

Apamea sphagnicola sp. n. — a surprising new species from the Azores in westernmost Europe (Lepidoptera, Noctuidae, Xyleninae, Apameini)

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Abstract: In November and December 2013 and in March 2014 the author found caterpillars of a species of the genus *Apamea* OCHSENHEIMER, 1816 in the uplands of São Miguel Island (Azores, Portugal) in a very special ecological niche in damp *Sphagnum* mosses in mostly shady, steep embankments and slopes. Because so far no *Apamea* species are known from the Azores (and the whole of Macaronesia), the larvae have been reared and the bionomics studied. As expected, the resulting adults could not be assigned to an existing species. Thus *Apamea sphagnicola* sp. n. is described in the present paper (holotype male in Senckenberg-Museum in Frankfurt am Main, Germany). The attractive species is superficially similar to *Apamea sordens* (HUFNAGEL, 1766), but has very unique characters as well in larval stage (e.g. large pinacula, glossy and wrinkled surface) and as an adult (e.g. contrasting reddish brown/white colouration, male genitalia with very wide, unforked costal process and strongly curved phallus, female genitalia with short and wide ductus bursae and characteristic bulges). Thus it is interpreted as most probably an old Azorean endemic and may be a direct descendant of the ancestors of today's continental *Apamea*.

Apamea sphagnicola sp. n. — eine überraschende neue Art von den Azoren im westlichsten Teil Europas (Lepidoptera, Noctuidae: Xyleninae, Apameini)

Zusammenfassung: Im November und Dezember 2013 sowie im März 2014 fand der Autor Raupen eines Vertreters der Gattung *Apamea* OCHSENHEIMER, 1816 in den Hochlagen von São Miguel (Azoren, Portugal). Die Tiere besiedelten eine sehr spezielle ökologische Nische in feuchtem Torfmoos (*Sphagnum*) steiler und meist schattiger Hänge und Böschungen. Da bis zu diesem Zeitpunkt noch keine *Apamea*-Arten von den Azoren (und ganz Makaronesien) bekannt waren, wurden die Raupen zum Falter weitergezogen und ihre Ökologie und Morphologie eingehend untersucht. Wie erwartet, konnten die erhaltenen Imagines keiner bekannten Art zugeordnet werden. Somit werden die Tiere in vorliegender Arbeit als neue Art *Apamea sphagnicola* sp. n. beschrieben (Holotypus Männchen im Senckenberg-Museum in Frankfurt am Main, Deutschland). Die attraktive Art ähnelt oberflächlich *Apamea sordens* (HUFNAGEL, 1766), weist aber sowohl als Raupe (große, stark chitinierte Borstenhöfe, glänzende und stark faltige Haut) als auch als Falter (kontrastreiche, rotbraune und weiße Färbung, männliches Genital mit sehr breitem, ungegabeltem Processus costalis und stark gebogenem Phallus, weibliches Genital mit kurzem und breitem Ductus bursae und charakteristischen Ausbauchungen der Bursa copulatrix) einzigartige Eigenschaften auf. Somit ist die Art sehr wahrscheinlich ein alter azoreanischer Endemit und möglicherweise ein direkter Nachfahre früher Formen der heutigen kontinentalen *Apamea*-Arten.

Introduction

The Azores in westernmost Europe are a group of 9 islands in the Atlantic between Portugal and North America. These islands cover a large area of sea with distances of some 600 km between the westernmost and

the easternmost islands. São Miguel is the largest island and belongs to the eastern group, some 1500 km from the Portuguese mainland, some 1700 km from North Africa and about 3600 km from the United States east coast.

São Miguel is of volcanic origin. Eastern parts of the island are at least 4–5 million years old. Originally, the Azorean islands had been mainly covered by laurel forests and peat mosses. Nowadays the lower regions are more and more used as usually overfertilized, EU-funded cattle pastures with mostly only steep barrancos still being forested down to the coasts (often with the neophytic Australian bush *Pittosporum undulatum* VENTENANT, Pittosporaceae). In the uplands, remnants of laurel forest, allochthonous coniferous forests and mainly Atlantic heathland with mosses, grasses (usually *Festuca franconi* PRIETO et al.), ferns (*Blechnum* etc.) and dwarf shrubs (Ericaceae: *Erica*, *Calluna*, *Vaccinium* etc.) occur. These uplands reach peaks between 800 and 1105 m above sea level in São Miguel island.

The climate is humid year-round (especially wet in winter and early spring) with annual precipitation ranging from more than 1000 mm in Ponta Delgada at the south coast up to 3000 mm and more in the mountains. Temperatures are quite balanced (uplands, 800–1000 m: mostly 5–12°C in winter, frost only exceptionally, 12–20°C in summer).

The Lepidoptera fauna of the Azores is rather well known at present due to several publications (e.g., WARREN 1905, REBEL 1940, PINKER 1971, MEYER & HELLERS 1991, SOUSA 1991, HACKER & SCHMITZ 1996, VIEIRA 2002, BORGES et al. 2005). The noctuid fauna (and also that of other families) is quite poor in species numbers (so far some 30 noctuid species are reported), but unique to a great extent because of the great distances to mainlands and the volcanic origin. It mainly consists of widespread subtropical elements [e.g., *Mythimna unipuncta* (HAWORTH, 1809), some Plusiinae], Palaearctic species [e.g., *Noctua pronuba* LINNAEUS, 1758, *Xestia c-nigrum* (LINNAEUS, 1758)], a few Nearctic elements like *Galgula partita* GUENÉE, 1852, and many Macaronesian and Azorean endemics. Among these endemics especially the genera *Noctua* LINNAEUS, 1758 and *Phlogophora* TREITSCHKE, 1825 should be mentioned, but also *Melanchnra granti* (WARREN, 1905) or *Mesapamea storai* (REBEL, 1940). Most endemics occur in higher altitudes.

By chance, I discovered caterpillars of the genus *Apamea* OCHSENHEIMER, 1816 (Figs. 1–10) in these uplands in wet places in mossy embankments in open heathland while searching for *Phlogophora* larvae during the day. From the first moment I believed having found a new species because this genus has been unknown from these islands

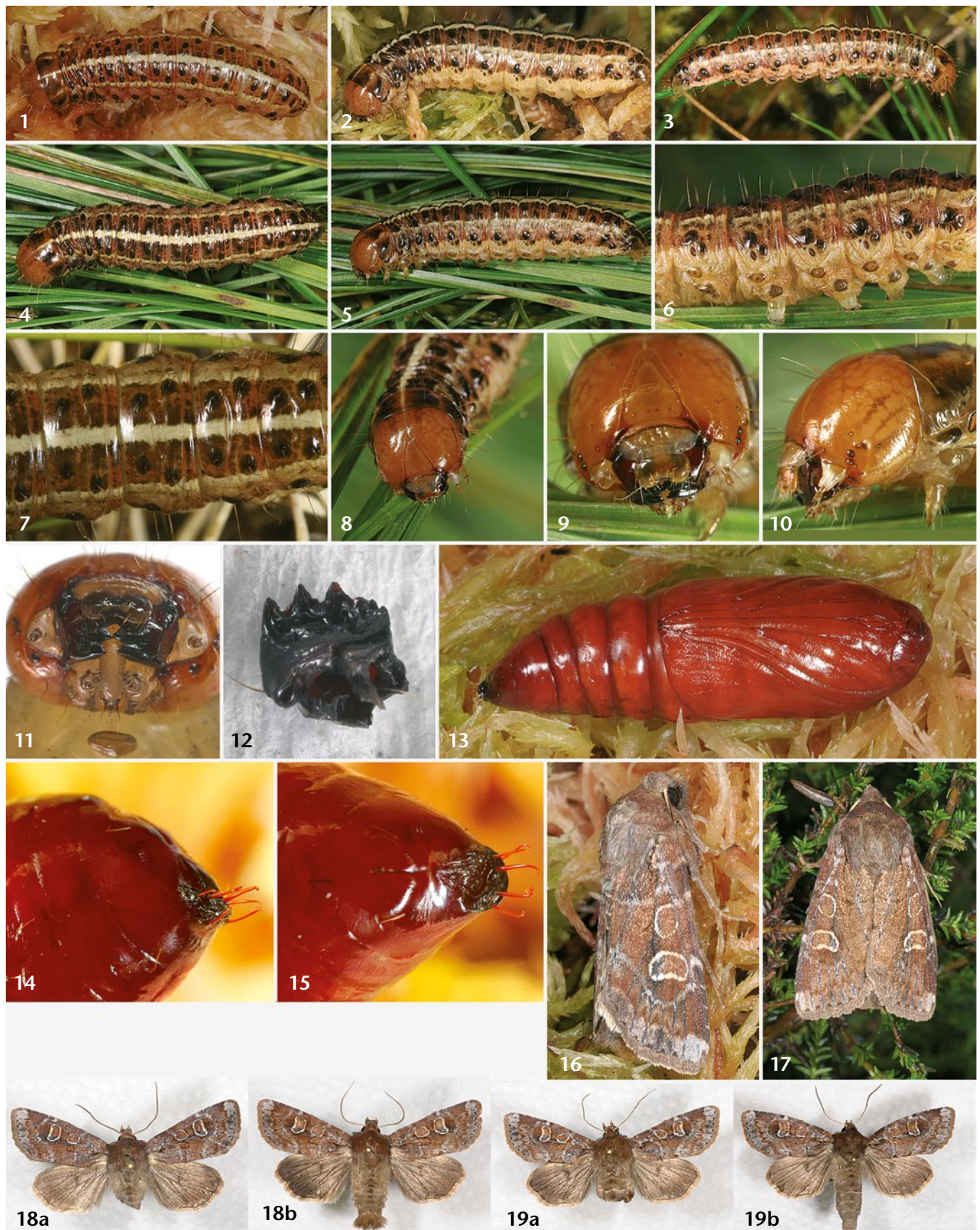


Plate 1: *Apamea sphagnicola* sp. n. (all material from Azores, São Miguel; if not indicated otherwise, most pictures from Serra Devassa). **Figs. 1–2:** Larva in thirdlast instar (22. xi. 2013). There are no major differences to the last instar. — **Fig. 3:** Larva feeding at night (20. xii. 2013). — **Figs. 4–10:** Last instar (14. xii. 2013). **Fig. 4:** Dorsal view. **Fig. 5:** Lateral view. **Fig. 6:** Lateral view, detail. **Fig. 7:** Dorsal view, detail, central abdomen; 1. xii. 2013. **Fig. 8:** Head, 14. xii. 2013. **Fig. 9:** Head, detail, 14. xii. 2013. **Fig. 10:** Head, lateral, 14. xii. 2013. — **Figs. 11–12:** Head details: alcohol material, e.l. Serra de Água de Pau, xii. 2013. **Figs. 11:** Spinneret, hypopharynx, mandibles. **Fig. 12:** Right mandible, inner side. — **Figs. 13–15:** Pupa, e. l., Serra de Água de Pau, larva in xii. 2013, pupa in i. 2014; **13:** pupa; **14:** cremaster lateral view; **15:** cremaster ventral view. — **Fig. 16:** ♂, ex larva, Serra de Água de Pau, larva in xii. 2013, adult in ii. 2014. **Fig. 17:** ♀ with only faint white elements (quite rare), ex larva Serra da Tronqueira, larva in xii. 2013, adult in late ii. 2014. — **Figs. 18–19:** Imagines (types). **Fig. 18a:** ♂ holotype, ex larva Serra da Tronqueira, larva 19. xii. 2013, adult in late ii. 2014. **Fig. 18b:** Paratype ♂, same data as 18a. **Fig. 19a:** Paratype (allotype) ♀, ex larva, larva on 22. xi. 2013, adult in late ii. 2014. **Fig. 19b:** Paratype ♀, same data as Fig. 19a.

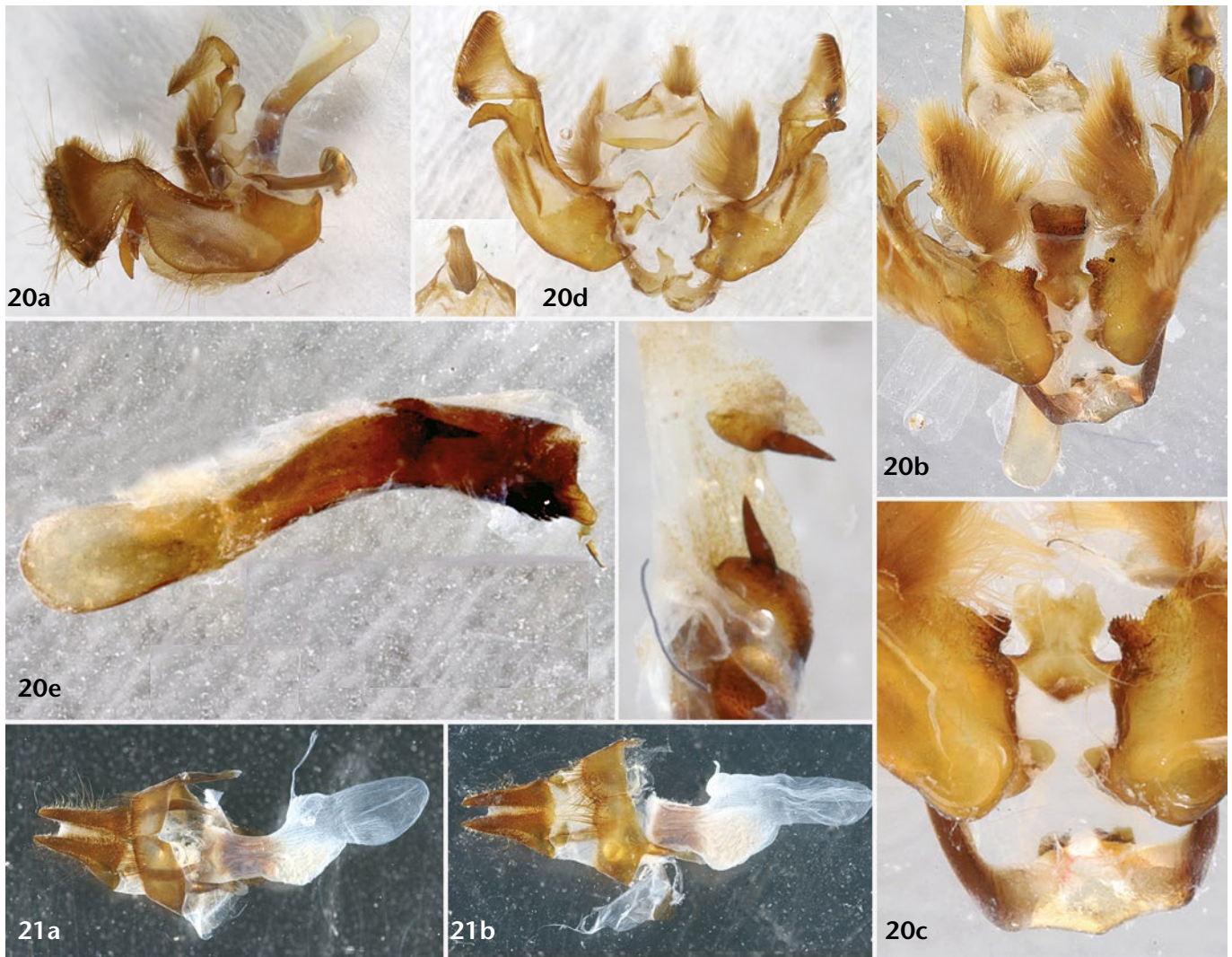


Plate 2: *Apamea sphagnicola* sp. n. **Figs. 20a–e:** ♂ genitalia. **Fig. 20a:** ♂ genital capsule, lateral view with cucullus, costal process, uncus, clavus and Phallus (Serra da Tronqueira). **Fig. 20b:** Saccus, clavus, juxta with aedeagus still connected, ampulla (Serra da Tronqueira). **Fig. 20c:** Juxta and clavus, phallus removed (Serra da Tronqueira). **Fig. 20d:** Juxta removed (Serra de Água de Pau). Small image: dry uncus. **Fig. 20e:** Serra de Água de Pau: phallus; insert image: cornuti of vesica. — **Fig. 21:** ♀ genitalia (21a: ex Serra Devassa, 21b: Serra de Água de Pau).

so far and the larvae – despite being clearly a member of *Apamea* – showed some specialities in both morphology and ecology. This was confirmed by the resulting adults and thus the new species is described in the following.

Apamea sphagnicola sp. n.

Holotype ♂: Portugal, Azores, São Miguel island, Serra da Tronqueira, larva 19. XII. 2013, adult in late February 2014, W. WAGNER leg. & cult.

Paratypes (in total 6 ♂♂, 8 ♀♀): 1 ♂, 2 ♀♀, Serra Devassa SE Sete Cidades, larva on 22. XI. 2013, W. WAGNER leg. & cult.; 1 of these ♀ paratypes is ♀ allotype. 1 ♀, Serra da Tronqueira, larva 19. XII. 2013. 5 ♂♂, 5 ♀♀, Serra de Água de Pau, larvae in XII. 2013, adults in February/March 2014.

Holotype and 7 paratypes (including allotype) will be deposited in the Lepidoptera collection of Senckenberg-Museum in Frankfurt am Main, Germany (Senckenberg Forschungsinstitut und Naturmuseum Frankfurt, Entomologie II) immediately after publication. The remaining specimens are in coll. W. WAGNER.

Derivatio nominis. The larva was always observed resting in *Sphagnum* mosses during daytime, thus named *sphagnicola* (Latin for “inhabiting *Sphagnum* mosses”).

Description

Imagines. No major differences in wing pattern between ♂♂ and ♀♀ (Figs. 16–19). Wingspan 37–41 mm; forewing length 17–18 mm.

Individual variability quite low and mostly restricted to intensity of white elements and suffusion in forewing (except reniform and orbicular stigmata, which are always bordered white), and intensity of dark elements (dark scales on veins, visibility of claviform stigma). Females sometimes slightly darker and more uniform.

Forewing base colour red-brown, with many contrasting white and a few blackish-grey elements. Blackish root streak present, sometimes not solid (mostly in ♂♂), but interspersed with red-brown scales. Large, broad, rounded, always whitish lined orbicular (sometimes open towards costa) and reniform stigmata. Dark bordered claviform stigma not always present. Whitish cross lines usually present, but sometimes faint and reduced. Post-median line recoiled towards costa and ending in costa in a broadened white spot, which is present even if the line is reduced. Apical from this three short, thin, sharp,

white diagonal slashes are present as it is typical also for other *Apamea*. Area between postmedial line and wavy line in principal of ground colour, a bit lighter only in central part. Wavy line often with some red-brown chevrons in central part. Terminal field whitish grey towards apex, but more or less suffused with darkish grey in other parts, especially on and around veins. Terminal field in these other parts sometimes (mostly in ♀♀) interrupted by brown elements between the veins and grey only on the veins and their surroundings. Dark terminal spots present. Media more or less darkish, also other veins especially beyond the postmedian line. Fringes light brownish grey. Hindwings grey-brown with dark discal spot (especially clear on underside). Head brown, breast mixed grey and brown, patagia red-brown. Abdomen greyish brown, posterior abdominal brush conspicuous, triline brush organs present.

Whitish (base) to grey antennae, thicker and longer ciliated in ♂♂.

Male genitalia (Fig. 20): Clavus with dark, heavily sclerotised apical square corner with rounded tip and small spines, basal process quite long. Uncus relatively broad, considerably expanded towards the heavily haired tip, tip principally rounded, but with shortly, but distinctly pointed apex. Cucullus relatively small, with heavily sclerotised pollex. Costal process broad, curved and tapering strongly only towards apex, relatively short and not forked (no clear recognizable own superior part). Ampulla quite long and slender. Juxta basis anchor-shaped, upper end with two lobe-like bulges. Phallus long, widened at basis, distinctly curved towards opening (juxta-side), compact vesica with two large, long and pointed cornuti with small base.

Female genitalia (Fig. 21): Papillae medium-long, quite broad. Appendices posteriores broad, curved inwards at first and then outwards near rounded and slightly widened tip. Appendices anteriores broad, more or less straight, dilating near tip. Ductus bursae short and wide, terminating in a large bulge and a smaller one on opposite side, with broad transition into the slender-baggy terminal part of bursa copulatrix.

Methods. All specimens have been collected in larval stage (altogether 35 larvae) in the field and reared to adults (altogether 16 adults).

Caterpillar: Full-fed 35–41 mm long (Figs. 3–7). Head (Figs. 8–11) light orange-brown, reticulate pattern most often only indistinct or missing, but sometimes better visible, also the coronal stripes. Setal punctures small, light, narrow blackish bordered, on head without pinacula. Bristle points on body usually with very large pinacula, larger than in other *Apamea*. These pinacula are reduced and less visible in last instar in only very few specimens (2 out of 35), but in earlier instars in presumably none specimens. Body surface very glossy and wrinkled. White dorsal line broad (0.4–0.5× the width of

the neighboured zone) and conspicuous, subdorsal lines weaker, but still clearly visible, all three lines irregularly confined. Lower border of subdorsal lines fragmentary dark greyish, but besides this only with weak contrast. Prothoracic shield mainly dark, interrupted by the narrowed white dorsal line and the diverging, less clear, here broader subdorsal lines. Anal plate inconspicuous, dorsal and subdorsal lines clearly visible. Field between dorsal and subdorsal line mixed darker and lighter brown, of double the width of the dorsal line, bearing on each side two large darkish, heavily sclerotised pinacula with each a long bristle, the cranial one nearer to the dorsal line. Lateral sides between subdorsal line and the spiracles light brownish, lighter than dorsal fields, below stigmatal line still much brighter. Spiracles light orangebrown, blackish bordered, creamy coronated. Central abdomen with a large dark pinaculum above each spiracle (in the light brown field) and another smaller one behind the spiracle. Outer proleg bases with another dark pinaculum, and dorso-cranial from this base finally another one, but with lighter colour. Bristles light brownish. Thoracic pinacula more confluent, with extra-pinacula, especially on dorsal side. Three darker larvae showed more confluent (respectively less clearly separable) pinacula also in central abdomen.

Prolegs with one smaller inner bristle and two ones on the outer respectively cranial side, crochets arranged as a semi-circle, numbers 16–18, 17–20, 24–26 (prolegs on abdominal segments 3, 6 and 11). Mandibles (Fig. 12) strong, with three very robust, comparatively long teeth. Hypopharynx with comparatively small spines, spinneret long, tapered, clearly longer than labial palps with its setae.

Seta SD2 on prothoracic segment long, on shield, SD1 vertically below, outside the shield, much shorter and inconspicuous. Antepenultimate (Figs. 1, 2) and penultimate instars with no conspicuous differences.

Pupa: 21–23 mm long, light redbrown (Fig. 13), dorsal side a bit darker, more or less rounded cremaster with typical stiff bristle pattern, comparable to *Apamea sordens* (HUFNAGEL, 1766), *A. anceps* ([DENIS & SCHIFFER-MÜLLER], 1775) or *Mythimna albipuncta* ([DENIS & SCHIFFER-MÜLLER], 1775), see PATOČKA (1995): four distally hooked bristles in row inserting on small bumps near the ventral tip of the cremaster, the inner two thicker than the outer ones, and two additional bristles (comparable to the outer ones) inserting a bit more away from the tip on the dorsal side (Figs. 14, 15).

Distribution. So far known only from Azores, São Miguel island: Serra Devassa (750–860 m, Lagoa Rasa, Pico das Éguas, 8 larvae), Serra de Água de Pau (650–900 m, Lombadas, Monte Escuro to Pico da Barrosa, Lagoa do Fogo, 23 larvae), Serra da Tronqueira (700–850 m, 2 km NW Pico do Bartholomeu, 4 larvae).

Diagnosis

Easily recognizable, unique species. The adults differ from the superficially somewhat similar species *Apamea sordens* in following characters: base colour reddish brown, stigmata mainly filled with ground colour, orbicular stigma larger, reniform stigma more rounded, not so emarginated on outer side, no dark spots on costa next to reniform stigma, field between postmedian line and wavy line darker (more or less in base colour), whitish stigmata borders always conspicuous.

Unique in combination of characters in ♂ genitalia, which show some similarities with *Apamea illyria* FREYER, 1846 on one hand and the group of *Apamea sordens* on the other: extended (broader than in *A. sordens* and related species) and moreover shortly pointed tip of uncus, not forked, short and very wide costal process (broader than in the moreover forked *A. sordens*), large cornuti (distinctly larger than in *A. sordens* and much larger than in *A. illyria*) and clavi more like *Apamea anceps*, differing clearly from *A. illyria*. Phallus curved as in some species of *Abromias* BILLBERG, 1820.

Female genitalia clearly identified by combination of *illyria*-like papillae, short, wide ductus bursae (similar to *Apamea sordens*) and bulge-pattern of bursa copulatrix; larger bulge than in *A. alpigena* (BOISDUVAL, [1837]) and *A. illyria*, but similar in basic pattern to some *Abromias*.

The larva can be distinguished from other European species (including *Apamea sordens*) easily because of the conspicuous, large pinacula in combination with true *Apamea* s. str. characters (medium long spinneret, line pattern, ornamentic). Furthermore, the body surface is much more glossy and wrinkled than in all known related species.

Bionomics

Larvae of *Apamea sphagnicola* n. sp. inhabit wet embankments or steep slopes in open heathland or more rarely in open woodland mostly between elevations of 700–900 m (supposedly up to 1100 m). These places (Figs. 22–27) usually show a mix of mosses (especially *Sphagnum* species) and grass tussocks (mainly *Festuca francoi* PRIETO et al.). They can be both partly sun-exposed or in quite shady northern exposition, with the latter being much more frequent. I observed the larvae in late November 2013 (8 larvae) mostly in the antepenultimate instar (Figs. 1, 2). They rested during the day between the dense stems of *Sphagnum* mosses 1–5 cm deep under the surface without webbing. In the second half of December 2013, I recorded 25 larvae mostly in the penultimate instar, but 8 already in the last one. The cavities were only strengthened by little webbing when moulting, because the larva then rests there for a few days. Otherwise the larva rests each day at a different spot, though often near the old one. These spots are identified by droppings when pulling apart the *Sphagnum* mosses.

Due to the occurrence in the wettest parts of the slopes with *Sphagnum*, the larvae could be searched precisely in so far unknown localities. At least the older larvae feed only at night. On 22. xi. 2013, I searched for larvae at about 22:00 local time with a torch and found three larvae feeding on *Festuca francoi* and on 20. xii. 2013 another one (Fig. 3). Three larvae had climbed a grass leaf and gnawed from the tip, the other rested on moss at the edge of the tussock and gnawed on shorter grass leaves. *Festuca francoi* (formerly referred to as *Festuca jubata* LOWE, see PRIETO et al. 2008) was often the only available grass. This species occurs in large areas of the so far uncultivated uplands, but no larval records succeeded on the most often somewhat drier places without *Sphagnum*.

In mid-March 2014 (17. iii. 2014), during a third visit to the island, I observed two mature larvae at night (Pico da Barrosa).

Pupation also occurs in the *Sphagnum* mosses shown by two records of empty pupal skins of last year. The larva creates a weakly webbed cavity for pupation.

In rearing, most moths emerged after a pupal phase of about 4 weeks (18–19°C) between 9:00 and 14:00 h in the second half of February 2014. The moths showed a more nervous behaviour than most other noctuids when photographing them. They walked around, mostly aiming straight to the ground and holed up there head-down in the litter or loose moss in a way similar observed in *Agrotis* OCHSENHEIMER, 1816 larvae burying themselves in the soil.

Discussion

Bionomics

Apamea sphagnicola is a hygrophilous species of higher altitudes and obviously shows a very narrow ecological ennicement in undisturbed, mostly ungrazed habitats though grasses are nowadays widespread on the island. The inhabited more open *Sphagnum* spots on often steep slopes surely constitute a natural type of habitat that has already been available since millions of years in the uplands of this island. The species' ability to settle also in open and semi-open places within wooded areas (e.g. Serra da Tronqueira) might be an adaption to the formerly quite densely wooded island (laurel forests). Though the climate of the uplands is generally quite humid, the species obviously cannot settle substantially in sunny dwarf shrub and grass heathlands, but is dependent on the even wetter and mostly more shady special habitats with *Sphagnum*. A decisive factor for this constriction may be the summer that is generally less wet.

The larvae live similar to those of *Apamea* s. str. without a permanent spun shelter at the base of the tussocks. They hide during daytime in mosses, but change the exact place each night and construct spun shelters only for moulting. But these resting places are often only centimetres away from each other and are easily spotted due to dropping



Plate 3: *Apamea sphagnicola* sp. n., habitats. — **Fig. 22:** Habitat in Serra Devassa (19. xi. 2013), the place of the first record. Larvae settled only the northeast exposed, more shady and humid right side of the gully. *Sphagnum* mosses occurred only there, too. **Fig. 23:** Same area and date, detailed view of the *Sphagnum* mosses with ferns and *Festuca francoi* grasses. — **Fig. 24:** Habitat in the eastern part of Serra de Água de Pau (17. xii. 2013). The reddish *Sphagnum* shows a small-scaled occurrence and the larvae had been strongly correlated with it. — **Fig. 25:** Habitat in the southwestern part of Serra de Água de Pau (15. xii. 2013): shady embankment with much *Sphagnum*. — **Fig. 26:** The most large-scale habitats exist in the north-facing slopes of the Serra de Água de Pau (17. xii. 2013), here near Lombadas. Parts of the slopes appear reddish due to *Sphagnum*. — **Fig. 27:** Habitat on a steep slope with much *Sphagnum* (here more green) in open forest (Serra da Tronqueira, 19. xii. 2013). — All photos and preparations taken by the author.

concentrations and tiny cavities. Thus there are clear differences to the still much more sedentary life style of *Abromias* larvae. But the obvious restriction to the often not so large moss stocks limits activity radius and it might be justified to consider a transitional form between *Apamea* and *Abromias* in life strategy, but clearly with a still greater portion of *Apamea*.

The species most probably has only one generation per year. According to own observations, larvae are half grown in November and mature between December and March. Thus, and confirmed by rearing, pupation should occur between mid-January and March, and the moths might be on the wing between late March and late May. The scarce observations on behaviour of the adults (in rearing) may be interpreted as follows: the moths are flying not often, but prefer to crawl around in their habitat with a tendency to hole up in the loose moss and litter during daytime. This can be explained as adaptation to the often strong winds on the Azores and furthermore explains that the species has gone undetected for such a long time.

The bionomics in summer are unknown so far. But I do not think that there is a second generation because of the quite long larval development time and the life cycles of related European species. It is thus probable that the young larvae develop only slowly in summer. Another possibility would be delayed hatching or other phases of dormancy. But this must all be studied in the field.

Morphology and systematics

The larva is in many characteristics a typical Apameini and here *Apamea* with moderately long spinneret (approximately 4× longer than wide, *Abromias*: 5–9×), line pattern, chaetotaxis (e.g. prothoracic segment) and ornamentic (compare BECK 1999, AHOLA & SILVONEN 2008). The pinacula are more extended than in all other *Apamea* s. str., where they obviously have been reduced in evolution. This character may be an old, plesiomorphic one that could reflect a quite original state of development within the genus *Apamea*. An also possible secondary enlargement of these pinacula is much less probable, especially if you consider the other more primitive characters (genitalia, ennichement). The broad dorsal line resembles *Apamea sordens* and *A. anceps*.

The external characters of the moths with their quite attractive appearance implicate a closer relationship to *A. sordens*, which is widespread on both sides of the Atlantic (ZILLI et al. 2005, MIKKOLA et al. 2009), even if the North American taxon *Apamea finitima* GUENÉE, 1852 is sometimes considered a vicariant, distinct species.

The genitalia show some characters that are found in species of several groups of *Apamea* s. l., but are quite unique in their combination. So some features resemble the species-group of *illyria*, others the *sordens*-group with *A. anceps* and *A. alpigena* and some even show similarities to *Abromias*.

These somewhat “primitive” characters of the new species and especially the ennichement are clear indicators for an old Azorean endemic which only could preserve its characters in the long-term isolation (maybe already for millions of years) and climatic stability of the Azores. Thus it is most likely an old species and a direct descendant (or remnant) of the ancestors of today’s group of *Apamea sordens*, or even of the Palaearctic *Apamea sensu lato* as a whole. But to reveal this, further research is essential, especially on the genetics (DNA).

Distribution, species threat

The species occurs in all three higher mountain ranges of the island and thus in west, central and east São Miguel. The largest population with the most extended larval habitat settles in the Serra de Água de Pau, e.g. south of Lombadas. The other populations are only small and thus vulnerable, especially in Serra Devassa. It would be very interesting to know if the species also occurs in other islands of the archipelago.

The species occurs mostly in nowadays protected landscapes because unprotected ones have mostly already been destroyed. Thus further survival is probable, especially in the Serra de Água de Pau, but not sure. Possible threats are expansion of cattle pastures, afforestations with exotic tree species and potentially tourism (hiking in sensible parts) or overgrowth by invasive plants. Mainly road-near habitats can also be affected by large-scale collecting of *Sphagnum* mosses as occasionally seen by the author.

So it is strongly recommended to map all existing reproduction areas (the author has detailed maps of the so far known localities) especially in the two areas with only small populations (Serra Devassa and Serra da Tronqueira) and prevent them from future disturbances. Furthermore, some sites or potential habitats could be improved by measures like removal of coniferous plantings or reduction of cattle. In principal undisturbed habitats need no or little maintenance as they are quite stable yet. If climate change or air-carried nutrient deposition (though much lower than e.g. in Central Europe) will have major influence, is not clear yet. Expansion of *Rubus ulmifolius* SCHOTT, however, can be stated already now in some Atlantic heaths.

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