.411

Type	Remarks / angle	Wattage effective (W) at 350 mA	Brand	Nr	300–400 nm	401–650 nm	651–1000 nm	300–1000 nm
LED Blue	60°	at 350 mA	Winger	WEPRB3-S1 Royal Blue	0.000	0.013	0.001	0.014
LED Green	0°	at 350 mA	Cree	XP-E2 Green	0.000	0.228	0.003	0.231
LED Green	30°	at 350 mA	Cree	XP-E2 Green	0.000	0.222	0.002	0.225
LED Green	60°	at 350 mA	Cree	XP-E2 Green	0.000	0.166	0.002	0.169
LED Green	0°	at 350 mA	Bridgelux	Emerald Green	0.000	0.213	0.001	0.214
LED Green	30°	at 350 mA	Bridgelux	Emerald Green	0.000	0.216	0.001	0.217
LED Green	60°	at 350 mA	Bridgelux	Emerald Green	0.000	0.202	0.000	0.202
LED Green	90°	at 350 mA	Bridgelux	Emerald Green	0.000	0.030	0.000	0.031
LED Green	0° in gauze tower	at 350 mA	Bridgelux	Emerald Green	0.000	0.230	0.001	0.231
LED Green	0°	at 350 mA	Winger	WEPGN3-S1 Green	0.000	0.236	0.001	0.237
LED Green	0° gauze I	at 350 mA	Winger	WEPGN3-S1 Green	0.000	0.167	0.001	0.167
LED Green	0° gauze II	at 350 mA	Winger	WEPGN3-S1 Green	0.000	0.168	0.001	0.169
LED Green	30°	at 350 mA	Winger	WEPGN3-S1 Green	0.000	0.236	0.000	0.237
LED Green	60°	at 350 mA	Winger	WEPGN3-S1 Green	0.000	0.213	0.000	0.214
LED Cool White	0°	at 350 mA	Cree	XP-L V6 Cool White	0.001	0.647	0.051	0.699
LED Cool White	0° gauze I	at 350 mA	Cree	XP-L V6 Cool White	0.001	0.417	0.036	0.453
LED Cool White	30°	at 350 mA	Cree	XP-L V6 Cool White	0.001	0.532	0.045	0.578
LED Cool White	60°	at 350 mA	Cree	XP-L V6 Cool White	0.001	0.359	0.034	0.394
LED Cool White	0°	at 350 mA	Bridgelux	Cool White	0.001	0.482	0.034	0.518
LED Cool White	30°	at 350 mA	Bridgelux	Cool White	0.001	0.399	0.030	0.429
LED Cool White	60°	at 350 mA	Bridgelux	Cool White	0.000	0.312	0.025	0.338
LED Cool White	90°	at 350 mA	Bridgelux	Cool White	0.000	0.014	0.001	0.015
LED Cool White	0° in gauze tower	at 350 mA	Bridgelux	Cool White	0.001	0.348	0.027	0.375
LED Cool White	0°	at 350 mA	Winger	WPCW3-S1 Cool White	0.001	0.314	0.015	0.331
LED Cool White	0° gauze I	at 350 mA	Winger	WPCW3-S1 Cool White	0.000	0.225	0.012	0.237
LED Cool White	0° gauze II	at 350 mA	Winger	WPCW3-S1 Cool White	0.001	0.237	0.012	0.250
LED Cool White	30°	at 350 mA	Winger	WPCW3-S1 Cool White	0.001	0.274	0.014	0.289
LED Cool White	60°	at 350 mA	Winger	WPCW3-S1 Cool White	0.001	0.182	0.010	0.193

A new species of *Platyptilia* Hübner, 1825 (Lepidoptera, Pterophoridae) from Europe

JARI JUNNILAINEN¹, JARI-PEKKA KAITILA²

1 *Mahlapolku 3 01730 Vantaa, Finland; junnilainen.jari@gmail.com*

2 *Kannuskuja 8 D 37 01200 Vantaa, Finland; jari.kaitila@perhostutkijainseura.fi*

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Abstract. *Platyptilia galicicaensis* sp. n. (Pterophoridae) is described. The species is found in the Republic of Macedonia, Ohrid, Galičica National Park. All specimens were collected around *Helichrysum zivojini* Černjavski & Soska, 1940 or *H. stoechas* (L.) Moench, 1794 (Asteraceae); one or both of these plants is probably the host plant of the new species.

Introduction

At the end of June 2014 we made an entomological expedition to Galičica National Park, Republic of Macedonia, mainly to investigate the microlepidoptera. In the first days of field work we observed a *Platyptilia* species (Pterophoridae) in large numbers around plants of *Helichrysum* Mill. (Asteraceae). As larvae of another species of *Platyptilia*, *P. tesseradactyla* (L., 1761), have also been recorded from *Helichrysum* (Hofmann 1896; Hannemann 1977) although they feed on *Antennaria dioica* (L.) (also Asteraceae) (Gartner 1862; Hofmann 1896; Huggins 1939; Beirne 1954; Gozmány 1962; Hannemann 1977; Buzsko 1986) in Scandinavian and Baltic countries, including Sweden, the type locality of *P. tesseradactyla* (Gielis 2003), and Finland, where the first author has reared *P. tesseradactyla* from *Antennaria dioica*, we wondered whether the specimens we observed belonged to this species. However, the Macedonian specimens externally resembled *P. gonodactyla* (Denis & Schiffermüller, 1775) or *P. calodactyla* (Denis & Schiffermüller, 1775) rather than *P. tesseradactyla*. As we were unable to find the known host plants of *P. gonodactyla* (*Tussilago* L., Asteraceae) and *P. calodactyla* (*Solidago* L., Asteraceae) in the locality where the unidentified *Platyptilia* species occurred, we decided to collect some specimens in order to clarify the species' status.

The genus *Platyptilia* Hübner, 1825 contains seven known species in Europe: *P. tesseradactyla*, *P. farfarellus* Zeller, 1867, *P. nemoralis* Zeller, 1841, *P. gonodactyla*, *P. calodactyla*, *P. iberica* Rebel, 1935 and *P. isodactylus* (Zeller, 1852). Here a new species, *P. galicicaensis* sp. n., is described. The new species is closest in appearance to *P. gonodactyla* and *P. calodactyla*. Both of these species have several junior synonyms. These were investigated and type specimens were examined by Arenberger (1988); the neotypes are in the Natural History Museum, Vienna (NHMW). In addition to the seven species that occur in Europe, the type specimens of *P. chondrodactyla* Caradja, 1920 and *P. kozanica* Fazekas, 2003 were also examined.

The genus *Platyptilia* is distributed in the Holarctic, Neotropical, Afrotropical and Indo-Australian Regions. Larvae of *Platyptilia* are Asteraceae feeders (Hofmann 1896; Barnes and Lindsey 1921;

Schwarz 1953; Gielis 1996). The new species exhibits typical characters of *Platyptilia* as given in the diagnosis of the genus (Gielis 1996) such as the well-developed costal triangular spot on the forewing, forewing vein R1 present, and the third lobe of the hindwing with a centrally placed scale-tooth. The new species was recorded for the first time at the end of June 2014 and again at about the same time in 2015 in Galičica National Park, near the town of Ohrid, Republic of Macedonia. Specimens were netted around *Helichrysum* plants at 1450 m a.s.l. in the evening just before sunset.

Material and methods

The species examined for comparative purposes are *Platyptilia chondrodactyla*: 1 ♂, Lectotype, 1 ♀, Allotype, both in coll. “Courtesy, the “Grigore Antipa” National Museum of Natural History”, Bucharest, Romania; *Platyptilia kozanica*: 1 ♀, Holotype; *Platyptilia gonodactyla*: 19 ♂, 10 ♀, in coll. J. Junnilainen; *Platyptilia calodactyla*: 24 ♂, 15 ♀, in coll. J. Junnilainen; *Platyptilia tessera-dactyla*: 19 ♂, 11 ♀, in coll. J. Junnilainen; *Platyptilia farfarellus* 2 ♂, in coll. J. Junnilainen; *Platyptilia nemoralis* 1 ♂, 1 ♀, in coll. J. Junnilainen; *Platyptilia isodactyla* 2 ♂, 2 ♀, in coll. J. Junnilainen.

All specimens of *P. galicicaensis* sp. n. were captured with nets late in the evening just before darkness when specimens were active around *Helichrysum* vegetation. Specimens were stored alive in glass vials and later killed in a freezer and then immediately spread. Later, dry specimens were labelled with the exact collecting data. Then the genitalia were dissected and first preserved in glycerol. After determination and comparative work under an Olympus VMZ 20–80X microscope, the genitalia were mounted on glass slides with euparal following the procedure of Robinson (1976). Later, dry genitalia slides were photographed with a Leica DM1000 microscope and an integrated Leica DF295 digital camera. Original images were cleaned and edited with Adobe Photoshop v. 11.0. The camera system used for images of the adult was a Nikon D800 with a Micro Nikkor 105 mm 1:2.8 D objective and three flash heads. The camera was moved between shots with a Cognisys Stackshot focussing rail. Zerene Stacker v. 1.04 and Adobe Lightroom 6.6 were used for processing the photos; 36 shots were combined in each photo stack.

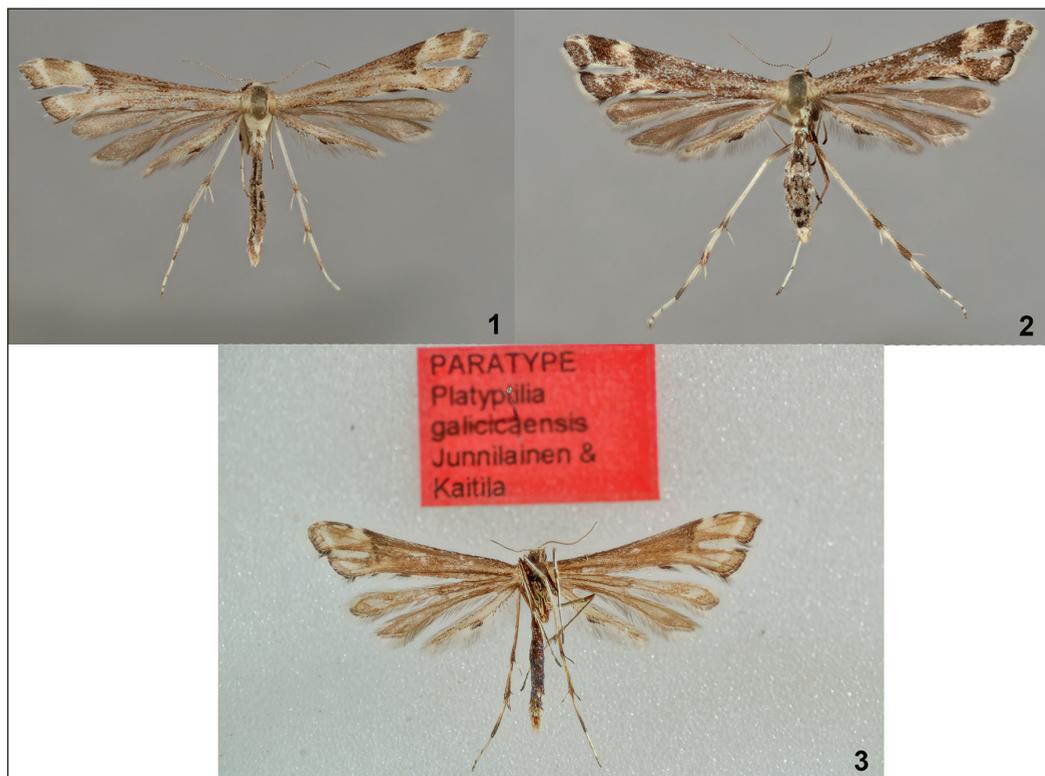
For the DNA analyses, one leg was removed from a dried specimen and moved to a lysis plate with 100% ethanol. A sample identification number MM24208 was given to the specimen. The sample was sent in a lysis plate to the Canadian Centre for DNA barcoding, Ontario, Canada, through the Finnish Barcode of Life campaign. DNA extraction, amplification, and sequencing of the barcode region of the mitochondrial cytochrome oxidase I (COI) gene (658 base pairs) were carried out successfully following protocols by deWaard et al. (2008). The specimen’s taxonomic and collection data, voucher image, COI sequence and GenBank accession number are available in the BOLD database (<http://www.barcodinglife.org/>) through the public dataset DS-PLATYUPEU.

Taxonomy

Platyptilia galicicaensis sp. n.

<http://zoobank.org/899F28A1-0FD6-4CCA-892E-7A597009B9F4>

Type material. Holotype: ♂, Macedonia, Ohrid, Galičica National Park, Old Ski Center Oteshevo 1450 m a.s.l., 40.980°N; 20.860°E, 26.vi.2014. J. Junnilainen leg. & coll. with red label “HOLOTYPE of *Platyptilia galicicaensis* Junnilainen & Kaitila”. - Paratypes 16 ♂, 7 ♀: 1 ♂, 3 ♀ same locality and data as holotype, 1 ♀

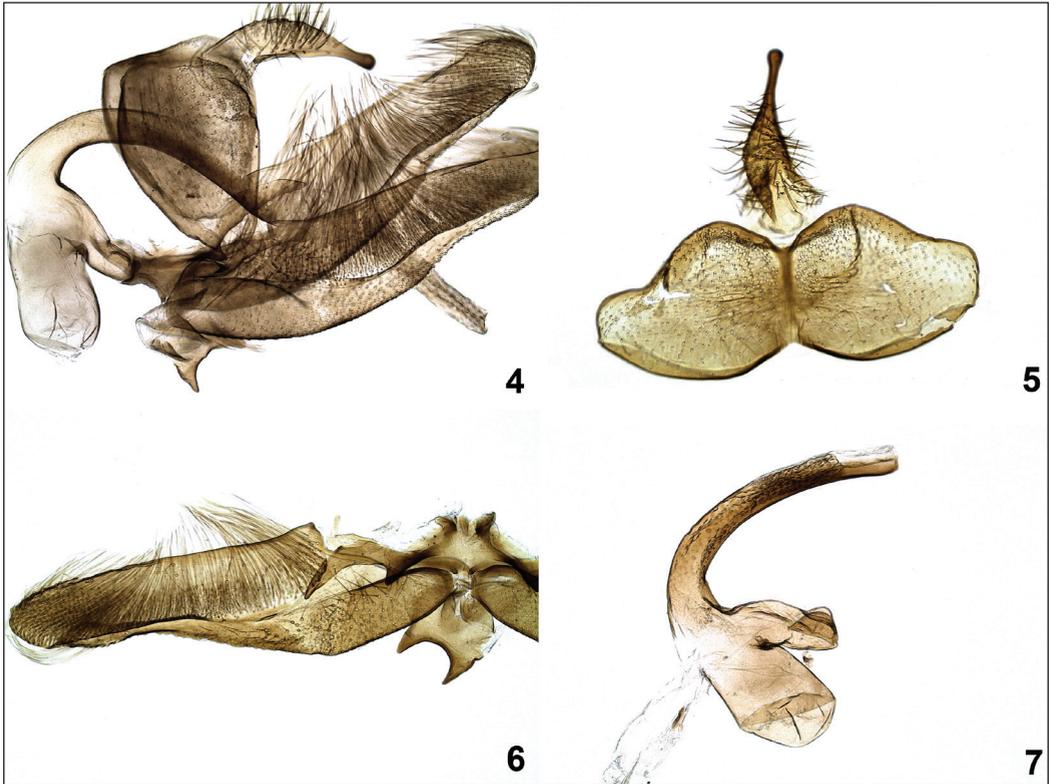


Figures 1–3. *Platyptilia galicicaensis* sp. n.: 1. male holotype; 2. female, paratype; 3. male, paratype, underside.

with label Gen. Prep. No: GPJJ201604 and 1 ♀ with green label DNA sample 24208 Lepid. phyl. and Gen. Prep. No: GPJJ201705; 8 ♂, 3 ♀ same locality as holotype but dates 3 ♂ 24.vi.2014, 2 ♂ genitalia preserved in glycerol; 1 ♂ 25.vi.2014 with label Gen. Prep. No: GPJJ201607; 2 ♀ 28.vi.2014; 3 ♂, 1 ♀ 14.vi.2015, 1 ♂ with label Gen. Prep. No: GPJJ201602; 2 ♂ 15.vi.2015; same data as holotype 4 ♂ except J-P. Kaitila leg. & coll.; same data except dates 1 ♂ 24.vi.2014 and 1 ♂, 1 ♀ 25.vi.2014. All paratypes with red labels “PARATYPE of *Platyptilia galicicaensis* Junnilainen & Kaitila”.

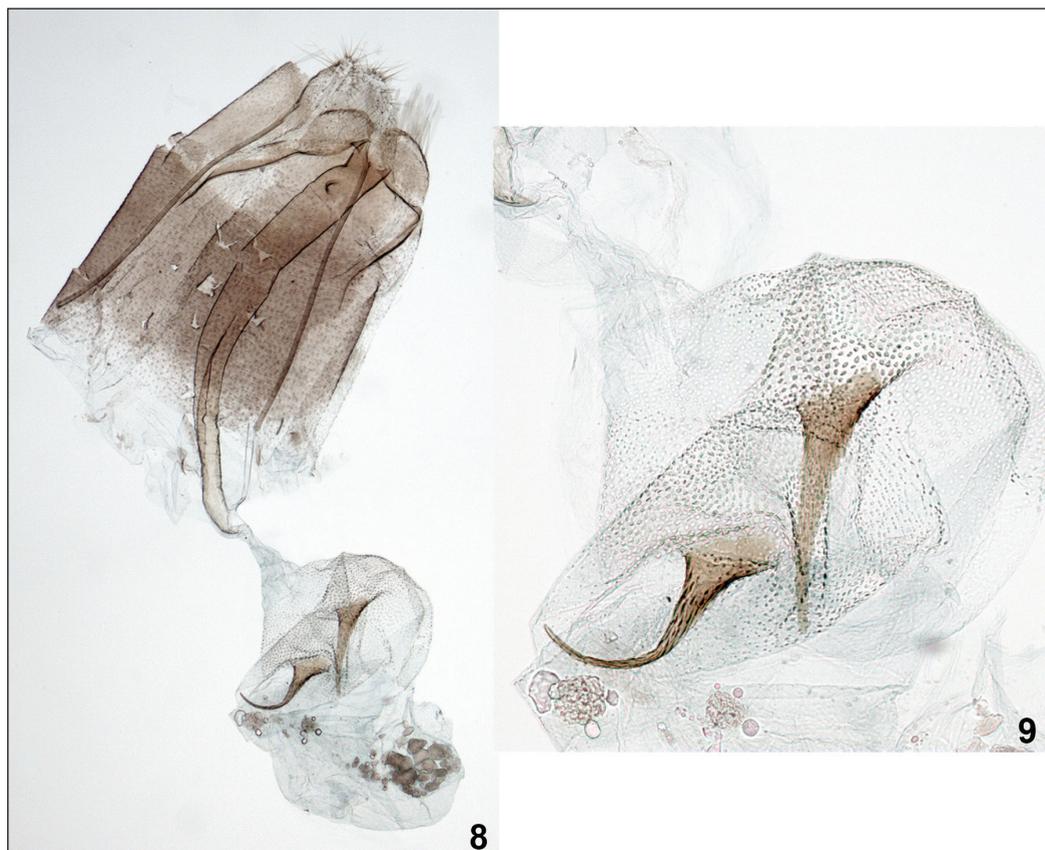
Deposition of types. The holotype of *Platyptilia galicicaensis* sp. n. is deposited in the private collection of J. Junnilainen. All paratypes of *P. galicicaensis* sp. n. are deposited in the private collections of J. Junnilainen & J-P. Kaitila. The type specimens can be borrowed by request through the Finnish Museum of Natural History, University of Helsinki or directly from the authors.

Description. Adult (Figs 1–3). Based on the holotype ♂ and 23 paratypes (16 ♂ and 7 ♀). Wingspan 19.5–25.5 mm. Labial palpus porrect, apex slightly turned down, twice as long as diameter of eye, covered with white, brown-tipped scales. Antenna relatively short, less than half length of forewing, slightly ciliate along its length, upper surface mottled with white and brown groups of scales, lower surface unicolorous pale brown, upper surface of scape and pedicel covered with scales of various colours, usually white or pale brown but sometimes even entirely brown, lower surface of scape and pedicel consistently more whitish. Head, thorax and tegula covered with white, brown-tipped scales, frons pure white. Ground colour of forewing ochreous-white mixed with grey scales,



Figures 4–7. *Platyptilia galicicaensis* sp. n., male genitalia: **4.** male genitalia, lateral view (GPJJ201607); **5.** unrolled tegumen with uncus; **6.** valva with saccus and anellus; **7.** phallus.

costa dark brown, female clearly darker than male. Base of cleft of forewing lobe almost reaching well-developed dark brown costal triangular spot. Pre-apical transverse white line distinct on both lobes. Termen of 1st lobe blunt, apex somewhat rounded; 2nd lobe with dark brown costal and dorsal spots connected to dark brown termen. Fringe white, with slightly fuscous at apex and termen of both forewing lobes; dorsum with three dark brown scale-teeth, 1st at 2/3 from base, 2nd below base of cleft and 3rd close to termen. Underside of forewing fuscous with sparse white scales along costa and both lobes mainly ochreous medially, ochreous colour reaching costa on 1st lobe at base of cleft, ochreous area on 2nd lobe divided by fuscous scales along Cu1 vein. Triangular costal spot, pre-apical costal spot, termen and two scale-teeth on dorsal margin dark brown. Hindwing fuscous, 3rd lobe with dark brown dorsomedial scale-tooth and row of dark brown scales in basal half. Fringe on 1st and 2nd lobes with two types of scales, shorter and fuscous scales cover basal half of fringe, long and whitish hair-scales cover distal half of fringe, fringe in 3rd lobe fuscous. Underside of hindwing fuscous except 1st lobe pre-apically ochreous and 3rd lobe distinctly paler with dark brown scales along both margins, dorsomedial scale-tooth dark brown. Fringe of hindwing lobes dorsally fuscous. Abdomen speckled with white and brown scales. Legs ochreous-white. Femur and tibia of foreleg brown, inner surface of midleg brown. Hindleg ringed brown around tibial spurs, distal half of 1st tarsomere fuscous, tarsomeres 2–4 fuscous distally, 5th tarsomere brown.



Figures 8–9. *Platyptilia galicicaensis* sp. n.: **8.** female genitalia (GPJJ201604); **9.** corpus bursae with a pair of signa.

Male genitalia (Figs 4–7). Five specimens examined. Uncus skittle broad basally with numerous setae, narrowing distally, with rounded apex, slightly curved towards valva. Tegumen a broad subov-al plate, anterior margin with broad obtusely V-shaped cleft with both sides rounded, lateral margins rounded, posterior margin with broad medial cleft, both sides medially concave. Valva symmetrical, parallel-sided, 4× longer than wide, with numerous, long setae, apex rounded. Sacculus extending nearly to apex of valva, basal third broad, parallel-sided, medial third tapering to narrow apical third. Saccus a broad quadrangular plate, anterior margin broadly U-shaped. Anellus arms relatively stout and strongly sclerotized, strong lateral projection 1/3 from base, apical half gradually tapered to digitate apex. Phallus strongly curved throughout its length, basally inflated with sub-basal process, distal part tube-like slightly tapered towards blunt apex, large group of spinule-like cornuti in vesica.

Female genitalia (Figs 8–9). Two specimens examined. Papillae anales oval, with few setae. Apophyses posteriores 2× longer than 8th tergite. Apophyses anteriores short, broadening basally. 8th sternite consisting of pair of oval plates just posteriad of ostium bursae. Ostium bursae cup-shaped. Antrum tubular, sclerotized part 8× longer than membranous part of ductus bursae, posterior half almost parallel-sided, anterior half slightly tapering towards bursa. Membranous part of ductus bursae posteriorly narrow then widening towards corpus bursae. Corpus bursae roundish



Figure 10. Habitat of *Platyptilia galicicaensis* sp. n. Macedonia, Galičica National Park.

with pair of hook-shaped signa. Signa basally wide, basal half strongly narrowing toward spinous and strongly curved distal half. Area surrounding signa base spiculate.

Variation. Females are overall much darker than males.

Diagnosis. Externally the new species differs from the most similar looking species in having a narrower, brownish forewing and the apex of the 1st lobe is more rounded. Also, transverse line near the forewing apex is white and more distinct. The most similar looking species, *P. gonodactyla* and *calodactyla*, have broader forewings and a sharper apex to the 1st lobe. The ground colour of *P. gonodactyla* is more greyish while that of *P. calodactyla* is paler yellowish with more reddish brown markings. The transverse line near the forewing apex is more yellowish in both those species. The male genitalia of the new species differ from those of its relatives in having a more parallel-sided valva, the tegumen having the posterior margin medially concave, the broader



Figure 11. *Helichrysum* vegetation in Galičica National Park.

and quadrangular saccus, the spine on the anellus arm located closer to the base, at 1/3 from base. The female genitalia differ in having a more cup-shaped ostium bursae, the sclerotized part of the antrum is $8\times$ the length of the membranous part of the ductus bursae compared with $7\times$ in *P. gonodactyla* and $6\times$ in *P. calodactyla*. Also, the signa are more curved and narrowly hook-shaped than in its nearest relatives which have broader, straighter, and more horn-shaped signa.

Distribution. Only known from the type locality, Galičica National Park, Ohrid, Republic of Macedonia.

Biology (Figs 10–11). Unknown, although it is expected that at least one or both *Helichrysum* species, *H. zivojini* and *H. stoechas*, which grow at the type locality are host plants of *P. galicicaensis* because the type series was captured near those plants.

Etymology. The name of the new species is dedicated to the famous Galičica National Park.

Discussion

Although the genus *Platyptilia* has a Holarctic distribution, we were unable to find any valid name for this new species. We are also aware that both *P. gonodactyla* and *P. calodactyla* have several junior synonyms available but none of these was described from the Balkan region or its eastern neighbouring regions where the new species might also occur. Neotypes were selected for both *P. gonodactyla* and *P. calodactyla* by Arenberger (1988), who illustrated the genitalia of both sexes. There is also one *Platyptilia* species quite recently described from central Turkey by Fazekas (2003), *Platyptilia kozanica*, but it clearly differs from our new species in having the triangular costal spot divided into two parts and in the female genitalia the antrum is much shorter, about 6× the length of the membranous part of the ductus bursae. We were also able to examine the lectotype and allotype of another species described from Turkey, *P. chondrodactyla*. It is a rather large species with a wingspan of 31 mm and almost unicolorous ochreous-brown without any distinct markings on the forewing, and the hindwings are ochreous coloured.

We sequenced the DNA barcode region of the new species to reduce the risk of creating a new synonym for an existing species. The DNA barcode sequence (sample ID MM24208) in BOLD (www.barcodinglife.org) shows a clear difference from all other species of *Platyptilia* and constitutes a unique BIN (BOLD: ACW2728). The nearest species is *Platyptilia johnstoni* Lange, 1940, a North American species differing by a minimum K2P distance of 4.87%. The next closest are *Platyptilia gonodactyla* with 5.12%, *P. calodactyla* with 5.84%, *P. nemoralis* with 6.14%, and *P. tesseraedactyla* with 6.83%. At the moment 29 species of *Platyptilia* have barcode data in BOLD, some of which are likely to be undescribed with an interim OTU name. Usually *Platyptilia* species have no or little intraspecific variation in barcodes, even when samples selected are geographically far from each other. For example, in all barcoded *P. gonodactyla*, including over 40 specimens, variation is less than 0.5% in BOLD. Because the barcode differences are so large between the new species and its nearest neighbours, it is clear that our new *Platyptilia* species has not been previously barcoded, not even amongst the several barcoded but un-named *Platyptilia* species.

The two *Helichrysum* species around which specimens of *Platyptilia galicicaensis* were flying, *H. zivojini* and *H. stoechas* grow in close association. Therefore it is difficult to determine which plant species is the actual host plant or whether both are used. Further studies are needed to confirm the host plant and describe the immature stages. Usually the ideal time to obtain larvae and pupae of *Platyptilia* is in late spring or early summer just before or after pupation when feeding signs of larvae are still visible on the host plant.

Galičica is a mountain situated along the border between the Republic of Macedonia and Albania. There is a National Park on the Macedonian side of the mountain, situated between the two largest lakes in the Republic, Lake Ohrid and Lake Prespa. It stretches over an area of 227 square kilometres (88 mi²). Galičica National Park is characterized by a high incidence of relict and endemic plants. One of these is *Helichrysum zivojini*, one of the possible host plants of *P. galicicaensis*. There are also some lepidopterological traditions in Galičica National Park, for example the famous Austrian entomologist Dr. Josef Wilhelm Klimesch spent summers in the town of Ohrid in the middle of the last century and collected numerous Lepidoptera in the Galičica Mountain Range. Later several other entomologists and specialists in Microlepidoptera and Macrolepidoptera also visited the area and several new species of Lepidoptera were described based on material collected from there. Recently the Park has become an SEL (Societas Europaea Lepidopterologica) study area.

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Description of the female of *Eulamprotes gemerensis* Elsner, 2013 (Lepidoptera, Gelechiidae)

ZDENKO TOKÁR¹

¹ P. J. Šafárika II, SK–92700 Šaľa, Slovakia: zdeno.tokar@gmail.com

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Abstract. The female of *Eulamprotes gemerensis* Elsner, 2013 is described and illustrated with colour photographs of the adult, exuviae, as well as the figures of female genitalia, tree of COI barcodes, its habitat and distribution map. The female was reared from a pupa found in moss on a stone in the Slovak Paradise National Park in Eastern Slovakia. The species is sexually dimorphic, with female having a reduced hindwing.

Introduction

Eulamprotes gemerensis Elsner, 2013 was described by Elsner (in Huemer et al. 2013) from material collected in the Muránska Planina National Park and the Slovak Karst National Park in Central and Eastern Slovakia. The description was based only on males. *E. gemerensis* belongs to gelechiids of the *Eulamprotes wilkella* (Linnaeus, 1758) group with whitish and or silvery or golden forewing markings according to a revision of the Palearctic species of the group (Huemer et al. 2013). Until now, the female was unknown.

In early May 2016, I carried out a faunistic study in the Slovak Paradise National Park in Eastern Slovakia, near the village of Vernár, searching for larvae of some psychids on rocks. In addition to cases of *Brevantennia ilonae* Weidlich, 2014, *Eosolenobia mannii* (Zeller, 1852) (Psychidae), and *Coleophora nubivagella* Zeller, 1849 (Coleophoridae), I gathered a few pieces of moss from the rocks. Surprisingly, a month later, one gelechiid female with reduced hindwings emerged from the moss material. I established that it represented the unknown female of *E. gemerensis*, which is here described and compared with other closely related females of the group.

Abbreviations

Gp	genitalia preparation
NNR	National nature reserve
NP	National park
TLMF	Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria
ZT	Zdenko Tokár

Taxonomy

Eulamprotes gemerensis Elsner, 2013

Material. ♀, NP Slovenský Raj (Slovak Paradise), Vernár 1 km SE, 760 m, 48°93.22'N; 20°28.59'E, pupa 6.v.2016, ex pupa 2.vi.2016, Gp ZT 12877, Z. Tokár leg., det. & coll.

Description of female. Adult (Fig. 1). Wingspan 9.5 mm. Second segment of labial palpus black with yellowish grey apical area. Third segment of equal length to the second, yellowish grey dorsally and black ventrally. Basal half of antenna black, apical part greyish white with first four segments of this part ringed black. Head, thorax and tegulae black. Frons light, bright yellow. Forewing narrower than in male, lanceolate, black with silvery white shiny markings. Oblique costal spot from 1/6 of forewing reaching fold; broken fascia in a form of several separate spots, from middle of costa to two-thirds towards dorsum; pre-apical costal spot angled towards termen; tornal spot in 5/6 of dorsum; termen with several silvery white scales of different sizes. Cilia black to blackish grey, whitish grey at tip of apex. Hindwing grey, lanceolate, reduced as compared to that of male, about three-quarters the length of forewing and at base one-third as broad as forewing, tapering to pointed apex. Abdomen distinctly larger than in male, dark brownish black; posterior part of each segment with silvery white scales.

Female genitalia (Fig. 2). Apophysis posterioris about 1.2 times as long as apophysis anterioris, both pairs slender, rod-shaped. Segment VIII with sclerotized posterolateral part, otherwise membranous. Ostium bursae without obvious sclerotized folds. Ductus bursae long and slender, about 3 times longer than apophysis anterioris. Oblong sclerite in posterior half of ductus bursae beyond tip of apophysis anterioris. Membranous part of ductus bursae about 1.6 times as long as sclerotized part, gradually expanded towards corpus bursae. Corpus bursae suboval, slightly longer than segment VIII. Signum a large subrectangular plate, posterior margin with two short spines, anterior margin with two spines, one short and one longer.

Diagnosis. A diagnostic comparison between the female of *E. gemerensis* and other females of the *E. wilkella*-group cannot be complete because females are currently known for only seven of the twelve Palaearctic species of this group (Huemer et al. 2013). The female of *E. gemerensis* has reduced hindwings that are three-quarters of the length of the forewing, whereas the females of *E. wilkella*, *E. ochricapilla* (Rebel, 1903) and *E. superbella* (Zeller, 1839) have almost normal hindwings. According to Huemer et al. (2013), however, hindwings of the female of *E. libertinella* (Zeller, 1872) are very short, no longer than the breadth of the forewings. Hindwings of females of *E. mirusella* Huemer & Karsholt, 2013 and *E. occidentella* Huemer & Karsholt, 2011 are both shorter than those of *E. gemerensis*, about two-thirds of the length of their forewings. Externally *E. gemerensis* also differs from those of the aforementioned species by having head, thorax, and tegulae black, and frons light bright-yellow. The female genitalia of *E. gemerensis* differ from those of other known females in the long membranous part of the ductus bursae, which is about 1.6 times as long as the sclerotized part.

Molecular data (Fig. 3). Legs of the female of *E. gemerensis* were sent for DNA analysis (sample TLMF Lep 20508). The sequenced COI barcode region from this specimen was compared with those of three males of the species. The other sequences are from BOLD (Barcode of Life Database; Ratnasingham and Hebert 2007). A tree was made using neighbour-joining (Kimura 2 parameter). It was confirmed that the female belongs to this species.



Figure 1. *Eulamprotes gemerensis*, female.

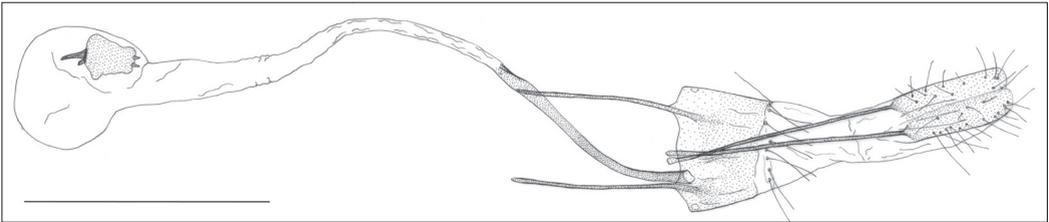


Figure 2. *Eulamprotes gemerensis*, ♀ genitalia, Gp ZT 12877. Scale bar 1.0 mm.

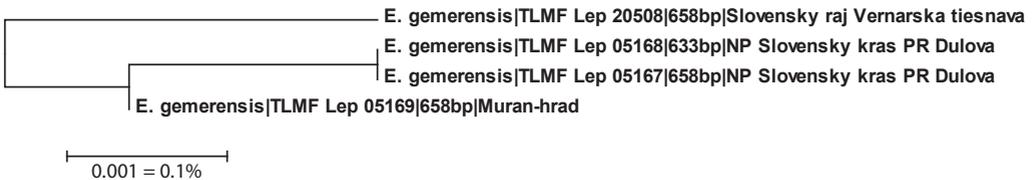


Figure 3. A neighbour-joining tree of four barcoded specimens of *Eulamprotes gemerensis* with a scale bar showing genetic distance between sequences.

Distribution (Fig. 6). Hitherto *Eulamprotes gemerensis* has been known from the Slovak region of Gemer, the Muránska Planina NP, and the Slovak Karst NP. The female was found in another Slovak national park, the Slovak Paradise NP, near the Vernárska Tiesňava NNR at an altitude of about 760 m. During 2016, a local population of the species was observed in the same NP eastwards, near the Ihrík Ridge (Endel, pers. comm.).

Biology. The female specimen was reared from a pupa found in moss growing on a stone in early May (Figs 4, 5). According to Huemer et al. (2013), the available data point towards moss



Figures 4–5. 4. The place where the pupa of *Eulamprotes gemerensis* was obtained. 5. Remains of exuviae in the moss.

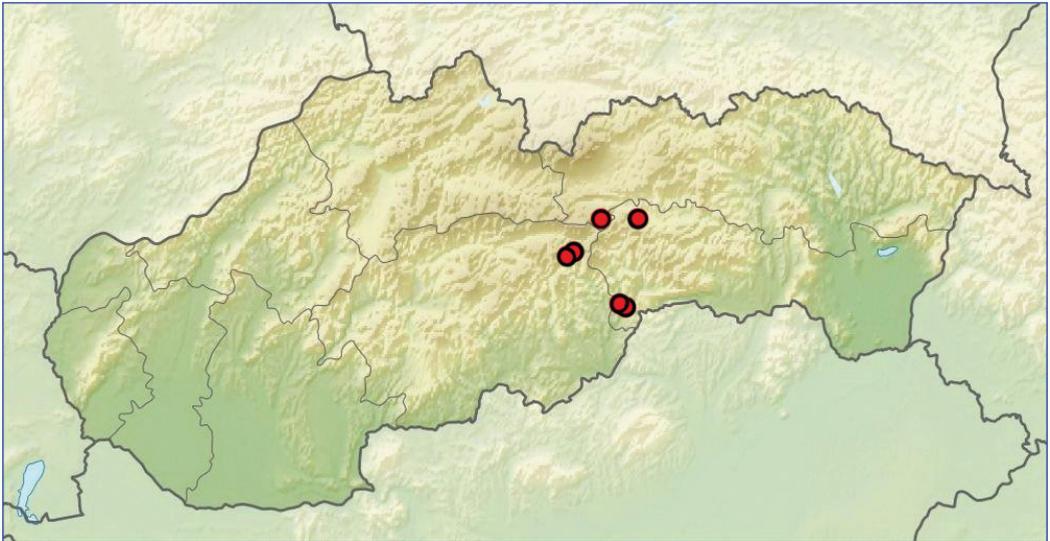


Figure 6. Map of distribution of *Eulamprotes gemerensis* in Slovakia.

being the primary food substrate of species in the *E. wilkella*-group. *Eulamprotes gemerensis* occurs on xerothermic limestone slopes and the flight period is between late May and early August. Male adults are attracted to light but can be also found flying over vegetation near rocks during early daylight hours. All records known to date are from the Slovak karst areas, from altitudes of about 500 to 1050 m.

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***Bankesia desplatsella* Nel, 1999 (Lepidoptera, Psychidae): a species new to the Italian fauna**

STEFANO SCALERCIO¹, EDGARDO BERTACCINI²

1 *Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA), Unità di Ricerca per la Selvicoltura in Ambiente Mediterraneo, Rende (CS), Italy; stefano.scalercio@crea.gov.it*

2 *Via del Canale 24, 47010 Roncadello (FC), Italy*

<http://zoobank.org/02CDE23F-0662-4CCA-949D-A693F7D22282>

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Abstract. *Bankesia desplatsella* Nel, 1999, is recorded here as new to the Italian fauna from specimens collected in the Calabria and Abruzzi regions. We provide the first description of the larval case, putatively belonging to this species, add details to our knowledge of the species' ecology, and analyse DNA barcodes of specimens from central and southern Italy. The female remains unknown.

Introduction

Four species of the genus *Bankesia* Tutt, 1899 (Psychidae, Taleporiinae) are distributed in the West Palaearctic (Sobczyk 2011). Three of them are known from Europe: *B. montanella* Walsingham, 1899 from Corsica, France; *B. desplatsella* Nel, 1999, from Bouches-du Rhône, France; and *B. conspurcatella* (Zeller, 1850) occurring in Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Spain, and the United Kingdom (Sobczyk 2011). Only *B. conspurcatella* has been reported in literature from Italy. It was described from Tuscany and has also been recorded from Piedmont, Liguria, Veneto, Emilia, Romagna, Abruzzi, Campania, Molise, Puglia, Basilicata, Calabria, and Sicily (Bertaccini 2010; Weidlich 2015). The males of this species fly early in the morning from late January to early May (Scalercio 2009; Bertaccini 2010; Weidlich 2015).

On 12 September 2013, a male specimen, initially attributed to *T. defoliella* Constant, 1896, which is known to fly at this time of the year, was collected in the Sila National Park, Calabria, Italy. After comparison with *T. defoliella* specimens deposited in the collection of the Unità di Ricerca per la Selvicoltura in Ambiente Mediterraneo, Italy, it was evident that the specimen belonged to a different species.

The authors searched through their collections for other specimens belonging to this unidentified species. They found 14 males identical to the one collected in the Sila National Park misidentified within a series of *T. defoliella* deposited in the Bertaccini private collection and collected in Abruzzi, Italy. Very few Taleporiinae species fly in the autumn, these being: *T. defoliella*, *T. autumnella* (Rebel, 1919), *T. henderickxi* Arnscheid, 2016 and *B. desplatsella*. After a study of literature available to the authors on autumnal Taleporiinae species (Constant 1896; Rebel 1919; Nel 1999; Hattenschwiler and Scalercio 2003; Arnscheid 2016), and after the examination of the male

genitalia of *T. autumnella* deposited in the Museum Witt, München, Germany, we identified our specimens as belonging to *Bankesia desplatsella*, a species new to the Italian fauna and, until now, considered endemic to France as it has not been recorded from other localities since its description based on two males.

The attribution of this species to the genus *Bankesia* is uncertain. In fact, due to the morphology of the male genitalia and especially because of the ciliation of the male antenna reported also in the original description, this species probably belongs to the genus *Pseudobankesia* Meier, 1963 or *Taleporia* Hübner, 1825 (Arnscheid, pers. comm.). Nevertheless, in this paper we use the original designation and await further studies to resolve the generic placement.

The first Italian male of this species was collected by chance in Calabria in the morning of 12.ix. 2013 on a wall of a building in the Centro Visita del Cupone (39°23.10'N; 16°32.97'E) of the Sila National Park, Italy. This site is near an artificial lake at ca. 1170 m a.s.l., in a forest mainly composed of Calabrian black pines (*Pinus nigra calabrica* (Loud.) Cesca and Peruzzi, Pinaceae). In the following years, we searched for males, females, and larval cases around the same site but without success. This specimen is housed in the Lepidoptera collection of the Unità di Ricerca per la Selvicoltura in Ambiente Mediterraneo, Italy (CREA-SAM).

In the Abruzzo region, *B. desplatsella* was collected around Scanno, in the locality of Frattura, L'Aquila (41°55.69'N; 13°52.30'E). The site is located at ca. 1200 m a.s.l., on the southern slope of Mount Genzana. The xerothermophilous habitat is composed of pastures and shrubs, with small woods of *Quercus pubescens* Willd. (Fagaceae).

Methods

One specimen of *B. desplatsella* from Calabria and two from Abruzzi were submitted for DNA barcoding (carried out at Zoologische Staatssammlung München, Germany, following the standard protocol; Wilson 2012) in order to confirm their conspecificity and to measure the genetic distance between them. A 658 bp long sequence of the mtCOI gene was obtained (standard for discrimination of species of Lepidoptera, Hebert et al. 2003). The sequences are deposited in the online BOLD database (<http://www.boldsystems.org/>; Ratnasingham and Hebert 2007).

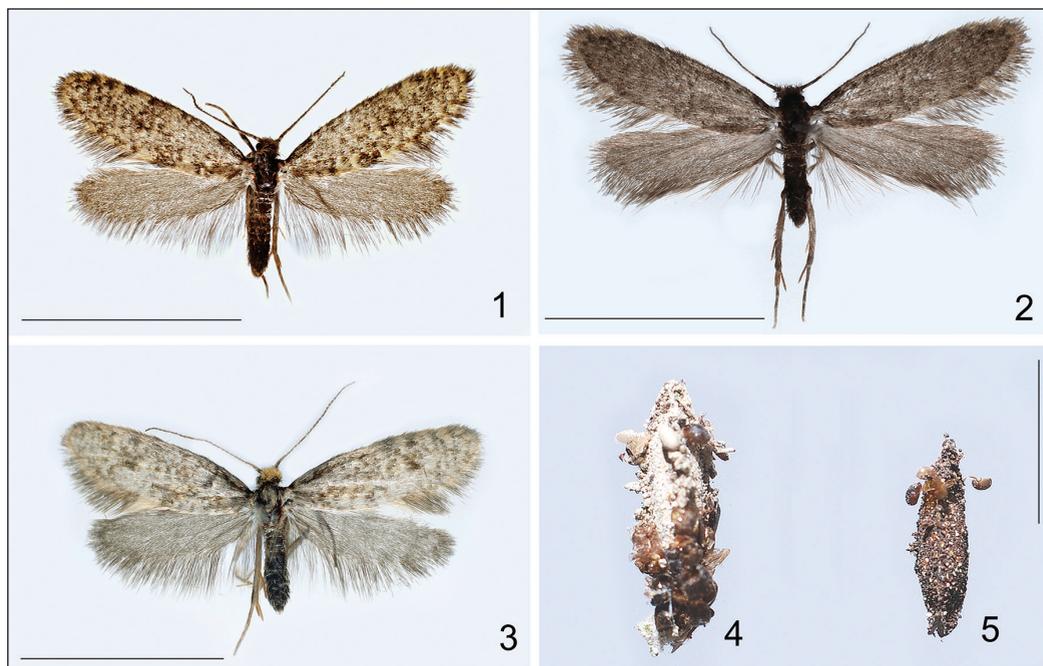
Material. The study was based on 15 males and 1 larval case, herein described for the first time.

Italy: 1 male, Calabria, Cupone, Spezzano della Sila (CS), 1170 m, 12.ix.2013, S. Scalercio leg., slide CREA-0030; 14 males, Abruzzo, Frattura di Scanno (AQ), 1200 m, 30.ix.2014, E. Bertaccini leg.; 1 larval case, Abruzzo, Frattura di Scanno (AQ), 1200 m, 27.ix.2015, E. Bertaccini leg.

Results

Diagnosis of males

As a result of the different phenology of other European *Bankesia* species, *B. desplatsella* can be confused only with *T. defoliella*, as also noted by Nel (1999). Diagnostic features are as follows (Figs 1–3, 6–11): 1) the background colour of the wings is grey in *B. desplatsella* and light-brown in *T. defoliella*, with some individuals of *B. desplatsella* being homogeneously dark-grey (Figs 1–3); 2) the wing shape is more rounded in *T. defoliella* (Figs 1–3); 3) the antennae of *B. desplatsella* are shorter than those of *T. defoliella* (Figs 1–3); 4) the male genitalia are distinct in



Figures 1–5. Comparison of males and larval cases of *Bankesia desplatsella* Nel, 1999 with similar species. **1.** *B. desplatsella*, Frattura di Scanno, Abruzzi. **2.** *B. desplatsella*, idem. **3.** *Taleporia defoliella* Constant 1896, Santa Sofia, Spinello, Romagna, ca. 900 m, 22.ix.2015. **4.** Larval case of *Bankesia conspurcatella*, Frattura di Scanno, Abruzzi. **5.** Candidate larval case of *Bankesia desplatsella*, idem. Scale bar 5 mm.

the shapes of the valvae, saccus and sacculus (Figs 6–9); and 5) the phallus of *B. desplatsella* is enlarged at the apex (Figs 10–11).

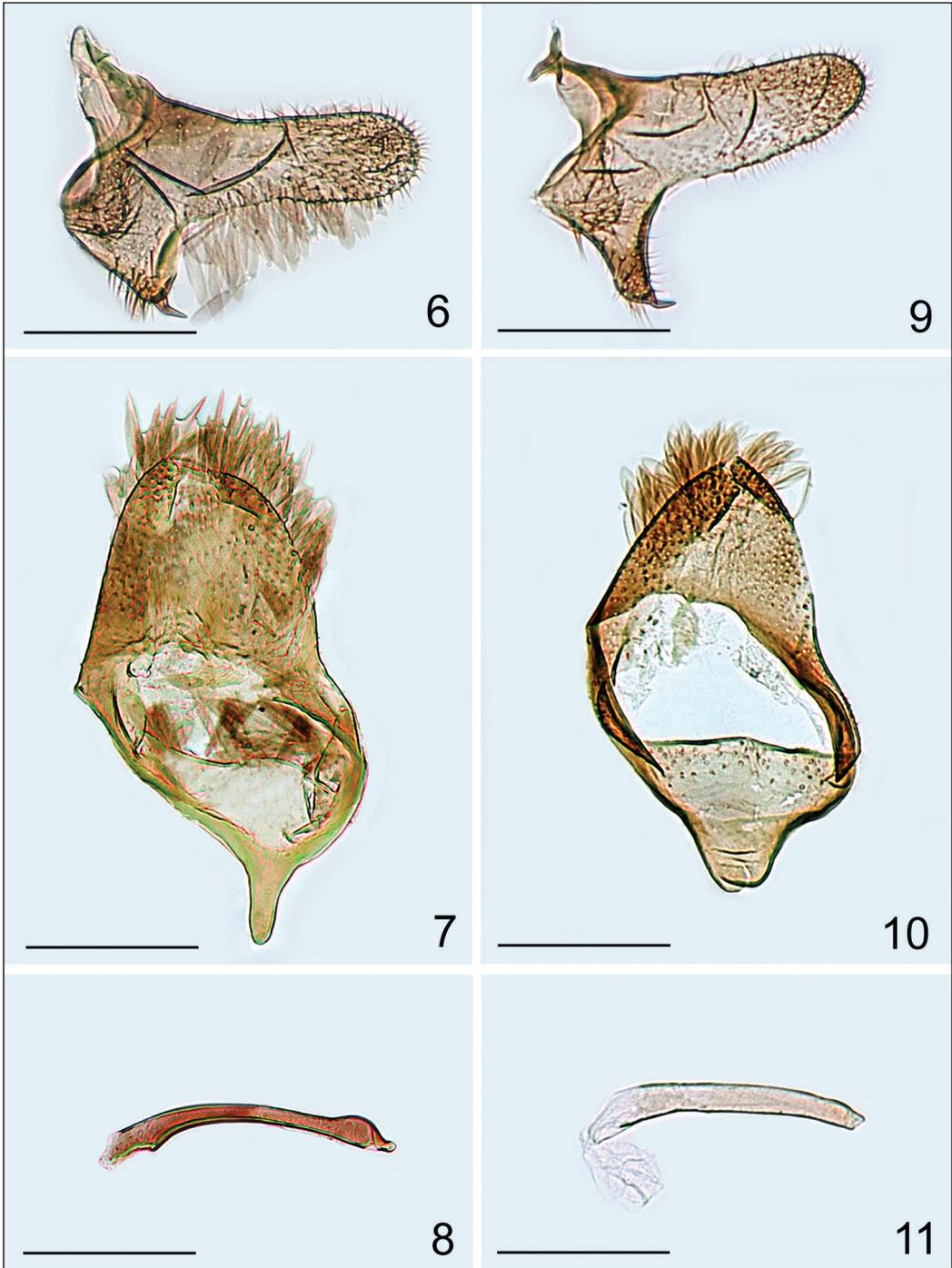
Barcoding

Three complete sequences (658 bp) were obtained from the barcoding analysis of the three specimens. They share the same Barcode Index Number (BIN Registry for BOLD:ACV0613), confirming their conspecificity. The Nearest-Neighbour available in BOLD is an unidentified *Pseudobankesia* Meier, 1963 from Bulgaria (BOLD:ACJ3767) showing a genetic distance of 4.49%. Whilst specimens from Abruzzi have identical sequences (BOLD IDs: BC ZSM Lep 91960, BC ZSM Lep 91961), they showed a difference of 0.92% compared with those from Calabria (BOLD ID: LEP-SS-00171), suggesting a possible genetic isolation between these two populations.

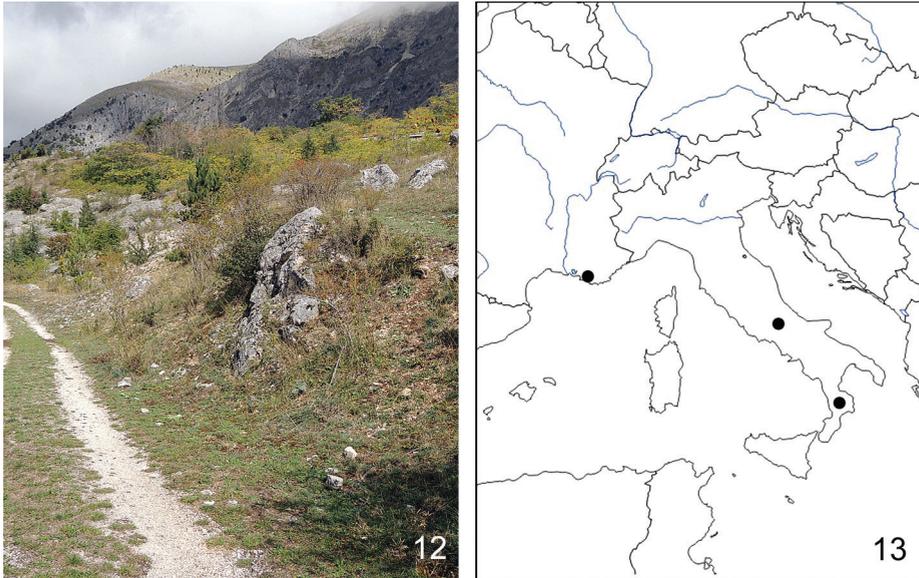
The genetic distance between the Calabrian *B. desplatsella* specimen sequenced in this study and a Calabrian specimen of *T. defoliella* available on BOLD (dataset “DS-PSYFO”, accessed at <http://dx.doi.org/10.5883/DS-PSYFOR>) (Scalercio et al. 2016) was very high (12.5%), definitively excluding conspecificity of these specimens.

Description of the larval case

One larval case, certainly attributable to a *Bankesia* species, was found in the vicinity of Frattura. It was evenly covered by soil particles and decorated with parts of dead insects and it probably



Figures 6–11. Details of male genitalia. *Bankesia desplatsella* (slide: 925 Bertaccini): **6.** valva; **7.** vinculum and saccus; **8.** phallus. *Taleporia defoliella* (slide: 927 Bertaccini): **9.** valva; **10.** vinculum and saccus; **11.** phallus. Scale bar 0.2 mm.



Figures 12–13. Habitat and range of *Bankesia desplatsella*. **12.** Habitat in central Italy, Abruzzi, Frattura di Scanno, L’Aquila, ca. 1200 m. **13.** Known range of *Bankesia desplatsella*.

belongs to *B. desplatsella*. Its specific identity cannot be determined with certainty as it was empty, but it cannot belong to *B. conspurcatella* as it was too small (Figs 4–5). It is certainly a mature case as it was empty and had the anal extremity opened as usually occurs after the extrusion of the mature pupa. Thus, it is a likely candidate for belonging to *B. desplatsella* or, less likely, to an undescribed *Bankesia* species. The case of *Taleporia defoliella* is easily distinguishable because it is not covered by any kind of soil or insect parts.

Ecology

Bankesia desplatsella has been found only in the mountains in Italy, where it was collected at ca. 1200 m a.s.l in both sites. As such, it contrasts with the type locality, which is at ca. 300 m a.s.l. The habitat varies from a Mediterranean garrigue dominated by *Erica multiflora* L. (Ericaceae) and *Quercus coccifera* L. (Fagaceae) in France (Nel 1999), to a Calabrian black pine forest in southern Italy, to a shrubby rocky slope in central Italy with small *Quercus pubescens* woods (Fig. 12) and it shows significant changes to the previously known range of the species (Fig. 13). Males were collected from mid-September to mid-October. Nothing is known about the biology of this species.

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A new pygmy leafmining moth, *Stigmella tatrica* sp. n., from the alpine zone of the Tatra Mountains (Lepidoptera, Nepticulidae)

ZDENKO TOKÁR¹, ALEŠ LAŠTŮVKA², ERIK J. VAN NIEUKERKEN³

1 *P. J. Šafárika 11, SK-92700 Šaľa, Slovakia; zdeno.tokar@gmail.com*

2 *Slavičková 15, CZ-796 01 Prostějov, Czech Republic; aleslastuvkaento@seznam.cz*

3 *Naturalis Biodiversity Center, PO Box 9517, NL-2300 RA Leiden, The Netherlands; nieukerken@naturalis.nl*

<http://zoobank.org/280E2DDD-F46A-4834-841D-44497F93BFA2>

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Abstract. *Stigmella tatrica* sp. n. is described from moths taken in the alpine zone of the Tatra Mountains in Slovakia. The new species is similar to several other montane species of *Stigmella* Schrank, 1802 in the *S. aurella* (Fabricius, 1775) group in external characters and male genitalia; its closest relative is *S. dryadella* (O. Hofmann, 1868). It is indistinguishable from *S. tormentillella* (Herrich-Schäffer, 1860) by the colour and pattern elements of the forewing; however, it differs in the male genitalia in the shape and number of cornuti, in the female genitalia by long apophyses with protruding ovipositor, and by COI barcodes. Immature stages are unknown, but *Dryas octopetala* L. (Rosaceae) is the possible hostplant. The long ovipositor suggests an unusual, possibly hidden place for oviposition. The male and female adults and genitalia of both sexes are figured and photographs of the habitat are provided.

Introduction

The pygmy leafmining moths or Nepticulidae have around 300 species in Europe, the great majority of which are leafminers, feeding on woody plants and they are abundant in forested areas (van Nieukerken et al. 2016). Overall they do not form an important aspect of the diversity of high mountain faunas (but see Stonis et al. (2016) for a group of *Stigmella* Schrank, 1802 species occurring in the high Andes). In Europe few Nepticulidae are adapted to high altitudes, and apart from some common species with large altitudinal ranges, only a few species of *Stigmella* are alpine specialists, particularly a group of species feeding on herbaceous Rosaceae (Klimesch 1981; Johansson and Nielsen 1990; Laštůvka and Laštůvka 1997).

The high altitude *Stigmella* species of the Tatra Mountains, especially above the tree line, have been poorly studied and all records reside in a handful of publications. In the Polish part of the alpine zone *Stigmella* species were first observed by Toll (1948) and Borkowski (1970). Buszko et al. (2000) mentioned three *Stigmella* species from the alpine grasslands: *S. pretiosa* (Heinemann, 1862), *S. aeneofasciella* (Herrich-Schäffer, 1855), and *S. dryadella* (O. Hofmann, 1868). From the Slovak part of the Tatras, only one faunal contribution is known: Gregor (1986) found mines of

S. dryadella in mid-October in the Belianske Tatra Mountains, Kvetnica and Bujačí Vrch Mountain at altitudes between 1500 and 1900 m (the number of mines and hostplant were not given). Most European alpine Nepticulidae belong to the *Stigmella aurella* (Fabricius, 1775) group, a Holarctic group of 18 named species (12 in Europe), all but one of which feed on Rosaceae, particularly herbs and shrubs such as *Rubus*.

In late July 2005, while inventorying the Lepidoptera fauna of the Western Tatra Mountains, the first author with his friend found four males of an unknown *Stigmella* species in alpine grasslands at altitudes between 1800 and 1900 m. Detailed study of two specimens by the second author was inconclusive, because of the relatively high similarities of their external appearance and male genitalia to closely related *Stigmella* species in the *S. aurella* group.

Later on, additional males were found in the eastern part of the Tatras, Belianske Tatra Mts at altitudes of ca. 2000 m. These specimens were sent to the third author for DNA analysis. In 2016 the first author's last visit to the locality brought success in the form of a large series of specimens, including two females. Individuals of the new species were observed flying around the low cover of high-altitude plant communities with *Dryas octopetala* L. An examination of the female genitalia of this tiny moth, as well as the analysis of the DNA barcodes, showed that it represents a hitherto undescribed *Stigmella* species.

Material and methods

All specimens were taken as adults during daylight, either using a net or caught directly from the leaves of *Dryas octopetala* into small glass vials. The genitalia were dissected in the usual way for small Lepidoptera, the preparations being stored in glycerol in small plastic vials or embedded in Euparal on glass. The drawings of the male and female were made by the second author using water colours. Drawings of the genitalia were made by the first author using Indian ink on transparent sheets. Photographs of the type locality were taken using digital cameras Canon PowerShot G11 and Nikon Coolpix P600.

For methodology of DNA barcodes we refer to papers of the third author and his colleagues (van Nieukerken *et al.* 2012a; Doorenoweerd *et al.* 2015). The specimen data for barcoded specimens are given in the public BOLD dataset DS-STIGTATR. Many of these barcodes were earlier published by van Nieukerken *et al.* (2012b). For the alpine species *Stigmella stelviana* (Weber, 1938) and *S. geimontani* (Klimesch, 1940) we were only able to obtain short barcodes of 146 base pairs. Tree-building was performed with PAUP and Phylip plugins in Geneious R8.1.8, as outgroup we used a specimen of *Stigmella tityrella* (Stainton, 1854).

The nomenclature of species follows the "Revised classification and catalogue of global Nepticulidae and Opostegidae" (van Nieukerken *et al.* 2016).

Abbreviations

AL	Aleš Laštůvka
BOLD	Barcode of Life Database
Gp	Genitalia preparation
RMNH	Naturalis Biodiversity Center, Zoological collections, Leiden, The Netherlands
ZT	Zdenko Tokár

Taxonomy

Stigmella tatrca Tokár, Laštůvka & van Nieukerken, sp. n.

<http://zoobank.org/97DD8700-29A6-4628-B331-8EE0ADC5E965>

Material. Holotype: ♂, pinned, with genitalia in glycerol in a small plastic vial. Original labels: “Slovakia, Belianske Tatry, Zadné Jatky, 1950–2010 m, 49°14.18'N; 20°13.50'E, 30.vii.2016, Zdenko Tokár leg.”, “HOLOTYPE *Stigmella tatrca* Tokár, Laštůvka & van Nieukerken” (red label), coll. Z. Tokár (to be deposited in the Central Slovakia Museum Banská Bystrica).

Paratypes: 14♂, 2♀, same locality and data as holotype, Gp. ZT ♂ 12873–5, 12878, 12918, ♀ 12876, ZT leg., coll. ZT & AL; 1♂, František Kuraj leg. & coll.; same locality as holotype, 2.viii.2014, 2♂, Gp. ZT 12266–7, ZT leg., coll. RMNH, DNA samples Tokar 12266, 12267; Belianske Tatry, Bujací Vrch, 49°13.48'N; 20°15.55'E, 4.viii.2011, 2♂, Ignác Richter leg. & coll.; Západné Tatry, Červené Vrchy, Stoly-Temniak, 49°13.28'N; 19°54.19'E, 29.vii.2005, 3♂, Gp. ZT 9085, 9087, 9132, ZT leg., coll. AL, DNA samples RMNH.5012163, RMNH.5012164 (DNA extracts in RMNH); 1♂, Gp. Richter 9847, Ignác Richter leg. & coll. All paratypes with red label “PARATYPE *Stigmella tatrca* Tokár, Laštůvka & van Nieukerken”.

Description. Adult, male (Fig. 1). Wingspan 4.0–5.0 mm. Head: frontal tuft black, collar with black lamellar scales. Antenna black, with 32–35 segments. Scape white. Thorax and tegula glossy black. Ground colour of forewing brown with dark golden sheen; dark violet metallic reflection around postmedial fascia and towards the forewing apex. Fascia shining silver, wider at costal margin. Fringe grey. Hindwing grey, no androconial scales. Abdomen brown to black with whitish scales on margins of segment and whitish anal tufts.

Female (Fig. 2). Wingspan 4.0–4.5 mm. Antenna shorter, with 26 segments. Forewing markings as male. Abdomen with remarkable protruding ovipositor, no anal tufts.



Figure 1. *Stigmella tatrca* sp. n., male, holotype, wingspan 4.0 mm.

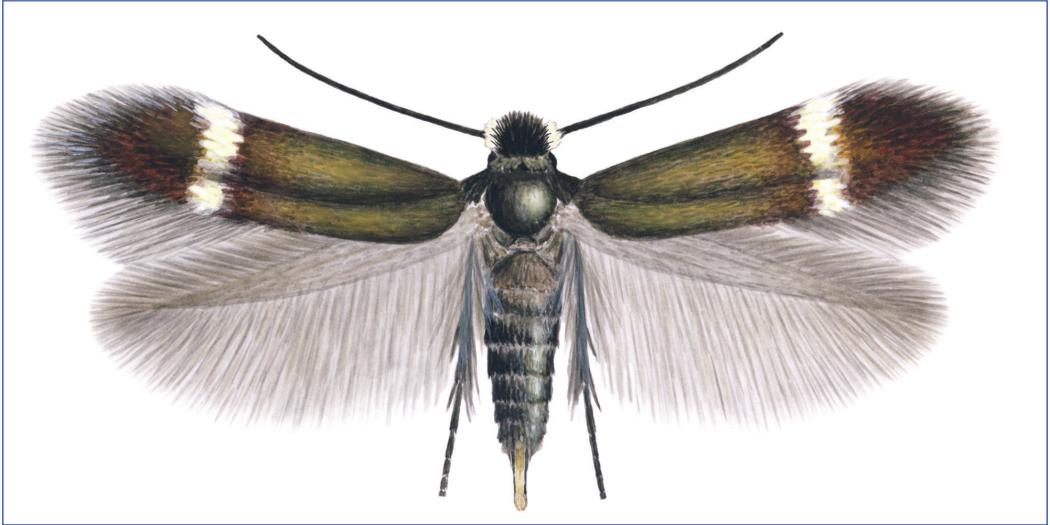
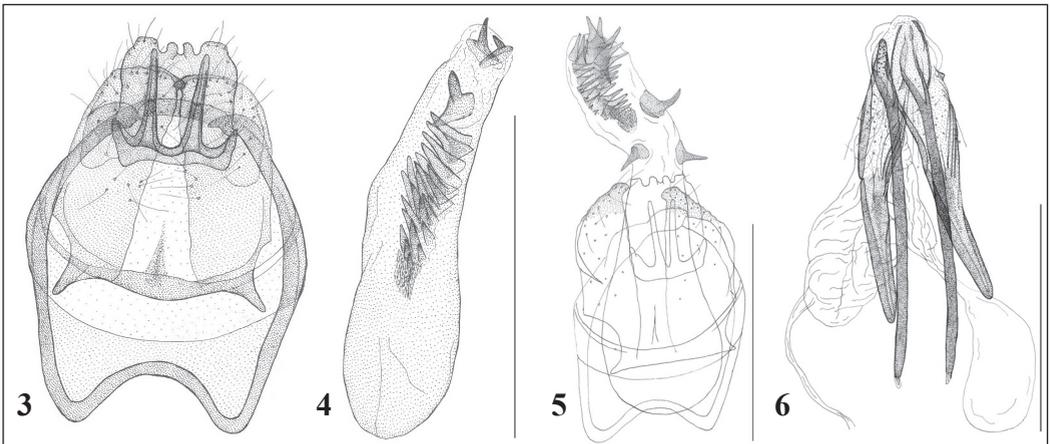


Figure 2. *Stigmella tatrica* sp. n., female, paratype, Belianske Tatras Mts, Zadné Jatyky Mt., 30.vii.2016, wing-span 4.5 mm.



Figures 3–6. Male and female genitalia of *Stigmella tatrica* sp. n., paratypes. **3.** Male genitalia, Gp. ZT ♂ 9085, dorsal view; **4.** phallus; **5.** Gp. ZT ♂ 9087, vesica everted. **6.** Female genitalia, Gp. ZT ♀ 12876. (Figs 3–5, scale bar 0.25 mm; Fig. 6, scale bar 0.5 mm).

Male genitalia (Figs 3–5). Vinculum moderately long, anteriorly slightly bilobed. Uncus very broad, with posterior processes well separated, each bilobed. Gnathos with long and separated posterior processes. Valva rectangular with very short and blunt distal process. Transtilla broad with relatively short sublateral processes. Phallus cylindrical, slightly longer than genital capsule, vesica with long series of pointed cornuti of different sizes and three separate thorn-shaped cornuti near phallosome.

Female genitalia (Fig. 6). Apophyses very long and strongly sclerotized, forming a conspicuous ovipositor protruding from abdomen. Posterior apophyses about 1.3 times as long as anterior apophy-



Figure 7. The Western Tatra Mts, Red Mts, Stoly Rocks, 29.vii.2005, locality where the first adults of *Stigmella tatraca* were obtained. Photograph Z. Tokár.

ses. Anterior apophyses very broad, well sclerotized anteriorly. Length of corpus bursae shorter than posterior apophyses, devoid of pectinations. Accessory sac heavily folded, longer than corpus bursae.

Diagnosis. *Stigmella tatraca* is somewhat similar to several other montane species in the *Stigmella aurella* group in forewing colour and pattern and in male genitalia. Externally it is indistinguishable from *S. tormentillella* (Herrich-Schäffer, 1860). Carpathian *S. dryadella* differs from the new species by more glossy forewings, a wider violet area before fascia and paler head and collar. In the male genitalia the new species is most similar to *S. geimontani*, *S. stelviana* and *S. aeneofasciella*, but it differs significantly from these externally. Unlike *S. tatraca*, *S. tormentillella* and *S. dryadella* have only one large cornutus in their vesica. In the female genitalia *S. tatraca* differs considerably from other species in the group by the long and strong apophyses, forming a protruding ovipositor.

Biology. The early stages of the new species are unknown. The adults were observed flying over low cover of high-altitude plant communities with the presence of *Dryas octopetala* and resting or quickly moving on leaves of that plant. Adults were collected during daylight hours between 29th July and 4th August (light collecting was not attempted). This likely represents a single annual generation.

Distribution and habitat (Figs 7–10). *Stigmella tatraca* is so far known only from the alpine zone of the Eastern and Western Tatra Mountains. In the Eastern Tatra it was found in the Belianske Tatra Mountains (*Belianske Tatry*), Zadné Jatky Mountain and Bujačí Vrch Mountain at an altitude of 1800–2010 m. In the Western Tatra it was taken in the Red Mountains (Červené Vrchy), Stoly Rocks at Temniak Mountain, near the Slovak-Polish border at an altitude of about 1800–1900 m.



Figure 8. The Belianske Tatra Mts, Zadné Jatky Mt., 30.vii.2016, type locality of *Stigmella tatrica*. Photograph Z. Tokár.



Figure 9. The Belianske Tatra Mts, Zadné Jatky Mt., 30.vii.2016, adult of *Stigmella tatrica* sitting on *Carex firma*. Photograph F. Kuraj.



Figure 10. The Belianske Tatra Mts, Zadné Jatky Mt., 30.vii.2016, adult of *Stigmella tatrica* sitting on *Dryas octopetala* leaf. Photograph F. Kuraj.

The Belianske Tatra Mountains and the Red Mountains are both karst areas, built of limestone and dolomite with a dominance of subalpine or alpine grasslands with many different plants growing there, many of which are endemic, rare or endangered species. The vegetation at the type locality could belong to the *Caricion firmae* Gams association, with the following higher plant species commonly present: *Carex firma* Host (Cyperaceae), *Dryas octopetala* L. (Rosaceae), *Androsace lactea* L., *Primula auricula* L., *Soldanella carpatica* Vierh. (Primulaceae), *Arenaria tenella* Kit., *Dianthus nitidus* Waldst. & Kit., *Silene acaulis* (L.) Jacq. (Caryophyllaceae), *Bartsia alpina* L., *Pedicularis oederi* Vahl. ex Hornem., *P. verticillata* L. (Orobanchaceae), *Bellidiastrum michelii* Cass., *Crepis jacquini* Tausch (Asteraceae), *Bistorta vivipara* (L.) Gray (Polygonaceae), *Campanula cochleariifolia* Lam. (Campanulaceae), *Chamorchis alpina* (L.) Rich. (Orchidaceae), *Festuca versicolor* Tausch (Poaceae), *Galium anisophyllum* Vill. (Rubiaceae), *Pinguicula alpina* L. (Lentibulariaceae), *Ranunculus alpestris* L. (Ranunculaceae), *Saxifraga aizoides* L., *S. caesia* L., *S. paniculata* Mill. (Saxifragaceae), *Selaginella selaginoides* (L.) P. Beauv. ex Schrank et Mart. (Selaginellaceae); the following mosses: *Ctenidium molluscum* (Hedw.) (Schimp.) (Hylocomiaceae), *Ditrichum flexicaule* (Schwaegr.) Hampe (Ditrichaceae), *Tortella tortuosa* (Hedw.) Limpr. (Pottiaceae); and the following lichen: *Cetraria islandica* (L.) Ach. (Parmeliaceae) (Šibík et al. 2004; Kliment et al. 2010).

Etymology. The specific name *tatrica*, an adjective, is derived from the Tatra Mts, where the new species was discovered.

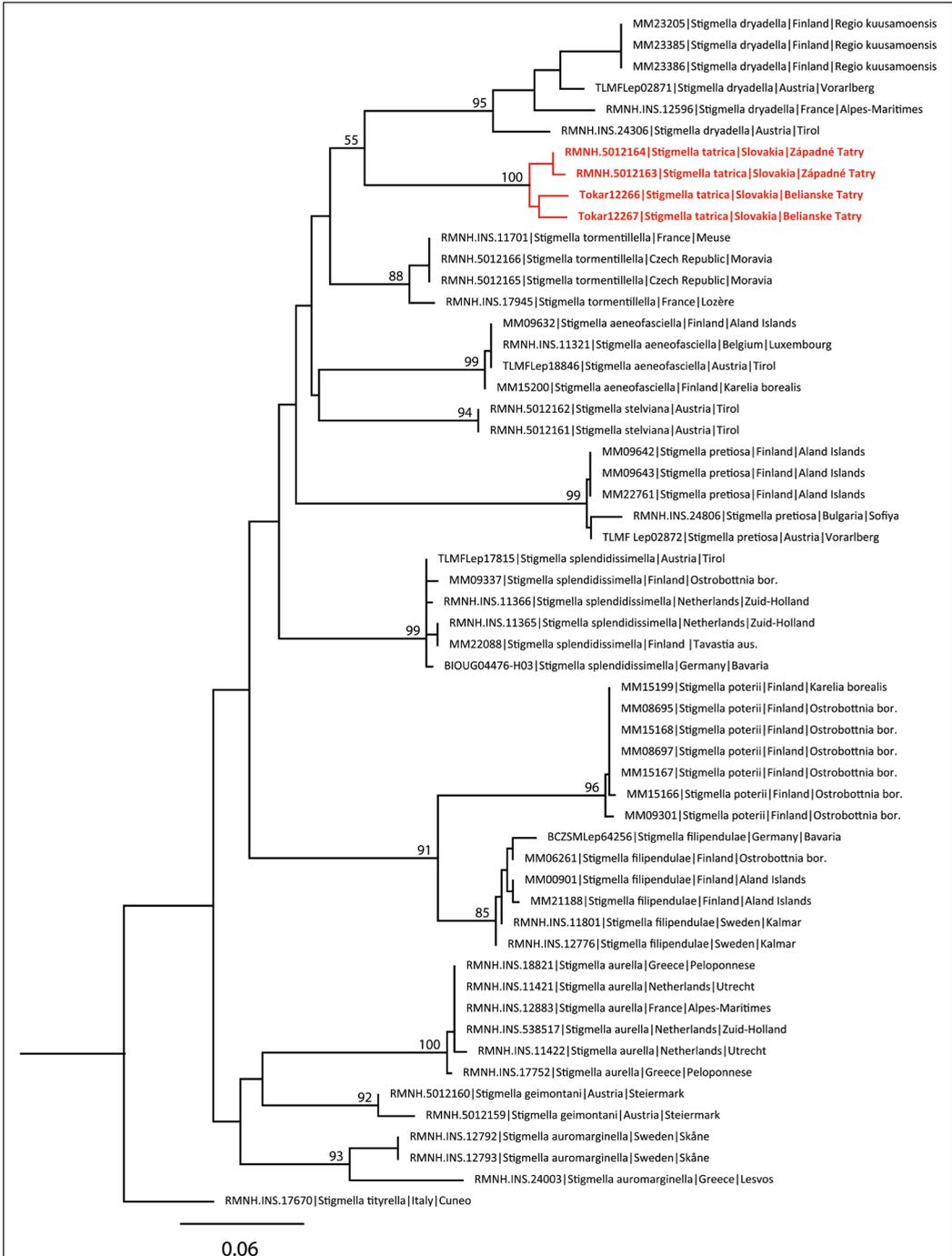


Figure 11. Maximum likelihood tree of European species of the *Stigmella aurella* group, showing the position of *Stigmella tatrca* in red. Small figures represent bootstrap values, after 100 replicates. Bootstrap values below 50 are not given. A specimen of *Stigmella tityrella* is used as outgroup. Nomenclature follows van Nieukerken et al. (2016).

Molecular data (Fig. 11). We obtained COI barcodes from legs of four specimens, two of which were partial barcodes. The Barcode Index Number is BOLD:ACU7181. The maximum K2P intraspecific distance for a full barcode is 1.5%. The nearest neighbour is *Stigmella tormentillella* at a distance between 6.2 and 7.1%. Both in Neighbour-Joining and Maximum Likelihood analyses *S. tatrlica* groups consistently with *S. dryadella*, but bootstrap support is lacking.

Remarks

Borkowski (1970) described *Stigmella geimontani tatrensis* from the Polish Tatra Mts, reared from *Geum montanum* L. (Rosaceae). Later he synonymised it with *S. pretiosa* (see Borkowski 1975). In the paper from 1970 he recorded also *S. stelviana* (as ssp. *crantziella*) and *S. dryadella* from the Tatras. He found mines of *S. stelviana* on *Potentilla crantzii* Crantz & Fritsch (Rosaceae) from the end of August to mid of September at altitudes 1200–1800 m but no adult was reared from these. The mines could therefore also have been made by larvae of *S. tormentillella* that are feeding on various *Potentilla* spp. He also mentioned mines of *S. dryadella* on *Dryas octopetala*. They were observed in September and in May at an altitude of about 1800 m. The aforementioned record by Gregor (1986) of *S. dryadella* mines was also not supported by reared adults.

Discussion

The discovery of *Stigmella tatrlica* shows that the montane fauna of Central European Nepticulidae is still insufficiently studied and can provide surprises. We expect that *S. tatrlica* can also be found in the Polish part of the Tatra and other parts of the Carpathians, e.g. in Romania; currently it seems to be an endemic species for the Carpathians. Although the partial mitochondrial gene COI as used for DNA barcodes is usually not sufficient for a robust phylogenetic analysis, both analytical methods invariably group *S. tatrlica* with *S. dryadella*, and this together with the fact that *S. tatrlica* has usually been collected on or near *Dryas octopetala*, suggest that the two species are sister taxa whose ancestor shifted to *Dryas*. The protruding ovipositor suggests that *S. tatrlica* has an unusual, possibly hidden oviposition site, and potentially rather different leafmines compared to *S. dryadella*, or even a different feeding mode.

Acknowledgements

Our thanks are due to Ignác Richter (Malá Čausa, Slovakia) and František Kuraj (Krompachy, Slovakia) for providing the specimens and accompanying the first author during his research trips in the Western and Belianske Tatra Mts, the latter also for taking the photographs of the habitat. Tomasz Jaworski (Raszyn, Poland) provided necessary literature. Zdeněk Laštůvka (Brno, Czech Republic) and Camiel Doorenweerd (Leiden, the Netherlands) are acknowledged for their advice on the manuscript. The latter and Frank Stokvis (Leiden, the Netherlands) performed the DNA analyses. Marko Mutanen (Oulu, Finland), Peter Huemer (Innsbruck, Austria), and Andreas Segerer (München, Germany) kindly gave permission to use DNA barcodes from their BOLD projects. We thank David Agassiz (Weston-super-Mare, UK) for linguistic editing.

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Leaving Nota in good hands

Jadranka Rota, Editor-in-Chief: May 2011 – May 2017

JADRANKA ROTA¹

¹ Lund University, Department of Biology, Biodiversity, Sölvegatan 37, 223 62 Lund, Sweden; jadranka.rota@biol.lu.se
<http://zoobank.org/16E6C285-47B6-4C28-B4D9-E707D632A700>

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As an outgoing Editor-in-Chief I am now reflecting on the past six years, since I took over the journal at the SEL congress in Luxembourg in 2011. Much has happened with our journal in this period of time. In the first place we introduced the subject editor system, so that subject editors handle the review process of submitted manuscripts and make a decision on their acceptance. We now have thirteen subject editors, covering diverse taxa and subjects, from non-ditrysians to macro-moths, and from systematics and taxonomy, molecular phylogenetics, biogeography, conservation, ecology, biological invasions, and other topics. The full list of all subject editors and their expertise is available on the Nota website (<https://nl.pensoft.net/editors/>). The Editor-in-Chief still has a responsibility to go through every submission and work with the authors and/or subject editors on any issues that may arise.

From the beginning of 2014, we transitioned from in-house production to a professional publisher – Pensoft – and we have been very happy with this decision. The result was an immediate improvement in the visibility of the journal. Each paper is now published online when it is ready, with final pagination. In addition to having a modern website and a professional editorial management software that allows for an easy overview of all the active submissions, we receive a lot of other support from Pensoft, including professional help with press releases and any technical issues that may arise during the submission and/or review process.

The number of submissions to Nota has been increasing. This year we have already published 11 papers in issue 1 (totalling 140 pages). These papers deal with many different topics, including descriptions of new species from several different families (Geometridae, Nepticulidae, Pterophoridae, and Psychidae), as well as new and surprising species records. However, by far the most popular paper based on the number of unique views on the Nota Lepidopterologica website has been Gunnar Brehm's paper describing a new LED lamp for night-time collecting (<https://nl.pensoft.net/article/11887/>). This is now the second most popular paper published in Nota since our transfer to Pensoft and is en route to become the number one!

Looking back at that day in May of 2011 in Luxembourg, I am glad that I accepted the challenge of editing Nota. My experience has been extremely positive at many levels. I learned a lot as a lepidopterist and I got to know many people in their role as authors, reviewers, or subject editors. Luckily, our society has many members with a high level of expertise, and two of them, Maria Heikkilä and David Lees, have accepted to become the new Editors-in-Chief of Nota – I am very happy to be leaving the journal in their hands! They are both experienced lepidopterists with expertise in several groups of Lepidoptera and in various subject areas, and I hope that they will enjoy their new roles. I will remain on the editorial board and continue contributing to the journal as a subject editor.

Editorial from the new co-editors-in-chief: Aiming to keep up the good work

MARIA HEIKKILÄ¹, DAVID LEES²

1 *Finnish Museum of Natural History, LUOMUS, P.O. Box 17, FI-00014 University of Helsinki, Finland; maria.heikkila@helsinki.fi*

2 *Natural History Museum, Cromwell Road SW7 5BD London, Great Britain; david@nhm.ac.uk*

<http://zoobank.org/9A99E5A9-6950-4D0F-8497-2E5DBC0FAFB3>

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It is an honour and a pleasure to have been chosen as the new editors-in-chief of *Nota Lepidopterologica*. We are very excited to become part of the team that strives to maintain the high standards of the journal, improve its visibility and make it more accessible to the readers.

We wish to express our sincere thanks to the outgoing editor-in-chief, Jadranka Rota, and acknowledge the fantastic job she has done in bringing *Nota* to where the journal is today. We realise that we have very big shoes to fill, as it will take two people to replace her! To ensure the transition goes smoothly, she has shared with us the knowledge and experience she has gained over the years as editor-in-chief and will continue to counsel us in the beginning of our new assignment as she stays on the *Nota* editorial board as a subject editor.

By having two editors-in-chief instead of one, we will also be able to better fulfil our responsibilities towards authors, reviewers, readers and the scientific community as the number of submissions to *Nota* has increased over the years. Maintaining the quality and publication speed of *Nota* would not be possible without the support of the editorial team of *Nota Lepidopterologica*, the expertise of reviewers and the staff at Pensoft. In addition to Jadranka, we will be working closely with twelve other subject editors, Sven Erlacher, Thomas Fartmann, Zdeněk Faltýnek Fric, Axel Hausmann, Lauri Kaila, Bernard Landry, Carlos Lopez Vaamonde, Vazrick Nazari, Thomas Schmitt, Erik van Nieukerken, Roger Vila and Alberto Zilli. They in turn correspond with reviewers ensuring the quality of the scientific content of the journal. The help of our linguistic editors Stella Beavan, Bob Heckford and Malcolm Scoble is essential in making sure the language of the articles is flawless. For layout and editorial issues we will collaborate with Plamen Pankov and Boriana Ovcharova at Pensoft. In fact, our first task will be to explore with the staff at Pensoft the possibilities of making the online system more user-friendly for authors, subject editors and reviewers.

We thank the SEL council and members for trusting us with this position at the 2017 meeting in Croatia. We look forward to receiving new submissions and will do our best to continue Jadranka's excellent work in overseeing that *Nota* is an outlet for high-quality peer-reviewed research across all fields of lepidopterology.

New records of Lepidoptera from Ukraine and description of a new species of *Caloptilia* Hübner, 1825 (Lepidoptera, Gracillariidae) from the mountains of Crimea

OLEKSIY V. BIDZILYA¹, YURI I. BUDASHKIN²

1 Institute for Evolutionary Ecology of the National Academy of Sciences of Ukraine, str. Academician Lebedev 37, 03143, Kiev, Ukraine; olexbid@gmail.com

2 T.I. Vyazemsky Karadag Scientific Station – Nature Reserve RAS, Kurortnoye, Feodosia, Crimea, 298188; budashkin@ukr.net

<http://zoobank.org/DD58C622-BD4B-47BE-A09E-51196633B205>

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Subject Editor: Vazrick Nazari.

Abstract. Twenty-eight rare and poorly known lepidopteran species from eleven families are recorded from different regions of Ukraine. Eight species are recorded for the first time: *Bucculatrix pannonica* Deschka, 1982 (Bucculatricidae); *Biselachista serricornis* (Stainton, 1854) (Elachistidae); *Aplota nigricans* (Zeller, 1852) (Oecophoridae); *Caulastrocecis pudicella* (Mann, 1861), *Scrobipalpa soffneri* Povolný, 1964, *Syncopacma polychromella* (Rebel, 1902) (Gelechiidae); *Phycita torrenti* Agenjo, 1962 (Pyralidae) and *Hodebertia testalis* (Fabricius, 1794) (Crambidae). The hitherto unknown female of *Filatima djakovica* Anikin & Piskunov, 1996, femina nova (Gelechiidae) is described based on material from the Kiev region. *Caloptilia jailensis* sp. n. (Gracillariidae) is described from the mountains of Crimea.

Introduction

The present contribution is a step towards preparing an inventory of the micromoth fauna for the Catalogue of Ukrainian Lepidoptera. According to our rough estimate at least 4000 species of Lepidoptera are known from Ukraine to date. As a result of our study of material collected by the authors and other collectors mainly in last years and identification of some specimens which remained unidentified for many years, 28 rare and poorly known Lepidoptera species from the families Tineidae, Bucculatricidae, Gracillariidae, Depressariidae, Elachistidae, Oecophoridae, Gelechiidae, Urodidae, Pterophoridae, Pyralidae and Crambidae were recorded from different regions of Ukraine. The annotated list of these species is given below. The adults and the male genitalia of *Elachista pollinariella* Zeller, 1839 and *Bucculatrix pannonica* Deschka, 1982 are illustrated. The differences between *Ostrinia kasmirica* (Moore, 1888) and *O. nubilalis* (Hübner, 1796) are briefly discussed, and the adults and the genitalia are illustrated for both species. We provide a description of the hitherto unknown female of *Filatima djakovica* Anikin & Piskunov, 1996 (Gelechiidae) – a poorly known species which was rather unexpectedly recorded from the Kiev region. One species – *Caloptilia jailensis* sp. n. (Gracillariidae) is described based on material collected by the second author in the mountains of Crimea (Karabi-jaila, Aj-Petri-jaila and Babugan-jaila).

Material and methods

The present study is based on material from the collection of the Zoological Museum, Kiev Taras Shevchenko National University, Ukraine (ZMKU) and T.I. Vyazemsky Karadag Scientific Station – Nature Reserve RAS, Crimea (KSS). The type material of *Caloptilia jailensis* sp. n., including the holotype, is deposited in the collection of ZMKU, and the rest of the paratypes in the KSS collection and in the collection of the Zoological Institute of the Russian Academy of Sciences, Saint-Petersburg, Russia (ZIN).

The adults were collected by light trap or by netting. Male and female genitalia were dissected and prepared using standard methods (Huemer and Karsholt 1999). Pinned specimens were photographed mainly with an Olympus E-410 digital camera attached to an Olympus SZX12 microscope. Slide-mounted genitalia were photographed with a Canon EOS 600D digital camera mounted on an Olympus U-CTR30-2 trinocular head combined with a Carl Zeiss microscope body. Sets of 10–20 images were taken for each specimen and assembled to deep-focused images using Helicon Focus 6 and edited in Adobe Photoshop CS5.

Results

Tineidae

Monopis crocicapitella (Clemens, 1859)

Material. 1 ♂, Ukraine, Odessa reg., Kiliya distr., Vilkovo, 11.v.2014, leg. E. Khalaim. Genitalia slide: O. Bidzilya prep. no. 279/16.

Distribution. North Africa, Central and Southern Europe, Russia (Center of the European part, Western Caucasus, Lower Volga region), South Africa, South Asia, North and South America, Australia, New Zealand (Zagulajev 1960; Petersen and Gaedike 1996; Baryshnikova 2008). It is also known from Crimea (Budashkin 2004).

Bucculatricidae

Bucculatrix pannonica Deschka, 1982

Figs 1, 2

Material. 2 ♂, Ukraine, Odessa reg., Ivanovskiy distr., Severinovka, at light, 30.iv.2016, leg. A. Zhakov. Genitalia slide: O. Bidzilya prep. no. 274/16.

Distribution. Austria, Slovakia, Hungary (Deschka 1982; Baraniak 1996). **New for Ukraine.**

Gracillariidae

Parornix tenella (Rebel, 1919)

Material. 1 ♂, Ukraine, Nikolaev reg., Aktovo vic., Arbuzinka river canyon, at light, 3.vi.2016, leg. O. Bidzilya.



Figures 1, 2. *Bucculatrix pannonica*. 1. Adult; 2. Male genitalia.

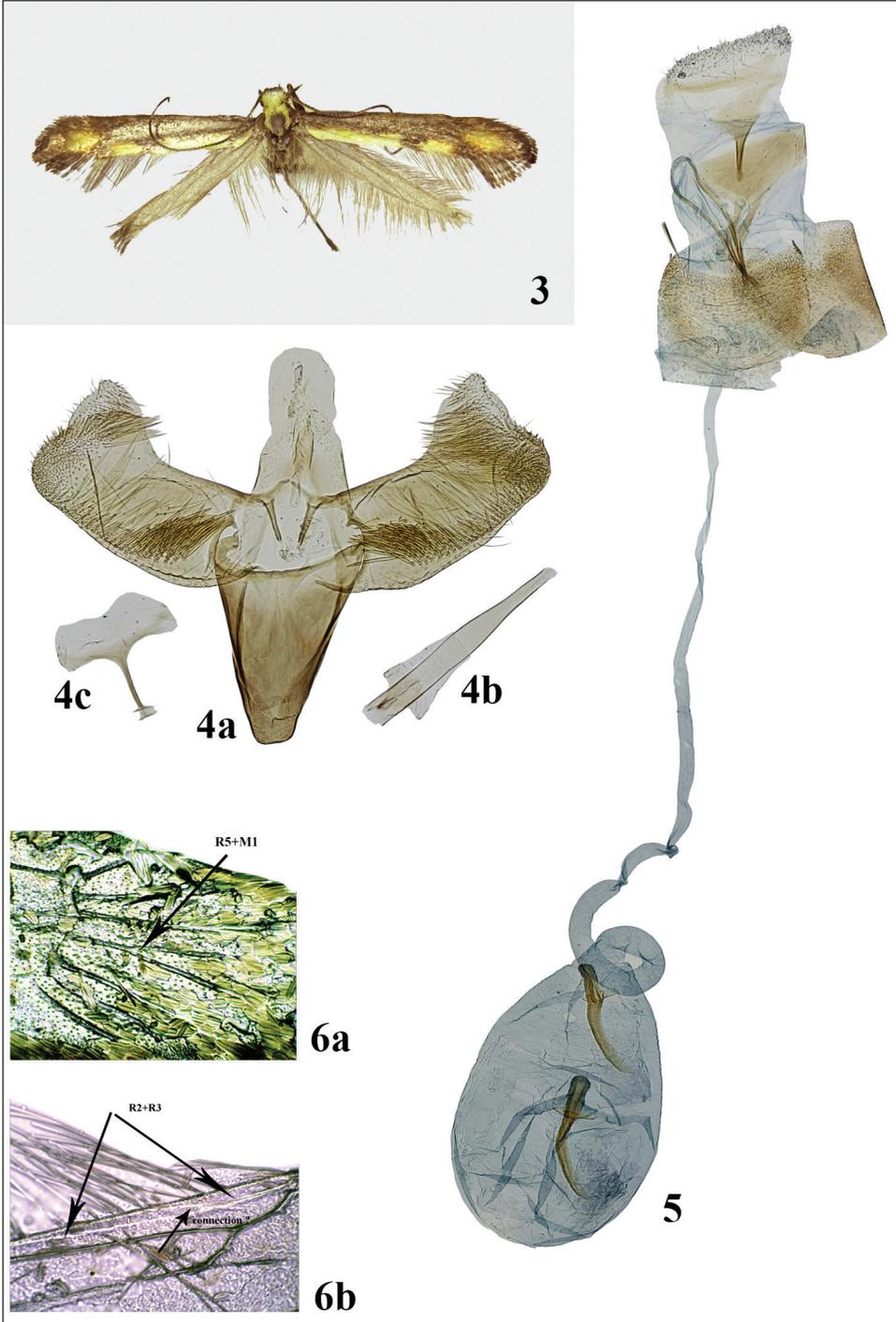
Distribution. Spain, Portugal, Italy (with Sicily), Austria, Croatia, Czech Republic, Slovakia, Hungary, Romania (Buszko 1996; De Prins and De Prins 2016). It is also known from Crimea (Budashkin 2004; Bidzilya et al. 2006).

***Caloptilia jailensis* sp. n.**

<http://zoobank.org/0AEBBE4E-C57F-4E01-99EC-A19758D1A839>

Material. Holotype ♂, “Crimea, Karabi-jaila, 1100 m, 8.vi.1994, in the morning on sunrise, leg. Yu. Budashkin” (ZMKU). Genitalia slide: O. Bidzilya prep. no. 627/14 (ZMKU). Paratypes: 6 ♂, 1 ♀, same data as holotype, Genitalia slide: O. Bidzilya prep. no. 628/14♀ (ZMKU, KSS, ZIN); 1 ♀, Crimea, Aj-Petri, 1200 m, at light, 14.vi.2002, leg. Yu. Budashkin (KSS); 1 ♀, Crimea, Crimean Reserve, Babugan-jaila, Bolshaja Chuchel mt., 1350 m, 3.vi.2006, evening collection, leg. Yu. Budashkin (KSS).

Description. Adult (Fig. 3). Sexual dimorphism not observed. Wing span 9.0–11.0 mm. Head light yellow, densely covered with erected scales, frons greyish-brown, smooth scaled. Scape and flagellum greyish-brown, without light rings. Labial palpus long, sickle-shaped, greyish-brown, inner surface of segment 2 and apical portion of segment 3 lighter, yellowish-brown. Maxillary palpus long and narrow, greyish-brown. Thorax and tegulae light yellow. Forewing comparatively broad (ratio length/width = 0.16), lanceolate. Ground colour of forewing greyish-brown. Wing pattern is very distinct: broad (about 1/3 width of forewing) light yellow patch from base to half length of forewing along the dorsal margin, sub-ovate yellowish-orange tornal spot at 2/3 forewing length, large rounded to ovate light orange spot in middle width from 3/4 length to wing apex. Cilia light brown from tornus to outer margin of forewing, then, along outer margin of forewing slightly lighter than ground colour, with well-developed medial dividing dark line. Hindwing light grey, more or less unicoloured, cilia slightly lighter, greyish-brown. Abdomen greyish-brown, last segment covered with yellowish-orange hair-like scales in male; male abdominal segments VII–VIII with coremata represented by paired tufts (two on one side and two on the opposite side) of hair-like scales of equal length. Male tergum VIII subrectangular with long and narrow anteromedial arm (Fig. 4c).



Figures 3–6. *Caloptilia jailensis* sp. n. **3.** Adult, holotype; **4.** Male genitalia and tergum VIII, holotype, genitalia slide: O. Bidzilya prep. no. 627/14; **a.** male genitalia; **b.** phallus removed; **c.** tergum VIII; **5.** Female genitalia, genitalia slide: O. Bidzilya prep. no. 628/14; **6.** Fragment of wing venation; **a.** forewing; **b.** hindwing.

Male genitalia (Fig. 4a, b). Tuba analis membranous, about as broad as distal portion of tegumen, far protruded over the top of tegumen. Subscaphium narrow. Tegumen longer than broad basally, weakly narrowed distally, with deep triangular anteromedial emargination. Valvae about twice as long as broad, slightly asymmetrical, dorsal margin with large subtriangular projection in distal 1/3, covered with dense long setae along dorsal and outer margin, dorsal branch of basal process 1.5 times longer than ventral branch. Saccus stout, of moderate length, very broad at base, then gradually narrowed apically, apex truncate. Phallus about as long as valva, narrowly bottle-shaped, without cornuti.

Female genitalia (Fig. 5). Papillae anales membranous, rather large, densely covered with short setae. Both pairs of apophyses thick and short, apophyses anteriores slightly longer than apophyses posteriores. Segment VIII subrectangular, postvaginal plate membranous but strongly edged. Antrum not developed. Ductus bursae long and narrow, the proximal portion weakly broadened and coiled before corpus bursae. Ostium a small indistinct hump between segments VII and VIII. Bursa copulatrix large, egg-shaped, signum paired, long and narrow, claw-shaped, weakly curved.

Differential diagnosis. The new species externally remotely resembles *Caloptilia aurantiaca* (Wollaston, 1858) from the Canary, Madeira and Azores Islands, having a forewing with dark costal and lighter dorsal parts. It differs from the latter and other *Caloptilia* species by having distinct yellowish-orange spots in the distal half of the forewing. The male genitalia are most similar to those of *Caloptilia cuculipennella* (Hübner, 1796), but the valva is about twice as long as broad, whereas in *C. cuculipennella* it is three times as long as broad; the saccus is truncate rather than tapered in *C. cuculipennella*, and the coremata are of different shape. The female genitalia most resemble those of *Caloptilia stigmatella* (Fabricius, 1781) but can easily be recognized by the membranous, more weakly developed postvaginal plate, a different location of the ostium and the shorter pairs of apophyses.

Distribution. Known only from the mountains of Crimea.

Life history. Host plant unknown. The new species was collected in horizontal meadow-steppes at the altitude of 1100 m on Karabi-jaila (Figs 7, 8) and at 1200 m on Aj-Petri-jaila. The single female from Babugan-jaila was collected on a rather steep slope of Bolshaja Chuchel Mountain at an elevation of about 1350 m. All specimens were collected by sweeping over the grass with a net except for one female which was collected at light on Aj-petri jaila.

Etymology. The specific name refers to the habitats of the new species – jaila (from Crimean-Tatar “*yayla*”, high mountains summer pastures), the open horizontal slightly hilly mesophytic plateaus at elevations of 1000–1500 m covered mainly with grass, which are very characteristic for the highest parts of Crimean mountains.

Remarks. The generic assignment of the new species is rather unclear. The presence of R2+R3 in hindwing is characteristic for the *Gracillaria*-group (Huemer et al. 2016); however, the stalked M5+R1 in forewing (Fig. 6a), the connection between R2+R3 and R1 in hindwing (Fig. 6b) and rather broad forewing were not observed in any genera of this group. We provisionally place the new species in the genus *Caloptilia*, subfamily Gracillariinae (Kawahara et al. 2017) based on the male genitalia characters until its position within Gracillariidae can be clarified by DNA studies and further examination of the wing venation.



Figures 7, 8. Karabi-jaila, Crimea. Type locality of *Caloptilia jailensis* sp. n. (photographs S. P. Ivanov).

Depressariidae

Agonopterix yeatiana (Fabricius, 1781)

Material. 3 ♂, Ukraine, Odessa reg., Kiliya distr., Vilkovovo, 11.v, 14-15.viii.2014, leg. E. Khalaim. Genitalia slide: O. Bidzilya prep. no. 12/17.

Distribution. North Africa, Central and Southern Europe, Russia (Belgorod region, Krasnodar region), Transcaucasia (Georgia, Azerbaijan) (Lvovsky 2008). It is also known from Crimea (Lvovsky 2006).

Elachistidae

Elachista pollinariella Zeller, 1839

Figs 9, 10

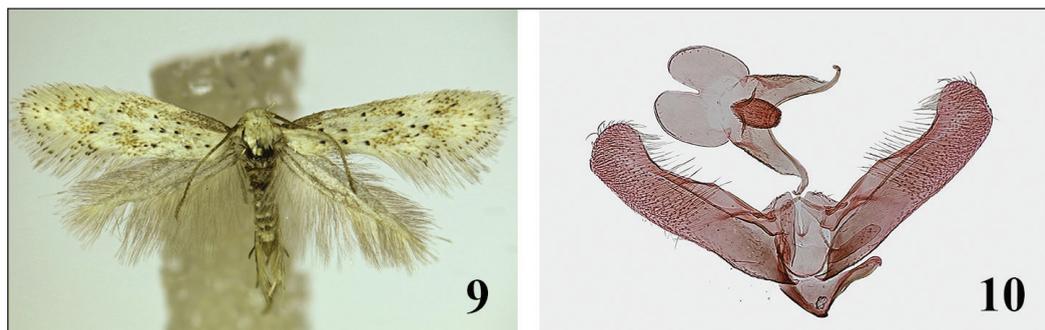
Material. 2 ♂, Ukraine, Kiev reg., Borodjanka distr., 2 km NW Potashnja, at light, 27.v.2016, leg. O. Bidzilya. Genitalia slide: O. Bidzilya prep. no. 273/16.

Distribution. Northern and Central Europe, Russia (Kaliningrad region, North-West and Center of the European part, Western Caucasus, Middle Volga region, South Ural) (Parenti 1996; Kaila et al. 2003; Sinev 2008a). In Ukraine it was known from Lvov and Tchernovtsy regions (Hormuzaki 1907; Schille 1930; Bidzilya et al. 2016).

Elachista gormella Nielsen & Traugott-Olsen, 1987

Material. 1 ♂, Ukraine, Odessa reg., 4 km E Gradenitsy, 1.v.2014, leg. E. Khalaim.

Distribution. Spain (with Balearic Islands), Portugal, France, Austria, Italy (with Sardinia), Czech Republic, Slovakia, Hungary, Russia (? Middle Volga region) (Parenti 1996; Sinev 2008a). It is also known from Crimea (Bidzilya et al. 2016).



Figures 9, 10. *Elachista pollinariella*. 9. Adult; 10. Male genitalia.

Elachista bisulcella (Duponchel, 1843)

Material. 1 ♂, Ukraine, Zaporizhzhia reg., Melitopol distr., Myrne Town, at light, N 46° 57', E 35° 26', 28.viii.2015, leg. A. Zhakov.

Distribution. Northern and Central Europe, Russia (Kaliningrad region, North-West of the European part, Middle Volga region, Altai) (Kaila 1992; Parenti 1996; Sinev 2008a). In Ukraine it was known from Lvov region only (Nowicki 1860; Schille 1930, as *zonariella* Tengström, 1848.; Bidzilya et al. 2016).

Biselachista serricornis (Stainton, 1854)

Material. 1 ♂, Ukraine, Rivne reg., Klevan 9 km N, Chervona Kalyna, 23.vii.2014, leg. O. Bidzilya; 1 ♂, 1 ♀, Ukraine, Odessa reg., Kiliya distr., Vilkoovo, 8, 10.viii.2016, leg. E. Khalaim.

Distribution. Northern and partially Central Europe, Russia (Northwest and Center of the European part) (Parenti 1996; Sinev 2008). **New for Ukraine.**

Oecophoridae

Batia lunaris (Haworth, 1828)

Material. 3 ♂, Ukraine, Odessa reg., Ivanovskiy distr., 5 km NW Severinovka vill., at light, 8.vi.2015, leg. O. Bidzilya. Genitalia slide: O. Bidzilya prep. no. 129/15.

Distribution. North Africa, Central and Southern Europe, Asia Minor, North America (Lvovsky 1996). In Ukraine it was known from Nikolajev region only (Bidzilya et al. 2013). The record from the Kiev region (Ljubomudrov 1917, Sovinskiy 1938) needs verification (Tokar et al. 2003).

***Aplota nigricans* (Zeller, 1852)**

Material. 4 ♂, Ukraine, Nikolaev reg., Actovo vic., Arbuzinka river canyon, at light, 3.vi.2016, leg. O. Bidzilya.

Distribution. Central and Southern Europe (Lvovsky 2006). **New for Ukraine.**

Gelechiidae***Caulastrocecis pudicella* (Mann, 1861)**

Material. 1 ♂, Ukraine, Lugansk reg., S vic. of Severedonetsk, dacha near Kleshnja lake, at light, 24.vi.2015, leg. S. Demianenko. Genitalia slide: O. Bidzilya prep. no. 173/16.

Distribution. Spain, Slovakia, Croatia, Romania, Asia Minor (Elsner et al. 1999). **New for Ukraine.**

***Metzneria intestinella* (Mann, 1864)**

Material. 1 ♂, Ukraine, Odessa reg., Ivanovskiy distr., Severinovka vic., at light, 2.v.2016, leg. A. Zhakov; 1 ♂, Zaporozhie reg., Akimovka distr., Atmanai, 17.iv.2016, leg. A. Zhakov.

Distribution. Portugal, Spain, France, Italy, Croatia, Macedonia, Slovakia, Hungary, Albania, Greece, Romania, Bulgaria (Karsholt and Riedl 1996; Elsner et al. 1999). It is also known from Crimea (Bidzilya et al. 2014).

***Ornathalva plutelliformis* (Staudinger, 1859)**

Material. 1 ♀, Ukraine, Kherson reg., Arabatskaya strelka, Schastlivtsevo, at light, 20.viii.2015, leg. O. Bidzilya.

Distribution. Spain (with Canary Islands), Portugal (with Madeira), North Africa, France (with Corsica), Italy (with Sardinia and Sicily), Malta, Macedonia, Hungary, Romania, Greece, Crete, Cyprus, Russia (Lower Volga region, Kalmykia), Iran, Central Asia (Uzbekistan), Pakistan, NW China (Karsholt and Riedl 1996; Elsner et al. 1999; Ponomarenko 2008; Falkovitsh and Bidzilya 2009). In Ukraine it was known from Zaporozhie region. It is also found in Crimea (Bidzilya and Budashkin 2004; Budashkin 2004).

***Chionodes electella* (Zeller, 1839)**

Material. 2 ♂, Ukraine, Kiev, Kiev National Taras Shevchenko University, Laboratory of Zoological Museum, on windowsill, 26.vi.2015, 24.vi.2016, leg. O. Bidzilya.

Distribution. Northern and Central Europe, Russia (North of European part, Amur region) (Huemer and Karsholt 1999; Ponomarenko 2008). In Ukraine it was known from Chernigov, Lvov and Ivano-Frankovsk regions (Schille 1930; Gershenzon 1988; Bidzilya et al. 2006).

Remarks. Two males were found in late June on a windowsill in the laboratory of the Zoological Museum during for two successive years. We assume that a population of the species exists on its host plant, a fir tree (*Picea abies* (L.) Karst. (Pinaceae) growing in the yard about 20 m away from the window. *Ch. electella* inhabits coniferous forests within the range of fir trees in western Ukraine. However, the species has also been recorded in artificial plantations (mainly in parks) of *Picea abies* in the forest zone in northern Ukraine (Gershenzon 1988). Our record confirms that *Ch. electella* is broadly distributed outside of the range of its host plant and may exist on single trees growing in isolation in urban habitats. This is similarly true for another gelechiid species, *Dichomeris latipennella* (Rebel, 1937), which has also been recorded from Kiev based on a single specimen bred from fir cones gathered under a single tree (Bidzilya et al. 2011).

Filatima djakovica Anikin & Piskunov, 1996, femina nova

Material. 4 ♂, 1 ♀, Ukraine, Kiev reg., Mironovka distr., 4 km W Khodorov vill., at light, 24.v.2015, leg. O. Bidzilya. Genitalia slide: O. Bidzilya prep. no. 10/17♂; 11/17♀.

Description. Herewith we provide the description of the hitherto unknown female.

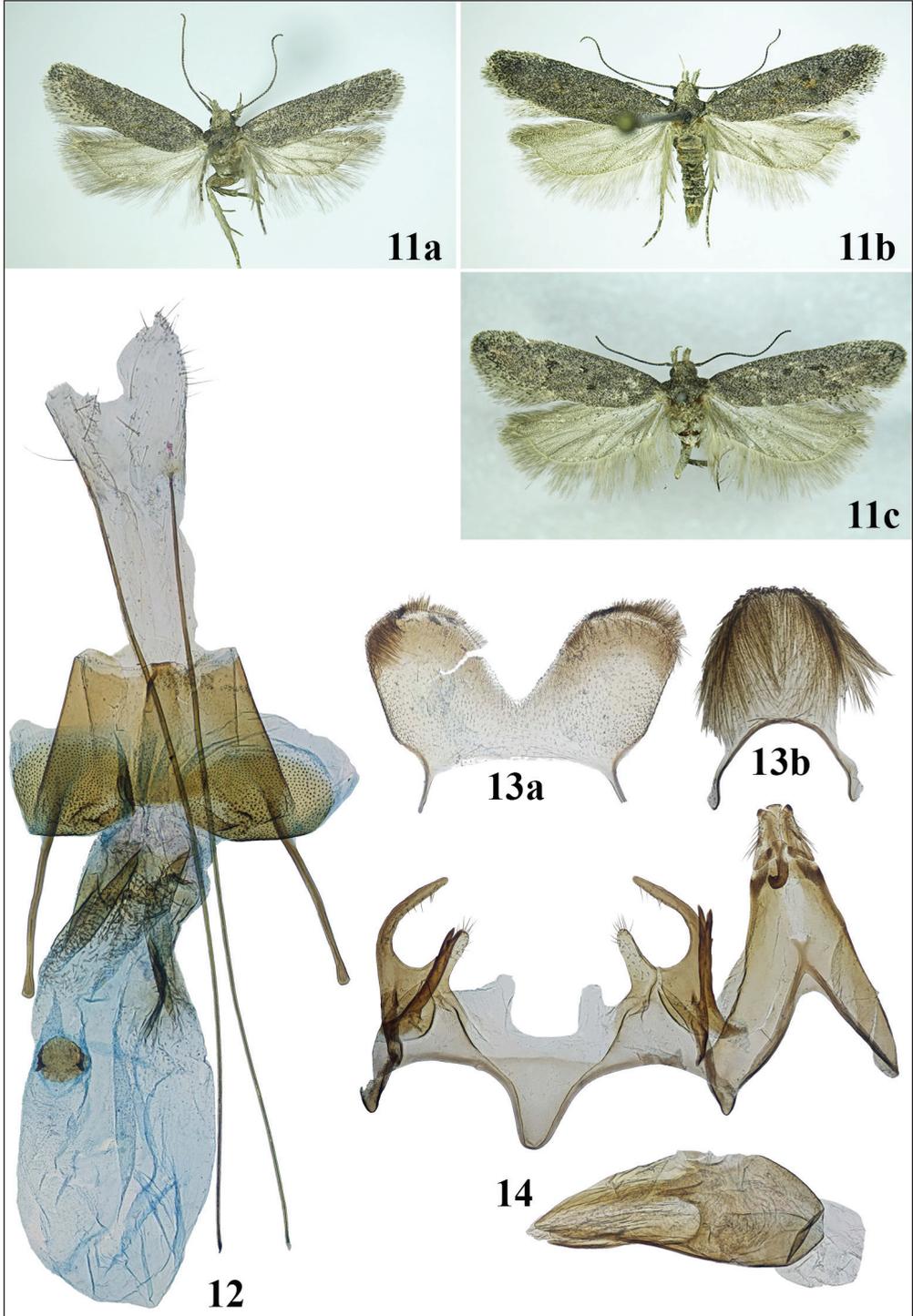
Female (Fig. 11a). Wingspan 12.1 mm. Head dirty white, neck mottled with brown, segment 2 of labial palpus dirty-white, outer and lower surface light grey mixed with brown-tipped scales, base brown, segment 3 whitish-brown, scape brown with some rare whitish scales, flagellum brown white-ringed in basal half. Thorax, tegulae and forewing covered with grey brown-tipped scales, fold light brown with indistinct black dash on base, three very indistinct black spots surrounded with light brown in cell, cilia light grey black-tipped. Hindwing light grey in basal half and dark grey in distal half, cilia grey.

Female genitalia (Fig. 12). Segment VIII trapezoidal, slightly narrowed distally; antrum narrow, tubular, of even width, the posterior margins strongly sclerotized, lateral sclerites large, rounded, densely covered with small spines; ductus bursae short and broad, covered with moderately long spines, with two elongated patches of lateral sclerotization; corpus bursae prolonged, signum a rounded plate with two basal short thorn-shaped processes.

Remarks. The sternum VIII of *F. djakovica* is most similar to that of *F. textorella* (Chrétien, 1908), but the lateral sclerites are larger. The antrum resembles that of *F. incomptella* (Herich-Schäffer, 1854) but lateral sclerotization is poorly developed and the spines are larger. The signum is similar to that of *F. tephritidella* (Duponchel, 1844) but it is more weakly edged and its lateral process is longer.

Distribution. Romania (Rákosy et al. 2003), Russia (Vladimir and Saratov regions) (Anikin and Piskunov 1996; Piskunov and Uskov 2006). In Ukraine it was known from Lugansk region only (Bidzilya and Budashkin 2004).

Notes. The single female differs from males in more uniformly greyish forewing with poorly expressed spots and in smaller size: the wingspan is 12.1 mm whereas the four males have a wing-



Figures 11–14. *Filatima djakovica*. 11. Adult; a. female; b, c. males; 12. Female genitalia; 13. Male abdominal segment VIII; a. sternum; b. tergum; 14. Male genitalia with phallus removed.

span 14.0–17.0 mm. The males are rather variable (Fig. 11b, c): the ground colour of the forewing varies from grey to brown, black spots in cell are usually hardly visible but can be well developed in some specimens. The male genitalia of our specimens (Figs 13, 14) match the holotype except for more weakly developed cornuti in the phallus. This variation has already been mentioned for specimens from the Vladimir region of Russia (Piskunov and Uskov 2006).

Scrobipalpa soffneri Povolný, 1964

Material. 4 ♂, Ukraine, Kherson reg., 10 km NE Radensk, Oleshki sands, 6.vi.2015, leg. O. Bidzilya.

Distribution. Bulgaria, Russia (Volgograd region, South Ural), Turkmenistan (Huemer and Karsholt 2010). **New for Ukraine.**

Scrobipalpa mixta Huemer & Karsholt, 2010

Material. 4 ♂, Ukraine, Zaporozhie reg., Akimovka distr., Atmanai, 17.iv.2016, leg. A. Zhakov.

Distribution. Macedonia, (?) Albania. It is also known from Crimea (Huemer and Karsholt 2010).

Klimeschiopsis kiningerella (Duponchel, 1843)

Material. 2 ♀, S Ukraine, Zaporizhzhia reg., Melitopol distr., Myrne Town, at light, N 46°57', E 35°26', 28.viii.2015, leg. A. Zhakov.

Distribution. Mountains of Central Europe, Scandinavia, Russia (Southern Ural) (Ponomarenko 2008; Huemer and Karsholt 2010; Junnilainen et al. 2010). In Ukraine it was known from Lvov region only (Schille 1930).

Sophronia semicostella (Hübner, 1813)

Material. 6 ♂, Ukraine, Kiev reg., Borodjanka distr., 2 km NW Potashnja, at light, 27.v.2016, leg. O. Bidzilya.

Distribution. Europe, Russia (North-West and Centre of the European part, Volga region) Turkey, Kazakhstan (?) (Elsner et al. 1999; Ponomarenko 2008; Kemal and Koçak 2017). In Ukraine it was known from Lvov region only (Schille 1930).

Syncopacma polychromella (Rebel, 1902)

Material. 1 ♂, Ukraine, Odessa reg., Beljaevskiy distr., 4 km E Gradentsu, 12.vi.2016, leg. S. Novitckiy.

Distribution. Spain (with Canary Islands), Portugal (with Madeira), Gibraltar, Italy (with Sicily), Austria, Malta, Croatia, Macedonia, Czech Republic, Greece, Crete, Cyprus, Middle East, Middle Asia, Mongolia, India. Introduced to Denmark, England and South Africa (Karsholt and Riedl 1996; Falkovitsh and Bidzilya 2009). **New for Ukraine.**

Urodidae

Wockia asperipunctella (Bruand, 1850)

Material. 1 ♀, Ukraine, Kiev reg., Brovary distr., Knjazhichi, at light, 29.vii.2016, leg. A. Zykov.

Distribution. France, Germany, Italy, Austria, Norway, Sweden, Czech Republic, Croatia, Slovenia, Poland, Slovakia, Hungary, Finland, Estonia, Latvia, Romania, Russia (European part and Altai), North America (Sinev 2016). In Ukraine it was known from Lvov region only (Schille 1930).

Pterophoridae

Agdistis satanas Milliere, 1876

Material. 1 ♂, Ukraine, Odessa reg., Kiliya distr., Vilkovo vic., Zhebrijanskaya grjada, 5–7.viii.2016, leg. E. Khalaim.

Distribution. North Africa, Southern and partially Central Europe, Asia Minor, Middle East (Arenberger 1995). It also known from Crimea (Budashkin and Savchuk 2008).

Stenoptilodes taprobanes (Felder & Rogenhofer, 1875)

Material. 1 ♂, Ukraine, Odessa reg., Kiliya distr., Vilkovo, 3-7.viii.2014, leg. E. Khalaim.

Distribution. Spain (with Canary Islands), Portugal (with Madeira), North Africa, France, Malta, Italy (with Sicily), Finland, Greece, Crete, Cyprus, Bulgaria, Asia Minor, Iran, Russia (Southern Primorye), India, Japan (Zagulajev 1986; Bigot and Picard 1996; Ustjuzhanin and Kovtunovich 2008). It is also known from Crimea (Budashkin 2006).

Pyralidae

Phycita torrenti Agenjo, 1962

Material. 4 ♂, 13 ♀, [Ukraine] Crimea, Karadag, biostancija, at light, 29.viii.1985, 10.ix.1986, 26.vii–17.x.1987, 28, 30.viii.2003, 20.viii.2014, leg Yu. Budashkin. Genitalia slide: O. Bidzilya prep. no. 640/14♀, 641/14♂, no. 75/15♂.

Distribution. Portugal, Spain, France, Croatia, Hungary (Pastoralis and Slamka 2015). **New for Ukraine.**

***Pempelia albariella* (Zeller, 1839)**

Material. 1 ♂, Ukraine, Odessa reg., Ivanovski distr., Russkaya Slobodka vic., at light, 4.vi.2016, leg. O. Bidzilya.

Distribution. Spain, France, Italy (with Sicily), Croatia, Macedonia, Slovakia, Hungary, Romania, Russia (Middle and Lower Volga regions), Transcaucasia, Middle Asia (Sinev 1986, 2008b; Speidel 1996). It is also known from Crimea (Budashkin 2004).

Crambidae***Ostrinia kasmirica* (Moore, 1888)**

Material. 1 ♂, Ukraine, Lugansk reg, S vicinity of Severodonetsk, dacha near Kleshnya lake, at light, 31.vii.2015, leg. S. Demyanenko. Genitalia slide: O. Bidzilya prep. no. 444/16; 1 ♀, Kherson reg., Arabat-skaya strelka, Schastlivtsevo, 2.viii.2016, leg. O. Bidzilya, Genitalia slide: O. Bidzilya prep. no. 37/17; 1 ♀, [Kazakhstan], Ural m., Uralsk, 6.vii.1913. Genitalia slide: O. Bidzilya prep no. 449/16.

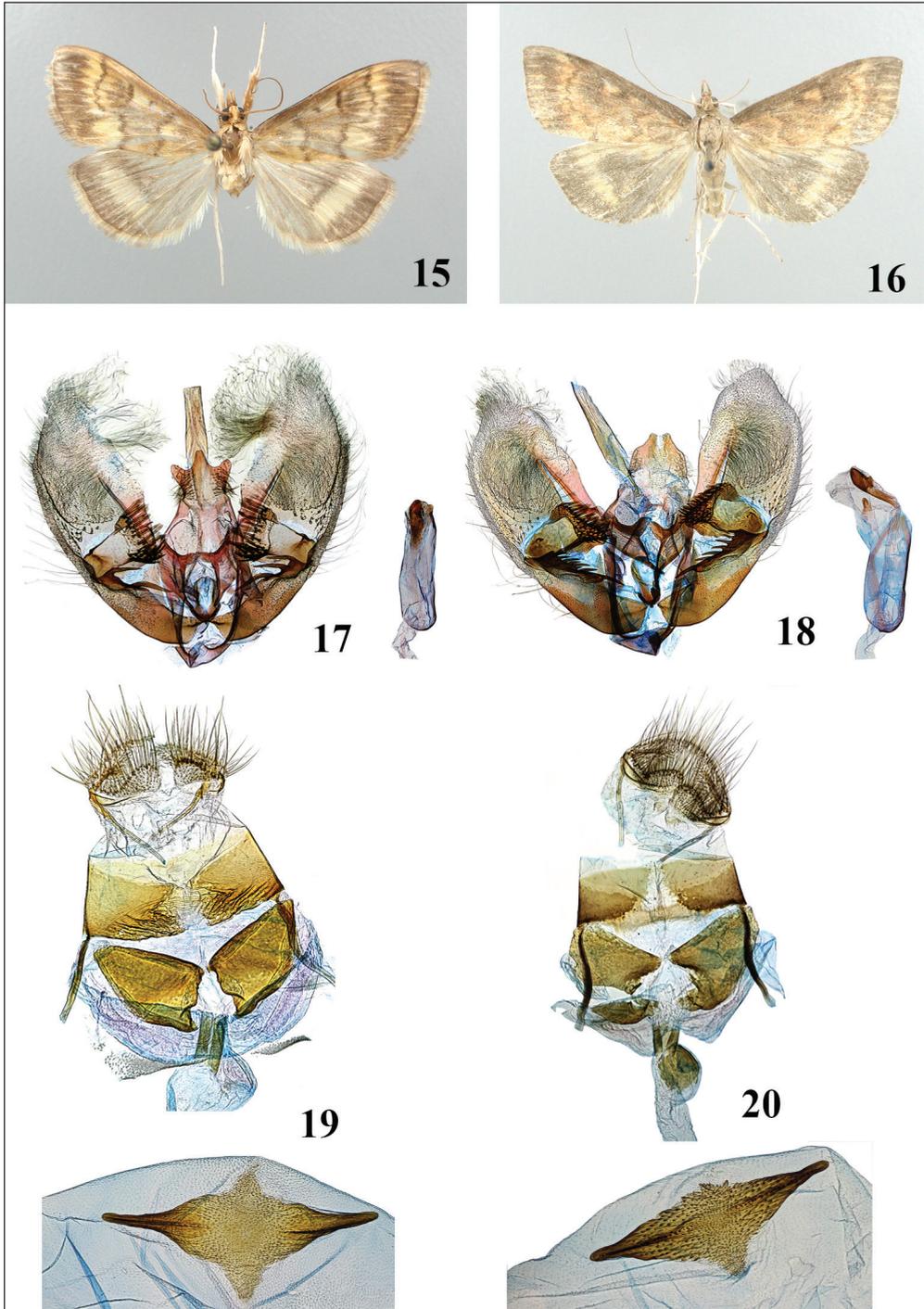
Remarks. *O. kasmirica* resembles externally *O. nubilalis* (Hübner, 1796) and *O. scapularis* (Walker, 1859) but differs from both related species in narrower and more serrated light fascia on the hindwing (Figs 15, 16). Additionally, *O. kasmirica* can be distinguished from *O. scapularis* by the hindtibia which is not thick and hairy in the male (Slamka 2013). The male genitalia of *O. kasmirica* differ from those of *O. scapularis* and *O. nubilalis* in the bilobed rather than trilobed uncus and the sacculus bears more spines (Figs 17, 19). The female genitalia of *O. kasmirica* are characterized by a narrow and not wrinkled sternum VIII in contrast to distinctly wrinkled and rather broad sternum VIII in related species (Figs 18, 20). In summary, *O. kasmirica* can easily be distinguished by the genitalia of both sexes, whereas the separation of two related European species, *O. nubilalis* and *O. scapularis*, remains rather problematic (Slamka 2013: 59).

Distribution. Ukraine, Russia (South Ural, Southern Siberia), Western Kazakhstan (Uralsk), Turkmenistan (ssp. *eurasiatica* Mutuura & Munroe, 1970), Pakistan, India (ssp. *kasmirica*) (Slamka 2013). In Ukraine it was known from Dnepropetrovsk region (Kosakevich 1978). It is also found in Crimea (Budashkin 2004).

***Hodebertia testalis* (Fabricius, 1794)**

Material. 1 ♂, 1 ♀, Crimea, Karadag, biostancija, at light, 20.ix, 6.x.2016, leg. Yu. Budashkin.

Distribution. Native to subtropics and tropics, probably resident in the Mediterranean area: Spain (with Canary Islands), Portugal (with Madeira), North Africa, Malta, France, Italy (with Sicily), Croatia, Greece, Asia Minor, Middle East. The records from Crimea as well as the single records from the British Isles and Switzerland belong most likely to migrants (Slamka 2013). **New for Ukraine.**



Figures 15–20. *Ostrinia* spp. **15, 17, 19.** *O. nubilalis*: **15.** Adult, male, Lugansk reg.; **17.** Male genitalia, Kiev reg.; **19.** Female genitalia, Kiev reg. **16, 18, 20.** *O. kasmirica*: **16.** Adult, female, Kherson reg.; **18.** Male genitalia, Lugansk reg.; **20.** Female genitalia, Kherson reg.

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***Gielisella* gen. n., a new genus and two new species from southern Spain (Lepidoptera: Elachistidae: Parametriotinae) with a catalogue of parametriotine genera**

J.C. (SJAAK) KOSTER¹, ERIK J. VAN NIEUKERKEN¹

¹ *Naturalis Biodiversity Center, PO Box 9517, NL-2300 RA Leiden, Netherlands;*
sjaak.koster@naturalis.nl; nieukerken@naturalis.nl

<http://zoobank.org/B34CC9BF-5C8F-40E1-BE7D-85E754F898D6>

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Abstract. The genus *Gielisella* gen. n., belonging to the Elachistidae: Parametriotinae is described with two new species from southern Spain: its type species *G. clarkeorum* sp. n. and *G. nigripalpis* sp. n., both only known from adults collected at light. DNA barcodes of both species are provided. The taxonomic history of the Parametriotinae is discussed and a catalogue of the 35 recognised genera is provided as appendix. The arguments for erecting a new genus are discussed and we hypothesize that this constitutes an overlooked native Palearctic element, although we cannot completely rule out the possibility of imported exotic species.

Introduction

With almost 20,000 described species, the Gelechioidea forms one of the mega-diverse superfamilies of the Lepidoptera, exhibiting maybe the largest diversity of life histories anywhere in Lepidoptera, including saprophagy, entomophagy, all kinds of phytophagy such as leafmining, galling, case-building, webbing, etc. (Kaila et al. 2011; Heikkilä et al. 2014). Phylogenetically the superfamily has a chequered history, particularly concerning the family level classification, with genera and subfamilies switching from one to another family and family size changing frequently (Minet 1990; Hodges 1998; Kaila 2004; Kaila et al. 2011; van Nieukerken et al. 2011; Heikkilä et al. 2014). One of the taxa that has such a chequered history is the group until recently known as the family Agonoxenidae, or the subfamily Agonoxeninae in Elachistidae. Once it was shown that the type genus *Agonoxena* Meyrick, 1921 does probably not form a monophylum with the other genera, these were removed to the subfamily Parametriotinae (Elachistidae) (Kaila 2004; Kaila et al. 2011; Heikkilä et al. 2014), of which more than 50 species are known in the Palearctic Region with 16 species in six genera in Europe (Koster and Sinev 2003; Sinev and Koster 2013).

In 1978 Cees Gielis collected a small unknown female gelechioid moth in Spain, province of Granada. The senior author and Sergey Sinev examined the specimen when preparing the manuscript for the series Microlepidoptera of Europe (Koster and Sinev 2003) and concluded that it belonged to an unknown genus and species in the Agonoxenidae. However, they considered the single female specimen insufficient for the description of a new genus and species and did not include it in their treatment (Koster and Sinev 2003).

In February 2013 the senior author became aware of new material of this species collected by Peter and Ginny Clarke in Almería, Spain, brought to his attention by Martin Corley. Photos of the female genitalia confirmed that the species was conspecific with the unknown species collected years ago in Granada. More material was gathered in the same locality the following years, and surprisingly turned out to belong to two closely related species.

Although we were convinced that the new species belong to Parametriotinae, the lack of a phylogenetic framework or even a taxonomic catalogue made our search for the correct placement of these species almost impossible. After we canvassed several specialists, we considered several possibilities, from an introduction from Australia to an unknown and hitherto overlooked Palaearctic genus. In view of the lack of a catalogue and of the fact that the composition of the subfamily has been considerably revised recently, we were prompted to prepare a generic catalogue of the subfamily, here published as an appendix. We also provide a brief diagnosis of the subfamily, and a brief taxonomic history.

Since we were unable to match our new species in external morphology or in genitalia to any of the described genera, we describe here the new genus *Gielisella* and two new species, and provide DNA barcodes of both species.

Methods

Genitalia were dissected following the methodology presented by Robinson (1976) and Brown (1997). It is often impractical to spread the valvae of the male genitalia of Parametriotinae in the ventral position, because of the rigid structure of the vinculum; we therefore avoided spreading. Adults are illustrated by water colours prepared by JCK and with photographs prepared by EvN. Watercolours are primarily prepared from a single specimen, but details may be taken from other specimens; in Fig. 1 the abdomen is taken from a different specimen; the left wings and antennae in the watercolours are not painted, but added in Photoshop as mirror images of the right counterparts. Drawings of the wing venation and the genitalia were made with a compound microscope using the camera lucida method. For this purpose a strong light source (slide projector) was used for the illumination on the mirror of the microscope. A prism was placed on top of the microscope eyepiece to bend the projection 90° and project the subject on drawing paper. All outlines were drawn by pencil and later set in Indian ink. The head in Fig. 3 was drawn and adjusted on the basis of a photograph.

Photographs of moths were prepared with an AxioCam digital camera attached to a motorized Zeiss SteREO Discovery V12, using the Module Extended Focus in the Carl Zeiss AxioVision software to prepare a picture in full focus from a Z-stack of about 10 to 25 individual photos. Genitalia were photographed with a similar AxioCam camera on a manually operated Zeiss Axioskop H, with just a single exposure.

Morphological terms follow Koster and Sinev (2003), except for the use of phallus rather than aedeagus and the separation of the veins Rs (radial sector) from R, following most modern Lepidoptera treatments (Kristensen 2003).

The distribution map was prepared with DMAP 7.2c (Morton 2000).

DNA barcodes were derived from extracts taken from either legs or the abdomen, following the procedures outlined by van Nieukerken et al. (2012). Sequence data have been deposited in the public BOLD dataset “*Gielisella* [DS-GIELIS]” [doi: 10.5883/DS-GIELIS] and GenBank (Table 1). For comparison we downloaded publicly available DNA barcodes of several other Para-

Table 1. *Gielisella* spp., registration numbers, BOLD numbers, COI gene length and GenBank accession numbers. See also BOLD dataset <http://dx.doi.org/10.5883/DS-GIELIS>.

Taxon	Type status	Sample Id	BIN	BOLD Process Id	COI-5P	GenBank	Collection
<i>Gielisella clarkeorum</i>	Holotype	RMNH.INS.544306	BOLD:ACU7245	LRMNH048-15	658	MF322622	RMNH
<i>Gielisella clarkeorum</i>	Paratype	RMNH.INS.544295	BOLD:ACU7245	LRMNH014-15	658	MF322624	RMNH
<i>Gielisella clarkeorum</i>	Paratype	RMNH.INS.544296	BOLD:ACU7245	LRMNH015-15	658	MF322623	coll. Clarke
<i>Gielisella nigripalpis</i>	Holotype	RMNH.INS.544307	BOLD:ACY4816	LRMNH049-15	658	MF322625	RMNH

metriotinae from the BOLD databases (Ratnasingham and Hebert 2007). The figured Neighbour Joining tree was prepared with the tree building tools on BOLD. The tree should not be regarded as showing phylogenetic relationships, since the selection of barcodes was done *a priori* and there are other, unrelated species, that have barcodes closer to some of these species.

Abbreviations

ANIC	Australian National Insect Collection, CSIRO, Canberra, ACT, Australia.
NHMUK	The Natural History Museum, London, United Kingdom.
BOLD	Barcoding of Life Datasystems, http://www.barcodinglife.com/
EvN	Erik J. van Nieuwerkerken
JCK	J.C. (Sjaak) Koster
MNCN	Museo Nacional de Ciencias Naturales, Madrid, Spain.
PGC	Collection Peter & Ginny Clarke, Glasbury on Wye, United Kingdom.
RMNH	Naturalis Biodiversity Center, Leiden, the Netherlands.
TMSA	Ditsong Museum of Natural History (former Transvaal Museum), Pretoria, South Africa.
ZIAN	Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia.

Systematics

Parametriotinae

Diagnosis

The subfamily is very heterogeneous and members are therefore difficult to distinguish from other families in Gelechioidea on external characters alone. There are similarities to species of Coleophoridae, Cosmopterigidae and Momphidae. If the forewing has a series of up to ten tufts of raised scales, more or less arranged in pairs, the moth belongs to the genera *Leptozelestis* Meyrick, 1924 or *Trachydora* Meyrick, 1897. The male genitalia in Parametriotinae are characterized by the divided gnathos with at each arm the typical distal appendage in the shape of a spherical process with spines or peg-like setae or by a bundle of teeth. In the female genitalia is the presence of a small to large antrum with which the underneath connected ductus seminalis in combination with the long, rather narrow ductus bursae and the elongated corpus bursae are characteristic. Examination of the genitalia is necessary for proper identification. Some Roeslerstammiidae (e.g. *Vanicela* Walker, 1864) have confusingly similar male genitalia with a similar paired spinose gnathos, but can be separated by the absence of scaling on the haustellum (Dugdale 1988, R.B.J. Hoare pers. comm.).

Description

Forewing length between ca 3–10 mm. Head smooth, neck tufts slightly raised, ocelli absent, haustellum well developed and scaled. Antenna from three-fourths length to longer than length of forewing, scape often with pecten. Labial palpi rather long and porrect, segment three angled upwards, segment two often shorter than segment two and often rough scaled ventrally, sometimes with protruding bundle longer than segment; maxillary palpi very short.

Forewing and hindwing lanceolate to very lanceolate, most genera with two to ten tufts of raised scales, sometimes with tubercular silvery metallic spots. Forewing with 11 veins, Rs3 and Rs4 stalked, M2, M3, CuA1 and CuA2 often from posterior end of cell and sometimes stalked. Hindwings with 8–10 veins, Sc + R to beyond middle of wing, rarely ending before middle; M1 and M2 stalked. Tibia of midleg apically with one pair of spurs of unequal length, tibia hindleg medially and apically with pair of spurs of unequal length and dorsally with comb of long hairs.

Tergites of abdomen without specialized scales or spines; apodemes tergite I strong and anteriorly widened, semi-circular to straight, apodemes tergite II long and thin, sometimes longer than apodemes of tergite I.

Male genitalia. Uncus present, but often weakly developed and hardly noticeable as small lobe(s); tegumen well-developed, often tapering distally; gnathos as separated pair of arms ending in spherical process with many with rows of spines or peg-like setae or as bundle of teeth; vinculum narrow to rather broad; saccus from small or even absent to very long and rod-shaped; anellus lobes pronounced and often distally dentose; juxta lobes present; valvae large and simple, sometimes small and rounded, weakly sclerotized, occasionally with costal lobe; phallus mainly long, cylindrical and often curved, sometimes short and tapering or distally hooked.

Female genitalia. Apophyses posteriores from almost similar in length to more than ten times as long as apophyses anteriores; sclerotization of tergite VIII can be of diagnostic importance; antrum rather small to very wide, sometimes with sclerotization; ductus bursae long and slender; ductus seminalis attached just anterior of antrum; corpus bursae elongate with a single signum or without signum.

Biology

Where known, larvae of Parametriotinae are bark- or twig-borers, fruit borers, leaf miners or gall makers on a variety of woody and herbaceous plants of various families. Larvae of European species have been found on Eudicot hosts of the following families: Asteraceae, Fagaceae, Rosaceae, Salicaceae, and Malvaceae (Koster and Sinev 2003). In other parts of the world Theaceae, Euphorbiaceae, Proteaceae, Myrtaceae and the conifers Araucariaceae and Cupressaceae have also been recorded as hostplants (Common 1990; Hodges 1997; Hodges 1998; Landry and Adamski 2004).

Taxonomic history of Elachistidae: Parametriotinae

In the 19th and in most of the 20th century the species, now in Parametriotinae, were placed in several families. Originally, in most 19th century works, like most Microlepidoptera, they were simply placed in the Tineidae. After splitting the Tineidae into several smaller groups, sometimes recognised as families or subfamilies, they were considered either to belong to Cosmopterigidae (Meyrick 1928; Réal 1966; Bradley 2000) or Momphidae (Spuler and Meess 1910; Benander

1946; Riedl 1969), family names that were often used for the same groups of genera that share narrow wings, venational characters and often tufts of raised scales on the forewings.

The name *Agonoxena* was introduced by Meyrick (1921) while describing *Agonoxena argaula* Meyrick, 1921, the coconut flat moth. He placed this genus in Coleophoridae, but stated that it was an aberrant form of doubtful position. Meyrick (1924) described another species of this genus of coconut feeders, but the third species connected to coconut was described in the new genus *Haemolytis* Meyrick, 1926, due to the different venation. Since these genera did not really fit in Coleophoridae or other existing families, Meyrick erected a new family Agonoxenidae (Meyrick 1926) for these coconut feeders. Bradley (1966), in his comparative study of the coconut flat moth, described a fourth species and synonymized *Haemolytis* with *Agonoxena* (Agonoxenidae). In his opinion the family had a closer affinity with Oecophoridae than with Cosmopterigidae.

Kusnezov (1916) described the tiny moth *Parametriotes theae* Kuznetsov, 1916, the larvae of which were injurious to tea bush plantations in Transcaucasia, which he likewise placed in the family Coleophoridae. The generic name *Parametriotes* Kuznetsov, 1916 was derived from *Metriotes* Herrich-Schäffer, 1853 (Coleophoridae) because of its superficial similarity with his new genus. Fletcher (1929) transferred *Parametriotes* to the Cosmopterigidae. Much later, Căpușe (1971) placed this genus in a new family, the Parametriotidae.

In North America Hodges (1962) in his revision of the Cosmopterigidae of North America noticed that he could divide the species of Momphidae into two groups according to the genitalia. He provisionally divided these in ‘*Mompha* and allies’ and ‘*Blastodacna* and allies’.

Clarke (1962) described a new species in the genus *Homoeoprepes* Walsingham, 1909, earlier described in Lavernidae (a synonym of Momphidae) from the Neotropics. He simply used the family name Blastodacnidae as an established name in the title, but did not provide any reasons for that, nor a description, and therefore the family name is a *nomen nudum* and unavailable (Nye and Fletcher 1991). Nevertheless the name Blastodacnidae was widely used after that, either as family name or as subfamily name Blastodacninae, but was never made formally available.

Hodges (1978), in his new classification of the Gelechioidea, placed Agonoxenidae in his list after the Coleophoridae. He divided the family in the subfamilies Agonoxeninae and Blastodacninae. The latter was also divided in the tribus Blastodacnini and Parametriotini. Hodges placed only the genus *Agonoxena* (the species feeding on palms, Arecaceae) in the subfamily Agonoxeninae. He placed 11 genera in the Blastodacninae, tribus Blastodacnini and two genera in the tribus Parametriotini: *Parametriotes* Kuznetsov, 1916 and *Aetia* Chambers, 1880 (a junior homonym of *Aetia* Agassiz, 1847 (Nye and Fletcher 1991)). Both are now considered to be synonyms of *Haplochrois* Meyrick, 1897 (Sinev 1999).

Hodges’ concept of Agonoxenidae, including the Blastodacninae, was followed widely for the next two decades, including major checklists such as those for the Nearctic (Hodges 1983), Neotropics (Becker 1984) and Europe (Riedl 1996), albeit in slightly different arrangements with related families.

There were two notable exceptions: Minet (1990) was the first to recognise an enlarged Elachistidae, and regarded Agonoxeninae as a subfamily. This was amongst others followed in the Austrian checklist (Huemer and Tarmann 1993).

However, in Australia, Common (1990) kept both Agonoxenidae and Blastodacnidae as separate families, later repeated in the Australian checklist (Nielsen 1996a; b).

Up to the end of the 20th century, the classifications were still based on classical taxonomic authority, giving diagnostic characters, which may be sometimes termed as apomorphies, but without modern phylogenetic analyses. This changed when Hodges (1998) published – in the Handbook of Zoology – a phylogenetic cladistic analysis of the Gelechioidea, in which he recognised a much enlarged Elachistidae, as Minet did before, and downgraded Agonoxeninae as a subfamily, with Blastodacninae and Parametriotinae as synonyms. The synonymy of Blastodacninae and Parametriotinae was followed in the key work by Koster and Sinev (2003), but using it again as a full family, Agonoxenidae.

A more extensive cladistic analysis, still based on morphology alone, was published by Kaila (2004). He also recognised an expansive Elachistidae, comparable to that of Hodges (1998), but he separated Parametriotinae from the Agonoxeninae, since *Agonoxena* in his analysis grouped with Elachistinae s.s. and not with the other parametriotine genera. The mainly Australian genus *Trachydora* (erroneously named *Trachystola* in some places in Kaila's paper), previously placed in Cosmopterigidae: Chrysopeliinae, also grouped with Parametriotinae in his analysis, that further comprised the genera *Blastodacna* Wocke, 1876, *Spuleria* Hofmann, 1898, *Heinemannia* Wocke, 1876 and *Microcolona* Meyrick, 1897.

The recent Lepidoptera family classification (van Nieukerken et al. 2011) accepted an expanded Elachistidae with Agonoxeninae and Parametriotinae as two of the eight subfamilies. Meanwhile, molecular studies were further changing the landscape of Lepidoptera classification, but the two pivotal studies until then (Regier et al. 2009; Mutanen et al. 2010) did not yet include any of the parametriotine or agonoxenine genera.

That changed in the first molecular phylogeny of Gelechioidea (Kaila et al. 2011), that included *Trachydora* Meyrick, 1897, *Microcolona*, *Heinemannia*, *Blastodacna* and *Chrysoclista* Stainton, 1854, but not *Spuleria*. These form a clade together with the mainly Australian genus *Leptozelestis*, earlier considered as Cosmopterigidae: Chrysopeliinae and the monotypic Australian *Coracistis* Meyrick, 1897, moved from the Stathmopodidae. Unfortunately the genus *Agonoxena* was not analysed, so that the placement of that genus could not be confirmed. This analysis also showed that such a large Elachistidae probably could not be maintained, as different subgroups ended up in different places in the tree. However, due to low support values, the classification was not yet changed.

In an elegant combined analysis of morphological and molecular characters, Heikkilä et al. (2014) finally provided a detailed phylogeny of Gelechioidea resulting in an updated classification. They dismantled the Elachistidae, removing most subfamilies to Depressariidae, and maintaining a much smaller Elachistidae, with subfamilies Elachistinae, Agonoxeninae and Parametriotinae. They analysed all eight genera that Kaila analysed in his previous papers, and in their maximum likelihood tree they group in two (relatively) well supported clusters: one mostly Australian (bootstrap support 100), with *Coracistis*, *Leptozelestis* and *Trachydora*, the other (bootstrap support 88, 100 without *Microcolona*) with *Microcolona*, *Heinemannia*, *Blastodacna*, *Chrysoclista* and *Spuleria*. Unfortunately the type-genus *Haplochrois* (= *Parametriotis*) has not yet been analysed.

Whereas these phylogenetic studies only comprise a subset of genera, more detailed taxonomic studies have in recent years added information on the composition of the subfamily, and on the basis of these works together (Hodges 1997; Becker 1999; Sinev 1999; Landry and Adamski 2004; Sinev 2004) and several other sources we provide a tentative catalogue of 35 genera in this subfamily (appendix). Lvovsky (1996) erected a separate subfamily Lamprysticinae for the genus

Lamprystica Meyrick, 1914. On the basis of morphological characters alone, Heikkilä et al. (2014) could not place this genus in the classification. We tentatively leave this subfamily outside of Parametriotinae.

***Gielisella* gen. n.**

<http://zoobank.org/003CB133-A2ED-4CC7-ABDD-ACDDD2C679CA>

Type-species. *Gielisella clarkeorum*, sp. n., by present designation.

Diagnosis. The narrow forewings, the long, slender and curved gnathos arms with a pecten in the male genitalia, in combination with the wide antrum and the irregular row of spicules in the ductus bursae in the female genitalia are characteristic for *Gielisella*. Resembles in Europe species in the genus *Haplochrois* in the narrow forewings and hindwings, but can easily be distinguished by the more colourful forewings with tufts of raised scales and by the male and female genitalia.

The morphology of the male genitalia differs from all other known Parametriotinae genera. Especially, the gnathos arms are peculiar. In many genera the gnathos arms have distal spheres covered with rows of spicules. In *Chrysoclista*, the gnathos arms are strongly sclerotized with distal teeth. In the new genus, the gnathos arms bear a pecten of flat pegs.

Description. Head (Fig. 3). Appressedly scaled, frons slightly convex, vertex smooth, neck tufts with longer and more protruding scales, antennae about 6/7 length of forewing, ocelli absent. Scape with pecten. Labial palpus of moderate length, about two and half times of diameter compound eye, upturned, not reaching top of head, first segment short, second segment two times length of third, widening distally by rough ventral scaling, third segment cylindrical. Maxillary palpus small, three segmented, fold over base of proboscis. Haustellum well-developed, scaled at base.

Thorax. Smoothly scaled, including tegulae. Legs: Tibia foreleg with epiphysis; tibia midleg with two short apical spurs, inner 1/3 longer than outer; tibia hindleg with two medial spurs, inner 2× length of outer, and two apical spurs, inner slightly longer than outer, dorsally and ventrally with comb of long hairs, dorsal comb 2× as long.

Wings (Fig. 4). Forewing lanceolate, apex acuminate with two small tufts of raised scales, 12 veins present, cell closed, Sc, R, Rs1–4 to costa, Rs3 and Rs4 stalked, M1–CuA2 to dorsum, CuP very weak and not reaching dorsum, 1A+2A to dorsum, forked at base. Hindwing lanceolate, apex acuminate, frenulum single bristle in male, two bristles in female, 7 veins present, Sc+R and Rs to costa, M1–CuA2 to dorsum, 1A+2A rudimentary, Sc+R strongly curving towards costa in middle.

Abdomen (Fig. 5). Apodemes tergite I semi-circular, hooked at tip; apodemes tergite II long and thin, apodemes and venulae of sternite II long and narrow in male, in female hardly visible.

Male genitalia (Figs 6–9, 13–20). Uncus short and broad. Gnathos with long and slender arms, bearing pecten of flat pegs or setae. Tegumen large. Valvae long and weakly sclerotized. Anellus lobes large and apically denticulate. Vinculum broad. Phallus long, curved about 90 degrees, vesica with row of needle shaped cornuti.

Female genitalia (Figs 11, 21–25). Antrum wide. Ductus bursae long and with irregular row of spicules in distal half. Corpus bursae with single signum.

Distribution. Currently only known from the two new species, found in a small area of Mediterranean Spain, provinces of Almería and Granada.

Etymology. The generic name *Gielisella* is derived from the family name Gielis, in honour of Cees Gielis, collector of the first specimen. The name is to be regarded as feminine.

***Gielisella clarkeorum* sp. n.**

<http://zoobank.org/AFBC51FB-25D0-4615-9EA4-598553329430>

Figs 1, 3–7, 10, 11, 13, 14, 17, 18, 21–29

Type material. **Holotype** ♂, **Spain**, Almería, Enix, 36°52'38.49"N 2°36'24.83"W, 5.iii.2015, coll. nr. 580, leg. PJ & VF Clarke; gen. slide JCK 8361, RMNH.INS.544306 (RMNH).

Paratypes: 1♂, 8♀. **Spain**, Almería, same locality as holotype, all leg. PJ & VF Clarke: 1♀, 17.iii.2007, coll. nr. 099, gen. slide Clarke 99 (NHMUK); 1♀, 17.iii.2007, coll. nr. 122, gen. slide Clarke 122 (PGC); 1♂ [moth lost], 17.iii.2008, coll. nr. 171, gen. slide Clarke 171, RMNH.INS.15524 (RMNH); 1♀ [left wings prepared], 17.iii.2008, coll. nr. 166, gen. slide Clarke 166, wing slide JCK 8200 (MNCN); 1♀, 17.iii.2008, coll. nr. 173, gen. slide Clarke 173 (PGC); 1♀ [specimen not spread], 15.ii.2013, coll. nr. 435, gen. slide JCK 8363, RMNH.INS.544295 (RMNH); 1♀ [specimen not spread], 21.iii.2013, coll. nr. 445, RMNH.INS.544296 (PGC); 1♀ [specimen not spread], 18.iii.2014, coll. nr. 544 (PGC). **Spain**, Granada, 1♀, Yator, 22.iv.1978, [leg. C. Gielis]; "Agonoxenidae gen.nov. spec.nov. det J.C.Koster, prep 3850 ♀", "Museum Leiden, ex collectie C. Gielis", "B. hellerella [handwriting Gielis]", RMNH.INS.15525 (RMNH).

Diagnosis. *Gielisella clarkeorum* can be separated from *G. nigripalpis* by the pale tipped palpi, and the longitudinal dark streaks on the forewings. In the male genitalia it differs by the two groups of setae on the uncus; by the wide and cylindrical apex of the anellus lobes with a lateral projection near the apex, the more longitudinal shape of the valvae and by the gradual increasing length of the cornuti.

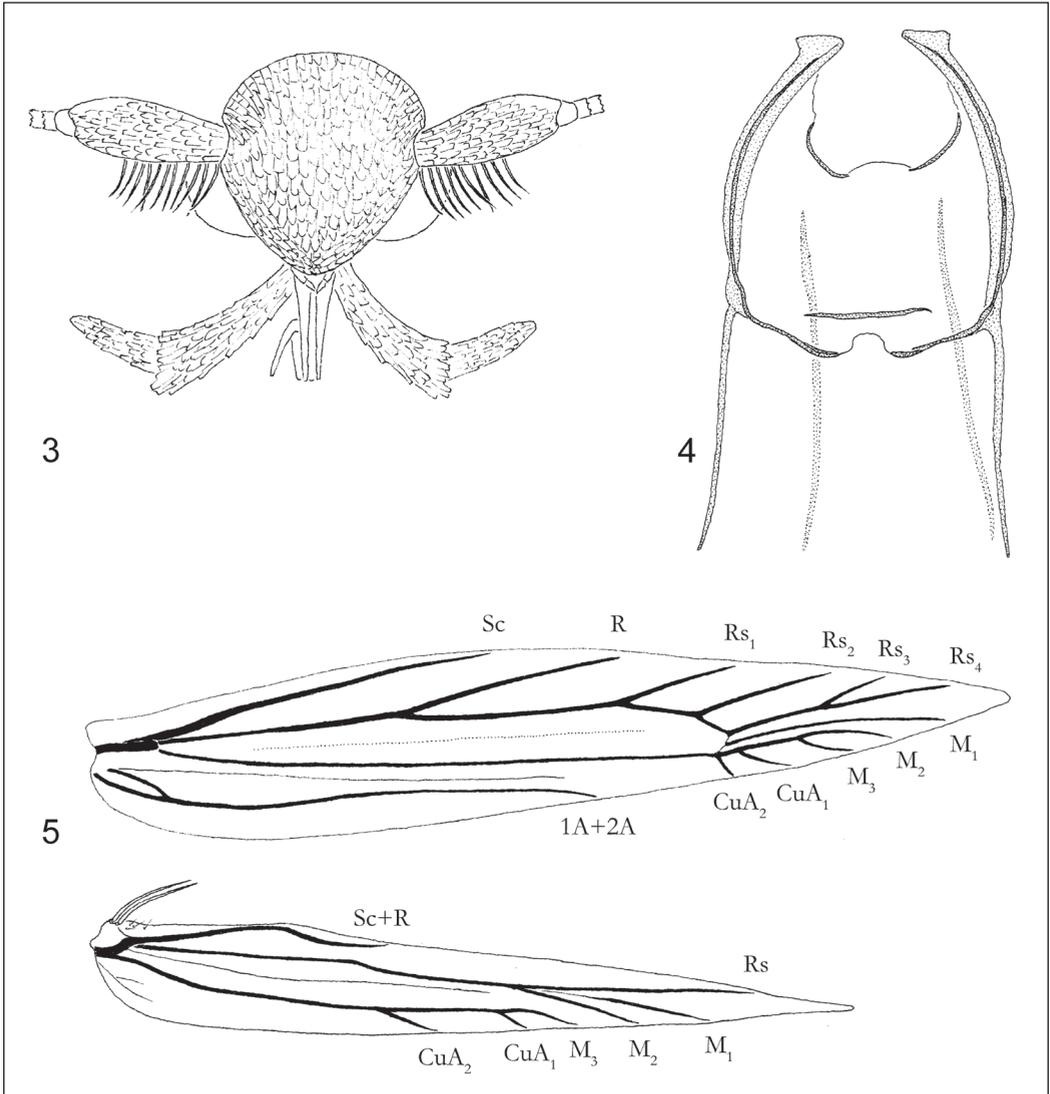
Description. Male (Fig. 11). Forewing length 6.7 mm. Head: frons shining white with greyish brown irroration ventrally, vertex, neck tufts and collar shining white, irrorate greyish brown; labial palpus first segment white, second segment white with irrorate greyish brown streak on outside, extending into subapical ventral spot, third segment white with irregular narrow sub-basal ring white and greyish brown tipped scales and similar coloured, broad subapical ring; scape dorsally white, strongly irrorate greyish brown with white anterior line, ventrally greyish white with 8–9 pecten hairs; flagellum shining brownish grey, basal six segments whitish. Thorax and tegulae shining ochreous-white, strongly irrorate greyish brown; thorax with broad dark greyish brown medial line, tegulae broadly lined white posteriorly. Legs: dorsally shining dark greyish brown, ventrally white with some greyish irroration; tibia midleg with white basal and medial streaks and white apical ring, tarsomeres one to four with whitish apical rings; tibia hindleg dorsally pale ochreous-grey, tarsomeres as midleg; spurs midleg and inner spur hindleg whitish, outer spurs hindleg dark brown. Forewing ground colour whitish more or less irrorate by greyish ochreous and greyish brown scales with dark brown and ochreous-yellow streaks in costal half and in apical area, the dark streaks almost fused; in middle of wing at two-fifths, dark brown elongated spot, at costal side connected to streak, edged white; two dark brow tufts of raised scales, first below fold at one-third, second and largest subdorsally at two-thirds, last spot surrounded by white scales, touching streak costally; white spot at apex connected to dark brown spot in apical cilia; several small dark brown spots in costal cilia; two dark brown fringe lines; cilia greyish white. Hindwing shining greyish white; cilia greyish white. Underside: forewing shining brownish grey; hindwing shining greyish white. Abdomen dorsally shining greyish brown, segment seven shining white banded posteriorly; ventrally shining greyish white; anal tuft shining white.



Figures 1–2. *Gielisella* species, habitus, watercolours. **1** (top). *G. clarkeorum*, female paratype(s); **2** (bottom). *Gielisella nigripalpis*, male holotype, abdomen reconstructed.

Female (Figs 1, 28). Forewing length 5.1–6.9 mm. femur foreleg apically with white dorsal spot. Forewings with streaks and spots clearly separated, not fused, overall paler than male. Anal tuft ochreous-brown.

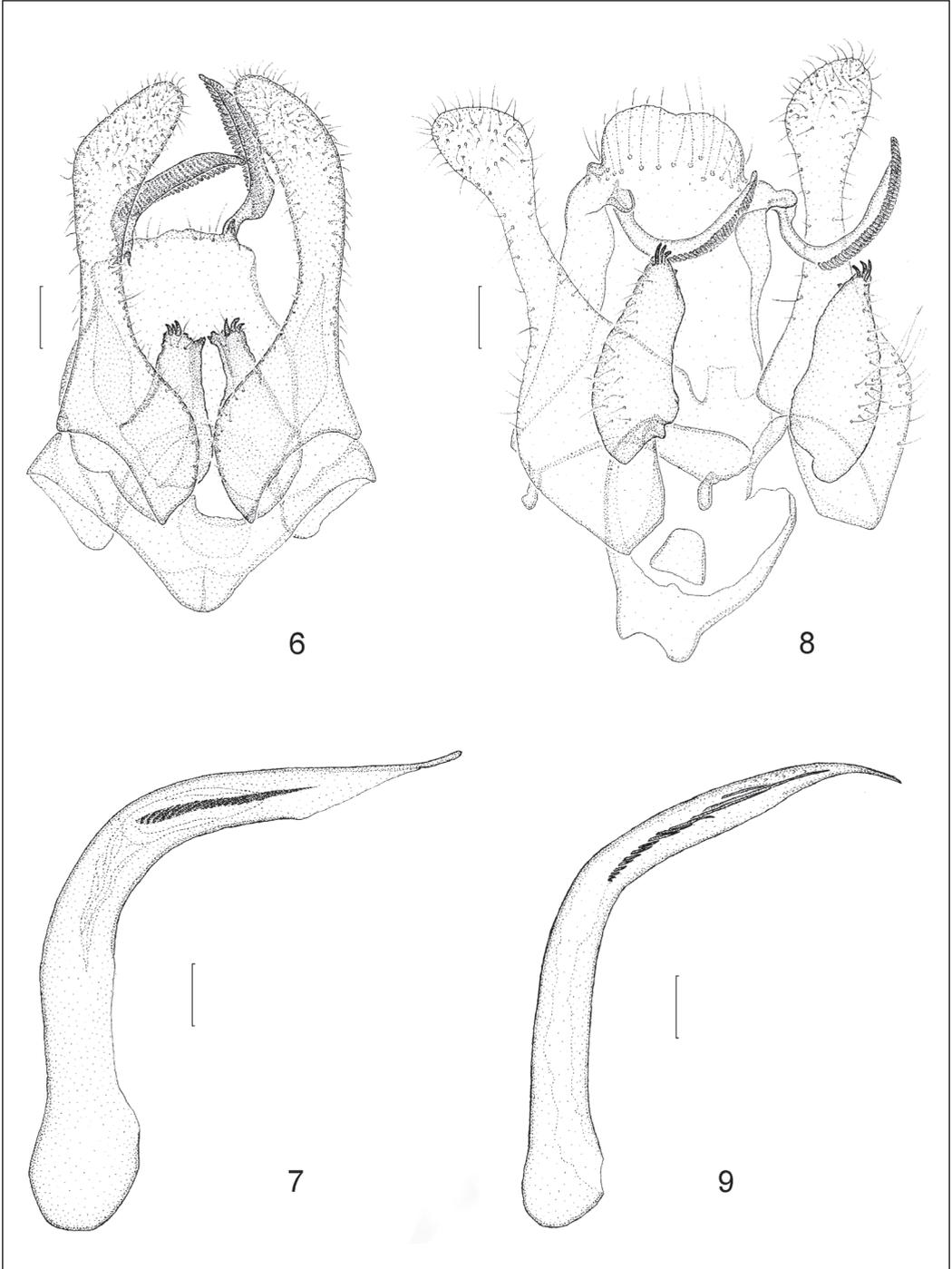
Male genitalia (Figs 6, 7, 13, 14, 17, 18). Uncus broad and very short, with 16 setae in two groups. Gnathos arms long and slender, upwards curved at one-third of base, upper side transversely covered with pecten of 32–33 flat peglike setae, about one and half width of gnathos arm (Fig. 14). Tegumen large, longer than wide, slightly narrowing distally. Valvae long, strongly narrowing after one-third, distally slightly widening till 3/4 and slightly narrowing apically with



Figures 3–5. *Gielisella clarkeorum*, morphological details. **3.** Head, frontal view; **4.** Basal segments of abdomen, genitalia slide Clarke 171; **5.** Wing venation with labelled veins, wing slide JCK 8200.

rounded tip, edges and apex weakly spiny. Anellus lobes large, strongly sclerotized, ventral edge with short spines, strongly tapering distally with distal third more or less cylindrical, apex with three curved teeth and laterally with irregular projection, both combined with several spicules. Vinculum broad with heart-shaped saccus and shield-shaped juxta. Phallus (Figs 7, 17, 18) long, curved ca. 90 degrees, slightly tapering distally, apex pointed, vesica with narrow row of approximately 15 slender cornuti in distal half, cornuti gradually becoming longer towards tip.

Measurements: Length from vinculum to uncus 460 μm , width 435 μm , valva length 560 μm , width 200 μm , phallus length (measured in straight line) 765 μm ; longest cornutus 110 μm .



Figures 6–9. *Gielisella* species, male genitalia of holotypes, phallus separately figured. **6, 7.** *G. clarkeorum*, genitalia slide JCK 8361; **8, 9.** *G. nigripalpis*, genitalia slide JCK8362. Scale bars: 0.1 mm.

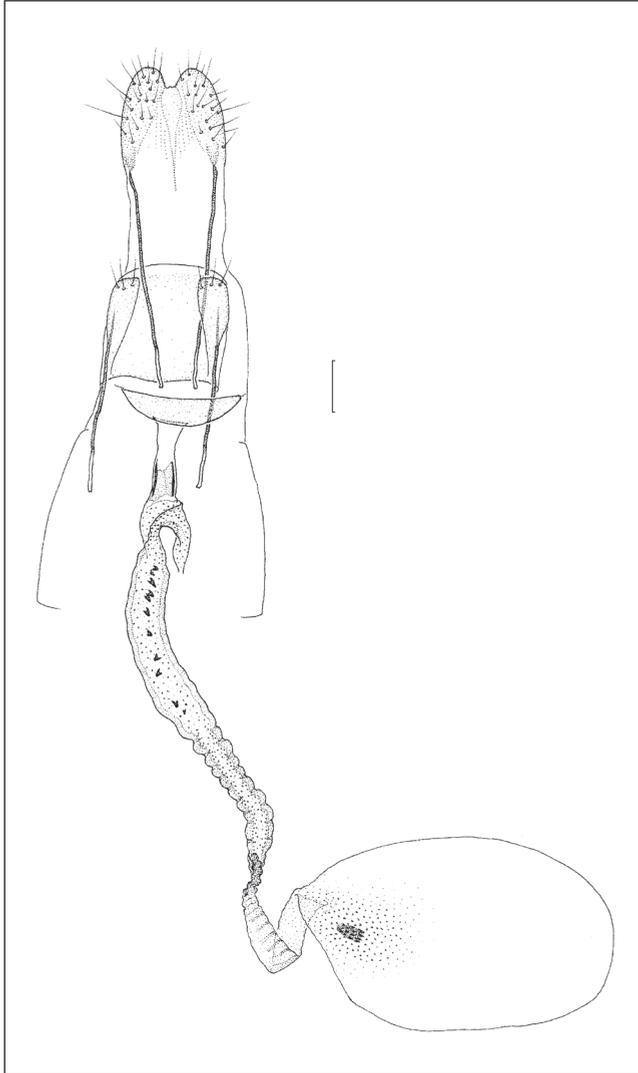
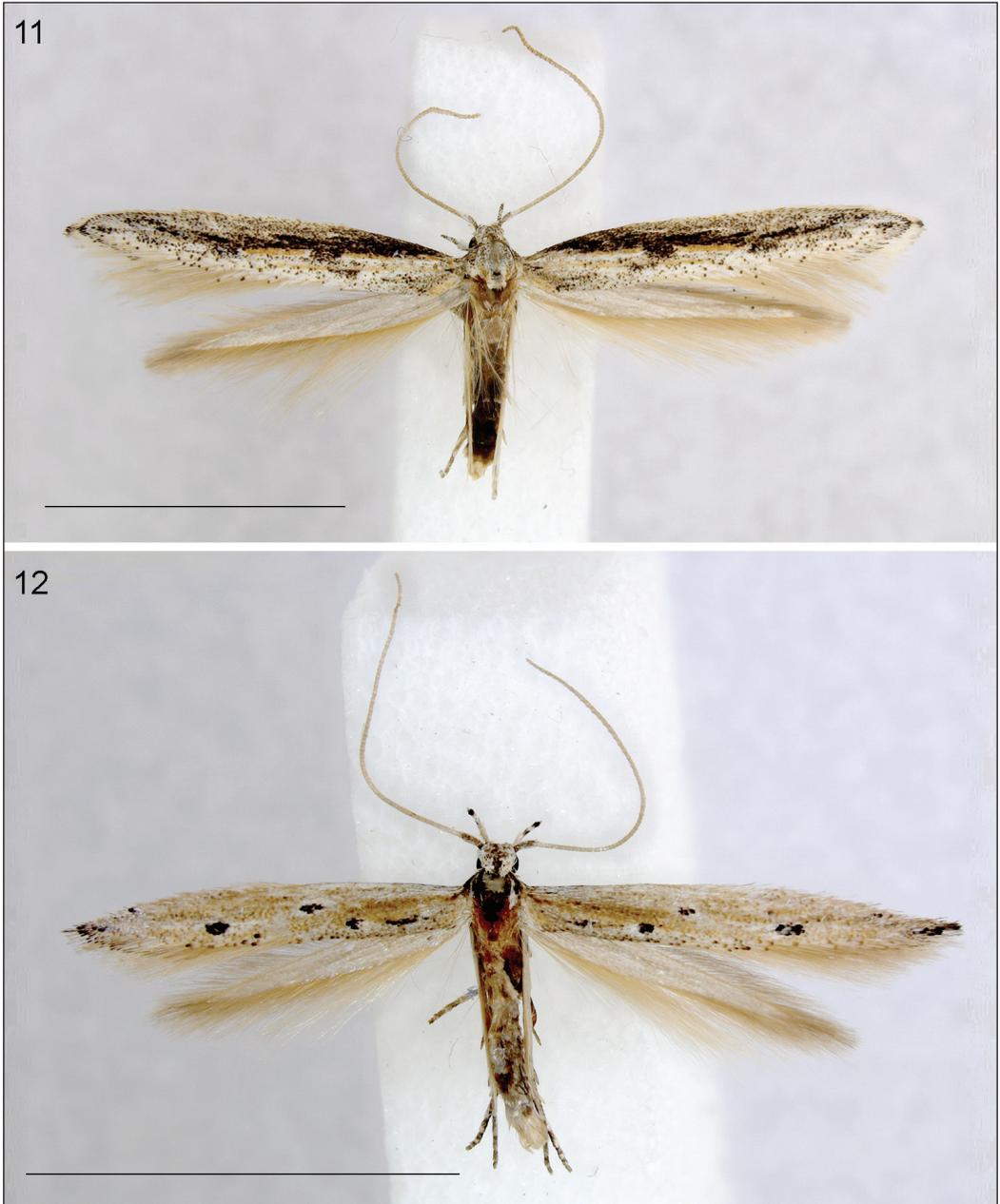


Figure 10. *Gielisella clarkeorum*, female genitalia, genitalia slide JCK3850. Scale bar: 0.1 mm.

Female genitalia (Figs 10, 21–25). Papillae anales short and rounded. Apophyses anteriores 1/4 shorter than apophyses posteriores. Antrum wide, bowl-shaped. Ductus bursae long, basal half lobed, small section below antrum narrow with partly sclerotized wall, followed by cleavage into ductus bursae and ductus seminalis, distal half of ductus bursae with irregular row of spicules. Corpus bursae egg-shaped, single signum as rectangular field of spines of variable size.

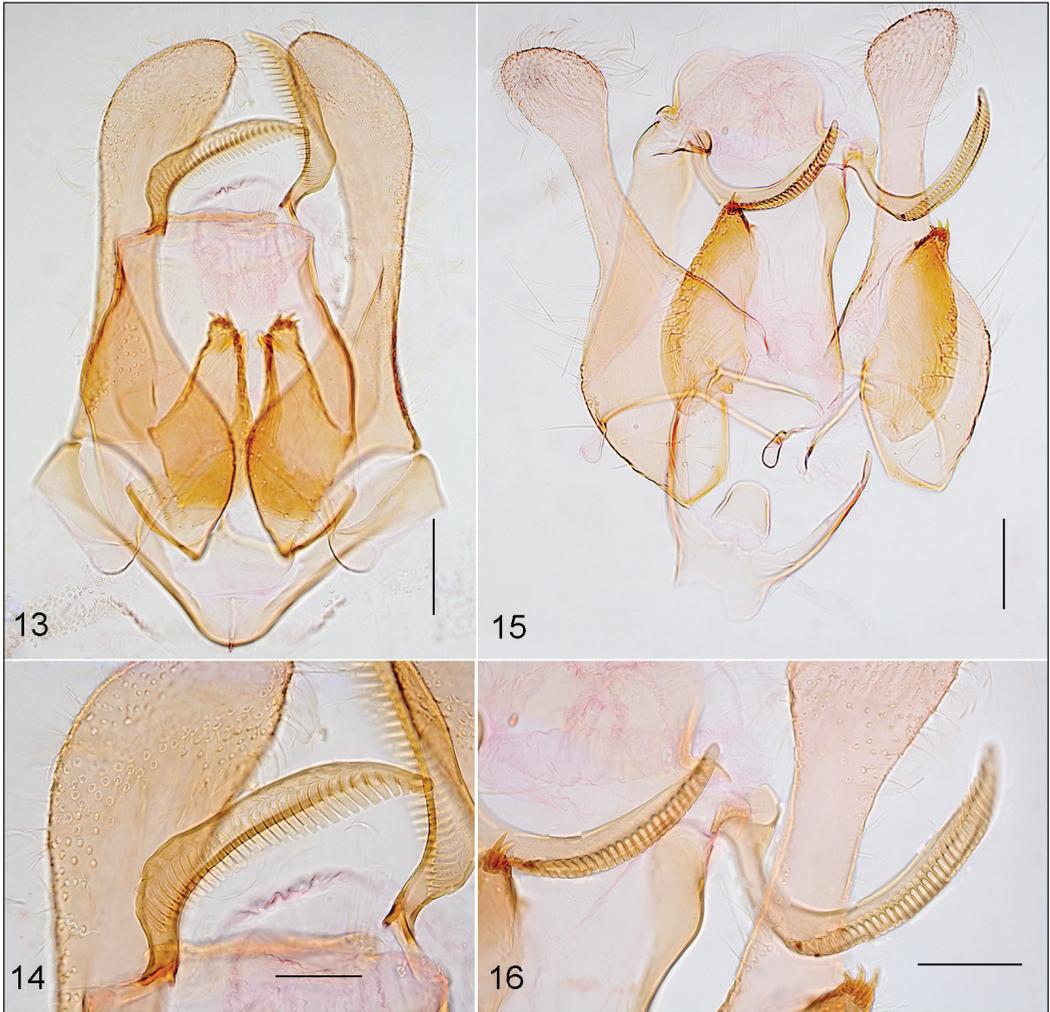
Distribution (Fig. 29). Spain, provinces of Almería and Granada. Type locality: 36.8770°N, 2.6036°W. The locality of the specimen from Granada was reconstructed by the collector as either 36.9544°N, 3.1436°W or 36.9528°N, 3.1375°W.

Biology. Host-plants and early stages are unknown. The adults have been collected at light from the end of January till late April. The specimen from Granada was collected on a dry northern slope



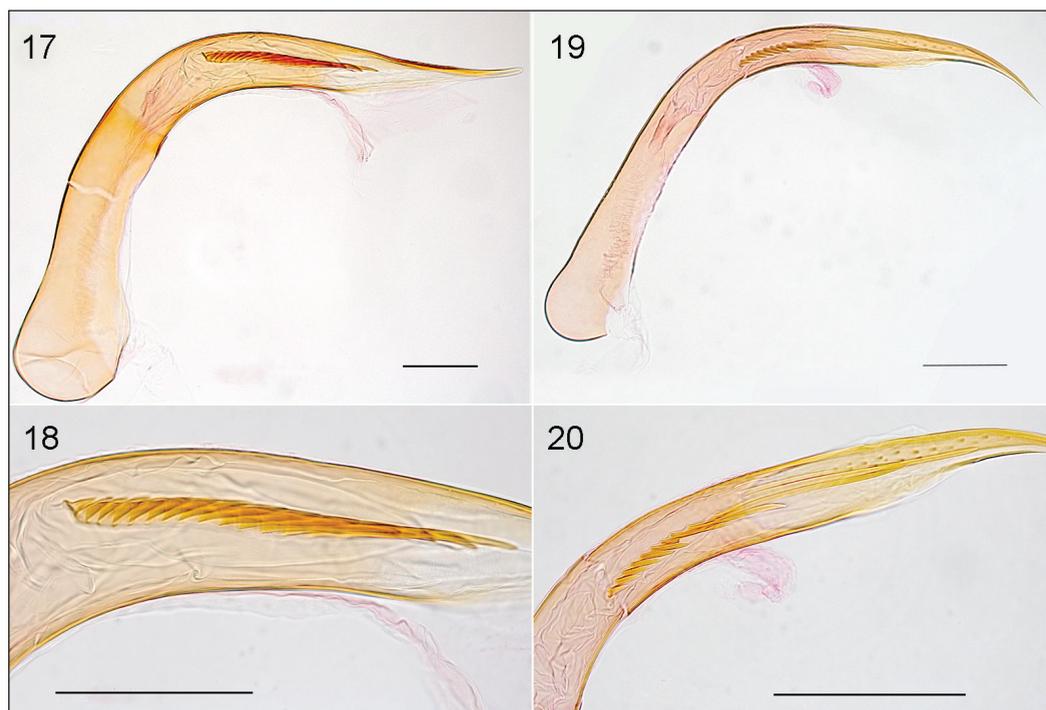
Figures 11–12. *Gielisella* species, male holotypes. **11.** *G. clarkeorum*; **12.** *G. nigripalpis*. Scale bars: 5 mm.

of a hill at an elevation of approximately 700 m. The vegetation consisted, among other things, of small shrubs and herbs belonging to Asteraceae, Cistaceae and Poaceae (Gielis, pers. comm.). The specimens from Almería were taken in a garden at the edge of a suburban area on the south facing slope of the Sierra de Gádor at an elevation of 720 m (Figs 26–27). In the garden grow



Figures 13–16. *Gielisella* species, male genitalia of holotypes, with gnathos arms enlarged. **13, 14.** *G. clarkeorum*, genitalia slide JCK 8361; **15, 16.** *G. nigripalpis*, genitalia slide JCK8362. Scale bars: 100 µm (13, 15), 50 µm (14, 16).

amongst others the vines and shrubs *Clematis cirrhosa* L. (Ranunculaceae), *Jasminum officinale* L. (Oleaceae), *Rosa* spec. (Rosaceae) and the following trees grow nearby: olive (*Olea europaea* L., Oleaceae), apple (*Malus pumila* Mill., Rosaceae), almond (*Prunus dulcis* (Mill.) D.A. Webb, Rosaceae), silver wattle (*Acacia dealbata* Link, Fabaceae) and at about 50 m from the collecting site a large eucalypt tree (probably *Eucalyptus gomphocephala* A.Cunn. ex DC., Myrtaceae), that was felled in 2015; weeds include *Salsola* sp. (Amaranthaceae) and *Dittrichia viscosa* (L.) Greuter (Asteraceae). The adjacent orchard area has an undergrowth of Poaceae, Juncaceae and *Rubus* sp. (Rosaceae) (Figs 26, 27). According to the collectors, the species started to appear in their garden after they planted the native *Clematis cirrhosa* L., and adults seem to hide in it. This observation requires further study.



Figures 17–20. *Gielisella* species, phallus of holotypes, with enlarged detail of cornuti. 17, 18. *G. clarkeorum*; 19, 20. *G. nigripalpis*. Scale bars: 100 μ m.

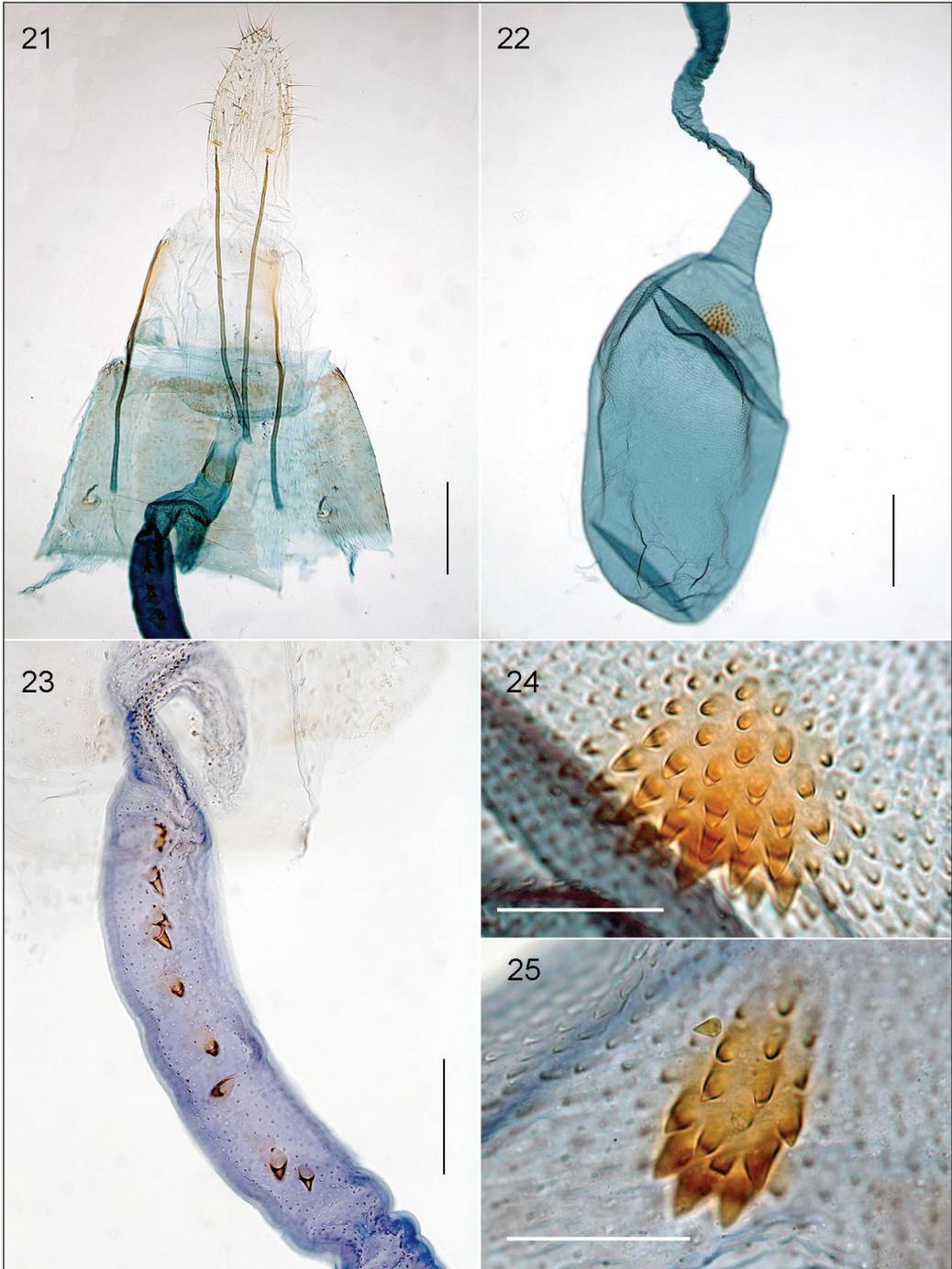
DNA barcodes. We barcoded three specimens, including the holotype, resulting in three identical barcodes, with BIN BOLD:ACU7245 (Table 1).

The barcode reads:

```
AACTTTATATTTTTATTTTTGGAATTTGAGCAGGAATAGTAGGAACATCACTTAGTTTATTAATTCGAGCTGAATT-
AGGAACCCCAGGCTCTTTGATTGGAGATGACCAAATTTATAATACTATTGTCACAGCTCATGCTTTTATTATAAT-
TTTTTTATAGTAATACCTATTATAATTGGAGGATTTGGTAACTGATTAGTTCCTTTAATATTAGGAGCCCCTGATAT-
AGCATTCCCTCGAATAAACAATATAAGTTTCTGACTTTTACCCCTTCTATTACTCTTCTAATTTCAAGTAGTATTG-
TAGAAAATGGAGCTGGAACAGGATGAACGGTTTACCCCTTTCATCTAATATTGCTCATAGAGGTAGAT-
CAGTTGATTTAGCAATCTTTTCTTTCATTTAGCTGGAATTTCTTCTATTTTAGGAGCTATTAATTTTATCACAATAT-
TATTAATATACGTCTAATAAATATATCTTTTGATCAAATACCTTTATTTGTTTGAGCAGTTGGAATTACAGCTTACT-
TCTGCTCTTTCTTTACCTGTTTTAGCTGGAGCTATTACTATGTATTAACAGATCGTAATCTAAATACTTCAITTTTT-
GACCCTGCTGGTGGAGGAGACCAATCTTTATCAACATTTATTT
```

Etymology. The specific epithet *clarkeorum*, a noun in genitive plural, is a tribute to the collectors of both species, Peter and Ginny Clarke.

Remarks. The forewing of the male holotype is darker than in all females examined, and the pattern elements are more or less fused. Whether this constitutes sexual dimorphism or simple variation can only be decided after collecting more males. We decided to select the male as holotype, since the male genitalia provide the best characters, and only males are known of the next species *G. nigripalpis*.



Figures 21–25. *Gielisella clarkeorum*, female genitalia, genitalia slides JCK8363 (21, 22, 24) and JCK3850 (23, 25). **21.** Terminal segments with apophyses, antrum, ductus bursae and ductus seminalis; **22.** Ductus and corpus bursae; **23.** Distal half of ductus bursae with spicules. **24, 25.** Variability of signum. Scale bars: 200 μm (21, 22), 100 μm (23), 50 μm (24, 25).



Figures 26–27. Type locality of both *Gielisella* species, Enix (Spain, Almería). **26** (top). Garden of the neighbours, next to the collection site, and surrounding mountains; **27** (bottom). Olive and almond orchards on the other side of the road, facing the collecting site. Photos by Marieta Sanjuan Martinez.



Figure 28. *Gielisella clarkeorum*, live female, collected on 18.iii.2014, Coll. nr 544. Photo by Peter & Ginny Clarke.

***Gielisella nigripalpis* sp. n.**

<http://zoobank.org/9F713A78-DF7A-4021-986F-5A6BCCE6CCDD>

Figs 2, 8, 9, 12, 15, 16, 19, 20, 26, 27, 29

Type material. **Holotype** ♂, Spain, Almería, Enix, 36°52'38.49"N 2°36'24.83"W, 7.iii.2015, coll. nr. 587; gen. slide JCK 8362, RMNH.INS.544307 (RMNH). **Paratype** 1♂, same locality as holotype, 30.i.2013, coll. nr. 431 (PGC) [abdomen lost during dissection].

Diagnosis. *Gielisella nigripalpis* differs from *G. clarkeorum* by the blackish brown tipped palpi, and the absence of the dark brown longitudinal streaks on the forewings. In the male genitalia it differs by the proportionally placed setae on the uncus; by apically narrowing anellus lobes without lateral projection; the spoon-shaped valvae and by the two very long cornuti at the distal end of the row cornuti.

Description. Male (Figs 2, 12). Forewing length 5.2–5.9 mm. Head: frons shining pale grey with greenish and reddish reflections and with greyish brown irroration laterally, vertex and neck tufts shining white, in middle strongly irrorate dark brownish grey, collar shining white, irrorate greyish brown; labial palpus first segment short, white, second segment white, strongly irrorate greyish brown dorsally and laterally on outside, apex white, third segment white with broad, brown basal and blackish brown apical ring, extreme tip white; scape dorsally and ventrally shining brownish grey, pecten with 8–9 hairs; flagellum shining pale ochreous-grey. Thorax shining white, strongly irrorate dark brownish grey in middle and laterally in anterior half. Tegulae shining dark brownish grey, laterally and ventrally lined white. Legs: dorsally shining dark greyish brown, ventrally white with some greyish irroration; tarsomeres one and two of foreleg with white apical rings; tibia midleg with white basal and medial streaks and white apical ring, tarsomeres one to four with whitish apical rings; tibia hindleg dorsally pale ochreous-grey,

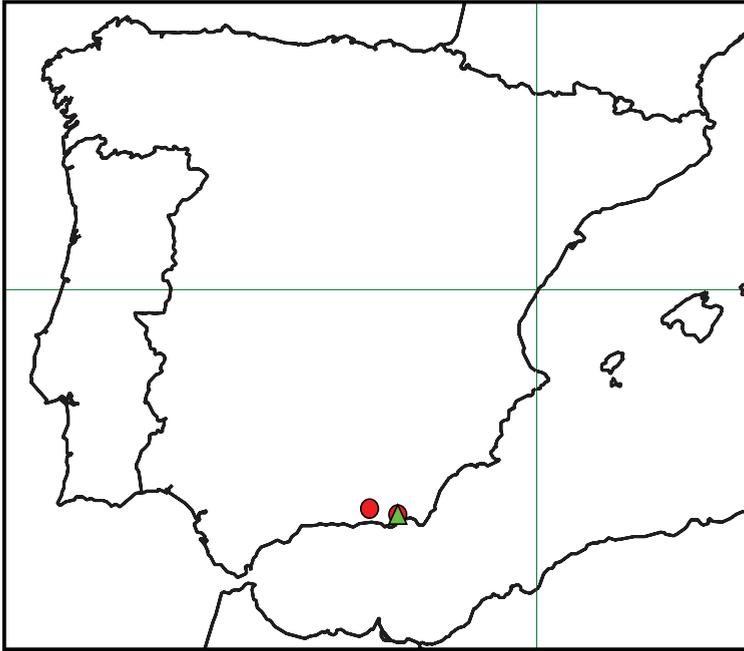


Figure 29. *Gielisella*: map of localities. Circles: *G. clarkeorum*, triangle: *G. nigripalpis*.

tarsomeres as midleg; spurs midleg and inner spur hindleg whitish, outer spurs hindleg dark brown. Forewing ground colour shining whitish with more or less irrorate by greyish ochreous and greyish brown scales and ochreous streaks; two blackish brown dots with raised scales and three blackish brown streaks, first spot below fold at one-fourth, second spot, larger than first, above fold at two-third, first streak narrow, above dorsum near base, second streak just above middle at one third, third streak at apex; several small dark brown spots in costal cilia; two small dark brown fringe lines; cilia pale ochreous-grey and with dark brown streak at apex. Hindwing shining greyish white with some greenish and reddish gloss; pale ochreous-grey. Underside: forewing shining brownish grey, ochreous-grey in distal half; hindwing shining greyish white. Abdomen not examined.

Male genitalia (Figs 8, 9, 14, 15, 19, 20). Uncus as two broad, short and rounded lobes with 16 setae proportional placed across the width. Gnathos arms (Fig. 16) long and slender, upwards bent at one-third of base, upper side transversely covered with pecten of 36 flat peglike setae, about one and half width of gnathos arm. Tegumen large, longer than wide, slightly narrowing distally. Valvae long, strongly narrowing after one-third, distally slightly widening till spoon-shaped apex, edges and apex weakly spined. Anellus lobes large, strongly sclerotized, ventral edge with short spines, strongly tapering distally, apex with three curved teeth, laterally with small triangular tooth. Vinculum broad with heart-shaped saccus and shield-shaped juxta. Phallus (Figs 9, 19, 20) long, curved less than 90 degrees, slightly tapering distally, apex pointed, vesica with narrow row of approximately 13 slender cornuti in distal half of last two cornuti are as long and longer than previous row.

Measurements: Length from vinculum to uncus 590 μm , valva length 525 μm , phallus length (measured in straight line) 655 μm ; longest cornutus 125 μm .

Distribution (Fig. 29). Spain, province Almería.

Biology. Host-plants and early stages are unknown. The specimens were collected at light in the same locality as *G. clarkeorum*, suggesting a similar life history (Figs 26–27). They were found in January and March.

DNA barcodes. We barcoded the holotype, with BIN BOLD:ACY4816, at a distance of 7.2% to *G. clarkeorum* (Table 1).

The barcode reads:

```
AACTTTATATTTTATTTTGGAAATTTGAGCAGGAATAGTAGGTACATCTCTTAGTTTATTAATTCGAGCT-
GAACTAGGAACCCCGGATCTTAAATTGGTGATGATCAAATTTATAATACTATTGTTACAGCTCACGCT-
TTTATTATAATTTTTTTTATAGTTATACCTATTATAATTGGAGGATTTGGAAATTGATTAGTTCCTTTAATATTAG-
GAGCCCAGATATAGCTTCCCGCAATAAATAATATAAGTTTTTGATTATTACCTCCTTCTCTTACCCCTTTAAT-
TTCAAGTAGTATTGTAGAAAATGGAGCTGGGACAGGATGAACGGTTTACCCCCCTTTCATCTAATATCGCTCAT-
AGAGGTAGATCAGTAGATTTAGCAATTTTTCCCTTCATTTAGCTGGAATTTCTTCAATTTTAGGACTATTAAT-
TTTATTACAATATTATAATACGATTAATAAATATATCTTTTGATCAAATACCCTATTGTTGAGCAGTTGGGAT-
CACAGCTCTTCTTCTTCTTTCTTACCTGTTTTAGCTGGAGCTATTACTATATTATAACAGATCGTAATTTAAA-
TACCTCATTTTTGATCCTGCTGGTGGAGGAGACCCTATTTTATACCAACATTTATTT
```

Etymology. The epitheton *nigripalpis* is the dative plural of the noun *nigripalpus*, meaning “with black palpi”, referring to the black palpal tip.

Discussion

Justification of the description of a new genus

The new species cannot confidentially be placed in any of the European genera of Parametriotinae. A phylogeny for the family is lacking and for many tropical species the genitalia have never been illustrated. Amongst the other 34 genera listed below we see resemblances, but none sufficient to incorporate these two species. In the narrow shape and features of the forewings the new genus resembles the Neotropical genus *Nanodacna* Clarke, 1964, especially *Nanodacna austrocedrella* Landry & Adamski, 2004 (Landry and Adamski 2004). However, it differs in the third segment of the labial palpus, that is one-half of the length of the second segment, whereas in *Nanodacna* it equals the second segment. In the venation of the forewing it further differs by the wide curve of 1A+2A towards dorsum, in the venation of the hindwing by the in the distal half strongly curved Sc+R1 and the stalked M1 and M2 to Rs. In the male genitalia it differs by the simple valvae, the presence of anellus lobes and by the peculiar shape of the gnathos arms. In the female genitalia it differs by the wide antrum, different ductus bursae and the single signum. This combination of characteristics does not occur at any other genus in the Parametriotinae. The Neotropical genus *Homoeprapes* Clarke, 1962 shows some similarity in the male genitalia with *Gielisella*, but the gnathos arms do not have a single pecten, but are covered with numerous spines (Clarke 1962). The Australian genus *Orthromicta* Meyrick, 1897 resembles *Gielisella* externally.

Considering the very rich Parametriotine fauna of Australia, and the fact that several Australian trees are frequently planted in Spain (eucalypts, wattles), also close to the type locality, made us

consider the possibility of an introduction of an Australian insect. Checking the DNA barcodes of both species in the BOLD database (Ratnasingham and Hebert 2007) did not give any close match, even though a majority of the Lepidoptera species (named and unnamed) present in ANIC have been barcoded (Hebert et al. 2013). In fact, in the total BOLD database, although the two species group together, *Gielisella* barcodes group otherwise with many totally unrelated moths, belonging to several completely different superfamilies, but not with Elachistidae. A quick search in BOLD shows that barcodes are available for 399 specimens of Parametriotinae, representing 99 BIN's (Barcode Identification Number), which represent probably a lower number of species. The majority of these are Australian, particularly belonging to the genera *Leptozeztis*, *Trachydora* and *Microcolona*. Several of these are known to feed on *Eucalyptus*. Ted Edwards (ANIC, Canberra) kindly compared photos of our species to the multitude of species in their collection, according to him the “most neglected part” of the collection, but he did not see any match. Genitalia slides of these species are rare, since they have not been revised since their original descriptions. Also David Lees (NHMUK) kindly compared photographs to several Meyrick types in London. Again, nothing matched. Lauri Kaila (Helsinki), who spent some time in Australia, studying Gelechioidea, suggested that such moths as *Gielisella* (considering both appearance and genitalia) do not occur in Australia as far as is known. He dissected quite a few species of *Leptozeztis* or *Trachydora* and *Microcolona*, and has not seen genitalia similar to our species. According to him, practically all Australian parametriotines have somewhat curved hindwings (costal margin concave). Kaila considers *Gielisella* to be closest to *Blastodacna*. However, we cannot reconcile the characters of our new species with the current concept of the genus *Blastodacna*, also considering the fact that there are no close DNA barcodes, consider placement in that genus unsatisfactory. Awaiting a more detailed future analysis, we therefore decided to erect a new genus for these two species. For the time we consider the hypothesis that *Gielisella* constitutes a native Palearctic element as the best working hypothesis. However, it is still possible that we are dealing with imported species, although the import of two congeneric species in the same locality sounds less likely, unless they were transported together with their hostplant.

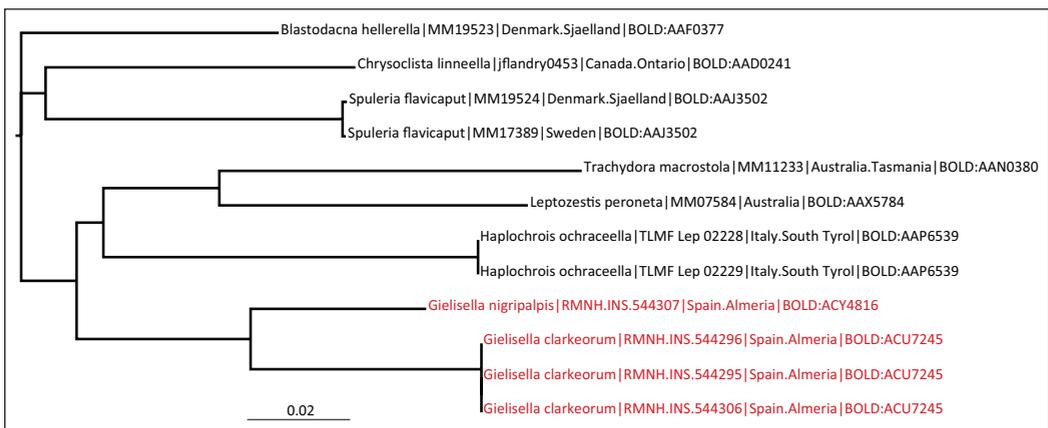


Figure 30. Neighbor Joining tree of DNA barcodes of *Gielisella* and selected other Parametriotinae, with BOLD Sample ID, country and province and Barcode Identification Numbers.

We strongly urge that diverse groups with important life histories, such as these Australian Parametriotinae that may damage *Eucalyptus* trees, should receive a proper taxonomic treatment, so that species can be identified, whether in their natural habitat or as imported species in other parts of the world. Unfortunately the decline of taxonomists has led to a reduction of taxonomic revisions.

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Note: references to authorities of taxon names are given at the end of the appendix.

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APPENDIX

Generic catalogue of Parametriotinae

All genera we believe belong to Parametriotinae are listed in alphabetic order. The total number of described species and the number per biogeographic region are given between square brackets after the generic name. In all we count 245 named species in 35 genera, with the largest representation in Australia and New Guinea with 108 species, followed by 44 Palaearctic, 41 Neotropical, 27 Oriental, 18 African, 6 Nearctic and 1 Pacific species.

On a second line we provide respectively the type species, original family assignments and later placements. Synonyms are indented.

In order to show some of the diversity we publish here a few water colours and drawings of Eastern Asian and African species, prepared by the senior author, that had not been published before (Figs 31–44).

Family Elachistidae Bruand, 1850: 50.

Subfamily Parametriotinae Căpuse, 1971: 55.

Type genus *Parametriotes* Kusnezov, 1916: 628, a junior synonym of *Haplochrois* Meyrick, 1897: 310.

Blastodacninae Clarke, 1962: 125. [unavailable]

Type genus *Blastodacna* Wocke, 1876: 428

Sinitineidae Yang, 1977: 261.

Type genus *Sinitinea* Yang, 1977: 262. Synonymized by Park (1986)

Agalmoscelis Diakonoff, 1955: 4. [3, Australian: New Guinea]

Type species *Agalmoscelis resplendens* Diakonoff, 1955, by original designation. Described in Heliodinidae. According to Sinev (unpublished) belonging to Elachistidae-Parametriotinae.

Araucarivora Hodges, 1997: 267. [1, Neotropic]

Type species *Araucarivora gentilii* Hodges, 1997, by original designation. Described in Elachistidae-Agonoxeninae.

Auxotricha Meyrick, 1931: 189. [1, Neotropic]

Type species *Auxotricha ochrogypsa* Meyrick, 1931, by monotypy. Described in Oecophoridae. Placed in Elachistidae-Agonoxeninae-Parametriotini by Hodges (1997).

Blastodacna Wocke in Heinemann & Wocke, [1876] 1877: 428. [14: Palaearctic 11, Nearctic 2 + 2 Palaearctic, Oriental 1]

Type species *Alucita hellerella* Duponchel, 1838, by subsequent designation by Fletcher, 1928. Described in Lavernidae (syn. of Momphidae). Placed in Cosmopterigidae by Fletcher (1929). Transferred to Blastodacnidae by Clarke (1964).

Sinitinea Yang, 1977: 262, synonymized by Park (1986).

Type species *Sinitinea pyrigalla* Yang, 1977, by original designation, described in new family Sinitineidae Yang, 1977, synonymized by Park (1986).

Chrysoclista Stainton, 1854: 225. [14: Palaearctic 7, Nearctic 3 + 1 Palaearctic, Oriental 2, African 1, Australian 1]

Type species *Phalaena linneella* Clerck, 1759, by subsequent designation by Fletcher, 1928. Described in Elachistidae. Placed in Cosmopterigidae by Fletcher (1929). Transferred to Blastodacnidae by Leraut (1980).

Glyphipteryx Curtis, 1827: 152, an unjustified emendation of *Glyphipterix* Hübner, [1825]: 421 (Family Glyphipterigidae).

Type species *Phalaena linneella* Clerck, 1759, by original designation. Described in Tineidae. Rejected by International Commission on Zoological Nomenclature (1986).

Circoxena Meyrick, 1916b: 418. [1, Australian]

Type species *Circoxena ditrocha* Meyrick, 1916b, by monotypy. Described in Plutellidae. Placed in Agonoxenidae by Sinev (2002).

Cladobrostitis Meyrick, 1921: 409. [1, Oriental]

Type species *Cladobrostitis melitricha* Meyrick, 1921, by monotypy. Described in Agonoxenidae. Placed in Elachistidae-Agonoxenidae-Blastodacninae by Hodges (1978).

Colonophora Meyrick, 1914a: 280. [2, African]

Type species *Colonophora cateiata* Meyrick, 1914a, by monotypy. Described in Cosmopterigidae. Placed in Blastodacnidae by Clarke (1965).

Coracistis Meyrick, 1897: 370. [1, Australian]

Type species *Coracistis erythrocosma* Meyrick, 1897, by monotypy. Described in Elachistidae. Placed in Heliodinidae by Meyrick (1914d). Placed in Elachistidae-Parametriotinae by Heikkilä et al. (2014).

Desertidacna Sinev, 1988: 17. [1, Palaearctic]

Type species *Desertidacna repetekiella* Sinev, 1988, by original designation. Described in Momphidae s.l. Placed in Agonoxenidae by Riedl (1994).

Dromiaulis Meyrick, 1922: 574. [1, Neotropic]

Type species *Dromiaulis excitata* Meyrick, 1922, by monotypy. Described in Cosmopterigidae. Placed in Agonoxenidae by Sinev (2002).

Dystebenna Spuler in Spuler & Meess, 1910: 386. [1, Palaearctic]

Type species *Elachista stephensi* Stainton, 1849, by monotypy. Described in Elachistidae. Placed in Blastodacnidae by Leraut (1980).

Gielisella Koster & van Nieukerken, 2017: 169. [2, Palaearctic] **gen. n.**

Type species *Gielisella clarkeorum* Koster & van Nieukerken, 2017, by original designation. Described in Elachistidae, Parametriotinae.

Glaucacna Forbes, 1931: 369. [1, Neotropics]

Type species *Glaucacna iridea* Forbes, 1931, by monotypy. Described in Gelechiinae. Transferred to Elachistidae-Agonoxeninae-Parametriotini by Hodges (1997).

Gnamptonoma Meyrick, 1917: 65. [1, Neotropics]

Type species *Gnamptonoma leptura* Meyrick, 1917, by monotypy. Described in Heliodinidae. Transferred to Agonoxeninae by Becker (1999) on the basis of the external similarity of *Haplochrois*. Status uncertain.

Haplochrois Meyrick, 1897: 299. [30: Palaearctic 11, Nearctic 1, Neotropic 13, Oriental 2, African 2, Australian 5]

Type species *Haplochrois chlorometalella* Meyrick, 1897 by original designation. Described in Elachistidae. Placed in Agonoxenidae by Sinev (1999). Senior synonym of type genus *Parametriotes*.

Aetia Chambers, 1880: 186, a junior homonym of *Aetia* Agassiz, 1847: 27 [Bryozoa].

Type species *Aetia bipunctella* Chambers, 1880, by monotypy. Described in Tineina. Synonymized by Sinev (1999) [no objective replacement name known].

Rhadinastis Meyrick, 1897:299.

Type species *Rhadinastis microlychna* Meyrick, 1897, by original designation. Described in Elachistidae. Synonymized by Sinev (1999)

Tetanocentria Rebel, 1902: 107.

Type species *Tetanocentria gelechiella* Rebel, 1902, by monotypy. Described in Elachistidae. Synonymized by Sinev (1999)

Platybathra Meyrick, 1911: 78.

Type species *Platybathra ganota* Meyrick, 1911, by monotypy. Described in Plutellidae. Synonymized by Sinev (1999)

Parametriotes Kusnezov, 1916:628.

Type species *Parametriotes theae* Kusnezov, 1916, by original designation. Described in Tineidae. Synonymized by Sinev (1999)

Syntetrernis Meyrick, 1922:574.

Type species *Syntetrernis xiphodes*, Meyrick 1922, by original designation. Described in Cosmopterigidae. Synonymized by Sinev (1999)

Chaetocampa Busck in Bottimer, 1926: 804. Type species *Chaetocampa crotonella* Bottimer, 1926, by original designation. Described in Cosmopterigidae. Synonymized with *Aetia* by Hodges, 1962.

Panclintis Meyrick, 1929: 511.

Type species *Panclintus socia* Meyrick, 1929, by monotypy. Described in Cosmopterigidae. Synonymized by Sinev (1999)

Prochola auct. [partim, misapplied, not the type species, see below]. See Hodges (1997).

Heinemannia Wocke in Heinemann & Wocke, [1876] 1877:428. [3, Palaearctic]

Type species *Tinea laspeyrella* Hübner, 1796, by subsequent designation by Fletcher, 1929. Described in Lavernidae. Placed in Cosmopterigidae by Fletcher (1929). Transferred to Agonoxenidae-Blastodacninae by Hodges (1978).

Tebenna Hübner, 1825: 414, a junior homonym of *Tebenna* Billberg, 1820: 90.

Type species *Tinea festivella* Denis & Schiffermüller, 1775, by subsequent designation by Fletcher, 1929. Synonymized by Leraut (1980).

Helcanthica Meyrick, 1932: 315. [1, Neotropics]

Type species *Helcanthica spermotoca* Meyrick, 1932, by monotypy. Described in Cosmopterigidae. Placed in Agonoxenidae by Becker (1984b).

Homoeoprepes Walsingham, 1909: 10. [3, Neotropic]

Type species *Homoeoprepes trochiloides* Walsingham, 1909, by original designation. Described in Lavernidae. Placed in Blastodacnidae by Clarke (1962). Placed in Agonoxenidae by Becker (1984b).

Ischnopsis Walsingham, 1881: 236. [4, African]

Type species *Ischnopsis angustella* Walsingham, 1881, by monotypy. Described in Tineidae. Transferred to Agonoxenidae by Sinev (2004).

Iriothyrsa Meyrick, 1908: 736.

Type species *Iriothyrsa melanogma* Meyrick, 1908, by monotypy. Described in Plutellidae. Synonymized by Sinev (2004).

Amblyxena Meyrick, 1914c: 207.

Type species *Amblyxena enopias* Meyrick, 1914c, by monotypy. Described in Coleophoridae. Synonymized by Sinev (2004).

Leptozeztis Meyrick, 1924: 91. [34: Neotropic 1, Oriental 2, Australian 31]

Type species *Syntomactis parascia* Meyrick, 1897, by original designation. Described in Cosmopterigidae. Placed in Elachistidae-Parametriotinae by Kaila et al. (2011).

Pogonias Lower, 1893 a junior homonym of *Pogonias* Lacépède, 1802.

Type species *Pogonias euryplaca* Lower, 1893, by monotypy. Synonymized by Meyrick (1897).

Meyrick (1924) proposed *Leptozeztis* for the Australian species previously placed in *Syntomactis* Meyrick, 1889: 173. *Syntomactis* was established for *Gelechia deamatella* Walker, 1864 from New Zealand and placed in Elachistidae (Meyrick, 1889). Meyrick (1924) came to the conclusion that this species belongs to *Pyroderces* Herrich-Schäffer 1853: 47. (Cosmopterigidae), thus synonymizing the two genera. For the Australian species in *Syntomactis* he erected *Leptozeztis* with *L. parascia* (Meyrick, 1897) as type species. In the BOLD database many unnamed species are listed as *Leptozeztis* spec.

Licmocera Walsingham, 1891: 128. [1, African]

Type species *Licmocera lyonetiella* Walsingham, 1891, by original description. Described in Tineidae. Placed in Heliodinidae by Meyrick (1913c). Transferred to Schreckensteiniidae by Fletcher (1929). Transferred to the Momphidae-Blastodacna-complex by Kasy (1976). Status uncertain. Probably belonging to Roeslerstammiidae (Hoare, pers. comm.).

Microcolona Meyrick, 1897: 370. [33: Palaearctic 1, Neotropic 1, Oriental 12, African 2, Australian 16, Pacific 1] Figs 31, 34–38.

Type species *Microcolona characta* Meyrick, 1897, by original designation. Described in Elachistidae. Placed in Momphidae-Blastodacninae by Sinev (1988). Transferred to Agonoxenidae by Riedl (1994).

Aganoptila Meyrick, 1915: 333.

Type species *Aganoptila phanarcha* Meyrick, 1915, by monotypy. Described in Cosmopterigidae. Synonymized by Sinev (2002).

Griphocosma Fletcher, 1929: 101.

Type species *Microcolona citroplecta* Meyrick, 1917, by monotypy. Described in Cosmopterigidae. The authorship of *Griphocosma* was attributed to “Meyrick MS.” by Fletcher (1929).

Nanodacna Clarke, 1964: 125. [5, Neotropics]

Type species *Nanodacna ancora* Clarke, 1964, by original designation.

Described in Blastodacnidae. Placed in Agonoxenidae by Nye & Fletcher (1991). Transferred to Elachistidae-Agonoxeninae-Parametriotini by Hodges (1997).

Nasamonica Meyrick, 1922: 555. [1, African] Figs 33, 39–40

Type species *Nasamonica oxymorpha* Meyrick, 1922, by monotypy. Described in Coleophoridae. Placed in Momphidae by Baldizzone (1979), but Kasy (in Baldizzone 1979), after studying the genitalia, placed it in Momphidae-Blastodacninae. [the illustrated species is undescribed]

Orthromicta Meyrick, 1897: 401. [3, Australian]

Type species *Orthromicta galactitis* Meyrick, 1897, by monotypy. Described in Elachistidae. Placed in Cosmopterigidae-Chrysopeliinae by Nielsen (1996). Transferred to Agonoxenidae by Sinev (2002).

Pammeces Zeller, 1863: 152. [5, Neotropic]

Type species *Pammeces albivittella* Zeller, 1863, by monotypy.

Described in Elachistidae. Placed in Elachistidae-Agonoxeninae-Parametriotini by Hodges (1997).

Hodges (1997) mentioned five species of this genus, but did not check the material. Becker (1999) added an additional species, but the drawing of the male genitalia does not resemble those of Parametriotinae. This species does not match the extensive description of the genus by Zeller (1863). The forewings are not sharply pointed and the antennae are too short. It is therefore not included here.

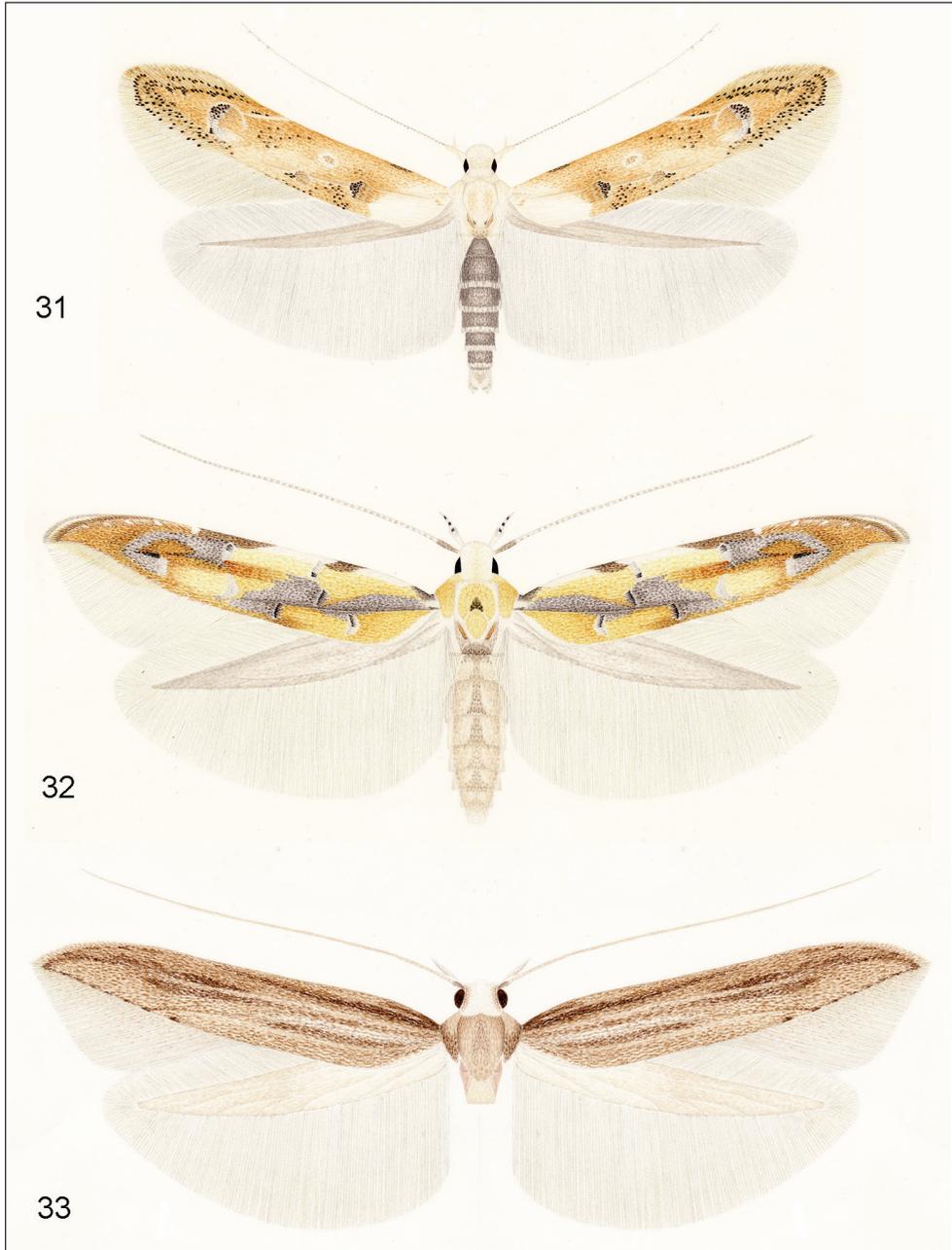
Psammece Walker, 1866: 1843. An incorrect subsequent spelling of *Pammeces* Zeller, 1863.

Patanotis Meyrick, 1913b: 80. [2, Oriental]

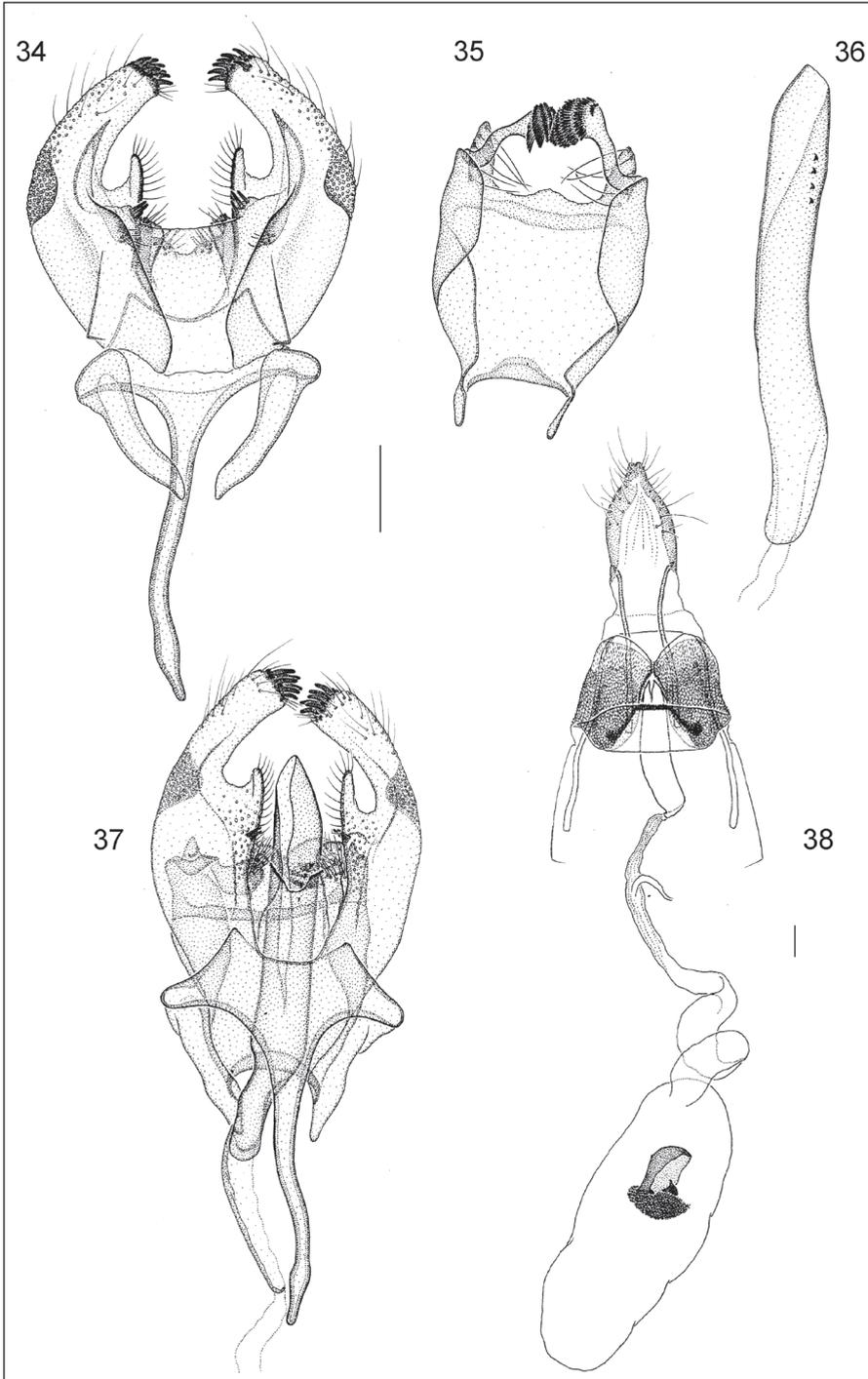
Type species *Patanotis harmosta* Meyrick, 1913b, by original designation. Described in Heliodontidae. Placed in the Momphidae-Blastodacna-complex by Kasy (1976). Status uncertain. Probably belonging to Roeslerstammiidae (Hoare, pers. comm.).

Pauroptila Meyrick, 1913a: 309. [1, African]

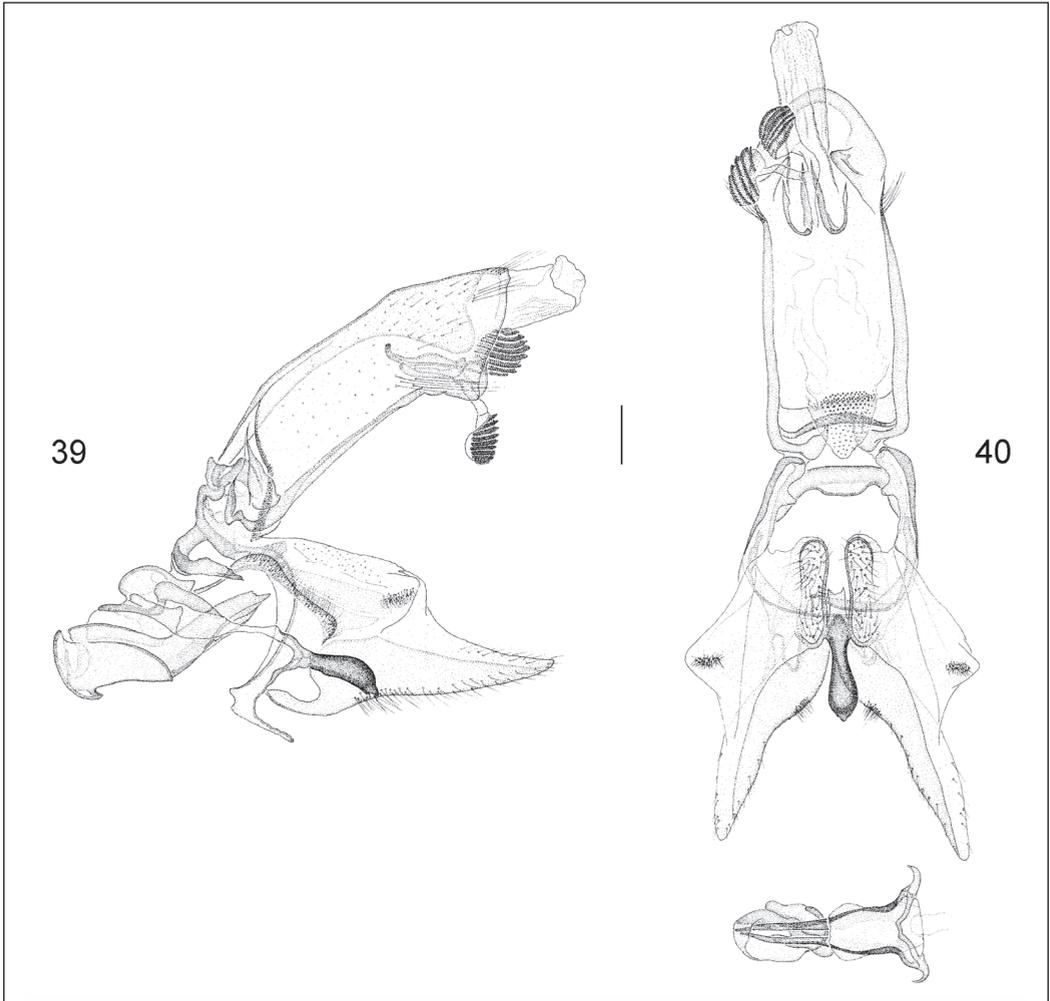
Type species *Pauroptila galenitis* Meyrick, 1913a, by monotypy. Described in Momphidae. Meyrick (1913a) mentioned in his description of the genus that it is related to *Microcolona*. Later authors (Janse 1917, Vári et al. 2002) placed the genus in Cosmopterigidae. Placed in Agonoxenidae by



Figures 31–33. Examples of adult Elachistidae-Parametriotinae species. **31** (top). *Microcolona aurantiella* Sinev, 1988, paratype male, Russia, Primorsky Kray, Khasan district, 3 km SE Andreevka, 21.vii–16.viii.1985, Sinev (ZIAN); forewing length 5.2 mm; **32** (middle). *Trachydora ussuriella* Sinev, 1981, paratype male, Russia, Primorsky Kray [Ussurian region], Spaskiy District, Yakovlevka, 13.vii–10.viii.1926, Dyakonov & Filipyev (ZIAN); forewing length 5.8 mm; **33** (bottom). Undescribed South African species of *Nasamonica*, male, Republic of South Africa], Sarnia, xi.[19]13, leg. Mrs. Gurry, coll. Janse (TMSA), forewing length 9.2 mm. Figs 31 and 32 at same scale.



Figures 34–38. *Microcolona aurantiella*. Male and female genitalia, genitalia in vials, data as Fig. 31. **34.** Valvae, vinculum and saccus; **35.** Tegumen, uncus and gnathos arms; **36.** Phallus; **37.** Male genitalia *in situ*, same as Figs 34–36; **38.** Female genitalia. Scale bars: 0.1 mm



Figures 39–40. Undescribed species of *Nasamonica*, male genitalia, genitalia slide Wf 5765, data as Fig. 33. **39.** Lateral view, phallus *in situ*; **40.** Ventral view, phallus *ex situ*. Scale bar: 0.2 mm.

Sinev (2002). A second species, *P. skikoraella* Viette, 1958 from Madagascar does not belong to Elachistidae-Parametriotinae judging from the genitalia drawings.

Phalaritica Meyrick, 1913b: 82. [1, Oriental]

Type species *Phalaritica vindex* Meyrick, 1913b, by monotypy. Described in Heliodinidae. Placed in the Momphidae-*Blastodacna*-complex by Kasy (1976). Status uncertain. Probably belonging to Roeslerstammiidae (Hoare, pers. comm.).

Phepsalostoma Meyrick, 1936: 626. [1, Oriental]

An objective replacement name for *Asterostoma* Meyrick, 1935b. Described in Cosmopterigidae. Placed in Agonoxenidae by Sinev (2002).

Asterostoma Meyrick, 1935b: 607, a junior homonym of *Asterostoma* Agassiz in Agassiz & Desor 1847.

Type species *Asterostoma electracma* Meyrick, 1935b, by monotypy. Described in Cosmopterigidae.

Spuleria Hofmann, 1898: 230. [3, Palaearctic]

Type species *Tinea aurifrontella* Geyer in Hübner, [1832], by monotypy. Described in Tineidae. Placed in Elachistidae by Stainton (1854). Placed in Cosmopterigidae by Fletcher (1929). Transferred to Agonoxenidae-Blastodacninae by Hodges (1978).

Tocasta Busck, 1912: 4. [3, Neotropic]

Type species *Tocasta priscella* Busck, 1912, by original designation. Described in Coleophoridae. Placed in Tineidae by Fletcher (1929). Placed in Coleophoridae by Becker (1984b). Transferred to Elachistidae-Agonoxeninae by Baldizzone (1989).

Amblytenes Meyrick, 1930: 229.

Type species *Amblytenes lunatica* Meyrick, 1930, by monotypy. Described in Cosmopterigidae. Placed in Coleophoridae-Batrachedrinae by Becker (1984b). Transferred to Agonoxenidae-Parametriotini and synonymized by Hodges (1997).

Diacholotis Meyrick, 1937: 79.

Type species *Diacholotis iopyrrha* Meyrick, 1937, by monotypy. Described in Cosmopterigidae. Placed in Agonoxenidae by Becker (1984b). Synonymized by Becker (1999).

The genus belongs to Parametriotinae according also to Hodges (1997) and Becker (1999). Becker (1999) resurrected *Amblytenes* Meyrick, 1930 as a good genus on the basis of differences in the male genitalia. In our opinion these differences are insufficient to support separate genera and we follow Hodges' synonymy.

Trachydora Meyrick, 1897: 390. [50: Australian 42, Palaearctic 4, Oriental 1, African 3] Figs 32, 41–44

Type species *Trachydora illustris* Meyrick, 1897, by original designation. Described in Elachistidae. Placed in Momphidae-Blastodacninae by Sinev (1982). Transferred to Cosmopterigidae-Chrysopeliinae by Nielsen (1996). Placed in Elachistidae-Parametriotinae by Kaila et al. (2011).

Anataractis Meyrick, 1916a: 565.

Type species *Anatarctis plumigera* Meyrick, 1916a, by monotypy. Described in Cosmopterigidae. Synonymized by Fletcher (1929).

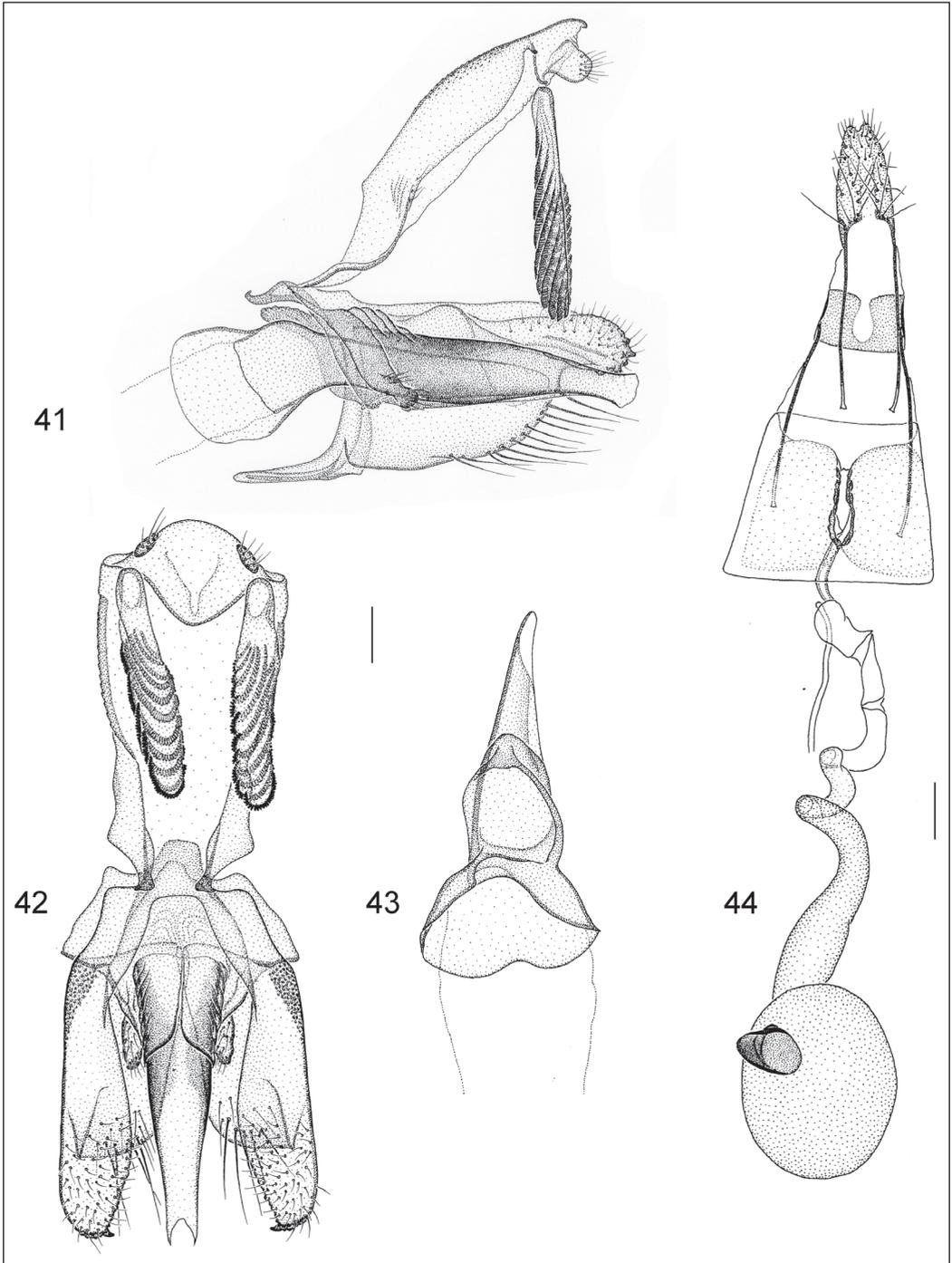
Balionebris Meyrick, 1935a: 573.

Type species *Balionebris bacteriota* Meyrick, 1935a, by monotypy. Described in Cosmopterigidae. Synonymized by Sinev (2002)

Sindicola Amsel, 1968: 22.

Type species *Sindicola squamella* Amsel, 1968, by original designation. Described in Cosmopterigidae. Synonymized by Kasy (1969).

Meyrick described this genus from Australia with 22 species. An additional 20 species were added by later authors. The genus shows external similarity with *Leptozeitis*; detailed taxonomic revisions are required to establish whether these two genera are separate or not.



Figures 41–44. *Trachydora ussuriella*. Male and female genitalia, genitalia in vials, phallus *ex situ*, data as Fig. 32. 41. Lateral view; 42. Ventral view; 43. Phallus in ventral view; 44. Female genitalia. Scale bars: 0.2 mm.

Zaratha Walker, 1864: 789. [13: Neotropic 4, Oriental 2, African 1, Australian 5]

Type species *Zaratha pterodactylella* Walker, 1864, by monotypy. Described in Lepidoptera-Heterocera. Placed in Agonoxenidae-Blastodacninae by Becker (1984a).

The genus has been described from Mexico. Becker (1984a) gives illustrations of the male genitalia of two species which clearly belong to Parametriotinae. Specimens identified as belonging to *Zaratha* from outside the New World have to be checked to see whether they actually belong to this genus.

Genera excluded from Parametriotinae

Lamprystica Meyrick, 1914b: 58.

Type species *Lamprystica purpurata* Meyrick, 1914b, by monotypy. Described in Glyphipterigidae. Placed in Oecophoridae (Stathmopodini) by Heppner (1981); in Oecophoridae (Depressariinae) by Kameda, 1988. The tribus Stathmopodini and the subfamily Depressariinae were later raised to separate families (Minet, 1986; Sinev, 1992). Placed as separate subfamily in Agonoxenidae by Lvovsky (1996). Here excluded from Elachistidae-Parametriotinae, either belonging to Oecophoridae or Depressariidae.

Nicanthes Meyrick, 1928: 395.

Type species *Nicanthes rhodoclea* Meyrick, 1928, by monotypy. Described in Cosmopterigidae. Placed in Agonoxenidae by Becker (1984b). Hodges (1997) checked the genitalia of the female and suggested that it belongs in Gelechioidea (possibly Gelechiinae), but not Agonoxenidae.

Prochola Meyrick, 1915: 331.

Type species *Prochola oppidana* Meyrick, 1915, by original designation. Described in Cosmopterigidae. Placed in Agonoxenidae by Becker (1984b). Placed in Cosmopterigidae-Chrysopeleinae by Hodges (1997).

The genus had already been removed from Parametriotinae by Hodges (1997), who recombined nine species with *Periploca* Braun, 1919: 261 (Cosmopterigidae-Chrysopeleinae) and four species with *Tetanocentria* Rebel, 1902: 107 (a junior synonym of *Haplochrois* Meyrick, 1897: 299) in Agonoxeninae –Parametriotini, overlooking the fact that Sinev (1979) already recombined the same species with *Tetanocentria*.

Only two species were left in *Prochola* by Hodges (1997), but he wrote “misplaced” after one, so that only the type species remains.

Vanicela Walker, 1864: 1039. [Australian 2]

Type species *Vanicela disjunctella* Walker, 1864, by monotypy. Described in Lepidoptera-Heterocera. Placed in Schreckensteiniidae by Fletcher (1929). Transferred to the Momphidae-Blastodacna-complex by Kasy (1976). Transferred to the Roeslerstammiidae by Dugdale (1988). The position in Roeslerstammiidae was confirmed by molecular studies by Heikkilä et al. (2015).

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Book review: The Natural History of Burnet Moths, Part I

GERHARD M. TARMANN¹

¹ *Naturwissenschaftliche Sammlungen, Sammlungs- und Forschungszentrum der Tiroler Landesmuseen, Krajnc-Straße 1, A-6060 Hall, Austria; g.tarmann@tiroler-landesmuseen.at*

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Preamble. Exactly three weeks have passed since I spotted the parcel with “The Book” in the foyer behind the entrance door. I had just returned from a five-week field trip to Liguria and Catalonia and was in the best mood. In this emotional moment, after having opened the parcel and seen it for the first time, I thought: ‘Praised be this day! Here it really is! “The Book”!’ These hardcover bound 630 pages with their 3.2 kg weight meant a lot to me. They are not only the first part (of three) of another book on burnet moths, they are a piece of the souls of two of my best friends and colleagues both of whom dedicated their lives to the study of Zygaenidae, like myself, and have put all their knowledge and that of many colleagues, friends and supporters together in an impressive monograph on the life history of the Zygaeninae, the burnet moths, the best known subfamily of this almost mystic group of Lepidoptera.

I had been asked to write a book review for *Nota Lepidopterologica* earlier and started to read almost immediately. A day later I was not only full of excitement, I was also irritated and emotionally at rock bottom. Too many personal remembrances had mixed with admiration and respect for how such a work could ever have been written. Only one year ago I had been on a wonderful field trip together with W. G. ‘Gerry’ Tremewan in Italy. We lost Gerry on 1 October 2016 just after Axel Hofmann had managed to show him the first chapters of their book ready for print. That he will never be able to see the now published printed version is really tragic. However, at least he had had the satisfaction to know this work was in the skillful hands of Axel and the knowing English editorship of Adrian Spalding, another old friend. During this last field trip to Italy in 2016 Gerry had talked about this book much more than he had on all earlier trips during the 20 years that we had had together. Every time he spoke about this work he was so full of vivacity and joy that even my own field work seemed almost irrelevant. It was always the search in the field for the authentic observation that can only be found by continuous personal experiences, exact documentation and meticulous comparison of facts that Gerry emphasised. He saw taxonomy more as a necessary burden that has also to be dealt with but his heart beat for the life history, genetics, distributional patterns and ecological phenomena. Gerry had found a congenial joint author in Axel Hofmann, who compiled an enormous amount of information from his and friends’ own experiences and combined it with all Gerry’s knowledge to create the manuscript, illustrated it with thousands of figures and pictures and finally skilfully edited and laid out the whole book.

It has taken me three weeks to recover from my feelings but this morning (it is the 26 July 2017), when an icy north-east wind of a rainy summer day in the Alps shook my window and the snow could be seen on the mountain tops when the clouds allowed sight for a short moment, I felt new power and the necessary strength of mind came back to allow me to write about a work that can only be commented on when in such good spirit and mood. It was this spirit of enthusiastic lepidopterists that was the beginning and will be the end of

this remarkable book project on burnet moths and which will hopefully enlighten those who are ready and sensitive enough to read themselves deeper into “The Book” that is, without any doubt, a milestone in entomological literature. For me it is not only a personal honour to be allowed to comment on it but also a great challenge. Knowing that I can hardly do justice to this outstanding work and can only do my best considering the shortcomings of a reader who has never dealt with burnets in such depth and is mainly working on other subfamilies of Zygaenidae, I hope to be able to find the right words to inspire readers to enjoy “The Book” (Fig. 1) with all its unique authentic information and beautiful pictures.

Axel F. Hofmann and W. Gerald Tremewan (2017): The Natural History of Burnet Moths (*Zygaena* Fabricius, 1775) (Lepidoptera: Zygaenidae). Part 1. Proceedings of the Museum Witt Munich 6 (1). Munich and Vilnius. 631 pp., 4663 figures (distribution maps, colour figures, black and white genitalia figures), 73 tables. Hardback. ISBN 978-3-940732-32-3. Price: 150 €*.

This book is the first part of three on the natural history of Zygaeninae (Burnet moths). The world’s two most renowned specialists on this group W. Gerald Tremewan (Great Britain) and Axel F. Hofmann (Germany) have combined the results of their life-long studies and produced a breathtaking opus that will without doubt significantly influence all further work on Zygaenidae. The book is dedicated to the two sons of the authors as a symbol to the fact that without the huge support of their families neither the compilation of all the information that is summarised in this book nor the years of production would have been possible.

As acknowledged in the first foreword by Roger L. H. Dennis, the authors, both travellers, explorers and scientists, have achieved an exceptional result in summarizing their dedicated life’s work. This book is a culmination of many papers and many journeys, with unselfish scientific comradeship, integrity and respect for the natural world.

The author of the second foreword, Günther Ebert, himself an experienced author, explorer, traveller and field worker, is impressed by the easy way such immense projects can come to fruition if the right persons come together. After an especially enjoyable collecting day in Morocco in the vicinity of Djebel Ayachi in 1989, both authors were sitting over a good cool bottle of rosé wine at their campsite near Midelt in the High Atlas when the idea to write a book on the natural history on burnet moths was agreed upon between them.

The book starts with a preamble that gives the reader a good impression of the long journey from the first idea to the final result. Ups and downs, joy and difficulties in the field, dangerous expeditions, meetings with exceptional friends and supporters, always with the final goal in their minds, the authors claim that they only could manage to finish the book within about a quarter of a century due to modern computer- and phototechnology. What an understatement! Alone the incredible expeditions of Axel Hofmann to Afghanistan in the last years to clear a few still unknown biologies of rare burnets give us an impression with what dedication the authors followed their agreed goal. The preamble ends with the hope that the reader will have as much pleasure with this book as the years of fieldwork, research and compilation of the typescript gave to the authors.

* For orders: hofmann@abl-freibug.de

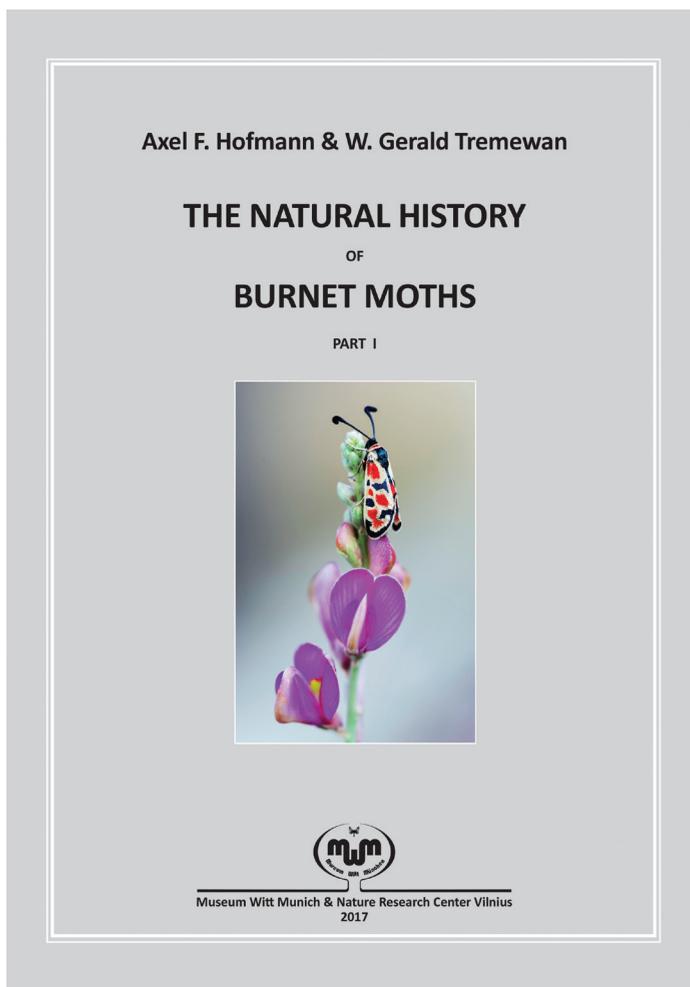


Figure 1. Cover of the book.

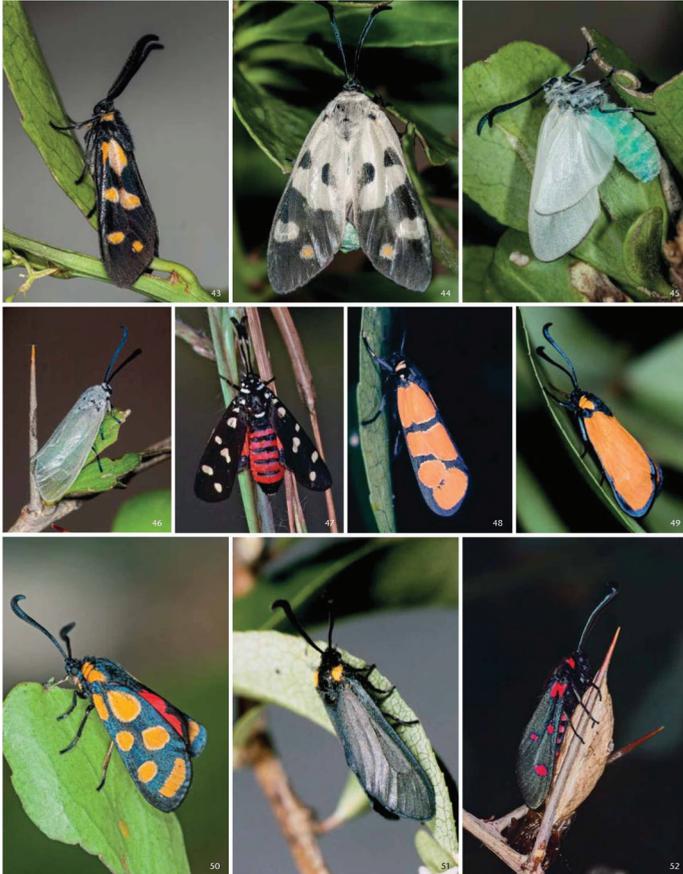
Two and a half pages of acknowledgements show how much knowledge is combined in this book. Many of the supporters have passed away in the meantime but their contributions will remain and most of them would be proud to see that they are present in this book.

Each chapter starts with a beautiful double page colour plate.

In the first chapter an overview, with abstracts on the content of all three parts of the whole work, is given after a short introduction. In 22 chapters (1–8 in part I and 9–22 in part II) information on all relevant contents such as the origin, phylogeny, systematics, distribution, zoogeography, morphology, variation, life history, phenology, reproductive biology, genetics, biochemical specialties, aposematism, mimicry, predators, parasitoids, and conservation of burnets is given. Part 3 of the book deals with the burnet species one by one in detail. Here all the field and rearing observations of the authors including the information that they received from others are summarised with special emphasis on their geographic differences.

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Origin, phylogeny, out-groups and systematics



Figs 43–52. Phenotypic diversity and evolutionary development of Zygaeninae moths (II). 43, *Orna contraria*, ♂ (South Africa: Eastern Cape, Hoegsback SW., c.l. 23.ii.2015). 44, *O. contraria*, ♀ (same locality, 15.ix.2015). 45, 46, *O. nebulosa*, ♀ (same locality, c.l. 8.ii.2014). 47, *Zutulba namaqua zelleri* (South Africa: Limpopo, Pietersburg, 9.i.1985). 48, *Praczygaena myodes* (South Africa: Hogsback, 12.ii.1986 (N. Duke)). 49, *P. ochroptera* (South Africa: Haenertsburg, 10 km W, 3.iii.2000, c.l.). 50, *P. agria* (South Africa: Pietersburg, 21 km S., c.l. 19.iii.2014). 51, *Epiorna abessynica* (Ethiopia: Goha Tsiyon, x.1989). 52, *Reissita simonyi* (Oman, Dhofar, c.l. 27.iv.2000). Photos: A. Hofmann (43–46, 50), C. M. Naumann (47–49, 51, 52).

Figure 2. Phenotypic diversity in burnet moths on page 18 of the book.

Chapter two deals with the origin, phylogeny, outgroups and systematics of the subfamily Zygaeninae starting with a close up photo of the first fossil zygaenid specimen that has been published, *Zygaena miocaenica* Reiss, 1936. All well preserved fossil Zygaeninae are figured. Phylogenetic relationships are discussed and graphically explained and the distributions of all Zygaeninae genera are shown in colour maps. This is followed by a beautiful double page colour plate of water colour paintings by Crapon de Caprona (1984) in which most of the currently known non-Palaeartic Zygaeninae species are figured. Biotope photos and excellent photos of living specimens by Axel Hofmann and Clas M. Naumann show the phenotypic diversity of adults and larvae (Figs 2–3). Moreover, the types of oviposition, the diversity of habits of the early stages, and the diversity of the cocoons including their ultrastructure are figured and discussed. After this overview the genus *Zygaena* Fabricius, 1775, is treated in detail. The authors' opinion on the phylogenetic relationships based on the published tree of Niehuis *et al.* (2007) is explained and comments on subgeneric and

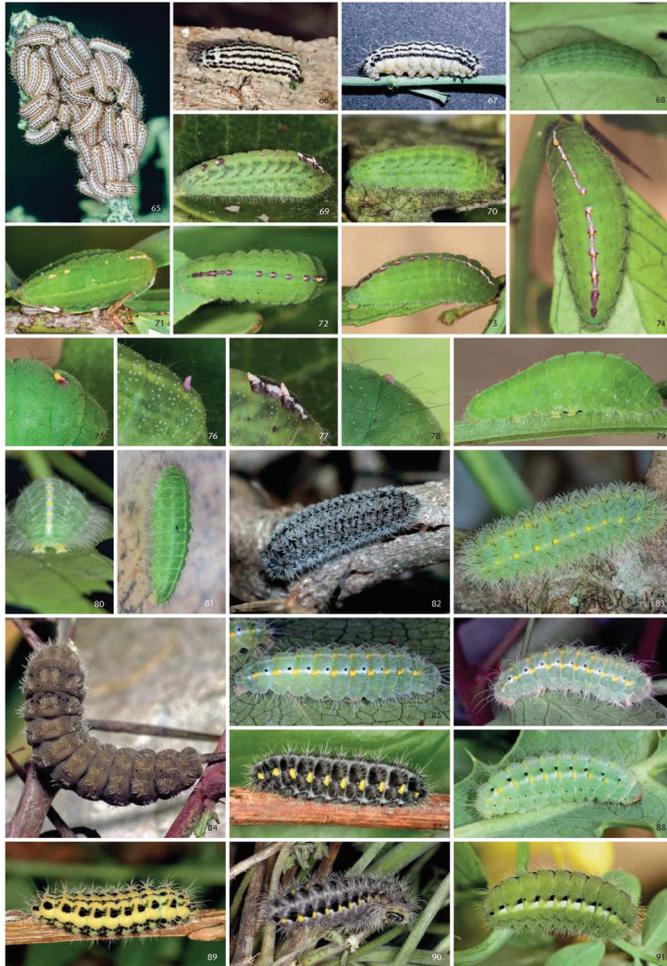


Figure 3. Larval diversity in burnet moths on page 20 of the book.

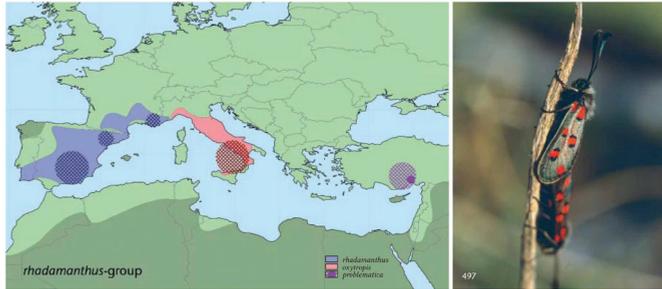
infrasubgeneric taxonomy are given. The three accepted subgenera *Mesembrynus*, *Agrumenia* and *Zygaena* are further commented on in detail and the possible origin, differentiation and current centres of diversity of the genus *Zygaena* are discussed in depth. Arguments about the possible centre of evolution of the genus are presented and compared, all of it illustrated with informative maps and trees. This is followed by a phylogeographic analysis of stem groups, species groups and species.

A complete checklist of the genus *Zygaena* Fabricius, 1775, lists 108 currently accepted species but it is also discussed that some species hybridise and their taxonomic position is still not completely clear.

Chapter three deals with one of the most difficult and unclear species groups, the *Zygaena purpuralis/minos* complex. This chapter impressively shows the challenge that taxonomists have to face when characters are not sufficiently known and, even when the morphology, biology and distribution is known, how difficult it is to decide as a scientist how to draw the right conclusions

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Distribution and zoogeography



Figs 496, 497. Refugia and current distribution of the *rhadamanthus*-group. 496, map showing ranges of *Zygaena rhadamanthus*, *Z. oxytropis* and *Z. problematica* (range of genus *Zygaena* in light green). 497, *Z. rhadamanthus guichardi*, the westernmost population with strongly isolated spots 5 and 6 (Portugal: Carrapatra vic., 50–100 m, 19.iii.1989). Photo: W. G. Tremewan.



Figs 498–500. Diversification of the *rhadamanthus*-group, from west to east. 498, *Zygaena rhadamanthus rhadamanthus* (France: Roussillon, 20.v.2013). 499, *Z. oxytropis oxytropis* (Italy: Potenza, Monte Sirino N., Tepe di Roccarossa S., 1,360–1,400 m, e.l., 8.v.2011, S). 500, *Z. problematica* (Turkey: Camliyayla 10 km E., 28.v.1995). Note the change in the black edging of the spots and in the distances between spots 5–6, which are widely separated in the westernmost populations in Portugal, closer in southern France, and connected in populations in the Apennines (*Z. oxytropis*) and in southern Turkey (*Z. problematica*). Photos: J.-M. André (498), A. Hofmann (499), C. M. Naumann (500).

The *rhadamanthus*-group. *Zygaena rhadamanthus*, *Z. oxytropis* and *Z. problematica*, comprising the *rhadamanthus*-group, represent a very good example of three allopatric species that are associated with a clearly defined phenotypic character progression, suggesting that the group expanded from west to east and not from east to west, as Naumann (1966: 17) and Naumann, Tarmann & Tremewan (1999: 50, text-fig. 51) interpreted. It is here suggested that the correct interpretation of the geographical character progression expressed in the *Z. rhadamanthus*-group is *Z. rhadamanthus* → *Z. oxytropis* → *Z. problematica*. For example, with reference to

of *Z. rhadamanthus* have a pronounced, red abdominal cingulum and the forewing spots (except spot 6) are always distinctly edged with black proximally and distally, whereas the cingulum is lacking in *Z. oxytropis* and *Z. problematica* and the black edging of the spots is reduced in the former species and absent in the latter, i.e. in phylogenetic terms, characters are lost instead of acquired. Moreover, it is easier to understand (and more parsimonious) if one deduces the derivation of the character-reduced species *Z. oxytropis* and *Z. problematica* from *Z. rhadamanthus*, i.e. the loss of cingulum, instead of postulating the development of this feature from non-cingulated forms. Less plausible also would be the

Figure 4. An example of the distribution and zoogeography of burnet moths on page 136 of the book.

from the summarised facts. All arguments are nicely accompanied by good illustrations of specimens, larvae and genitalia of males and females.

Chapter four is a real highlight of the book. It is dedicated to zoogeography, the distributional patterns of the various species, the diversity of habitats, possible historical origins of populations, refugia and distributional pathways, endemism, expansion and invasion of areas and habitats and phylogeography, and concludes with a profound and impressive comparative analysis of the 15 presented and discussed geographic subareas where *Zygaena* currently lives (Fig. 4). Alone this chapter could form an impressive book of its own. On 190 pages, illustrated with hundreds of excellent pictures of specimens, habitats, distribution maps, tables, graphics and trees the authors present a firework of informational highlights showing their great enthusiasm and outstanding knowledge.

Chapter five deals with the morphology of the adults and the early stages of *Zygaena*. The figures in this part of the book are partly taken from the late Clas M. Naumann's huge archive



Figs 1303–1320. Intraspecific variability in imaginal phenotype (II) of *Zygaena ephialtes*. Forms and morphs from Greece. This polytypic species comprises monomorphic and -opposited to *Z. carniolica* - polymorphic populations; the latter especially occurring in the Balkans where there is a broad contact zone of the main morphs *Z. peucedani* and *Z. ephialtes*. Here a selection of specimens of various colours (red, yellow, orange and brown), of ephialoid, peucedanoid and transitional melanistic forms, of five-spotted, six-spotted and intermediates, of uningulated, one or three segments coloured specimens. Note that twelve specimens (1307–1318) derive from a single (!) locality. Some of the figured forms/morphs from Kepesovon are very rare in nature or were exclusively found in cultures (1303–1306, 1309, 1312, 1313, 1317), whilst others (1307, 1308, 1310, 1311, 1314–1316, 1319, 1320) regularly occur in the wild.

1303, 1304, subsp. *chalkidikae*; 1305, ab. *immaculata*, red form (Greece: Thessalia, Pilon, Chorefton vic., 200 m, F6, e.p.: 1.v.1992, St. & G. Reijß); 1304, orange form (same data, F2, e.p.: 25.v.1989, A. Hofmann, St. & G. Reijß); 1305–1318 subsp. *smolikiana*; 1305, 1306, brown forms (1305, brown-ephaloid; 1306, brown-peucedanoid; Greece: Smolikas-Massiv, Kouitsa SE., Ag. Paraskevi, 900–1250 m, F4, e.p.: 21.v.1986, I. G. & St. & G. Reijß); 1308–1318, various forms/morphs (Greece: Epiros, Findos, Timfi, Kepesovon-Vradetou, 1,400–1,580 m, F1–F7, e.p.: 1988–1995, H. & A. Hofmann); 1312, ab. *acingulata*. 1319, subsp. *tymphrestica* with accessory red hindwing spot (Greece: Peloponnes, Korinth SW., Nemea WNW., Psari 10–12 km SE., 500 m, F1, e.p.: 7.v.1988, A. Hofmann). 1320, subsp. *odysseus*, with absent hindwing spot (Greece: Ionian island, Kefalonia, Poros NW., Agios Nikolaos NW., 250–400 m, F2, e.p.: 13.xi.1988, H. & A. Hofmann).

Figure 5. Intraspecific variability in burnet moths on page 341 of the book.

that has been provided to Axel Hofmann by Storai Naumann for publication in this book. Clas Naumann did a lot of innovative work on zygaenids in his time as professor of zoology in the university of Bielefeld in the early 1980s including the first series of stereoscan pictures. Many of these results were still unpublished at his death and are presented here for the first time. Throughout their lives both Axel Hofmann and Gerry Tremewan were not just gifted field workers but also keen breeders of *Zygaena* and this has led to an archive of photos of eggs, larvae, pupae, cocoons and adults that has no comparison worldwide. Thousands of pages of notes about the habits of all stages are stored in this archive. Only a small part of these treasures could be presented in this book but even that is more than enough to illustrate the peculiarities in structure and life of *Zygaena*.

Chapter six deals with the well known variability in the phenotype of adults and larvae of *Zygaena*. On 59 pages and illustrated with 652 colour figures this chapter gives the reader an idea



Figs 1837–1851. Polymorphism in Zygaeninae (II). Afrotropical taxa (I). Sex-independent polymorphism of yellow and red forms from South Africa. 1837–1842, *Praclyptis agria*. This dimorphism is hardly visible when the wings are closed as it is only expressed on the hindwings and the abdomen, while the tegulae, collar and other characters remain uniform (Limpopo, Pietersburg ca. 30 km N, 1.350 m, e.l., cp.: 19.iii–18.vi.2014, S). 1843–1846, *Neurosymploca concinna*. Here the dimorphism is recognizable with closed or open wings. While the tegulae and collar are only weakly changed in colouration, the change from red to yellow is complete on the wings (1843, 1844, Western Cape, Oudshoorn NW, Gr. Swartberg pass, 1.000 m, 1.ii.2016, S; 1845, 1846, Eastern Cape, Hoeghsback SW, 850 m, e.o., 18.xi.2014, S). 1847–1851, five distinct colour morphs of *N. naumanniola*; 1847, pure red form (Western Cape, Leipoldtville N, 120 m, e.l., 12.ii.2016); 1848, red wings, orange abdominal cingulum (Western Cape, Lambertsbai 16 km ESE, 100 m, e.l., 1.iii.2016); 1849, 1850 (Western Cape, Nieuwoudtville W, Van Rhyns pass, 730 m); 1849, (orange forewings and tegulae, red hindwings and cingulum; e.l., 26.ii.2015); 1850, (orange forewings and tegulae, yellow hindwings and cingulum; e.o., 23.v.2016); 1851, complete yellow form (Western Cape, Piketberg W, Verfeld pass, 570 m, e.l., 21.ii.2016). Photos: A. Hofmann.

Figure 6. An example of the polymorphism in burnet moths on page 385 of the book.

why *Zygaena* has been one of the most popular genera for collectors and photographers and a model group for studies about variation. Axel Hofmann's exceptional selection of specimens for this chapter enables easy understanding of complicated phenomena and shows much skill by the authors in educating the reader to look and understand (Fig. 5). Many non-Palaearctic Zygaenini are also figured showing the same polymorphism as many species of *Zygaena* (Fig. 6).

Chapter seven is dedicated to geographical patterns and clusters in *Zygaena*. It deals with the interesting question of supraspecific phenomena and characters bound to special geographical regions, called by the authors 'pheno-geography'. An important example is the syntopic occurrence of melanistic subspecies of different *Zygaena* species in several regions of their distribution, both larvae and adults. But there are more such phenomena known, such as an increase of red or white

coloration in certain regions. Again the information is perfectly summarized by the authors, richly illustrated and accompanied by informative distribution maps.

Chapter eight gives an overview on historical observations and publications on the biology of burnet moths, starting with a frontispiece that shows *Zygaena* species in a ca. 260-year-old oil painting by Otto Marseus van Schrieck housed in the Simferopol Art Museum in Crimea and discussed by Efetov & Tarmann in 2007 [Efetov KA, Tarmann GM (2007) Van Schrieck's burnet moth – an image of a *Zygaena* species (Lepidoptera: Zygaenidae) a century before Linnaeus. *Entomologist's Gazette* 59: 62–64, figs 1–2]. However, the reader learns that the oldest known illustration of a *Zygaena* is figured in Cocharelli's medieval work *Leaves from a prose treatise on the Seven Vices* dated from between 1330 and 1340 which clearly shows a Mediterranean *Zygaena lavandulae*. The authors then give a summary starting from pre-Linnaean observations up to today mentioning all important authors who have dealt, in some way, with the natural history of *Zygaena*. They illustrate this chapter with original portraits and many reproductions of colour plates. The fact that Gerry Tremewan was, for many years, the professional editor-in-chief of the *British Museum's Bulletin (Natural History)* and in retirement maintained good connections to the world's best library of old books on natural history was clearly a unique advantage and the deep respect and love of the authors for history and literature can be felt on each page. The chapter ends with an illustrated report on the 14 international symposia on Zygaenidae held between 1980 and 2014 with a summary of their content.

These eight chapters are followed by a short introduction on the genital morphology of *Zygaena* and black and white photos of the relevant diagnostic characters of the male and female genitalia of all known species.

The references, a glossary of special terms and an alphabetic index finish this amazing book.

Conclusion

Hofmann & Tremewan's 'The Natural History of Burnet Moths' is a never before seen monumental opus on the subfamily Zygaeninae of Zygaenidae in all its diversity and beauty. Already the now published first part gives the impression of the complete final work as a milestone in entomological history. It is of unique completeness, illustrated with thousands of excellent pictures, graphics and maps. It is the result of the collaboration of two enthusiastic authors summarising their lifelong studies of literature, collections, observations in nature, rearing experiments, and endless discussions between the authors and other scientists. The spirit of joy for this work can be felt on each page and it is immensely inspiring to go through the chapters step by step learning a lot and being surprised by the sheer unbelievable diversity of life.

Thanks to the financial support of the Thomas-Witt-Stiftung in Munich, the price for this monumental work could be kept on an affordable basis not only for entomologists but also for lovers of beautiful nature books. It only can be heartily recommended to make a present to oneself or friends with this book as a never ending well of joy for the beauty and astonishing diversity of nature.

It is expected from a reviewer to also find some criticism on the work that he is reviewing. But to criticise the few typing errors and missed references that can be recognised in this book seems simply unnecessary.

Corrigendum: New records of Lepidoptera from Ukraine and description of a new species of *Caloptilia* Hübner, 1825 (Lepidoptera, Gracillariidae) from the mountains of Crimea

OLEKSIY V. BIDZILYA¹, YURI I. BUDASHKIN²

1 *Institute for Evolutionary Ecology of the National Academy of Sciences of Ukraine, str. Academician Lebedev 37, 03143, Kiev, Ukraine; olexbid@gmail.com*

2 *T.I. Vyazemsky Karadag Scientific Station – Nature Reserve RAS, Kurortnoye, Feodosia, Crimea, 298188; budashkin@ukr.net*

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