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Diasemiopsis ramburialis (Duponchel) (Lepidoptera, Pyralidae *s. l.*, Spilomelinae) in Iran: first record for the country and first host plant report on water fern (*Azolla filiculoides* Lam., Azollaceae)

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Abstract. During a survey at the Rice Research Institute of Iran (RRII, Rasht, Guilan) for potential biocontrol agents of water fern, *Azolla filiculoides* Lam. (Pteridophyta: Azollaceae), larvae of *Diasemiopsis ramburialis* (Duponchel) (Pyralidae *s. l.*, Spilomelinae) were discovered feeding on water fern. Larvae were found to cause serious feeding damage on leaves of water fern in the laboratory. The biology, life cycle, and the morphology of all stages of this species are described and illustrated for the first time. This is also the first record of this cosmopolitan species in Iran. We report water fern as a host for *Diasemiopsis ramburialis*; until now the host plant of *D. ramburialis* was unknown.

Introduction

Diasemiopsis ramburialis (Duponchel) is a snout moth in the subfamily Spilomelinae, the most species-diverse subfamily of Pyralidae *sensu lato* (or Crambidae, depending on authors, see Regier et al. 2012). Diagnostic characters for this subfamily are: head without chaetosemata, male hindwing without subcostal retinaculum, tympanal organs with a bilobed praecinctorium, projecting fornix tympani, and pointed spinula, male genitalia without gnathos, and corpus bursae of female genitalia usually without rhomboid signum (Minet 1982; Regier et al. 2012).

Diasemiopsis was described by Munroe (1957) with *Hydrocampa ramburialis* Duponchel, 1833 as type species. Only one other species, *D. leodocusalis* (Walker, 1859), described from the United States of America, is currently assigned to this genus (Nuss et al. 2015). The full synonymy of *D. ramburialis* is given by Nuss et al. (2015).

Adults of *D. ramburialis* are grey or brown, with two broad zigzagging white lines across each wing. They measure 17–22 mm in wingspan (n=20) (Fig. 1). Described from France (Corsica), this species has been reported from Africa (e.g. Maes 2004), the Seychelles (Aldabra Atoll) (Shaffer and Munroe 2007), Réunion (Guillermet 2009), Europe (Karsholt and Nieukerken 2013), Puerto Rico (Möschler 1890; Schaus 1940; Patterson 2015), Austral Islands (Rapa) (Clarke 1971), French Polynesia (Tahiti) (Oboyski 2015), Australia (Shaffer et al. 1996), Taiwan (Wang and Speidel 2000), and India (Kirti and Sodhi 2001). Clarke (1971) reported it as a cosmopolitan species and illustrated the habitus and male and female genitalia (see also Guillermet (2009) and Slamka (2013) for additional illustrations). Regarding records from the New World, Munroe (1957) mentioned

Figure 1. Adult of *Diasemiopsis ramburialis*.

that they actually refer to *D. leodocusalis* (Walker). Maes (2004) added that the species seemed to be linked to swampy areas. There is no record of host plant or any description of the immature stages available for *D. ramburialis*.

Azolla filiculoides Lam. (Azollaceae) is considered a major aquatic weed in several countries (Zimmerman 1985). It is a small-leafed floating aquatic fern native to the tropics, subtropics, and warm temperate regions of Africa, Asia, and the Americas (Costa et al. 2009). It is one of the world's fastest growing aquatic macrophytes, with a doubling time of only 2–5 days in biomass (Zimmerman 1985; Taghi-Ganjiet al. 2005). Some species of *Azolla* provide various benefits such as a source of organic nitrogen, soil improvement and nutrient availability, weed suppression, and as food for livestock, chicken, ducks and fishes (Anonymous 1987; Ferentinos et al. 2002). However, some of them, *A. pinnata* (R. Br.) and *A. filiculoides* in particular (e.g. Barreto et al. 2000), are considered major weeds in South Africa, Europe, and New Zealand (Hill 2003; Bodle 2008; Sadeghi et al. 2013) and *A. filiculoides* is an alien species in Iran (JICA 2005; Delnavaz and Azimi 2009).

In Iran, this weed invades rice fields and aquatic natural habitats, such as the Anzali (Delnavaz and Azimi 2009; Sadeghi et al. 2013) and Amir-kelayeh wetlands (Fig. 2) of the Guilan province. These wetlands have ecological importance for breeding, wintering, and survival of many species of birds, fish, and microorganisms (Khoshechin 1993; Naddafi et al. 2005; Charkhabi and Sakizadeh 2006; Moradinasab et al. 2012). Infestations of *A. filiculoides* reduce the quality of the water used for agricultural and human use, and simplify local aquatic food webs (Hill 1998). Control options for the water fern in Iran are limited because mechanical methods are impractical and there are no registered herbicides for aquatic ecosystems. This situation stimulated the use of biological control as a sustainable strategy for the long term management of *A. filiculoides* (Richerson and Grigarick 1967; McConnachie et al. 2003). *Stenopelmus rufinasus* Gyllenhal (Coleoptera: Curculionidae), a weevil native to the USA, had a huge impact on *A. filiculoides* as a biological control agent. This weevil controlled water fern in Africa, USA, and other regions (Hill et al. 2008; Partt

Figure 2. A waterway near Amir-kelayeh wetland covered with water fern.

et al. 2013). However, the identification of other active herbivores on *Azolla* as biotic resistance factors and competitor species with the main biological control agent was found to be desirable because other species may have negative or positive effects on the establishment of the main biological control agent. We conducted surveys in rice fields for two years due to a lack of information on local herbivores attacking *A. filiculoides* in Iran. The specific objective of this paper is to report the life history of *D. ramburialis* attacking *A. filiculoides* in Iran.

Material and methods

Rearing: Laboratory colonies were established by collecting larvae from water fern located on waterways and experimental rice fields at the Rice Research Institute of Iran (RRII) (N37°12’22.2”, E049°38’40.7”, 80 masl) from September to November 2013 and 2014.

Larvae were kept in 14 cm diameter petri dishes filled with water fern and 100 cc of distilled water. Petri dishes of the same size were used to cover the dishes to provide more space for larvae and newly emerged adults. Water was changed every 4 days and water fern was added if needed. The petri dishes were changed every 10 days to prevent the growth of fungi and bacteria.

Upon emergence, a pair, a male and female, were released into 14 cm covered petri dishes. To provide more space for the moths, we set up three 6 cm petri dishes each filled with 10 cc of distilled water and 5 g of water fern. The 6 cm petri dishes were changed daily and placed in an incubator until egg hatching. The incubator was set at 25–27 °C and 16: 8h (L: D) photoperiod. Thereafter, first or second instar larvae were placed in 6 cm petri dishes provided with 10 cc of water and 5 g of water fern in groups of one, two, and three individuals in each dish. Since the lar-

vae had wandering habits, each 6 cm petri dish was placed in a 14 cm covered petri dish. The 6 cm petri dishes were changed every three days and water fern was added if necessary. Moth colonies were inspected daily and all activities, including egg hatching, larval feeding period, pupation, and emergence of adults were recorded.

Identification: Twenty adults were used for preliminary identification based on wing venation and other morphological characters. Dissection of both male and female genitalia (Figs 7–9), were made following Landry (2003) and Lee and Brown (2009). Dissections were conducted at the RRII laboratory and sent to B. Landry for final determination. The specimens were identified as *Diasemiopsis ramburialis* (Duponchel, 1834).

Field observations: During 2013 and 2014, feeding damage observations by *D. ramburialis* on water fern and other potential host plants were conducted in the waterways and experimental rice fields located at RRII.

Results

Eggs: About 1 mm in diameter, globular, opaque to pale orange (Fig. 3), they turn to dark orange or reddish brown before hatching. They are laid singly or in groups of two or three on water fern leaves or smooth surfaces of other material (Petri dishes) near the food plant. Development time at 25–27 °C was approximately 4 days.

Larva: Newly hatched larvae are dark orange to reddish brown with a black head (Fig. 4), about 1.5 mm in length, and have sparse setae on the body. As the larva develops, its colour becomes darker, the setae increase in length, and dark spots appear at the base of the setae. The last instar larva is greenish brown (Fig. 5) and about 18 mm in length. There are black plates on each thoracic and abdominal segment. The prothoracic shield is pigmented laterally and unpigmented medially and there are four dorsal, two lateral, and two ventral pinacula on the meso- and metathorax. On abdominal segments I–VII there are four dorsal, two lateral, and two ventral pinacula on each segment. On abdominal segment VIII there are three dorsal pinacula in a triangular pattern of two rows: two pinacula in first row and one in second row; this segment has two lateral and two ventral pinacula as well. Abdominal segments IX and X respectively have one dorsal pinaculum and one dorsal and one lateral pinaculum. There is little space between these pinacula and these areas appear as three longitudinal bands. The development time of 100 larvae at 25–27 °C was 14 to 15 days.

Pupa: Pupation usually occurred on dried water fern or mud on the side of the dishes. The length of pupa is approximately 7–9 mm and the colour turns from yellowish brown to dark brown during development (Fig. 6). The development time of 50 pupae at 25–27 °C was 7 days.

Adults: The habitus and male and female genitalia are illustrated in Figs 1 and 7–9. The longevity of adults at 25–27 °C with and without a sugary solution (10% honey) was <30 days and 14 days, respectively (at least 30 adults were followed under each treatment).

Symptoms of damage on host plants: Larvae of *D. ramburialis* are phyllophagous. We have observed that newly hatched larvae build shelters by binding leaves together with silk and remain hidden in their shelters when they are not actively feeding. When larvae mature, they leave their shelter and wander on water fern leaves in silky tunnels filled with frass (Figs 10 and 11). Feeding damage by larvae facilitated the infection of water fern with bacteria and fungi. Egg laying occurred during the entire lifetime (ca. 30 days) and the number of eggs per day varied considerably.

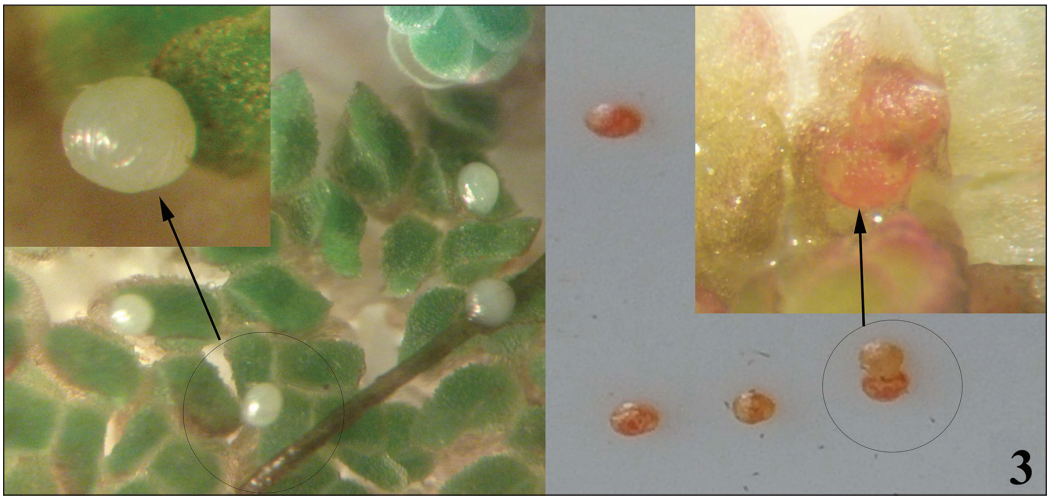
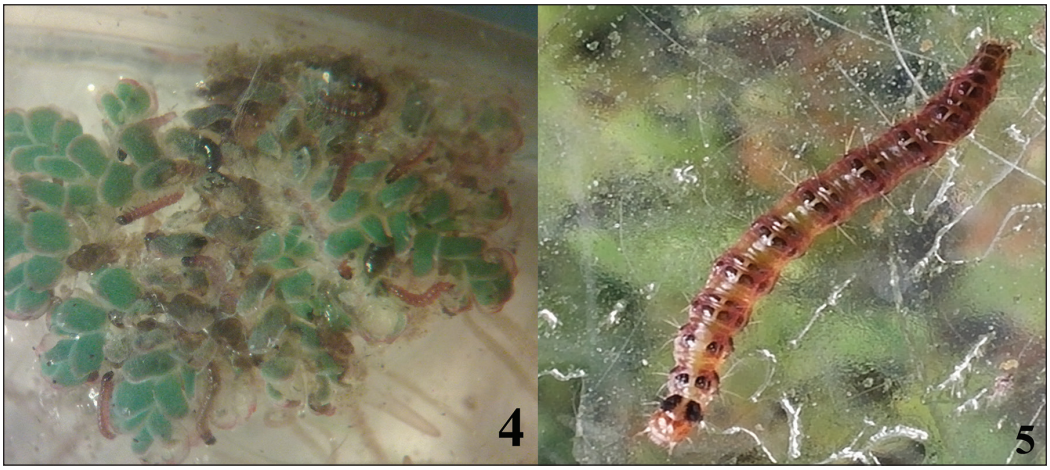


Figure 3. *Diasemiopsis ramburialis* eggs (Right: Infertile, Left: Fertile).



Figures 4, 5. *Diasemiopsis ramburialis* larvae **4.** First instar, **5.** Last instar.

Discussion

In northern regions of Iran, aquatic ecosystems such as stagnant waters, ponds, ditches, canals or paddy fields may be covered seasonally by *Azolla* (Delnavaz and Azimi 2009; Sadeghi et al. 2013) in association with other floating aquatic plants including *Lemna minor* L. (duckweed: Lemnaceae), *Trapa* sp. (water caltrop: Trapaceae), *Wolffia* sp. (water meal: Lemnaceae), or *Salvinia* sp. (Salviniaceae), and mud-rooting species such as *Ceratophyllum demersum* L. (hornwort: Ceratophyllaceae), *Ludwigia palustris* (L.) Elliott (water purslane or water primrose: Onagraceae), and *Polygonum arenastrum* Boreau (knotweed: Polygonaceae) (Delnavaz and Azimi 2009; Kannaiyan and Kumar 2006; Mozafarian 2007). *Azolla* is not native to the northern region of Iran and was introduced in 1986 (Delnavaz and Azimi 2009). However, many of the above-mentioned aquatic plants are native in this region (Mozafarian 2007) and many insects use them as food plants.

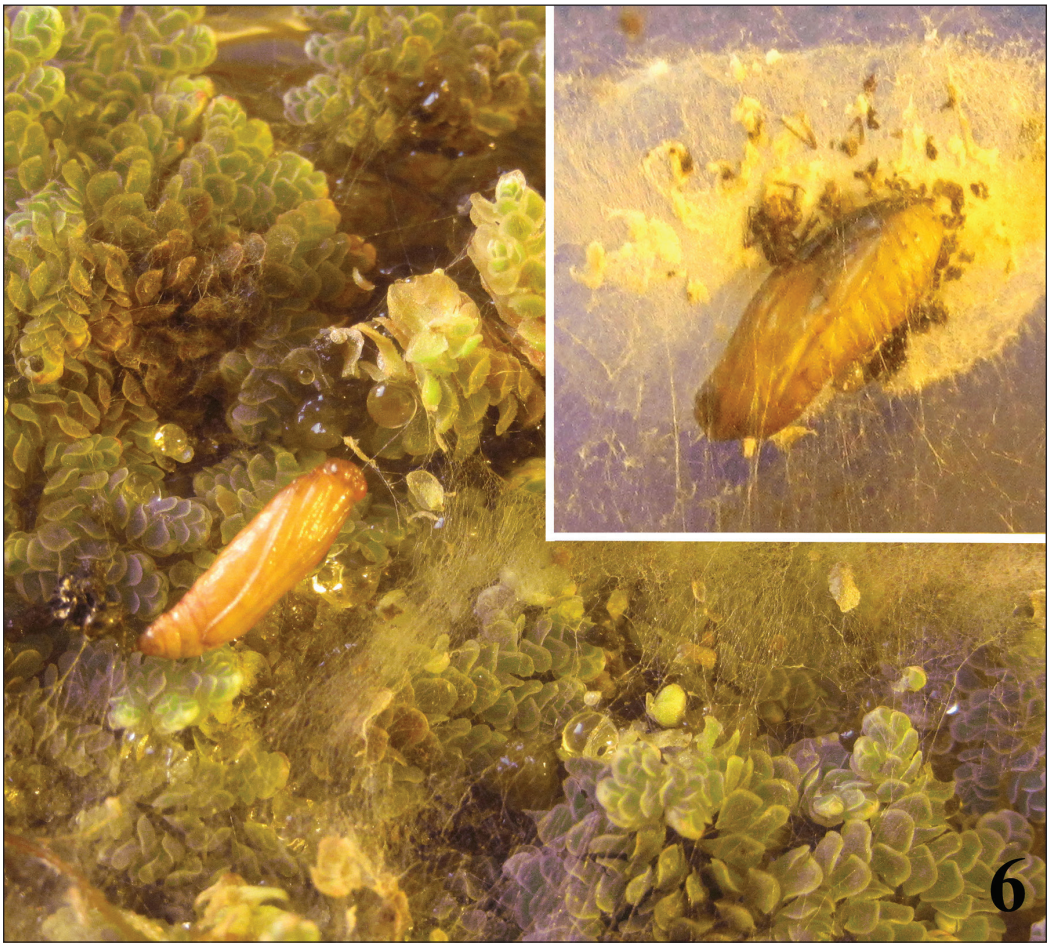
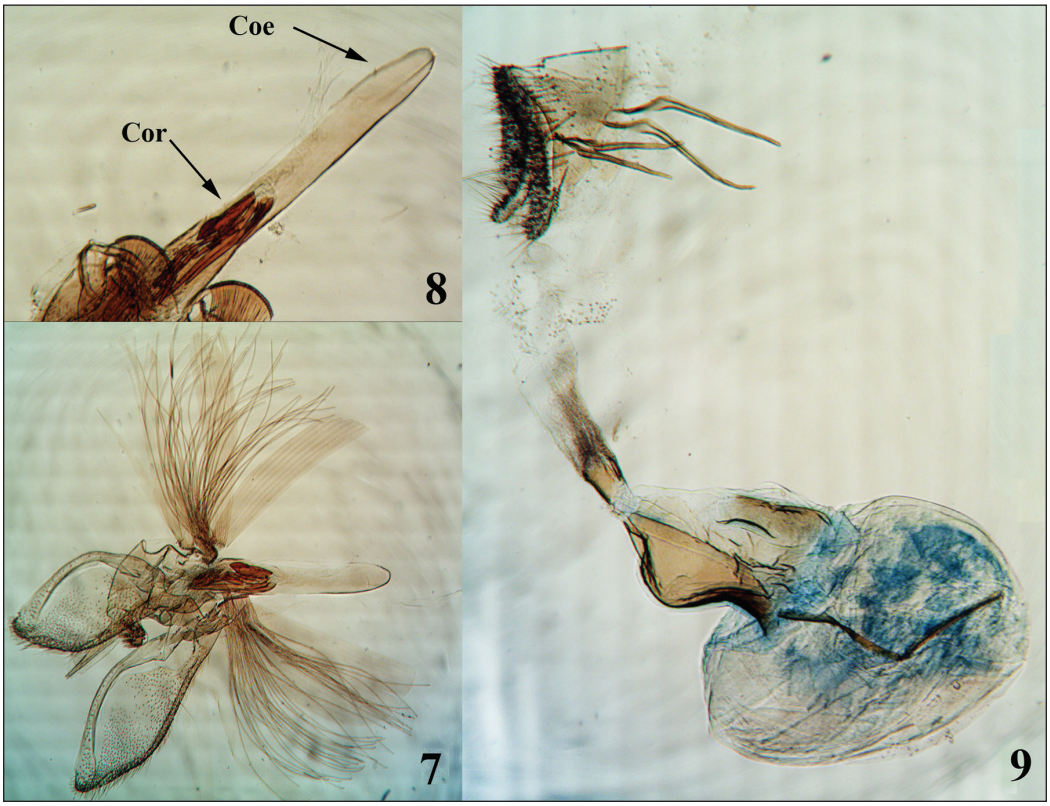


Figure 6. *Diasemiopsis ramburialis* pupa (Magnified: Mature pupa).

During the present study we investigated the activity of *D. ramburialis* on *Azolla* in rice fields. In Iran, *D. ramburialis* adults start their activity in July but they are most active in rice fields from September to late October. In these areas, this is almost the end of harvesting time and the end of the summer. The temperature gets slightly cooler and fields become half-dried, which eases harvesting. The reasons for the increase in the activity of adults in rice fields at the end of the summer, when water fern is getting dry due to water stress, are not clear.

Water depth could be a restricting factor for the activity of *D. ramburialis*. It is possible that pupae are sensitive to high water depth and are not able to survive under submerged conditions in rice fields during the cultivation season. In addition, culturing operations in rice fields disturb the water fern layer constantly and destroy pupae. However, after harvesting, since water fern remains undisturbed and fields become dry, *D. ramburialis* can increase its populations.

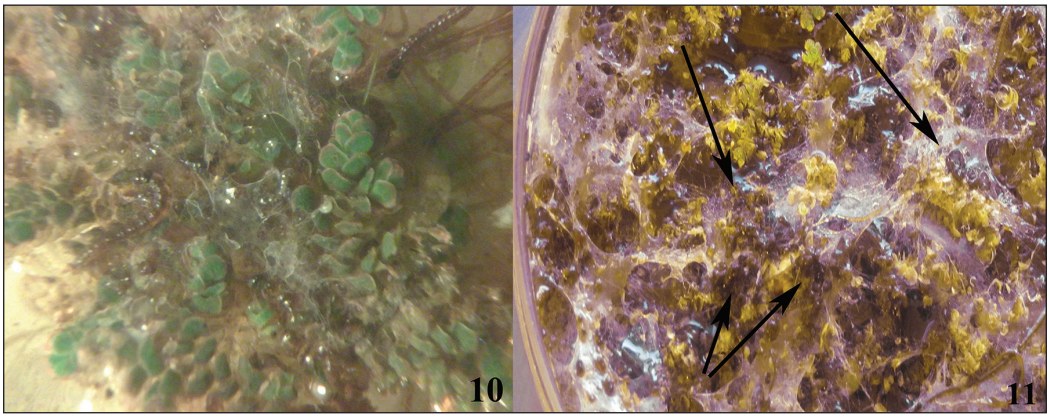
On the other hand, rice fields are an anthropogenic agricultural ecosystem in which thermal conditions can differ significantly from those of natural aquatic habitats. Discharge of heated water, artificial mixing of thermal strata, impoundment, diversion, regulation of water level



Figures 7–9. *Diasemiopsis ramburialis* genitalia. **7.** Male genitalia with phallus to the right and uncus+tegumen underneath right (top) valva. **8.** Phallus (Cor = Cornuti; Coe = Coecum). **9.** Female genitalia.

and flow, and canopy opening in riparian zones, through harvest or grazing, severely modify the thermal environment for aquatic species (Ward and Stanford 1982). Therefore, in wetlands without the disturbance of agricultural processes and chemical compounds *D. ramburialis* could behave differently.

Our study is the first to record a host plant for *D. ramburialis* and the genus *Diasemiopsis* because the host plant of the North American *D. leodocusalis* is still unknown. However, there are other Spilomelinae, such as the salvinia stem borer *Samea multiplicalis* (Guenée), that feed on several Salviniaceae and *Azolla*. This moth has been known as a potential biocontrol agent for *Salvinia molesta* DS Mitchell (Pelli et al. 2008). In host range tests Knopf and Habeck (1976) stated that this moth has three main host plants in Florida (USA): *Azolla caroliniana*, *Pistia stratiotes*, and *Salvinia rotundifolia*. However, this moth has not been reported on these host plants from Iran or the Palaearctic and African regions. Although we briefly studied the biology of *D. ramburialis* as a probable biotic resistance factor for water fern, many other important biological aspects such as life span in natural habitats, population growth parameters, host range, and host preference remain unclear. Also, we could not find any specific parasitoid or predator for this moth although there are many generalist predators and parasitoids active in rice fields (Ooi and Shepard 1994; Shepard et al. 1987) that could affect *D. ramburialis*.



Figures 10–11. Feeding activity and webbed shelters of *D. ramburialis* larvae. **10.** First instar larva making feeding shelter with silk. **11.** Shelter full of frass after larval feeding.

Conclusion

Environmental conditions of northern regions of Iran, in addition to agricultural activity, put native living organisms under various kinds of stress and shape them into trying to adapt to different conditions. However, in comparison to the long period of adaptation of native species, some exotic organisms such as water fern have adapted themselves to local conditions in a shorter period of time and have become dominant in some areas (Delnavaz and Azimi 2009; Sadeghi et al. 2013). This invasion puts native plants under pressure and the insects that feed on native plants either have to use new plants as a food resource or die of hunger. Despite a rich fauna of aquatic and semi-aquatic insects, water fern biotic resistance factors in Iran are still poorly known. We started our surveys on water fern biotic resistance factors in Iran's northern region rice fields in 2013 and this is the first report of our results. More studies are under way to uncover important facts on the biotic resistance factors of this non-native invasive weed in northern regions of Iran.

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Taxonomy of two montane *Dichrorampha* species from the Balkans and Caucasus (Lepidoptera, Tortricidae)

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Abstract. *Dichrorampha pentheriana* (Rebel, 1917), previously known only from the type locality in Montenegro, is reported from the Vitosha Mountains in Bulgaria, at an altitude of 2100 m. Data on the habitat and the suspected larval host plant (*Achillea lingulata* Waldst. & Kit., Asteraceae) are provided. A new species, *Dichrorampha sakartvelana* sp. n., is described from the Georgian Great Caucasus Mountains, at altitude 2280 m. Male and female moths and their genitalia are illustrated with photographs and line drawings.

Introduction

The genus *Dichrorampha* Guenée, 1845 comprises 142 species as listed in the Online World Catalogue of the Tortricidae (Gilligan et al. 2014). Most known representatives occur in the Holarctic region, but this tendency may change; a plethora of new species from the Neotropics have been described during last few years (e.g., Razowski 2011, Razowski and Becker 2012). The complicated taxonomy of the genus is reflected in the extended synonymy (a total of 89 synonyms is listed in the Catalogue). Many *Dichrorampha* species have a limited distribution and may be restricted to particular mountain ranges, i.e. endemism is a common phenomenon within the genus, and one can expect larger numbers of undescribed relict and endemic taxa in high mountain massifs. In this context discovery of a new species from the vast Great Caucasus Mountains range was not surprising. More than 30 species are known from Caucasus (Danilevsky and Kuznetzov 1968, Esartiya 1988), 13 of them are endemics for this region. More unexpected was the discovery of *Dichrorampha pentheriana* (Rebel, 1917) in the vicinity of Sofia, in the small but relatively high (2290 m) Vitosha Mountains. Twenty-three *Dichrorampha* spp. are reported for Bulgaria, one of them (*D. rilana* Drenowsky, 1909) endemic for the highest Bulgarian mountains (including Vitosha).

The larvae of most *Dichrorampha* spp. feed on different Asteraceae, mainly two genera: *Achillea* and *Tanacetum* (Danilevsky and Kuznetzov 1968). They are internal feeders in root tissues.

Two nicely patterned female *Dichrorampha* were swept from *Achillea lingulata* Waldst. & Kit. (Asteraceae) in the summer of 2012 in Vitosha Mountains, Bulgaria. Dissection of the genitalia of the female did not provide a reliable identification; additional male specimens were needed but at the time of dissection the season was already over. Collecting of males was postponed to the year 2014, which unfortunately had a very cold and rainy summer; only a single worn female came from the three excursions. Eventually, in June 2015, two males as well as two females were swept from a mountain meadow with numerous flowering *A. lingulata*. The unmistakable genitalia of the

dissected male clearly demonstrated that this odd looking *Dichrorampha* is *D. pentheriana* (Rebel, 1917), until now known only from the type series.

An unknown *Dichrorampha* was discovered in 2014 during an entomological expedition in the Great Caucasus Mountains, Georgia. The two moths were captured in late afternoon flying around tufts of *Achillea* sp. growing on the rocks alongside a mountain road. Subsequent sweeping of the same (and other) *Achillea* species did not provide more material, and an approaching thunderstorm suspended any further efforts to collect additional specimens; the locality was not visited again. The specimens collected have identical wing patterns and are of similar size, which in combination with their synchrony and syntopy suggest that they are conspecific. The habitus, wing pattern and genital characters of both male and female moths show unquestionable affiliation to the genus *Dichrorampha*, but do not match any known species in this genus.

The purpose of the paper is to illustrate and provide additional data and a redescription for the little known *Dichrorampha pentheriana* and to describe *D. sakartvelana* sp. n.

Abbreviations of collections

BFUS	Zoological collection of Sofia University St. Kliment Ohridski, Faculty of Biology, Bulgaria
NHMW	Naturhistorisches Museum Wien, Austria
NMNHS	National Museum of Natural History Sofia, Bulgaria

Methods

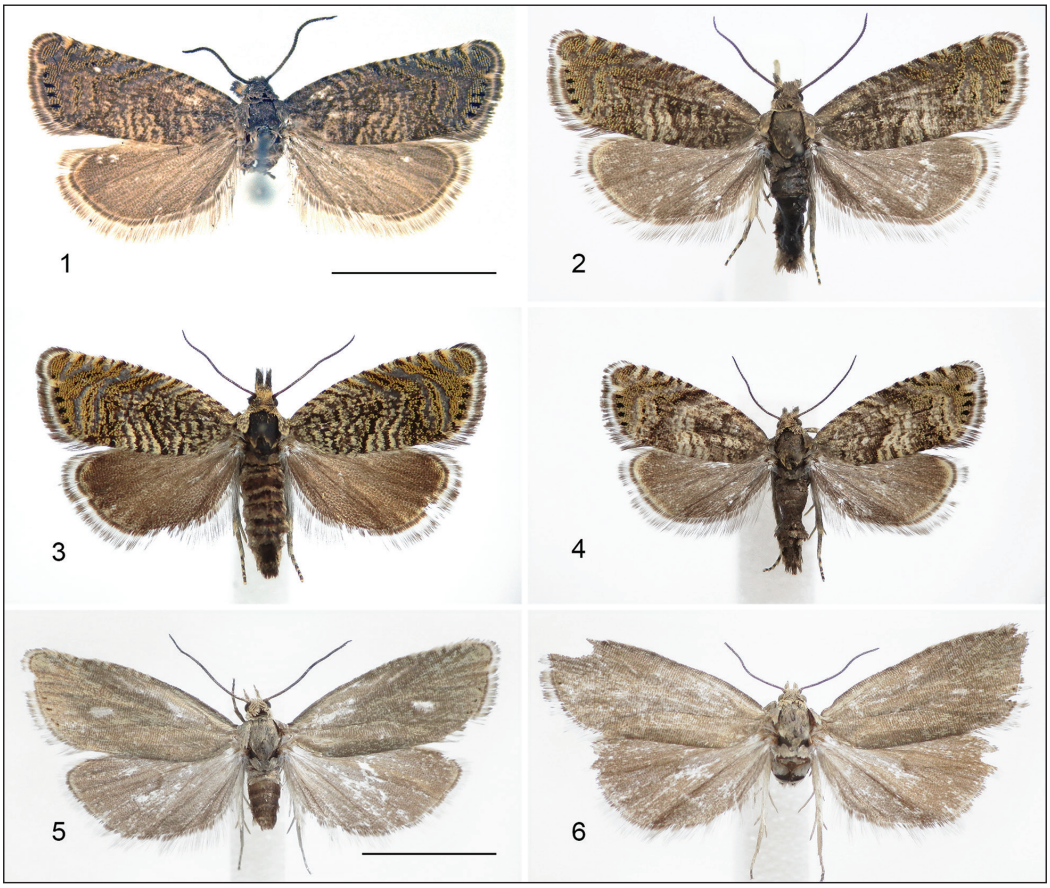
The moths were captured with aerial insect nets, killed with ethyl acetate and spread immediately. Later the abdomens were dissected and the genitalia were processed following the procedure of Robinson (1976). The type series of *D. pentheriana* was used for comparison with the Bulgarian specimens. The male paratype of *D. sakartvelana* was compared with male specimens of *D. petiverella* (Linnaeus, 1758) and *D. filipjevi* (Danilevsky, 1948). The nomenclature of the wing pattern follows mainly Baixeras (2002). The holotype of *D. sakartvelana* sp. n. will be deposited in BFUS, and the paratype in NMNHS. The *D. pentheriana* specimens are preserved in BFUS.

Dichrorampha pentheriana (Rebel, 1917)

Figs 1–4, 7–10, 14

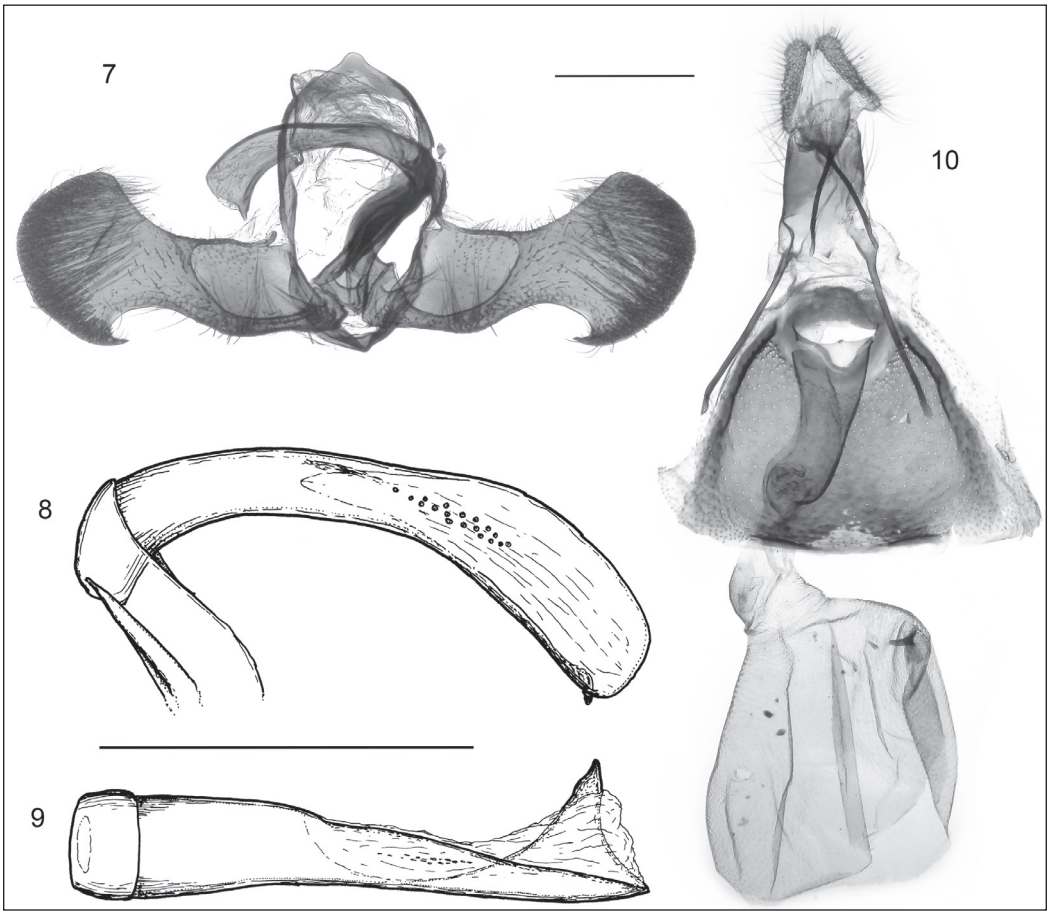
Material. 2 ♂, Bulgaria, Vitosha Mts, near Cherni vrah chalet, 2100 m a.s.l., N 42°34’20” E 23°17’03”, 11.vii.2015, leg. B. Zlatkov & E. Tasheva, coll. BFUS; 2 ♀, ibid.; 2 ♀, ibid. but 13.vii.2012, leg. B. Zlatkov & D. Gradinarov; 1 ♀, ibid. but 25.vii.2013, leg. B. Zlatkov.

Redescription based on the Bulgarian specimens (Figs 2–4). Sexual dimorphism subtle. Head: Frons and vertex pale brown, palpus labialis yellow encircled with black scales. Antennae with beige scales. Thorax: Upperside, including patagia and tegulae, grey-brown, in some specimens scales with beige tips. Underside anterior pale grey, posterior and legs dark grey. Forewing length male 6.7–6.8 mm, female 5.7–6.5 mm, wingspan in set specimens 12.0–14.5 mm. Forewings moderately wide, without costal fold in males, with slightly convex costal edge (more convex in females than in males). Upperside wing pattern contrast, especially in females (Figs 3, 4),



Figures 1–6. *Dichrorampha* spp. **1–4**, *D. pentheriana* (Rebel, 1917): **1.** lectotype ♂, Montenegro, Zljeb Mts, 23.vi.1916, coll. NHMW (courtesy of NHMW); **2.** ♂, Bulgaria, Vitosha Mts, 11.vii.2015, coll. BZ; **3.** ♀, the same data but 13.vii.2012; **4.** ♀, the same data but 11.vii.2015; **5–6**, *D. sakartvelana* sp. n.: **5.** paratype ♂, Georgia, Great Caucasus Mts, 27.vii.2014, coll. NMNHS; **6.** holotype ♀, ibid. Figures **1–4** and **5–6** are proportional. Scale bar: 5 mm.

consisting of numerous pale and dark transverse lines. Nine pairs of creamy distinct costal strigulae. Lead refractive transversal lines (striae) emerge from pairs 3–7; line of pair 3 ill-defined and pronounced only in some specimens; line of pair 4 reaching the discal cell; lines of pairs 5 and 6 initially merged then divided forming the refractive lines of the speculum; line of pair 7 short, dot-like; lines of pairs 8 and 9 relatively short, convergent and connected with creamy terminal ("postapical") strigulae. All pattern elements from the wing base to the median fascia consist of black and beige ill-defined lines, forming a vestigial dorsal patch in the region of the interfascial area basad to the median fascia. Median fascia darker, with black and golden-tipped scales; these scales predominate in the distal wing pattern. Four black terminal dots are present in most specimens; in some an additional dot above the terminal strigula is present. Forewing underside beige-grey, with distinct costal and terminal strigulae and terminal dots corresponding to the same upperside elements. Cilia grey-brown with pale median line. Hindwings upperside monochrome



Figures 7–10. Genitalia of *Dichrorampha pentheriana* (Rebel, 1917). **7.** Male genitalia photographed under coverslip, specimen Vitosha Mts, 11.vii.2015; **8–9**, phallus drawn without coverslip in left (**8**) and dorsal (**9**) view. **10.** Female genitalia, specimen Vitosha Mts, 13.vii.2012. Figures 7 and 10 are to the same scale. Scale bar: 0.5 mm.

grey-brown with beige terminal line. Underside pale grey with paler terminal line. Cilia paler than those of the forewing. Abdomen dark grey.

Male genitalia (Figs 7–9): In agreement with the preparation of the genitalia of the lectotype as well as the description by Razowski (1971). The shape of valva and phallus depends on the pressure of the coverslip. For example, the cavity at the proximal part of cucullus looks deeper or shallower depending on the pressure applied. The same is valid for the phallus: the large triangular terminal process in natural condition is pointed laterally at right (Figs 8, 9), but under a coverslip it is ventrally oriented (Fig. 7).

Female genitalia (Fig. 10): In agreement with the preparation of the genitalia of the female paralectotype and the description by Razowski (1971).

Diagnosis. The wing pattern of *D. pentheriana* resembles that of *D. distinctana* (Herrich-Schäffer, 1851) but is easily distinguished by lacking the costal fold. The male genitalia are

distinctive and do not show obvious affinities to other species of the genus. The shape of the valva is relatively similar to those of some forms of *D. plumbana* (Scopoli, 1763), but the phallus is strikingly different. The female genitalia are less characteristic, with antrum (sclerotised posterior part of ductus bursae) similar to some extent to those of *D. bugnionana* (Duponchel, 1843).

Biology. The species is on the wing from mid June to late July. The larval host plant in all likelihood is *Achillea lingulata* Waldst. & Kit., considering the fact that many *Dichrorampha* feed on *Achillea* and all specimens were swept during the florescence period of *A. lingulata* from its stems or surrounding grass vegetation. Other *Achillea* spp. and also other Asteraceae growing in the vicinity were searched for *D. pentheriana* without a positive result, so *D. pentheriana* is likely to be monophagous. The habitat is a subalpine meadow at an altitude of ca. 2000 m (Fig. 14).

Distribution. Zljeb Massif (part of Prokletije Mts, between Montenegro and Serbia) and Vitosha Mts (Bulgaria).

Remarks. Rebel (1917) described *D. pentheriana* from three specimens (2 males, 1 female) collected in Zljeb Mountains, Montenegro, at an elevation of 1700 m, preserved in NHMW. Obraztsov (1953) did not examine the type series and erroneously claimed that it consists of only two males. Danilevsky and Kuznetzov (1968) also did not examine the specimens and similarly gave wrong information about the specimens of the type series: three males and one female. Razowski (1971) dissected a male and female syntype, designated the male as lectotype, and provided descriptions and illustrations of male and female genitalia for the first time. The subtle differences in the genitalia of the Bulgarian specimens compared to those of the type series are likely due to normal variation and/or deformation by pressure of the coverslip.

No colour illustrations of the adult can be found in literature with the exception of those in Razowski (2003) (paralectotype male; the photograph is apparently altered digitally and shows some differences with the original appearance of the specimen). The lectotype (Fig. 1) is illustrated here for comparison with some of the Bulgarian specimens. As seen in the figure, the moths from Vitosha demonstrate two differences with the types: a more contrasting forewing pattern, especially in females and the presence of pale terminal line on the hindwings.

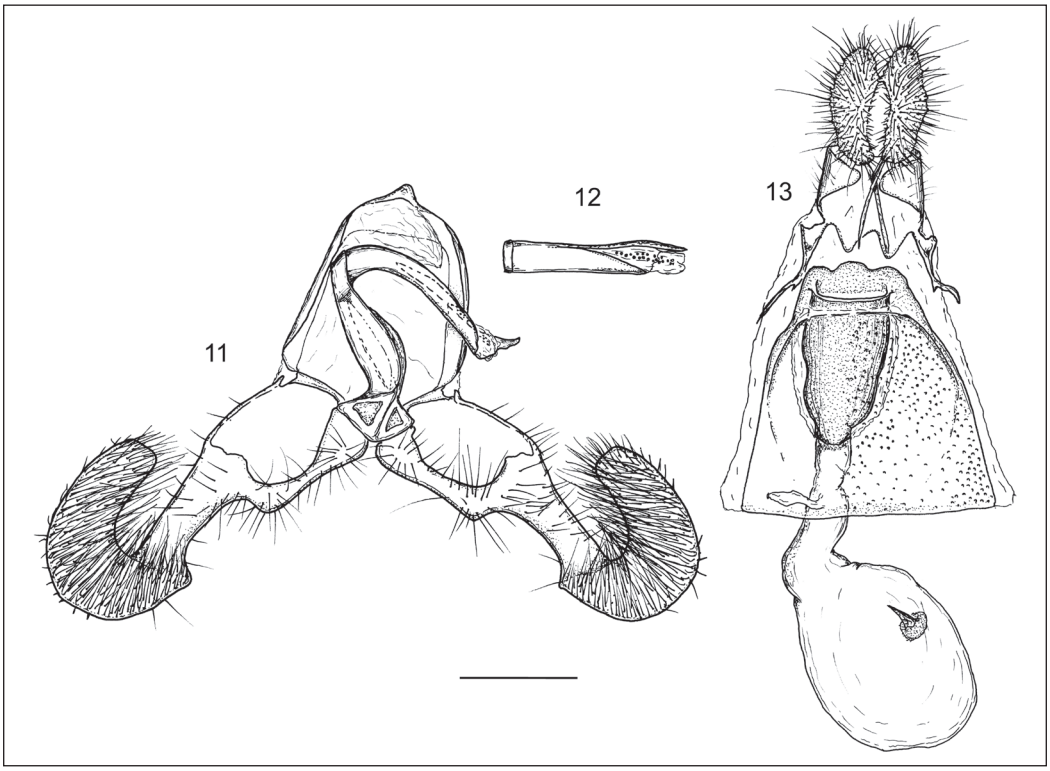
Dichrorampha sakartvelana sp. n.

http://zoobank.org/1919B149-1E92-49DA-90BB-4E1689F9C42D

Figs 5–6, 11–13, 15

Material. Holotype ♀, with three labels: "Georgia, Great Caucasus | Mountains, Caucasus Range, | near Abano pass | 2280 m N 42°15'54" E 45°30'17" | 27.vii.2014, netting | leg. B. Zlatkov", "Holotypus ♀ | *Dichrorampha* | *sakartvelana* | det. B. Zlatkov 2015 [red label]", "BFUS | ♀ | Genitalia slide | No. 27.vii.2014/1", BFUS. – Paratype ♂, with three labels: the first as in Holotype; the other two: "Paratypus ♂ | *Dichrorampha* | *sakartvelana* | det. B. Zlatkov 2015 [red label]", "NMNHS | ♂ | Genitalia slide | No. 27.vii.2014/2", NMNHS.

Description. Adult (Figs 5–6). Sexual dimorphism subtle. Head: Frons and vertex covered with brown-grey scales. Palpus labialis with whitish basal and brown-grey distal segment; the second segment with whitish base and brown tuft at the distal end. Antennae covered with dark grey scales. Thorax: Nota, patagia and tegulae uniformly grey, thorax underside (including coxae) whitish, legs brown. Forewings comparatively wide, in male with costal fold with 1/5 of the length of the costal edge. Forewing length male 8.65, female 8.90 mm, wingspan in set specimens



Figures 11–13. Genitalia of *Dichrorampha sakartvelana* sp. n. **11.** Male genitalia, paratype; **12.** Phallus, dorsal view, paratype; **13.** Female genitalia, holotype. Scale bar: 0.5 mm.

18.5–19 mm. The specimens are worn, but preserved areas on the forewing upperside have pale greenish-grey overlaying scales which apparently do not form an obvious pattern. No markings are visible with the exception of five pairs of faint distal costal strigulae (pairs 5–9 sensu Baixeras, 2002). Three black terminal dots are present. Underside uniformly brown. Cilia creamy with pale brown margin. Hindwings with pale brown upperside and whitish underside. Cilia whitish. Abdomen covered with pale grey scales.

Male genitalia (Figs 11–12): Tegumen bearing a small lobe as uncus. Valva broad basally with wide basal cavity. Costal edge slightly convex. Sacculus nearly parallel to costal edge, indistinctly concave, ending with nearly straight angle. Ventral incision elongated, trapezoidal. Neck of valva slender, more than two times narrower than the basal part of valva and relatively long, 3/4 of its length. Cucullus with large dorsal lobe, densely covered with long setae, and a small rectangular ventral prominence. Phallus slender, ca. 3/5 of the length of valva, bent ventrally in the basal part, with membranous area extending at first on right, then on dorsal side. A large triangular prominence pointed dorsally at the right side of the tip is present. Circa 20 sockets of deciduous cornuti are counted.

Figures 14–15. Habitats. **14.** Habitat of *Dichrorampha pentheriana* (Rebel, 1917), Vitosha Mts, 13.vii.2012, foreground: the suspected larval host plant *Achillea lingulata* (photo: D. Gradinarov); **15.** Habitat of *D. sakartvelana* sp. n., Great Caucasus Mts, Tusheti Range, 27.vii.2014 (photo: M. Ilieva).

Female genitalia (Fig. 13): Papillae anales wide. Apophyses posteriores equal in length to the apophyses anteriores, the latter look naturally deformed. Sterigma sclerotised, slightly asymmetrical, trapezoidal, with two incisions on the posterior margin of the postostial part. Ostium wide. Subgenital plate trapezoidal with distinctly sclerotised lateroposterior margins and rounded posterior angles. Antrum with the length of the membranous part of ductus bursae, well sclerotised, remarkably wide, nearly symmetrical, wineglass shaped and enveloped in a thin cuticular membrane visible after staining. The proximal sclerotisation of ductus bursae is barely discernible only under higher magnification. Ductus seminalis emerging at the middle of the membranous ductus bursae. Corpus bursae ovoid. A single moderately sized signum is present.

Diagnosis. The new species is characterized externally by uniformly coloured forewings (though the specimens are not fresh) and large size. The male genitalia resemble some species of the "section petiverellae" (sensu Danilevsky and Kuznetzov 1968), which apparently are closely related to *D. sakartvelana* sp. n. *D. flavidorsana* Knaggs, 1867 and *D. filipjevi* (Danilevsky, 1948) have similarly shaped valva, but the apical prominence of the phallus is pointed ventrally, and the ventral process of the cucullus is much larger in *D. filipjevi*. *D. petiverella* (Linnaeus, 1758) and *D. proxima* (Danilevsky, 1948) are also similar in general, but they have two distinct processes of the cucullus. Female genitalia do not demonstrate clear affinities to any Palaearctic *Dichrorampha*.

Preimaginal stages. Unknown.

Biology. The moths were collected at the end of July, but their condition presumes that they are on the wing earlier. The larval host plant is most probably *Achillea* sp. above which the moths were flying (plant material was not preserved and an exact identification is thus not possible). The habitat (Fig. 15) is a subalpine meadow at an elevation of ca. 2300 m with denuded rocks where the host plant grows.

Distribution. Known from the type locality only.

Etymology. The name of the species is an adjective, derived from the autonym for Georgia, *Sakartvelo*, and the specific ending for Tortricidae -*ana*.

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New data on the distribution of Cossidae (Lepidoptera) in Mongolia

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Abstract. We recorded a new species of Cossidae – *Acossus terebrus* (Denis & Schiffermüller, 1776) – for Mongolia (Tov Aimak). We also report on the most northern habitat of the cossid genus *Gobibatyr* Yakovlev, 2004 (North-West Mongolia, Bayan-Ulegej Aimak), which shows the permeability of the Mongolian Altai Mountain Range for some elements of the Dzungarian fauna. Additionally, our sampling resulted in adding new localities to the ranges of *Catopta perunovi* Yakovlev, 2007 and *Cecryphallus nubila* (Staudinger, 1895) (first discovered in Hovd Aimak).

Introduction

The Carpenter-Moths (Lepidoptera, Cossidae) in Mongolia are relatively well known compared to their fauna in most other countries. Several articles (Daniel 1965, 1969, 1970, 1973; Yakovlev 2004, 2015a) treating the systematics and distribution of Mongolian Cossidae were published. It was established that the Cossidae fauna of Mongolia is distinct (Yakovlev and Dubatolov 2013; Yakovlev 2015b). In total, 23 species were reliably recorded; in addition, two species, *Acossus viktor* (Yakovlev, 2004) and *Cossus shmakovi* Yakovlev, 2004, were recorded from the border regions of Russia (the Republic of Tuva, the Tes-Khem River valley), so they are likely present in Mongolia as well.

It is worth noting that the Cossidae fauna of Mongolia is highly distinct based on the presence of 13 endemic species (*Catopta saldaitisi* Yakovlev, 2007, *Gobibatyr ustyuzhanini* Yakovlev, 2004, *Chingizid gobiana* (Daniel, 1970), *Ch. transaltaica* (Daniel, 1970), *Ch. kosachevi* Yakovlev, 2012, *Cossus kerzhneri* Yakovlev, 2011, *Deserticossus beketi* (Yakovlev, 2004), *D. churkini* Yakovlev, 2006, *D. mongoliana* (Daniel, 1969), *Eogystia kaszabi* (Daniel, 1965), *Kerzhnerocossus sambainu* Yakovlev, 2011, *Dyspessa saldaitisi* Yakovlev, 2011 and *Phragmataecia anikini* Yakovlev, 2011) and two endemic genera (*Kerzhnerocossus* Yakovlev, 2011 and *Chingizid* Yakovlev, 2011). All Mongolian endemics, except for *Catopta saldaitisi*, inhabit deserts and semideserts. The field study of the first author in 2015, data from other researchers and the material studied in the Hungarian Museum of Natural History (Budapest) enabled us to uncover new localities for a series of rare species and also to discover a species new for the Mongolian fauna.

Material and methods

The adult Cossidae were collected using the combined light lamp Phillips−250 W mounted above a fabric screen, battery light traps with the lamp Philips TL 8W/05 and chloroform as the killing agent.

Results

New species for Mongolian fauna

Acossus terebrus (Denis & Schiffermüller, 1776) (Figs 1A, 2) – widely distributed transpalaearctic species (Daniel 1956; Yakovlev 2007, 2011a), rather rare in most of the localities, for the first time reliably recorded in the Mongolian fauna. This discovery was expected as *A. terebrus* is reliably known from the neighboring regions of Russia (the Republic of Altai, Tuva, Buryatia, Irkutsk and Chita regions) and China (Inner Mongolia Province) (Hua et al. 1990).

Material examined: 1 ♂, Mongolia, Töv aimag, 11 km S Jargalant, 48°24.875'N; 105°50.713'E, 1320 m, 7.vii.2008, leg. Balász Benedek (Hungarian Museum of Natural History, Budapest).

New records

***Gobibatyr ustyuzhanini* Yakovlev, 2004** (Figs 1B, 2)

The genus *Gobibatyr* Yakovlev, 2004 was established for *Cossus colossus* Staudinger, 1887. *Gobibatyr colossus* (Staudinger, 1887) was reported from several localities in the Ili River valley in southeast Kazakhstan, Kyrgyzstan (the Naryn River valley) and extreme southwest of Mongolia (the Bayan-Gol River valley (right tributary of Bulgan-Gol River) in Hovd Aimak) (Yakovlev 2004, 2015a). The second species of this genus is *G. ustyuzhanini* Yakovlev, 2004, described from southwestern Mongolia (type locality − S Mongolia, Gobi-Altai Aimak, 30 km S Biger) (Yakovlev 2004). Later the distribution of *G. ustyuzhanini* in Mongolia was specified (Yakovlev 2015a). In addition to the discoveries in Mongolia, this species (given as *Cossus colossus*) was indicated (without specification of exact localities) for Qinghai, Gansu, and Ningxia Chinese Provinces (Hua et al. 1990). It was found that the larvae of *G. ustyuzhanini* Yakovlev, 2004 feed on the underground parts of *Nitraria schoberi* L. (Zygophyllaceae) (Yakovlev 2011b). The same paper gives the description of the eggs and pupae (based on exuvia). During the Russian expedition to Mongolia, M. Bush (Moscow) collected a series (3 males, 1 female) of *G. ustyuzhanini* in the northeast of Bayan-Ulegej Aimak in Mongolia on the southern bank of Achit-Nuur Lake. The exact data on the label are the following: Mongolia, Bayan-Ulegej Aimak, 65 km NW of Ulegej, S bank of Achit-Nuur lake, 49°25'52.16''N; 90°30'19.01''E, 1440 m, Bush M. legit. (coll. R.V. Yakovlev, Barnaul, Russia).

Remarks. The Mongolian Altai is a significant frontier in the distribution of insects. This conclusion is based on the distribution of Orthoptera (Sergeev 1986), Coleoptera (Kryzhanovskij 2002), Papilionoidea (Yakovlev 2011), and Cossidae (Yakovlev 2015b). The discovery of *G. ustyuzhanini* significantly extends the range of the genus *Gobibatyr*. All the previously known discoveries of *G. ustyuzhanini* were located on the south (Dzhungarian) macroslope of the Mongolian Altai, in Dzungarian and Zaaltayskaya Gobi on the territory of Hovd, Gobi-Altai and South Gobi Aimaks of Mongolia (Hovd Aimak, Janatin Dolon, 40 km N Somon Manchan, SW bank of Khar-Us nuur Lake; Hovd Aimak, Bodonchijn-Gol basin, Hundijn-Gol River valley; Hovd Aimak, 10

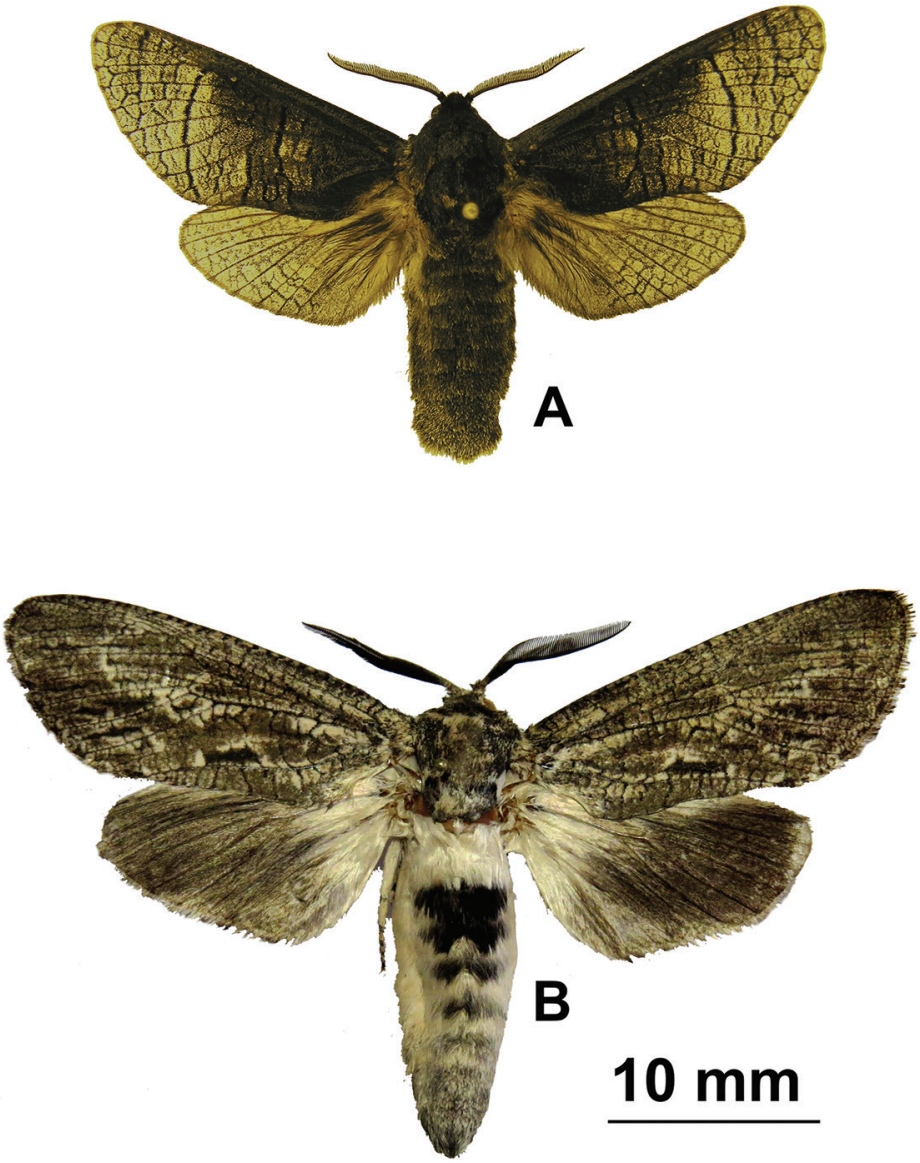

Figure 1. (**A**) *Acossus terebra* (Denis & Schiffermüller, 1776), Mongolia (Hungarian Museum of Natural History, Budapest) and (**B**) *Gobibatyr ustyuzhanini* Yakovlev, 2004, male (coll. R.V. Yakovlev, Barnaul, Russia) (Lepidoptera, Cossidae).

km SSW Somon Bulgan; Gobi-Altai Aimak, between Beger nuur and somon Beger; Gobi Altai Aimak, Baga nuur urd els, SE bank of Doroo nuur Lake; Gobi-Altai Aimak, Zachuj Gobi, 10 km N of Chatan chajrchan Mountain; Gobi-Altai Aimak, Mongolian Altai Mountains, S slope, Mogoijn-Gol Valley; Gobi-Altai Aimak, 30 km N of Biger; Southern Gobi Aimak, 70 km SW of Khan-Bogdo Somon; Southern Gobi Aimak, 50 km SSE of Noen; Southern Gobi Aimak, Bulgan

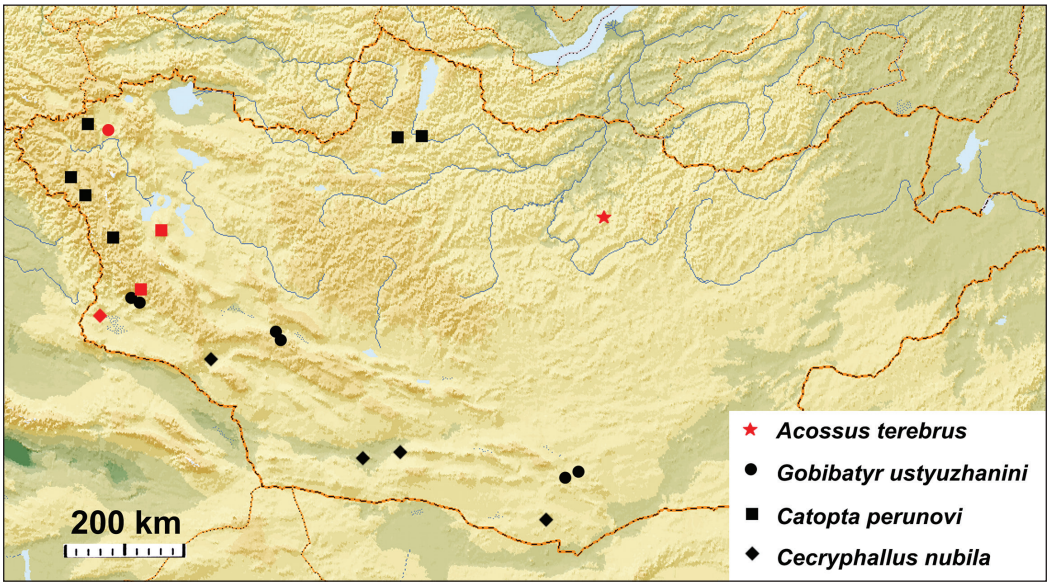

Figure 2. Distribution map of *Catopta perunovi* Yakovlev, 2007, *Gobibatyr ustyuzhanini* Yakovlev, 2004, *Acossus terebra* (Denis & Schiffermüller, 1776) and *Cecryphallus nubila* (Staudinger, 1895) in Mongolia (Lepidoptera, Cossidae). Red = new locality.

Somon, Talyn Bulay) (Yakovlev 2015a). It was previously believed that the Mongolian Altai is a barrier to the dispersal of *G. ustyuzhanini* to the north, preventing its penetration to the Great Lakes Valley (Yakovlev and Dubatolov 2013; Yakovlev 2015b).

Catopta perunovi Yakovlev, 2007 (Fig. 2)

The species was described from the material from Russia, Altai Rep., Ongudai. It was recorded in several localities of northwestern Mongolia on the territory of Chovsgol and Bayan-Ulegei Aimaks (Yakovlev 2015a), first reliably recorded in Hovd Aimak.

Material examined: 8 ♂, W Mongolia, Hovd Aimak, Dzun-Dzhargalant-Khairkhan, Ar-Shatyn-Gol River Valley (47°44'N; 92°27'E), 2130 m, 26.vi.2015., leg. R. Yakovlev; 1 ♂, SW Mongolia, Hovd Aimak, Mongolian Altai (S slope) Bodonchin-Gol basin, Khondijn-Gol Valley, (46°08'N; 92°30'E), h = 1750 m, 27.vi.2015. leg. R. Yakovlev (coll. R.V. Yakovlev, Barnaul).

Cecryphallus nubila (Staudinger, 1895) (Fig. 2)

The species was described from Kaschgar [northwestern China, Tura], widespread in southern Kazakhstan, Kirgiziya, southern Mongolia (Gobi-Altai, Bayan-Khongor and South-Gobi Aimaks), Uzbekistan, Tadzhikistan, Azerbaijan, southern Armenia, Turkmenistan, northern Iran, and Xinjiang, China (Yakovlev 2015a). First discovered in Hovd Aimak.

Material examined: 1 ♂, SW Mongolia, Hovd Aimak, Dzhungarian Gobi Desert, S slope Barangijn-Nuruu Mts., 3 km S Barangijn-Tataal kuduk, (45°53'N; 91°19'E), 1300 m, 3.vii.2015, leg. R. Yakovlev (coll. R.V. Yakovlev, Barnaul).

Conclusion

At present 24 Cossidae species from 13 genera have been reliably recorded in Mongolia. The distribution of the genus *Gobibatyr* Yakovlev, 2004 has been significantly extended (the northern border of the habitat has been shifted by 450 kilometers). Despite numerous past efforts focused on the study of the Mongolian Cossidae, it appears that much can still be discovered, especially in the southeast of the country, from where little material is known.

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A synonymic list of names associated with western Palaearctic *Melitaea phoebe* (Denis & Schiffermüller, 1775) species group taxa (*M. phoebe*; *M. punica* Oberthür, 1876; *M. ornata* Christoph, 1893) (Lepidoptera, Nymphalidae)

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Abstract. Following indecision and confusion in the literature regarding nomenclature and distribution of *Melitaea phoebe* (Denis & Schiffermüller, 1775) and its closely associated congeners *M. punica* Oberthür, 1876, and *M. ornata* Christoph, 1893, a synonymic list of *phoebe* names, and of names both correctly and mistakenly associated with *phoebe* species-group taxa, is presented. Explanatory footnotes provide the basis of a stable source for future discussion of *M. phoebe* species-group populations throughout the species' ranges.

Introduction

According to a recent revision (van Oorschot and Coutsis 2014), the genus *Melitaea* Fabricius, 1807, comprises some 98 species of phenotypically similar, medium sized nymphaline butterflies that occur throughout most of the Palaearctic Region and beyond. Adults are invariably orange-brown on the upper surface, with a series of black lines and other markings; several *Melitaea* species are notoriously difficult to separate using wing morphology due to their similarity in appearance (Jugovic and Koren 2014).

In this paper, we consider the common and widespread butterflies *Melitaea phoebe* (Denis & Schiffermüller, 1775) and *M. ornata* Christoph, 1893; the latter was not fully recognised as a species distinct from *M. phoebe* until 2005 (see below). We also confirm, not for the first time, that *M. punica* Oberthür, 1876, historically considered a subspecies of *M. phoebe*, is restricted in distribution to Africa north of the Sahara; the specificity of *M. punica* was confirmed by Tóth and Varga (2011). Some fundamental confusion has encompassed the use of names relating to these three phenotypically similar *Melitaea* species in the western Palaearctic. We believe that confusion, for which the present authors must take some responsibility (with others!), arose as a direct result of the realisation that a second *phoebe*-like taxon occurred in Europe, before the extent of the range of *M. ornata* was fully understood. Before that was established, some other names were briefly used in the literature (e.g. *emipunica* [by Russell et al. 2005] and *ogygia* [by Varga et al. 2005]).

As recognised here, the western Palaearctic Region extends from the Iberian Peninsula and Africa north of the Sahara in the west to the Ural Mountains and Kazakhstan in the east (approxi-

mately 60º East), and from the North Cape of Norway in the north to the Middle East, including Iran and Iraq, in the south (approximately 30º North). We recognise that a number of names relate to *Melitaea* taxa east of the Urals, and where these apply or may apply to the taxa considered in this paper, they are also included.

Background

A detailed analysis of the Palaearctic forms and varieties associated with *Melitaea* Fabricius, 1807, was made by Higgins (1941, 1944 [errata], 1955 [additions]). He recognised *M. phoebe* as a distinct species (Higgins 1941: 325–343, plate 14, figs 1–12; plate 15, fig. 8) with three subspecies: nominotypical *phoebe* (throughout the region except the Iberian Peninsula and North Africa), *occitanica* Staudinger, 1871 (Iberian Peninsula) and *punica* (North Africa). Considering what was available to Higgins at that time, he provided what remains a generally accurate assessment of the division of *M. phoebe sensu lato*. Higgins provided (1941: 325–343) an annotated list of 74 named forms, mostly originating from the western Palaearctic, and many described individual variations, seasonal forms and aberrations. He later added (Higgins 1955: 118) five additional synonyms for *M. phoebe*.

So where did it all go so wrong? Modern confusion seems to stem from Hesselbarth et al. (1995: 1030), who mistakenly (see Appendix: Note 3), used the complex name: '*M.* (*phoebe*) *punica telona*' for those *phoebe*-like butterflies from Turkey which were not, in their opinion – and undoubtedly correctly – *M. phoebe sensu stricto*. Understandably, their work was used as an anchor for subsequent papers on the region; for example, Çalişkan and Bozaci (2015) described a male aberration of what they considered to be *M. phoebe* from the province of Adana, Turkey, placing the name *ornata* as a synonym of "*M. punica telona*". They referenced Hesselbarth et al. (1995), from where their use of the combination '*punica telona*' presumably originated. With several researchers working in different parts of Western Europe and the Russian Federation, it is perhaps understandable that this spurious use of the name *punica* became so widely used (see Appendix: Note 3).

M. ornata was first recognised as a species separate from *M. phoebe* simultaneously by Varga et al. (2005), from Hungarian specimens, under the specific name *M. ogygia* Fruhstorfer, 1908 [TL: Island of Poros, Peleponnese, Greece] and by Russell et al. (2005), from specimens reared from a female from Montagna Longa, Palermo district, Sicily, under the name *M. emipunica* Verity, 1919 [TL: Palermo district, Sicily, Italy]. The presently known eastern limit of the distribution of the invariably univoltine species *M. ornata* may coincide with the eastern limit of our interpretation of the western Palaearctic (see above), although a recent publication by Korb et al. (2015) recorded *M. ornata* from Middle Asia (Kyrghyz Mts., Transili Alatau Mts. and Kungey Ala-Too Mts.). Previously, Korb (2011: 178) reported this same material as *M. phoebe saturata* but following molecular analysis of the preserved specimens by Korb et al. (2015) their identity was reassessed as *M. ornata*. We note that larvae from this area are yet to be observed and believe further research is required to confirm their identity.

Placement of *M. ornata* and some associated Russian taxa as synonyms of *M. phoebe* by van Oorschot and Coutsis (2014: 60) compounded the confusion referred to above. In the expectation of resolving some long-standing matters of nomenclature and distribution, we present an alphabetical list of names associated with *Melitaea phoebe* species-group taxa and place each

as a synonym of *M. phoebe* [Notes 1 & 6], *M. ornata* [Notes 2 & 6], or *M. punica* [Notes 3 & 6]. These actions are explained and supported by detailed notes (see the Appendix). The present authors do not recognise any subspecific divisions of *M. ornata* or *M. punica*; however, *M. phoebe s.s.* occurs in two distinct subspecies based on larval colour and distribution: *M. phoebe phoebe* [Note 4] and *M. phoebe occitanica* [Note 5], with which some names will be synonymised.

Distribution of *Melitaea phoebe*, *M. punica*, and *M. ornata* within the western Palaearctic, as currently known and understood

Distribution of *M. phoebe phoebe* and *M. phoebe occitanica* in the western Palaearctic is presented in Note 1. However, it is considered important to clarify some details as to where, so far as is currently known, *M. phoebe* has been recorded as being present in the literature but is not in fact present:

(1) *M. phoebe* has been recorded from Lésvos and Chíos (Gaskin and Littler 1986) but it is *M. ornata* which is present there (Russell and Pateman 2013c); in fact it is almost certain that all reports of *M. phoebe* from the Aegean Islands should be regarded as *M. ornata* (Russell and Pamperis 2011, 2012).
(2) In Greece *M. phoebe* has not been confirmed as occurring south of Mt. Vardousia, Fokida (Lafranchis pers. obs., ex Pamperis pers. comm.), and is absent from the Peleponnese (Lafranchis 2007).
(3) In Italy *M. phoebe* is not known to occur in southern Calabria, or in Sicily where only *M. ornata* is present (Russell and Pateman 2011: 26, as *telona*); however, Villa et al. (2009: 244) gave the distribution of *M. phoebe* as throughout Italy including Sicily.
(4) In the east *M. phoebe* is absent from Israel, except coastal areas in the North (Benyamini, pers. comm.), southern and eastern Iran and Iraq, except for one record from the extreme northeast (Tshikolovets et al. 2014: 319), although this may refer to the record of Wiltshire (1957: 33), who referred to f. *dorae* and stated that there was only one generation per year, flying in early summer. This suggests that this was most probably not *M. phoebe* but *M. ornata*.
(5) So far as the authors are aware *M. phoebe* is also absent from Jordan, where it is replaced by *M. ornata* (Katbeh-Bader et al. 2003: 17; Wahlberg and Zimmermann 2000: voucher specimen).
(6) It is quite likely that *M. phoebe* is absent from Syria; although Riemis (1993: 93) recorded *M. phoebe* from 50 km south of Aleppo on the road to Damascus, this was before *M. ornata* was separated at species level. The only figured specimens known to the authors from Syria (Van Haeringen 2015) are eight individuals labelled "*M. phoebe telona*" (= *M. ornata*), originating from Bloudan (26.iv.2008), Halbourn (27.iv.2008) and Damascus (5.iv.2010). These specimens exhibit antennal and wing morphological characters typical of *M. ornata* (see Table 1).

Those European regions in which both *M. phoebe* and *M. ornata* have been recorded as being present (although not necessarily sympatric or synchronic) are as follows: France (Var only), Italy (northern Calabria as far north as Campania (Russell and Pateman 2011), Greece (central and north, see above), Macedonia (FYROM) (Verovnik et al. 2010; Verovnik 2012; Russell et al. 2015), Montenegro (Russell 2015), Slovenia (Russell et al. 2014), Hungary (Varga et al. 2005). There are additional reports of the presence of *M. ornata* (unconfirmed) from regions where *M.*

Table 1. Identification difficulties arise in part because of a lack of clear diagnostic features to guarantee separation of adult butterflies; the only apparently constant feature appears to be the colour of late instar larvae. However, there are other features which might aid identification, presented here with an indication of their level of usefulness.

Character	*M. phoebe*	*M. ornata*	*M. punica*	Reliability of character
number of ova in batch	usually more than 100	usually 30–60	data lacking	good
larva L4- final instar head colour	black	red-brown	black	confirms *M. ornata*
final instar larva lateral stripe colour	white (*phoebe phoebe*) orange (*phoebe occitanica*)	no obvious stripe	orange	good (confirms *occitanica* outside North Africa)
distal end of antenna	club shaped	spatulate	variable	fair
shape of forewing apex	acute	rounded	rounded	fair
wing underside background colour	creamy	white	white	fair
hindwing underside premarginal marks	arcuate	triangular	variable, often triangular	poor
premarginal markings touching veins	yes	no	variable, often not touching	fair
voltinism	single to triple brooded	strictly univotine	double to triple brooded	good

phoebe is also known to occur – Croatia (Koren and Štih 2013), Romania (Rákosy and Varga 2001; Székely 2008), Bulgaria (Kolev 2015), and Slovakia (Zitnan pers. comm.). The report by Jakšić (2011: 46–47) of *M. ornata* from Serbia is considered to be dubious; it is not otherwise known from there, and *M. phoebe* is widespread throughout that country. In the east, both species occur in Lebanon and Israel (*M. phoebe* occurs in northern coastal district only; Benyamini, pers. comm.), Turkey (Hesselbarth et al. 1995), the Caucasus (Tshikolovets and Nekrutenko 2012: 293–295; Tikhonov and Russell 2015), the Russian Federation (Russell and Kuznetsov 2012), Syria (but see above), northeast Iraq and northern and western Iran (Tshikolovets et al. 2014). Eisenstein (2000: 190, fig. 234) figured a larva in Israel with a red-brown head feeding on *Centaurea iberica* (Spreng) (*M. ornata*: see also Russell et al. 2007).

The authors see no evidence to support subdivision of *M. ornata* into five subspecies (Tshikolovets 2011: 498–499); previous gaps in the known distribution of this species are rapidly being filled, making recognition of subspecies on a geographical basis increasingly difficult to support. Also, the diverse variety of host-plants used by *M. ornata* is more likely to be dependent on which Asteraceae species are available for use by larvae in any particular locality, rather than any evolutionary preference resulting in development of subspecies. The differing ability of closely related species to metabolise apparently suitable host-plants is also significant (Tóth et al. 2015); however, it is of interest to note that different host-plants were being used by *M. ornata* on the adjacent eastern Aegean Islands of Lésvos and Chíos, where adult butterflies were almost identical (Russell and Pamperis 2011; Russell and Pateman 2013c).

Despite use of the name *punica* by various authors for populations of *M. ornata* in a number of different countries, *Melitaea punica* is entirely confined to North Africa, where it is restricted to Morocco and Algeria; there have been no reports from Tunisia (see Appendix: Note 3).

Synonymic list

Melitaea phoebe abbas Gross & Ebert, 1975 [Note 7] [Type Locality (TL): 50 km. NW Ardkan, Tange Sorkh, Fars, Iran, 2250 m, 12–15.vi.1975].

Melitaea ornata adversaria Korb, Stradomsky & Kuznetsov, 2015 [Note 8] [TL: Kirghizia, Kirghiz Mts., Ala-Too settlement vicinity, 1100–1200 m].

Melitaea phoebe var. ***aetherea*** Eversmann, 1851 [Note 9] [TL: Russia 'au Sud qu'au Nord'].

Melitaea phoebe aethereaeformis Verity, 1919 [Note 10] [TL: central Italy].

Melitaea phoebe alatauica Wagner, 1913 [Note 11] [TL: Issyk-kul, Ili mountains, Kazakhstan].

Melitaea phoebe ab. ***albina*** Verity, 1904 [Note 12] [TL: Lucca, Italy]

Melitaea phoebe allophylus Rütimeyer, 1942 [Note 13] [TL: Porté, Pyrénées Orientales, France].

Melitaea phoebe almana Gaede, 1930 [Note 14] [TL: Elman Dagh N Syria]

Melitaea phoebe alternans Seitz, 1909 [Note 15] [TL: Zermatt, Switzerland].

Melitaea phoebe Knoch var. ***amanica*** Rebel, 1917 [Note 16] [TL: Kushdjula, Taurus Mountains and Das Dagh, Amanus Mountains, Turkey].

Melitaea phoebe rovia autumnalis Fruhstorfer, 1919 [Note 17] [TL: between Brione & Contra, Italy].

Melitaea phoebe ab. ***baccata*** Delahaye, 1909 [Note 18] [TL: Saint-Barthélemy, Maine-et-Loire, France].

Melitaea phoebe Knoch rassa ***bethune-bakeri*** de Sagarra, 1926 [Note 19] [TL: Sierra Nevada, Spain].

Melitaea phoebe Knoch sbsp. n. ***canellina*** Stauder, 1922 [Note 20] [TL: vicinity of Innsbruck, Austria].

Melitaea phoebe capreola Varga, 1967 [Note 21] [TL: Podalia, Kiverci, Ukraine].

Melitaea phoebe var. ***caucasica*** Staudinger, 1870 [Note 22] [TL: "Kindermann ganz ähnliche Stücke im Caucasus fing (?-Helenendorf; Kindermann leg.)"].

Melitaea phoebe caucasicola Verity, 1919 [Note 23] [TL: "Kindermann ganz ähnliche Stücke im Caucasus fing (?-Helenendorf; Kindermann leg.)"].

Melitaea phoebe changaica Seitz, 1909 [Note 24] [TL: Changai Mountains, Mongolia].

Melitaea phoebe ab. ***cinxioides*** Muschamp, 1905 [Note 25] [TL: Switzerland].

Melitaea phoebe Knoch ab. ***confusa*** Joannis, 1908 [Note 26] [TL: Vannes, France].

P.* [*apilio*]** N. Phal. [*Nymphalis Phaleratus*] ***corythallia Esper, [1781] [Note 27] [TL: France (environs of Paris?)]

Melitaea phoebe crassenigra Verity, 1928 [Note 28] [TL: Rozier, Gironde, France].

Melitaea phoebe form ***deleta*** Verity, 1919 [Note 29] [TL: Tuscany, Italy].

Melitaea phoebe Knoch ***dorae*** Graves, 1925 [Note 30] [TL: Nabatea, Petra, Jordan].

Melitaea phoebe tusca emipauper Verity, 1919 [Notes 31 & 96] [TL: Vallombrosa, Tuscany, Italy].

Melitaea phoebe emipunica Verity, 1919 [Note 32] [TL: Palermo district, Sicily, Italy].

Melitaea phoebe mod. ***enoch*** Higgins, 1941 [Note 33] [TL: Askhabad, Turkmenistan].

Melitaea phoebe occitanica f. ***estrela*** Higgins, 1941 [Note 34] [TL: Sierra de Estrela, Portugal]

Melitaea phoebe Knoch ab. ***fasciata*** Galvagni, 1934 [Note 35] [TL: 'Austria Inferior'].

Melitaea phoebe Knoch rassa ***occitanica*** Staudinger 2-gen. ***francescoi*** de Sagarra, 1926 [Notes 5 & 36] [TL: between St. Pere & Vilamajor, Catalonia, Spain, July/August].

Melitaea phoebe gaisericus Hemming, 1941 [Note 37] [TL: Mogador (=Essaouira), Morocco].

Melitaea phoebe galliaemontium Verity, 1928 [Note 38] [TL: Mont Dore, Puy de Dome, France].

Melitaea phoebe gerinia Fruhstorfer, 1917 [Note 39] [TL: Lisbon, Portugal].

Melitaea phoebe ab. ***geyeri*** Aigner-Abafi, 1906 [Note 40] [TL: Szaár (Komitat Fejér), Hungary].

Melitaea phoebe guevara Fruhstorfer, 1917 [Note 41] [TL: Castile, Spain].

Melitaea phoebe Knoch ab. ***gürtleri*** Joukl, 1908 [Note 42] [TL: Plitvička Jezera, Croatia]

Melitaea phoebe occitanica f. ***juliae*** Molina & Ocete, 1986 [Note 43] [TL: Loma de la Amoladera, Guadalcanal (Seville), Spain]

Melitaea phoebe koios Fruhstorfer, 1908 [Note 44] [TL: Klausen, Switzerland].

Melitaea phoebe kovacsi Varga, 1967 [Note 45] [TL: Budakeszi, Hungary].

Melitaea phoebe leechi Rothschild, 1917 [Note 46] [TL: Mogador (= Essaouira), Morocco].

Melitaea phoebe lokris Fruhstorfer, 1908 [Note 47] [TL: Saratov, Russia].

Melitaea phoebe malvida Gaede, 1930 [Note 48] [TL: Meklen Pass, Bosnia].

Melitaea phoebe mandarina Seitz, 1909 [Note 49] [TL: Mongolia].

Melitaea phoebe var. ***melanina*** Bonaparte, 1831 [Note 50] [TL: Monti Subiaco (= Livata), near Santa Scolastica, Arbruzzo, Italy.

Melitaea phoebe minoa Fruhstorfer, 1917 [Note 51] [TL: Engadin, Switzerland].

Melitaea phoebe ab. ***minor*** Wheeler, 1903 [Note 52] [TL: Switzerland].

Melitaea phoebe monilata Verity, 1919 [Note 53] [TL: Wallis (= Valais), Switzerland].

Melitaea phoebe monilataeformis Verity, 1919 [Notes 54 & 96] [TL: Tuscany, Italy].

Melitaea phoebe narenta Fruhstorfer, 1917 [Note 55] [TL: Jablanica, Herzegovina].

Melitaea phoebe nigroalternans Verity, 1919 [Note 56] [TL: Mont Cenis, French/Italian border].

Melitaea phoebe nigrogygia Verity, 1939 [Note 57] [TL: Abbazia = Opatija, Istria, Croatia].

Melitaea phoebe mod. ***nimbula*** Higgins, 1941 [Note 58] [TL: Espinama, Picos de Europa, Cantabria, Spain].

Melitaea phoebe occitanica Staudinger, 1871 [Note 5] [TL: Andalusia, Spain].

Melitaea phoebe ogygia Fruhstorfer, 1907 [Note 59] [TL: Island of Poros, Greece].

Melitaea phoebe ornata Christoph, 1893 [Notes 2 & 6] [TL: *Circa* 'Guberli', promontorium uralensium australium (Guberlya, Orenburg Province, Russian Federation)].

Melitaea phoebe Schiff. ***ornatiformis*** (gen. aestiva) de Sagarra, 1930 [Note 60] [TL: Villacabras, Cuenca, Spain].

Melitaea phoebe ottonis Fruhstorfer, 1917 [Note 61] [TL: "Kindermann ganz ähnliche Stücke im Caucasus fing (?-Helenendorf; Kindermann leg.)"].

P.* [*apilio*]** NP ***Paedotrophos Bergsträsser, 1780 [Note 62] [TL: Hanau-Münzenberg, Germany]

Melitaea phoebe subsp. ***parascotosia*** Collier, 1933 [Note 63] [TL: Sutschan, Russian Federation].

Melitaea phoebe ab. ***parva*** Gerhard, 1882 [Note 64] [TL: Fünfkirchen (= Pecs), Hungary].

Melitaea phoebe var. ***parva*** Caradja, 1895 [Note 65] [TL: Bucharest, Romania].

Melitaea phoebe pauper Verity, 1919 [Notes 66 & 96] [TL: Florence, Italy].

P.* [*apilio*] *phoebe Denis & Schiffermüller, 1775 [Notes 1, 4 & 6] [TL: environs of Vienna, Austria].

Melitaea phoebe phoebina Turati, 1919 [Note 67] [TL: Aspromonte Mountains, Calabria, Italy].

Melitaea phoebe postnarenta Verity, 1939 [Note 68] [TL: St. Dionisio, Mt. Olympos, Greece].

Melitaea phoebe postogygia Verity, 1939 [Note 69] [TL: Salonica (= Thessalonica), Greece.

Melitaea phoebe virgilia postvirgilia Verity, 1950 [Notes 70 & 100] [TL: Vence, Alpes-Maritimes, France].

Melitaea phoebe pseudosibina Alberti, 1969 [Note 71] [TL: Mt. Elbrus, Itkol, Kabardino-Balkaria, Russia].

Melitaea phoebe punica Oberthür, 1876 [Notes 3 & 6] [TL: Tazoult-Lambèze (Lambessa), Algeria].

Melitaea phoebe punica-powelli Oberthür, 1915 [Note 72] [TL: Algeria].

Melitaea phoebe forma ***punicata*** Ragusa, 1919 [Note 73] [TL: Sicily, Italy].

Melitaea ornata reliquiae Korb, Stradomsky & Kuznetsov, 2015 [Note 74] [TL: Russia, Volgograd Province, Olkhovsky distr., Kamenny Brod].

Melitaea phoebe rostagnoi Turati, 1920 [Notes 75 & 96] [TL: Rome, Italy].

Melitaea phoebe rovia Fruhstorfer, 1919 [Note 76] [TL: Monte Generoso, Maroggia, Tessin, Switzerland].
Melitaea phoebe f. ***rubialesi*** Gómez Bustillo, 1973 [Note 77] [TL: Loeches (Madrid), Spain]
Melitaea phoebe forma ***rubrofasciata*** Gušić, 1922 [Note 78] [TL: Podsused, nr. Zagreb, Croatia].
Melitaea phoebe Knoch ***sarvistana*** Wiltshire, 1941 [Note 79] [TL: Sarvistan, SE of Shiraz salt lake, Iran].
Melitaea phoebe var. ***saturata*** Staudinger, 1892 [Note 80] [TL: Kentai Mountains, Mongolia].
Melitaea phoebe ab. ***seminigra*** Delahaye, 1909 [Note 81] [TL: Pignerolles, Maine-et-Loire, France].
Melitaea phoebe Knoch var. ***sextilis*** Jachontov, 1909 [Note 82] [TL: Zheleznovodsk, Stavropol Krai, Russian Federation (North Caucasus)].
Melitaea phoebe Knoch var. ***sibina*** Alphéraky, 1881 [Note 83] [TL: Kuldjà, Ili Valley, China].
Melitaea phoebe rostagnoi ab. ***sterlineata*** Turati, 1920 [Note 84] [TL: Monte Autore (Province of Rome), Italy].
Melitaea phoebe streltzovi Kolesnichenko & Yakovlev, 2004 [Note 85] [TL: Western Mongolia, Hovd aimak, 30 km north-northwest from Bulgan somon, junction of Bajan-Gol and Bulgan-Gol rivers, 1500 m 11–13 August 2003].
Melitaea phoebe subcorythallia Verity, 1928 [Note 86] [TL: Auzay, Vendée, France].
Melitaea phoebe suboccitanica Verity, 1928 [Note 87] [TL: Auzay, Vendée, France].
Melitaea phoebe subtusca Verity, 1952 [Notes 88 & 96] [TL: Nans-les-Pins, St. Baume, Var, France].
Melitaea phoebe sylleion Fruhstorfer, 1917 [Note 89] [TL: Cogne, Piedmont, Italy].
Melitaea phoebe tatara Krulikovsky, 1891 [Note 90] [TL: Casanum = Kazan or Casan, Republic of Tatarstan, Russian Federation].
Melitaea phoebe telona Fruhstorfer, 1907 [Note 91] [TL: Jerusalem, Palästina (Israel)].
Melitaea phoebe *forma* ***totila*** Stauder, 1914 [Note 92] [TL: Monte Cocuzzo, Consenza, Calabria, Italy].
Papilio tremulae Piller & Mitterpacher, 1783 [Note 93] [TL: between Drau & Sawe, Croatia].
Melitaea phoebe tungana Seitz, 1909 [Note 94] [TL: "Sajan District", Russian Federation].
Melitaea phoebe tungusa Herz, 1899 [Note 95] [TL: Witim & Vilui mountains, Siberia, Russian Federation].
Melitaea phoebe tusca Verity, 1919 [Note 96] [TL: Tuscany, Italy].
Melitaea phoebe var. ***occitanica*** ab. ***uclensis*** Melcón, 1910 [Note 97] [TL: Uclo, Cuenca, Spain].
Melitaea phoebe ufensis Krulikovsky, 1902 [Note 98] [replacement name for ***uralensis*** [Note 99]].
Melitaea phoebe uralensis Krulikovsky, 1897 [Note 99] [TL: district of Ufa, Russia].
Melitaea phoebe virgilia Fruhstorfer, 1917 [Note 100] [TL: Alpes Maritimes, France].
Melitaea phoebe wagneri Wnukowsky, 1929 [Notes 11 & 101] [replacement name for ***alatauica*** Wagner].
Melitaea phoebe scotosia yagii Nire, 1917 [Note 102] [TL: *c.* 5 km west of Mt. Asama, Shinano Province, Japan].
Melitaea zagrosi Tóth & Varga, 2011 [Note 103] [TL: Zagros Mountains, Iran].

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Appendix

Note 1. ***Melitaea phoebe*** (Denis & Schiffermüller, 1775) [Type Locality (TL): environs of Vienna, Austria]: type material lost; neotype ♂ designated by Tennent and Russell (2010), reared from larva collected from near Vienna, Austria. An often double or even triple brooded species.

Note 2. ***ornata***: (***Melitaea ornata***) Christoph, 1893 [TL: *Circa* 'Guberli', promontorium uralensium australium (near Guberlya, Orenburg Province, Russian Federation)]: this taxon was first recognised as a species distinct from *phoebe* by Tóth and Varga (2011), based on morphometric measurements of male and female genitalia. It was discovered in the Volgograd region at Ilovlya by Tuzov and Churkin (2000: 73, pl. 46, figs 7–9 & 15–17) who wrongly used the name *M.* (*phoebe*) *punica*; Kuznetsov and Stradomsky (2010) subsequently used the name *Melitaea telona*. Kuznetsov (2011) provided details of the biology of this taxon and Russell and Kuznetsov (2012: figs 1–3) demonstrated that larvae from the Volgograd region had red-brown heads. This character is diagnostic for *M. ornata* (within the *Melitaea phoebe* species group – *M. cinxia* larvae also have red-brown heads).

The colourful adults were illustrated by Higgins (1941: pl. 14, fig. 10), Gorbunov and Kosterin (2007: 2: 84, figs 197, 198) and van Oorschot and Coutsis (2014: pl. 12: figs 20, 21 & pl. 13: figs 2, 3). *M. ornata* contrasts with the less colourful *M. phoebe* flying at the same localities in the southern Ural Mountains (present authors, pers. obs.). Tshikolovets (2011: 498) and Tshikolovets et al. (2014: 319) recognised *ornata* as a distinct species. The fact that van Oorschot and Coutsis (2014: 60) placed *ornata* as a synonym of nominotypical *phoebe* is in part what prompted the present paper. The first author has reared many hundreds of specimens of both *phoebe* and *ornata* from many localities in Europe and both authors have seen adults of the two species (sympatric but not synchronic) flying in the Urals. There can be no doubt whatever that *Melitaea phoebe* and *Melitaea ornata* (=*telona*: see Note 91) are distinct species, with different early stages, voltinism (*M. ornata* is invariably single brooded *M. phoebe* often double or triple brooded) and they often have different host-plants.

Recognition of *ornata* as a distinct species paved the way for the realisation that what had recently been referred to as "*emipunica*" (Russell et al. 2005), "*ogygia*" (Varga et al. 2005) and "*telona*" (Kuznetsov and Stradomsky, 2010) all represented the same species (*i.e. ornata*).

Note 3. ***punica***: (***Melitaea punica***) Oberthür, 1876 [TL: Tazoult-Lambèze (Lambessa), Algeria]: This species was described by Oberthür (1876: 25) as a subspecies of *M. phoebe*, but Oberthür himself subsequently raised it to the status of a distinct species (Oberthür 1914: 102). It is now recognised as a distinct species by most modern authors. Following the unfortunate introduction of a quadrinomen "*M.* (*phoebe*) *punica telona*" (this actually encompassed three distinct species: *phoebe*, *punica* and *ornata* [as *telona*]) by Hesselbarth et al. (1995: 1030), the status of *punica* became very confused. It was repeated in that form by Koçak (2000: 9), and a number of authors (e.g. Koçak and Seven 1998: 4) used the combination "*Melitaea punica telona*". Nazari (2003) placed all the taxa mentioned (including *telona* but not *punica*) as synonyms of *M. phoebe*, with the rather unhelpful note: "For further synonymy see Higgins (1941: 338–343)".

Subsequently, and presumably as a direct result of the action by Hesselbarth et al. (1995: 1030), the name *punica* was frequently wrongly associated with the name *telona* Fruhstorfer, 1908 (see also Note 2). For example Abadjiev (2000, 2001: 271), Tuzov and Churkin (2000: 73, pl. 46, figs 7–9, 15–17), Rákosy and Varga (2001), Gorbunov and Kosterin (2003 2: 84) and more recently Baytaş (2007: 128), Székely (2008: 175), Aghababyan (2012: 13), Hüseyinoğlu and Akyol (2013: 11 & 14) and Hüseyinoğlu (2013: 1293), all used

the combination '*Melitaea* (*Cinclidia*) (*phoebe*) *punica*' for the taxon *ornata*. This confusion was undoubtedly brought about by the fact that the underside hindwing pattern (particularly in the submarginal area) of *M. punica* (*cf.* Russell et al. 2006: figs 12–26) is very similar to those non-*phoebe* specimens from Europe and Turkey. This was clearly demonstrated by Russell and Pamperis (2011: 140–142 & figs 3–8; 2012) and Russell and Pateman (2012: figs 4–7). Other authors simply used the name *punica* for the species which was not *M. phoebe s.s.*: *e.g*. Leraut (1999: 173), who gave the distribution of "*C*[*inclidia*] *punica*" (*i.e. Melitaea punica*) as Italy to Turkey and Jordan, with no mention of North Africa, the TL of *punica* and the only place where *M. punica* is actually known to occur.

More recently, Tóth and Varga (2011) and van Oorschot and Coutsis (2014: 66) separated *punica* from *phoebe* on the basis of differences in the male genitalia, and this was followed by Tshikolovets (2011: 497). Collectively, the published literature during the last two decades has created substantial confusion which, insofar as it affects *M. punica*, is clarified here: *Melitaea punica* is confined to North Africa; it occurs from the Atlantic coast of Morocco throughout the Atlas and Rif Mountains to eastern Algeria but apparently not into Tunisia (Tennent 1996: 52). The larva is very similar to that of *M. phoebe occitanica* (Note 5) (Russell et al. 2006: figs 1–4 & 6); however, *punica* butterflies in North Africa are quite different in appearance to *phoebe occitanica* in Spain (*cf.* Higgins 1941: pl. 14, figs 6 & 11; Russell et al. 2006: figs 8–26; Tolman and Lewington 2008: 203).

Note 4. ***Melitaea phoebe phoebe***: The body of the final instar larva of *M. phoebe phoebe* is black, including the head carapace, with black or orange tubercles and white spots spaced around each segment; these spots usually coalesce on each side to form an often prominent lateral white line (see Table 1; also Bodi 1985: plate XI, fig. 92; Lafranchis 2000: 391, fig.; Russell et al. 2007: 159, fig. 14; Lafranchis 2007a: 41, fig. 13; Lafranchis 2008: 6 (fig.); Tennent and Russell 2010: 151, fig. 9). Its distribution ranges from the Ural Mountains to *c.* 60º N., through the Caucasus, south to Iraq, Iran and Lebanon, reaching its southern limit in northern Israel (Benyamini pers. comm.), westwards through Turkey, the Balkans, Hungary, Austria, southern Germany and the alpine and sub-alpine regions of France, Switzerland and Italy.

Some of the name bearing types originate from the eastern Palaearctic. For the sake of completeness these have been included. They are synonymised with nominotypical *phoebe* due to the fact that Kosterin (see Korshunov and Gorbunov 1995) described a final instar larva of *M. phoebe* from near Zabaikalye (south-eastern Russia) as follows: "white with fine black reticulate ornament, so that looks grey; this ornament fuses into a black line along the back and a more diffuse line on either side (between 2nd and 3rd row of false spines from beneath); a white stripe (without ornament) goes through 2nd row beneath false spine row. Thoracic legs and ventral prolegs yellowish-grey; head greyish-black, set with tiny black hairs". This description precisely matches that of the final instar larvae of the European populations of nominotypical *phoebe*. Adult butterflies are very variable, and we are unable to separate populations of *phoebe s.s*. in western Europe to the Urals into distinct races (subspecies).

Note 5. ***Melitaea phoebe occitanica*** Staudinger, 1871 [TL: Andalusia, Spain]: the Type Locality of this subspecies was given originally by Staudinger as "It" (= Italy?) but it is now generally accepted that this was an error (*recte* 'Iberia': Higgins 1941: 336); Verity (1928: 163) limited the Type Locality to Barcelona, Spain, and this was accepted by van Oorschot and Coutsis (2014: 60). Previously, however, Fruhstorfer (1916: 82 (A) (2): 1) was of the opinion that the source of the *occitanica* phenotype was Andalusia and Higgins (1941: 336) considered that this should stand, based on the original description by Staudinger, who did not specify a 'Type' but labelled the series upon which the description was based with the word '*original*' (Higgins 1941:

336). The body of the final instar larva of *M. phoebe occitanica* is black, including the head, with obscure white spots on the body, black tubercles dorsally and a row of orange tubercles with orange hairs laterally, which form an obvious orange lateral line (Lafranchis 2000: 388, fig.; Maravalhas 2003: 281, fig.; Russell et al. 2007: 159, fig. 13; Lafranchis et al. 2015: 464–467, figs), in contrast to the white lateral line of nominotypical *phoebe* (see Table 1, and Note 4).

This subspecies has also been separated from nominotypical *phoebe* using the results of enzyme electrophoresis by Pelz (1995: 57), who was of the opinion that genetic differences were sufficiently significant for *occitanica* to be considered as a "semispecies". This subspecies is distributed from the Iberian Peninsula eastwards through France and peninsular Italy as far south as northern Calabria (Russell pers. obs.); it has also been found in Istria, Croatia (Russell and Pateman 2013a: 47, fig. 6).

Tshikolovets (2011: 496) suggested that the distribution of this subspecies included northern Greece, the southern and eastern parts of the Balkans, western Turkey and Ukraine. The present authors do not agree and consider that these areas are occupied by nominotypical *phoebe*; larvae from Romania, for example, are clearly of the 'white lateral stripe form' associated with nominotypical *phoebe* (Russell et al. 2007: 159, fig. 13). Where the two subspecies meet, for example in Var, France and Istria, Croatia, the larvae can be intermediate in form, as one might expect (Russell and Pateman 2013: 47, figs 8, 9). The colourful adult has been illustrated by many authors, including Higgins (1941: pl. 14, fig. 11), Manley and Allcard (1970: plate 10, figs 1–7) and Lewington in Tolman and Lewington (1997: plate 50).

Note 6. The species ***phoebe, punica, ornata***: despite a series of articles (e.g. Russell et al. 2005, 2006, 2007), Tolman and Lewington (2008: 202–203) recognised only one species *M. phoebe.* However, all three species were separated using DNA sequences by Lenevue et al. (2009) and Tóth et al. 2014. Recognition of these distinct species is now accepted by most recent authors (Tshikolovets 2011: 496–499; Tóth and Varga 2011; van Oorschot and Coutsis 2014: 60–64 & 66), although not necessarily using correct species and/or subspecies names in the correct combinations. The *raison d'être* for this paper is to resolve this nomenclatural muddle.

Note 7. ***abbas*** Gross & Ebert, 1975: 44, fig. 61: synonym of ***Melitaea ornata***. Tshikolovets et al. (2014: 320, map) gave this taxon subspecific status of *M. ornata* and stated that it was found in west and south Iran. Their figures (Plate LX: figs 7, 8, 10, 11 & 12) depicted specimens which appear to have spatulate antennae and black arched submarginal underside hindwing markings not touching the intervening veins, both features typical of *M. ornata* (see Table 1). Subsequently, van Oorschot and Coutsis (2014) figured 5 specimens (plate 13: figs 8, 11, 12, 13 & 16), all from western Iran, of *M. ornata* (as *M. telona*).

Note 8. ***Melitaea ornata adversaria*** Korb, Stradomsky & Kuznetsov, 2015: 142 & plate VI: tentative synonym of ***Melitaea ornata.*** This material has been classified as both *Melitaea phoebe saturata* (Korb 2011: 158: see Note 80) and *Melitaea ornata adversaria* (Korb et al. 2015). The latter was based on molecular analysis of the preserved specimens and we Note that Korb et al. (2015: 142) considered that *M. phoebe* was not present in the Kyrghyz Mountains. The flight period was given (Korb 2011: 158) as May–July, at elevations between 500 and 2000 m; we consider that July is likely to be beyond the flight time of *M. ornata* and that larvae would be in diapause by the end of June. So far as we are aware, larvae of the *Melitaea* populations in this region have not been reported; our synonymy is thus tentative, pending further data.

Note 9. ***aetherea*** Eversmann, 1851: 5: 73 and plate IX: figs 5, 6: synonym of **nominotypical *phoebe***. Synonymised with *M. phoebe* by Higgins (1941), and followed by van Oorschot and Coutsis (2014: 60). A

large but weakly marked form (Higgins 1941: 338, plate 14: fig. 9). Korshunov and Gorbunov (1995: species 174) gave a very full description of the larva of this form, which clearly associated it with nominotypical *phoebe*. Tshikolovets (2011: 497) used this name at subspecies rank.

Note 10. ***aethereaeformis*** Verity, 1919: 183: synonym of ***phoebe occitanica***. Specimens from central Italy which were similar in appearance to *aetherea* Eversmann, 1851 (Higgins 1941: 338) were due to its geographical location placed with *occitanica*. Overlooked by van Oorschot and Coutsis (2014).

Note 11. ***alatauica*** Wagner, 1913, vol. 2: 89 (fig.): Junior primary homonym of *M. parthenie alatauica* Staudinger, 1881, and presumed synonym of **nominotypical *phoebe***. The authors consider that this name is most probably related to *M. phoebe* since it occurs in the eastern Palaearctic outside the presently known eastern limit of the distribution of *M. ornata* (see introduction). Placed with *M. phoebe* by van Oorschot and Coutsis (2014: 60), who suggested that it could be synonymous with *M. sibina* Alphéraky, 1881 (see Note 83).

Note 12. ***albina*** Verity, 1904: 54: we cannot place this form with either *M. phoebe* or *M. ornata*. An aberrant individual having the ground colour of the right hindwing yellowish-white (Higgins 1941: 339); both species may occur in the Lucca region of Italy.

Note 13. ***allophylus*** Rütimeyer, 1942: 438: synonym of ***phoebe occitanica***. Higgins (1955: 118) recognised this form as "leading to *occitanica* Staudinger" and suggested that it should be synonymised with *M. corythallia* Esper, 1781 (*i.e. phoebe occitanica*, see Note 27).

Note 14. ***almana*** Gaede, 1930: 208: probable synonym of ***Melitaea ornata***. This name, attributed to Rebel, appears to have been first published by Gaede under *M. phoebe* (in Seitz, Supplement). Neither Higgins (1941: 339) nor the present authors were successful in their efforts to find an original Rebel reference, and as a result it is provisionally treated as a Gaede manuscript name. Gaede stated that it was a pale race from Asia Minor similar to *M. telona* (*i.e. ornata*). Hesselbarth et al. (1995: 1031) referred to Graves (1925: 101), who stated that this form came from Elma Dagh, Syria. They suggested that it may have been a misspelling of *amanica* Rebel (see Note 16) and synonymised it with *Melitaea punica telona* (*i.e. ornata*), although it is Noted that Gaede treated both names separately. Not mentioned by van Oorschot and Coutsis (2014).

Note 15. ***alternans*** Seitz, 1909: 216: synonym of **nominotypical *phoebe***. A large brightly coloured subalpine form; not figured by either Seitz (1909) or Higgins (1941) but figured by Tolman and Lewington (1997: plate 50; 2008: 203 [same painting]); Higgins (1941: 339) suggested that it was 'proceeding to *occitanica* Staudinger' but only because of its brighter colouring, which is typical of both Alpine and Spanish specimens. See also *monilata* (Note 53).

Note 16. ***amanica*** Rebel, 1917: 252: synonym of ***Melitaea ornata***. Tshikolovets and Nekrutenko (2012: 295) synonymised this form with *telona*, placing the latter as a subspecies of *M. ornata*, and recorded its distribution as the Lesser Caucasus, Djavakheti-Armenian plateau and Talysh. The form is univoltine, with a flight period of May (sometimes late April) – June. Tuzov et al. (2000: plate 46: figs 7–9) figured three specimens in colour with the legends: "*Melitaea* (*phoebe*) *punica amanica* Rebel", two from Armenia, Azavan and one from Azerbaijan, Talysh Mts, Zuvand Plateau, Gosmalyan, 1500 m, 4.vi.1981. Antennal clubs of these specimens appear short and the hindwing underside markings in the submarginal area appear similar to those

of *M. ornata*. Van Oorschot and Coutsis (2014: plate 13, fig. 7) figured in colour a specimen from Armenia, Vedi, vicinity of Chosrov, 27.v.1974, under the name *M. telona* (*i.e. ornata*), which appears from its underside hindwing markings to be correct.

Note 17. ***autumnalis*** Fruhstorfer, 1919: 169: synonym of **nominotypical *phoebe***. The second generation form of *rovia* Fruhstorfer, 1919 (see Note 76). Bernardi and de Lesse (1951: 141) identified a holotype for *autumnalis* (as *automnalis*).

Note 18. ***baccata*** Delahaye, 1909: 10: aberration of ***phoebe occitanica***. The supplement in which this name was published was not available to Higgins (1941: 339), but was kindly supplied to the authors by Eric Drouet. The name refers to an aberrant female specimen which was taken in August at Saint-Barthélemy, Maine-et-Loire in west-central France and thus outside the known ranges of both nominotypical *phoebe* and *M. ornata*. Not mentioned by any recent author.

Note 19. ***bethunebakeri*** de Sagarra, 1926: 130: synonym of ***phoebe occitanica***. Higgins (1941: 339) correctly considered it synonymous with *occitanica* Staudinger 1871. Not mentioned by van Oorschot and Coutsis (2014).

Note 20. ***canellina*** Stauder, 1922: 18: synonym of **nominotypical *phoebe***. Higgins (1941: 339) suggested this was synonymous with *minoa* Fruhstorfer, 1917 (see Note 51); the TL places it outside the known ranges of both *phoebe occitanica* and *ornata* but within the distribution of nominotypical *phoebe*. Overlooked by van Oorschot and Coutsis (2014).

Note 21. ***capreola*** Varga, 1967: 131: synonym of ***Melitaea ornata***. Varga described this as a subspecies of *M. phoebe*, but subsequently (Tóth and Varga 2011) placed it with *M. ornata*; van Oorschot and Coutsis (2014: 63) placed it with *M. telona* (*i.e. ornata*).

Note 22. ***caucasica*** Staudinger, 1870: 59, Taf. 1 fig. 2: synonym of **nominotypical *phoebe***, but name preoccupied by *M. didyma caucasica* Staudinger, 1861; see *ottonis* Fruhstorfer, 1916 (a replacement name for *caucasica*: Note 61), and *caucasicola* Verity, 1919 (Note 23), a later replacement name. A lectotype ♀ and a paralectotype ♂ were designated by Nekrutenko (Hesselbarth et al. 2: 1028) from the Staudinger collection, housed at Zoologisches Museum der Humboldt Universität, Berlin.

Note 23. ***caucasicola*** Verity, 1919: 184: a replacement name for *caucasica* Staudinger, 1870 (see Note 22); a junior subjective synonym of *ottonis* Fruhstorfer, 1916 (see Note 61).

Note 24. ***changaica*** Seitz, 1909: 217: synonym (provisional) of **nominotypical *phoebe***. Occurs in the eastern Palaearctic, further east than the presently known eastern limit of the distribution of *M. ornata*. Kosterin figured a final instar larva of this taxon from 10 km NNW of the village of Tasyrkhoi S Chita region (Dahuria), Transbaikalia, Siberia, Russia, 19.vi.1995. Its black head carapace confirms probable synonymy with *M. phoebe*.

Note 25. ***cinxioides*** Muschamp, 1905: 69 (fig.): aberrational form of **nominotypical *phoebe***. Its origin in Switzerland is outside the distributional areas of both *phoebe occitanica* and *M. ornata*. An aberrant form with black spots in the submarginal brown spots of the hindwing upperside, resembling *M. cinxia*. This recurrent

aberration is known to occur almost anywhere (pers. obs.). Placed with *M. phoebe* by Higgins (1941: 339). Not mentioned by any recent authors.

Note 26. ***confusa*** Joannis, 1908: 45: synonym of ***phoebe occitanica***. An aberrant ♂ form in which the upperside forewings are more reddish with the black markings reduced, the transverse black lines in the discal region are nearly obliterated and the hindwings are dark basally. The underside forewings have similar markings but the hindwings are yellowish white with enlarged dark markings. Higgins (1941: 339) attributed this name to Oberthür but with Joannis' reference, and he did not correct this in his *errata* (Higgins 1944). The TL of Brittany, northwest France, places it outside the known ranges of nominotypical *phoebe* and *M. ornata*. Not mentioned by any recent authors.

Note 27. ***corythallia*** Esper, [1781]: 65, 67, Taf. 61, figs 4, 5: synonym of ***phoebe occitanica***. Verity (1928: 163) was of the opinion that *occitanica* Staudinger (see Note 5) should be placed as a synonym of *corythallia* Esper, on the basis that he believed the specimens representing *corythallia* originated from the Iberian Peninsula. Higgins (1941: 336) disagreed with this course of action and showed that Verity's assumption was incorrect, as Esper ([1781]: 67), stated that they were the original specimens of Geoffroy's *Papilio cinxia* var. *B*, which were from France (Higgins 1941: 336). Whether the origin of the specimens of *corythallia* were from France or Spain is unimportant because the same subspecies of *M. phoebe* (*i.e. occitanica*) occurs in both countries. Hesselbarth et al. (1995: 1028) and van Oorschot and Coutsis (2014: 60), synonymised this name with *M. phoebe*. Although the name *corythallia* predates *occitanica*, type material of the former appears to be lost (Hesselbarth et al. 1995: 1028) and the name *occitanica* has been used extensively by authors in referring to *phoebe* populations from the Iberian Peninsula. The present authors have followed this course of action.

Note 28. ***crassenigra*** Verity, 1928: 162: synonym of ***phoebe occitanica***. An *occitanica* form with heavy discal spotting from southwest France (Higgins 1941: 339).

Note 29. ***deleta*** Verity, 1919: 184: aberration of (presumably) ***phoebe occitanica***. Aberrant female of form *tusca* (see Note 96) with almost all the black markings obliterated (Higgins 1941: 339). Larvae reared from populations of *M. phoebe* from peninsular Italy have, so far as the authors are aware, all been of the *occitanica* form (see Note 5).

Note 30. ***dorae*** Graves, 1925: 100: synonym of ***Melitaea ornata***. Graves (1925: 103–106) gave a two page description of this form, and a table of "Index of Nigrescence of *M. phoebe* races (upperside)", which demonstrated that it was paler than either *telona* or *ogygia*. Higgins (1941: 339) paraphrased this description as "small and pale, with the black markings fine and partly obsolete"; this is typical of phenotypes in xerothermic biotopes. Hesselbarth et al. (1995: 1031) synonymised this name with '*M. punica telona*' (*i.e. ornata*) and Tshikolovets (2011: 499) with '*Melitaea ornata telona*' (*i.e. ornata*). Van Oorschot and Coutsis (2014: 63) synonymised this with *M. telona* (*i.e. ornata*) and illustrated (van Oorschot and Coutsis 2014: plate 13, fig. 6) a specimen from Wadi Zarqa, Jordan, 400 m, the underside hindwing pattern and spatulate antennae of which suggest synonymy with *ornata*.

Note 31. ***emipauper*** Verity, 1919: 184: synonym of ***phoebe occitanica***. Described by Verity as a medium sized, summer brood form of *tusca* Verity, 1919 (Higgins 1941: 340) (see Note 96).

Note 32. ***emipunica*** Verity, 1919: 184: synonym of ***Melitaea ornata***. This name was used by Russell et al. (2005) when the species was first identified as being distinct from *M. phoebe* by the red-brown head colour of the stage L4 to the final instar larvae, reared from a female taken at Montagna Longa, within the Type Locality (*i.e.* Sicily). This was afforded subspecific status by Tshikolovets (2011), with a distribution given as SE France (Var), Sicily and S Italy (Calabria, Basilicata, Campania). It was synonymised with *M. telona* (*i.e*. *ornata*) by van Oorschot and Coutsis (2014: 63). Brief use of *emipunica* by Russell et al. (2005) and of *ogygia* by Varga et al. (2005) was before the wide distribution of *M. ornata* was fully appreciated, and was (in part) the cause of ensuing confusion.

Note 33. ***enoch*** Higgins, 1941: 337: synonym of ***Melitaea ornata***. Figured by Higgins (1941: plate 14, fig. 4), who gave other locations for this form: Arwas and Achal Tekke, 2000 m, July, and Jablonowka from the same region (Transcaspia). He placed it with *M. phoebe occitanica* but suggested that this placement was due to the colour contrast of the wings being similar to, but not quite so strongly marked as, those of 'Spanish *occitanica'*. Higgins further noted a slight difference in male genitalia and suggested the possibility that *enoch* should be ranked as a subspecies of *M. phoebe*. Tshikolovets et al. (2014: 319 and plate LX: figs 6 and 9) placed *enoch* as a subspecies of *M. ornata*. Van Oorschot and Coutsis (2014: 63) placed it as a synonym of *M. telona* (*i.e*. *ornata*).

Note 34. ***estrela*** Higgins, 1941: 337: ***phoebe occitanica***. Said by Higgins (1941: 337) to be: "very bright … labelled *estrela* Romei, but I cannot trace a reference to a description, and do not know whether the name was ever published validly …"; the present authors have also failed to find a published reference by Romei, and place the name as a *nomen nudum*.

Note 35. ***fasciata*** Galvagni, 1934: 2: an aberration of **nominotypical *phoebe***. This extreme aberration has the upper surface of the wings almost black with the forewing discal macules radially elongated into a fascia. The specimen was taken on 6.viii.1933 near Vienna; its origin places it with nominotypical *phoebe*. The name has been used by a number of authors to describe specimens in which the black markings coalesce to form fasciae; for example Wiltshire (1946: 26; plate 3, fig. d) used it to describe a specimen of *M. phoebe* from Shiraz, Fars, SW Iran, suggesting it was similar to "mod. or ssp. *telona*" (= *ornata*).

Note 36. ***francescoi*** de Sagarra, 1926: 130: synonym of ***phoebe occitanica***. A name raised for specimens of the second brood of *occitanica* Staudinger, 1871, flying in July/August (Higgins 1941: 340) (see also Note 5).

Note 37. ***gaisericus*** Hemming, 1941: 207: synonym of ***Melitaea punica***. A replacement name for *leechi* Rothschild (see Note 46) (Higgins 1941: 340); Higgins (1941: pl. 15, fig. 8) figured an example from Azrou, Morocco. Synonymised with *M. punica* by van Oorschot and Coutsis (2014: 66).

Note 38. ***galliaemontium*** Verity, 1928: 162: synonym of ***phoebe occitanica***. A name raised for small, second brood specimens (Higgins 1941: 340) from France. Overlooked by van Oorschot and Coutsis (2014).

Note 39. ***gerinia*** Fruhstorfer, 1917: 1: synonym of ***phoebe occitanica***. This form is more uniform in colour than the contrasting highly coloured form found in Spain (Higgins 1944: 340) (see Note 15). In raising the name *gerinia*, Fruhstorfer (1917: 1–2) did not refer to specimens he had seen, as a result of which Bernardi and de Lesse (1951: 141) were unable to identify syntypes.

Note 40. ***geyeri*** Aigner-Abafi, 1906: 208: **status uncertain**. It is not possible to synonymise this aberrant male with either *M. ornata* or nominotypical *phoebe*, since both fly in Hungary (*cf.* Varga 1967; Varga et al. 2005). This name was credited to Abafi-Aigner (sic) by Higgins (1941: 340).

Note 41. ***guevara*** Fruhstorfer, 1917: 19: synonym of ***phoebe occitanica***. A lightly marked form from Spain with pale yellow ground colour, markings reduced on both wing surfaces (Higgins 1941: 340). It was synonymised by van Oorschot and Coutsis (2014: 61) with *M. phoebe*; its origin suggests it is synonymous with *phoebe occitanica* (see also Note 19).

Note 42. ***gurtleri*** Joukl, 1908: 97: **status uncertain**. This name was based on a single aberrant specimen, with a bright orange ground colour on the upper surface of the wings and underside wing bases that were said to be very dark. This sounds like *M. ornata* rather than *M. phoebe*, but the presence of *M. ornata*, although reported from Croatia (Koren and Štih 2013) has yet to be confirmed there. *M. phoebe* is certainly present further north than the Plitvice Lakes [TL], in Istria (Russell and Pateman 2013a, b). Overlooked by van Oorschot and Coutsis (2014).

Note 43. ***juliae*** Molina & Ocete, 1986: 869: form of *Melitaea phoebe occitanica*.

Note 44. ***koios*** Fruhstorfer, 1908: 194: synonym of **nominotypical *phoebe***. Holotype examined by Bernardi and de Lesse (1951: 141) from specimens in the Museum National d'Histoire Naturelle de Paris (MNHN). Van Oorschot and Coutsis (2014: 60) gave the TL as: "Italy (S Tyrol), Switzerland (Klausen)". Higgins (1941: 340) synonymised this large and rather dark form with nominotypical *phoebe*, and this was followed by van Oorschot and Coutsis (2014: 60).

Note 45. ***kovacsi*** Varga, 1967: 131: synonym of ***Melitaea ornata***. This form has been placed in various combinations, including *M. ogygia kovacsi* (Varga et al. 2005) and *M. ornata kovacsi* (Tóth and Varga 2011). The post diapause larvae have red-brown heads (Varga et al. 2005: 67, fig. 2; Russell et al. 2007: 159, fig. 18). The present authors can find no significant morphological features to separate *kovacsi* from nominotypical *ornata*.

Note 46. ***leechi*** Rothschild, 1917: 99: ***Melitaea punica***. A junior primary homonym of *Melitaea leechi* Alphéraky, 1895 (van Oorschot and Coutsis 2014: 66) (see also Note 37).

Note 47. ***lokris*** Fruhstorfer, 1908: 194: synonym of **nominotypical *phoebe***. The upperside black pattern is more extensive than that of *ottonis* Fruhstorfer, 1916 (see Note 61) (Higgins 1941: 340). Type material was examined by Bernardi and de Lesse (1951: 141) from specimens in the MNHN, Paris.

Note 48. ***malvida*** Gaede, 1930, *in* Seitz (Supplement: 207, fig. 13d): presumed synonym of **nominotypical *phoebe***. Gaede attributed this name to Fruhstorfer, but without a date; unable to find an original Fruhstorfer reference, Higgins (1941: 340) attributed it to Seitz (we have also failed to find any original Fruhstorfer reference, but we note that the *Melitaea* section of Seitz' Palaearctic supplement was by Gaede, not Seitz). Gaede noted that *malvida* had pointed forewings, suggesting a form of *phoebe* rather than of *ornata* and suggested an association with form *narenta* (see Note 55). He also illustrated (in Seitz 1930, Supplement: plate *Neptis-Argynnis*, fig. d: 5) the upperside, which is not helpful for identification. Although Tóth et al. (2014: 752, fig. 1, map) indicated the presence of *M. ornata* in Bosnia, no locality in Bosnia was given in their specimen

list (Tóth et al. 2014: 751, table 1); the present authors are not aware of any modern records of *ornata* from Bosnia, and a TL of Bosnia suggests synonymy with nominotypical *phoebe*. Thurner (1964: 34), using the name *malvinda* Fruhstorfer (presumably a misspelling of *malvida*), suggested this form was also found in the Republic of Macedonia (formerly Yugoslavia).

Note 49. ***mandarina*** Seitz, 1909: 217: synonym (provisional) of **nominotypical *phoebe***. This very large form (Higgins 1941: 340) occurs in the eastern Palaearctic, considerably further east of the presently known eastern limit of *M. ornata*. Higgins (1941:340) suggested its separation from form *changaica* (see Note 24) was doubtful. Synonymised with *phoebe* by van Oorschot and Coutsis (2014: 60).

Note 50. ***melanina*** Bonaparte, 1831 (125): 159: aberration of ***phoebe occitanica***. This male aberration had the discal ground colour of the underside of the hindwings and the submarginal lunules black. It was taken in July at Subiaco, which is only 400 m above sea level, thus it was almost certainly a specimen from a second brood, ruling out *M. ornata*. Not mentioned by any modern authors.

Note 51. ***minoa*** Fruhstorfer, 1917 (A. 2): 2: synonym of **nominotypical *phoebe***. Higgins (1941: 341) treated this as a small dark race found at high levels, probably identical with nominate *phoebe*; van Oorschot and Coutsis (2014: 61) also placed this with *M. phoebe*. Type material was examined by Bernardi and de Lesse (1951: 141).

Note 52. ***minor*** Wheeler, 1903: 84: an aberration of **nominotypical *phoebe*** based on size, specimens having less than 38 mm wingspan. This was an infra-subspecific name, with no status under The Code, but for the record, the name is preoccupied by *Melitaea arcesia minor* Elwes, 1899 (Higgins 1941: 341). Higgins (1941: 341) suggested, and the present authors concur, that the authority was probably Wheeler as there is no reference given for Frey in Wheeler's book.

Note 53. ***monilata*** Verity, 1919: 184: synonym of **nominotypical *phoebe***. A large, boldly marked and bright alpine form; a specimen of this form from Simplon, Berisal, Switzerland, was figured by Higgins (1941: plate 14, fig. 1); who believed (Higgins 1941: 341) it was related to *ottonis* (Note 61). It is placed with nominotypical *phoebe* due to its TL and similarity to *alternans* (Note 15). Overlooked by van Oorschot and Coutsis (2014).

Note 54. ***monilataeformis*** Verity, 1919: 184: synonym of ***phoebe occitanica***. This name was raised by Verity (1919: 184) for those specimens of *tusca* Verity, 1919 (see Note 96), which displayed *monilata* characters (see Note 53); a TL of peninsular Italy suggests synonymy with *phoebe occitanica*.

Note 55. ***narenta*** Fruhstorfer, 1917 (A. 2): 1, pl. 1, fig. 1: synonym of **nominotypical *phoebe***. Fruhstorfer gave the TL as "Jablanica, Herzegovina", which van Oorschot and Coutsis (2014: 61) wrongly interpreted as Mount Jablanica, which is on the Macedonia (FYROM)/Albania border. Seitz (1909: 207) and Higgins (1941: 341) described this as a large dark race, likening it to *ottonis* (see Note 61). Holotype ♂ inspected by Bernardi and de Lesse (1951: 141). Adults reared from a population of confirmed *M. phoebe* (*i.e.* final instar larvae with black heads and a white lateral stripe) from Serbia were large and dark (Peter Russell pers. obs.); it is likely that such adults are referable to *narenta*. Both sexes of this form were figured by Gaede (in Seitz 1930:

supplement: pl. *Neptis-Argynnis*, figs d: 3, 4) but these were not as dark as reared specimens from Serbia. Synonymised with *phoebe* by van Oorschot and Coutsis (2014: 61).

Note 56. ***nigroalternans*** Verity, 1919: 184: synonym of **nominotypical *phoebe***. An alpine form, which resembles *alternans* (see Note 15) but with a more extensive black pattern (Higgins 1941: 341). Overlooked by van Oorschot and Coutsis (2014).

Note 57. ***nigrogygia*** Verity, 1939: (17): synonym of ***phoebe occitanica***. There has been some confusion related to this taxon. The TL was clearly stated by Verity (1939: (17); 1938: plate III, figs 12 and 14) to be Abbazia, Istria. At that time Istria was part of Italy but after World War 2 it became part of Croatia and the name was changed to Opatija. Higgins (1955: 118) gave the TL as "St. Dionisio, Macedonia at 800 m., gen. 2", mistakenly using data from Verity's *postnarenta* (see Note 68). Tóth and Varga (2010: 274) correctly cited the TL as 'Opatija, Croatia'; but later wrongly as 'Opatija, Macedonia' (Tóth and Varga 2011: 264). Tóth and Varga (2011: 259–260), who did not examine any specimens from Croatia in their published researches on *Melitaea phoebe* species-group genitalia, suggested that 'race' *nigrogygia* was a subspecies of *M. ornata* and not of *M. phoebe*. Van Oorschot and Coutsis (2014: 63) also placed this taxon under '*Melitaea telona*' (*i.e. ornata*) as opposed to *M. phoebe*, accepting the information for the TL given by Higgins (1955: 118) (John Coutsis pers. comm.). Verity (1950: 4 p.152 and Tav. 43: figs 70 and 71) figured the same two ♂♂ he figured in 1938, with the added information: 'captured 15 May' (year not stated) with the original locality data: 'Abbazia, Istria'. A capture date of 15 May does not fit with second generation specimens of *M. phoebe*, as was suggested by Higgins (1955: 118). Russell and Pateman (2013a, b) reared a brood of *M. phoebe* from eggs laid by a female "*nigrogygia*" taken within 20 kilometres of Opatija; the larvae had black heads throughout their lives and most had an orange lateral stripe, clearly associating the taxon *nigrogygia* with *M. phoebe occitanica,* with which it is synonymised here. A study of Verity's actual specimens may provide further enlightenment.

Note 58. ***nimbula*** Higgins, 1941: 337: synonym of ***phoebe occitanica***. Higgins (1941: 337) raised this name for specimens of *occitanica* (see Note 5) with an exaggerated black pattern on the upperside. It was overlooked by van Oorschot and Coutsis (2014).

Note 59. ***ogygia*** Fruhstorfer, 1907: 310: synonym of ***Melitaea ornata***. Recognised as a distinct species by Lafranchis (2007a, b, 2008) but considered a subspecies of *M. ornata* by Tshikolovets (2011), with a distribution of 'S. and C. Greece (including Peleponnese and W. Aegean Is.); probably S.-W. Bulgaria and European Turkey'. *M. ornata* appears to be widespread in Bulgaria (Kolev 2015, pers. comm.). Hesselbarth et al. (1995: 1031–1033) listed over 150 locations for this species (as '*punica telona*'), all of which were in Asian Turkey. So far as the authors are aware *M. ornata* has not been recorded from the Greek region of Thrace, adjacent to European Turkey (Pamperis 2009: 433). The name *ogygia* was placed as a subspecies of *M. ornata* by Tshikolovets (2011: 498), as a synonym of *M. punica telona* (*i.e. ornata*) by Hesselbarth et al. (1995: 1030), and as a synonym of *M. telona* (*i.e. ornata*) by van Oorschot and Coutsis (2014: 63). Russell et al. (2007: 159, figs 16, 17) demonstrated that the larvae had red-brown heads and thus *ogygia* is placed as a synonym of *M. ornata*. The TL was given by Hesselbarth et al. (1995: 1031) as 'Poros, Meerenge von Salamis'; the Straits of Salamis do not exist near Poros Island, nor does it feature on any of the original specimen labels (Russell and Pamperis 2011: 143). Holotype identified by Bernardi and de Lesse (1951: 140).

Note 60. ***ornatiformis*** de Sagarra, 1930: 114: synonym of ***phoebe occitanica***. Type material taken by Querci, 24.viii.1928 at Villacabras, central Spain. Despite its nomenclatural association with *ornata*, geographical source clearly places this with *phoebe occitanica*.

Note 61. ***ottonis*** Fruhstorfer, 1917 (A. 2): 1, nota: synonym of **nominotypical *phoebe*** (a replacement name for *M. phoebe* var. *caucasica* Staudinger 1870 (see Note 22)). Higgins (1941: pl. 14, fig. 1) figured an example of this form from Simplon, Berisal, Switzerland, from which the size and the wing markings clearly suggests synonymy with nominotypical *phoebe*. Tshikolovets (2011: 497) treated this as a subspecies of *M. phoebe*, as did Tshikolovets and Nekrutenko (2012: 293) and Tshikolovets et al. (2014: 318–319). Specimens figured by Hesselbarth et al. (1995 3: Tafel 80/81: figs 30–33 ♂♂; Tafel 82/83: figs 1–4 ♀♀) from eastern Turkey, by Tshikolovets (2003: plate 24: figs 16 ♂ and 17 ♀) from Taberda, Russian Caucasus and by Tshikolovets et al. (2014: plate LX, figs 1–3 ♀♀) from Iran suggest that *ottonis* is best placed as a synonym of nominotypical *phoebe*, as van Oorschot and Coutsis (2014: 61) suggested.

Note 62. ***paedotrophus*** Bergsträsser, 1780: 14, pl. 75, figs 5–6. Synonym of **nominotypical *phoebe***.

Note 63. ***parascotosia*** Collier, 1933: 54: ***Melitaea scotosia***. Name based on a single ♀ specimen taken in July 1923; the author considered this subspecies to be intermediate between *scotosia* Butler and *mandarina* Staudinger. Higgins (1941: 341) considered that the name was "Probably referable to *scotosia*". Lee (1982: 46) placed *scotosia* Butler [TL: Tokyo, Japan] as a subspecies of *M. phoebe.* However, Tuzov et al. (2000: 2: 74), Gorbunov and Kosterin (2007: II: 85) and van Oorschot and Coutsis (2014: 67) synonymised the name with *Melitaea scotosia* Butler, which occurs in the eastern Palaearctic. Although originally described as a subspecies of *M. phoebe*, it does not appear to be associated with any of the three taxa (*phoebe, ornata, punica*) dealt with in this paper.

Note 64. ***parva*** Gerhard, 1882: 126: synonym of **nominotypical *phoebe***. A bright "second generation" form, reared from a larva – colour and host-plant unknown. Higgins (1941) and van Oorschot and Coutsis (2014) overlooked this form.

Note 65. ***parva*** Caradja, 1895: 47: probable synonym of **nominotypical *phoebe***. A small, brightly marked variety of the first generation (Higgins 1941: 341). A larva from Transylvania, Romania, having typical characters (black head with white lateral stripe) of nominotypical *phoebe* was figured by Russell et al. (2007: 159, fig. 14). Székely (2008: 175–176) included reports (unconfirmed by larval head colour) by T. Hácz of *M. punica telona* (= *ornata*) from Transylvania and North-Dobrudja in Romania; however, these records were reported later by Hácz (2012: 73) as *M. phoebe*. Not mentioned by van Oorschot and Coutsis (2014). Since both this and the previous entry are infrasubspecific, they are not covered by The Code.

Note 66. ***pauper*** Verity, 1919:183: synonym of ***phoebe occitanica***. Described as a small, lightly marked form with pale ground colour, the usual summer brood form of *tusca* Verity, 1919 (Higgins 1941: 341 and pl. 14, fig. 3) (see also Note 96).

Note 67. ***phoebina*** Turati, 1919: 222: synonym of ***Melitaea ornata***. A small mountain form (Aspromonte, above 1400 m) rather dark and heavily marked, related to *totila* Stauder, 1914 (Higgins 1941: 341) (see Note 92). According to Turati (1919: 222) there is no second generation of this form, which he considered similar

to that from Ficuzza, Palermo, Sicily (see Note 32). The TL is outside the range of *M. phoebe*, which has not been observed south of Monte Martinellal, Cosenza, Calabria, at the much lower elevation of 880 m (*cf.* discussion on altitudinal separation in Italy in Russell and Pateman 2011: 28) from where 5♂♂ were taken by the first author (identification confirmed from genitalia, club shaped antenna and underside hindwing pattern). Overlooked by other authors, including van Oorschot and Coutsis (2014).

Note 68. ***postnarenta*** Verity, 1939: (17): synonym of **nominotypical *phoebe***. Verity (1939: (17) gave this name to small second generation specimens of *M. phoebe*, resembling *emipauper* (see Note 31). The TL and details of collection for this form were mistakenly attributed by Higgins (1955: 118) to *nigrogygia* (see Note 57). Resemblance to *emipauper* is superficial. Overlooked by van Oorschot and Coutsis (2014).

Note 69. ***postogygia*** Verity, 1939: (16): synonym of **nominotypical *phoebe***. Verity (1939: [16]) gave this name to a small form flying in the hills above Thessalonica in August; close association with the name *ogygia* (*i.e. M. ornata* – see Note 64) is misleading. Higgins (1955: 118) included the name in his list of synonyms of *M. phoebe* and indicated a similarity with *parva* (see Notes 64 and 65) and *pauper* (see Note 66). A second generation form (*M. ornata* is single-brooded – see Note 2) from central Greece places this taxon with nominotypical *phoebe*. It was overlooked by van Oorschot and Coutsis (2014).

Note 70. ***postvirgilia*** Verity, 1950: 154: synonym of **nominotypical *phoebe***. The second generation of the Alpine first generation form *virgilia* (see Note 100). Not listed by Higgins (1941, 1955) or any recent authors.

Note 71. ***pseudosibina*** Alberti, 1969: 192, Taf. 1, figs 1c and 2c.: synonym of **nominotypical *phoebe***. Synonymised with nominotypical *phoebe* by Hesselbarth et al. (1995: 1028), and with "*M. phoebe*" by van Oorschot and Coutsis (2014: 61). Judging from the paratypes figured by Alberti (1969: Taf. 1, figs 1c and 2c) and the specimen figured by van Oorschot and Coutsis (2014: plate 12, fig. 24), which has clubbed antenna and hindwing underside arcuate submarginal markings reaching the intervening veins, this is correct. Tshikolovets (2011: 497) placed it as a synonym of *Melitaea phoebe ottonis* (see Note 61), as did Tschikolovets and Nekrutenko (2012: 293).

Note 72. ***punicapowelli*** Oberthür, 1915: fig. 2338: synonym of ***Melitaea punica***. Specimens of *M. punica* which have the black pattern partly obsolete (Higgins 1941: 342).

Note 73. ***punicata*** Ragusa, 1919: 150: synonym of ***Melitaea ornata***. Equated to *emipunica* (see Note 32) by Higgins (1941: 342).

Note 74. ***reliquiae*** Korb et al., 2015: 143 and plate VI: synonym of ***Melitaea ornata***. Information on the populations in the Volgograd region was first published by Kuznetsov and Stradomsky (2010) under the name *Melitaea telona* and later by Russell and Kuznetsov (2012) under the name *M. ornata*.

Note 75. ***rostagnoi*** Turati, 1920: 223: synonym of ***phoebe occitanica***. A small second generation form, probably much the same as *emipauper* Verity (see Note 31) and *autumnalis* Fruhstorfer (see Note 17) (Higgins 1941: 342). Synonymised with *M. phoebe* by van Oorschot and Coutsis (2014: 61).

Note 76. ***rovia*** Fruhstorfer, 1919: 169: synonym of **nominotypical *phoebe***. According to Higgins (1941: 342) this is a low elevation form with reduced black markings. A holotype and allotype were examined by Bernardi and de Lesse (1951: 141). Synonymised with *M. phoebe* by van Oorschot and Coutsis (2014: 61).

Note 77. ***rubialesi*** Gómez Bustillo, 1973: 36: form of ***Melitaea phoebe occitanica***.

Note 78. ***rubrofasciata*** Gušić, 1922: 95: probably a synonym of **nominotypical *phoebe***: Higgins (1941: 342) Noted this as a small form with a deficiency of black pattern on the discal area of the wings. However, the name seems to indicate the presence of some red colour on the wings. Although Koren and Štih (2013) recorded *M. ornata* from five localities in Croatia, one of which was near Zagreb, the identity of the species has been questioned (Koren pers. comm.) The first author visited two of the locations concerned in May 2015 and considered that the biotope was unsuited to *M. ornata*. Podsused (the TL) is on the banks of the River Sava at *c*. 125 m above sea level and appeared on recent inspection to be encompassed by industrial buildings (Russell pers. obs.); it would seem unlikely that either species would be extant currently in that locality.

Note 79. ***sarvistana*** Wiltshire, 1941: 473, fig. 3: ***Melitaea sarvistana***. Originally described as a race of *M. phoebe* based on two male specimens; a large form, with black submarginal lunules complete on both wings, other markings faint with nearly obsolete discal markings; on the underside of hindwings the black markings are prominent (Wiltshire 1941). Wiltshire (1946: 25, plate 1: figs 1 and 2)), from an examination of the genitalia, elevated this to species status. Higgins (1955: 117, pl. I, fig. 17 pl. II, fig. 17) also considered it a distinct species. Eckweiler and Hofman (1980: 10), Racheli (1980: 80–81), Koçak et al. (1997: 4), Nazari (2003), Kolesnichenko (2007: 30), van Oorschot and Coutsis (2014: 69 and pl. 14, figs 20–22) and Tshikolovets et al. (2014: 321 and pl. LX, figs 13–15, 18) all followed Wiltshire in recognising *sarvistana* as a distinct species. The present authors have no personal experience of this taxon but it appears to be different from any examples of the taxa under consideration; its inclusion here is only because it was originally described in association with *M. phoebe*.

Note 80. ***saturata*** Staudinger, 1892: 323: synonym of **nominotypical *phoebe***. A large brightly coloured form resembling many mountain forms of *phoebe* (Higgins 1941: 342). It occurs in the eastern Palaearctic and, since the presently known eastern limit of the distribution of *M. ornata* is Kazakhstan, southeast of the Ural Mountains, placement with nominotypical *phoebe* seems appropriate. Synonymised with *M. phoebe* by van Oorschot and Coutsis (2014: 60). Korb (2011: 158) identified *Melitaea* specimens from N Tian-Shan as *M. phoebe saturata*. The TL of *saturata* is Mongolia, some 2500 km northeast from Tian-Shan. Korb et al. (2015: 142–143, Col. pl. VI, figs 3 and 4), who then considered that *M. phoebe* was absent from Tian-Shan, reassessed this population as *M. ornata*; we consider *saturata* a synonym of *M. phoebe phoebe*.

Note 81. ***seminigra*** Delahaye, 1909: 10: aberration of ***phoebe occitanica***. This aberrant female specimen, with almost black forewing uppersides, was taken in June at Pignerolles, Maine et Loire in west central France and thus outside the ranges of both nominotypical *phoebe* and *M. ornata*. Higgins (1941: 342) stated that he did not view the original publication and thus could make no comment on this name. It has not been mentioned by any recent author.

Note 82. ***sextilis*** Jachontov, 1909: 285: synonym of **nominotypical *phoebe***. A small second generation form of *caucasica* (see Notes 22, 61) taken in the southern Caucasus in August. Higgins (1941: 342) and van Oorschot and Coutsis (2014: 60) placed this with *M. phoebe*.

Note 83. ***sibina*** Alphéraky, 1881: 400, Tabl. XIV fig.13: **status unclear** (distinct species/synonym of **nominotypical *phoebe***). This taxon is distributed mainly outside the western Palaearctic, with a western distribution limit in the Republic of Kazakhstan (Tshikolovets 2003: 328). Originally described as a variety of *M.*

phoebe, it was given species status by Higgins (1941: 349, plate 15: figs 5, 6, 11 and 12) and this has been followed by some recent authors (for example: Tshikolovets 2003: 328–329, 2005: 338; van Oorschot and Coutsis 2014: 65–66). It does not appear to be directly associated with any of the three taxa dealt with in this paper. We note that Tóth and Varga (2011) and Tóth et al. (2014) were unable to separate it from *M. phoebe* using molecular or morphometric procedures.

Note 84. ***sterlineata*** Turati, 1920: 223, Tav. II, figs 10–12: synonym of ***phoebe occitanica***. Although placed by Turati as an aberration of *phoebina* (= *ornata*, see Note 64), the specimens were taken by GC Krüger, at 800 m altitude, in September 1909; it must therefore represent a second or even third generation form, which precludes it from being *ornata*, which is univoltine.

Note 85. ***streltzovi*** Kolesnichenko & Yakovlev, 2004: 103: synonym of **nominotypical *phoebe***. Distributed along the south-western slopes of the Mongolian Altai. All specimens taken in the first part of July, flying in mesophilous grasslands and river valleys. The figures (Kolesnichenko and Yakovlev 2004: figs 10, 11 on plates V and VI) show both sexes are heavily marked with a pale background on the upper surfaces of both fore- and hindwings. The club shaped antenna and the arcuate submarginal markings appearing to reach the intervening veins (see Table 1), suggest association with *M. phoebe* rather than *M. ornata*. Synonymised with *M. phoebe* using van Oorschot and Coutsis (2014: 61)

Note 86. ***subcorythallia*** Verity, 1928: 162: synonym of ***phoebe occitanica***. "The second generation of France" (Higgins 1941: 342).

Note 87. ***suboccitanica*** Verity, 1928: 162: synonym of ***phoebe occitanica***. "The first generation of France" (Higgins 1941: 342).

Note 88. ***subtusca*** Verity, 1952: 349: synonym of ***phoebe occitanica***. Verity (1952: 349) referred this form from southeast France to *tusca* from central Italy (see Note 96), and it is placed with *phoebe* o*ccitanica* as a result. *M. ornata* from Var, France occurs in a very different phenotype from the form of *phoebe occitanica* occurring in central Italy (Verity 1951: plate 44, figs 1–16), the former being much darker in colour and having triangular submarginal lunules (Russell et al. 2007: 162 fig. 52). Overlooked by van Oorschot and Coutsis (2014).

Note 89. ***sylleion*** Fruhstorfer, 1917 (A. 2): 2: synonym of **nominotypical *phoebe***. Higgins (1941: 342) considered this form to be inconsistent. The holotype and allotype were inspected by Bernardi and de Lesse (1951: 141). It was placed by van Oorschot and Coutsis (2014: 61) as a synonym of *M. phoebe*.

Note 90. ***tatara*** Krulikovsky, 1891: 236: **status uncertain** (possibly a hybrid). Spelt *tartara* (sic) by Higgins (1941: 342) but subsequently corrected (Higgins 1944: 46). The origin of this name refers to Tatastan, a Russian Province in which Casan, the TL, is located. Although Krulikovsky placed it under *M. phoebe*, *M. ornata* was not at that time established as a species. Higgins (1941: 342) said: 'An example in which there is a double black line across both wings parallel to the outer margin' but this is not helpful to place it with either species. Krulikovsky's figure (1890: 236, VIII, fig. g) does not allow identification; in fact Krulikovsky himself suspected that it was a hybrid between *M. phoebe* and *M. athalia*. Having later observed a ♂ *M. phoebe* coupling with a ♀ *M. arduinna* (Esper, [1783]), Krulikovsky (1897: 321), restated his suspicion that *tatara* was a

hybrid. It is noted that hybrids have been recorded between *M. ornata* and *M. phoebe* by Bálint and Ilonczai (2001: 217) in Hungary and by Russell et al. (2014: 140, figs 7–9) in Slovenia; since both species probably occur in this area to the west of the Urals in the Russian Federation, a hybrid origin remains a possibility.

Note 91. ***telona*** Fruhstorfer, 1907: 310: synonym of ***Melitaea ornata*** (but see below). The holotype and allotype were examined by Bernardi and de Lesse (1951: 140). This name was placed as a subspecies of *M. ornata* by Tshikolovets (2011: 499) and by Tshikolovets and Nekrutenko (2012: 295). This is the name used by a number of authors for what is now known to be *M. ornata*, including the first author (Russell 2008; Russell and Pateman 2011), prior to our present understanding of the range of *M. ornata*, which led to the recognition that *ornata* and *telona* were conspecific. Russell et al. (2007: 159, fig. 15) demonstrated that the larva of *telona* from its TL has a red-brown head; larvae of *ornata* from Volgograd region, Russia, are similarly coloured and also has a red-brown head (Russell and Kuznetsov 2012: figs 1–3), suggesting synonymy with *M. ornata*. However, recent molecular analysis by Tóth et al. (2014) apparently suggests that *telona* may represent a species distinct from *ornata*; only two samples of *telona* from Lebanon, the origin of the 'voucher specimen' used as an example of *telona* by Wahlberg and Zimmermann (2000) for their mtDNA sequencing, were included in their analysis. Until this is resolved, it is considered prudent to retain *telona* as a synonym of *M. ornata*. Rather confusingly, van Oorschot and Coutsis (2014: 63) considered *telona* a distinct species and placed *ornata* as a synonym of *M. phoebe*.

Note 92. ***totila*** Stauder, 1914: 373: synonym (provisional) of ***Melitaea ornata***. The first author visited Monte Cocuzzo, the TL, on a number of occasions but, in spite of the presence of a known host-plant (*Centaurea deusta* Ten.: Russell and Pateman 2011) only discovered one worn ♀ at *ca.* 1200 m, which unfortunately died prior to ovipositing. It appeared from its hindwing markings and spatulate antenna to be *M. ornata*. Also, a single ♂ was taken on Monte Mancuso, Calabria, some 24 km to the south, which from an examination of genitalia and external morphology, was almost certainly *M. ornata*. This form is therefore provisionally placed with *M. ornata*.

Note 93. ***tremulae*** Piller & Mitterpacher, 1783: 69, Taf. 4: figs 1 and 2: synonym (provisional) of **nominotypical *phoebe***. The TL of Croatia, from where there have been no substantiated reports of *M. ornata*, strongly suggests association with *phoebe phoebe*. Hesselbarth et al. (1995: 1028) synonymised this name with *M. phoebe phoebe*. Not mentioned by any more recent authors.

Note 94. ***tungana*** Seitz, 1909: 216: synonym (provisional) of **nominotypical *phoebe***. The specimens were described by Seitz (1909: 216) as very melanic but the specimens examined by Higgins (1941: 342) showed that this character was variable in the Sayan Mountains (the TL) and suggested that many of these specimens were close to *monilata* Verity (see Note 53) and other Alpine forms (see Higgins 1941: 334). The form *tungana* has a distribution in the eastern Palaearctic and outside the presently recorded distribution of *M. ornata*, the authors provisionally place *tungana* with *M. phoebe*. Overlooked by van Oorschot and Coutsis (2014).

Note 95. ***tungusa*** Herz, 1899: 240: synonym (provisional) of **nominotypical *phoebe***. A small form with obscure markings, in appearance somewhere between var. *caucasica* Staudinger (see Note 22) and *M. ornata* (see Note 2). Synonymised with *M. phoebe* by van Oorschot and Coutsis (2014: 60). Since it occurs in the eastern Palaearctic, it is synonymised with nominotypical *phoebe* until further information becomes available.

Note 96. ***tusca*** Verity, 1919: 183: synonym of ***phoebe occitanica***. Described by Verity (1909: 183) as a form with bright orange upperside ground colour and reduced black markings. Higgins (1941: 342) considered this to be a first (spring) brood form from central Italy, and was of the opinion that the names *emipauper* Verity, 1919, *pauper* Verity, 1919 and probably *autumnalis* Fruhstorfer, 1919 referred to the second or third (summer) broods of *tusca* (see Notes 31, 65 and 17, respectively). Placed here as a synonym of *phoebe occitanica* largely due to its geographical location in peninsular Italy. This name was overlooked by van Oorschot and Coutsis (2014).

Note 97. ***uclensis*** Melcón, 1910: 219: aberration of ***phoebe occitanica***. Described as an aberration of *occitanica* with the upperside black marginal semi-lunules separated from the black marginal line by red ground colour. Its origin in central Spain clearly places it with *occitanica*. Overlooked by van Oorschot and Coutsis (2014).

Note 98. ***ufensis*** Krulikovsky, 1902: 555 (footnote): synonym of ***Melitaea ornata***. A replacement name for *uralensis* Krulikovsky, 1897 (see Note 99); van Oorschot and Coutsis (2014: 60) incorrectly placed this as a synonym of *M. phoebe*.

Note 99. ***uralensis*** Krulikovsky, 1897: 3: name preoccupied by *Melitaea arduinna uralensis* Eversmann, 1844. Replaced with *ufensis* by Krulikovsky (1902: 555 footnote). Van Oorschot and Coutsis (2014: 60) incorrectly placed this as a synonym of *M. phoebe* (see Note 98).

Note 100. ***virgilia*** Fruhstorfer, 1917 (A. 2): 2: synonym of **nominotypical *phoebe***. Higgins (1941: 343) treated this as a large race with pale ground colour and black markings reduced, although he recognised that these features were not constant. The relatively larger than average size and its TL in the French Alps places this taxon with nominate *phoebe*, with which it was placed by van Oorschot and Coutsis (2014: 61). Holotype and 5 ♀♀ paratypes were examined by Bernardi and de Lesse (1951: 141).

Note 101. ***wagneri*** Wnukowsky, 1929: 222: replacement name for *alatauica* Wagner, 1913 (see Note 11).

Note 102 ***yagii*** Nire, 1917: 146, including fig. 2: ***Melitaea scotosia***.This taxon is confined to the eastern Palaearctic. The name *yagei* (sic) was synonymized with *M. scotosia* Butler, 1878 by Higgins (1941: 343). This synonymy and misspelling were followed by van Oorschot and Coutsis (2014: 67). Although originally placed with *M. phoebe*, it does not appear to be associated with any of the three taxa (*phoebe*, *ornata*, *punica*) dealt with in this paper.

Note 103. ***zagrosi*** Tóth & Varga, 2011: 265: synonym (provisional) of ***Melitaea ornata***. This name was raised as a distinct species based on male and female genitalia and underside wing markings. However, it would appear from Tshikolovets et al. (2014: 320, map) that the type locality of this form is within the distributional area of *abbas*, which they elevated to a subspecies of *Melitaea ornata*. Van Oorschot and Coutsis (2014: 64) discussed the status of *zagrosi* at some length, referring to the unreliability of wing markings, which has been demonstrated in *Melitaea* taxa by Jugovic and Koren (2014), and genitalia preparations when placed in covered slides creating distortion. They concluded that there was insufficient evidence to support the erection of a new taxon and classed it as '*status incertus*'. Tshikolovets et al. (2014: 320) synonymised it with *M. ornata abbas* (*i.e. ornata*) (see Note 7). The elevations at which these two forms occur (*zagrosi*, 300 m; *abbas*, 1500–2500 m) may be significant. Until additional evidence becomes available, it is provisionally placed with *M. ornata*.

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In Memoriam: Marc Meyer (1954–2015)

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Figure 1. Marc Meyer 2006 (photo: C. Harbusch).

Marc Theo Jean Meyer was born on November 29, 1954 in Luxembourg, and he died on February 28, 2015 in Merzig, Saarland, much too early, at the age of only 60 years. Nevertheless, he has left a remarkable legacy with almost 100 scientific publications and extensive entomological collections, as shall be pointed out in this obituary.

After attending primary and secondary schools in Luxembourg he received his high school diploma in 1974 and began his studies in biology and geography at the University of the Saarland. He was one of those exceptional students who was not motivated by the syllabuses of the subjects taught to him, as he had already acquired much of the knowledge involved. Even as a schoolboy he had published scientific contributions in "Entomologische Zeitschrift" and "Bulletin de la Société des Naturalistes Luxembourgeois" (1972, 1973). It is mentioned there that it was his father Jean Meyer who inspired his love of nature and who accompanied him on almost all of his early entomological excursions. Already as a pupil he had founded an entomological working group "Jeunesse Naturaliste du Luxembourg" in 1972, and he was twice prize-winner of the contest "Jugend forscht".

In his studies, apart from entomology, he was most interested in lectures on zoogeography. During excursions to France (Champagne and Provence) in 1976 and to the Pyrenees in 1979 he had to record the observed and collected Lepidoptera (Fig. 2). Figure 3 shows him reporting about Lepidoptera to members of the natural history societies Delattinia of the Saarland and to those of Luxembourg at the nature reserve Hammelsberg near Perl in 1981.

He finished his studies by taking the state examination for teaching in high schools in 1979. The topic of his treatise "Systematic and chorological investigations of the Rhopalocera-fauna of São

Figure 2. Marc as a student on a biogeographical excursion in 1976 (photo: H. Schreiber).

Sebastião", a south-Brazilian coastal island, was chosen by his supervisor Prof. Paul Müller, who had visited the island for herpetological studies in 1964, 1965, and 1967. Lepidoptera, collected by him for Prof. de Lattin, had not previously been evaluated. Marc Meyer had to prepare the material as a first step. He then identified the specimens very carefully as can be seen by the fact that he consulted well-known specialists of South American Lepidoptera (Keith Brown, Olaf Mielke, and Heinz Ebert) in cases where he was not certain. Altogether, 95 butterflies from the island of 335 square km were treated in detail with respect to their differences from the mainland populations.

At the same time the treatise laid the foundation for his lifelong interest in the biogeography of islands. In excursions to Madeira, to the Azores, and the Canaries and in publications (1991, 1993, 1995, 1997), with co-authors (1990, 1997, 1998), he later on became concerned with the Lepidoptera of the Macaronesian isles and collected extensive material from there. It was his intention to write a thesis in that field. However, the chances to do so were not only much limited by his professional duties but also by his obvious honourable awareness that he had not studied for a doctorate.

After the probationary period at the technical lyceums Michel-Lucius in Luxembourg and Mathias Adams in Pétange in 1981, he obtained and held the position of Curator for Entomology at the Museum for Natural History in Luxembourg until his retirement owing to illness after 28 years of service in 2013. Building reconstruction was carried out where his office had been during the time of his employment and a new building of the Museum was opened in 1996. Little space, however, existed for the collections in his charge in a compact installation within the museum itself. A larger part is out-housed to a warehouse in Kehlen near Capellen in SW Luxembourg and which had to be visited by him in his work. It was his main task to register the fauna of Luxembourg, especially the Lepidoptera. His work is documented by regular publications mainly from the working group for invertebrate research (1981, 1983, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993), partly together with co-authors (1979, 1984) – see below. His commitment in mapping European invertebrates can be seen from the publication "Atlas Provisoire des Insects du Grand-Duché de Luxembourg", published together with A. Pelles in 1981.

Being multilingual, Marc was the ideal person for the position of the General Secretary of the "European Invertebrate Survey" (EIS), a position he held for 12 years. The task made it necessary for him to travel regularly to other countries, e.g. to the European Parliament in Strasbourg. It involved

Figure 3. Marc demonstrating Lepidoptera at the nature reserve Hammelsberg near Perl in 1981 (photo: H. Schreiber).

furthermore the organization of congresses. He founded a cross-border working group of experts for Lepidoptera in 2001 and organized several "days of entomology of the Sar-Lor-Lux-Region".

He was a member of relevant professional societies such as SNL in Luxembourg and was responsible for the compilation of "Paiperlék" for many years. He was a member of the natural history society "Delattinia" of the Saarland, the "Société Entomologique" of Mulhouse and subscriber of "Oreina (Les Papillons du France)"; he was member of "SHILAP" in Spain and of "Societas Europaea Lepidopterologica" (SEL). He hosted the SEL Congress in Luxembourg together with the team of the Invertebrate section of the museum in 2011.

Marc was awarded the orders of "officier de l'ordre de mérite" and "officier de l'ordre Grand Ducal de la Couronne de Chéne" for his scientific work and his manifold engagement in organization by the State of Luxembourg.

Of his publications the revision of the European populations of *Lycaena helle* (1981–1982) has first to be mentioned. *Lycaena helle* (violet copper) is a glacial relict with many peculiarities. He had published repeatedly on this species (1980) and reported about it at the SEL Congress in Cambridge in 1982 (1985).

It is of great merit that with his co-editors Jan Habel and Thomas Schmitt a volume of 235 pages concerning this extremely endangered species was published by 2014. Nineteen contributions of authors from all of Europe deal with biogeography, ecology, and questions of conservation. The volume was published in English by Pensoft in Sofia (2014). It bears the title "Jewels in the Mist" since the violet copper can be found on wet meadows with *Polygonum bistorta*, which are certainly often enveloped in mist. It is amazing how he even found the time for any private life given the huge number of excursions to countries like Morocco, Australia, Ecuador, and Costa Rica in addition to the islands of Macaronesia. The voucher material collected from the Sar-Lor-Lux-region is stored in the Museum of Natural History in Luxembourg while exotic material and such from Macaronesia collected on private excursions has been transferred to "Delattinia" for further studies.

Marc married Dr. Christine Harbusch in 1999. They had become acquainted at the Natural History Museum of Luxembourg. They renovated and moved into a farmhouse in Perl-Kesslingen and shared it with several larger and smaller animals in the course of time. Marc accepted with tolerance his home turning more and more into a sort of charity hostel for animals without realizing that he himself would one day become an invalid because of illness.

We were able to celebrate with him his retirement from office in February 2013 and his 60th birthday, when he was already in a nursing home in Beckingen, in November 2014.

We feel grateful for his legacy and will keep Marc in great honour.

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Alucitidae (Lepidoptera), a new family for the Mongolian fauna

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Abstract. Lepidoptera family Alucitidae is reported for the first time for the fauna of Mongolia. *Alucita helena* Ustjuzhanin, 1993 was discovered in West Mongolia in the ranges of the Dzun-Dzhargalant-Khairkhan.

Introduction

The Lepidoptera fauna of Mongolia in general, and that of the Mongolian Altai in particular, is still poorly known. There are relatively detailed records available for the Papilionoidea (Tshikolovets et al. 2009; Yakovlev 2012), Sphingidae (Derzhavets 1977; Yakovlev et al. 2015), Zygaenidae (Efetov et al. 2012), Cossidae (Yakovlev 2004, 2015), Notodontidae (Schintlmeister 2008), *Eupithecia* (Geometridae) (Mironov and Galsworthy 2014), and Pterophoridae (Ustjuzhanin and Kovtunovich 2008). There were no detailed records for other lepidopteran taxa currently available.

Much new information was obtained on the distribution and systematics of Lepidoptera of Mongolia during expeditions by entomologists and botanists from the Altai State University (Barnaul, Russia) starting in 1999. These studies were concentrated in the territory of West Mongolia, primarily in the Mongolian Altai Mountains (aimaks Bayan-Ulegei, Khovd and Gobi-Altai). During the expedition of 2015 in the ranges of Dzun-Dzhargalant-Khairkhan, a large series of *Alucita helena* Ustjuzhanin, 1993 of the family Alucitidae (Lepidoptera) was collected. This species is a new family record for Mongolia. The "many-plumed moths" of the world include 216 species (van Nieukerken et al. 2011).

Material and methods

Adult Alucitidae were collected using a combination of a Philips–250 W lamp mounted above a fabric screen and battery-powered light traps using TL 8W/05 lamps. Chloroform was used as a killing agent. The collected material is deposited in the private collection of the first and second authors.

Results

Alucita helena Ustjuzhanin, 1993

Figs 1–5

Alucita helena Ustjuzhanin, 1993: 83. Type locality: Russia, Altai Republic, Ongudai District, village of Inya.

Material examined. 112 ex. from Western Mongolia, Khovd Aimak, Dzun-Dzhargalant-Khairkhan, Ar-Shatyn-Gol River, N47º44' / E92º27', 2100 m, 26.vi.2015., leg. R. Yakovlev.

Notes. In addition to the type locality, specimens of *A. helena* were examined from the Republic of Altai (Ongudai District, near B. Yaloman village; Kosh-Agach District, 15 km up from Beltir village, Chagan River; Kosh-Agach District, 15 km E Kokorya; Ust-Kan District, Shiverta River Valley, 5 km SW of Beshozek village; Ulagan District, 10 km NW of Aktash village, Chuya road) (Fig. 4). Probably larvae of this species are associated with *Lonicera* (Caprifoliaceae) (Zagulajev 1986). There are two generations with adults of the first flying in June and those of the second in August. The adults of the second generation are larger and darker than those of the first.

Figure 1. *Alucita helena* Ustjuzhanin, 1993. Adult male, Mongolia.

Figure 2. Male genitalia of *Alucita helena*.

Figure 3. Female genitalia of *Alucita helena*.

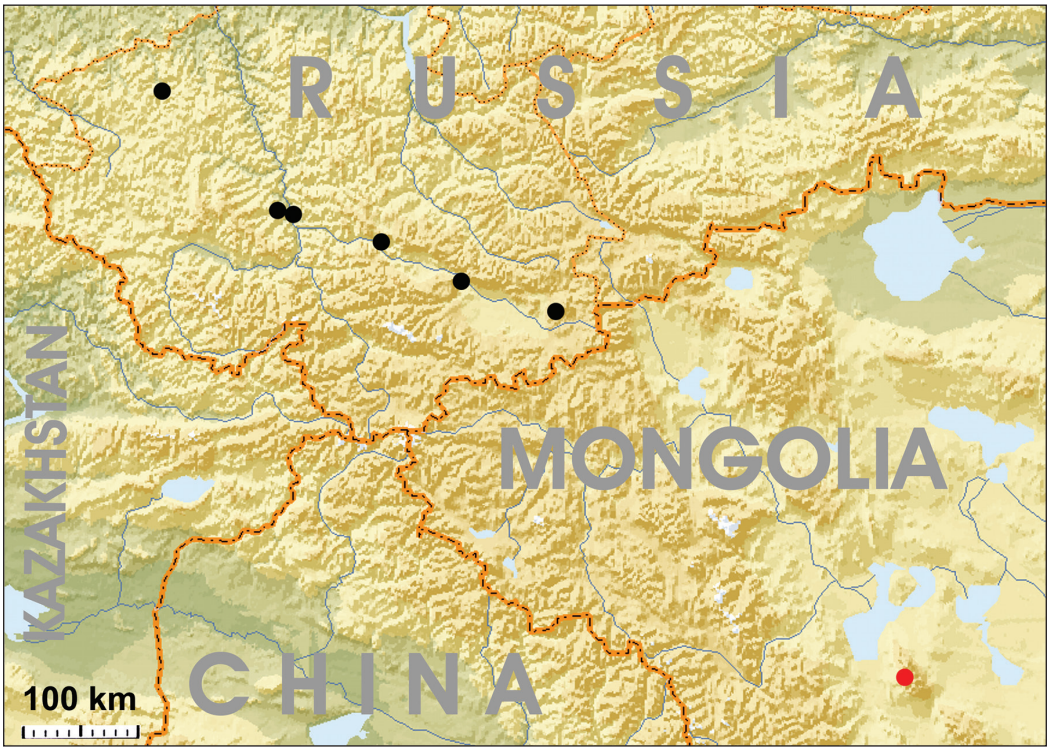

Figure 4. Distribution of *Alucita helena*.

Figure 5. Biotope at collecting locality of *Alucita helena* in Mongolia.

Specimens were collected in Mongolia at Khar Us Nuur National Park, Dzhargalant-Khairkhan Ridge (Fig. 5). The 850 000 ha park is located 45 km southeast of the center of Khovd Aimak. In the central portion of the park there are lakes Khar Us, Khar, and Durgun. The park includes the Chono Kharaih River and the eastern spurs of Dzhargalant-Khairkhan.

According to the new botanical-geographical zonation scheme for Mongolia (Kamelin 2010), the Dzhargalant-Khairkhan Ridge is located in the boreal region, steppe subregion of the Tuva-Mongolian Province, Khovd District. The eastern macroslope of the ridge borders the Lacustrine-Basin District and in the South the Shargyn Gobi exclave of the Gobi Subregion. The predominant type of the ridge vegetation is steppe with dry and desert areas reaching 3000 m.a.s.l. The extent of desert plant species in this steppe is not great, in contrast to the Shargyn Gobi exclave steppe where they predominate. In the foothills and middle mountains of Dzhargalant-Khairkhan, the desert steppe is widespread. Steppe plants occupy plains and slopes of the mountains at the altitudes of 1700 (2100)−2250 (2300) m.a.s.l. (Karamysheva et al. 1984). A petrophyte vegetation has developed on the steep slopes of the ridge while a vegetation of rocky substrates occurs on the ravine bottoms and in valleys (Pyak 2006). Poplar forests of *Populus laurifolia* Ledeb. (Salicaceae) and the shrub *Lonicera microphylla* Willd. Ex. Schult. (Caprifoliaceae) grow on rocky substrates along the river valleys. *Salix ledebouriana* Trautv. (Salicaceae) and *Rhodiola krylovii* A.V. Polozii & N.V. Revyakina (Crassulaceae) occur in narrow gorges. The highland ridge belt is occupied by the kobresia and kobresia-sedge alpine heathlands and the cryophilic meadow-steppe where *Papaver pseudotenellum* Grubov (Papaveraceae), *Pulsatilla bungeana* C. A. Mey ex. Ledeb. (Ranunculaceae) and *Pedicularis achilleifolia* Stephan ex. Willd. (Orobanchaceae) occur. During the field work in the National Park over 100 Lepidoptera species were collected. The material is being studied and results will be published later.

Conclusion

The composition of the Lepidoptera fauna of the Mongolian Altai appears rich and the discovery of a new family in this region clearly indicates that other interesting taxa will be discovered. Also of interest is the relative disjunction of the Mongolian population of *A. helena* from other known localities for the species (Fig. 4).

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In Memoriam: Pamela Gilbert (1932–2015)

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Pam Gilbert pictured in the Reading Room of the General Library, Natural History Museum, May 2008 – the "gentle smile … sparkling eyes and … challenging look" still very much in evidence. Tools of the trade include a large lens, and one of those seemingly unique NHM tear-off paper 'book-boards'. [Photograph: Lorraine Portch]

Best wishes for the future. You deserve it for all you have put into life.
Eric Classey, on the occasion of Pam Gilbert's retirement, 1992

Early years

Pamela Gilbert was born at Queen Charlotte's Maternity Hospital, Hammersmith, London, on 14th December 1932, the daughter of Albert Edward Gilbert and Ellen Isabella Gilbert (née Clark). At this time the family were living at 121 Cromwell Road SW7 – only a few hundred metres west of the Natural History Museum, where she later spent all her working life. Today 121 Cromwell Rd looks an imposing address, given that her father is described on the birth certificate as a "general labourer". Pam later recalled her father as a taxi driver; her mother, who died at a relatively young age, had employment as a cook and housekeeper.

By the outbreak of WWII the family were living in the Ladbroke Grove area, near Paddington railway station. They survived the blitz of 1940 but, with the continuing bombing raids, like so many other London children, the following year Pam was 'evacuated' – in her case to Nailsworth, Gloucestershire, a country town about 40 km NE of Bristol. Many evacuees endured a miserable existence, away from family and friends, but Pam remembered this as a happy time – she was placed in the care of a kind family, other children from her part of London were around, she attended a good junior school, and it was her first experience of country living. But by 1944 there was concern regarding her secondary education and she was moved, with many other evacuees, to a special school in the Oxford area.

By the end of the war Pam had rejoined her family, who had moved at some point to the Bounds Green area of North London. Pam completed her secondary education at Trinity County Grammar School, Wood Green, gaining School Certificate qualifications in English (Language and Literature), French, Mathematics, Biology, History, Geography, Shorthand and Typewriting, passing with distinction in French, Biology and Geography, and then gained, at Higher Level, a qualification in Botany.

From part of a photograph available on the Trinity Old Scholars Association website (http://tosa.homestead.com/19496thFormL.html) showing the Trinity School 6th form for 1949–50. Pam, not identified on the website legend, is centre, sitting to the left of a girl identified as Miss Yvette Borrell, and to the right of an unidentified fellow pupil. [Photograph: TOSA, permission applied for]

Entomology at the Natural History Museum

Noting her aptitude for biology, a school careers adviser suggested she try for a post at the Natural History Museum in South Kensington. Apparently, Pam had never heard of the place! But thus encouraged, she applied to become an "Assistant (Scientific)" at what was then officially known as the British Museum (Natural History). So it came to pass that on 1st October 1951, eleven weeks before her 19th birthday, Pam Gilbert started work in the Setting Room – a service unit for the Museum's Department of Entomology that also acted as a training section for new assistants. The Setting Room at that time was managed by S.J. ('Dick') Turpin, also responsible for discipline(!) amongst the junior staff. Duties included learning how to prepare specimens for the collections, slide making, printing labels, looking after and administering departmental stores, packing parcels of insects for the post, and 'Saturday Duty' – a rota requiring two assistants each Saturday to run the Entomology Department enquiry desk, and deliver internal mail throughout the museum as a whole.

New staff spent months, sometimes years in the Setting Room before, typically, being allocated to one of the several taxon-based sections into which the department was divided. In 1954 Pam was assigned to the Diptera Section which, at that time, notably included Paul Freeman, Harold Oldroyd, Peter Mattingly and Ralph Coe but, for various reasons, she was not very happy there. In the following year she was offered the chance of a transfer to one of the Museum's earth science libraries, but declined due to her lack of relevant background. But Pam's direct association with the dipterists was anyway short-lived, as she successfully transferred to the Entomology Library in 1956 "at her own request" (Freeman, memorandum, 9th June 1969). At that time the departmental libraries of the Museum were still under the direct control of the Keepers, the heads of the scientific departments – the Keeper of Entomology in 1956 being W.E. China, successor to the long-serving N.D. Riley.

The Entomology Library

The Department of Entomology (1913–2012) did not take responsibility for the purchase and control of purely entomological publications and library material until 1937. By this time Clarence ('Charlie') Wood was in charge of the Entomology Library, with Bernard Clifton a part-time attendant. At the outbreak of WWII the library was dispersed to How Caple Court, near Ross-on-Wye, and Wray Castle, Ambleside.

In 1946 Bernard Clifton returned from war service and, due to Wood's ill health, gradually took over, by 1949 effectively becoming the Entomology librarian. In February 1952, on final completion of the long delayed Entomology Building (only about half of it had been completed before WWII), the main part of the insect library was relocated on the third floor. Pam Gilbert was appointed Assistant Librarian on 1st October 1956, as the second member of staff, replacing Wood on his retirement.

At the time of her first employment at the Museum, Pam was still living near Bounds Green, but she later moved to the Paddington area, and thus much closer to her work. To become better fitted for her new role, Pam took the First Professional Examination of the Library Association (now 'CILIP'), and then attended their course for Associate status – but did not sit the ALA exam because of a change to full-time attendance as a requirement. Her LA studies were carried out, at least in part, at the North Western Polytechnic in Kentish Town – historically, part of what is now London Metropolitan University. In addition to French, Pam had some German, Russian and Turkish.

In 1974, on Clifton's retirement, Pam became the entomology Librarian. By this time she had been promoted, first to the rank of Senior Scientific Assistant (1960), then Experimental Officer (1st December 1970). Pam remained as head of the Entomology Library until 1991, when she became full-time Deputy Head of the Museum's Department of Library Services, with the grade of Principal Scientific Officer.

By the late 1960s the Entomology Library, which occupied about a quarter of a floor of the Entomology building, was almost literally bursting at the seams. Fortunately there was a plan. By 1972 the Museum's new ornithology building at Tring had been completed, and the very substantial NHM bird collection which at that time occupied much of the three lower floors of Entomology was relocated. In return, up from Tring came the Rothschild Lepidoptera and various other insect collections – but there was still a net gain of space at South Kensington. The adjacent Diptera collections and staff were moved from the 3rd to the 1st floor, allowing the library literally to double in extent. Into this space were packed dozens of new book cases.

So close to his own retirement, Bernard Clifton showed little interest in this development and, perhaps somewhat ungallantly, left all the arrangements to Pam. With little other assistance, Pam set about reorganising the entire library, moving nearly all of the many tons of books herself. A positive outcome was that, as a result, Pam had a wonderful grasp of where all the various volumes and serials were to be found, as she had first allocated all of the spaces, and then moved everything onto the shelves herself.

During her tenure Pam demonstrated not only first-rate librarianship but also, because of her earlier training in entomology alongside professional taxonomists, an excellent understanding of the needs and issues affecting systematic entomology, as it was practised during that period. This, plus her sunny disposition and remarkable patience, meant that she was soon much in demand from staff and visitors alike, gaining a reputation amongst entomologists as "an entomologists' librarian". Pam's special ability was wonderfully recalled at the time of her retirement by the late Vic Eastop who, lamenting, wrote "who will now tell me the author and date of "the small brown (before it was rebound) book with a picture of an aphid gall near the back, that before the library was extended, used to be on the second or third shelf down, in either the fourth or fifth row of book cases to the left of the door as you went in (or perhaps it was as you came out)"?" Pam really could make sense of such enquiries!

Pam also took a great interest in preserving manuscripts and other historical material, difficult "stuff" that entomologists seem able to generate in profusion. Under her guidance and leadership, the Entomology Library was one of the happier and more effective 'engine rooms' of the Museum. It was also a social connection, especially for smokers. Smoking was necessarily strictly forbidden throughout the entomology building, but 'les fumeurs' were allowed to indulge on the roof of the adjacent zoology 'Spirit Building', reached from a door very close to the library. Pam, a moderate smoker herself, often joined these alfresco gatherings, where many things, including museum gossip of course, were discussed.

The Department of Library Services

In 1975 all the Museum's subject libraries were brought together administratively into the Department of Library Services, headed by Librarian Maldwyn Jones ('Mal') Rowlands (1918–1995). Pam also served under the two subsequent head librarians, A.P. ('Tony') Harvey, and then Rex E.R. Banks. It was during Rex's tenure (1988–1996) that Pam was promoted, initially part-time, to Deputy Librarian. Pam's working relationship with Rex evolved into a lasting friendship. Well into retirement they used to meet at least once a year for a pub lunch in Westerham, Kent, a small town half

way between their respective homes – and this only ceased as Pam's lack of mobility due to arthritis worsened to the point where walking even a short distance had become just too painful to bear.

A key feature of the period when Pam was Deputy was the introduction of a large scale photocopying service that benefited an international research community. Before the era of the internet and electronic scanning, the only means of making available the content of antiquarian books and difficult to locate scientific journals and books to researchers who could not travel to specialist libraries, was to produce photocopies, sent by post. The Natural History Museum library during the 1980s and early 90s processed many thousands of such photocopy requests, with individual orders often listing hundreds of references. This major logistical challenge to library staff, checking and locating often obscure references, collating large orders and posting parcels to all parts of the world, was calmly managed by Pam. Many natural history books and papers published during this time fully acknowledge the important contribution of this photocopy service. In the late 1980s Pam was also instrumental in recognising that the library would need to adopt computer technology and, together with Rex Banks, they organised the scanning and transcription of hundreds of thousands of library catalogue cards into the first library database. This provided the foundation of the current on-line library catalogue which now benefits thousands of users every day via the internet.

Although the Natural History Museum, its libraries and their users were the core of Pam's professional life, it would be wrong to give the impression that her work was limited entirely to South Kensington. At various times Pam acted as Secretary to the ASLIB Biological Group, attended ASLIB conferences, and was a member of the Standing Conference of National and University Libraries (now the *Society of College, National and University Libraries*). Her involvement with various joint NHM, Hill House and Nokomis facsimile projects took her to Singapore and Australia, and she also visited Japan. Even so, there is no doubt that her focus was always very much in the Cromwell Road.

Group photograph, NHM Department of Library Services staff, *circa* 1980, taken on the steps of the Main Hall of the 1881 Waterhouse Building. In the centre of the front row, immediately to Pam's resplendent left is Tony Harvey (glasses), then Mal Rowlands (tallest), and Rex Banks (chequered tie). Immediately behind Pam, just slightly to her left, is Cindy Cogan. [Photograph: NHM London]

Publications

A group of entomologists with whom Pam developed particular rapport were members of the European lepidopterological union, Societas Europaea Lepidopterologica (SEL), a new society founded in Bonn in 1977. Starting the following year, Pam made 13 major contributions to SEL journals. These were annual bibliographical lists (sometimes with supplements) of publications on Lepidoptera that had appeared in Europe, or were relevant to the European fauna. In all cases Pam acted as editor, but also as a contributor. All were published under the rubric 'Bibliography of Palaearctic Lepidoptera', but in four different "series":

The first two (1978, 1979), for which Pam formally appeared as author, were published as papers in the Society's main journal, *Nota Lepidopterologica*. But from 1982, when the third part appeared, covering 1979–80, these bibliographies became the subject of a separate, more cheaply produced SEL serial – which had its formal title changed twice during Pam's involvement. In all these subsequent publications Pam was formally both Editor and one of the collective contributors. The seven annual parts published 1982–1988 appeared as *Bibliographia Europaea Lepidopterologica*, part 10 (in 1989) as *Bibliographica Palaearctica Lepidopterologica*, and the last three parts (1990–1992) as the eponymous *Bibliography of Palaearctic Lepidoptera*. These 13 bibliographic contributions under Pam's editorship amounted in total to 792 pages, listing approximately 10,000 references, and undoubtedly did much to foster and strengthen the nascent society. On reaching retirement, Pam stepped down as editor, and the series then underwent another metamorphosis, to become the *Index of Publications on European Lepidoptera* (which first appeared in 1995, for the years 1991–1992, numbered as part 14). Harald Schreiber has given a historical account of Pam's important contribution to the Society (*Societas Europaea Lepidopterologica (SEL) News – Nachrichten – Nouvelles* (43): pp.10,15,16, 2007). Pam was elected an Honorary Member of SEL in 1988.

Pam also co-authored a valuable source book for general entomology (Gilbert and Hamilton 1983, updated 1990), and a key work on manuscripts held in the library of the Natural History Museum London (Harvey, Gilbert and Martin 1996). However, remarkably, she is best known for her very first publication – *A Compendium of the Biographical Literature on Deceased Entomologists* (1978) and its continuation 30 years later, the companion volume *A Source Book for Biographical Literature on Entomologists* (2007).

What was initially "The biographical index of entomologists" was the subject of a publication proposal dated 29th June 1973 by David Ragge, then Deputy Keeper of Entomology at the NHM, at which time the book was expected to have 6500 entries and 14000 references. To commence your publication career at over 40 years of age with something so ambitious is surely most unusual – and fraught with academic danger. Such works, almost all 'data' and very little interpretation, are always subject to errors and omissions – and when first published, the work received various criticisms. Some were speculative. Thus Harold Oldroyd (*Journal of Natural History* 13(1): 122, 1979) wondered why two dipterists of interest to him, J.M.R. Surcouf and Gertrude Ricardo, were missing. Pam's 2007 volume has entries for both – but these were not written until many years after the original *Compendium* appeared! John Clark states that the *Source Book* includes over 8000 entomologists and 21,500 citations (*Archives of Natural History* 37: 181, 2010). The sheer scale of this undertaking is reflected in a personal letter to Pam from Michael Ruijsenaars of Backhuys Publishers, dated 27th November 2007: "With every new book we publish, I always have a sense of gladness … but … with your work, this feeling is considerably more poignant, in the knowledge of the enormous amount of work and time that you have lavished on this production."

A genuine and rather amusing source of error in the *Compendium* concerned the fact that, as Klaus Sattler recalls, "Pam did not [then] appreciate that Eastern European countries in particular often published eulogies to commemorate birthdays or retirements. Pam might have noticed that a surprising number of entomologists had 'died' on their 60th birthday … I myself knew four people who survived their 'death' by a good many years!" But in the total scheme of things such errors are mere peccadilloes. That these works remain so tremendously useful and so widely used, as Klaus observes, is testimony to their author's remarkable vision, tenacity and ability.

PAM, HAT, OBE, HM (1992: photographer unknown)

Retirement

Pam officially retired from the museum on 13th December 1992. Earlier that year she had been honoured in the Queen's Birthday Honours list with an OBE (Officer of the Most Excellent Order of the British Empire), announced in the *London Gazette* on 12th June. Some years earlier Pam had moved south of the river to the Croydon area, good for commuting by rail. But after retirement she relocated even further south, to Warlingham, a leafy, outer London suburb set amongst the North Downs. By this time she had learned to drive, and would set out in her little car soon after 5 am to make the 25 km journey to South Kensington. Arriving by 6.30 she became very well-known to museum security staff. This remarkable strategy for someone supposedly in retirement enabled her to produce several more publications, some of them very substantial (see Bibliography).

Due to her increasing mobility problems, as the years passed, Pam's visits to Cromwell Road became less frequent. Her general health started to deteriorate, but she was still absolutely determined to pursue her bibliographical endeavours. In the end only the car made this possible, reducing painful walking to an absolute minimum. Although her last recorded publication appeared in 2012, she continued working to the very end, most notably transcribing the correspondence of the 18th century silversmith and entomologist Dru Drury. Pam died shortly before her 83rd birthday, on 8th December 2015, at Redhill, Surrey.

Retirement: Pam at home [Photograph: Noleen Glavish]

Memories and Reflections

At the time of her retirement, Laurence Mound, then Keeper of Entomology, wrote of Pam: "To me you have always epitomised the Natural History Museum – outstanding scholarship, worn lightly and with unfailing courtesy and humour, but with clarity of purpose and determination. Sharing your career has given me much inspiration, enlightenment – and sheer pleasure". Memoranda in the Museum's archives from the period of her first establishment as Entomology Librarian, notably by Turpin, Clifton, China, Riley and Freeman, reveal that Pam was always regarded in the same positive light by her colleagues.

Thus, in support of her promotion from Senior Scientific Assistant to Experimental Officer (for an insight into the structure of UK civil service science at that period, see *Science* 124(3222): 567–571, 1956), Paul Freeman wrote to the Museum Director on 9th June 1969: "Miss Gilbert is an educated, intelligent woman, well up to E.O. standard, conscientious in her work and has been a great asset to the smooth running of the Library … She is particularly noted for the helpful way in which she will go to endless trouble to assist enquirers, regardless of their rank and has shown considerable skill at times in handling what could be difficult cases". Proof that Pam never lost this skill comes from a recent email by one of those many "enquirers", the extraordinary Australian lepidopterist and publisher Bernard d'Abrera:

"Thank you for the most important item of news regarding the passing of our great mutual colleague, Pamela Gilbert OBE. What a magnificent person she was, both professionally and socially. I never once saw her lose her temper or be ungracious to anyone. I've seen her provoked

beyond human endurance, and every time there was this gentle smile, followed by that famous deep baritone chuckle. The sparkling eyes and the challenging look which made the offender feel gently but firmly corrected – I was one of them on several occasions when I pushed my luck a little too far. She never once denied me any assistance that I might have sought, and was always on hand to guide and help through several of my seemingly outrageous projects." [Bernard d'Abrera, in litt., 2016.]

And it was through the d'Abrera connection that Pam first met Noleen Glavish, when she travelled to Melbourne for the launch of the Hill House Banks/Cook Portfolio (Gilbert, ed., 1990). As Noleen recalls, "Pam and I became instant friends when we met. She stayed at my house during that visit. I later visited London three times during the following four years and stayed with Pam – and we dug out the Bauer Collection. But as time went on my relationship with Pam was not so much business but a friendship, and I always visited her and often stayed at her house after Nokomis published the Ferdinand Bauer Collection prints in 1994. We used to sit for hours far into the night talking about all manner of things. If I hadn't met Pam I wouldn't be publishing today – she was the driving force that got me to publish the Bauer Collection and it moved on from there. So I owe her a great deal."

Cindy Cogan, who worked in the Entomology Library at the end of the 1960s, recalls Pam thus: "I had been working on the Coleoptera Section for three years and I had to go to the Library to sort out a map reference. Pam passed by and just asked if I had found what I was looking for and we started to chat. I commented that I was a bit fed up with my current job and later, due to Pam's recommendation, I was offered a post in the Entomology Library. She was my boss for two years, and taught me everything I needed to know to enable me to survive the everyday functioning of a specialist library. She created a happy atmosphere and we worked together as a team. Pam was very generous and at Christmas she would take me out for a meal. She had a great sense of humour and we were always laughing, and she could always see the funny side of the absurd. During the dreaded 'book checks' she was often to be seen up the ladders, sharing all the work, and never made me feel that I was only her assistant. Whenever I came back from leave, I found that most of my everyday work had been kept up-to-date and I was not greeted by a desk piled so high that I didn't know where to start. Pam was also a great cook, and when we organised leaving parties it was always great fun, as she made the best sausage rolls I've ever tasted! I'm so glad that I knew Pam and shared part of my life with her." Cakes were also a speciality – so much so that Krystyna Plater recently referred to these works of culinary art as "Pamtastic!"

Indeed, Pam Gilbert was a truly fantastic colleague, one of the very best, and her passing is mourned not only by numerous present and previous museum staff, but literally thousands of visitors to the museum who had need, reason or desire to access the Museum's entomological library, or better understand the literature of natural history.

Acknowledgements

The authors wish to thank Bernard d'Abrera, Paulene Green, and Trinity Old Scholars Association, together with several colleagues and former colleagues – including Harriet Campbell Longley, Sue Chambers, Richard Fortey, Goulven Keineg, Krystyna Plater, Adrian Pont and Gerry Tremewan – for their encouragement, help and information.

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A new species of the genus *Spiniphallellus* Bidzilya & Karsholt, 2008 (Lepidoptera, Gelechiidae, Anomologini)

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Abstract. *Spiniphallellus chrysotosella* **sp. n.** (Gelechiidae: Anomologini) is described. The species is recorded from Bulgaria, Georgia, and Turkey. All three localities of *S. chrysotosella* are rather similar dry rocky slopes where *Jasminum fruticans* L., 1753 (Oleaceae) is a dominant shrub. It is also expected to be the host plant of the new species.

Introduction

The genus *Spiniphallellus* was described and its members diagnosed by Bidzilya and Karsholt (2008) and it was placed in Anomologinae, one of the subfamilies of Gelechiidae. The genus was established for three species collected from mountainous and desert areas of Palaearctic Asia: *S. desertus* Bidzilya & Karsholt, 2008 (Uzbekistan, Turkmenistan, Kazakhstan), *S. stonisi* Bidzilya & Karsholt, 2008 (Kazakhstan), and *S. fuscescens* Bidzilya & Karsholt, 2008 (Turkey). Later on, Šumpich and Skyva (2012) reported *S. desertus* from European Russia. Here a new species of the genus, viz. *S. chrysotosella* sp. n. is described. All these species have specific structures of the genital organs which are typical for the Anomologinae, such as a reduced gnathos, a relatively short valva closely connected to the tegumen, a short tegumen and a well-developed transtilla lobe (Piskunov 1975: 857; Povolný 1979: 44). The new species was recorded for the first time with one specimen from Turkey, Anatolia 01.v.1996 during a sunny day around 10 a.m. It was caught by netting *Jasminum fruticans* L., 1753 (Oleaceae) vegatation on a small dry, rocky hill area. This specimen remained undetermined for several years until three additional specimens were found from Caucasus (Georgia, Gremi) 23–25.v.2011 (Fig. 4). The habitat was again a dry rocky slope with plenty of *Jasminum fruticans*. The specimens were found resting on the leaves of *Jasminum* around 10 a.m. on a bright warm sunny day.

At the end of April, 2013, two additional specimens were found on *Jasminum fruticans* vegetation on the Rupite volcanic hill area near the town of Petrich in SW Bulgaria, Blagoevgrad district. The weather was unusually hot, over 30 degrees Celsius still at dusk. The specimens were attracted by artificial light during the first dark hours.

Zdenko Tokár proposed that the specimens should belong to the genus *Spiniphallellus* and the study of the known species of the genus justified the description of the new species, here named as *Spiniphallellus chrysotosella* sp. n.

Spiniphallellus chrysotosella sp. n.

http://zoobank.org/30102FE9-4C78-4DB7-87CC-6608F85966BC

Material. Holotype: ♂, **Bulgaria** SW, Struma River valley, Rupite, 41.462°N; 23.256°E, 30.iv.2013. J. Junnilainen leg & coll.: GPJJ201578 and red label "HOLOTYPE of *Spiniphallellus chrysotosella* Junnilainen". – Paratypes: 1 ♂, same locality and data as holotype with green label DNA sample 24244 Lepid Phyl.; 3 ♂, **Georgia** Gremi 42.002°N; 45.657°E, 23–25.v.2011 J. Junnilainen leg., Coll. J. Junnilainen. 1 ♂, **Turkey**, Anatolia, Manavgat, 36.788°N; 31.416°E, 01.v.1996 K. Nupponen & J. Junnilainen leg., Coll. J. Junnilainen. Gen Prep No.7126 Bo Wikström. All paratypes with red label "PARATYPE of *Spiniphallellus chrysotosella* Junnilainen".

Description. Adult (Fig. 1). Wingspan 9–9.5 mm. Labial palp brown with golden shine. Antenna brown, slightly serrate. Head, tegula, and thorax dark brown with glossy golden and purple hue.

Forewing brown with golden shine, with five shiny golden spots: three on the costa, one at 1/5 length of wing from base extending to fold, second at middle of costa, and third 2/3 from base; two spots in fold: one at 1/3 wing length from base and second at 3/5 from base. Hindwing fuscous. Abdomen and legs brown somewhat shiny golden.

Male genitalia (Figs 2, 3). Sternite VIII broad sub-rectangular, laterally rounded, with broad anterior projections on both sides, posterior margin broadly rounded with weak medial indentation. Tegumen relatively short with V-shaped anterior margin; uncus formed as almost sub-rectangular plate, except with posterior margin broadly extended medially, latero-medially with two strong setae and with 6–8 short and thinner setae; valva twice as long as tegumen, elongate, apical half

Figure 1. Adult of *S. chrysotosella* sp. n. (Paratype).

Figures 2–3. Male genitalia of *S. chrysotosella* sp. n. **2** Unrolled male genitalia. **3** Phallus.

Figure 4. Habitat of *S. chrysotosella* in Georgia, Gremi.

strongly hirsute, apex sharp, weakly pointed inwards; transtilla lobe relatively long, digitate, apically with some fine setae; posterior margin of vinculum medially with broad rounded indentation, laterally formed as sub-triangular plate, distally covered with fine setae; saccus broad, rounded; basal half of phallus almost round, distal part relatively slender, tapered apically; ankylosed by strongly sclerotized and tightly attached anellus.

Diagnosis. Externally the new species is characterized by its forewing with gold shiny markings, which are absent in other close relatives. The species differs from *S. fuscescens* Bidzilya & Karsholt, 2008 by its longer and slenderer valva, longer transtilla lobe and by the form of its vinculum; from *S. stonisi* it differs by its broader uncus, slenderer valva and by distinctive transtilla lobes, lacking in *S. stonisi*; and from *S. desertus* it differs by its slenderer valva, narrower shape of the transtilla, and more rounded saccus.

Female genitalia. Unknown.

Distribution. Bulgaria, Georgia, and Turkey.

Biology. Early stages are still unknown although *Jasminum fruticans* seems to be the most probable host plant. The imago is mostly day active. Flight period begins at the end of April or beginning of May. *S. chrysotosella* has probably been overlooked due to its small size and because it is apparently diurnal and might not be usually attracted to lights.

Etymology. The species name is derived from its golden shiny forewing markings, which are absent from other related taxa.

Remarks. *Spiniphallellus* was originally named based on the characteristic thorn or spine laterally in the medial part of the phallus. This process, however, is actually a strongly sclerotized part of the anellus, tightly fused to the phallus. The phallus is very difficult to remove during dissection without breaking the juxta-anellus complex.

The DNA barcode (sample ID MM24244) shows a very clear difference to all other moths in BOLD (www.barcodinglife.org). The nearest species is *Diasemia grammalis* Doubleday, 1848, which is an exotic Crambiinae moth differing by 8.16%. This barcode difference is so large that its placement is not considered meaningful. No other species of *Spiniphallellus* has been barcoded so far.

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I want to thank Lauri Kaila and Bo Wikström (Finland) for their valuable comments and grammatical corrections of the manuscript. Marko Mutanen (Finland) gave invaluable help with arranging the barcoding of the specimens. Zdenko Tokár (Slovakia) and Ole Karsholt (Denmark) provided important taxonomical information. Boyan Zlatkov (Bulgaria) helped with fieldwork and upgraded my knowledge of Bulgarian plants. Kimmo Silvonen and Bo Wikström (Finland) helped with the processing of the photographs. I also thank Kari Nupponen (Finland), Urmas Jürivete (Estonia), and Timo Ranki (Luxembourg) for their delightful company during fieldwork.

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Records of host ant use of *Phengaris* Doherty, 1891 (Lepidoptera, Lycaenidae) in the Czech Republic

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Abstract. The specificity of the specialisation of *Phengaris* Doherty, 1891 caterpillars to their host ants is still not fully understood. In this report, we summarize all available records of *Phengaris* in ant nests from the Czech Republic. *P. alcon* (Denis & Schiffermüller, 1775) was found exclusively in nests of *Myrmica scabrinodis* Nylander, 1846 at four sites, and one *P. nausithous* (Bergsträsser, 1779) caterpillar was found in a nest of *M. scabrinodis*. According to published records, *P. nausithous* may use *M. scabrinodis* at the edges of its range but should be adapted exclusively to *M. rubra* (Linnaeus, 1758) in the centre of its range. No records of *P. arion* (Linnaeus, 1758), *P. teleius* (Bergsträsser, 1779) and *P. alcon* populations feeding on *Gentiana cruciata* (Gentianaceae) ("*P. rebeli*") are available from the Czech Republic.

Introduction

Phengaris Doherty, 1891 (=*Maculinea* van Eecke, 1915) butterflies are among the most studied insects in Europe due to both their vulnerability and unique myrmecophilous life habits (Settele et al. 2005). Females lay eggs on the flowers of species-specific host plants, and hatched caterpillars feed on unripe seeds inside the flowers. After the first three instars, caterpillars leave their host plants and fall to the ground, where they are immediately adopted by ants of the genus *Myrmica* Latreille, 1804. Then, caterpillars feed on ant brood or mimic ant larvae and are fed directly by ant workers. They overwinter once or twice inside ant nests before they pupate (Chapman 1916; Settele et al. 2005).

The level of *Phengaris* specialisation on host ant species has been much discussed during the past few years. According to previous thinking, each species (or population) of *Phengaris* should be specialised to one species of *Myrmica* as their "primary host" and possibly one or several more species as "secondary host" ants (Thomas et al. 1989; Settele et al. 2005). The survival of caterpillars should be much higher in the nests of primary hosts than in the nests of secondary hosts. Caterpillars may be adopted by many ant species, but they die in nests of non-host ants. As more records of caterpillars in *Myrmica* nests have appeared, however, the intimacy of the *Phengaris* specialisation has become questioned (Pech et al. 2007). Today, the level of specialisation and character of the *Phengaris*-*Myrmica* host system is still not completely understood (Filz and Schmitt 2015) and new data are needed for future analyses.

Most *Phengaris* host specificity data were obtained in central and eastern Europe, especially in Poland and Hungary (Stankiewicz et al. 2005; Tartally et al. 2008; Tartally and Varga 2008; Witek et al. 2008; Sielezniew and Dziekańska 2009; Sielezniew and Stankiewicz-Fiedurek 2009). The

use of this information is quite problematic for *Phengaris* populations in other parts of Europe, because the *Phengaris* host specificity shows geographical variability, at least in some cases (Als et al. 2002; Stankiewicz et al. 2005). For example, *M. scabrinodis* Nylander, 1846 is the most common host of *P. alcon* (Denis & Schiffermüller, 1775) in central Europe, but not used in development of caterpillars at all in Denmark (Als et al. 2002).

The area of the Czech Republic is very interesting from a biogeographical point of view as a result of quarternary history. The ranges of many closely related species from different taxa (originating from a common ancestor in refugees of southern Europe during the last glacial) meet in or close to the Czech Republic, e.g. snails (Horsák and Novák 2005), slow worms (Gvoždík et al. 2010), hedgehogs (Bolfíková and Hulva 2012), as well as ants (Seifert 1995; Schlick-Steiner et al. 2006) and butterflies (Konvička et al. 2008). Knowledge of the host specificity of *Phengaris* blues in the Czech Republic (as well as in Germany) will add a potentially interesting piece to the mosaic of the *Phengaris*-*Myrmica* system. We have tried to summarize all published records of *Phengaris* caterpillars in ant nests available from the Czech Republic and unpublished records from Czech lepidopterologists and other conservationists interested in *Phengaris* blues. Because there is only one paper dealing with *Phengaris* host specificity data from the Czech Republic (Witek et al. 2008) and we can not find anyone having unpublished records available, we have decided to publish data (however scarce) from our field research. Although our data are far from complete and exhaustive, we believe that even anecdotal records may contribute to the mosaic of our present knowledge about the geographical variation of *Phengaris* host specificity.

Methods

All searched sites of *P. alcon* (Placy, Mečichov, Jindřichovice, Nahošín) and *P. nausithous* (Bergsträsser, 1779) (Josefov) are wet meadows with *Molinia caerulea* L. (Moench) (Poaceae) as a dominant component. In Placy (central Bohemia, 49°40’N, 14°06’E), five plots (1×2m, all in the close vicinity of *Gentiana pneumonanthe* L., Gentianaceae) were searched. All nests in the plots were opened using a garden rake to collect a sample of ants and to check for the presence of *Phengaris* at the surface. In Jindřichovice (49°23’N 13°51’E) and Nahošín (49°21’N 13°50’E) (both south-western Bohemia), 10 whole nests from the vicinity of host plants (*G. pneumonanthe* or *Sanguisorba officinalis* L., Rosaceae) were dug out and searched through in the lab. In Mečichov (49°20’N, 13°47’E; south-western Bohemia), many ant nests were opened using a garden rake in 2000–2001, with nests checked in a 325 m^2 area independently of the position of host plants. This research was not aimed at studying the *Phengaris* host specificity and the numbers of infested ant nests were not recorded precisely; thus, these results are not useful for quantitative analysis. To obtain some basic quantitative data, 15 whole nests were dug out and searched in the same manner as in Jindřichovice and Nahošín. In Josefov (eastern Bohemia, 50°20’N, 15°55’E), a caterpillar was found incidentally during the investigation of two *Myrmica* nests, which were dug out and searched through in the lab to count ant workers and juveniles.

Results and discussion

There are very few records of *Phengaris* caterpillar or pupae in *Myrmica* nests from the Czech Republic. In addition, there are as yet no records of *P. arion* (Linnaeus, 1758) or *P. alcon* popula-

tions feeding on *Gentiana cruciata* L. (Gentianaceae) ("*P. rebeli*") (see Kudrna and Fric (2013) and Tartally et al. (2014) for a recent view on taxonomical status and biology of *P. alcon* and *P. rebeli* (Hirschke, 1904)).

Witek et al. (2008) published data from two localities of *P. teleius* (Bergsträsser, 1779) from the Czech Republic. *M. scabrinodis* was the only recorded host ant, but as *P. teleius* commonly develops in nests of many *Myrmica* species (Pech et al. 2007; Witek et al. 2008), these exclusive records from *M. scabrinodis* nests are clearly related to the low number of observations and other host ants cannot be ruled out.

Several records of *P. alcon* and one of *P. nausithous* were obtained by our field research (Table 1; Fig. 1). *P. alcon* used *M. scabrinodis* as a host at all four localities (Fig. 2). In addition to the data in Table 1, 260 nests of *M. scabrinodis*, 61 of *M. ruginodis* Nylander, 1846, four of *M. vandeli* Bondroit, 1920, three of *M. rubra* (Linnaeus, 1758) and in total 54 nests of non-*Myrmica* ants

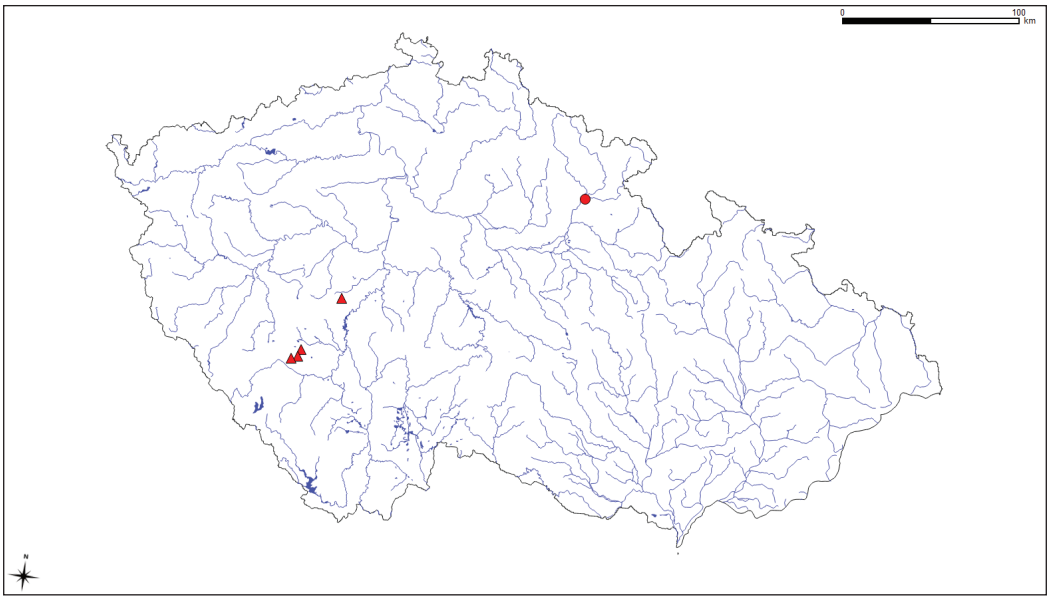

Figure 1. Location of sites where records of caterpillars of *P. alcon* (triangles) and *P. nausithous* (circles) in ant nests are known in the Czech Republic.

Table 1. Records of *P. alcon* and *P. nausithous* caterpillars in ant nests in the Czech Republic.

Site	*Phengaris*	*Myrmica*	Searched nests	Infested nests	Total number of caterpillars/pupae	Source
Placy	*P. alcon*	*M. scabrinodis*	16	1	3	Pech, Sedláček, Henebergová, Kupková, 1.7.2015. unpubl.
		M. ruginodis	1	-	-	
Mečíchov		*M. scabrinodis*	15	3	6	Pech, Křenová, Janda, May 2001, unpubl.
Jindřichovice		*M. scabrinodis*	10	3	7	Pech, Křenová, Janda, May 2001, unpubl.
Nahošín		*M. scabrinodis*	10	1	1	Pech, Křenová, Janda, May 2001, unpubl.
Josefov	*P. nausithous*	*M. scabrinodis*	2	1	1	Pech, 19.12.2012, unpubl.

Figure 2. Pupae of *P. alcon* in a *M. scabrinodis* nest. Locality Placy near Příbram in Central Bohemia, 1 July 2015. Photo: Ondřej Sedláček.

(*Lasius niger* (Linnaeus, 1758), *L. platythorax* Seifert, 1991, *L. flavus* (Fabricius, 1782), *Formica fusca* Linnaeus, 1758 and *F. polyctena* Förster, 1850) were opened in Mečichov in 2000–2001. We found many nests of *M. scabrinodis* infested by *P. alcon*, but no other ants hosting these caterpillars at this locality. Unfortunatelly, the presence of caterpillars in ant nests was not recorded precisely to allow quantitative analysis, but the observations correspond to the published data, because *M. scabrinodis* is the most common host of *P. alcon* in central Europe, although *P. alcon* is able to develop in the nests of many *Myrmica* ants (Pech et al. 2007; Witek et al. 2008; Sielezniew and Stankiewicz-Fiedurek 2009; Sielezniew et al. 2015).

Interestingly, a single caterpillar of *P. nausithous* was found in a *M. scabrinodis* nest in Josefov (Fig. 3). *P. nausithous* is the *Phengaris* species with the lowest number of known *Myrmica* hosts (two species only). It usually parasitizes nests of *Myrmica rubra* (Thomas et al. 1989; Tartally and Varga 2005; Witek et al. 2008), and the only other known host species of *P. nausithous* is *M. scabrinodis*. However, there are very few such records, all of them from the southwestern or eastern edge of the European range of *P. nausithous* (Munguira and Martín 1999; Witek et al. 2008; Tartally et al. 2008, 2010). According to Jansen et al. (2012), *P. nausithous* may depend on *M. rubra* in the centre of its range, whereas populations at the edges of its range may use *M. scabrinodis*. The caterpillar was found in December, 3–4 months after the adoption by ants. Because *Phengaris* caterpillars can be adopted by many ants (including non-host species) (Thomas et al. 1989), but then later die in their nests, our finding may be such a case. However, this is contradicted by the data of Patricelli et al. (2010), who

Figure 3. The locality near Josefov, Eastern Bohemia, where the caterpillar of *Phengaris nausithous* was found in a nest of *Myrmica scabrinodis*. Photo: Pavel Pech.

found that *P. nausithous* juveniles died in nests of non-host *Myrmica* ants within one month of adoption. Thus we suggest that it is legitimate to consider *M. scabrinodis* as a true host of this caterpillar.

The host specificity of *P. nausithous* and its relationship to host ants thus may be more complicated than previously thought. Our record in Josefov shifts the use of *M. scabrinodis* 200 kilometres closer to the heart of the European distribution of *P. nausithous* according to Wynhoff (1998). Unfortunately, there are almost no other data from this part of the *P. nausithous* distribution. It should be noted that *P. nausithous* is sometimes common at sites where *M. rubra* is absent or rare (Czech Republic - pers. observation; Netherlands - Jansen et al. 2012), and, if present, the infestation of *M. rubra* nests by *P. nausithous* is usually low (Tartally and Varga 2005; Witek et al. 2008). In such situations, it is unclear whether a rich population of *P. nausithous* can be supported. At the moment, the relationship of *P. nausithous* to *Myrmica* remains to be fully elucidated.

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Taleporia henderickxi sp. n., a new psychid species of the subfamily Taleporiinae from Crete (Lepidoptera, Psychidae)

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http://zoobank.org/FDECDFE3-B5E7-4B9A-9263-6A750BB7FD67

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Abstract. *Taleporia henderickxi* **sp. n.** is described from the south-western part of Crete (Greece) and compared with its likely close relatives *Taleporia defoliella* Constant, 1896 and *Taleporia autumnella* (Rebel, 1919). The new species is well characterized by its dark brownish grey coloured forewings, the less elongated wing shape, the fringe scales of the forewings and by the structures of the male genitalia.

Zusammenfassung. *Taleporia henderickxi* **sp. n.** wird aus dem süd-westlichen Teil von Kreta (Griechenland) beschrieben und mit den vermutlich nächstverwandten *Taleporia defoliella* Constant, 1896, und *Taleporia autumnella* (Rebel, 1919) verglichen. Die neue Art ist gekennzeichnet durch die dunkel braun-graue Farbe der Vorderflügel, ihre weniger gestreckte Flügelform, die besondere Form der Fransenschuppen der Vorderflügel sowie die Struktur der männlichen Genitalarmatur.

Samenvatting. *Taleporia henderickxi* **sp. n.** wordt beschreven van het zuidwestelijke deel van Kreta (Griekenland) en vergeleken met de vermoedelijk meest verwante soorten *Taleporia defoliella* Constant, 1896 en *Taleporia autumnella* (Rebel, 1919). De nieuwe soort wordt gekenmerkt door de donkerbruin-grijze kleur van de voorvleugels, hun minder langwerpige vleugelvorm, de bijzondere vorm van de franjeschubben van de voorvleugels en de structuur van de mannelijke genitaliën.

Introduction

The actual species inventory of the psychid genus *Taleporia* Hübner, 1825 of Europe seems well established as no new species have been found for nearly a hundred years. Worldwide the genus includes 24 species (Sobczyk 2011). The last species was described by De Freina and Witt (1984) as *Taleporia pseudoimprovisella* from two specimens collected in 1860 by Mann from Asiatic Turkey.

During expeditions to Greece and Spain and the Canary Islands over the past 20 years, Hans Henderickx (Mol, Belgium) discovered several new psychid species along with other arthropods. He described them as *Pseudobankesia hauseriella* Henderickx, 1998, *Pseudobankesia leleupiella* Henderickx, 1996, *Luffia gomerensis* Henderickx, 1996, and *Pseudobankesia aphroditae* Weidlich & Henderickx, 2002. In the autumn of 2000 and 2002 he also visited Crete and collected a few cases with larvae of a small *Taleporia* species from which he reared three males and one female.

Comparing this material with the likely closely related taxa, as well as subsequent analysis of the adult morphology including the male genitalia structures, supported the recognition of a new species, which is described here as *Taleporia henderickxi* sp. n.

Material and methods

This new species was found with the aid of an adapted hand vacuum cleaner, used to investigate invertebrates under bark and rocks in the estuary of the River Megalopotamos in South Crete. The primary objective of vacuuming was for the capture of pseudoscorpions, but the small *Taleporia* species was present in the same habitat, on the ground, under rocks and bark near ground level.

Figures 1a, b, d and Figure 4 were made with a Canon 5D mark III and a MP-E 65 macro objective, with soft flash illumination. Figure 1c was made from a slide mounted male genitalia preparation in Pertex with a Leitz microscope and a 10x Leitz objective on the same camera. The phallus in this figure was coloured red with Adobe Photoshop afterwards. Figure 2 was made with a Pentax digital camera by using an Olympus stereo microscope. Figures 3a–f were made with the FEI Quanta 200 electron microscope at the Royal Belgian Institute of Natural Sciences, Brussels. Special attention was given to non-destructive examination with an Environmental Scanning Electron Microscope (ESEM) with scanning performed in low pressure–low temperature water vapour, for the option of collecting electron micrographs of specimens that are "wet," uncoated, or both by allowing for a gaseous environment in the specimen chamber.

Results

Taleporia henderickxi Arnscheid, sp. n.

http://zoobank.org/D8FF7091-3273-4BAE-858E-05392FAB118E

Material. Holotype ♂: Kreta (GR), Preveli, near Preveli beach 0 m, case 10.x.2000, male exit on 13.xii.2000, leg. Henderickx, accessory label "TALPRE ♂3" (Staatliches Museum für Naturkunde Karlsruhe (SMNK), Germany).

Paratypes: 1 ♂ Zuid-West Kreta, larva 28.iv.2000 (Estuary Preveli tussen schors Eucalyptus), imago 28.ix.2000, accessory label "TALPRE ♂1"; 1 ♂ Kreta, Limni Preveli, ex l. 24.x.2002, leg. Hans Henderickx, cult. Hättenschwiler, accessory label "TALPRE ♂2"; 1 ♀ Kreta (zuid), Preveli (estuary), N35°09.295, E24°28.430, case 28.iv.2000, imago 18.xi.2000, leg. Henderickx (all in the private collection of the author).

Etymology. It gives me great honour to dedicate this beautiful new species to Hans Henderickx. He discovered the new species and we are grateful for his contributions to the knowledge of the invertebrate fauna of Crete.

Diagnosis. *Taleporia henderickxi* is among the smallest *Taleporia* species (wingspan 9 and 10 mm). Looking closely at the genus the new species resembles *T. defoliella* from southern France but it differs by a couple of morphological features. The forewings of *Taleporia henderickxi* are broader and less elongated. Forewing index (forewing length / forewing width, after Sobczyk 2002) 2.45 and 2.63, average 2.54 (*T. defoliella* 2.69–2.72, average 2.71). The brownish spot at the inner margin is more prominent. The scales (of the distal third) of the forewings of the new species are mostly short and uniformly serrated distally with three equal dentations. The scales of *T. defoliella* are more or less triangular with mostly three hardly visible dentations with one longer dentation medially. The fringe scales

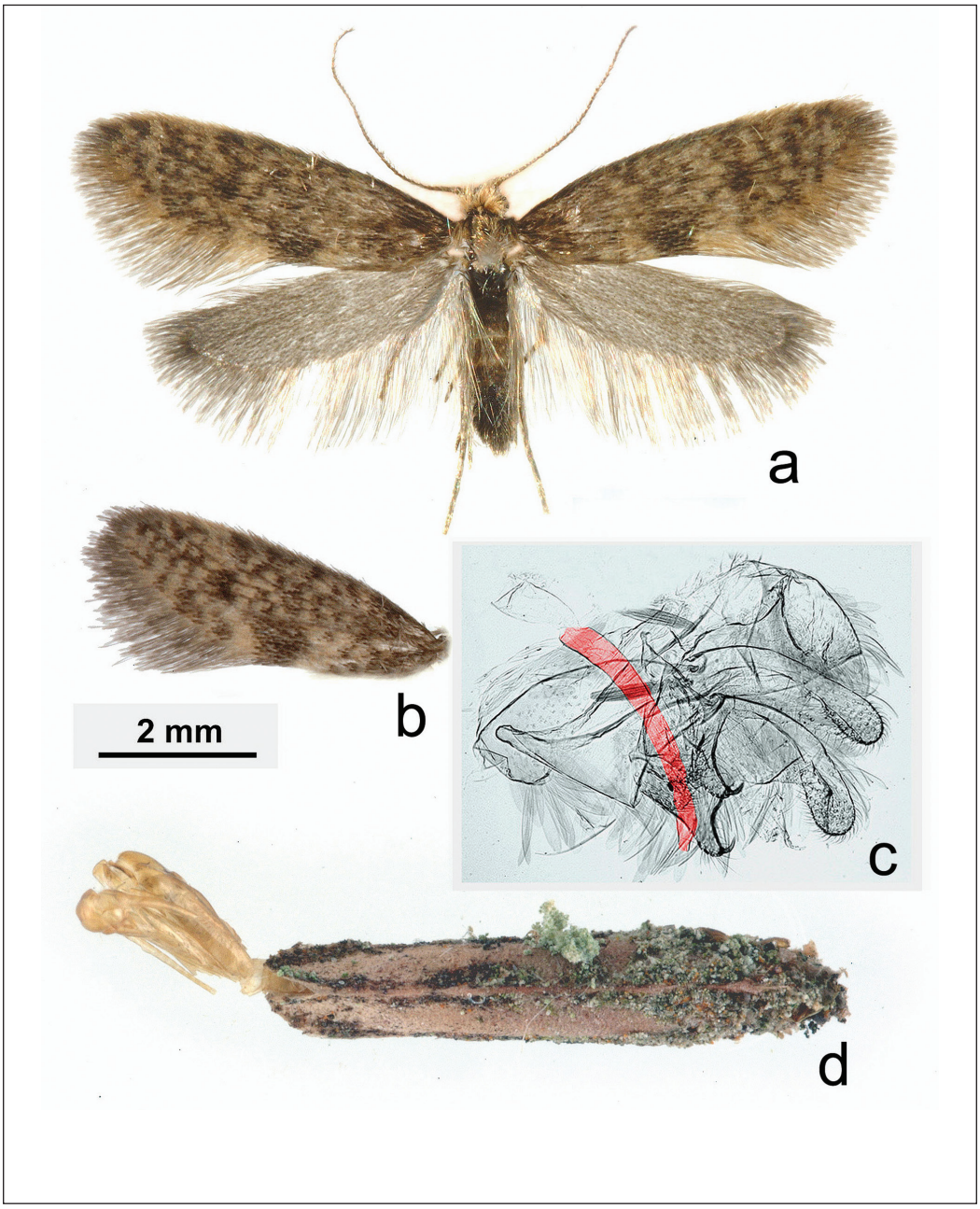

Figure 1. *Taleporia henderickxi* sp. n. **a** – holotype ♂; **b** – forewing of paratype; **c** – male genitalia; **d** – male case with exuvia.

are distinctly different. The fringe scales of the new species are long stalked, narrow, distally with 4–6 dentations. The fringe scales of *T. defoliella* are narrower and show mostly only 1–3 dentations.

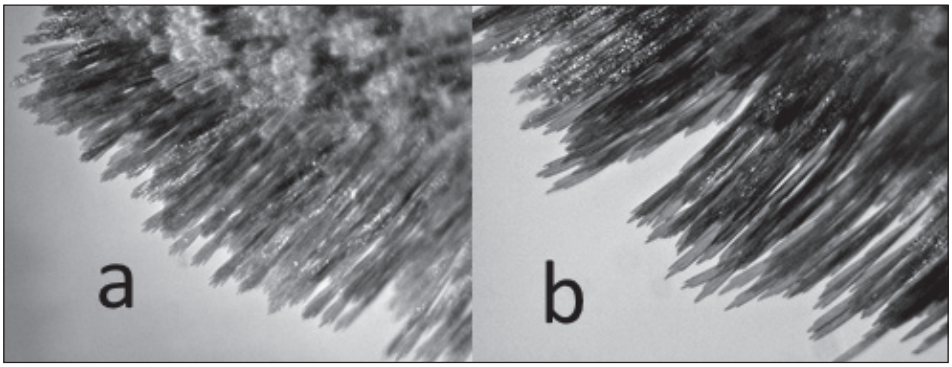

Figure 2. Fringe scales of forewing of **a** – *T. henderickxi* sp. n.; **b** – *T. defoliella*.

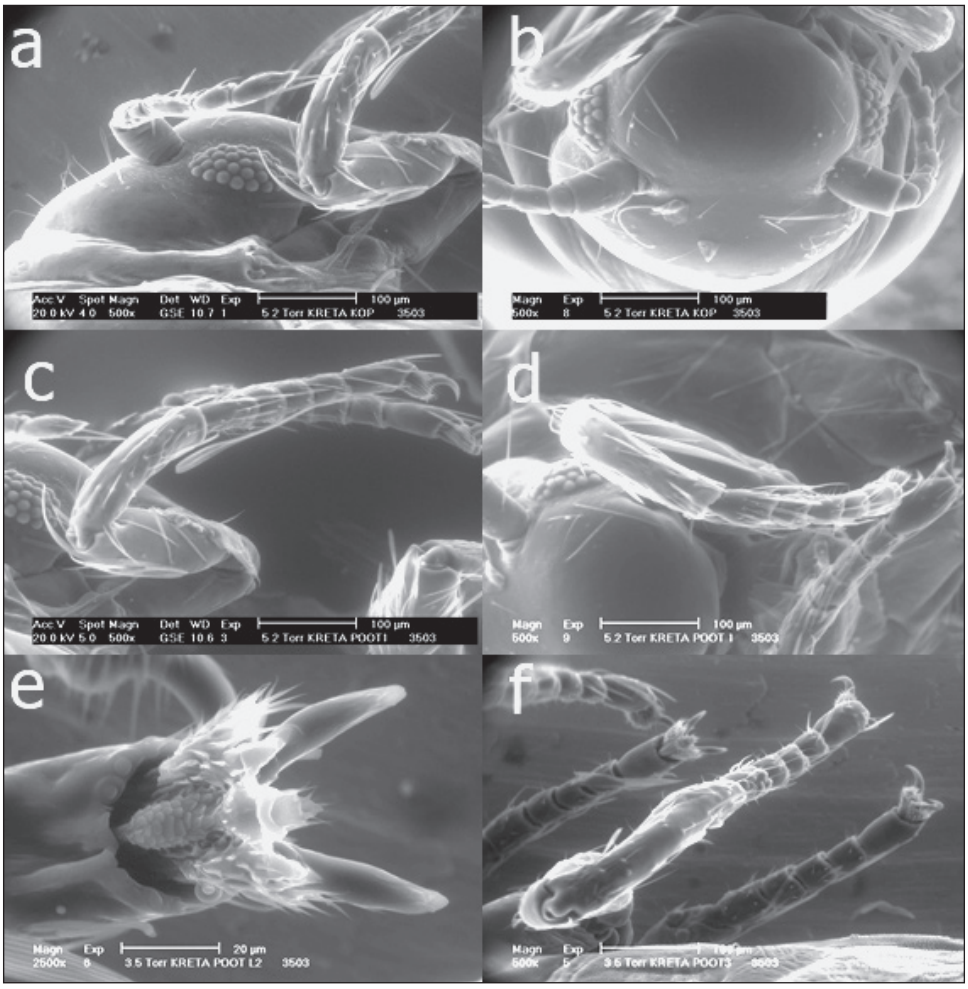

Figure 3. Electron microscope images of female characters: **a, b** – head with antenna and eyes (a – lateral view, b – dorsal view); **c, d** – foreleg; **e** – claw; **f** – tarsi with claws.

Figure 4. Female on the larval case in attracting mode.

Taleporia henderickxi differs also in the male genitalia. The setae of the distal part of the valva are more dense and slightly longer than in *T. defoliella*. The genital index (phallus length / valva length, after Sauter 1956) is distinctly higher (1.55 and 1.57, average 1.56, n=2) than in *T. defoliella* (1.17–1.20, average 1.18, n=3).

The new species differs from all other *Taleporia* species due to its small size and the extremely late period of flight. It is also characterized by its remote geographical location. No other *Taleporia* species occur on Crete and it is extremely unlikely that it is conspecific with any of the mentioned taxa. In an earlier phase of the study Peter Hättenschwiler, Uster (Switzerland) also concluded that this taxon is a separate species (P. Hättenschwiler, in litt.).

Figure 5. Hans Henderickx in the estuary of the River Megalopotamos in South Crete, the type locality of *T. henderickxi*.

Description. Male (Fig. 1). Wingspan 9 and 10 mm, forewing length 5.0 and 4.9 mm (average 4.95), dark brownish with distinct golden shine. Forewings covered with scattered small dark brown spots. A larger brown spot at the distal end of the discal cell, another one at middle of inner margin. Scales broad, with 3–4 dentations (class 6 after Sauter 1956). Fringe scales long (Fig. 2), become distinctly longer towards inner margin; long stalked, narrow, with 4–6 dentations. Hindwings uniform dark greyish with a tinge of golden gloss, scales moderately broad (class 3–4 after Sauter 1956). Venation hardly visible under magnification, with 10 veins from discal cell, accessory cell present. Head appearing hairy, with rough yellowish brown scales of variable lengths; external ocelli present. Antenna thread-like with 26–28 segments; scaled dorsally, each segment with two brush-shaped groups of setae. Forelegs with tibial epiphysis, midlegs with one pair of apical tibial spurs and hindlegs with medial and apical tibial spurs.

Genitalia typical for *Taleporia* (Fig. 1c) with tegumen indented distally, slightly vaulted, distinctly narrower distally in lateral view, with two lobe-shaped extensions. Clasper of sacculus distinctly sclerotized, upwardly curved, thorn-shaped. Valva broad, densely covered with short setae on the second half towards distal end. Vinculum short, triangular, saccus very short, broad. Phallus nearly as long as valva, thin, slightly curved in the last third caudally, vesica without cornuti. Genital index (phallus length / valva length) 1.56 (average, n=2).

Female (Figs 3, 4). Wingless. Length 3.5 mm (excluding ovipositor), yellowish white, dorsally head, thorax and each abdominal segment distinctly brownish, moderately sclerotized; ventrally less sclerotized with mostly divided brownish narrow plates. Eyes black, very small; antenna very

short, segmented. Labial palpus reduced. Legs with five tarsal segments. Anal hair-tuft darkish brown; ovipositor long, extensible.

Case. Similar in both sexes. Length 7 mm, width 1 mm, slightly triangular in cross section. Light greyish brown, sparsely covered with plant debris and sand (Figs 1d, 4).

The habitat of *T. henderickxi* is in the estuary of the River Megalopotamos in South Crete. Along this estuary there is a major cluster of the endemic palm tree *Phoenix theophrasti* (Arecaceae) (Fig. 5).

Discussion

Hättenschwiler and Scalercio (2003) transferred *T. defoliella* from *Bankesia* back to *Taleporia*. They redescribed females and males based on the morphological characters and also described the life history for the first time. The distribution of *T. defoliella* ranges from southern France throughout northern Italy, southwards to Calabria. This species is especially characterized by its flight period in September and October. Within the genus, only one other species, *T. autumnella* (Rebel, 1919), has a similar flight period, known from only two males collected by Galvagni in Istria (Croatia). Both specimens were captured in late September. This taxon has never been collected again since its discovery. In the description, Rebel compared *T. autumnella* with *T. tubulosa* (Retzius, 1783) but they differ in general appearance and by shorter cilia on the male antenna. De Freina and Witt (1985) designated the lectotype without discussing the taxonomic status. In 2011, the author had the opportunity to study the lectotype in the Witt Museum Munich. The comparison of *T. autumnella* and *T. defoliella* shows that the two taxa are very similar in all external characteristics, male genitalia and the uncommon flight period. In addition, the study of Hättenschwiler and Scalercio (2003) drew fresh light on the distribution of *T. defoliella* and *T. autumnella*. In all probability the distribution of the two taxa is rather similar because it is very likely that *T. defoliella* is distributed even in the north-eastern part of the Apennine peninsula. Thus, further studies may show that these taxa are conspecific.

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Hans Henderickx is gratefully acknowledged for the permission to describe the new species. I also express my sincere gratitude to Dr. Thomas J. Witt for his support in the Witt Museum Munich and Peter Hättenschwiler, Uster (Switzerland) for useful comments and the gift of specimens of *T. defoliella*. I also wish to thank Julien Cillis of the Royal Belgian Institute of Natural Sciences, Brussels, for the use of the ESEM electron microscope. My special thanks go to my friend Dr. Michael Weidlich, Neißemünde (Germany) for a stimulating and critical discussion and to Deborah Matthews (Gainesville, Florida, USA) for her critical comments and linguistic correction.

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Nota Lepi. **39**(2) 2016: 101–107 | DOI 10.3897/nl.39.5148

A new species of *Micropterix* Hübner, 1825 from Lebanon (Lepidoptera: Micropterigidae)

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Abstract. *Micropterix jabalmoussae* Zeller, Kullberg & Kurz, **sp. n.** is described from the mountain Jabal Moussa Biosphere Reserve (Lebanon) and compared with all other known species of *Micropterix* from this region and similar species of the Western Palaearctic. *M. jabalmoussae* is the fifth species of the genus *Micropterix* Hübner, 1825 known from the Levant.

Introduction

The genus *Micropterix* is distributed through the Palaearctic from North Africa and Europe to Japan in the east (Gibbs 1987; Zeller et al. 2013; Gibbs and Lees 2014) and even down to the foothills of the Himalayas (Lees et al. 2010). This study of a new species follows the recently published review of *Micropterix* of Cyprus and the Middle East (Zeller-Lukashort et al. 2009).

This description is based on two specimens collected by Jaakko Kullberg and Tommi Lievonen in Lebanon from the naturally rich Biosphere Reserve of Jabal Moussa (The Mountain of Moyses) located about 50 km north-east of the capital city Beirut in the Keserwan-Jbeil area, on the western side of the Mount Lebanon high plateau. The topography of the area is impressive. There is a Mediterranean vegetation zone starting at an elevation of 300 m grading up to arid mountain habitats surpassing 1700 m altitude on the high plateau (Association for the Protection of Jabal Moussa (APJM) 2016). Locally, Jabal Moussa carries a special importance, as it was designated in 2009 as the third biosphere reserve in Lebanon as part of the UNESCO Network of Biosphere Reserves under the Man & Biosphere (MAB) program. The reserve is surrounded by Nahr Ibrahim and Nahr Ed-Dahab rivers and the mountain is rich in local fauna and flora. For more information see http://www.jabalmoussa.org. Especially at higher altitudes from 700 m and upwards the Lepidoptera fauna is mostly of Irano-Turanian origin and partly east Mediterranean, but in fact several familiar widespread species common to the Central European fauna are present in the mountains. Many of these are close to the southernmost edge of their distribution.

Methods

The morphology of the new species is compared with all other known species from this region and also with similar species of the Western Palaearctic (Kurz and Kurz 2016)[1]. We consequently build on the important identification treatments by Heath (1987), Kozlov (1989, 1990a, b) and Zeller-Lukashort et al. (2007).

The genitalia preparation follows standard techniques used for the family Micropterigidae. Due to the problems and difficulties in preparing female genitalia of specimens in the genus *Micropterix*, no attempt has been made to prepare the genitalia of the single available female of the new species (Zeller-Lukashort et al. 2007).

The photograph of the holotype was taken with a NIKON D200 digital camera, a NIKON Micro-Nikkor 105mm 1:2.8 lens and three LED lamps for illuminating. The photograph of the male genitalia of the holotype was taken with an OLYMPUS FHT trinocular microscope and NIKON D800 digital camera, manipulated using the focus stacking software HELICON FOCUS 6.4.1 to extend depth of field. All photos were developed using ADOBE PHOTOSHOP CS2.

For more information about collection sites, preparation techniques and a data archive of *Micropterix* spp. see Zeller-Lukashort et al. (2007).

The two studied specimens are deposited in the Finnish Museum of Natural History, University of Helsinki, Finland (MZH).

Results

Checklist of *Micropterix* of the Levant

The following species occur within the Levant (Wikipedia 2016) presented here in alphabetical order (Zeller-Lukashort et al. 2009; Kurz and Kurz 2016).

Micropterix berytella de Joannis, 1886
Micropterix cypriensis Heath, 1985
Micropterix elegans Stainton, 1867
Micropterix islamella Amsel, 1935
Micropterix jabalmoussae sp. n.

Taxonomic part

Micropterix jabalmoussae Zeller, Kullberg & Kurz, sp. n.

http://zoobank.org/AEE90EBE-86C8-4243-816A-D2F6291DA492

Material. Holotype ♂: http://id.luomus.fi/GK.6673, Lebanon, Kesrouan 950 m, 34°03.96'N 35°45.07'E, Jebel Musa, Mar Geryes, 25.v.2012, J. Kullberg & T. Lievonen leg., label with identification numbers CZ-Z27207 and AP: MK-

[1] To access informations about these species login as "guest" at http://www.nkis.info, go first to "DATA ANALYSIS" (top menu) and choose "taxonomical descriptions (individual query)" (left side menu) and then input the taxonomic name of the requested species in the input field that will now display (main window).

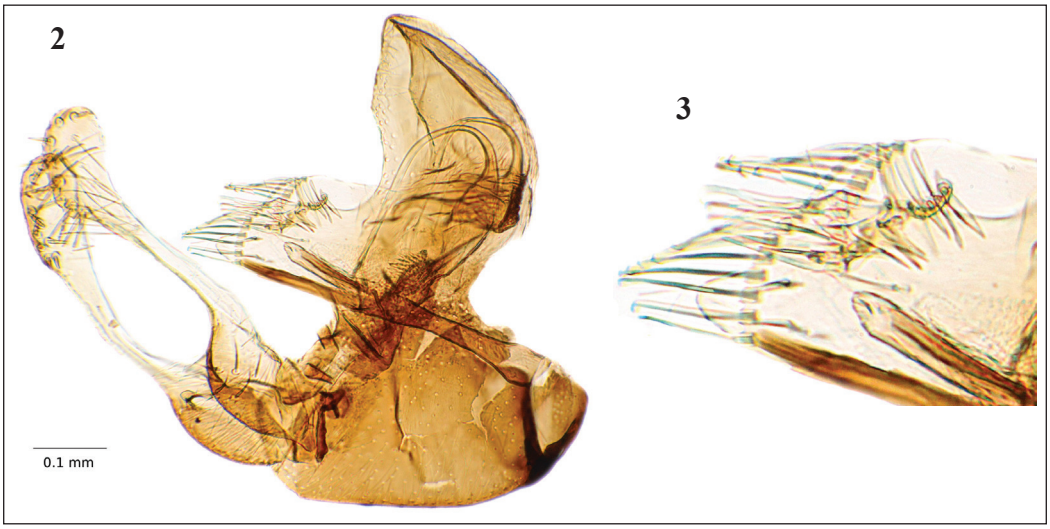
Figure 1. Male holotype of *M. jabalmoussae* sp. n.

1062 and red label "HOLOTYPE of *Micropterix jabalmoussae* Zeller, Kullberg & Kurz". – Paratype: 1 ♀, same data as holotype but http://id.luomus.fi/GK.6675, label with identification numbers CZ-Z27208 and red label "PARATYPE of *Micropterix jabalmoussae* Zeller, Kullberg & Kurz.

Description. Adult (Fig. 1). Forewing length 3.5 mm (♂), 3.6 mm (♀). Head black-brown; vestiture of hair-like scales on head light yellow; antennae dark brown, 3/4 (♂), respectively, 1/2 (♀) forewing length; thorax and tegulae violet with golden gloss; forewings bronze golden, with purple tinge at apex, with silvery white markings: a narrow fascia across whole wing width at 1/4; a narrow, outwardly bent fascia across whole wing width at nearly 1/2, somewhat broadened at costa; at 3/4 an oval or rectangular spot reaching from costa to middle of the forewing; fringe bronzy golden; hindwings bronzy golden, apically tinged purplish; fringe bronzy golden; legs and abdomen brown, golden shining.

Male genitalia (Fig. 2). Uncus very short and stout, beneath uncus a sclerotized twin structure of curved and slender shape, bearing hair-like setae at tip; accessory claspers nearly square, distally with rounded margin, bearing three groups of setae: about ten long setae with hooked ends at distal margin, a group of about eight T-shaped setae on inner surface and more dorsally and two clearly separated setae also on inner surface but more ventrally (Fig. 3); valvae moderately long, base thickened, medially distinctly constricted, distal parts spoon-like; distal parts at inner surface with one to two rows of short, straight, stout and thickened setae at ventral margin; phallus typical for genus, without cornuti.

The twin structures overlying the ventral margin of the accessory claspers randomly are part of the phallus and do not belong to the accessory claspers.



Figures 2–3. 2. Male genitalia of *M. jabalmoussae* sp. n. (holotype). **3**. Accessory claspers of male genitalia in higher magnification.

Diagnosis. *M. berytella* and *M. elegans* occur in the same region and show similar wing markings (Zeller-Lukashort et al. 2009). The new species is externally somewhat similar to *M. cypriensis* (Cyprus), *M. corcyrella* Walsingham, 1919 (southern Balkans), *M. aruncella* (Scopoli, 1763) (Europe), *M. erctella* Walsingham, 1919 (Sicily), *M. uxoria* Walsingham, 1919 (Sicily), *M. renatae* Kurz et al., 1997 (Italy) and *M. italica* Heath, 1981 (Italy). From all these species the new species is clearly separated by its male genitalia, e.g. by the distinct shape of uncus, accessory claspers and valvae (Zeller-Lukashort et al. 2007, 2009; Kurz and Kurz 2016). In the male genitalia the new species somewhat resembles *M. wockei* Staudinger, 1970 from Greece but can easily be distinguished by its different valvae and shorter uncus (Kurz and Kurz 2016). *M. islamella* was found together with the new species but can easily be distinguished by its different wing pattern (Zeller-Lukashort et al. 2009).

Distribution. The new species is so far known from the mountain Jebel Musa (Kesrouan, Lebanon) from an elevation of about 950 m.

Life history. The early stages are unknown. The new species was found in a dry slope meadow within a semi-open forest with *Malus sp.*, *Crataegus sp.*, *Rosa sp.*, *Sorbus sp.*, *Prunus sp.* and *Quercus sp.* (Figs 4, 5). *M. islamella* was also found at the same locality.

Etymology. The name of the new species is derived from the mountain Jebel Musa, also transcribed as Jabal Moussa or Gebel Musa, which literally means “The Mountain of Moyses”.

Remark. Based on morphological characters the new species is considered to belong to a species-complex together with *M. aglaella* (Duponchel, 1838), *M. wockei*, *M. aureatella* (Scopoli, 1763), *M. herminiella* Corley, 2007 and *M. sikhotealinensis* Ponomarenko & Beljaev, 2000 (Kurz et al. 2016).

During the dissection of the male genitalia of the holotype, the whole body (abdomen, thorax, mesothorax, legs and wings) was unfortunately severed from the head. The broken part is stored in a micro vial attached on the pin. Figure 1 was taken before dissecting.

Figures 4–5. Type locality of *M. jabalmoussae* sp. n..

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Book Review: A revision of the genus *Calliteara* Butler, 1881 (Lepidoptera, Erebidae, Lymantriinae)

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Subject Editor: Jadranka Rota.

Tatyana Trofimova, Dmitry F. Shovkoon and Thomas Witt 2016: A revision of the genus *Calliteara* Butler, 1881 (Lepidoptera, Erebidae, Lymantriinae). Proceedings of the Museum Witt, Volume 3, Munich and Vilnius. 117 distribution maps, 17 colour plates, 68 plates with genitalia figures, 292 pages. ISBN: 3-978-940732-21-7. Price €78[1]

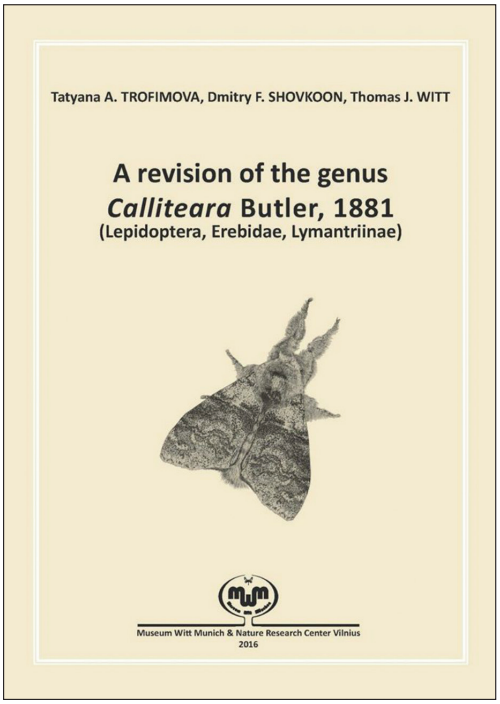

Figure 1. The cover of the book "A revision of the genus *Calliteara* Butler, 1881 (Lepidoptera, Erebidae, Lymantriinae)".

I was surprised when I first heard that a book (Fig. 1) like this would be published and even more so when I had a chance to see the first versions, with such a huge diversity of species in the revised genus. The introduction includes general characteristics of the genus, a list of newly described species, and all synonyms and combinations. Then it continues fluently into a systematic part dedicated to the general morphology of each developmental stage. The genus *Calliteara* Butler, 1881 belongs to the tribe Orgyiini and occurs across Palaearctic, Oriental, Australian, and Oceanic Regions. A list of 70 already described species was extended to number 116. The synonymization of the genus *Iropoca* Turner, 1904 and four other species is very important. Likewise, in many of the other genera of Lymantriinae, we can also find prominent sexual dimorphism in size and wing pattern as well as other more specific features. Moreover, males possess a modified 8th tergum and a unique structure of the valvae. Based on these characteristics, all described species were grouped by Holloway into seven species groups (such as the

[1] The book can be ordered online from the Museum Witt Munich website (http://www.insecta-web.org/MWM/htmls/museum_proceedlings_en.html).

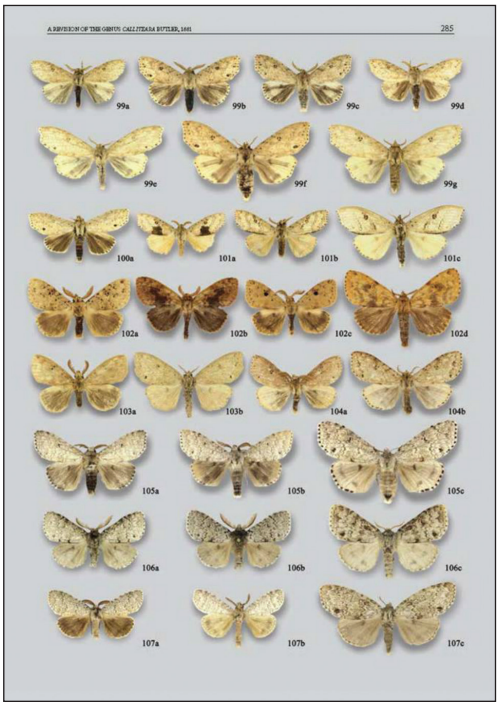

Figure 2. An example of adult habitus plate from the book (page 285, colour figures 99–107).

Calliteara pudibunda species complex). In this revision three new species groups were added. It was also very interesting (but not unexpected) to see descriptions of three new species from Vietnam and four new species from Thailand in one genus only.

The systematic part continues with review of all necessary characters used for proper identification (e.g. anatomy of the head, legs, genitalia, tymbal organs, and wing venation). The authors also barcoded 373 specimens and the results (COI sequences) were evaluated with Kimura 2-parameter (K2P) implemented in BOLD Systems and used to clear uncertainties around geographic and individual variability. Each species has original description, diagnosis, and notes about distribution displayed on maps. Many species in the checklist are also supplemented with information about their bionomy. The conclusions part is mainly dedicated to the evaluation of diversity in different regions. The title "biogeography" is not really the correct word, as there is no real biogeographic analysis based on ecological, molecular, or morphological data.

The graphical content of the book is quite impressive. Everybody will appreciate separated parts for male and female genitalia. The genitalia are shown in black and white, mostly with good contrast. I only have a problem with the complete lack of scale bars, because obviously the phallus and genitalia have been illustrated to different scales. Colour photographs of specimens (Fig. 2) could be sharper and lighter in many cases. What could be improved is the tone of the background colour, which has a negative impact on the colouration and general impression of the wings. Personally I also do not like the shadows around the wings which together with the lighter background makes the wings of many specimens darker than they really are. What I really admire is the plate with photographs of caterpillars. However, here I miss a plate with a selection of photographs of biotopes in different regions, where the species live.

This revision nicely follows up the work on the genus *Lymantria* published 12 years ago by Dr. A. Schintlmeister in Quadrifina (2004/7). It will be a key publication for working with and identification of tussocks from this genus. I hope that this book will also motivate us to continue with revisions in the Lymantriinae. I strongly recommended this book to anybody who works on biodiversity and ecology, as well as to people interested in forest and plant control.

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Book Review: The Butterfly Fauna of Sri Lanka

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George Michael van der Poorten and Nancy E. van der Poorten 2016: The Butterfly Fauna of Sri Lanka. Lepodon Books, Colombo. ISBN: 978-1-77136-189-7. Price Rs 7500 within Sri Lanka, ca. €100 outside Sri Lanka[1]

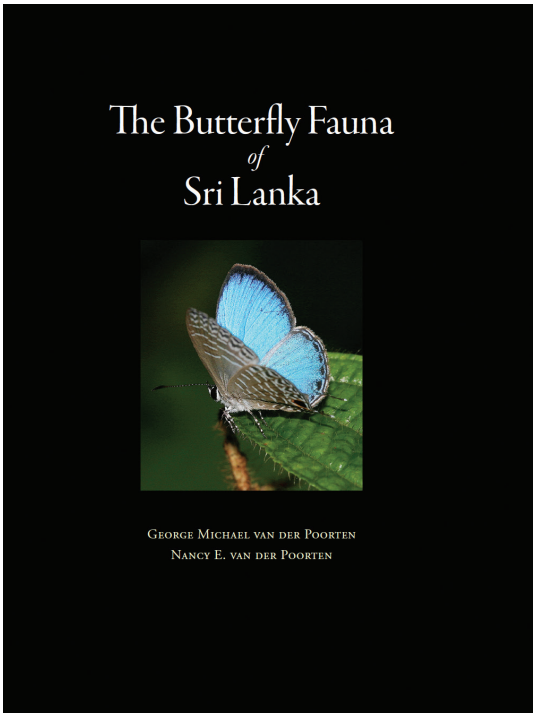

Figure 1. The cover of the book The Butterfly Fauna of Sri Lanka.

An absolute delight – this was the first impression as I first leafed through this book, and the feeling only became deeper as I read through. Sri Lanka desperately needed a comprehensive, updated reference to its butterflies, and the long wait for such a book appears to have been worth it. This book fulfills a glaring lacuna. For long, butterfly enthusiasts have had to rely on outdated, colonial era butterfly guides to identify or study Sri Lankan butterflies. Although Bernard D'Abrera's '*The Butterflies of Ceylon*', published at the turn of the Century, provides a photographic reference to all the then known butterflies of the country, it lacks a key, and has no natural history information. Other works that include identification keys tend to be rather dense for the typical butterfly watcher, and are not comprehensively illustrated. What was needed was a butterfly reference covering all species, and including informative photographs (or illustrations) which anyone can use to identify all the butterflies of the region. '*The Butterfly Fauna of Sri Lanka*' covers all these bases, and more.

The gorgeous photographs illustrate dorsal and ventral wing surfaces of males and females. If field photographs were unavailable, photographs of set specimens are included. Combined with the

[1] Available from Lepodon Books: LepodonBooks@gmail.com

species descriptions and identification keys provided in the book, any serious butterfly watcher or researcher can now easily identify any Sri Lankan species. Close-ups are provided wherever needed. Rather than provide a taxonomic identification key to all butterflies, the authors provide keys to distinguish among similar looking butterflies, for e.g. the Hedge Blues (page 155), or comparative 'plates' with images of similar species along with distinguishing marks carefully highlighted, e.g. *Eurema* (page 315). In my opinion, these are more practical than a descriptive taxonomic key, especially for those who are not taxonomists or researchers. However, I would have liked to see a comprehensive taxonomic key to all species presented somewhere.

The comparative plates of immature stages are very useful, but understandably photographs are not available for all species. Now that the book is published, I believe many more amateurs will start rearing butterflies and we will soon have illustrated guides to the immature stages of all Sri Lankan species. The addition of photographs of hostplants further increases the value of the book.

The book caters not only to amateurs, but will also be a very important reference for scientists, students and conservation planners. The authors appear to have done a very good job conforming to state-of-the-art in butterfly taxonomy, which is no mean feat. The decades of field experience of the authors, and their profound dedication to the butterflies of the country, clearly show through in all aspects of the book. The authors have also described a new butterfly species from Sri Lanka, the first after several decades. I cannot think of other people who would be more befitting to author such a seminal book.

There are many recent Asian butterfly books that are born not out of long term experience with butterflies, but instead depend largely on collation of information available in existing literature, much of it dating back to the early 1900s. The authors of this book not only have synthesized taxonomic and natural history information from previous work, but also rely heavily on their immense experience, both in the field and during rearing butterflies. The result is a book which includes an impressively detailed account of the natural history of almost all the butterflies of the country. Additionally, the authors offer some information on issues related to the conservation of particular species.

If a regional butterfly guide does not make butterfly enthusiasts far and wide yearn to visit the region, then either the region's butterflies are not very exciting or the guide is not of great quality. Sri Lanka's butterflies are indeed very diverse and intriguing, and exceptionally important from a biogeographic perspective. Having used butterfly guides from several regions across the world, I can confirm without reservations that '*The Butterfly Fauna of Sri Lanka*' is one of the best I have come across in terms of usefulness, comprehensiveness, aesthetics and attention to detail. I am fully confident that this book will turn hordes of Sri Lankans into butterfly watchers, and entice many others from around the world to visit Sri Lanka to experience its marvelous butterfly fauna. And there are bound to be many positive results. Awareness about conservation issues will surely increase. The current knowledge-base of the natural history of Sri Lankan butterflies (to which this book is by far the best introduction) will expand, and in turn will encourage many researchers to take up butterfly model systems for research.

The book does not come cheap, but the price is well justified. If you are a researcher or taxonomist interested in butterflies, I highly recommend that you get a copy. If you are interested in visiting Sri Lanka, and would like to know more about its butterflies, grab a copy (with the caveat that this is not a light book to carry around during travel!). Given that the Sri Lankan butterfly fauna is very similar to that of Southern India, this book should also form a welcome and useful addition to the bookshelves of scores of Indian naturalists. Indeed, after seeing this book, my longing for a similar book on Indian butterflies has become more desperate.

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Phtheochroa unionana (Kennel, 1900) recognised as a dimorphic Cochylini species, with description of the hitherto unknown male genitalia (Lepidoptera, Tortricidae)

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Abstract. The previously unknown male genitalia of *Phtheochroa unionana* (Kennel, 1900) are described and illustrated. The species is dimorphic: one form is white with very faint yellow scales in the fascial areas and the other is white with distinct orange fasciae. The everted vesicae of the males do not show interspecific variation but are remarkably different from those of a closely related species. Apparently, the morphology of the everted vesica is a useful tool for species recognition in this genus. The conspecificity of the two forms of *P. unionana* is further corroborated by evidence from COI barcodes.

Introduction

The genus *Phtheochroa* Stephens, 1829, comprises 107 species worldwide (Gilligan et al. 2014) and 53 species with a Palaearctic distribution (Razowski 2009). No synapomorphies are known for the genus, but some groups of species demonstrate clear morphological affinities (Razowski 1991). According to Razowski (1991), *P. unionana* (Kennel, 1900) belongs to a group of *ca.* 13 species defined by a simple valva without a free termination of the sacculus. In this group several species externally show similarity with *P. unionana*. Their genitalia are considerably simplified in comparison to other *Phtheochroa* spp. and species recognition sometimes is difficult. Further studies of the genitalia morphology combined with molecular data probably will reveal other problems and unknown facts for this group.

During an expedition to Armenia in 2014 a single male of a pure white *Phtheochroa* was collected. The genitalia of the specimen did not fit any known species, which, combined with the forewing colour, convinced us that this was a male *P. unionana*. Study of additional material also collected from Armenia revealed other *P. unionana* specimens. Unexpectedly, the genitalia of an undetermined *Phtheochroa* from the same area with orange fasciae were nearly identical to those of *P. unionana*, indicating conspecificity of the two forms, a hypothesis supported by subsequent DNA barcoding.

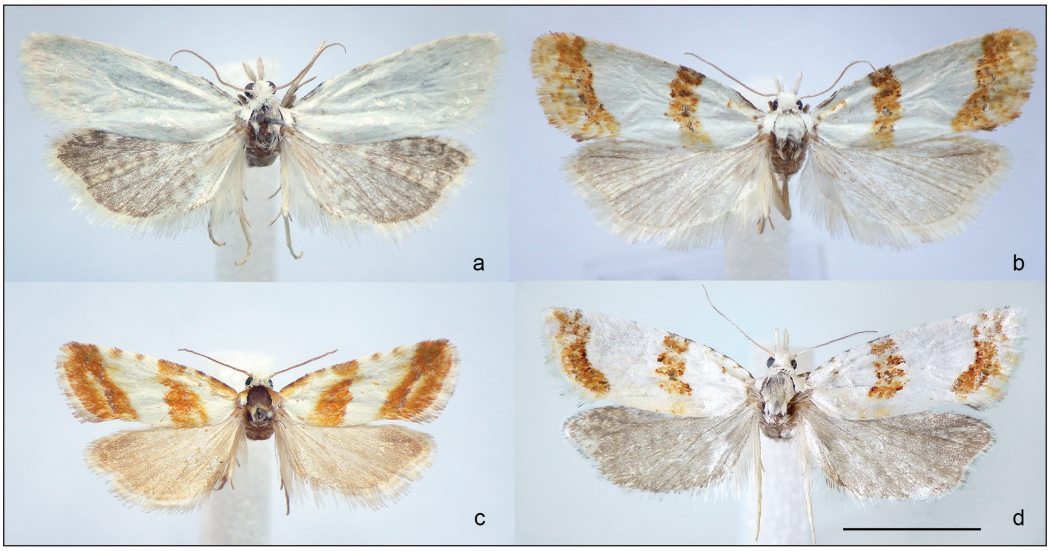

Figure 1. *Phtheochroa* adults. **a, b, d**, *P. unionana*. **a.** Male, Armenia, Dilijan, 12–14.vii.2011. **b.** Male, Armenia, Tsaghkadzor, 9–11.vii.2011. **d.** Female, Georgia, Lesser Caucasus, 28.vii.2014. **c.** Male of *P. procerana*, Bulgaria, Balchik, 21.vi.2007. All figures to the same scale, scale bar = 5 mm.

Material and methods

Material examined: *Phtheochroa unionana*: Armenia: 4 ♂♂ (2 white, 2 fasciate), Tavush region, Dilijan, N40°45', E44°51', 1340–1450 m, 12–14.vii.2011, leg. O. Karsholt, coll. ZMUC; 1 ♂ (fasciate form), Kotayk region, Tsaghkadzor, N40°32', E44°32', 1870–2350 m alt., 9.–11.vii.2011, leg. O. Karsholt, coll. ZMUC; 1 ♂ (white form), Lori region, Lermontovo vill., N40°44'55", E44°39'40", 1860 m alt., 29.vii.2014, at light, leg. B. Zlatkov & D. Chobanov, coll. BFUS. Georgia: 1 ♀ (fasciate form), Lesser Caucasus, Kvemo Kartli region, Sakire, N41°14'13", E44°17'02", 1260 m alt., 28.vii.2014, leg. B. Zlatkov & D. Chobanov, coll. BFUS. *Phtheochroa procerana* (Lederer, 1863): Bulgaria: 1 ♂, Bulgaria, Black Sea coast, Balchik–Kavarna, N43°24'21", E28°12'28", 100 m alt., 21.vi.2007, leg. B. Zlatkov & S. Beshkov, coll. BFUS; 1 ♂, Bulgaria, Veliko Tarnovo region, Emen Gorge, N43°08'20", E25°21'41", 150 m alt., 16.vii.2011, leg. B. Zlatkov & O. Sivilov, coll. BFUS.

The moths were collected at a "light tower" with a 160 W MBFT lamp and blacklight fluorescent tube, and traps with blacklight tubes. The genitalia were dissected following Robinson (1976) with the exception of the phalli; they were processed following Zlatkov (2011). The description of the cornuti generally follows Anzaldo et al. (2014). The phalli with everted vesicae were submerged in Euparal essence and attached to a needle with a diameter of 0.15 mm inserted through the entering excavation of the ductus ejaculatorius into the phallus. A compound microscope with attached camera lucida was used for the line drawings.

DNA barcode sequences of the mitochondrial COI gene (cytochrome c oxidase 1) were obtained from three specimens of *P. unionana* and an other three of *P. procerana*. DNA samples from dried legs were prepared according to prescribed standards using a standard high-throughput protocol (deWaard et al. 2008). Samples were processed at the Canadian Centre for DNA Barcoding (CCDB, Biodiversity Institute of Ontario, University of Guelph) to obtain DNA barcodes (Ratnasingham and Hebert 2007). DNA sequencing resulted in barcode sequence of 658 bp and a sequence

of 604 bp for *P. unionana* and two sequences of 623 bp and 627 bp for *P. procerana*; sequencing of a third specimen of each species failed. Details of successfully sequenced voucher specimens including complete voucher data and images can be accessed in the Barcode of Life Data Systems (Ratnasingham and Hebert 2007). Degrees of intra- and interspecific variation in the DNA barcode fragments were calculated using Kimura 2 parameter (K2P) model of nucleotide substitution using analytical tools in BOLD systems v3.0 (BOLD 2015). A neighbour-joining tree of DNA barcode data of European taxa was constructed using MEGA 6 (Tamura et al. 2013) under the K2P model for nucleotide substitutions.

Abbreviations

ZMUC Zoological Museum, University of Copenhagen
BFUS Zoological collection of Faculty of Biology, Sofia University

Results

Redescription of *Phtheochroa unionana*

Head (Fig. 1a, b, d). Frons, vertex, palps white. Antennae filiform, with white scales at base and inner side.

Thorax. White, legs grey-brown. Forewing with small costal fold (*ca.* 1.5 mm), forewing length 7.9–9.5 mm. Upperside pattern dimorphic: fasciate or white with some yellow scales. Fasciate form: white ground colour and ochreous-orange fasciae. Median fascia equal in width for its entire length, subterminal and terminal fascia not separated but the latter paler, with reticulate pattern. Fasciae with small groups of raised rust brown reflective scales. Cilia pale orange with alternating darker areas. White form: white, with more or less pronounced groups of yellow scales in the fasciate areas. Raised reflective scales correspond to those of the fasciate form but are pearly white. Underside in both forms dark grey brown, costa white with dark grey spots, cilia white. Hindwing upperside in males of both forms grey with pale anal area and reticulate pattern of darker and paler areas and white cilia, in females more uniform, with less pronounced reticulate pattern. Underside of both forms whitish with more or less prominent grey scattered spots, especially in the costal area, cilia white.

Abdomen. Grey-brown.

Male genitalia (Figs 2, 3). Uncus slender and long, slightly widened at the middle, with small setae on the apical area. Socii large, pendant, emerging close to the base of uncus, rounded apically, with external surface setose. Valva relatively narrow, with costa and sacculus nearly parallel and apex rounded, densely covered with setae. Sacculus strongly sclerotized and extending for more than 1/3 of the lower margin of valva. Transtilla slightly trapezoidal, dorsally spinulous. Central area of juxta ovoid. Phallus large, almost length of valva, ventrally bent, with short straight ventral process and two unequal cornuti the larger of which is *ca.* 0.5 the length of phallus, coecum wide. Vesica voluminous, strongly asymmetrical; median area mainly membranous bearing narrow, conical, intensively stainable diverticulum on the ventral side that posteriorly forms a sclerotized plate; left portion large and covered with minute spines (acanthae); right portion considerably larger, dorsally widened, with acanthae and extended posteriorly with two long cylindrical diverticula,

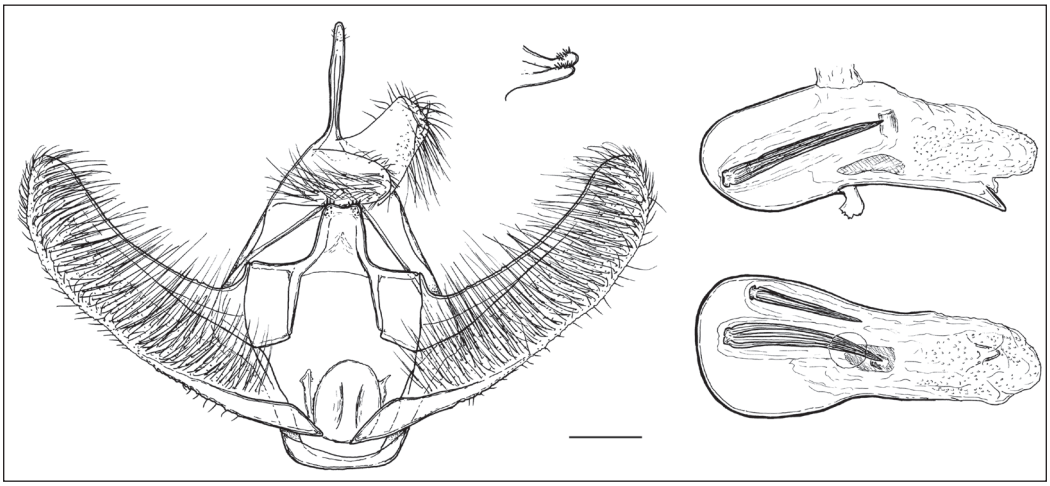

Figure 2. Male genitalia of *Phtheochroa unionana*. Inset: transtilla in dorso-lateral view; phallus with inverted vesica, lateral (above) and dorsal (below) view. All drawings to the same scale, scale bar = 250 µm.

pointing left and right, each of which ending with a strong cornutus; right diverticulum and associated cornutus smaller than the left ones; cornuti acicular, non-deciduous, slightly curved, strongly sclerotized, longitudinally striated, with large sockets (capitate); gonopore located dorsally on the middle area of vesica, surrounded by a spinose, sclerotized semi-cylinder.

Female genitalia (Fig. 4). Apophyses anteriores *ca.* 1.8× longer than apophyses posteriores. Sterigma nearly twice as broad as ductus bursae, the latter weakly sclerotized posteriorly and membranous anteriorly. Corpus bursae ovoid; the wall sclerotized into three large plates. An elongated lateral sclerite on the left side connects the ductus bursae with the dorsal side; a second –the largest– sclerite covering most of the ventral side, extends ventrolaterally and then dorsally and forms folds near the middle area of corpus bursae; a third relatively small sclerite located lateroposteriorly on the left side. A densely folded membranous area present at the right side anterolaterally. Ductus seminalis emerges medioventrally from corpus bursae. No sclerotized spines visible under a stereomicroscope, but observation at high magnification under the microscope (e.g., 200 ×) reveals small unsclerotized spiniform structures at the left side of the emerging area of ductus seminalis.

Diagnosis. The wing pattern of the fasciate form of *P. unionana* is similar to *P. chalcantha* (Meyrick, 1912), *P. durbonana* (Lhomme, 1937), *P. purissima* (Osthelder, 1938), *P. procerana*, *P. aureopunctana* (Ragonot, 1894), and *P. purana* (Guenée, 1845). The white form is easily distinguished from all other *Phtheochroa*. The male genitalia of *P. unionana* are also similar to the aforementioned species. The uncus is relatively long and slender and the transtilla bears a broad, rectangular, median process as in *P. chalcantha*, *P. durbonana*, *P. procerana* and *P. purana*, but the cornuti in *P. procerana* and *P. durbonana* are of nearly equal size; however, the size of cornuti is not absolutely constant (e.g., Fig. 3a–d). The cornuti of *P. chalcantha* are similarly unequal but look much larger compared with the length of the phallus. The uncus in *P. purana* is widened at the apex, and the cornuti are more curved. The shape of the valva should be used with caution because it varies slightly depending on the pressure applied on the coverslip, at least in *P. unionana*. The female genitalia superficially resemble those of the discussed species but details in the shape of

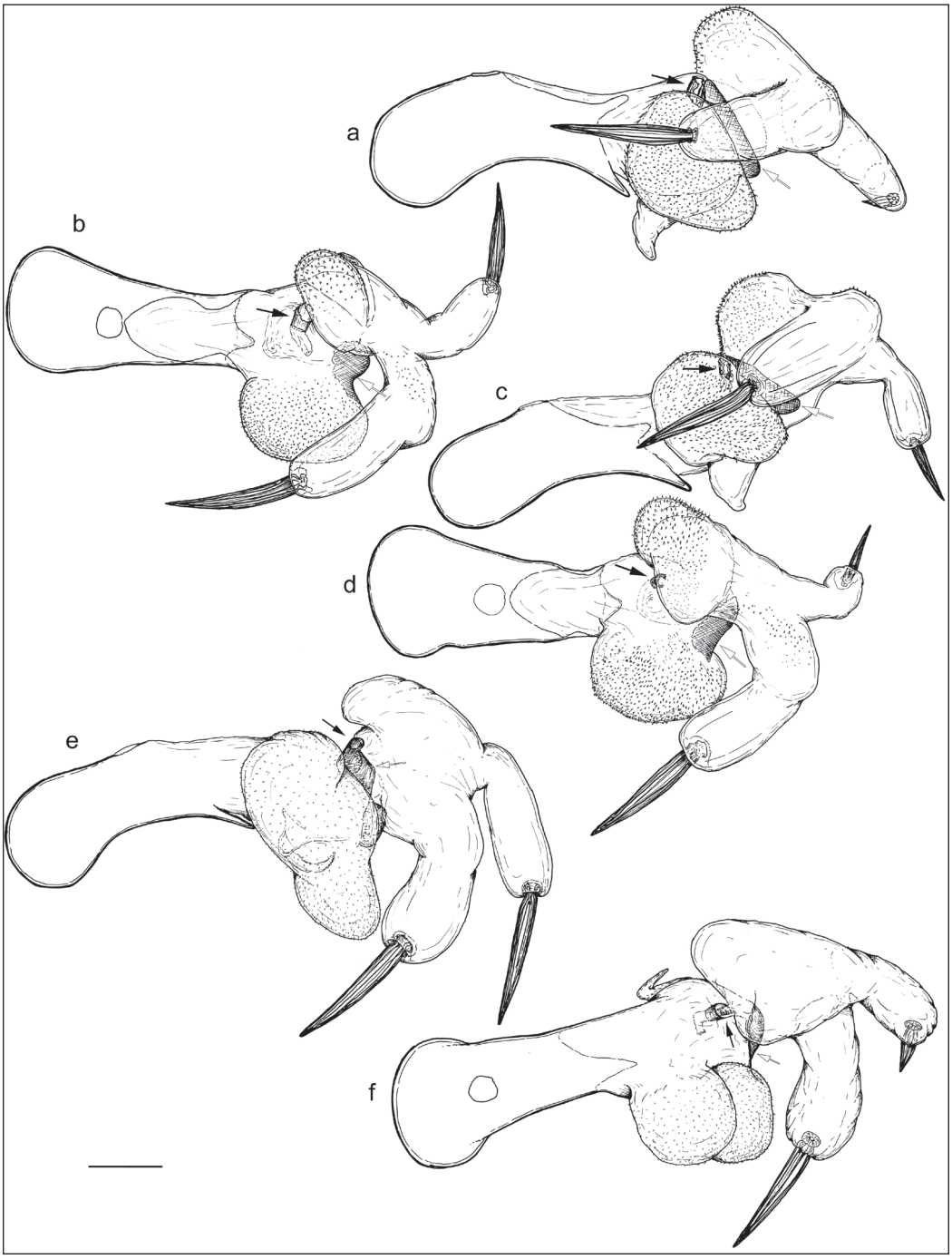

Figure 3. Phallus with vesica everted of *Phtheochroa* spp. **a–d,** *P. unionana*; **a, b,** white form, Armenia, Lori region, 29.vii.2014; **c, d,** fasciate form, Armenia, Tsaghkadzor, 9–11.vii.2011. **e–f,** *P. procerana*, Bulgaria, Emen Gorge, 16.vii.2011; **a, c, e,** left; **b, d, f,** dorsal. The black arrows shows semicylindrical sclerotisation around the gonopore, the white arrows – posterior sclerotisation of the median part of vesica. Scale bar = 250 µm.

Figure 4. Female genitalia of *Phtheochroa unionana*, striated form, Georgia, Lesser Caucasus, 28.vii.2014. Scale bar = 500 µm.

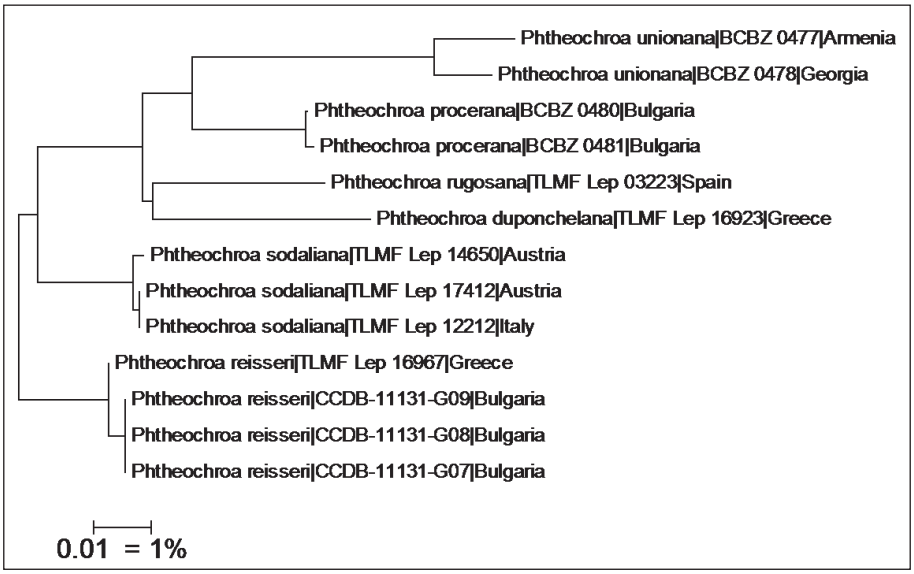

Figure 5. Neighbour-joining tree with a subset of *Phtheochroa* spp. (Kimura 2 parameter, built with MEGA 6; cf. Tamura et al. 2013). Source: DNA Barcode data from BOLD (Barcode of Life Database, cf. Ratnasingham and Hebert 2007).

sclerites distinguish *P. unionana* from the other related species, particularly the sclerite connecting ductus bursae with corpus bursae is diagnostic.

Phallus and vesica of *Phtheochroa procerana* (Fig. 3e, f)

The phallus of *P. procerana* is similarly shaped as in *P. unionana*, with relatively wider coecum. The asymmetrical vesica comprises all components found in the previous species. The median part is sclerotized posteriorly and bears a small curved diverticulum ventrally; a semi-cylindrical sclerotized spiny plate is located dorsally, around the gonopore. The right part is larger than in the previous species, with two unequal diverticula pointed ventrally. The right diverticulum is smaller than the left one, but the cornuti are of equal size. Acanthae are seen only on the right portion of vesica and are comparatively smaller than in *P. unionana*.

Molecular data (Fig. 5)

The intraspecific divergence is considerable with 2.38% (n=2) in *P. unionana* but low with only 0.16% (n=2) in *P. procerana*. The variation in the former is also reflected by two different BINs: BOLD:ACZ3163, BOLD:ACZ3164. Based on the two BINs the distance to the Nearest Neighbour in BOLD of *P. unionana* is *P. procerana* with 7.4% and the Nearctic *P. aegrana* (Walsingham, 1879) with 7.9% divergence whereas the distance of *P. procerana* to its Nearest Neighbour *P. rugosana* (Hübner, 1796) is 5.42%.

Discussion

P. unionana was described from two male specimens from the Caucasus (without details of the locality), both with white forewings with barely discernible yellow fasciae (Kennel 1900). The specimens were later lost and the male genitalia remained unstudied (Razowski 1970). Female

specimens collected subsequently were assigned to this taxon based entirely on the appearance of the forewing, but no further males were reported prior to the present study. Thus for the first time we are able to describe the genitalia morphology of the male. Razowski (1970, 2009) placed *P. unionana* near *P. procerana* based on the external appearance and female genitalia. With regards to the male genitalia, this position seems correct. The everted vesicae of both species demonstrate similarity though there are certain differences in the details: the same components are present in both species but their position and shape is different. It should be emphasised that the shape of the vesica, even the relative position of the diverticula and cornuti, are relatively constant at specific level though some small differences can be detected (Fig. 3a–d). A remarkable character is present in both species: a sclerotized semi-cylindrical plate around the gonopore. Though its function is not known, it suspends eversion of the ductus ejaculatorius. The peculiar ventral "diverticulum" with a conical shape and uneven surface does not correspond to any structure of the tortricid vesica known to us. It may be even non-eversible in the living moth. The female genitalia agree well with the illustrations by Razowski (1970, 2009) but the latter probably were drawn from the dorsal side instead of the ventral. This assumption is supported by the genitalia of the related species: the lateral sclerite connecting the corpus bursae with the ductus bursae is located at the left side in *P. procerana* (specimens studied by us), *P. durbonana* and *P. purissima* (judging from illustrations in literature).

Though a special case, comparison of the vesicae of two related species proves the taxonomical significance of this structure in the Cochylini, at least in *Phtheochroa*. Detailed comparison is achievable only after complete inflation of the vesicae, then numerous characters became visible and can be used for morphological analysis. The taxonomic significance of this character was tested by comparison with the closely related species *P. procerana* from which fresh material was available (Fig. 1c). As well as the morphology, the barcode divergence of 7.4% between *P. unionana* and *P. procerana* also clearly supports two separate species.

The conspecifity of two strikingly different forms in *P. unionana* is less supported by molecular data because the intraspecific distance between the forms is considerable at 2.38% but this may be due to geographic variation as one sequenced specimen originated from Armenia and the other from Georgia. Such divergence rates have been attributed either to intraspecific variation or interspecific divergence, varying from case to case (Huemer et al. 2014 and references within). However, the full conformity of genitalia morphology in both forms and their co-occurrence support a single species hypothesis. Male genitalia structures including the everted vesicae of the fasciate and white syntopic specimens appeared identical. Furthermore, the genitalia of a female specimen with fasciate forewings appeared identical to the available illustrations of the female genitalia of *P. unionana*. As a result we conclude that *P. unionana* has two forms that differ by forewing pattern. Extreme variation in the wing pattern is common in the subfamily Tortricinae, especially in the genus *Acleris*, and in many Cochylini, e.g. *Cochylimorpha* and *Aethes*.

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Udea ruckdescheli sp. n. from Crete and its phylogenetic relationships (Pyraloidea, Crambidae, Spilomelinae)

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Abstract. DNA barcode data reveal a distinct group of *Udea* specimens collected on Crete and previously misidentified as *Udea fulvalis* (Hübner, 1809) and *U. languidalis* ab. *veneralis* (Staudinger, 1870). Morphological examination of the specimens corroborates their status as a distinct species which is described as *Udea ruckdescheli* **sp. n.** Images of the adults and the genitalia of both sexes, as well as the DNA barcode sequences are presented. A phylogenetic analysis using molecular (*COI*, *wingless*) and morphological data indicates that the new species belongs to the *Udea numeralis* (Hübner, 1796) species group and is sister to the *Udea fimbriatralis* (Duponchel, 1833) species complex.

Introduction

Udea Guenée (in Duponchel), 1845 is the most species-rich genus of Spilomelinae, comprising 214 described species (Nuss et al. 2003–2016). *Udea* species inhabit every continent except Antarctica, but their main diversity is found in temperate regions and on oceanic islands (Munroe 1966). A number of *Udea* species such as *U. ferrugalis* (Hübner, 1796), *U. decrepitalis* (Herrich-Schäffer, 1848) and *U. costalis* (Eversmann, 1852) are widely distributed, while many others, e.g. *U. accolalis* (Zeller, 1867), *U. carniolica* Huemer and Tarmann, 1989, *U. cretacea* (Filipjev, 1925) and the species of oceanic islands have a much narrower distribution or are even endemic to a small region.

With 38 species occurring in Europe, *Udea* constitutes almost 40 percent of the European Spilomelinae diversity (Nuss et al. 2003–2016). Even though the European pyraloid fauna is relatively well studied in comparison to other regions of the Earth, a considerable number of *Udea* species have been described in the past few decades (Huemer and Tarmann 1989; Leraut 1996; Meyer et al. 1997; Slamka 2013; Tautel 2014).

Taxonomic and systematic research in *Udea* is impeded by the morphological homogeneity of the species: the uniform wing pattern between closely related species differs only slightly in colouration and maculation, and genitalia of both sexes provide only minor structural differences (Munroe 1966). In a phylogenetic analysis on the genus with a focus on European species, Mally and Nuss (2011) proposed four species groups supported by apomorphic characters of the wings

and genitalia. Nevertheless, taxonomic problems still persist, e.g. in the *U. fimbriatralis* complex, the *U. numeralis* complex, the *U. itysalis* (Walker, 1859b) species group and in *U. rhododendronalis* (Duponchel, 1834) (Munroe 1966; Leraut 1996; Slamka 2013). The increasing availability of molecular data enables a re-investigation of such taxa. Easily amplifiable gene sequences such as the DNA barcode (Hebert et al. 2003) allow quick and efficient screening of large numbers of specimens for overlooked and cryptic species (e.g. Huemer and Hebert 2011; Mutanen et al. 2012).

Combining morphological and molecular data in taxonomic studies not only increases the amount of information, but also allows for a comparison of the outcome of the different data sets against each other (Schlick-Steiner et al. 2010). This integrative approach is used to evaluate *Udea* specimens from Crete.

Material and methods

DNA barcodes were either obtained via sending a leg per specimen to the Barcode of Life Facilities in Guelph, Canada, or via DNA extraction and amplification from the abdomen according to the procedure of Knölke et al. (2005): the abdomen was detached from the dried specimen and DNA was extracted using the DNeasy Blood & Tissue kit (Qiagen) according to the manufacturer's protocol. The mitochondrial *COI* gene was amplified using the primers HybLCO (forward) and HybNancy (reverse) (Folmer et al. 1994; Wahlberg and Wheat 2008). For the nuclear *wingless* gene we used the primers HybLepWg1 (forward) and HybLepWg2 (reverse) (Wahlberg and Wheat 2008). Both primer pairs contained a 5' tail of the universal sequencing primers T7 (forward) or T3 (reverse), denoted by the 'Hyb' in the primer names. The 25 µl reactions contained 400 nM of forward and reverse primer, 0.75u *TaKaRa Ex Taq* Hot Start DNA Polymerase, 2.5 µl *Ex Taq* buffer (incl. $MgCl_2$), 800 µM dNTP mix and 2µl of DNA of concentration as extracted. PCR results were examined via gel electrophoresis on a 1% agarose gel and GelRed as dying agent. Successful PCR samples were cleaned with Exonuclease I (Exo) and Shrimp Alkaline Phosphatase (SAP). For the Sanger-sequencing PCR reactions we used 0.25–3.0 µl PCR sample, depending on the thickness of the respective agarose gel band, 160 nM of the sequencing primers T7 and T3, 0.5 µl BigDye, 1.0 µl sequencing buffer, and added up with distilled water to the 10 µl reaction volume. Sequencing was conducted at the sequencing facility of the University of Bergen, Department of Molecular Biology. PCR and sequencing PCR were performed on a Bio-Rad C1000 thermal cycler, ExoSAP clean-up was done with an MJ Research PTC-200 thermal cycler. Sequences were aligned using PhyDE version 0.9971 (Müller et al. 2008).

Dissection of genitalia was performed according to Robinson (1976). Morphological structures were investigated using a Leica M125 stereomicroscope. Photographic documentation of imagines was done with a Canon EOS 60D in combination with a Canon EF 100mm 1:2,8 Macrolens and Canon EOS Utility Version 2.10.2.0 on a Windows PC. A Leica CTR6000 Microscope in combination with a Leica DFC420 camera and Leica Application Suite programme, version 3.8.0 on a Windows PC was used for documentation of the genitalia.

The Bayesian inference of the combined molecular and morphological data was conducted using MrBayes 3.2.5 (Ronquist et al. 2012). We used the dataset published by Mally and Nuss (2011) and added the information for the six specimens of *U. ruckdescheli* for which we had molecular data available (see Table 1). The phylogenetic analysis of Mally and Nuss (2011) found a clade containing *Deana hybreasalis* (Walker, 1859a), *Mnesictena marmarina* Meyrick, 1884 and *Ude-*

oides muscosalis (Hampson, 1913) as sister to *Udea*, therefore we used this sister clade as outgroup in our analysis. This taxon sampling resulted in the morphological character 17, "Uncus – apex with bulbous thickening: absent (0); present (1)", being constant, therefore we excluded it from the dataset.

The data were divided into three partitions: *COI* (1459 bp), *wingless* (363 bp) and the morphological data (23 characters). We applied the GTR+G model for the gene partitions and the Mk model (Lewis 2001) with gamma rate variation for the morphological partition. The parameters for gamma shape, proportion of invariable sites, character state frequencies and GTR substitution rates were unlinked for the three partitions, and the overall rate was allowed to vary across partitions. The analysis was run for two million generations with four simultaneous analyses, sampling of the Markov chain at every 1,000th cycle and a burn-in of 25%. Effective sampling sizes and degree of convergence of the analyses were evaluated in Tracer (Rambaut et al. 2014). The final consensus tree was annotated using TreeGraph 2.9.2 (Stöver and Müller 2010), with all branches with posterior probabilities < 0.90 collapsed.

Abbreviations

BC	Barcode
bp	base pairs
COI	cytochrome oxidase subunit I
DNA	desoxyribonucleic acid
EBI	European Bioinformatics Institute, Saffron Walden, Great Britain
MTD	Senckenberg Museum of Zoology („Museum für Tierkunde") Dresden, Germany
NHMO	Natural History Museum Oslo, Norway
PCR	polymerase chain reaction
prep.	preparation
TLMF	Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria
ZMHB	Zoological Museum, Humboldt University, Berlin, Germany
ZMBN	Zoological Museum Bergen, Norway
ZSM	Zoological State Collections Munich, Germany

Results

The analysis of DNA Barcodes of *Udea* specimens from Crete resulted in three clusters: *U. ferrugalis*, *U. numeralis* and one unknown cluster. The latter remained unknown when analysing these sequences together with the data set of Mally and Nuss (2011), covering most of the European *Udea* species, revealing no congruence with any known species. Eventually, the specimens of the unknown cluster were morphologically compared against the known *Udea* species, which showed evidence that the specimens in question represent a still undescribed species. This new species belongs to *Udea* based on its forewing pattern with both cellular stigmata well developed and the postmedian line with a characteristic loop below the distal cellular stigma. Further diagnostic characters that place the new species in *Udea* are the narrow, elongate valvae and the bulbous, dorsally setose uncus head in the male genitalia as well as the elongate, lanceolate signum in the corpus bursae of the female genitalia.

Udea ruckdescheli sp. n.

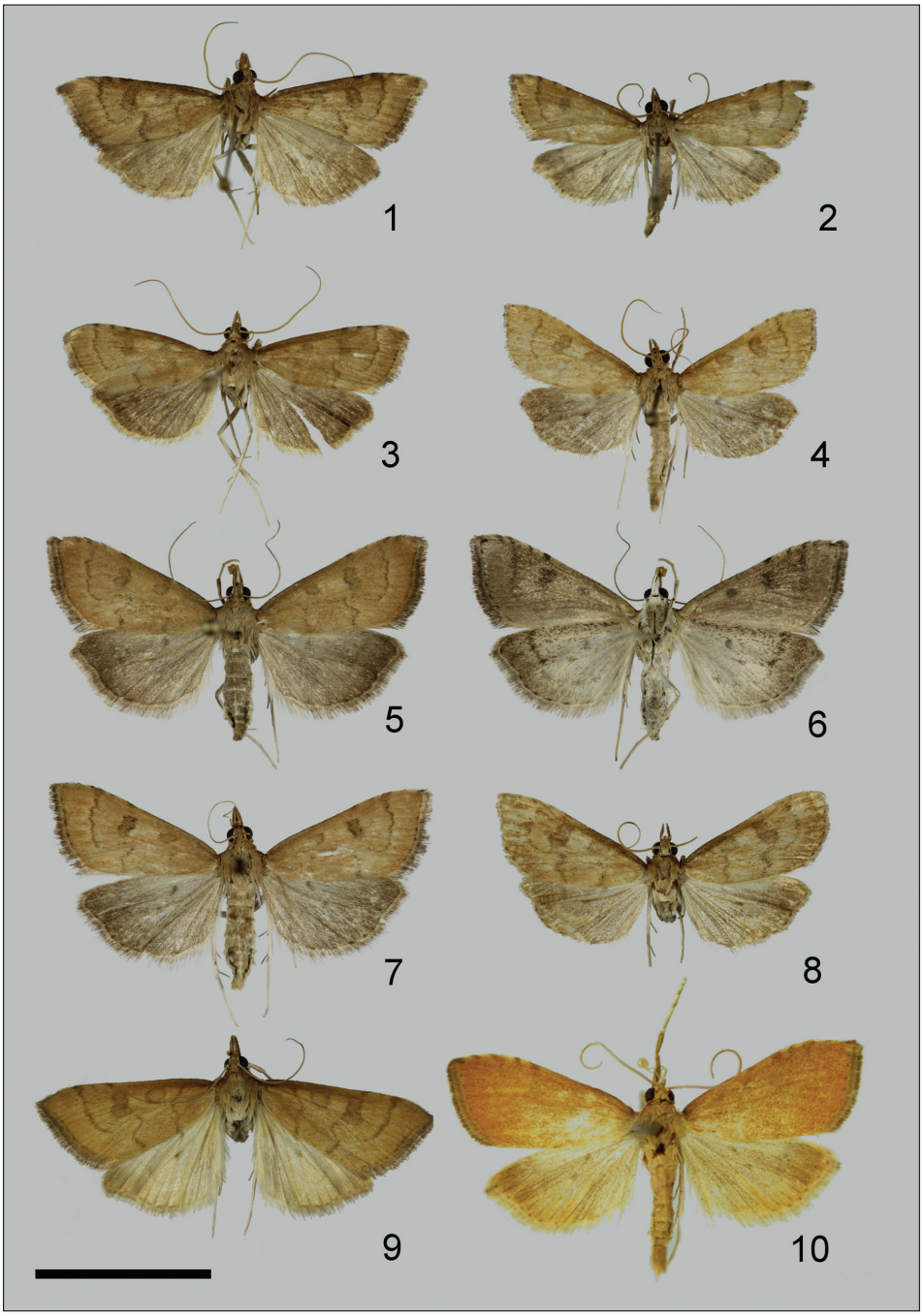
http://zoobank.org/883EB672-9EA7-4ABA-957F-71DAC41484EA
Figs 1–7, 11–15, 20–21

Type locality. Greece, Crete, Lasithi, near Moni Kapsa monastery, Perivolakia gorge, 10 m, 35.021555°N 26.050902°E.

Material examined. Holotype: ♂ "Perivolakia-Schl. 10m | M.Kapsa, N.Lassithi | KRETA/GRAECIA | (Tagf.T F - Lwd./BL) | leg. W. Ruckdeschel | [transverse, handwritten] 20.5.2000", [yellow label] "86509:ZSM | coll. W. Ruckdeschel | Udea | ruckdescheli | det. Segerer", [mint green label] " BC ZSM Lep 61775", [yellow label] "DNA voucher | Lepidoptera | ZMBN 2015 | [transverse] no. 087", "Mally prep. no. | [handwritten] 872 ♂" (ZSM). **Paratypes:** 1♂ as HT, but "86508" on yellow label, plus [orange label] "DNA voucher | Lepidoptera | ZMBN 2015 | [transverse] no. 129" and "Mally prep. no. | [handwritten] 932 ♂" (ZSM); 1♂ as HT, but "86510" on yellow label, [orange label] "DNA voucher | Lepidoptera | ZMBN 2014 | [transverse] no. 086", and "Mally prep. no. | [handwritten] 863 ♂"; 1♂ "Ano Saktouria | N. Rethymnon, 400m | KRETA/GRAECIA | (Leuchtturm SL+BL) | leg. W. Ruckdeschel | [transverse, handwritten] 18.5.2000", [yellow label] "86529:ZSM | coll. W. Ruckdeschel | Udea | ruckdescheli | det. Segerer", [mint green label] "BC ZSM Lep 61774", [orange label] "DNA voucher | Lepidoptera | MTD 2013 | [transverse] no. 1590", "Mally prep. no. | [handwritten] 663 ♂"; 1♂ "GREECE Crete, | Chania Prov.: Imbros | 35S KU 4170 0122 | 570 m. 11. vi. 2013 | leg. Leif Aarvik", [yellow label] "DNA voucher | Lepidoptera | ZMBN 2015 | [transverse] no. 152", "Mally prep. no. | [handwritten] 982 ♂" (NHMO); 1♀ "GREECE Crete, | Chania Prov.: Imbros | 35S KU 4170 0122 | 570 m. 15. vi. 2014 | leg. Leif Aarvik", [yellow label] "DNA voucher | Lepidoptera | ZMBN 2015 | [transverse] no. 151", "Mally prep. no. | [handwritten] 981 ♀" (NHMO); 1♀ same data except for "20. vi. 2014", [yellow label] "DNA voucher | Lepidoptera | ZMBN 2015 | [transverse] no. 150", "Mally prep. no. | [handwritten] 980 ♀" (NHMO). – **Additional material. GREECE.** 1♂ "GREECE Crete, | Chania Prov.: | Hora Sfakion | 35S KU 4031 9864 | 9-21. vi. 2014 | leg. Leif Aarvik"; 1♀ "GREECE Crete, | Chania Prov.: Imbros | 35S KU 4170 0122 | 570 m. 11. vi. 2013 | leg. Leif Aarvik"; 2♀ same data except for "20. vi. 2014" (NHMO).

Diagnosis. In wing pattern elements, *Udea ruckdescheli* is similar to *U. accolalis* (Zeller, 1867), *U. afghanalis* (Amsel, 1970), *U. ardekanalis* Amsel, 1961, *U. ferrugalis* (Hübner, 1796), *U. fimbriatralis*, *U. fulvalis*, *U. languidalis* (Eversmann, 1842), *U. praefulvalis* (Amsel, 1970) and *U. rubigalis* (Guenée, 1854). *Udea accolalis*, *U. ferrugalis* and *U. rubigalis* belong to the *Udea ferrugalis* species group, whose members differ by features of male and female genitalia (Mally and Nuss 2011).

The other similar species mentioned above belong to the *Udea numeralis* species group according to the presence of a longitudinal split posteriorly in the sclerotized section of the phallus, an autapomorphic character for this species group (Mally and Nuss 2011). In *Udea afghanalis* and *U. praefulvalis* the postmedian line forms an evenly arched line parallel to the termen, with the loop below the distal cellular stigma more accentuated and finger-shaped with parallel sides, whereas in *U. ruckdescheli* the loop is usually more angled, and anterior and posterior sections of the postmedian line are not aligned, i.e. the postmedian line's posterior section is further away from the termen than the anterior section. The valvae of *U. afghanalis* and *U. ardekanalis* are narrower, particularly in *U. ardekanalis* where they taper off into a narrow tip. The distal phallus apodeme of *U. afghanalis*, *U. fulvalis* and *U. praefulvalis* lacks the elongate dentate crests of *U. ruckdescheli* (Figs 12–15), and the apodeme is shorter in *U. fulvalis* (Fig. 17) and *U. praefulvalis*. In wing pattern elements, *U. ruckdescheli* cannot be distinguished from *U. fulvalis* (Fig. 8), but differs in male genitalia in the characters mentioned above as well as by the smaller vinculum saccus and the shorter fibulae (compare Fig. 11 with Fig. 16 of *U. fulvalis*). In the female genitalia,



Figures 1–10. Adult specimens. **1–7.** *Udea ruckdescheli*. **1.** Holotype ♂ (ZSM), Crete, Lasithi; **2.** Paratype ♂ (ZSM), Crete, Lasithi; **3.** Paratype ♂ (ZSM), Crete, Lasithi; **4.** Paratype ♂ (NHMO), Crete, Imbros; **5–6.** Paratype ♀ (NHMO), Crete, Imbros, dorsal (5) and ventral (6) aspect; **7.** Paratype ♀ (NHMO), Crete, Imbros. **8.** *U. fulvalis* ♂, Germany, Brandenburg. **9.** *U. languidalis* ♀, Iran, Golestan. **10.** *U. fimbriatralis* ab. *veneralis*, original specimen ♂ (ZMHB), Greece, Naxos. Scale bar represents 1 cm.

U. ruckdescheli (Figs 20–21) is distinguished from *U. fulvalis* by the conical antrum (tubular in *U. fulvalis*, see Fig. 22).

U. ruckdescheli is different from its sister species *U. fimbriatralis* and *U. languidalis* (Fig. 9) as the forewings are dorsally brownish with a diffuse ground colour, without a dark brown fringe, and the hindwings are brownish-grey dorsally (Figs 1–5, 7); *U. fimbriatralis* and *U. languidalis* have an orange, more homogenous forewing ground colour and a contrasting brown fringe as well as a whitish hindwing colour. The new species cannot be reliably distinguished from *U. fimbriatralis* and *U. languidalis* (Figs 18–19) in the male genitalia. In the female genitalia, *U. ruckdescheli* (Figs 20–21) is distinguished from *U. fimbriatralis* and *U. languidalis* by the sclerotisation of the posterior end of the ductus bursae being shorter than the colliculum (as long as or longer than colliculum in *U. fimbriatralis* and *U. languidalis*, see Fig. 23).

The DNA barcode (Table 1) of *U. ruckdescheli* is unique and does not match any other species barcoded so far. Intraspecific Barcode variation among the six sequenced specimens ranges from 0.00% to 0.65% (p-distance). The nearest neighbour is *U. languidalis*, with a p-distance of 1.94% to 2.26%.

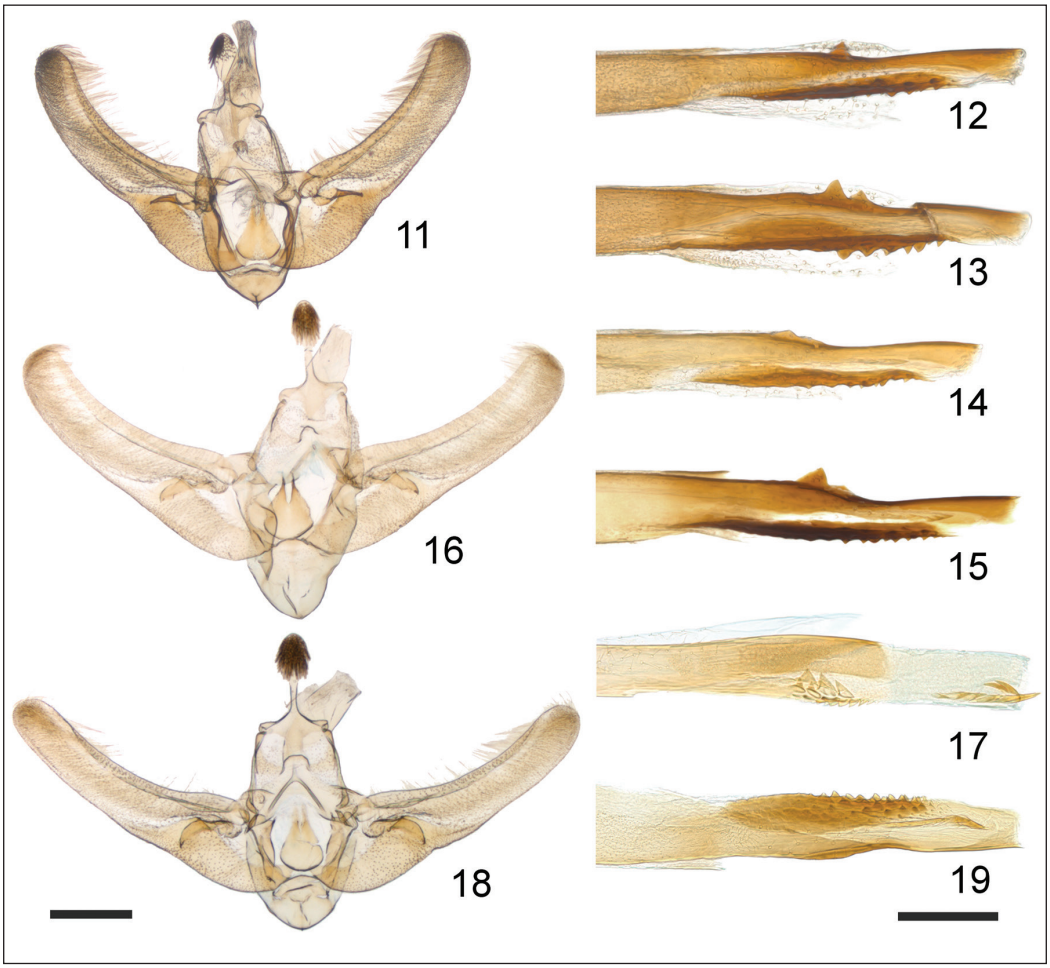
Description of adults. Head: Head greyish to light brown; frons slightly bulged; labial palps porrect, brownish, 1st segment and ventral side of 2nd segment white, 3rd segment in females approximately twice the length compared to males; maxillary palps well developed, with whitish scales; haustellum well developed, with whitish scales on base; eyes large, hemispherical; ocelli present; antennae ciliate, light brown, cilia in males dense and shorter than 1/4 of antennal diameter, ciliation in females shorter than in males; vertex with light brown spatulate scales; chaetosemata absent.

Thorax: Dorsal side light brown; ventral side cream to whitish; forelegs light brown, mid- and hindlegs cream to whitish; tibial spurs on fore-, mid-, hindleg: 0, 2, 4, on hindlegs anterior outer spur minute while inner spur almost reaching base of posterior pair of spurs.

Wings: Forewing ground colour diffuse light brown to orange-brown; diffuse dark brown antemedian line running obliquely distad, after half of length bending and running more or less orthogonally towards dorsum; proximal cellular stigma circular, distal cellular stigma 8-shaped, both stigmata bordered dark brown; postmedian line dark brown, running from costa parallel to termen, at half of length bending proximad, running below distal cellular stigma, then turning in semicircle towards lower end of termen and then half that way approaching dorsum orthogonally; postmedian line distally framed by lighter diffuse band; subterminal band with dark brown spots where it meets with wing veins; fringe dark brown; costa slightly darker than ground colour, with dark spots at ends of costal veins. Hindwings with one frenular bristle in males and two in females, without subcostal retinaculum on forewing, but with basal tuft of filiform scales reaching over the frenular bristle; ground colour brownish-grey, cell with a proximal and a distal brown spot, both often faint; postmedian line brown, clear to diffuse; continuous brown subterminal line with dark spots where it meets with veins; fringe dark brown. Undersides (Fig. 6) pale brown; forewings with prominent dark spots at the vein ends on costa and termen, distal cellular stigma and postmedian line visible as diffuse fuscous patterns; hindwings with the two central spots and postmedian line relatively clear.

Abdomen: Light brown, underside somewhat lighter.

Male genitalia: (Figs 11–15) Uncus base broad, constricted at lateral juncture with tegumen, uncus neck thin, head ovate, ventrally densely studded with bifurcate, anteriad setae. Tegumen

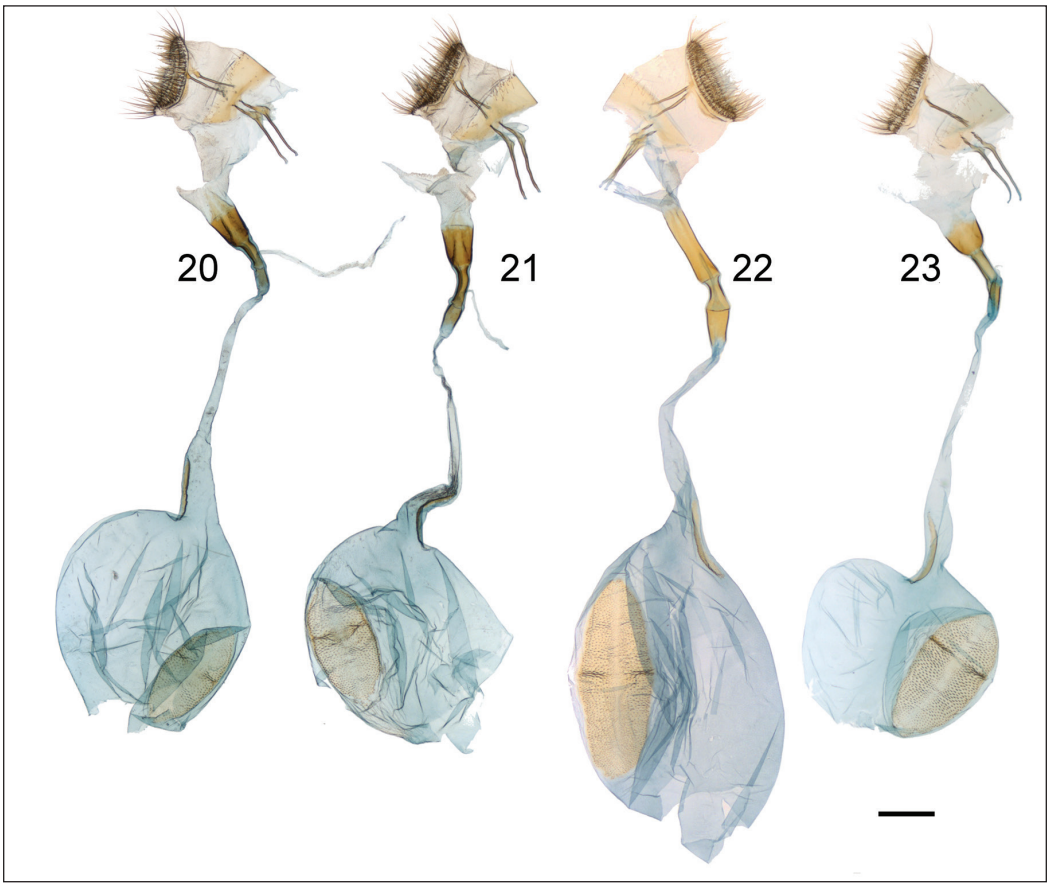


Figures 11–19. Male genitalia. **11–15.** *Udea ruckdescheli*. **11–12.** Holotype, Greece, Crete, N-Lasithi (Mally prep. no. 872; ZSM), male genital (11) and posterior phallus (12); **13.** Paratype, Crete, Ano Saktouria (Mally prep. no. 663; ZSM), posterior phallus (posterior section fractured); **14.** Paratype, Crete, N-Lasithi (Mally prep. no. 863; ZSM), posterior phallus; **15.** Crete, Imbros (Mally prep. No. 982; NHMO); posterior phallus. **16–17.** *U. fulvalis*, Romania, Orşova (Mally prep. no. 132; MTD), male genital (16) and posterior phallus (17). **18–19.** *U. languidalis*, Iran, Golestan, NP Golestan, Tange Gol (Mally prep. no. 163; TLMF), male genital (18) and posterior phallus (19). Left scale bar represents 500 µm for male genitalia, right scale bar represents 200 µm for posterior phalli.

rectangular, posteriomesally with a short dorsad, bulged pseudognathos. Vinculum roughly rectangular, with evenly rounded, ventrally keeled saccus. Juxta drop-shaped to elongated triangular, dorsal part tapered and deeply split, apices pointed. Valvae elongate, apex evenly rounded, costa proximally somewhat inflated, ventral edge straight to convex, but slightly concave near distal sacculus; sacculus roughly triangular, reaching distal end of fibula base; fibula elongate, triangular to claw-shaped, straight or slightly curved, posterioventrally directed, with small apical tooth. Transtilla arms short, triangular. Phallus tubular, slightly curved dorsad, without coecum; posterior

Table 1. Molecular data used in this study. GenSeq nomenclature after Chakrabarty et al. (2013).

Origin	Collection	DNA collection number	COI GenBank/ EBI access number; BOLD Barcode number	Wingless GenBank/ EBI access number	GenSeq nomencl.
Greece, Crete, Lasithi, near Moni Kapsa monastery, Perivolakia gorge, 35.021555°N, 26.050902°E, 10 m	ZSM (holotype ♂)	ZMBN Lep087	KX422253; BC ZSM Lep 61775	–	genseq-1
Greece, Crete, Rethymnon, Ano Saktouria, 35.121994°N, 24.614528°E, 400 m	ZSM (paratype ♂)	MTD Lep1590	KX422252; BC ZSM Lep 61774	–	genseq-2
Greece, Crete, Lasithi, near Moni Kapsa monastery, Perivolakia gorge, 35.021555°N 26.050902°E, 10 m	ZSM (paratype ♂)	ZMBN Lep086	LT595884	–	genseq-2
Greece, Crete, Chania Province, Imbros, 35.220867°N, 24.161978°E, 570 m	NHMO (paratype ♀)	ZMBN Lep150	LT595885	LT595888	genseq-2
Greece, Crete, Chania Province, Imbros, 35.220867°N, 24.161978°E, 570 m	NHMO (paratype ♀)	ZMBN Lep151	LT595886	LT595889	genseq-2
Greece, Crete, Chania Province, Imbros, 35.220867°N, 24.161978°E, 570 m	NHMO (paratype ♂)	ZMBN Lep152	LT595887	LT595890	genseq-2



Figures 20–23. Female genitalia. **20–21.** *Udea ruckdescheli*. **20.** Paratype, Greece, Crete, locality (Mally prep. no. 980; NHMO); **21.** Paratype, Greece, Crete, locality (Mally prep. no. 981; NHMO). **22.** *U. fulvalis*, Romania, Orşova (Mally prep. no. 020; MTD). **23.** *U. languidalis*, Iran, Golestan, NP Golestan, Tange Gol (Mally prep. no. 104; TLMF). Scale bar represents 500 µm.

apodeme dorsally with a short sub-posterior ridge bearing one to three more or less prominent triangular teeth, and a simple stout posterior ending; ventrally with weakly sclerotised strip encircling a strongly sclerotised, longitudinal, dentate sclerite; four to seven small, conical cornuti present.

Female genitalia. (Figs 20–21) Corpus bursae globular to ovoid, membranous, with a lentiform, denticulate (main) signum bearing transverse ridge of larger denticles posterior to its centre. Ductus bursae emerging from posterior centre of corpus bursae, narrowing to thin tube; anterior part of ductus bursae with slim longitudinal accessory signum of approximately half of length of main signum stretching posteriad from junction with corpus bursae; posterior part of ductus bursae slightly widened, with short sclerotized section of approximately half of length of tubular, slightly bent colliculum. Ductus seminalis emerging from short membranous intersection between posterior part of ductus bursae and colliculum. Antrum conically widening posteriad, with central channel flanked by diffuse sclerotisations stretching posteriad into the otherwise membranous ostium bursae; posterior sclerotisation of ductus bursae, colliculum and anterior part of antrum with thickened mesocuticula. Apophyses anteriores slightly angled at broadened section at one third of their length; apophyses posteriores simple, approximately half the length of apophyses anteriores. Papillae anales simple, ventrally and dorsally connected to each other, with long, simple setae.

Immature stages and food plants. Unknown.

Distribution. So far only known from the Greek island of Crete, and potentially endemic. The altitudinal distribution ranges from 10 m to 570 m.

Etymology. The species is named after Walter Ruckdeschel, the collector of the initial part of the type material.

Phylogenetic placement. The morphological investigation of external and genital characters of the adult moths of *U. ruckdescheli* resulted in the following morphomatrix coding based on the characters proposed by Mally and Nuss (2011): (1) 0; (2) 1; (3) 1; (4) 0; (5) 0; (6) 1; (7) 1; (8) 0; (9) ?; (10) 0; (11) ?; (12) 0; (13) 1; (14) 0; (15) 1; (16) 1; (17) 1; (18) 0; (19) 1; (20) 1; (21) 0; (22) 0; (23) 0; (24) 0.

The phylogenetic analysis of the combined data resulted in the well-supported placement of *U. ruckdescheli* in the *U. numeralis* species group, where it is sister to the species pair *U. languidalis*–*U. fimbriatralis* (Fig. 24). This placement is in concordance with the autapomorphic longitudinal strip of the praephallus proposed by Mally and Nuss (2011) for the *U. numeralis* species group.

Remarks. The original specimen of *Botys fimbriatalis* [sic] ab. *veneralis* Staudinger, 1870 at ZMBH (Fig. 10) is not conspecific with the specimens discussed and depicted in Slamka (2013: 76, Pl. 15 Figs 107o–r, Pl. 22 Fig. 107d, Pl. 86 Fig. 107d) as *Udea languidalis* ab. *veneralis*. Instead, the specimens and genitalia depicted in Slamka (2013) are conspecific with *Udea ruckdescheli* sp. n.

Discussion

Udea ruckdescheli was found to co-occur spatially and temporally with its closest look-alike *U. fulvalis* (leg. L. Aarvik, NHMO). Therefore, collection vouchers identified as *U. fulvalis* should be re-identified. This is a pre-requisite to elucidate the geographical distribution, which according to current knowledge would be restricted to arid habitats of the southern part of Crete from elevations between 10 m and 570 m. In addition, further collecting in the entire eastern Mediterranean would help to shed light on the geographic distribution pattern of *U. ruckdescheli*.

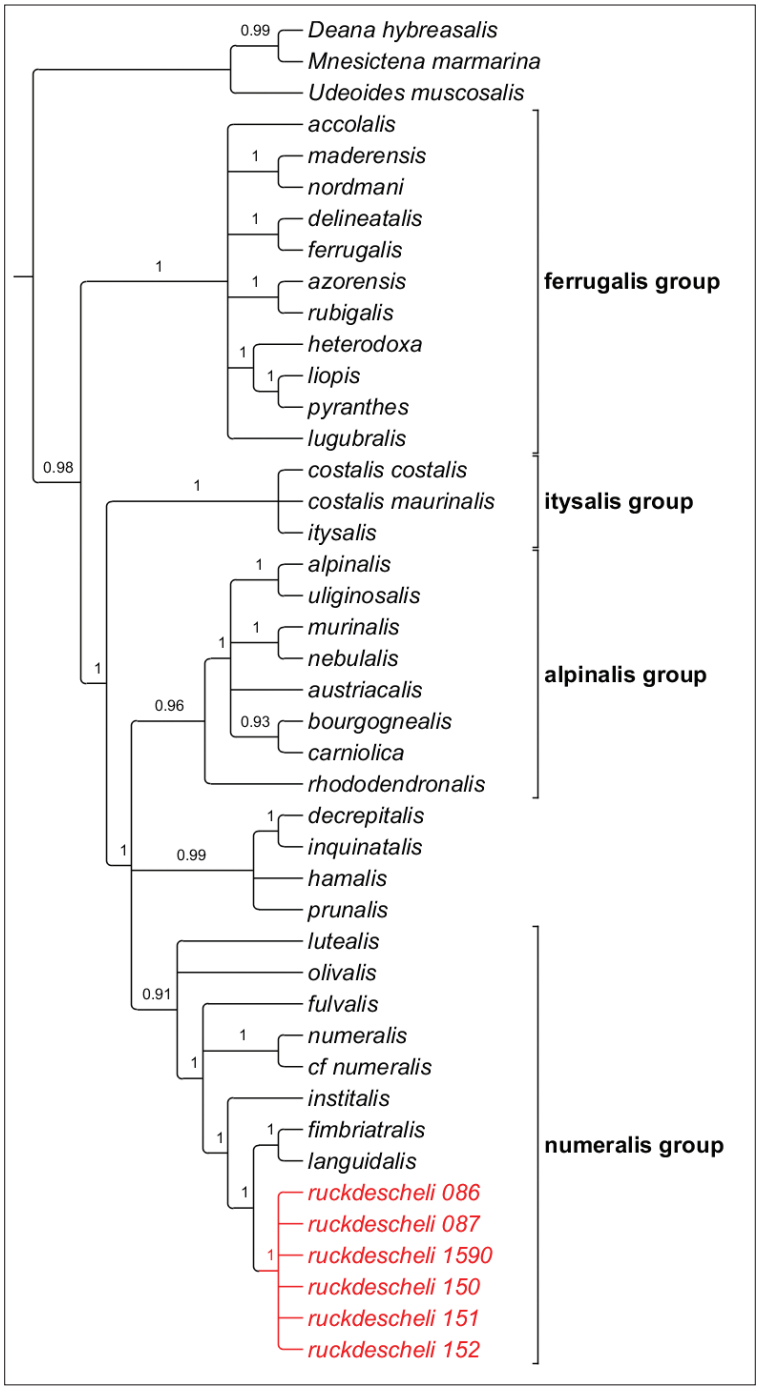


Figure 24. Bayesian inference phylogeny of European *Udea* species including *U. ruckdescheli*, sp .n. (red clade, numbers correspond to DNA collection numbers in Table 1), based on *COI*, *wingless*, and morphological data analysed with MrBayes 3.2.5. Numbers at the nodes represent posterior probabilities ≥ 0.90, nodes with posterior probabilities < 0.90 are collapsed.

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The first discovery of the genus *Narycia* (Lepidoptera, Psychidae) from Japan, with description of a new species

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Abstract. A new species of the family Psychidae *Narycia emikoae* Niitsu, Jinbo & Nasu, **sp. n.** is described from Japan with illustrations of adults and genitalia, biological information, and DNA barcode data. The larvae feed on lichens on rocks. The discovery of the new species might help us to understand the Palaearctic biogeography of psychid moths.

Introduction

The family Psychidae is comprised of nearly 1,350 species globally (Sobczyk 2011). The larvae of these moths usually make their larval cases of dead leaves and small twigs; thus, the members of this family are called bagworm moths. Adult females are usually wingless, but the females of the more primitive lineages have normal wings.

The genus *Narycia* was established by Stephens in 1836 (type species: *Tinea monilifera* Geoffroy, 1785). This genus belongs to the tribe Naricini of the subfamily Narycinae, and includes several species known from the Palaearctic Region (Sauter and Hättenschwiler 1991). Sobczyk (2011) recognized seven species of the genus: *duplicella* (Goeze, 1783) from Central to Northern Europe; *astrella* Herrich-Schäffer, 1851 from Central to Southern Europe; *negligata* Diakonoff, 1955 from Papua New Guinea; *infernalis* Herrmann, 1986 from France; *tarkitavica* Zagulajev, 1993 from Russia; *maschukella* Zagulajev, 1994 from Russia; and *archipica* Zagulajev, 2002 from Russia. Most species from the Oriental and Afrotropical region described as *Narycia* are incorrectly placed in this genus (Sobczyk 2011), and it is unclear whether *N. negligata* truly belongs to the genus. Until now, the genus *Narycia* has not been recorded from Japan.

In 2011, 2013, and 2015, one of us (SN) collected some unknown psychid larval cases at Yunomaru-kougen in Gunma Pref., Honshu, Japan. Through morphological observation of the larval cases we noticed that they were similar to those of the genus *Narycia*. They were reared and emergence of both male and female adults was obtained, both of which have well-developed wings and are capable of flight. Based on examination of the wing venation, genitalia and the foreleg condition of this species, we concluded that it belongs to the genus *Narycia* and is new to science.

In the present paper it is described as a new species, *Narycia emikoae* sp. n., and its biology is described, including the structure of the larval cases.

Materials and methods

The larvae and pupae of the new species described here were collected at the following localities: Yunomaru-kougen, Tsumagoi-mura, Gunma Pref., Honshu, Japan in 2011–2015.

For examination of the wing venation, wing scales were removed in 70% aqueous ethanol, and wings stained with acetocarmine solution. Legs and genitalia were dissected after being macerated in a 10% aqueous solution of potassium hydroxide for about ten hours at room temperature. The legs were stained with acetocarmine solution and the genitalia with chlorazol black E.

Images of adults were obtained using digital cameras. For pictures of adults, multi-focused montage (stacked) images were produced using Helicon 4.75 Pro from a series of source images taken by a Canon EOS Kiss X5 digital camera attached to a Nikon SMZ1270 microscope. In addition, images of legs and genitalia were taken using a Nikon Coolpix 8400 camera attached to a Nikon Eclips E200 microscope. Digital images of adults, genitalia and larval case were enhanced using Adobe Photoshop software.

For DNA analysis, a hind leg was removed from each reared adult (two males). Total DNA was extracted using Qiagen DNAeasy Blood and Tissue Kit and following the manufacturer's instructions. Fragments of the mitochondrial COI gene were amplified following the standard protocol for capturing DNA barcodes. The DNA fragments obtained were sequenced by the Dragon Genomic Center, Takarabio Inc, or using an ABI 3500 Genetic Analyzer. The closest species were searched, based on the DNA barcode sequence obtained, using the identification engine of Barcode of Life Data Systems (BOLD) (Ratnasingham and Hebert 2007) with all barcode records option. Sequences determined in this study are registered in the DNA Data Bank Japan (Accession No. LC160294 and LC160295).

Description

Genus *Narycia* Stephens, 1836

Nom. Br. Insects (2): 118.

Type species. *Tinea monilifera* Geoffroy, 1785 (=*Narycia elegans* Stephens, 1836), by monotypy.

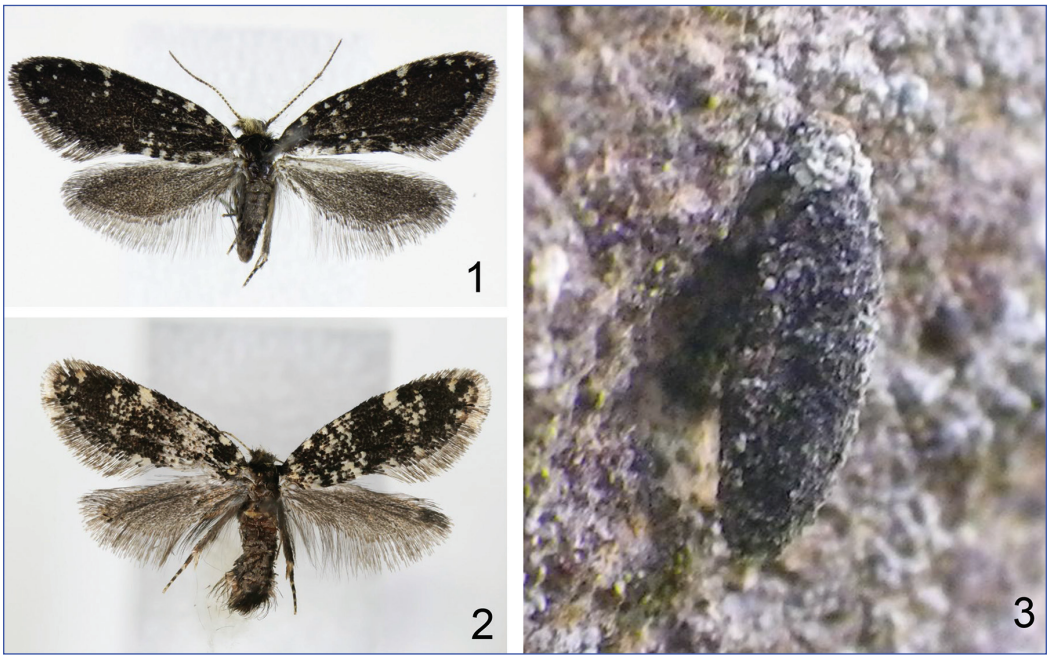
Narycia emikoae Niitsu, Jinbo & Nasu, sp. n.

http://zoobank.org/AD739F56-47BC-4907-BBF7-77C92923BC08

Japanese name: Shimofuri-chibi-minoga

Figs 1–14

Diagnosis. Small-sized blackish-brown moths (wing span 9.0–11.0 mm) with fully developed wings in both sexes. The present new species is closely similar to European *Narycia astrella* on the basis of wing color and pattern, but different from it as follows. The wing span of *emikoae* is much smaller than that of *astrella* (wing span 12–14 mm given by Kozhanchikov 1956). The large



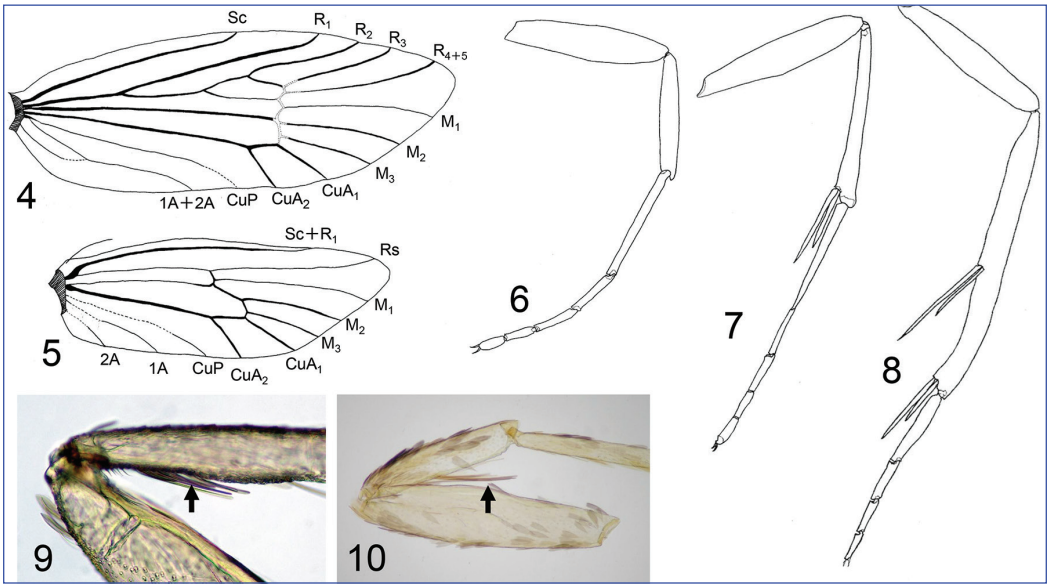
Figures 1–3. *Narycia emikoae* Niitsu, Jinbo & Nasu, sp. n. **1.** Paratype male from Yunomaru. **2.** Paratype female from Yunomaru. **3.** Larval case.

yellowish-white spot at the central costal area of the forewing in the female is much larger than that of *astrella*. It is smaller in size than *astrella* as the ratio of valva and phallus in *emikoae* is 1.0, while that of *astrella* is about 0.6 (Dierl 1972).

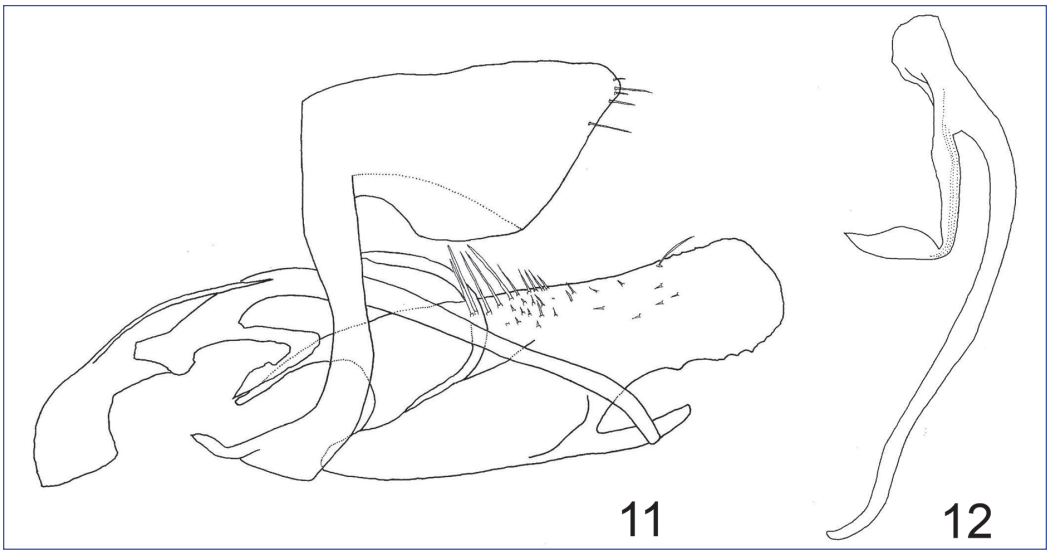
Adult (Figs 1, 2). Head clothed with light greyish-yellow hair-like scales. Antenna simple, greyish-yellow, nearly as long as half-length of forewings. Thorax and tegula blackish brown. This new species shows distinct sexual dimorphism on the point of forewing spot patterns and wing size. Forewing expanse 10.5–11.0 mm in male, and 9.0–11.0 mm in female. Forewing conspicuously triangular, narrow, blackish brown with scattered pale yellowish spots. Costal area with a row of 3–4 small clearly defined spots in both sexes. The large yellowish-white spot at the central costal area of the forewing in the female is much larger than that of male. Forewing cilia of male brown, in contrast that of female striped between greyish-yellow and blackish-brown. Hindwings narrower than forewings. Fore-tibia with a hair tuft (Figs 9–10, arrow), but lacks epiphysis in both sexes. Abdomen covered with fuscous to blackish brown scales.

Venation of wings (Figs 4, 5). Venation typical of *Narycia*. Sc terminating before middle to costa; R_1 from near middle of dicoidal cell; R_4+R_5 fused. Forewings with accessary cell cut off at upper angle of discoidal cell by the stem of R_{4+5}. The R_{4+5} reaches costa. M-stem clearly observed. The media divides the discoidal cell in half. The two branches of the cubitus are short and widely separated. 1A+2A form a short cell in the basal area and are fused in the middle area. Hindwing media simple in discoidal cell; M_1 to termen; M_3 nearer to CuA_1 than M_2; 1A and 2A separate; 3A absent.

Male genitalia (Figs 11, 12). Tegumen slightly long. Uncus rudimentary. Vinculum long and narrow; saccus small. Phallus slender, curved without cornutus, and same length as valva (Fig. 11).



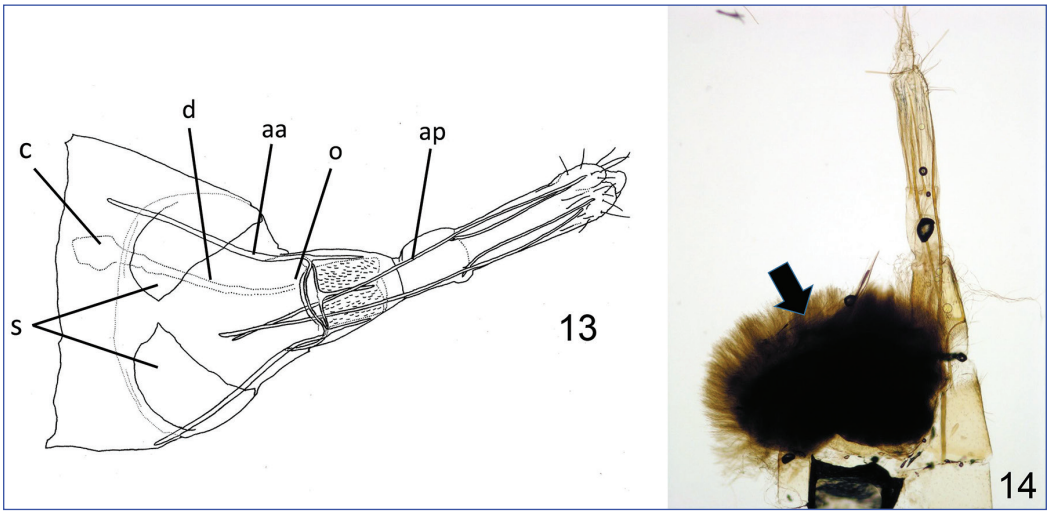
Figures 4–10. *Narycia emikoae* Niitsu, Jinbo & Nasu, sp. n. **4.** Forewing venation. **5.** Hindwing venation. **6.** Female left foreleg. **7.** Female left midleg. **8.** Female left hindleg. **9.** Male left tibia of foreleg, scaled condition. **10.** Female left tibia of foreleg, scaled condition. Black arrows point to the long hair tuft of the fore-tibia in Figs 9–10.



Figures 11–12. *Narycia emikoae* Niitsu, Jinbo & Nasu, sp. n. **11.** Entire male genitalia, lateral view. **12.** Phallus, lateral view.

Valva almost rectangular; costa armed with several setae basally; sacculus sharply protruded, becoming a finger-like process.

Female genitalia (Fig. 13). Papilla analis slender, bearing several long setae.



Figures 13–14. 13. *Narycia emikoae* sp. n. female genitalia, ventral view. (aa, apophysis anterioris; ap, apophysis posterioris; c, corpus bursae; d, ductus bursae; o, ostium bursae; s, sclerotizations of 7th sternite armed with hair tuft). **14.** A pair of large hair tufts on the seventh sternite of the female (black arrow).

Ovipositor long. Apophysis posterioris slender, longer than apophysis anterioris. Ostium bursae opens in a posterior position on segment VIII, but unclear (Fig. 13o). Ductus bursae narrow, weakly sclerotized (Fig. 13d). Corpus bursae small, weakly sclerotized, without signum (Fig. 13c). Seventh sternite with a pair of semi-circular sclerotizations (Fig. 13s), armed with a large hair-tuft (Fig. 14).

Distribution. Japan (Gunma Pref., central Honshu).

DNA barcode. Sequences of DNA barcode region were obtained from two specimens and registered to DDBJ (Accession No. LC160294, 287 bp; LC160295, 648 bp). No difference was found between 287 bp of the two obtained fragments. According to a search using BOLD identification engine, the DNA barcode sequence of the new species is the closest to those of *Narycia duplicella* with 96.53 to 97.25% similarity. The difference between the DNA barcode sequences of two species suggests that the two species should be recognized as distinct species. On the other hand, we cannot compare the new species and *N. astrella* because there is no registered sequence of the latter species in BOLD database.

Type material. Holotype - Male. Yunomaru-kougen, Gunma Pref., Honshu, Japan, 1. vii. 2011 (emerg.), S. Niitsu (Coll. ID NSMT:I-L:30417). Paratypes: 2 males, same locality as the holotype, 25. vi. 2015 (emerg.), S. Niitsu (NSMT:I-L:30420; Accession No. LC160294), 28. vi. 2015 (emerg.), S. Niitsu (NSMT:I-L:30421; Accession No. LC160295); 2 females, same locality as holotype, 22. vi. 2013 (emerg.), E. Niitsu (NSMT:I-L:30418), 27. vi. 2013 (emerg.), E. Niitsu (NSMT:I-L:30419). Types are deposited in the National Museum of Nature and Science, Japan.

Biology. Larvae feed on lichens. The larval case is oval, covered with dark green lichen and sand (Fig. 3). Length of the full-grown larval cases is 5.1–5.5 mm. The larval cases of this species have a triangular cross section and resemble those of related *Narycia* species. They are found on rocks and stone monuments that are covered with bryophytes and lichens. Adults emerge from late June to early July in mountainous areas of central Honshu. Field work has shown that the new species appears to have a two-year life cycle, from egg to adult.

Etymology. The species name is dedicated to Emiko Niitsu, who helped us to collect the bagworm of the new species.

Discussion

The genus *Narycia* is allied to the genus *Paranarychia* Saigusa, 1961, a monotypic genus known from Japan. According to Saigusa (1961), the members of the two genera resemble each other in wing coloration and pattern, with minute spots on wings of both sexes, but *Narycia* can be distinguished from *Paranarychia* by the following characters: 1) the forewings with an accessory cell ending at the upper angle of the discoidal cell by the stem of R_{4+5}, 2) the hindwing media is simple in the discoidal cell, and 3) the fore-tibia has a well-developed epiphysis. Hättenschwiler (1997) regarded the fore-tibia with a well-developed long hair tuft instead of an epiphysis in females as another diagnostic character of *Narycia*.

The new species undoubtedly belongs to the genus *Narycia*. The wing venation, the forewing color patterns and the male genitalia are typical of other *Narycia* species. The result of DNA barcode analysis also supports the inclusion of this species into *Narycia*, though DNA barcode data is available only for one known species *N. duplicella.* However, the new species has one unique character, i.e. the fore-tibia of the new species lack an epiphysis not only in the female, as other member species of *Narycia*, but also in the male. Such foreleg condition, without an epiphysis in the male, is unique to this new species.

The genus *Narycia* is widely distributed throughout the Palaearctic Region. The six known Eurasian *Narycia* species usually inhabit forests, while the new Japanese species mostly inhabits open and arid places such as roadsides. In addition, the species is also found in high altitude mountainous areas of Japan. It is considered that the high altitude areas of central Honshu in Japan function as interglacial refugia in Far East Asia for many organisms of cold regions, including Lepidoptera (Nakatani et al. 2007).

In general, small-sized psychid species feeding on lichens have low migration ability and speciation might occur in various places. In fact, the distribution area of each *Narycia* species is restricted in certain areas. Taken together, the new *Narycia* species found from central Honshu in Japan might be a relic from the glacial epoch, and this discovery may help us bring new insight to the biogeography of Palaearctic psychid moths. In future, a phylogenetic and biogeographical study will be required to clarify the systematic position of this species, the evaluation of the unique character of the male fore-tibia with a hair tuft, and the diversification of this genus.

Acknowledgments

We express our thanks to Thomas Sobczyk for taxonomic literature and useful information on the genus *Narycia* and to Emiko Niitsu for her kind assistance in our field survey. We are furthermore grateful to Dr. Ian Sims for his improvement of our English and his useful comments. Our thanks are also due to Dr. Takashi Yamasaki for his help in taking and arranging digital microscopic photographs. We also thank Drs Aino Ota-Tomita and Nobuaki Nagata for their support with the molecular analysis.

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Catapterix tianshanica sp. n. – the second species of the genus from the Palaearctic Region (Lepidoptera, Acanthopteroctetidae)

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Abstract. Based on a single adult male collected in Central Asia (Kyrgyzstan) the new species *Catapterix tianshanica* **sp. n.** is described and illustrated. The new species differs from related species by details of the male genitalia, especially by the reduction of the medial process of the transtilla and by the structure of the uncus. It is the second species of the genus and family found in the Palaearctic Region so far. The record significantly expands the distribution of *Catapterix* from Europe to Asia.

Introduction

In the 1980s the Russian lepidopterists A. K. Zagulaev and S. Y. Sinev collected an unusual micromoth on the Crimean peninsula. The species could not be assigned readily to any of the known families in Europe. As a result of a detailed study of the adult morphology (head, abdomen, wing venation, male genitalia) the collectors were convinced of having discovered a representative of a hitherto unknown evolutionary lineage within the homoneuran Glossata. It was described as *Catapterix crimaea* spec. nov. and gen. nov. and assigned to the simultaneously established family Catapterigidae (Zagulajev and Sinev 1988). The new family was placed in the then suborder Dacnonypha (outdated term for non-aglossatan, non-neolepidopteran families) and diagnosed as sister-group of Acanthopteroctetidae, a small family of five species in one genus restricted to western North America at that time (Davis 1978, 1984).

The concept of Catapterigidae did not gain much acceptance. Nye and Fletcher (1991: p.xiv) included the family in Acanthopteroctetidae (without providing a formal synonymization however) and this view was followed by most subsequent authors (Nielsen and Kristensen 1996; Kristensen 1998; Kristensen et al. 2007; Kristensen et al. 2013).

The morphological differences between the two families involve head morphology, wing venation, wing coupling and abdominal sternites – strong characters which are usually of significant weight in other lepidopteran taxa, but in light of the shared, unique genital morphology of the males, these characters appear to be homoplasious and of less importance, and thus, are of little value for separating the two families. In this evolutionary lineage even the presence or absence of a frenulum or jugum is obviously of low phylogenetic significance in comparison with other superfamilies. In addition to the male genitalia the corresponding peculiar vestiture of the antennal

segments also point to a close relationship of *Catapterix* Zagulajev & Sinev, 1988 with *Acanthopteroctetes* Braun, 1921.The two genera make up the family Acanthopteroctetidae Davis, 1978, with Catapterigidae as its junior synonym (following Nyeand Fletcher 1991).

Acanthopteroctetes was long thought be an endemic genus in western North America. Recent discoveries in South America (Kristensen et al. 2013) and South Africa (Mey 2011) demonstrated that the genus and family have a much larger distribution on the globe, which is in agreement with the antiquity of the group that is certainly of Mesozoic age (Grimaldiand Engel 2005).

Since 2002 Oleksiy Bidzilia from the Zoological Museum in Kiev has been a regular visitor to the Lepidoptera/Trichoptera collection of the Museum für Naturkunde in Berlin. He has always brought and donated Trichoptera material, which he and the second author collected during field trips in Asia. Among a number of pinned microcaddisflies from Kyrgyzstan, a single, tiny micromoth was found, which in its un-spread state indeed resembled a caddisfly from the family Hydroptilidae. Since the individual did not have eye-caps or other external characters that provided a family identification, the abdomen was removed and the genitalia examined. The specimen turned out to be a second species of the hitherto monotypic genus *Catapterix*. The surprising finding was immediately communicated to lepidopterists, who have since been collecting in Central Asia in the hope of obtaining further material of this interesting, primitive micromoth species. This hope has remained unsatisfied, and after six years of waiting we have decided to publish the description of the species at this time.

Taxonomy

Catapterix tianshanica sp. n.

http://zoobank.org/20BDD944-51DA-49A4-8578-4F8C6F0D45FE

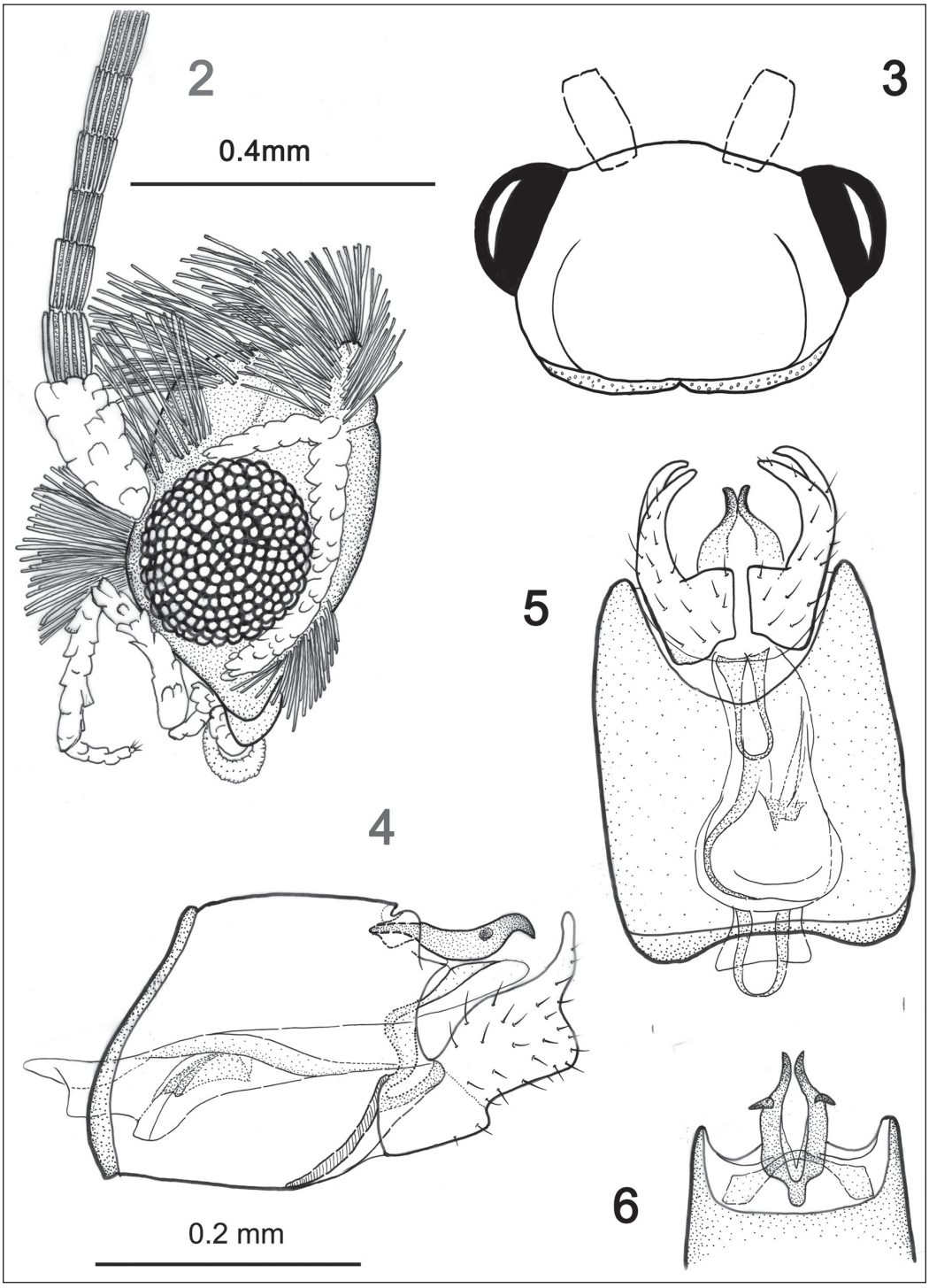
Material. Holotype ♂, labeled: "**Kyrgyzstan**/ Tian-Shan/ prov. Dzhalal-Abad/ distr.:Kotshkor-Ata/ prope pag. Toskool/ fauc. Alash-Saj/alt. 1100M, 16–17.v.2003/E. Rutjan leg. *Lum*.[at light]". Genitalia slide Mey 34/16, Museum für Naturkunde Berlin.

Description. Adult (Fig. 1). Head (Figs 2, 3): Frons, vertex and occipital area fuscous; vestiture consisting of bundles of erect, grey, hairlike scales on frons, vertex and occipital margin; vertex convex and extended dorsad, becoming flat toward the eyes; head capsule around compound eyes with grey, appressed scales; interocular index 0.6 (vertical eye diameter/interocular distance); ocelli absent. Antennae with 29 intact flagellomeres (apical ones broken off); scape covered by grey-brown scales; proximal part of pedicellus and flagellomeres with complete ring of 12–14 elongate, piliform scales, as long as antennal segment and notched at apex; cilia absent. Maxillary and labial palpi rough-scaled. Proboscis pale brown.**Thorax:** Pronotum with erect, hairlike scales; tegulae small; mesothorax with lamellar, grey-brown scales; metascutellum with few scales. Venter pale grey. Legs light fuscous to grey; epiphysis absent; spur formula 0.1.4.; tibial segments with pairs of apical, short spines. Length of forewing 3 mm; wingspan 7 mm; wings very slender with acute tips; forewings light brown, with bronzy iridescence, but without spots or fascia; some darker scales randomly scattered over apical half; fringe grey. Hindwings paler than forewings, less iridescent, uniformly grey-brown; a long frenular bristle present at costal base; jugum on both wings absent. Venation as in *Catapterix crimaea*. **Abdomen:** Uniformly grey-brown; third

Figure 1. *Catapterix tianshanica* sp. n., holotype in dorsal view.

segment without filamentous sensilla. **Male genitalia** (Figs 4–6): Segment IX clearly longer than valvae, forming a well-sclerotized, ringlike structure, not dissociated into vinculum and tegumen, but with a separated, dark ribbon on proximal margin; on ventral side proximal margin slightly excavated. Uncus in horizontal position, deeply bilobed, with ventrad curved, acute apices and one small, triangular process on each lateral side. Gnathos absent. Transtilla nearly membranous; medial process indistinct, without teeth or serrations on ventral side. Juxta incorporated into segment IX and situated in proximal position before bases of valvae, elongate, plate-like, with sclerotized margin and rounded base. Valva with somewhat rectangular base, but without sclerotized basal apophysis; broad sacculus present, bent mediad; costal margin sinuslike, terminating in a digitate process, curved dorso-mediad. Phallus tubular, as long as the entire genitalia apparatus, connected with juxta at distal opening; interior walls with folds and indistinct sclerotizations; cornuti apparently absent. **Female:** unknown.

Diagnosis. The external characters and the male genitalia of this new species are similar to *C. crimaea*. There are, however, some remarkable differences. The head capsule of the latter species is evenly rounded on the dorsal side from eyes to top of vertex, whereas in *C. tianshanica* sp. n. the head capsule around the eyes is somewhat protruded laterally to form a flattened area on the dorsal and frontal sides next to the eyes. This area is covered by appressed, lamellar scales, which are absent in *C. crimaea* and replaced by the usual hairlike scales of the head. The male genitalia



Figures 2–6. *Catapterix tianshanica* sp. n. **2.** lateral view of head; **3.** dorsal view of head capsule without vestiture; male genitalia: **4.** lateral, **5.** dorsal, **6.** ventral.

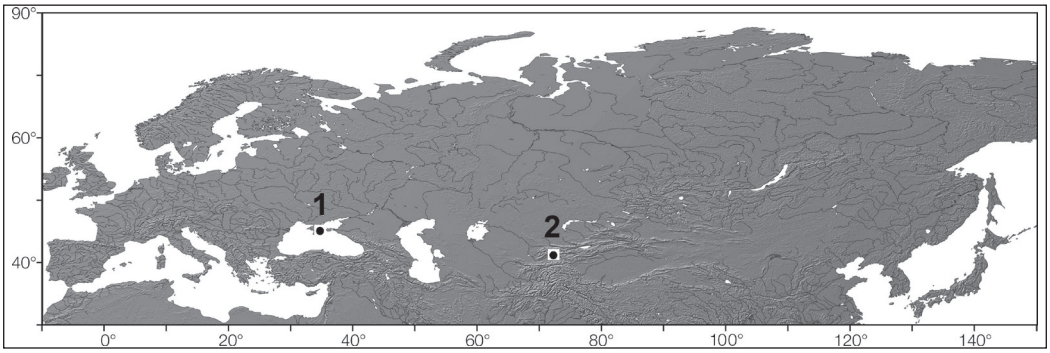


Figure 7. Distribution of *Catapterix* in the Palaearctic Region. **1.** *C. crimaea* Zaguljaev & Sinev; **2.** *C. tianshanica* sp. n.

of both species exhibit a bifid valva with apex of costal margin and sacculus as elongate processes, curved mediad. This form of valva is diagnostic to *Catapterix*. The valva of *Acanthopteroctetes* is slender, with slightly expanded sacculus. The medial, sclerotized process of the transtilla is a prominent feature of both genera. In *C. tianshanica* sp. n., however, this process is reduced and nearly membranous. Another autapomorphic character of the latter species is the enlarged uncus with subapical, triangular processes or spines on the dorsolateral sides.

Zagulajevand Sinev (1988) listed a number of differences between the genera. Some of them are not visible in the single individual of *C. tinshanica* sp. n., and are therefore omitted in the following key.

The two genera of Acanthopteroctetidae can be separated as follows:

1 Forewing uniformly coloured, or with fascia or fuscous and yellow spots; interocular index 0.75–0.8; medial process of transtilla serrate on ventral margin and tip upcurved; valva simple ..... ***Acanthopteroctetes***

– Forewing uniformly coloured; interocular index 0.6; medial process of transtilla without serration and tip straight or down-curved; valva bifid ..... ***Catapterix***

Biology. The hostplant of *Catapterix* is unknown. The larva of the North American *Acanthopteroctetes unifascia* Davis, 1975 is a leafminer of *Ceanothus* (Rhamnaceae). Another species was found to be a miner in leaves of *Ribes* (Grossulariaceae) (Regier et al. 2015, Eiseman 2016). In the western Tianshan Mts. several species of *Ziziphus* and *Rhamnus* (Rhamnaceae) are known to occur (Eisenman et al. 2013), which are potential hostplants of the new species

Biogeography. Due to the arid climate Middle Asia is an impoverished refuge of Tertiary forests, which survived only in favorable places in the mountain chains of the Tianshan. This concerns especially the deciduous trees, which are present in large numbers (Breckle and Agachanjanz 1998). The occurrence of *C. tianshanica* as an ancestral species fits quite well into this area of refuge.

The distance between the known localities of the two *Catapterix* species is about 3000 km (Fig.7). In between of these areas the Caucasus, the Elburz, and the Kopeth Dagh are situated, each representing mountain systems that contain relict species of plants and animals. The Microlepidoptera faunas of all three mountain systems are poorly explored, and thus there is a high probability that further representatives of *Catapterix* could be found there in the future.

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Examination of the Scythrididae in the Bruand d'Uzelle collection: faunistic and taxonomic implications for the genus *Scythris* (Lepidoptera, Scythrididae)

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Abstract. A review was made of the Scythrididae in the Bruand collection. This led to certain faunistic and taxonomic changes for Bruand's taxa. *Scythris subcinctella* (Bruand, 1851), **stat. rev.**, **valid spec.**, has priority over *Scythris crassiuscula* (Herrich-Schäffer, 1855). Several synonymies are established: *Scythris curtulella* (Bruand, 1851), *nomen dubium*, is possibly conspecific with *Scythris limbella* (Fabricius, 1775); *Scythris crassiuscula* (Herrich-Schäffer, 1855), **syn. nov.** (= *Scythris subcinctella* (Bruand, 1851)); *Scythris subaureicinctella* (Bruand, 1856), **syn. nov., emendation** (= *Scythris subcinctella* (Bruand, 1851)); *Scythris cinefactella* (Bruand, 1851) is a ***nomen nudum*** (= *Scythris tributella* (Zeller, 1847), not *Scythris laminella* (D. & S., 1775) as considered by earlier authors); *Scythris jurassiella* (Bruand, 1858) is a ***nomen nudum*** (= *Scythris bornicensis* Jäckh, 1977). *Scythris apicalis* (Zeller, 1847) is deleted from the French checklist. Other species from the Doubs (France) are either confirmed or refuted. The year of publication of most of the taxa described by Bruand is 1851 and not 1847 as stated in the literature.

Résumé. Les Scythrididae de la collection Bruand sont examinés. Les identifications sont revues, entraînant certaines modifications faunistiques et taxonomiques pour les taxons décrits par Bruand. *Scythris subcinctella* (Bruand, 1851), **stat. rev.**, **valid. spec.**, a priorité sur *Scythris crassiuscula* (Herrich-Schäffer, 1855). Plusieurs synonymies sont établies: *Scythris curtulella* (Bruand, 1851) *nomen dubium*, est probablement conspécifique avec *Scythris limbella* (Fabricius, 1775); *Scythris crassiuscula* (Herrich-Schäffer, 1855), **syn. nov.** (= *Scythris subcinctella* (Bruand, 1851)); *Scythris subaureicinctella* (Bruand, 1856), **syn. nov., emendation** (= *Scythris subcinctella* (Bruand, 1851)); *Scythris cinefactella* (Bruand, 1851) est un ***nomen nudum*** (= *Scythris tributella* (Zeller, 1847), non *Scythris laminella* (D. & S., 1775) comme considéré par les anciens auteurs); *Scythris jurassiella* (Bruand, 1858) est un *nomen nudum* (= *Scythris bornicensis* Jäckh, 1977). *Scythris apicalis* (Zeller, 1847) est à supprimer de la faune de France. D'autres espèces sont confirmées ou réfutées, provenant du Doubs (France). L'année de publication de la plupart des taxons décrits par Bruand est 1851 et non 1847 comme mentionné dans la littérature.

Introduction

Among the best known works undertaken by Charles Théophile Bruand d'Uzelle (1808–1861) are those concerning the Geometridae, Coleophoridae (Bruand 1859; Baldizzone 1991) and in particular Psychidae (Bruand 1853). However, other families merit our attention, such as Scythrididae,

because of Bruand's description of new taxa belonging to that family (Bruand 1851, 1858) the status of which is uncertain (Bengtsson 1997: 177, 179; Passerin d'Entrèves and Roggero 2007). Bruand's life and entomological works are the subject of two biographical publications, one by Pierre Millière (1861) and the other by Alphonse Delacroix (1862).

Bruand's collection was donated in 1849 or 1850 to the Museum of the Citadel of Besançon (Doubs, France) (Millière 1861: 653). Its condition having somewhat deteriorated, it was transferred to modern collection boxes during the second part of the 20th century, perhaps by the intervention of Pierre Réal, a French lepidopterist (Audibert 2012; Delmas 2015). Some of the specimens are in bad condition (missing abdomens, mould) or they have disappeared completely with just the label remaining.

Between 1844 and 1851, Bruand published his "Systematic and synonymic catalogue of the Lepidoptera of the département of the Doubs" ("Catalogue systématique et synonymique des Lépidoptères du département du Doubs") (Bruand 1845–1851). He dealt with the Scythrididae in 1851, placing them in the genus *Butalis* Treitschke, 1833 (= *Scythris* Hübner, 1835), pages 41 & 42 corresponding to species numbers 1323–1329. Two other species of *Scythris* were included in the genus *Roeslerstammia* (Bruand 1851: 43) with numbers 1347 & 1348, and one species in the genus *Oecophora* (Bruand 1851: 45), numbered 1362. Two species were included in the supplement to his catalogue in the articles entitled "Bulletin entomologique" (Bruand 1856: 129, 130) under numbers 1362 and 1364. In total, seventeen species are listed by Bruand for the département of the Doubs.

In his classification of the Tineidae (Bruand 1858), Bruand divided the genus *Butalis* into three groups: species with broad bodies and short proboscis; those with the male body less broad and flattened, the head looser against the prothorax; and those with a longer proboscis. In this article he revisited the list of known species of *Scythris* for Europe, mentioning the species known for the Doubs.

The date of publication of his catalogue was the subject of a study by Pierre Viette (1977). Viette gave 1851 as the date of publication of the part dedicated to the Scythrididae (part 6 after Viette), based upon receipt of the "Mémoires de la Société d'Émulation du Doubs" at the office of the French entomological society in Paris, thanks to dates handwritten in the journals.

Material and methods

In the course of a trip to Besançon, the museum curator Pascal Leblanc allowed me to examine the collection with the help of Daisy Steck. The specimens were photographed, identified by examination of the genitalia (mounted in Euparal) when this was possible (abdomen present) and the whole of the annotations made on the labels photographed and recorded.

The examination of the collection enabled the clarification of certain identifications made by Bruand and the establishment of the status of the four taxa of the Scythrididae described by him: *Butalis curtulella* Bruand, 1851, *Butalis subcinctella* Bruand, 1851, *Oecophora cinefactella* Bruand, 1851, and *Butalis grandipennis* var. *jurassiella* Bruand, 1858.

All of the French localities (Besançon, Morteau, Maison Rouge (commune of Les Bréseux), Jougne, and Mont d'Or (commune of Jougne)) are in the département of the Doubs (France).

Abbreviations: LT – lectotype; MNHN – Museum Natural d'Histoire Naturelle (Paris, France); TL – Type locality.

Systematic list of the Scythrididae in the Bruand collection

For each species, the name employed by Bruand (1849, 1858) is given. Then comes the information taken from the literature, including the original description, followed by records from the collection and the current nomenclature. Finally, there are comments on the taxonomy (possible synonyms) and the faunistics. The information in square brackets concerns external information, notably related to the handwritten labels.

Scythris obscurella (Scopoli, 1763)

There are two specimens that appear to represent *S. obscurella* (Scopoli):

1. Bruand's identification in his collection. *Butalis esperella* Hübner, 1799.

Details given in catalogue. "1323. Esperella H.[übner], Tr.[eitschke] sup.[plément], D.[uponchel] cat.[alogue] +. Juillet. De Morteau au Saut-du-Doubs. Haute-Montagne" [1323. Esperella H.[übner], Tr.[eitschke] sup.[plement], D.[uponchel] cat.[alogue] +. July. From Morteau at Saut-du-Doubs. High altitude] (Bruand 1851: 41).

Material examined. "But.[alis] esperella. B.[ruand] Cat.[alogue] du D.[oubs] [n°] 1323. Coll.[ection] Bruand. Doubs Hte [Haute]-Montagne". One specimen in box no. 55.

Current combination. *Scythris obscurella* (Scopoli, 1763) (Zeller 1855: 173).

Remarks. Identification was confirmed by examination of the genitalia (preparation no. 6012, 1 male). This species is known from mountainous areas in France (Jura, Pyrénées, Massif central, Alps), also recorded for the Doubs by Réal and Robert (1980a,b; Delmas 2015).

2. Bruand's identification in his collection. *Butalis apiciella* (Zeller, 1847) [*sic*].

Details given in catalogue: "1326. Apiciella, Z.[eller] Juin. Morteau [Doubs]. Haute Altitude" (Bruand 1851: 42) [1326. Apiciella, Z.[eller] June. Morteau [Doubs]. High Altitude].

Material examined. "But.[alis] apiciella Z.[eller] Juin Led. [Lederer?] d'un brun plus mat que seliniella / Bruand hte [Haute] montagne "[But.[alis] apiciella Z.[eller] June Led. [Lederer?] more matt brown than for seliniella / Bruand High Altitude]. One specimen in box no. 55.

Remarks. The examination of the genitalia of this specimen revealed that it is in fact *S. obscurella* (Schläger, 1847) (genitalia no. 6009, 1 male), not *S. apicalis* (Zeller, 1847) (*apiciella* as was written by Bruand) (Bengtsson 1997).

Lhomme (1935–1946: 788) listed this species as only being found in France in the Doubs, based upon this record (no. 3400). *S. apicalis* Z. 1847. [France: signalé seulement du Doubs (Bruand). VI. Chenille inconnue no. 3400. *S. apicalis* Z. 1847. In France only known from the Doubs (Bruand). VI. Larva unknown]. *S. apicalis* (Zeller, 1847) is now removed from the French checklist because there has been no other observation subsequent to this mention by Bruand and its known distribution (Armenia, Lebanon, Turkey, Iran, Greece, Romania) suggests it is absent from France (Bengtsson 1997; Passerin d'Entrèves and Roggero 2007). In addition, a search in the MNHN collection in Paris revealed no example of *S. apicalis* coming from France. On the other hand, *Scythris obscurella* is common in the Jura massif (Delmas 2015).

***Scythris bornicensis* Jäckh, 1977**

Scythris jurassiella (Bruand, 1858) **stat. rev., *nomen nudum***
Butalis grandipennis var. *jurassiella* Bruand, 1858, Classification des Tineites et examen des caractères et de leur importance relative d'après la méthode naturelle. *Annales de la Société entomologique de France*, (3), 6, 1858: 644.

Bruand's identification in his collection. *Butalis grandipennis* var. *jurassiella* Bruand, 1858.

Original description. In 1851, Bruand cited the taxon *grandipennella* [sic] (= *grandipennis* (Haworth, 1828) in his catalogue under the number "1324. Grandipennella, Haw.[orth], Gué.[née] Juin. Prise à Morteau et aussi à Maison-rouge (1ère et 3e zone)" 1324. Grandipennella, Haw.[orth], Gué.[née] June. Taken at Morteau and also at Maison-rouge (1st & 3rd zone)] (Bruand 1851: 41).

In his revision of the Tineidae (Bruand 1858: 644), Bruand made a subsequent mention of the taxon *jurassiella* as a variety of *grandipennella* [sic] [= *grandipennis*]: "var. *Minor*? *jurassiella* Brd. *in museo* (des hautes montagnes du Doubs). No description or figure accompanies this citation.

Material examined. Box no. 55 of the collection contains a specimen corresponding to this taxon, pinned under the specimen is "But.[alis] grandipennella, var. Gué [Guénée] Vr. [variété] jurassiella, Brd [Bruand]. Bruand. Doubs, hte montagne. Cat. Du D., 1324 suivant" with another label above the specimen "644 [?] M-R [Maison-Rouge] Juin xx" (Fig. 1a, b). There is also another specimen, labelled as follows: "B.[utalis] grandipennella Anglet.[erre]".

Type. Lectotype female [here designated], TL: France, Doubs, village of Les Bréseux, locality Maison-Rouge. No date. Altitude: 787 m. Kept in the Museum of Citadel of Besançon (Doubs, France).

Description of habitus: one female specimen; wingspan 15 mm; forewings and hindwings with a clear chocolate brown ground colour, bronzy. Uniform brown-bronzy, long cilia of both wings the same chocolate colour as the wing. No patterns on wings. Abdomen and head brown, bronzy. Habitus similar to a lot of others species of *Scythris*. Male unknown (see Fig. 1a, b).

Female genitalia (preparation no. 6014) (Fig. 1c). Sterigma bell-shaped with an anterior margin incised. Examination of the genitalia of this specimen shows that it is similar to *Scythris bornicensis* Jäckh, 1977 (Bengtsson 1997: fig. 384). It is not a variety of *S. grandipennis*. This taxon is not valid because there is no original description or figure made by Bruand. Therefore the status of this name is proposed to be a *nomen nudum* that is conspecific with *Scythris bornicensis* Jäckh, 1977.

Remarks. Since the citation in 1858 this name has not been mentioned in any catalogue (Lhomme 1935–1946; Leraut 1997; Bengtsson 1997; Passerin d'Entrèves and Roggero 2007) as being a *nomen nudum*.

S. bornicensis Jäckh, 1977 has been recorded in the département of Cantal (Tourlan 1986) in France. *S. bornicensis* belongs to the *grandipennis* group and is rarely observed in France (Cantal, Doubs). Known, in addition, from Germany, Switzerland and Spain (Bengtsson 1997). The citation of *S. grandipennis* in the Doubs by Bruand is, therefore, an error, as stated by Lhomme (1935–1946: 787). In contrast, *S. grandipennis* is known from the Jura, a neighbouring département to the Doubs, and from Great Britain (Bengtsson 1997).

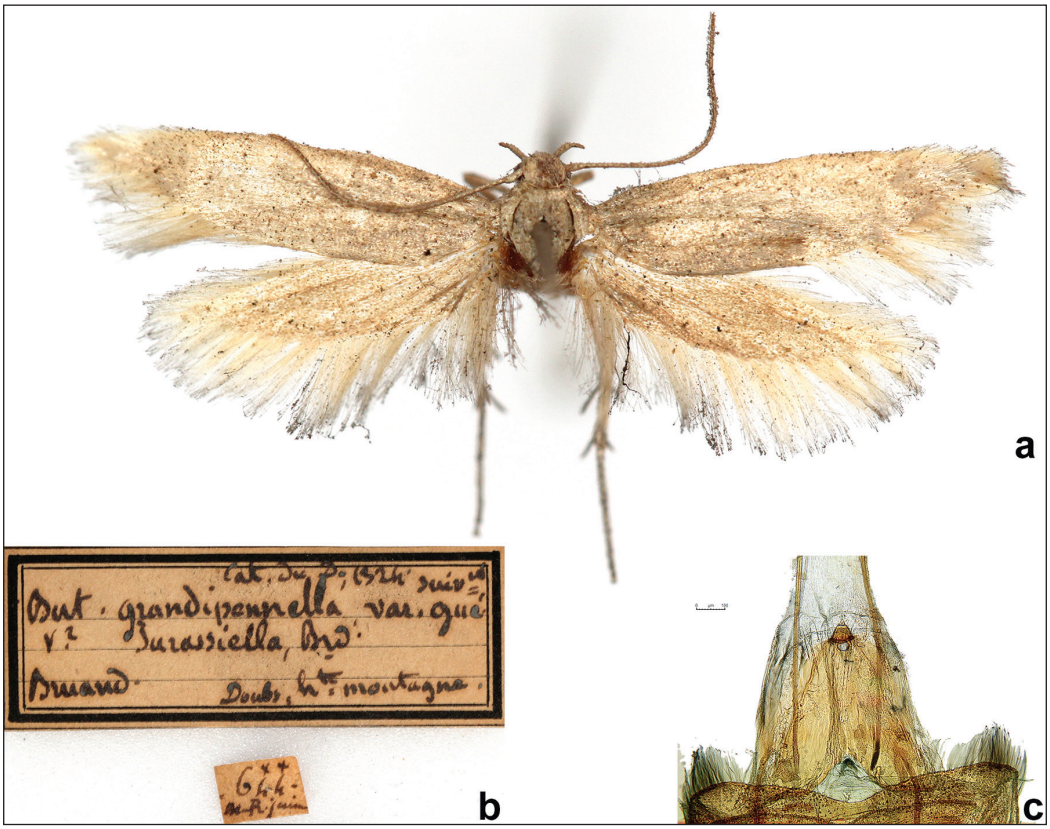

Figure 1. Holotype of *Scythris jurassiella* (Bruand, 1858), female. **a** – habitus, wingspan 15 mm; **b** – original labels; **c** – genitalia, detail of sterigma.

In 1997, Leraut cited the name "*grandipennella* Bruand, 1859" as a synonym of *grandipennis* (Haworth, 1828) (Leraut 1997: 115). The use of this name is probably a mistake. Bruand (1858: 644) used the name "*Grandipennella* (*pennis*), Haw. Vood., Gué (in litteris), […]"; no description or figure follows this citation and no publication of Bruand in 1859 concerning this taxon has been found. Therefore *grandipennella* is considered an incorrect spelling of *grandipennis*.

Scythris fallacella (Schläger, 1847)

Bruand's identification in his collection. *Butalis fallacella* Zeller [*sic*].

Details given in catalogue. "1325. Fallacella, Z.[eller] *1 Juin. Jougne. Haute montagne" [1325. Fallacella, Z.[eller] *1 June. Jougne. High altitude] (Bruand 1851: 42).

A note at the bottom of the page "*1" corresponds to the following comment: "*Fallacella* Z. est très voisine de *Seliniella*; un peu plus petite, et plus claire. Ne serait-ce pas une simple variété de cette dernière?" [*Fallacella* Z. is very close to *Seliniella*; a little smaller and paler. Is this not simply a form of the previous species?].

Material examined. "But.[alis] fallacella Z.[eller] Cat.[alogue] Lep.[idoptères] Doubs [n° 1325] Bruand hte [haute] montagne". One specimen in box no. 55.

Current combination: *Scythris fallacella* (Schläger, 1847). It is Schläger who described *fallacella* and not Zeller as written on the label.

Remarks. Examination of the genitalia for this specimen shows that it is certainly this taxon (preparation genitalia no. 6008, 1 male). The species is relatively common in French mountainous areas including the Doubs (Delmas 2015). Bruand's data is referenced in Lhomme (1935–1946: 787).

***Scythris curtulella* (Bruand, 1851), *nomen dubium*, stat. rev.**

Butalis curtulella Bruand, 1851. — Catalogue systématique et synonymique des Lépidoptères du département du Doubs. *Mémoires de la Société d'Émulation du Doubs*, (1), **3** – {**3**} (5–6), **1851**: 42.
? = *Scythris limbella* (Fabricius, 1775)

Bruand's identification in his collection. *Butalis curtulella* Bruand, 1851.

Details given in catalogue. "1327. Curtulella, Bruand * 2 Juin Jougne. Haute montagne" [1327. Curtulella, Bruand * 2 June Jougne. High altitude] (Bruand 1851: 42).

Original description. A note at the bottom of the page "* 2" gives the following comment: "Cette espèce ressemble pour la couleur à *Seliniella*; elle a le corps aussi robuste, mais beaucoup plus court, et les ailes une fois moins longues" [This species is similar in colour to *Seliniella*; it has a more robust body, but it is much shorter, as are the wings] (Bruand 1851: 42).

Material examined. There is a single specimen in the collection corresponding to this description, in box no. 55, but in bad condition with the abdomen missing. It is accompanied by a label above the specimen: "But. [Butalis] curtulella Brd [Bruand] Cat.[alogue] of the D.[oubs] [n°] 1327 Bruand Jougne" (Fig. 2a, b).

Current combination. *Scythris curtulella* (Bruand, 1851).

Taxonomic notes. The date the species was described is 1851 and not 1847 as given by Bengtsson (1997: 177) and by Passerin d'Entrèves and Roggero (2007: 19) in accordance with the details given by Viette (1977).

Bengtsson (1997) classified this species as a *nomen dubium* due to the inability to find relevant material. He noted, in addition, that this taxon could correspond to many species.

Without the abdomen, a definitive identification is uncertain. Nevertheless, the markings on the forewing strongly resemble those of *S. limbella*. The brief description by Bruand makes reference to *seliniella,* but this taxon, absent from the collection, is without ornamentation (Bengtsson 1997), in contrast to *curtulella*, which has a pattern on the forewing.

Type. Lectotype [here designated here], TL: France, Doubs, Jougne. Kept in Museum of the Citadel, Besançon, France.

Description of habitus (Fig. 2a,b) can be made as follows, with reservations considering the condition of the specimen: one example of unknown sex; wingspan 14 mm; forewing with a clear golden brown ground colour, cream subapical streak in the form of Z and the appearance of cream marking in the middle of the wing. Brown ground colour more strongly evident in the region of the subapical streak. Hindwings a uniform brown, cilia of both wings the same colour as the wing.

Figure 2. Holotype of *Scythris curtulella* (Bruand, 1851). **a** – wingspan 14 mm; **b** – original labels.

Head and abdomen missing. Left hindwing missing. A small pinhole in the left forewing. These different morphological features could permit us to propose a synonymy with *S. limbella* (Fabricius, 1775) but because of the deteriorated state of the specimen, this is uncertain, in particular as there are indications that the forewings may have been glued to the specimen. Therefore *S. curtulella* is left as a *nomen dubium*.

***Scythris subcinctella* (Bruand, 1851), Stat. rev., valid species.**

Butalis subcinctella (Bruand, 1851). — Catalogue systématique et synonymique des Lépidoptères du département du Doubs. *Mémoires de la Société d'Émulation du Doubs*, (1), 3–{3} (5–6), 1851: 42.
Scythris crassiuscula (Herrich-Schäffer, 1855), **syn. nov**.
Scythris subaureicinctella (Bruand, 1856), **syn. nov., emendation**

Bruand's identification in his collection. *Butalis subcinctella* Bruand, 1851.

Details given in catalogue. "1328. Butalis subcinctella, Bruand * 3 An. praeced femin? June Morteau. Haute montagne" (Bruand 1851: 42).

Original description. "*3" corresponds to the following comment in the note at the foot of the page: "Semblable par la taille à *curtulella*, mais l'abdomen porte en dessous un demi-anneau d'un jaune d'or. L'exemplaire unique que j'ai pris à Morteau est une femelle. Serait-ce celle de *curtulella*? [Similar to *curtulella* in size, but the abdomen is marked underneath with a golden semi-circle. The sole example that I took at Morteau is a female. Is this that of *curtulella*?].

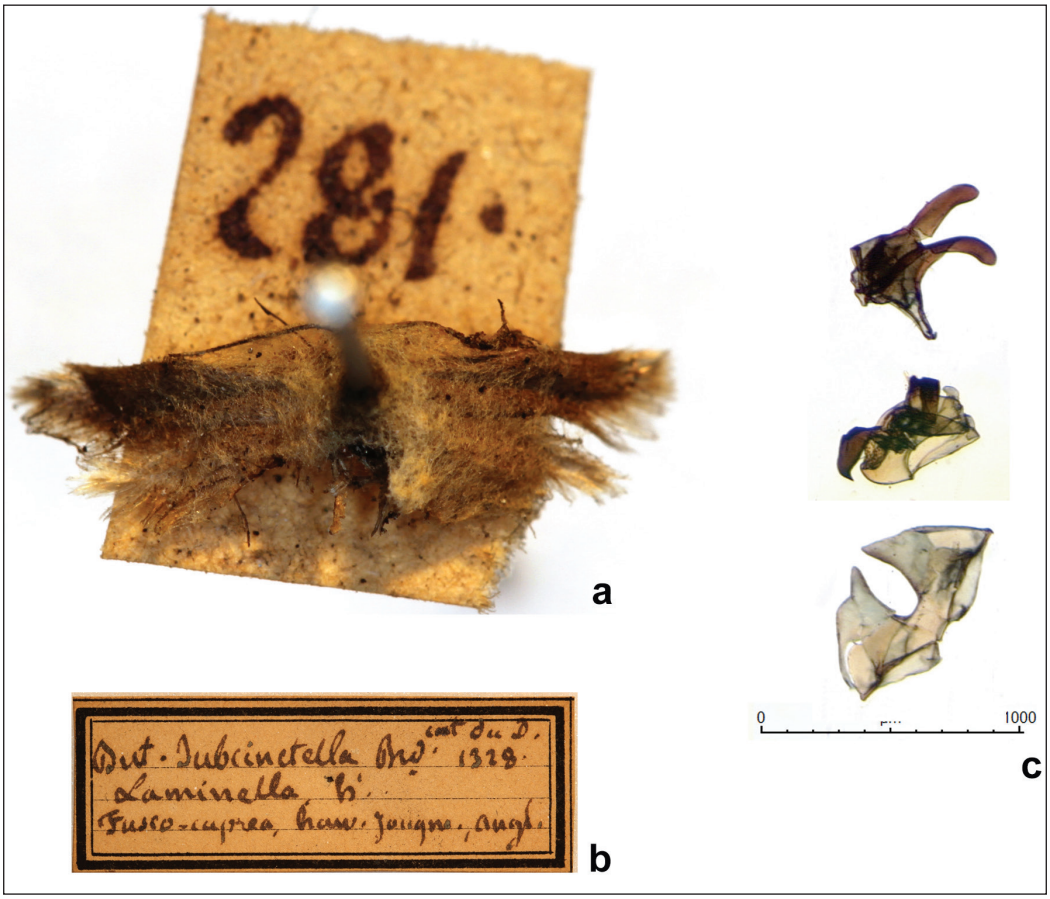

Figure 3. Holotype of *Scythris subcinctella* (Bruand, 1851), male. **a** – habitus, wingspan 9.5 mm; **b** – original label; **c** – genitalia.

Material examined. "But.[alis] subcinctella Brd [Bruand] - laminella – fusco-cuprea Haw.[orth] /Cat[alogue] du Doubs [n°] 1328 indiqué Jougne, Angl.[eterre?]" [But.[alis] subcinctella Brd [Bruand] - laminella – fusco-cuprea Haw.[orth] /Cat[alogue] of the Doubs [n°] 1328 labelled Jougne, Engl.[land?]], with a label pinned below the specimen "281"[?]. Box no. 55, a single specimen. See Fig. 3a, b.

Taxonomic notes. The description was made in 1851 and not 1847 as stated by Bengtsson (1997: 179) based on details given by Viette (1977).

Bruand listed Morteau in his catalogue, but only "Jougne" and "Angleterre" (England) are mentioned on the label. He further stated that the specimen is a female, but it is in fact a male. The type bears many patches of mould on the wings and abdomen, making it impossible to discern the golden semi-circle mentioned by Bruand. The fore- and hindwings are a uniform dark brown without any markings, as with most *Scythris* species. The remark in his catalogue "An. Praeced. Femin." refers to the hypothesis that *subcinctella* is the female of *curtulella*. The examination of both specimens show clearly that they represent two different species.

Bengtsson (1997: 179) and Passerin d'Entrèves and Roggero (2007: 40) considered this taxon a *nomen dubium* due to the inability to find relevant material.

Type. Lectotype [here designated], 1 male. TL: France, Doubs, Jougne. Kept in Museum of Citadel of Besançon (Doubs, France). No date. See Fig. 3a, b.

Description of habitus: wingspan 9.5 mm. Small species. Fore- and hindwings uniform dark chocolate brown, without markings. Abdomen and head dark cholocate.

Male genitalia (Fig. 3c). Preparation genitalia no. 6010. Uncus bilobed, sclerotized. Gnathos sclerozited with a terminal angle. Sternum 8 with deep incurvation. Similar to *Scythris crassiuscula* (Herrich-Schäffer, 1855) (Bengtsson 1997: 246, fig. 157).

In 1858, Bruand again used the name *subcinctella* and elaborated at the foot of the page (p. 645) "En 1856, j'ai désigné cette espèce sous le nom plus caractéristique de *subaureicinctell*a" [In 1856, I gave this species the more appropriate name *subaureicinctella*]". This proposal of an emendation of name adds to the confusion, the more so because no trace of a publication in 1856 with this emendation of the name has been found.

In conclusion, this taxon described by Bruand in 1851 has priority over *crassiuscula* Herrich-Schäffer in 1855.

***Scythris laminella* (Denis & Schiffermüller, 1775)**

Lita aereella Duponchel, 1842, **syn. nov.**

Bruand's identification in his collection. *Butalis (Lita) aereella* (Duponchel, 1842)

Details given in catalogue. "1329. Butalis aereella, D. (*Lita*) Juin-Juillet. Morteau. Haute montagne ["1329. Butalis aereella, D. (*Lita*) June-July. Morteau. High altitude] (Bruand 1851: 42).

Material examined. Box no. 55 of the collection contains a single matching specimen, together with a label above it: "But. aereella D.[uponchel] Déterminé par lui [Duponchel] gravatella Zeller suivant Led.[erer] Bruand hte [Haute] montagne "[But. aereella D.[uponchel] Identified by him [Duponchel] gravatella Zeller after Led.[erer] Bruand hte [Haute] montagne] and with a label below the specimen 17.X Morteau". See Fig. 4a, b.

Taxonomic notes. The status of *Lita aereella* Duponchel, 1842 has been the subject of a number of articles (Duponchel 1842, 1844; Herrich-Schäffer 1855; Joannis 1915). Currently it is thought to be a synonym of *S. tributella* (Zeller, 1847), but with some reservations because of the absence of types for *aereella* (Bengtsson 1977).

Bengtsson (1977) summarised the history of this taxon. Duponchel (1842: 475–476, pl. 86, fig. 11) described the species, without giving a locality, under the name of *Lita aereella*. In 1844, Duponchel placed it in synonymy with *Oecophora parvella*, this time giving Germany as the type locality. Herrich-Schäffer validated the name *parvella* 1855. In addition, *O. parvella* H.-S., 1855 is considered to be a junior synonym of *S. terrenella* (Zeller, 1847), itself a junior synonym of *S. tributella* (Zeller, 1847) (Passerin d'Entrèves 1980).

The note on the label for *aereella* in the Bruand collection "identified by him" indicates that Duponchel had identified the specimen that Bruand possessed. There is no type specimen in the Duponchel collection in the MNHN in Paris. Examination of the genitalia indicates that it is *Scythris laminella* (Denis & Schiffermüller, 1775) (genitalia no. 6011, 1 male, Fig. 4c, d).

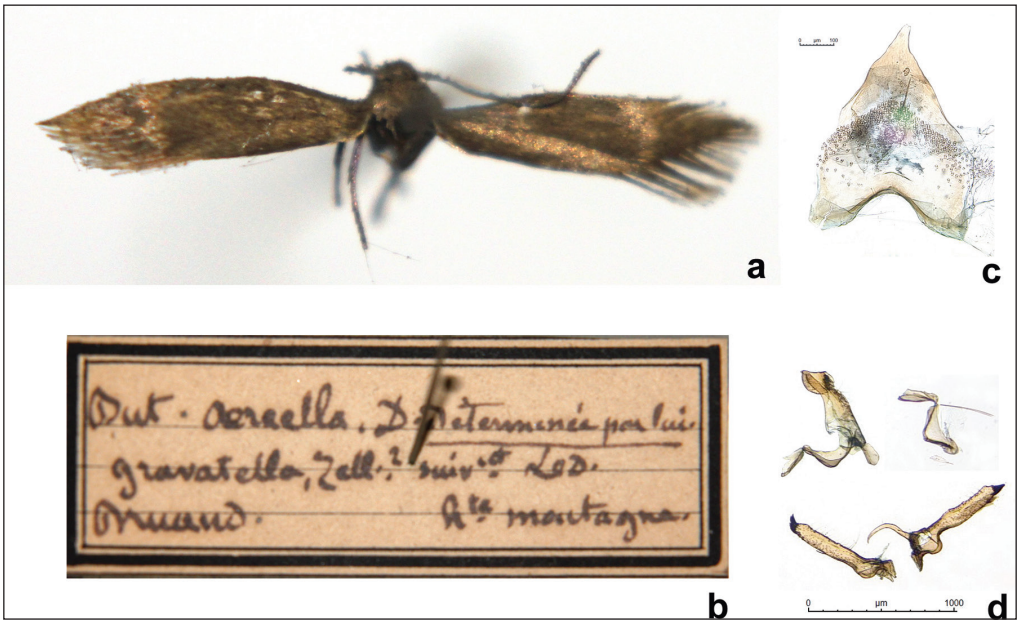

Figure 4. *Scythris laminella* (D. & S., 1775) (identified by Bruand as *Butalis* (*Lita*) *aereella* (Duponchel, 1842)), male. **a** – habitus, wingspan 12 mm; **b** – original label; **c** – genitalia, sternum 8; **d** – genitalia.

Scythris tributella (Zeller, 1847)

Scythris cinefactella (Bruand, 1851), **stat. rev.,** ***nomen nudum***.
Scythris laminella (D. & S., 1775) *partim, s. authors*
Oecophora cinefactella Bruand, 1851. — Catalogue systématique et synonymique des Lépidoptères du département du Doubs. *Mémoires de la Société d'Émulation du Doubs*, (1), 3 – {3} (5–6), 1851: 43.

Bruand's identification in his collection. *Butalis cinefactella* Bruand, 1851.

Details given in catalogue. This taxon was mentioned by Bruand for the first time in 1851 (p. 43) in the genus *Oecophora* under number 1362. Cinefactella, Gué.[née] Juin. Montagne. [1362. Cinefactella, Gué.[née] June. Mountains.]. No description or complementary information accompanies this name.

In 1858 (p. 646) he mentions this taxon in the genus *Butalis* as "cinefactella, Gué. [Guénée (sic): Guenée] (*in litteris*), Laminella, H.?".

Original description. none.

Material examined. In the box no. 55 of the collection there are two corresponding specimens with a label above them reading: "But. cinefactella. Laminella, B^{r} [?, Bruand]. Bruand. Gué. [Guénée (*sic*): Guenée] Chatill. [on-sur-Lison] M^{n} Rge [Maison rouge]". See Fig. 5a, b.

Taxonomic notes. *S. cinefactella* was placed in synonomy with *S. laminella* (Denis & Schiffermüller, 1775) by Leraut (1997: 115), probably by taking into account a statement of synonomy by

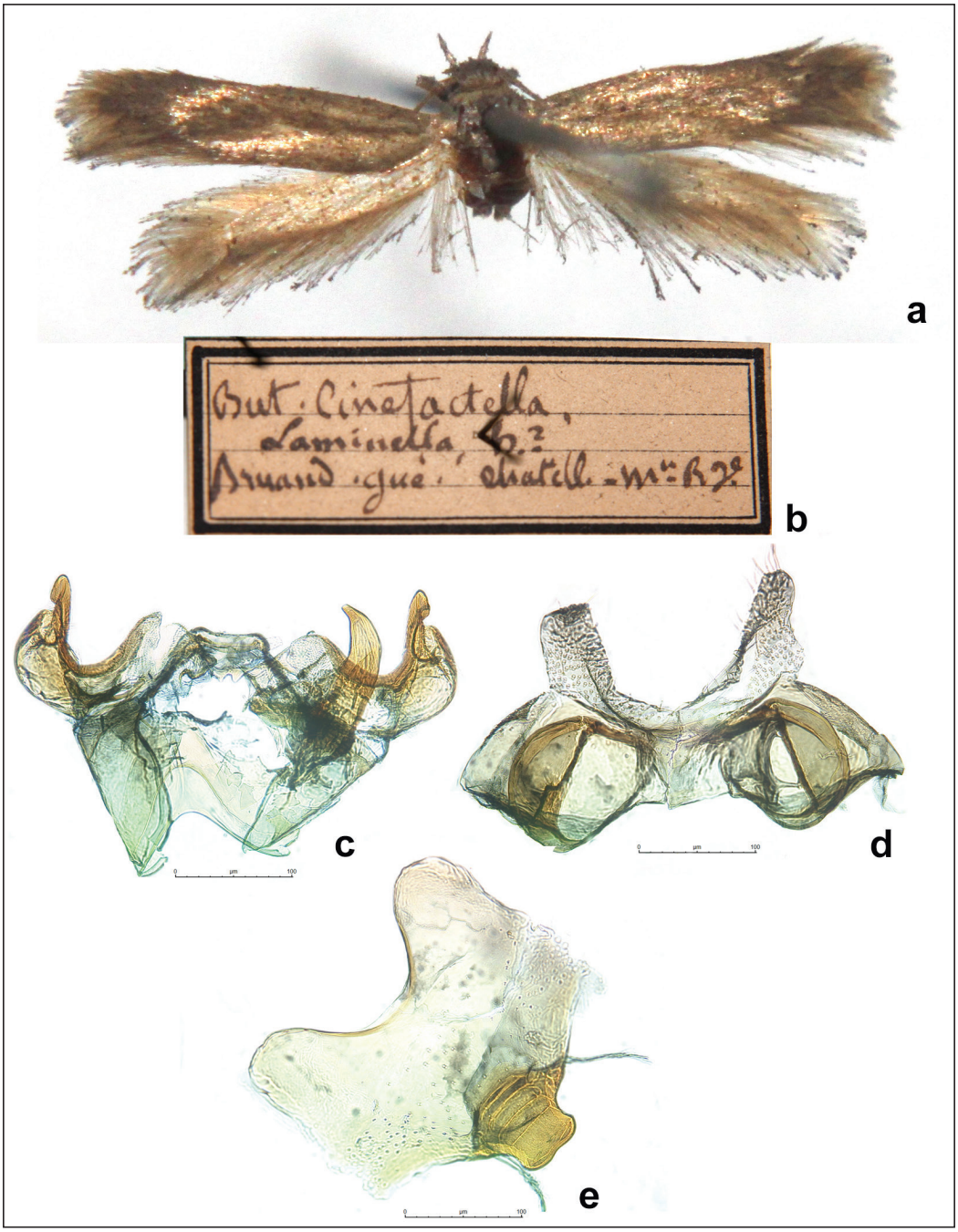

Figure 5. Holotype of *Butalis cinefactella* (Bruand, 1851), male. **a** – habitus, wingspan 12 mm; **b** – original label; **c** – genitalia, valvae, phallus, tegument, and gnathos; **d** – genitalia, tergum 8; **e** – genitalia, sternum 8.

Bruand himself in 1858 with *S. laminella* (Bruand 1858: 646). However, the specimen referred to is *S. tributella* (genitalia no. 6005, 1 male). Since this citation is dated to 1851, the taxon was not mentioned by Lhomme (1935), by Bengtsson (1997) or by Passerin d'Entrèves and Roggero (2007).

Type. Lectotype male [designated here], TL: France, Doubs, Chatillon-sur-Lison. Deposited in Museum of Citadel of Besançon (Fig. 5a, b).

Description of habitus: very small species, wingspan 12 mm; fore- and hindwing chocolate brown without markings, wings slightly shiny at the base, head and abdomen black, hindwings lighter than forewings. The description of the imago is consistent with that for *tributella.*

Genitalia (preparation genitalia no. 6005, Fig. 5c, d, e) male. The description is strictly similar to *tributella*: "Valvae resembling a bird-head; phallus short, tapered. Tergum 8 trapezoid, with anterior margin incurved, posterior strongly sclerotized. Sternum 8 bell-shaped" as written by Bengtsson (1997: 114).

***Scythris picaepennis* (Haworth, 1828)**

Bruand's identification in his collection. *Butalis fuscocuprella* Haworth, 1828 [*sic*].

Details given in catalogue. None.

Material examined. In box no. 55, a label (pinned above the specimen) mentions the species "B.[utalis] fuscocuprella Haw.[orth] subauricinctella Brd [Bruand] subcinctella Cat.[alogue] du D.[oubs] [n°] 1328 Angl.[eterre]. "[B.[utalis] fuscocuprella Haw.[orth] subauricinctella Brd [Bruand] subcinctella Cat.[alogue] du D.[oubs] [n°] 1328 Eng[land]]. Another label pinned under the specimen reads "282" [?] (Fig. 6a, b).

Taxonomic notes. The taxon *fuscocuprella* Haw. [*sic*], the correct spelling of which is *fuscocuprea* Haworth, 1828, was placed in synonomy with *Monochroa tenebrella* (Hübner, 1817) (Gelechiidae) by Bradley (1966). However, examination of the relevant specimen shows that it is *Scythris picaepennis* (Haworth, 1828) (preparation genitalia no. 6007, 1 female, Fig. 6c). The species is known from Great Britain (Bengtsson 1997). The specimen must have been sent by Edward Doubleday (1881–1849), an English lepidopterist with whom Bruand corresponded regularly. That three names are mentioned on the label is probably an error by Bruand, who deals separately on the one hand in his monograph of the Tineidae with *fuscocuprella* Haw. [*sic*], and on the other hand with *subcinctella* Bruand and *subaureicinctella* Bruand (see the remarks to *S. subcinctella*).

***Scythris seliniella* (Zeller, 1839)**

Bruand's identification in his collection. *Butalis seliniella* Zeller, 1839.

Details given in catalogue. "1324 bis. But.[alis] seliniella Z.[eller], D.[uponchel], sup. Juin Haute montagne; abondante à Jougne, flanc méridional du Mont d'Or" [1324 ditto. But.[alis] seliniella Z.[eller], D.[uponchel], sup. June Mountains; at Jougne abundant, southern face of Mont d'Or] (Bruand 1856: 130).

Material examined. There is a corresponding specimen in box no. 55 of the collection, in a bad state, the abdomen missing, accompanied by a label above the specimen which reads "But.[utalis] seliniella Z.[eller] D.[uponchel] Sup.[plément] Cat.[alogue] du D.[oubs] [n°] 1324 bis Bruand. hte [Haute] montagne Jougne"

Figure 6. *Scythris picaepennis* (Haworth, 1828) (identified by Bruand as *Butalis fuscocuprella* Haworth, 1828), female. **a** – habitus, wingspan 11 mm; **b** – original label; **c** – genitalia.

[But.[utalis] seliniella Z.[eller] D.[uponchel] Sup.[plement] Cat.[alogue] of the D.[oubs] [n°] 1324 ditto Bruand. hte [Haute] montagne Jougne].

Current combination: *Scythris seliniella* (Zeller, 1839).

Remarks. It is impossible to identify this specimen without the abdomen.

***Scythris punctivitella* (O. G. Costa, 1836)**

Bruand's identification in his collection. *Butalis knochella* Fabricius, 1794.

Details given in catalogue. The species is mentioned in the revision of the Tineidae of the Doubs (Bruand 1858: 645) with no further comments.

Material examined. In box no. 55 of the collection there is a corresponding specimen, with a label above it which reads "But.[alis] knochella F. not knochiella, h. [Herrich-Schäffer] Soc. Linn. Mann Spalato [Split, Croatie]" and with another label pinned under the specimen "381" [?].

Current combination: *Scythris knochella* (Fabricius, 1794).

Remarks. Instead of *S. knochella* as so far considered, the specimen is in fact *Scythris punctivitella* (O. G. Costa, 1836) (preparation genitalia no. 6013, 1 male). The species is known from Croatia (Bengtsson 1997). This specimen was probably sent to Bruand by Josef Johann Mann, a famous lepidopterist.

***Scythris gravatella* (Zeller, 1847)**

Bruand's identification in his collection. *Butalis vagabundella* Zeller [*sic*] and *Butalis gravatella* Zeller, 1847.

Details given in catalogue. The taxa *vagabundella* and *gravatella* are mentioned in the revision of the Tineidae (Bruand 1858: 646) with no place of origin given.

Material examined. In box no. 57 of the collection there is a corresponding specimen, without abdomen, accompanied by a label above the specimen which reads "B.[utalis] anae vagabundella Z.[eller], Bruand, Alpes" and another, without abdomen, with the label "B. anae gravatella Z.[eller] Bruand Jougne".

Current combination: *Scythris gravatella* (Zeller, 1847). *S. vagabundella* H.-S., 1855, is a synonym of *S. gravatella* (Zeller, 1847) (Bengtsson 1997: 134). The name of the author of *vagabundella* is Herrich-Schäffer and not Zeller.

Remarks. It is curious that, without explanation, the word *anae* appears before the name of the species. The locality "Alps" and the impossibility of verification (specimen without abdomen) makes this record of little use. The species is more commonly known from southern Europe. *S. gravatella* is known from the Mediterranean region and from Charente-Maritime (Courtois 1995; Delmas 2015) but there are no records from the Jura.

***Scythris noricella* Zeller, 1843**

Bruand's identification in his collection. *Butalis noricella* F.-R. [*sic*].

Details given in catalogue. The species is mentioned in the revision of the Tineidae without giving any distribution information (Bruand 1858: 646).

Material examined. There is one specimen without abdomen in box no. 56 of the collection, the label as follows: "But.[alis] noricella F.[ischer von] R.[öslerstamm] Autriche".

Current combination: *Scythris noricella* Zeller, 1843. The author is Zeller, not Fischer von Röslerstamm as noted by Bruand.

Remarks. Known from Austria (Bengtsson 1997) and from France (Leraut 1980: 116; Delmas 2015) in the Alps. The validity of the identification cannot be established because of the missing abdomen.

Scythris limbella (Fabricius, 1775)

Bruand's identification in his collection. *Butalis chenopodiella* Hübner, 1813

Details given in catalogue. "1348. Chenopodiella, H.[übner], F.-R. [Fischer von Röslerstamm], Z.[eller], D.[uponchel] Cat.[alogue] Juin. Besançon et au-dessous. Côtes boisées" [1348. Chenopodiella, H.[übner], F.-R. [Fischer von Röslerstamm], Z.[eller], D.[uponchel] Cat.[alogue] June. Besançon and below. Wooded hillsides] (Bruand 1851: 43).

Material examined. Three specimens are in box no. 58 of the collection under the name "Butalis chenopodiella H.[übner] Tristella D.[uponchel] not H.[übner] Bes. [Besançon]". The first is labelled "357", the second "granges pré Julien" [barns Pré Julien], which poses a problem in identifying the location, and the last is without a label.

Current combination: *Scythris limbella* (Fabricius, 1775) (Bengtsson 1997).

Remarks. Examination of the genitalia of the third specimen (1 female, preparation genitalia no. 6015) confirms this identification. The species is mentioned in the Catalogue of the Lepidoptera of the Doubs (1849: 43) in the genus *Roeslerstammia* and appears again in his revision of the Tineidae (1858: 646) with a reference to the Doubs "Cat. du D." under the genus *Butalis*. The record for the Doubs is mentioned in Lhomme (1935–1946: 802).

Scythris scopolella (Linnaeus, 1767)

Bruand's identification in his collection. *Butalis scopolella* Linnaeus, 1767.

Details given in catalogue. "1347. Scopolella, H.[übner] [fig.] 246, Z.[eller] [2] Juin Côtes rocailleuses et boisées. Besançon et au-dessous" [1347. Scopolella, H.[übner] [fig.] 246, Z.[eller] [2] June Rocky and wooded hillsides. Besançon and below]. The note related to asterisk [2] reads "Le nom des *scopolella* doit être maintenu, car la *scopolella*, H. 145, n'est autre que la *quadrella*, F." [The name *scopolella* must be retained, because the *scopolella*, H. 145, is none other than *quadrella*, F.].

Material examined. Three specimens are in the collection box no. 54 with the note "Besançon" and conform to the taxon indicated by Bruand.

Current combination: *Scythris scopolella* (Linnaeus, 1767).

Remarks. The species is mentioned in the Catalogue of the Lepidoptera of the Doubs (1851: 43) under the genus *Roeslerstammia*. Then it is also listed in his revision of the Tineidae (1858: 646) with a record for the Doubs "Cat. du D." in the genus *Butalis*. A common species, if not very common, in France.

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Phylogeography of *Koramius charltonius* (Gray, 1853) (Lepidoptera: Papilionidae): a case of too many poorly circumscribed subspecies

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Abstract. *Koramius charltonius* (Gray, 1853) (Lepidoptera: Papilionidae) is distributed in the mountains of Central Asia. We analysed genetic and phylogeographic patterns throughout the western part of its range using a mitochondrial marker (COI). We also analysed the wing pattern using multivariate statistics. We found that the species contains several unique haplotypes in the west and shared haplotypes in the east. The haplotype groups do not correspond to the wing pattern and also the described subspecies do not correspond to either the haplotypes or the groups circumscribed by the wing pattern. Currently, there are more than ten subspecies of *K. charltonius* in Central Asia; based on our analyses we suggest a reduction to only five of them. The following nomenclatural changes are applied: (1) *K. charltonius aenigma* Dubatolov & Milko, 2003, **syn. n.**, *K. charltonius sochivkoi* Churkin, 2009, **syn.n.**, and *K. charltonius alrashid* Churkin & Pletnev, 2012, **syn. n.** are new synonyms of *K. charltonius romanovi* (Grum-Grshimailo, 1885); (2) *K. charltonius marusya* Churkin & Pletnev, 2012, **syn. n.**, *K. charltonius eugenia* Churkin, 2009, **syn. n.**, *K. charltonius anjuta* Stshetkin & Kaabak, 1985, **syn. n.**, and *K. charltonius mistericus* Kaabak, Sotchivko & Titov, 1996, **syn. n.** are new synonyms of *K. charltonius vaporosus* (Avinov, 1913); and (3) *K. charltonius safronovi* Korb, Shaposhnikov, Zatakovoy & Nikolaev, 2013, **syn. n.** is a new synonym of *K. charltonius voigti* (Bang-Haas, 1927).

Introduction

The systematics of Parnassiinae (Papilionidae, Lepidoptera) is complicated and has been a subject of many debates. The first classification was created by Austaut (1889) based on the sphragis structure (sphragis is a part of female genitalia, formed after copulation). The next classification was based on wing venation and was published by Stichel (1906). At the same time, other classifications based on male genitalia and wing pattern were created (Moore 1902; Sokolov 1929; Bryk 1935). This classification treated species-groups as separate genera or subgenera. The last genitalia-based classification was created by Korshunov (1988, 1990); he erected four generic-group taxa and built a new system for the subfamily. Kreuzberg and Dyakonov (1990) divided the 'genus *Parnassius*' into six separate (sub)genera (unable to decide between the two, they used this term) based on larval host-plant alkaloids. Many other modifications of the Parnassiinae classification were made based on wing pattern, genitalia structures, immature stages and/or host-plants preferences (Ford 1944; Munroe 1961; Eisner 1974; Higgins 1975; Hiura 1980; Hancock 1983; Igarashi 1984; Koçak 1989; Korb and Bolshakov 2011; etc.). Two major directions found in almost all the

proposed systems are splitting Parnassiini into several genera or placing all the taxa into a single genus *Parnassius* with several subgenera or groups.

Molecular studies in the last two decades did not change these systems in general. Yagi et al. (2001) showed that *Driopa stubbendorfii* (Ménétriès, 1849) and *D. glacialis* (Butler, 1866) descend from the same ancestor. Omoto et al. (2004) showed that *Hypermnestra* Ménétriès, 1848 is more closely related to *Parnassius* than to *Archon* Hübner, 1822, and they divided *Parnassius* into eight groups. Katoh et al. (2005) made the same conclusions. Nazari and Sperling (2007) and Nazari et al. (2007) showed that *Hypermnestra* and *Parnassius* form sister groups. They also found that the *Parnassius* ancestor originated in the Iranian Plateau and Central Asia. Michel et al. (2008) placed *Baronia* Salvin, 1893 into Parnassiinae and divided *Parnassius* into eight subgenera; the same division (but without placing *Baronia* inside *Parnassiinae*) was made by Omoto et al. (2008). Korb (2012) divided *Parnassius* into six genera based on male genitalia, host plants, and molecular data.

Using all the available data on Parnassiinae and published phylogenetic trees, we can conclude that 1) directions in trophic evolution in Parnassiinae (Kreuzberg and Dyakonov 1990) are similar to those in morphological evolution; and that 2) all morphological modifications in male genitalia are synapomorphic (i.e., every group having characteristic features is monophyletic) (these morphological groups correspond to published molecular groupings – for more details about male genitalia in Parnassiinae see Korb 2012).

Based on these conclusions, we follow the Parnassiinae classification developed by Sokolov (1929), Bryk (1935), Eisner (1974), Korshunov (1988, 1990), Korb (2012) and other authors, treating species-groups or subgenera as stand-alone genera, and we adopt the idea that the classification should be based on all available morphological and molecular data, rather than on selection of only one "taxonomically important" set of characters. Below is the list of taxa that we recognize as genera, together with their diagnostic features.

Genus *Driopa* Korshunov, 1988. Diagnostic characters: primary host-plants are Fumariaceae; saccus well developed; uncus and tegumen connection solid; gnathos present; valva without harpa, no caudal branches, no chaetae; sphragis massive, sclerotized, and occupying more than 3 abdominal tergits. In cladograms as a separate clade or sister to *Koramius* (see for example Omoto et al. 2004; Korb 2012).

Genus *Parnassius*. Diagnostic characters: primary host-plants are Crassulaceae, secondary host-plants are Fumariaceae; uncus and tegumen connection not solid; saccus reduced; valva with a massive harpa; sphragis not massive, occupying fewer than 3 abdominal tergits. In cladograms always as separate clade.

Genus *Tadumia* Moore, 1902. Diagnostic characters: host-plants are Crassulaceae or Fumariaceae; gnathos present; valva divided into sclerotised basal lobe with long harpa and non-sclerotised caudal lobe; uncus massive, sclerotised; sphragis weakly sclerotised. In cladograms always close to *Koramius*.

Genus *Kreizbergius* Korshunov, 1990. Diagnostic characters: host-plants are Scrophulariaceae; sphragis absent; uncus with only one lobe; uncus and tegumen connection solid; valva small, scale-shaped; phallus very long and curved (almost 90 degrees). In cladograms always as separate clade.

Genus *Sachaia* Korshunov, 1988. Diagnostic characters: primary host-plants are Fumariaceae; subscaphium present; uncus consisting of two separate lobes; saccus massive and with two parts; sphragis skinny. In cladograms most often clustering with *Kreizbergius*, but sometimes as separate clade (Omoto et al. 2004; Korb 2012).

Genus *Koramius* Moore, 1902. Diagnostic characters: host-plants are Fumariaceae; gnathos absent; uncus with direct connection to tegumen; harpa located in the median part of valva; valva with sets of chaetae; saccus cylindrical; sphragis tube-shaped. In cladograms always as separate clade. Divided into two subgenera: *Koramius* – with a two-lobed tube-shaped sphragis, short uncus (shorter than tegumen) and short harpa (less than half of valval length); *Kailasius* Moore, 1902 – with a one-lobe tube-shaped sphragis, long uncus (equal length or longer than tegumen) and long harpa (longer than half of valval length). See male genitalia in Figs 1–3.

***Koramius charltonius* (Gray, 1853)**

Koramius charltonius (Gray, 1853) (=*Parnassius charltonius*) is one of the most enigmatic butterfly species from the Central Asian mountains and as such it appears to be of never-ending interest to butterfly collectors. Almost every known population has been described as a standalone subspecies, making one wonder whether this is a case of taxonomic inflation, similar to what is seen in other species of the genus *Parnassius* (Rose 1995). The species belongs, according to Bryk (1935), Korshunov (1988, 1990), Korb (2012) and many other authors, to the genus *Koramius*, subgenus *Kailasius* together with *K. autocrator* (Avinov, 1910), *K. inopinatus* (Kotzsch, 1940), *K. davydovi* (Churkin, 2006), and *K. loxias* (Püngeler, 1901) (Omoto et al. 2004; Michel et al. 2008; Condamine et al. 2012; Korb 2012). All of them are distributed in the area of Central Asian mountains.

The mountains of Central Asia represent a biodiversity hotspot between rather poor arid lowlands and quite rich mountainous habitats (Kohler and Maselli 2009). The area consists of several mountain ranges (Alai, Tian Shan, Hindukush, Pamir, Karakoram and Kunlun) and is connected to the Himalayas. Central Asia experienced several cooling and aridification events since the Eocene-Oligocene Transition (cf. Zhang et al. 2014). The area was also an important crossroad between Asia via Iranian and Anatolian plateaus and the Mediterranean region (Manafzadeh et al. 2014). Finally, the mountains were essential for the ancestral distribution of many species now occurring further north (e.g., Kleckova et al. 2015) and also played an important role as refugia for northern species during glacial periods (Zhang et al. 2013). Michel et al. (2008) documented in several species of the genus *Koramius* that the mitochondrial lineages show a geographically structured latitudinal pattern.

Although there are several different species concepts, there is some agreement among practicing systematists on what constitutes a species. However, the same cannot be said for subspecies, but as the discussion about subspecies concept is not the aim of our study, we follow the one by Braby et al. (2012): “the definition of subspecies [should] be restricted to extant animal groups that comprise evolving populations representing partially isolated lineages of a species that are allopatric, phenotypically distinct, and have at least one fixed diagnosable character state, and that these character differences are (or are assumed to be) correlated with evolutionary independence according to population genetic structure”. The main conclusion is simple: if it is impossible to extract even a single distinguishable feature for a whole population, this is not a distinct subspecies.

We use *Koramius charltonius* as an example of a species with many described subspecies of uncertain or unstable status. From Central Asia, subspecies have been described from almost all locations where the species was found in the last 20 years. The distribution is probably wider than known and could correspond to a distribution of its host-plants, *Corydalis stricta* Steph. & Fisch. and *C. gortschakovii* Schrenk. (Fumariaceae) (Pototski and Salo 2012).

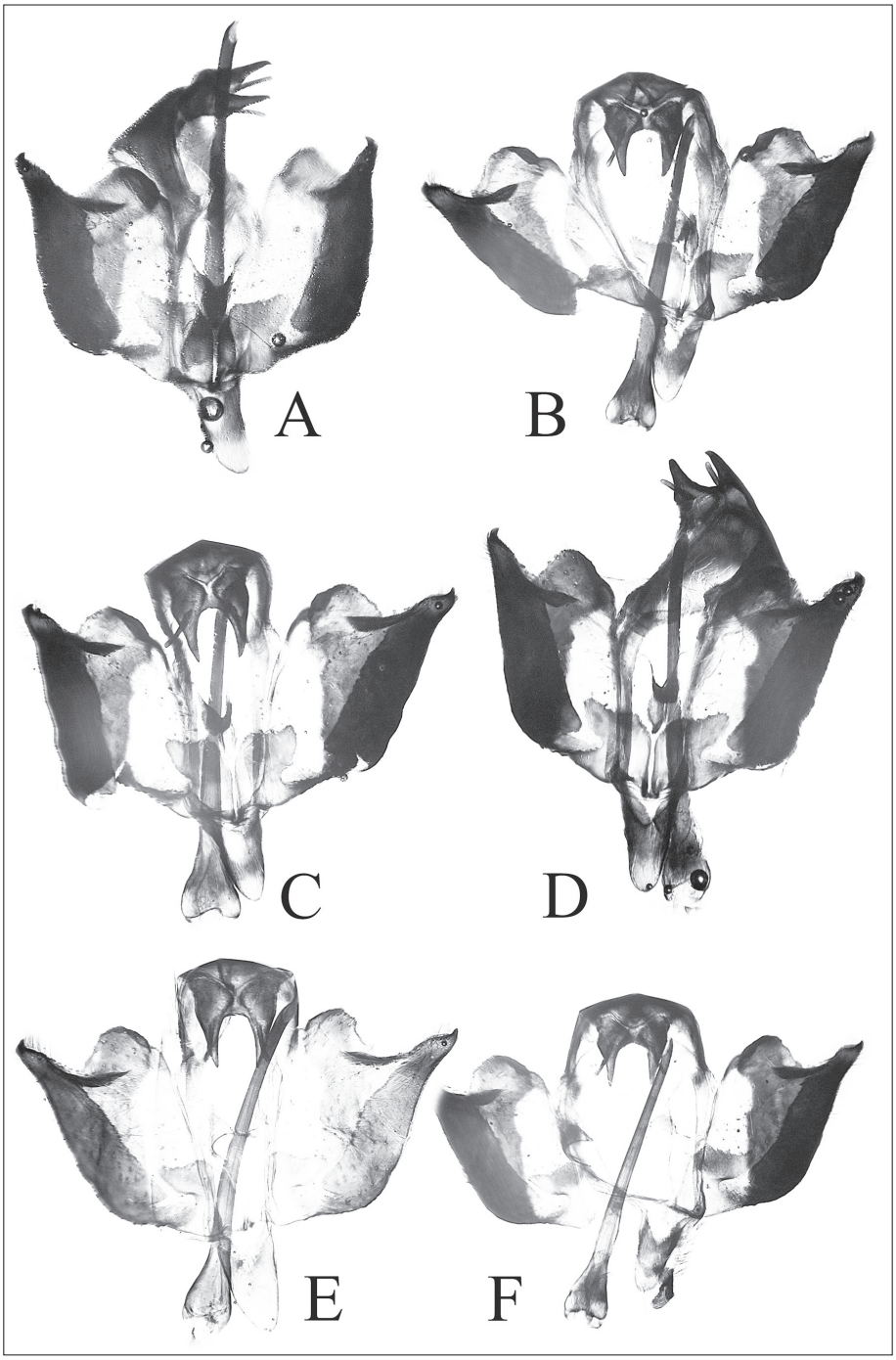

Figure 1. Male genitalia of *Driopa mnemosyne* (Linnaeus, 1758) from different locations: **A** – Kirghizia, Suusamyrtoo Mts., right shore of Suusamyr River, 2300 m; **B** – Russia, Caucasus, Teberda; **C** – EU, Slovakia, Boleraz; **D** – Kirghizia, Kirghiz Mts., Issyk-Ata Valley, 2000 m; **E** – Kirghizia, Alai Mts., Kul-Kush Valley; **F** – Kazakhstan, Transili Alatau Mts., Bolshaya Almaatinka Valley, 2500 m.

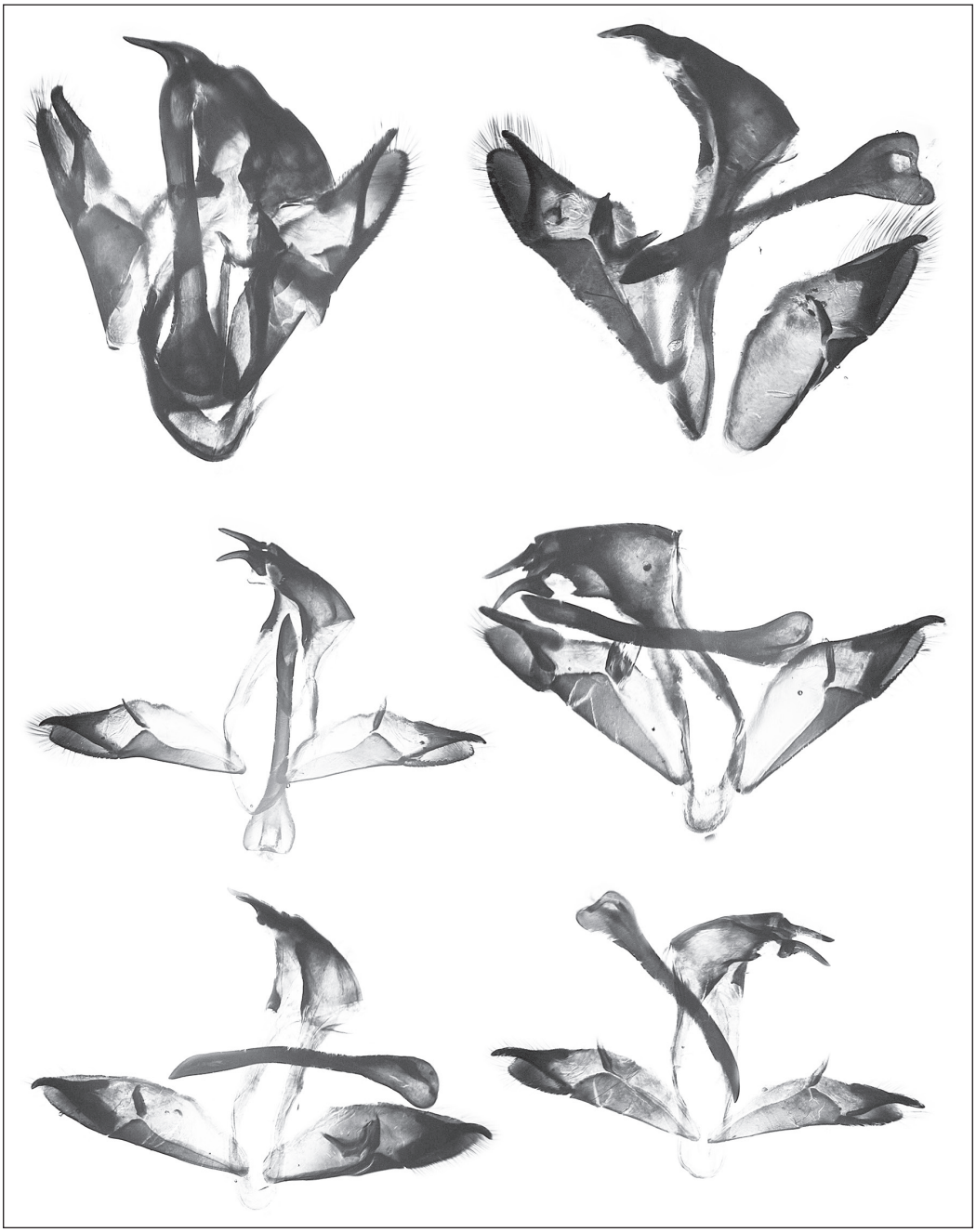

Figure 2. Male genitalia of *Parnassius apollonius* (Eversmann, 1847) from the same locality. Kirghizia, Suusamyr Valley, west shore of Karakol River, 2200–2500 m.

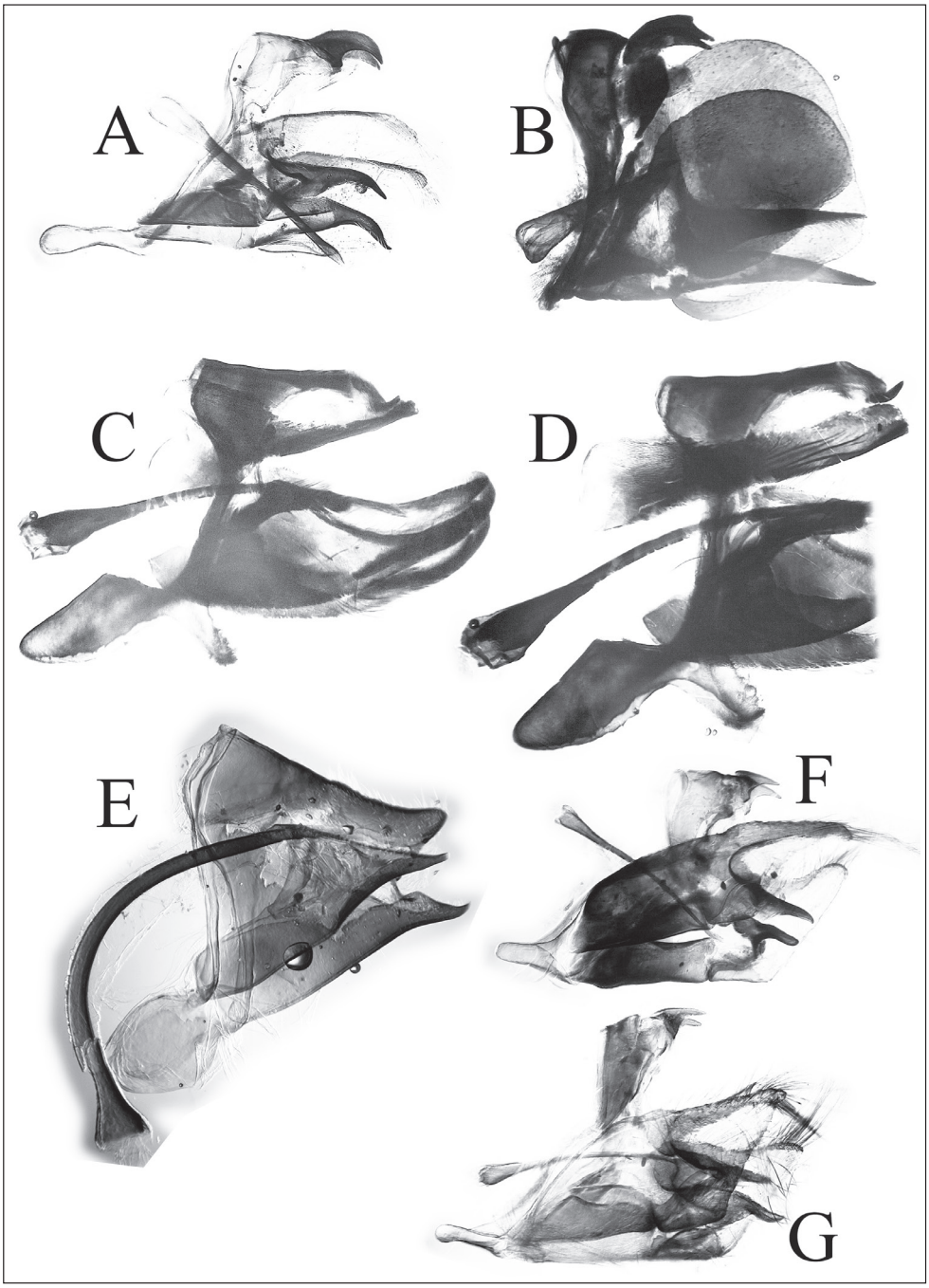

Figure 3. Male genitalia of Parnassiinae. **A** – *Koramius* (*Kailasius*) *autocrator*, Tajikistan, Sarezskoe Lake; **B** –*Lingamius szechenyii* (Frivaldsky, 1886), China, Qinhai near Tsa-Ka; **C, D** – *Sachaia tenedius* (Eversmann, 1851), Russia, Transbaikal, Mondy (in C subscaphius removed); **E** – *Kreizbergius simonius* (Staudinger, 1889), lectotype; **F** – *Koramius* (*Koramius*) *staudingeri* (Bang-Haas, 1882), lectotype; **G** – *K. stoliczkanus* (C. & R. Felder, 1865), Kashmir.

Recently Churkin and Michel (2014) sequenced a number of specimens of *K. charltonius* from various mountain ranges and they split the species into two separate species, *K. charltonius sensu stricto* and *K. romanovi* (Grum-Grshimailo, 1885). They also reassigned various subspecific names into these two species. However, we argue that their conclusions are unsupported by their own molecular data, since *K. charltonius* appears deeply paraphyletic in the published phylogenetic tree. First lineage to branch off is a sample of *K. c. voigti* (Bang-Haas, 1927) from Afghanistan, the next branch is Chinese *K. c. charltonius* (the type population!) and only after this there is a separation of *K. c. romanovi*. Also, differences in genitalia can be artefacts as proposed for instance by Stradomsky (2005). He showed that if the genitalia slide is not prepared in a uniform way of pressing the glass top onto its glass base, even specimens taken from the same population will show differences in genitalia features. In the genitalia figures by Churkin and Michel (2014), it can be seen that these micropreparations are not pressed: they have very characteristic light reflection parts which can be seen only if light falls directly on a liquid drop (without a glass top) where genitalia are located simply because the surface is not as flat as when the preparation is pressed. Therefore, in our opinion these genitalia pictures and their analysis are untrustworthy. We researched the male genitalia variability in Parnassiinae: *Driopa mnemosyne* (Linnaeus, 1758) (over 200 dissected specimens), *Parnassius apollonius* (Eversmann, 1843) (over 100 dissected specimens), *Parnassius tianschanicus* Oberthür, 1879 (over 50 dissected specimens), *Koramius delphius* (Eversmann, 1843) (over 100 dissected specimens), *Lingamius hardwickii* (Gray, 1831) (over 50 dissected specimens), as well as all other species inside this group (1–20 dissected specimens), and no variability has been found (Korb 2012). In Fig. 1 (specimens from different localities) and Fig. 2 (specimens from the same locality), this lack of variability can be seen from several examples of male genitalia.

Koramius charltonius' (Fig. 4) range includes north-western Nepal, western-most Tibet, the mountains in north-western India and northern Pakistan, north-eastern Afghanistan, Tajikistan, and southern Kyrgyzstan (Kocman 2009: 124). According to Weiss (1991), 18 subspecies of *charltonius* were recognized by the end of the 20th century. Since publishing of his book, in the last 25 years, 11 new subspecies have been added, a ratio close to one new subspecies per two years: *ljudmilae* (Lesin and Kaabak 1991), *mistericus* (Kaabak et al. 1996), *aenigma* (Dubatolov and Milko 2003), *bamianicus* (Heinkele 2003), *eugenia*, *sochivkoi*, *varvara* (Churkin 2009), *platon* (Sotchivko and Kaabak 2011), *marusya*, *alrashid* (Churkin and Pletnev 2012), *safronovi* (Korb et al. 2013). Ten of these 11 taxa have been described from the countries Tajikistan and Kyrgyzstan. Korb and Bolshakov (2011: 19–20) listed nine subspecies in these countries (taxon *sochivkoi* has been synonymised with *romanovi*; Korb and Bolshakov 2011).

Many described taxa belonging to *K. charltonius* are very difficult to place into a logical system because differences described in original descriptions begin to disappear in larger series. The wing pattern and even wing venation in Parnassiinae are very variable and cannot be used for taxon differentiation without statistical support (Korb 2012). Not even one description of a new subspecies of *K. charltonius* was based on statistically supported features (no statistical analysis based on the type or non-type series was ever made). Due to the high commercial interest, the subspecies situation is unclear and complicated, but it also gives us enough material to study a Central Asian species with fragmented distribution in high mountains suspected to have full interpopulation isolation because of the island effect. Below is the list of subspecific names of *Koramius charltonius* in Central Asia (without synonymisations). For the distribution of type localities, see Fig. 5 (numbers in Fig. 5 are taken from Table 2).

Figure 4. *Koramius charltonius* (Gray, 1853). Imago (*mistericus*, paratype, KP689312), genitalia (Chitral, Baroghil Pass), host-plant (*Corydalis gortschakovii*), habitat (Tajikistan, West Pamirs, 35–45 km N of Khorog, the type locality of *safronovi*) and sequenced specimens.

Figure 5. Distribution map of *Koramius charltonius* (Gray, 1853) in Central Asia. Black circles – type localities of described subspecies with no DNA sampled by us (mined from GenBank); black circles with grey ovals – type localities with sampled specimens (paratypes or topotypes). For numbers see Table 2.

1) *aenigma* Dubatolov & Milko, 2003. Type locality: "Kyrghyzstan, east from the Alai valley, right bank of the Kyzylsuu river at its confluence with the Koksuu river, loess-pebble bluff, 2900 m".

2) *alrashid* Churkin & Pletnev, 2012. Type locality: "NE Alai, Gulcha river".

3) *anjuta* Stshetkin & Kaabak, 1985. Type locality: "East Pamir, Mynkhadzhim mountain gorge, 4200 m".

4) *deckerti* Verity, 1907. Type locality: "Kaschmir, 4200–4800 m".

5) *eugenia* Churkin, 2009. Type locality: "Tadjikistan, Muksu R.".

6) *ljudmilae* Lesin & Kaabak, 1991. Type locality: "Tadzhikskaya SSR, Gissarsky Mts., Diakhan-Dara upper stream 40 km N of Shakhrinav, 3700 m".

7) *marusya* Churkin & Pletnev, 2012. Type locality: "Tajikistan, Obikhingou r.".

8) *mistericus* Kaabak, Sotchivko & Titov, 1996. Type locality: "Tadjikistan, South-East Pamirs, western spurs of Sarykolsky Mts Ridge, Dunkeldyk Lake, rocky crumbling slope, 4300 m above sea level".

Table 1. Material used in the morphometric analysis.

N	Subspecies	No. males	No. females	Locality
1	*aenigma*	29	8	East Aiai, Kok-Su/Kysyl-Su (Kyrgyzstan)
2	*alrashid*	13	13	East Alai, Gulcha (Kyrgyzstan)
3	*anjuta*	38	32	Mynkhadzhir (Tadjikistan)
4	*charltonius*	37	29	Tibet
5	*deckerti*	33	31	Ladakh
6	*flaugeri*	13	13	Jammu and Kashmir (India)
7	*kabiri*	15	14	Vantch Mts., Gushkhon (Tajikistan)
8	*ljudmilae*	15	12	Hissarsky Mts. (Tajikistan)
9	*marusya*	11	11	Obikhingou (Tajikistan)
10	*mistericus*	-	11	Dunkeldyk Lake env. (Tajikistan)
11	*nuristanus*	7	7	Nuristan (Afghanistan)
12	*platon*	16	15	Turkestansky Mts., Isfana (Kyrgyzstan)
13	*romanovi*	29	27	Aram-Kungei, Transalai Mts (Kyrgyzstan)
14	*safronovi*	2	7	Khorog env. (Tajikistan)
15	*sochivkoi*	26	26	North-East Alai, Ak-Bura (Kyrgyzstan)
16	*vaporosus*	42	38	Darvaz, Viskharvi Pass; Darvaz, Obimazor River (Tajikistan)
17	*varvara*	10	10	Tian-Shan, Dzhaman-Too Mts. (Kyrgyzstan)
18	*voigti*	11	11	Panjshir Valley (Afghanistan)
	In total:	**347**	**315**	

9) *platon* Sotchivko & Kaabak, 2011. Type locality: "SW Kyrgyzstan, Turkestansky Mts. Range, Sarkat River, 1500 m above s. l.".

10) *romanovi* Grum-Grshimailo, 1885. Type locality: "Transalai" (by the lectotype). Actually type locality shown in the original description located in mountainous pass near Katta-Karamuk village, South Kyrgyzstan.

11) *safronovi* Korb, Shaposhnikov, Zatakovoy & Nikolaev, 2013. Type locality: "Tajikistan, South-West Pamir, Shakhdarinsky Mts., 35–45 km N of Khorog, 3700 m".

12) *sochivkoi* Churkin, 2009. Type locality: "North-East Alai, Ak-Bura River, 2600–2700 m".

13) *vaporosus* Avinov, 1913. Type locality: "Bukhara, Darvaz, Viskharvi Pass".

14) *varvara* Churkin, 2009. Type locality: "Kyrgyzstan, Dzhaman-Too Mts., Karasu R., …2900 m".

Recently the phylogeography of several Parnassiinae species has been studied using DNA markers (Gratton and Sbordoni 2005; Gratton et al. 2006, 2008; Todisco et al. 2010, 2012). Almost all published research concerning Parnassiinae phylogeography supports the refugial theory of their dispersal across the Palaearctic Region. From these studies it is obvious that species associated with open habitats (*Parnassius apollo* (Linnaeus, 1758) and *P. corybas* Fischer von Waldheim, 1824 complex) were more widely distributed during glacial periods, whereas *Driopa mnemosyne* (Linnaeus, 1758) had a more restricted distribution during the cold phases. Our data on *K. charltonius*, which also inhabits open habitats, supports these conclusions too.

The species *K. charltonius* is currently of high commercial interest; the new subspecies are becoming valuable commodities on the market. We stress three main aims of this study: 1) to reveal the relationships of individual populations of *K. charltonius* throughout the Central Asian mountains (western part of the distribution); 2) to investigate the phylogeographic pattern in the area; and 3) to use the available information to try to test the validity of the described subspecies.

Material and methods

Specimen sampling

For this study, we selected populations known from Central Asia (we use this term to refer to the countries of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan). No special attention to selection of phenotypes has been done; rather, we paid much more attention to the reliability of localities for our specimens than to the external features, based on the principle that if a specimen originates from the locality which is now treated as an area of a certain subspecies, it must have this subspecies' features (including the COI sequence). All sequenced specimens are depicted in Fig. 4. The species is distributed also in Afghanistan, Pakistan, Tibet and India; however, it is not easy to get fresh material from these countries. We did use several samples from these locations to see how they are connected to our delimited area and we included samples of *K. charltonius* from GenBank (mainly from publications of Omoto et al. 2004; Katoh et al. 2005; Michel et al. 2008; Churkin and Michel 2014; Tables 2, 3) and also other taxa as outgroups and for calibration points (*Hypermnestra helios* (Nickerl, 1846), *Koramius stoliczkanus* (Felder & Felder, 1865), *K. acdestis* (Grum-Grshimailo, 1891), *K. augustus* (Fruhstorfer, 1903), *K. imperator* (Oberthür, 1883), *K. inopinatus* (Kotzsch, 1940), *K. autocrator* (Avinov, 1913), *K. loxias* (Püngeler, 1901)) (Table 4). To overcome the problem with potentially incorrect collecting information for the taxonomic part of our work, in cases of uncertainty we restricted our data to the type material and we omitted material from GenBank. We also investigated the type material deposited in various collections to compare it with our available specimens. Used material originated from the following collections: collected specimens by the first author (SK); private collections of Dr L.V. Kaabak (Moscow, Russia), Mr V.V. Titov (Zheleznodorozhny, Russia), Mr Y.B. Kosarev (Nizhny Novgorod, Russia); collections of the following institutions: Zoological Museum of Moscow University (Moscow, Russia), Zoological Institute of the Russian Academy of Sciences (St. Petersburg, Russia), Finnish Natural History Museum (Helsinki, Finland), British Natural History Museum (London, UK), Museum für Naturkunde an der Humboldt-Universität zu Berlin (Berlin, Germany).

The type specimens of the following *K. charltonius* taxa have been studied: *aenigma* (paratypes, 1 ♂, 1 ♀), *anjuta* (holotype ♂, paratypes 3 ♂, 3 ♀), *charltonius* (syntype 1 ♀), *eugenia* (paratypes 2 ♂, 2 ♀), *ljudmilae* (holotype ♂), *mistericus* (holotype ♂, paratypes 3 ♂, 3 ♀), *platon* (paratypes 2 ♂, 2 ♀), *romanovi* (paralectotypes 1 ♂, 1 ♀), *safronovi* (complete type series), *sochivkoi* (paratypes 1 ♂, 1 ♀), *vaporosus* (lectotype ♂), *varvara* (paratype ♂).

Additional material studied (all topotypes): *aenigma* (12 ♂, 6 ♀), *alrashid* (2 ♂), *anjuta* (14 ♂, 6 ♀), *eugenia* (2 ♂), *ljudmilae* (2 ♂, 1 ♀), *mistericus* (32 ♂, 12 ♀), *platon* (26 ♂, 26 ♀), *romanovi* (112 ♂, 43 ♀), *sochivkoi* (12 ♂, 2 ♀), *vaporosus* (56 ♂, 42 ♀); also non-topotypic material have been studied for morphometric analysis (see Table 1 for the number of specimens and origin).

Morphology and multivariate statistics

The genitalia in Parnassiinae do not show much variability and the majority of the taxa were described using only wing pattern. Therefore we selected ten wing pattern characteristics for males and females for 18 subspecies described from Central Asia. In total, we measured 347 males and 315 females (Table 1). The wing characteristics were: (1) postdiscal belt on forewing (complete or incomplete, coded as dummy variable; PosBe); (2) colour of discal and discoidal spots (black/grey, coded as dummy; Dspo); (3) white centres in red spots on hindwing upperside (total amount;

Table 2. Sampled specimens of *K. charltonius* (see Fig. 4).

N	"Subspecies" ID	Sequence ID	GenBank Accession Number	Locality	Haplotype (#, group)
1	*anjuta*	CHAR22/14	KP689301	Tajikistan, East Pamir, Mynkhadzhir mountains, 4200 m (PARATYPE)	14, C
2	*aenigma*	CHAR004/14	KP689302	Kyrgyzstan, eastern part of Alai valley, confluence of Rivers Kok-Suu and Kyzyl-Suu, 3000 m.	15, B
3	*alrashid*	IDPARN12/14	KP689303	Kyrghyzstan, Alai Mts., Gulcha River valley, 3200 m.	17, B
4	*eugenia*	PARN222/14	KP689308	Tajikistan, NW Pamirs, Muksu River valley, 3600 m.	10, A
5	*ljudmilae*	PARNB09/14	KP689304	Tajikistan, Gissarsky Mts., Shakhrinav environs, 3700 m.	12, A
6	*mistericus*	KORB0018/12	KP689312	Tajikistan, Sarykolsky Mts., Dunkeldyk lake, 4200 m. (PARATYPE)	14, C
7	*marusya*	PARN221/14	KP689307	Tajikistan, Darvazsky Mts., Obikhingou River valley, 3700 m (PARATYPE)	9, A
8	*platon*	KORB0017/12	KP689311	Kyrgyzstan, Turkestansky Mts., Sarkat River valley, 1500 m. (PARATYPE)	26, D
9	*romanovi*	IDPARN04/14	KP689305	Kyrgyzstan, Alai Mts., Kichik-Alai gorge, Isfairamsay River valley, 3500 m.	16, B
10	*safronovi*	CHAR003/14	KP689309	Tajikistan, W. Pamirs, 35- 40 km N of Khorog, 3800 m (HOLOTYPE)	21, C
11	*sochivkoi*	CHAR012/14	KP689306	Kyrgyzstan, Alai Mts., Kichik-Alai gorge, Ak-Bura River valley, 3500 m. (PARATYPE)	17, B
12	*varvara*	KORB0016/12	KP689310	Kyrgyzstan, Dzhaman-Too Mts., Karasu River valley, 2900 m (PARATYPE)	1, A
13	*voigti*	KORB0021/12	KP689313	Afghanistan, Koh-i-Baba Mts.	29, D

WcRSpot); (4) red spots on hindwing upperside (amount; RedHWU); (5) black submarginal oval spots on hindwing upperside (amount; BSubmHWU); (6) number of violet centres in black spots on hindwing upperside (VcBSpot); (7) configuration of middle red spot on hindwing upperside (oval/rounded, as a dummy; MRedS_ov/MRedS_ro); (8) colour of middle red spot on hindwing upperside (black/grey, coded as a dummy; MRedS_black/MRedS_grey); (9) ratio of width in apical part of marginal/submarginal belt on forewing upperside (PosBelInc); and (10) suffusion of central vein and central red spot on hindwing upperside (present/absent; dummy; HWU_NoSu/HWU_BlSu). We use these characteristics as predictors for inter-subspecific differences between two taxa. For the calculations we used Canonical Correspondence Analysis, which allows testing of explanatory variables on multidimensional ordination data, and the Forward Selection approach until the variability explained by the variables cannot be improved. We ran two separate analyses for males and for females in CANOCO for Windows ver. 4.5 (Leps and Smilauer 2003) with the Monte Carlo permutation test (999 permutations).

DNA sequencing and molecular data processing

DNA extraction, PCR and sequencing were carried out according to the protocols described in Vodolazhsky and Stradomsky (2008) and Fric et al. (2014). Primers LCO and HCO were used (Folmer et al. 1994), covering the "barcode region" of the first half of the mitochondrial gene Cy-

Table 3. Samples of *K. charltonius* from GenBank used in current study.

N	"Subspecies" ID	GenBank Accession Number	Locality	Haplotype (#, group)
1	*aenigma*	KJ961627	Kyrgyzstan: Irkeshtam, Chinese Kyzyl-Su River	29, D
2	*alrashid*	KJ961626	Kyrgyzstan: Gulcha River (2200–2500 m), East Alai	28, D
3	*amabilis*	KJ961611	India: Bhaga valley, Baralacha La (4400 m)	7, A
4	*anjuta*	KJ961616	Tajikistan: Mynkhadzhyr Mts., East Pamir	1, A
5	*charltonius*	KJ961609	China: Mandhata Mt. (4800-5200 m), W. Tibet	30, -
6	*charltonius*	DQ407774	Pakistan: Satrapa Pass	22, D
7	*deckerti*	KJ961610	India: Lamayuru (3900 m), Ladakh	5, A
8	*deckerti*	KJ961613	India: S. of Khardung La (5000 m), Ladakh	3, A
9	*ducalis*	KJ961618	Pakistan: Birmoglasht (2500-4000 m), Chitral	1, A
10	*eisnerianus*	KJ961612	India: N. of Tsokar (4600 m), Ladakh	6, A
11	*ella*	KJ961617	Pakistan: Soost (3000-4000 m), Khudabaad Mts.	2, A
12	*ella*	KJ961615	Pakistan: Phakora to Naltar (2000-3200 m), Gilgit	1, A
13	*eugenia*	KJ961629	Tajikistan: Muksu River, Peter I Mts.	23, D
14	*flaugeri*	KJ961614	Pakistan: Babusar Pass	4, A
15	*kabiri*	KJ961625	Tajikistan: Gyshkhun (3000 m), Vanch Mts., W. Pamir	13, C
16	*kabiri*	KJ961624	Tajikistan: Kuh-i-Lal (3500 m), W. Pamir	14, C
17	*ljudmilae*	KJ961630	Tajikistan: Karatag River basin (3500 m), Ghissar	24, D
18	*marusya*	KJ961623	Tajikistan: Obikhingou River (2200–2400 m), Darvas	23, D
19	*platon*	KJ961621	Tajikistan: Yangiaryk (1800-1900 m)	25, D
20	*romanovi*	KJ961620	Kyrgyzstan: Aram Kungei River (3500 m), Trans-Alai	22, D
21	*sakai*	AM231451	Sonamarg, Kashmir, India	8, A
22	*sochivkoi*	KJ961631	Kyrgyzstan: Ak-Bura River (2600–2700 m), NE Alai	27, D
23	*varvara*	KJ961628	Kyrgyzstan: Karasu River (3000 m), Dzhaman-Too Mts., Tian-Shan	29, D
24	*vaporosus*	KJ961622	Tajikistan: Obimazor (3500 m), Mazorsky Mts., Darvas	19, C
25	*vaporosus*	EF473789	No data	14, C
26	*voigti*	KJ961619	Afghanistan: Panjshir valley (3500-4000 m), Parvan Prov.	11, A

tochrome Oxidase subunit I. Sequencing was partly conducted in the Biology Centre of the Czech Academy of Sciences, and partly at the Nizhny Novgorod State University.

For the sequence processing, phylogenetic analysis, and producing a timed-tree we used the software BioEdit (Hall 1999), MEGA 6 (Tamura et al. 2013), MrBayes 3.2.4 (Ronquist et al. 2012), and BEAST v. 1.8.0 (Drummond et al. 2013). Maximum Likelihood tree was computed in MEGA (ML: test of phylogeny is bootstrap method (10000 replications); Tamura-Nei model; uniform rates and use all sites; ML heuristic method – NNI; branch swap filter very strong; codons included 1st+2nd+3rd+non-coding), and Bayesian trees in MrBayes (best substitution model was selected by MrModelTest v.2.2. as GTR+G+I; we ran the program for 10,000,000 generations, with 4 chains). In BEAST we applied a molecular clock using four calibration points from Condamine et al. (2012). The haplotype network was computed in TCS 1.21 (Clement et al. 2000). We also used MEGA for a construction of a genetic distance matrix. Distance matrices based on geographical coordinates and morphological data were constructed in R i386 3.2.3. The matrices were compared for potential correlation using Mantel test in a package *ade4* with 9999 permutations. Processing

Table 4. Samples of other *Koramius* and other outgroup species from GenBank used in this study.

N	Species ID	GenBank Accession Number	Country
1	*Hesperia comma*	HQ004516	Romania
2	*Hypermnestra helios*	FJ663610	Uzbekistan
3	*Koramius acdestis*	AM231457	China
4	*K. acdestis*	DQ407760	China
5	*K. charltonius* (wrongly determined as *inopinatus*)	EF473790	Afghanistan
6	*K. inopinatus*	AM231453	Afghanistan
7	*K. autocrator*	AM231454	Afghanistan
8	*K. autocrator*	EF473788	Tajikistan
9	*K. autocrator*	DQ351029	Tajikistan
10	*K. loxias*	AM231452	Kyrgyzstan
11	*K. loxias*	EF473791	Kyrgyzstan
12	*K. augustus*	AM231456	China
13	*K. imperator*	DQ407775	China
14	*K. imperator*	EF473793	China
15	*K. acdestis*	AM231457	China

of illustrations was done in Corel Draw X4 and Photoshop CS6. Statistical calculations were made by StatSoft STATISTICA for Windows.

We ended up excluding several samples from Churkin and Michel (2014) from the final phylogenetic and haplotype analyses because after inclusion of these samples, some of them did not cluster with our samples of the same subspecies/origin (Figs 7, 8). We cannot exclude the possibility that their data are good, but there are also two alternative explanations: first, laboratory mistake, and second, locality labelling mistake. Because we suspect an error at some level, we decided to exclude these samples (KJ958545, KJ958546, KJ958547, KJ958548, KJ958549).

Results and discussion

Morphometric analyses

The majority of our measured wing characteristics poorly separated subspecies of *K. charltonius*. The only excluded variable from the final model was the colour of MRedSp in males (for single-term tests, see Table 5). The models were highly significant both for males (first canonical axis: eigenvalue=0.855, F=20.013, p>0.001; all axes: trace= 3.919, F=14.635, p<0.001) and females (first canonical axis: eigenvalue=0.877, F=16.541, p<0.001; all axes: trace=5.181, F=13.327, p<0.001). Wing pattern elements explain 26.13% of variability between subspecies in males and 30.48% of variability in females. Males of *varvara*, *safronovi* and *flaugeri* form a cluster, characterized by round MredS; another cluster of males of *kabiri*, *deckerti*, *anjuta* and *voigti* is characterised by PosBeCom, PosBelIn and VcBSpot. Males of *alrashid*, *platon*, *aenigma*, *sochivkoi*, *romanovi*, *marusya*, and to some extent also *charltonius*, are characterised by HWU_NoSu and WcRSpot (Fig. 6A). A very different pattern is seen in females, where none of the male clusters are found (Fig. 6B). One female group is formed by *anjuta*, *safronovi* and *mistericus* and is characterised by grey MredS. Another group is formed by *alrashid*, *charltonius*, and to some extent also by

Table 5. Single term tests of wing pattern analyses for males and females of *K. charltonius* from CCA with 999 Monte Carlo permutations.

	Males		Females	
	F	p	F	p
PosBeCom	14.67	0.001	10.12	0.001
PosBeInc	14.67	0.001	10.12	0.001
Dspo_black	0.82	0.589	15.26	0.001
Dspo_gray	0.82	0.589	15.26	0.001
WcRSpot	11.87	0.001	14.49	0.001
RedHWU	15.81	0.001	12.92	0.001
BSubmHWU	3.43	0.002	4.17	0.001
VcBSpot	12.18	0.001	13.66	0.001
MRedS_ov	16.44	0.001	13.91	0.001
MRedS_round	16.44	0.001	13.91	0.001
MRedS_black	NA	NA	8.95	0.001
MRedS_grey	NA	NA	8.95	0.001
PosBelInc	18.55	0.001	16.04	0.001
HWU_NoSuff	12.33	0.001	4.13	0.001
HWU_BlSuff	12.33	0.001	4.13	0.001

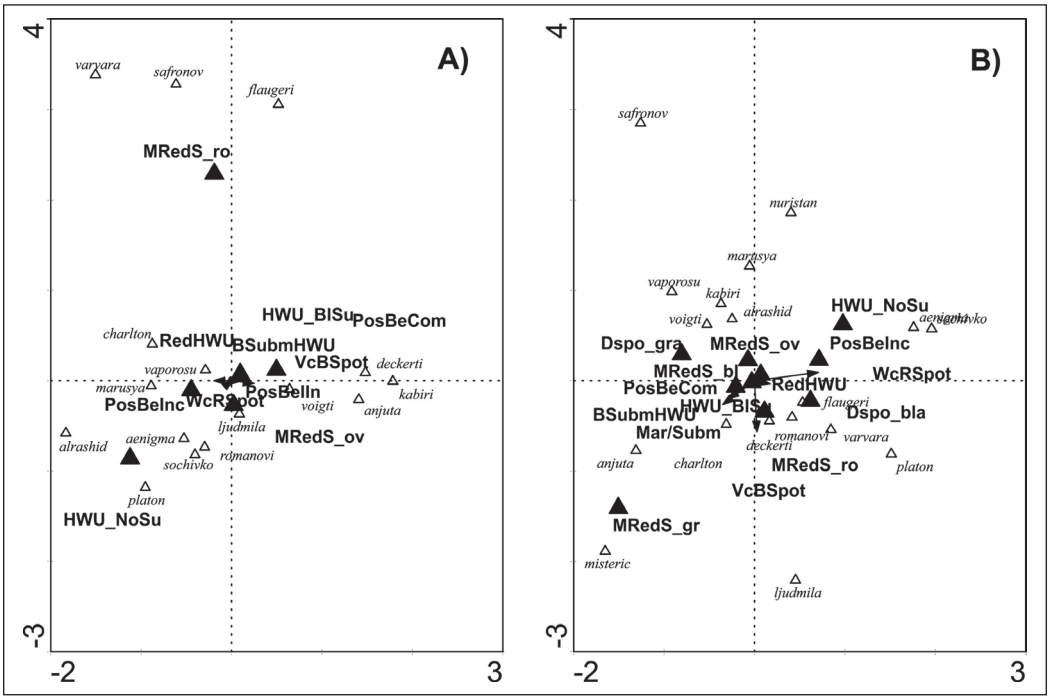

Figure 6. Ordination plots of CCA analyses of variables of wing pattern elements on subspecies of *K. charltonius*. **A**) males, **B**) females. Plotted are ordination axes 1 and 2. Continuous variables are plotted as arrows, dummy variables as white triangles. Black triangles represent the centroid of subspecies.

ljudmila and *vaporosus*, and they are characterised by oval MredS and higher ratio between Mar/Subm. Females of *aenigma*, *platon*, *flaugeri*, *varvara* and *sochivkoi* have round MredS and, together with *ljudmila*, *romanovi* and *nuristanus* also black Dspo, PosBeInc and WcRSpot.

Phylogeny and phylogeography

According to our molecular analyses (Fig. 7), *Koramius charltonius* samples form a clade that is sister to *Koramius inopinatus* + (*K. autocrator* + *K. loxias*). A surprise is that one specimen of *K. inopinatus* (Genbank Accession Number EF473790, from Omoto et al. 2004) goes inside of *charltonius* (potential causes are introgression, hybridization, or misidentification), while the second specimen of this species groups with *K. autocrator* + *K. loxias* (Fig. 7).

K. ch. charltonius from Tibet, i.e. the nominotypical subspecies, is sister to all the other populations of *K. charltonius*, which are split into two clades (ML tree; this is also supported by the network analysis and thus we prefer this arrangement), or with *K. ch. voigti* sister to other Central Asian populations (BI tree). With this exception, the BI and ML trees are very similar despite low support for the main clades. One clade is formed by populations from east Tajikistan and Kashmir (haplotype group A in Fig. 7; ssp. *ljudmilae*, *sakai*, *eugenia* and a paratype of *marusya*) plus surprisingly *varvara* from an isolated area in Kyrgyzstan. The next clade is formed by populations from Kyrgyzstan (Alai and Turkestansky Mts.) (haplotype group B in Fig. 7; *platon*, *alrashid*, *sochivkoi* and *romanovi*) as well as by close and genetically indistinguishable populations from the northern "main" mountain ranges of the Central Asian mountains, from Pamir to Tibet (haplotype groups C and D in Fig. 7; *voigti*, *safronovi*, *mistericus*, *vaporosus*, *anjuta*, *aenigma* and *charltonius s.str*.). Only populations from the eastern part of the species' range differ from the other populations. Multiple specimens from the same subspecies cluster with specimens of different subspecies in *alrashid*, *romanovi*, *vaporosus* etc. In *ljudmilae*, *voigti* and *charltonius s.str.* different specimens even belong to different clades.

Haplotype network analysis shows high haplotype divergence (Fig. 8). In total there are 30 haplotypes, which can be separated into several clusters. There are distant connections between southern (Tajikistan + Kashmir) and Kyrgyz populations and much shorter connections in haplotype rich northern and north-eastern populations. The first offshoot of *K. charltonius* on the phylogenetic trees, *K. ch. charltonius*, with our default settings does not belong to the same network. First haplotype group (A) is widely distributed across the species range. The second haplotype group is restricted to southern Kyrgyzstan. The third group is distributed in Tajikistan and Afghanistan, whereas the fourth group is again shared between a vast part of the species area.

The messiness of the phylogenetic relationships among these putative taxa is reflected in the messiness of the systematics of this species. Clearly, using the phylogenetic tree, it is impossible to circumscribe separate subspecies and this result supports our conclusions about the unrealistic number of subspecies of *K. charltonius*. On the other hand, the haplotype network visualizes the grouping and connections between the populations and it can be used for taxonomic interpretations, as it was done recently, for example, by Pazhenkova et al. (2015).

Taxonomic implications

Even when we take into account the differences between ML and BI trees, we see that the number of described subspecies is not realistic. Moreover, our results do not support the traditional division of described subspecies into groups (*sensu* Weiss 1991) as all the clades are a mix of several

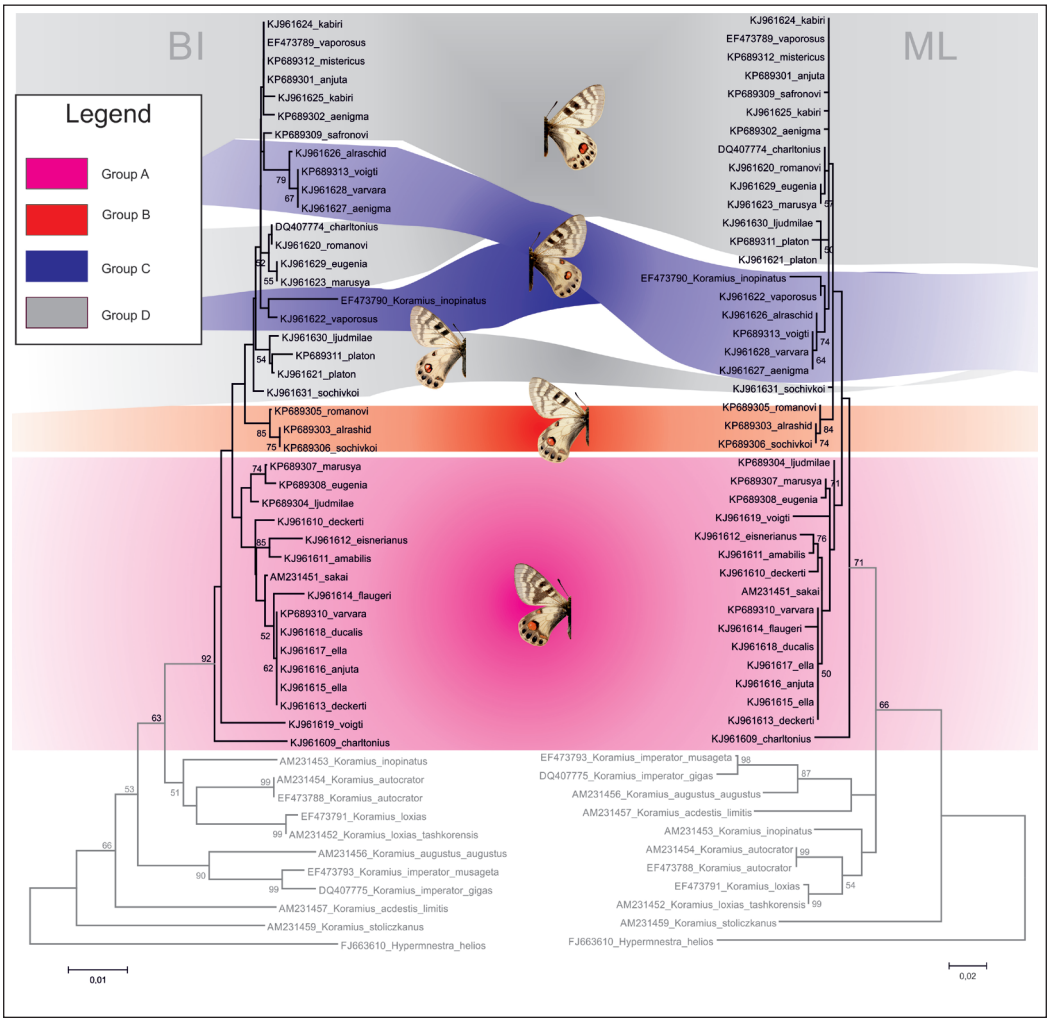

Figure 7. The Bayesian inference (BI) and maximum likelihood (ML) trees of *Koramius charltonius* and closely related taxa. Outgroups are shown in grey. The colours represent the four haplotype lineages.

subspecies groups and these groups are scattered across the tree. On the other hand, the subspecies form several clusters according to the geography (see the type localities of all subspecies of *K. charltonius* described from Central Asia in Fig. 5) as well as genetic clusters (Fig. 7), but the genetic differences inside the clusters are very small, with over 50% of sequenced specimens having a barcode pairwise distance smaller than 0.2% between them. The overall mean distance between samples was only 0.00141. Unfortunately, because of the low number of individuals per subspecies/population, we are unable to see the local variation, but evidently, while some local populations (subspecies) are well separated, other samples show that about half of described subspecies are paraphyletic, and represent local variability between closely related populations and not separate forms.

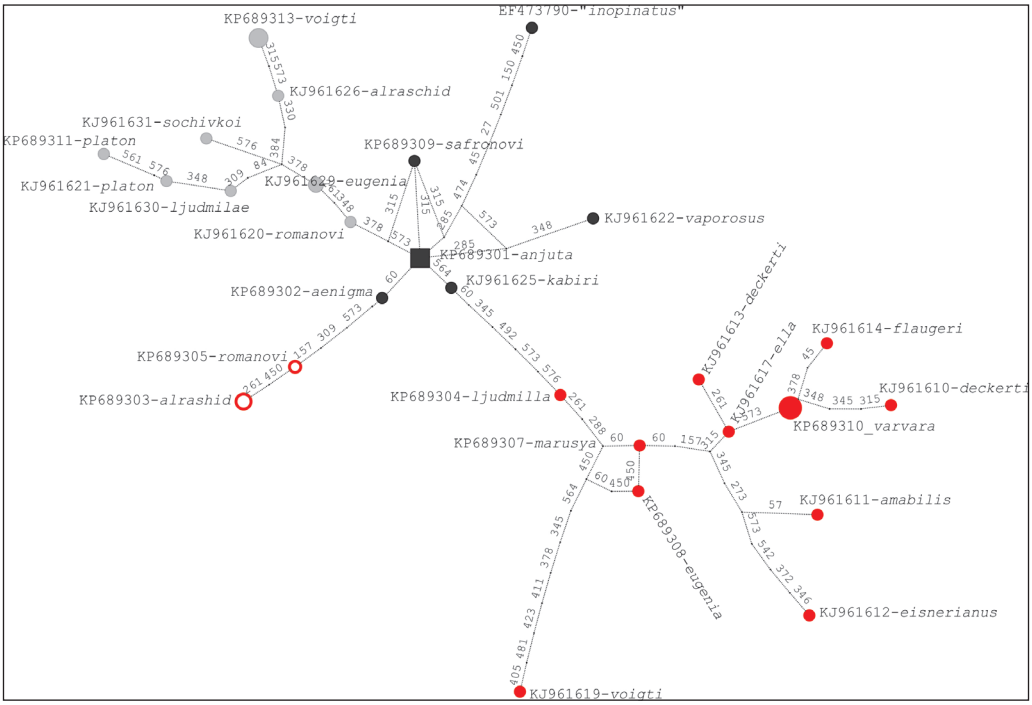

Figure 8. The haplotypes network of *Koramius charltonius* in Central Asia, median-joining, constructed using only verified sequences. Haplotype group A – red dots; group B – red circles; group C – black dots; group D – grey dots. See text for details.

The genetic distances were marginally positively correlated with geographic distances (Mantel test, r = 0.271, p = 0.071), but they were not correlated with morphological distances (r = 0.051, p = 0.324). Even when we made comparison with only males (r = -0.021, p = 0.567) or females (r = 0.082, p = 0.253), we did not find any correlation. Also, when comparing morphology distance matrices for males and females, we did not find a correlation (r = -0,001, p = 0.481). Thus the differences between these subspecies are not real; for some specimens it is not possible to identify to which subspecies of *K. charltonius* they belong without having geographical data. Recognizable phenotypes are present only in subspecies *romanovi*, *varvara*, and *platon*. Additionally, it is possible to identify some groups of subspecies according to the wing pattern.

Based on the results of our examinations, we propose a preliminary subspecific division of *K. charltonius* in Central Asia. It is possible that it will be necessary to further reduce the number of subspecies in the future because there is no clear pattern in phylogenetic trees. We used the haplotype network and morphometric data as a basis for the following division:

a) *varvara*, characterised by island-distribution in the Inner Tian-Shan (it is possible that this subspecies name will be synonymized after further investigation).

b) *romanovi*, characterized by distribution in the Alai and Transalai Mts. The southern border of this subspecies is on the high-mountainous plain starting from the southern slope of the

Transalai Mts., the eastern border is at the beginning of the Zeravshan River Valley. Synonyms: *aenigma* Dubatolov & Milko, 2003, **syn. n.**, *sochivkoi* Churkin, 2009, *alrashid* Churkin & Pletnev, 2012, **syn. n.**

c) *platon*, characterized by distribution in the north-eastern limit of the species range in Central Asia (Turkestansky Mts.) and by the mid-altitude mountainous vertical distribution (1500–2100 m). This kind of vertical distribution is unusual for this species and makes a notable ecological isolation from other known populations.

d) *ljudmilae*, characterized by the distribution in the south-eastern limit of the species distribution in Central Asia (Hissarsky Mts.). There are long distances (over 200 km) to its other closest known populations.

e) *vaporosus*, characterized by distribution in east, central and north-west Pamir and Darvaz. The borders of this subspecies are Alichur River in the south, highland plains of East Pamir in the east, the high-mountainous plain starting from the southern slope of Transalai Mts. in the north, and the eastern slopes of Darvaz Mts. in the west. Synonyms: *marusya* Churkin & Pletnev, 2012, **syn. n.**, *eugenia* Churkin, 2009, **syn. n.**, *anjuta* Stshetkin & Kaabak, 1985, **syn. n.**, *mistericus* Kaabak, Sotchivko & Titov, 1996, **syn. n.**

f) *voigti*, distributed in West Pamir and Afghan Badakhshan. The northern border is in the Akademii Nauk Mts. and adjacent glaciers. Synonym: *safronovi* Korb, Shaposhnikov, Zatakovoy & Nikolaev, 2013, **syn. n.**

Phylogeography

We present the phylogenetic relationships of populations of *Koramius charltonius* based on one mitochondrial gene from the western part of its range. Whereas two haplotype groups (A and D) are widely distributed throughout the range, two other haplotype groups (B and C) indicate a separation of larger historical areas by vicariance, first in isolated sections of the westernmost parts of the area (isolation of *platon* and *ljudmilae*), then separation of *voigti*, and then separation of the southern (*vaporosus*) and northern (*romanovi*) branches with *deckerti* in between. Shatravin (2000) summarized the history of the Pleistocene glaciation in the Pamirs and Tian-Shan (mountainous Central Asia), which consisted of three parts: first Pleistocene stage (about 74,000–70,000 years ago), second Pleistocene stage (about 54,000–52,000 years ago), and third Pleistocene stage (about 24,000–22,000 years ago).

The observed pattern suggests that the species had a wide distribution in Central Asia in the past, at least up to the southern ridges of Tian-Shan (probably wider). The first Pleistocene stage divided the area of the *K. charltonius* ancestor into several large areas separated by high mountain ridges, which were covered by glaciers: e.g., Alai and Transalai, Sary-Kol etc. (Shatravin 2000). Further separations followed in the second and third stages and inter-stage times. This is supported by larger differences between subspecies: the most ancient ones are located in the northern parts of the species area and have the COI-differences of about 1% (*varvara*, *platon*).

These results indicate a shrinking of the original range, with western populations becoming isolated due to the gradual drying of the mountains rather than dispersal. Also, it is evident that the eastern populations are not really genetically isolated and thus the majority of the described subspecies lack genetic justification.

Conclusions

We found very weak support for the traditional division (Weiss 1991) of *Koramius charltonius* into subspecies and even less into the subspecies groups; the phylogenetic division follows latitudinal geographic structure and not the formal taxonomy. We are aware of the limitations of mitochondrial data for answering questions about evolution, but our results are probably meaningful since they are concordant with geography. Also, our findings are similar to the findings of Michel et al. (2008), who, however, worked on the specific level, whereas we focused more deeply on the populations.

Many of the new subspecies descriptions are frequently inadequately erected, based rather on partial data than on systematic comparison of large series and using adequate analyses. Even worse, many of such subspecies might have been established only to increase the price of the insect specimens on the market. However, these taxa are still valid in the sense of the zoological nomenclature. Taxonomists must acknowledge every described taxon, they must place it in its correct position or synonymize it, and we have done our best with this difficult case based on all the currently available data.

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