

An integrative taxonomic approach to resolving some difficult questions in the Larentiinae of the Mediterranean region

(Lepidoptera, Geometridae)

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Abstract

Some difficult problems in the taxonomy of Mediterranean Larentiinae are resolved by an integrative approach combining molecular and morphological methods. Six new species and one new subspecies are described: *Xanthorhoe sardisjuncta* **sp. n.** from Sardinia, *Xanthorhoe pederi* HAUSMANN & FRIEDRICH, **sp. n.** from Cyprus, *Colostygia fezae* **sp. n.** from Turkey, *Coenotephria antonii* **sp. n.** from southern Italy, *Coenotephria florianii* **sp. n.** from the Lebanon, *Nebula carlae* **sp. n.** from southern Italy, and *Nebula ibericata fiumii* **ssp. n.** from Sardinia. *Euphyia vallantinaria* (OBERTHÜR, 1890) is recorded as new for the European fauna, with vouchers collected in southern Spain. The taxon *Larentia adlata* STAUDINGER, 1895 is downgraded from species rank to synonymy of the East-Mediterranean species *Mattia callidaria* (JOANNIS, 1891). A lectotype is designated for *Cidaria nebulata pirinica* REISSER, 1936 from Bulgaria, simultaneously the taxon is raised from subspecies of *Nebula nebulata* (TREITSCHKE, 1828) to species rank. A neotype is designated for *Larentia probaria* HERRICH-SCHÄFFER, 1852 from Croatia. The taxon *Cidaria salicata hangayi* VOJNITS, 1986 (northern Iran), previously treated as subspecies of “*Nebula salicata*”, is subordinated at subspecies rank under *Coenotephria ablutaria* (BOISDUVAL, 1840). The taxon *Larentia schneideraria* LEDERER, 1855 is transferred from genus *Nebula* to *Coenotephria* (comb.n.). The study highlights the need for integrative taxonomy combining molecular and morphological data. DNA barcoding of 778 species and 6103 individuals of European geometrids in the framework of the iBOL project yielded 188 cases of deep intraspecific divergences which need to be carefully addressed in such an integrative approach.

Introduction

During the preparation of Volume 3 of the Geometrid Moths of Europe (HAUSMANN & VIIDALEPP 2012) many difficult taxonomic questions have arisen. Many Larentiinae genera are poor in valuable differential characters in male and female genitalia. For example, the species pairs *Epirrhoe alternata* (MÜLLER, 1764) – *E. rivata* (HÜBNER, 1813), *Thera variata* (DENIS & SCHIFFERMÜLLER, 1775) – *T. britannica* (TURNER, 1925), *Ecliptopera silaceata* (DENIS & SCHIFFERMÜLLER, 1775) – *E. capitata* (HERRICH-SCHÄFFER, 1839), *Coenotephria salicata* (DENIS & SCHIFFERMÜLLER, 1775) – *C. ablutaria* (BOISDUVAL, 1840), *Entephria nobiliaria* (HERRICH-SCHÄFFER, 1852) – *E. flavata* (OSTHELDER, 1929), *Operophtera brumata* (LINNAEUS, 1758) – *O. fagata* (SCHARFENBERG, 1805) and many others show no or very little interspecific differences in genitalia. Volume 3 will be the first volume in the GME series considering data from the modern technique of DNA barcoding. Careful analysis should always be integrative, involving molecular data sets as well as morphological and ecological details without considering molecular data a priori as a ‘last instance’ when deciding taxonomical questions. Nevertheless they recently proved their suitability for resolving difficult questions and for opening the eye for overlooked diversity or synonymy (see discussion). In this article some of the questions regarding GME Volume 3 are anticipated to yield nomenclatorial availability.

Material and Methods

Abbreviations

ZSM – Bavarian State Collection of Zoology, Munich

CCDB – Canadian Centre for DNA Barcoding

BOLD – Barcode of Life Data Systems

GME – Book series “Geometrid Moths of Europe”

COI – mitochondrial cytochrome *c* oxidase I (COI) gene, region near the 5' terminus (barcode fragment, 658 bp)

Sampling

In the run of the preparation of the GME3 volume some 200,000 specimens of European Larentiinae (excl. Perizomini and Eupitheciini, subject of Vol. 4: MIRONOV 2003) have been examined at the Bavarian State Collection of Zoology (ZSM), other >100,000 were studied in several other museums and private collections. For identification, more than 2,500 male and female dissections were made, applying standard procedure (ROBINSON 1976).

DNA barcodes for 250 out of 265 species of the GME3 volume were obtained by sampling dry legs from 2,300 European Larentiinae specimens, mainly in the ZSM. Additional DNA barcodes were analysed from projects of the Tiroler Landesmuseum Ferdinandeum Innsbruck (P. HUEMER), the University of Oulu (M. MUTANEN), Museum für Naturkunde Chemnitz (S. ERLACHER) and some private collections (cf. acknowledgements). Barcode sampling strategy aims to gain a best possible coverage of the distribution area of each species. At the present stage, potential sampling bias due to insufficient geographical coverage are expected to play a negligible role.

DNA Analysis

PCR amplification and DNA sequencing was performed at the CCDB following standard high-throughput protocols (IVANOVA et al. 2006; DEWAARD et al. 2008), that can be accessed under <http://www.dnabarcoding.ca/pa/ge/research/protocols>. PCR amplification with a single pair of primers consistently recovered a 658 bp region near the 5' terminus of the mitochondrial cytochrome *c* oxidase I (COI) gene that included the standard 648 bp barcode region for the animal kingdom (HEBERT et al. 2003). DNA extracts are stored at the CCDB, with aliquots being deposited in the DNA-Bank facility of the ZSM (see <http://www.zsm.mwn.de/dnabank/>). All sequences are deposited also in GenBank according to the iBOL data release policy. Complete specimen data including images, voucher deposition, GenBank accession numbers, GPS coordinates, sequence and trace files can easily be accessed in the Barcode of Life Data System (RATNASINGHAM & HEBERT 2007; RATNASINGHAM 2011) in the public projects GZPPL, GZPPT.

Data Analysis

Sequence divergences for the barcode region were calculated using the Kimura 2 Parameter model, employing the analytical tools on BOLD (RATNASINGHAM & HEBERT 2007) and MEGA 5 (TAMURA et al. 2007; 2011). Genetic distances between species are reported as minimum pairwise distances, while intraspecific variation is reported as maximum pairwise distances.

Systematic account

Mattia callidaria (JOANNIS, 1891), comb. n. (= *adlata* STAUDINGER, 1895, syn.n.)

Cidaria callidaria JOANNIS, 1891: Bull. Soc. ent. Fr. 1891: 82 (lxxxii) (Lebanon: Beirut). Holotype ♂ (MNHN, illustrated in LERAUT 2009). In SCOBLE (1999) combined with *Anticlea*, in LERAUT (2009) with *Thera*.

Larentia adlata STAUDINGER, 1895: Dt. ent. Z. Iris 7: 294 (Lebanon: Beirut; Israel: Jerusalem). Syntype(s) (MNHU). Herewith downgraded from species rank to synonymy (syn.n.). In HAUSMANN (1991) combined with *Antilurga*, in SCOBLE (1999) with *Nebula*, in Fauna Europaea (HAUSMANN et al. 2004; 2010) and LERAUT (2009) with *Mattia*.

Diagnosis: Wingspan 21–26 mm, ♀ on average larger than ♂. Forewing costa often straighter in ♂, apex pointed. Transverse fasciae brown and grey, ♀ usually more brownish and lighter than ♂. Apical streak, ante-

and postmedial lines blackish, fine. No significant and constant difference observed between examined populations from Israel, Lebanon, Cyprus, Crete and mainland Greece, well matching the type specimen of *Cidaria callidaria* (cf. figure in LERAUT 2009). Genetically homogenous (COI barcode region).

Male and female genitalia: No significant and constant differences observed between dissected specimens from Israel, Lebanon, Cyprus, Crete and mainland Greece.

Distribution: East-Mediterranean. Southern Greece (Peloponnes, Crete). – Outside Europe on Cyprus and in the Levant.

Remarks: Synonymy of *adlata* and *callidaria* was previously suggested by WILTSHIRE (1939) but drawn into doubt by PROUT (1938). Genus name *Mattia* [VIIDALEPP] was introduced without description in Fauna of Europe (first version 2004; part 'Larentiinae I' by J. VIIDALEPP), then repeated in the second version (HAUSMANN et al. 2010) and in LERAUT (2009), still as nomen nudum. Ad interim I refer here to the genus description of J. VIIDALEPP in GME3 scheduled for publication by early 2012. The taxa *adlata* and *callidaria* were combined with *Nebula* and *Anticlea*, respectively (SCOBLE 1999). Position close to *Antilurga* was suggested by HAUSMANN (1991) basing on morphology of genitalia. In a neighbor joining tree (Kimura 2 Parameter) based on COI barcode data of all Palearctic Larentiinae, the position of *Mattia* is aside genus *Antilurga*, at a distance of 9.96%.

***Xanthorhoe sardisjuncta* sp. n.** (Figs 5-6; Gen. figs 21; 27)

Cidaria disjunctaria: sensu BYTINSKI-SALZ (1937) nec *Larentia disjunctaria* LA HARPE, 1860 (Bull. Soc. vaudoise Sci. nat. 6: 407; locus typicus: Sicily).

Holotype: 1♂, [Italy] Sardinien, Provinz Olbia - Tempio, San Pantaleo, 200m, e.o., (mother 06.IV.2007), leg. B. MÜLLER, coll. ZSM, DNA barcode BC ZSM Lep 60032.

Paratypes: 1♀, id.; 1♂, [Italy] Sardinien, Provinz Olbia - Tempio, San Pantaleo, 200m, 16. April 2007, leg. et coll. B. MÜLLER, DNA barcode SE MNC Lep 00067; 1♀, id., 13. April 2007, DNA barcode SE MNC Lep 00069; 2♀, id.; 1♂, id., 8. April 2007; 7♂7♀, id. e.o. 15.VII.-15.VIII.2007 (mother 16.IV.2007); 2♂, [Italy] Sardinia, 8km E of Porto Torres Platamona Lido, 5m, 30.III.2002, leg. et coll. P. SKOU (Stenstrup), one with gen.prp. Hausm. 14501; 1♂, [Italy] Sardinia, Muravera, 5 km N of an Vito, 200m, 4.IV.2002, leg. et coll. P. SKOU; 9♂9♀, [Italy] Sardinia, 4km SW of Fluminimaggiore, 250m, 7.-8.IV.2002, leg. et coll. P. SKOU; 1♂, [Italy] Sardinia, Alghero, 50m, 15.III.2007, leg. G. DELRIO, coll. Consortio Studi Univ. Sassari, DNA barcode BC ZSM Lep 14144; 1♂, [Italy] Sardinia, Nuoro, Siniscola, 50m, 21.IV.2007, leg. et coll. O. CAO, DNA barcode BC ZSM Lep 06306; 2♂, Italy, Sardinia, San Salvatore Cabras (OR), 09.X.2008, leg. M. GUIDI, coll. G. FIUMI; 2♂, [Italy] Sardinia, Cala Gonone Dorgali (NU), 20.X.2008, leg. CABELLA, coll. G. FIUMI; 2♀, Italien, Nordsardinien, Costa Smeralda, San Pantaleo, 200m, N 41.02 E 09.29, 7.-17.IX.2007, leg. M. LEIPNITZ, coll. ZSM; 5♂1♀, id., coll. M. LEIPNITZ; 9♂, id., 15.-26.IX.2007.

Description: Wingspan 22-25 mm. Forewings whitish grey, fresh specimens with greenish tinge, mainly between veins of forewing. Veins with white markings in the distal half of forewing and in the basal area. Ante- and postmedial lines double, white, subbasal and submarginal lines white. Medial area dark grey with brown or green tinge, varying in width, darker in the second generation, broader in ♀, projecting in three lobes towards termen between M2 and CuA1. Discal spot usually encircled by a pale ring. A grey costal double spot near apex. Wavy line conspicuous on all wings, zigzagging or crenulate. Hindwings grey with paler transverse lines, zigzagging or undulate. Male antennae sub-quadripectinate, length of longest pectinations at basis of antennomeres 0.23-0.27 mm, on the opposite side of flagellum with shorter branches, length 0.1-0.15 mm. Posterior end of antennomeres with paired very short branches, length 0.06-0.07 mm. Palpi exceeding frons by approx. 0.4 mm, i.e. by half diameter of eye.

Differential diagnosis: Sardinian populations (n=4 barcodes) genetically distinct from *X. fluctuata* (distance 1.7%; n=39) and from Sicilian and southern Italian *X. disjunctaria* (distance 1.9%; n=23). Paraphyletic position in the neighbor joining tree (Fig. 1) not supporting subordination under *X. disjunctaria* as suggested by wing pattern and as postulated by earlier authors (e.g. BYTINSKI-SALZ 1937; MÜLLER 1996). Strict bivoltinism with two sharply defined generations at large temporal distance reminiscent of *X. disjunctaria*. The latter differing in habitus by absence of greenish coloration, on forewing sharper contrasted black and white, discal spot usually without pale ring, thus hidden in the medial area. ♂ antennal pectinations on average slightly shorter in *X. disjunctaria*: outer basal branches of antennomeres 0.17-0.25 mm – inner basal branches 0.08-0.15 mm – posterior projections 0.05 mm. In *X. fluctuata* shorter, too: outer basal branches of antennomeres 0.15-0.22 mm – inner basal branches 0.1-0.15 mm – posterior projections 0.05 mm.

Male genitalia: Differing from those of *X. disjunctaria* by the strongly bulbed terminal projection of the costa of the valva (closely fused to valvula in nominotypical *X. disjunctaria*), thus similar to equivalents in *X. fluctuata* (LINNAEUS, 1758). Compared with the latter saccus often more triangular in *X. disjunctaria* and *X. sardisjuncta*, cornuti and calcar slightly narrower.

Female genitalia: Similar to those of *X. fluctuata* and *X. disjunctaria*, but antrum broader (width 0.25 mm; length 0.25 mm) with lateral margins convex, ductus bursae shorter, corpus bursae smaller, globular, signum much shorter, length 0.4-0.5 mm only (*X. fluctuata* 1.0-1.2 mm; *X. disjunctaria* 0.8-1.2 mm).

Distribution: So far known only from Sardinia. In coll. HERBULOT (ZSM) there are four males from Porto Ercole (Tuscany, mid-October), one with typical habitus of *X. fluctuata*, three with habitus approaching *X. sardisjuncta*. The possibility of occasional gene-flow from Sardinia towards Italian peninsula requires further study.

Phenology: Bivoltine, with sharply delimited flight periods: early April to late April; mid-September to late October. Second generation somewhat earlier in sister species *X. disjunctaria*.

Biology: Larvae oligophagous on Brassicaceae. Sardinian specimens successfully reared on 'rucola' and 'broccoli', *Diplotaxis tenuifolia*, *Brassica oleracea* (LEIPNITZ pers. comm.; cf. Figs 36-37) and on *Alliaria petiolata* (MÜLLER pers. comm.).

Etymology: The species name refers to the type locality (Sardinia) and the closely related species *X. disjunctaria*.

Xanthorhoe disjunctaria (LA HARPE, 1860), 'var. *scoriaria*'

Larentia disjunctaria LA HARPE, 1860: Bull. Soc. vaudoise Sci. nat. 6: 407 (Sicily). Syntypes 9♂♀.

Cidaria disjunctaria var. *scoriaria* TURATI, 1909: Naturalista Siciliano 21: 106, pl. 7, fig. 34-41 (Sicily: Ficuzza, monte Busambra, Etna). Syntypes. Status unclear.

Examined material: 1♂, Italia, Sicilia, Etna or., Milo Camping, 37.717 N, 15.10 W, 02.IX.1997, leg. A. HAUSMANN, coll. ZSM, DNA barcode BC ZSM Lep 09524; 1♀, id., gen.prp. ZSM G 14499, DNA barcode BC ZSM 09523; 1♂, Italia, Sicilia, Aetna, Nicolosi, ab ovo, 8.1908, leg. PÜNGELER, coll. ZSM, gen.prp. ZSM G 14498.

Remarks: The above mentioned specimens differ from other Sicilian populations of *X. disjunctaria* by the dark coloration of the forewing medial area and the dark terminal areas of all wings, thus corresponding well to TURATI's 'var. *scoriaria*'. In ♂ genitalia 'scoriaria' is characterised by a large, lobous projection of the costa of the valva, whilst not or slightly projecting in several dissected Sicilian males of *X. disjunctaria*. One dissected ♀ 'scoriaria' shows a rather short signum of 0.8 mm length, whilst measuring 1.0-1.2 mm in several dissected Sicilian females of *X. disjunctaria*. These differences and the large genetic distance (4.2% in the COI barcode region) between one of the three mentioned specimens from Mt. Etna (Milo) and other Sicilian populations suggest separate taxonomic status for *scoriaria*. The female (BC ZSM Lep 09523), however, collected in the same night at the same place on Mt. Etna, genetically corresponds well to the typical *disjunctaria*-haplotype. The question awaits a broader study and examination of other material. Interestingly the COI-distance between the genetic aberrant from Mt. Etna (BC ZSM Lep 09524) and southern Italian *Epirrhoe alternata* (MÜLLER, 1764) is at 3.8% only. This short distance may be a product of genetic 'long-branch attraction', as the 'scoriaria'-specimen is clearly placed as a sister of *X. disjunctaria* in an analysis of all European *Xanthorhoe* and *Epirrhoe* species.

Xanthorhoe fluctuata (LINNAEUS, 1758)

Phalaena Geometra fluctuata LINNAEUS, 1758: Syst. Nat. (ed. 10) 1: 527 (Europe). Syntype(s) (LSL).

Remarks: Delimitation of the taxa *fluctuata* LINNAEUS, 1758, *disjunctaria* LA HARPE, 1860 and *iberaria* STAUDINGER, 1871 is not yet completely cleared up taxonomically and even extensive study of ♂ and ♀ genitalia did not reveal unambiguous differential characters. Thus, from the classical entomological point of view all three taxa might be regarded as conspecific. Molecular data (COI barcoding), however, suggesting separate species status for *X. disjunctaria* sensu stricto (Sicily and Calabria; n=23 barcodes) from *X. fluctuata* (n=39 barcodes) with a genetic distance of 1.6% (minimum pairwise distance). In the area of sympatrical occurrence of *X. disjunctaria* and *X. fluctuata* in northern Calabria and southernmost Basilicata the typical barcodes for both taxa are correlated with habitus, i.e. complete medial fascia or medial fascia reduced to a costal spot. Tunisian populations of 'disjunctaria'-habitus genetically closer to *X. fluctuata* (distance 0.9 %; n=4 barcodes from Tunisia). Also the Iberian populations of 'iberaria' (n=10) often show a complete medial

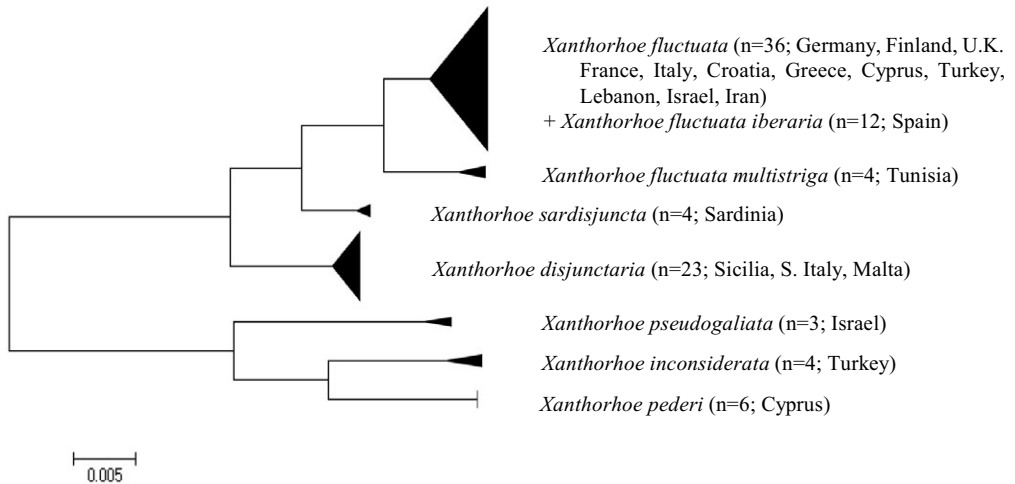


Fig. 1: Neighbor Joining tree (Kimura 2 parameter, built with MEGA 5; cf. TAMURA et al. 2007; 2011) Only barcodes (>500 bp) considered. Width of triangles represent sample size, depth the genetic variation within the cluster. Source: DNA Barcode data from BOLD (Barcode of Life Database, cf. RATNASINGHAM & HEBERT 2007).

fascia, and thus are reminiscent of *X. disjunctaria*. Genetically, however, they are identical with *X. fluctuata* (n=39 barcodes from various European and Westasiatic countries). As a consequence 'iberaria' should be subordinated under *X. fluctuata* and validated at subspecies rank (comb. rev.) because of its different coloration and pattern. Similarly the genetic data suggest to transfer the North African populations from *X. disjunctaria* to *X. fluctuata* as ssp. *herculeana* (comb. rev.) and ssp. *multistriga* (comb. rev.).

***Xanthorhoe pederi* HAUSMANN & FRIEDRICH, sp. n.** (Figs 7-8; Gen.figs 22; 28)

Holotype: ♀, Cyprus occ., Troodos Mountains, Arminou, 660m üNN, 34°52'30" N 32°43'27" E, 04.11.2008 'Lichtfang' [at light], leg. E. Friedrich, coll. ZSM, gen.prp. ZSM G 14480, DNA Barcode BC ZSM Lep 21988.

Paratypes: 1♂, id, gen.prp. ZSM G 14218; 1♀, id., coll. E. Friedrich (Jena); 1♀, Cyprus cent. Troodos Mountains, Chandria, Adelfoi, 1580m üNN, 34°57'22" N 32°59'44" E, 25.10.2008 Lichtfang [at light], leg. et coll. E. Friedrich; 1♂1♀, Cyprus cent. Troodos Mountains, Foini, Chantara Waterfalls 1020m üNN, 34°54'14" N 32°50'21" E, 01.11.2008 Lichtfang [at light], leg. et coll. E. Friedrich; 1♂, Cyprus, Troodos, 1750m, 14.-20.X.1996, leg. P. Svendsen, D. Nilsson & M. Fibiger, coll. Skou, gen.prp. ZSM G 18283. The holotype and all 6 paratypes have been DNA barcoded, under the specimenID's BC ZSM Lep 21985-21990; 35603 (cf. <http://www.boldsystems.org/views/taxbrowser.php?taxid=205626>).

Description: Wingspan ♂♀ 23-26 mm. Ground colour dirty white. Pattern grey with greenish-brown tinge. Medial area of forewing not much contrasted against ground colour, with distal border crenulate. Discal spot sharp, black. Postmedial fascia narrow, suffused with grey scales. Terminal area of forewing entirely dark, wavy line conspicuous at the whole length. Hindwing with basis and terminal area darker, postmedial fascia comparatively straight. Fringe chequered. ♂ antennae bipectinate with setose patches at the distal end of antennomeres (from where an additional pair of branches arises in quadripectinate congeners). Length of ♂ antennal branches 0.35-0.4 mm, i.e. 4 times width of flagellum. ♀ antennae filiform, setose, length of setae 0.5-0.6 times width of flagellum. Frons flat, with whitish and grey scales mixed, the latter prevailing. Palpi exceeding frons by about 1/3 diameter of eye.

Differential diagnosis: Closest related species *Xanthorhoe inconsiderata* (STAUDINGER, 1892), at a genetic distance of 2.3%. Ground colour whitish, medial area darker than in the new species, much better contrasted, without greenish tinge. Distal border of medial area less arched. Postmedial fascia of forewing broad, white. Wavy line inconspicuous towards tornus because concolorous with the large whitish tornus area. Hindwing with postmedial fascia contrasted, projecting towards termen between veins M3 and CuA1. Length of ♂ antennal branches 0.4 mm.

Male genitalia: Costa of valva at tip narrowly projecting, length of free tip 0.3-0.4 mm. Ventral part of forked costal tip attached to dorsal margin of valvula. Length of aedeagus 1.35-1.4 mm. In *X. inconsiderata* costa of valva at tip much stouter, length of free tip 0.45-0.5 mm. Ventral part of forked costal tip attached to centre of valvula. Length of aedeagus 1.45-1.5 mm.

Female genitalia: Ductus bursae straight, sclerotised, length 0.8 mm. Corpus bursae globular, signum almost absent, in lateral position, reduced to 6-7 minute spinules. In *X. inconsiderata* length of ductus bursae 1.0 mm, signum in posterior position, strongly developed as a large semicircular patch of >50 spines.

Distribution: So far known only from Cyprus, probably endemic.

Phenology: Univoltine: mid-October to early November. We do not expect the existence of a spring generation for this species considering the extended collecting activities on Cyprus in the spring months without detecting that species.

Habitat (Figs 38-39): The three known habitats are at elevations from 660 m up to 1,750 m above sea-level. Both the lower localities, i.e. Arminou (type locality) and the site near Foini are characterised by *Quercus/Crataegus*-scrubland and partial usage as extensive pasture (goats), whilst the high locality at Chandria differs strongly and is situated in a rocky steppe, poor of vegetation, close to the mountain top. The preferred ecological niche of the species requires further research.

Etymology: The species is dedicated to PEDER SKOU, who contributed a paratype of that new species and who recognized it as a potentially undescribed species. The senior author is also grateful for the major contribution of PEDER SKOU to lepidopterology through the Geometrid Moths of Europe publication project.

***Colostygia multistrigaria* (HAWORTH, 1809)**

Geometra multistrigaria HAWORTH, 1809: Lepid. Brit. (2): 306 (England: Norfolk). Syntype(s) (BMNH).

Remarks: Central Spanish populations of *olbiaria* MILLIÈRE, 1865 at a genetic distance of 4.8% from Central European *C. multistrigaria*, suggesting separate species status. In ♂ and ♀ genitalia without significant and constant differences. Length of ♂ antennal branches 0.45-0.55 mm in nominotypical populations from England and Germany to central France, 0.55-0.7 mm in *olbiaria* from southern France to Spain. Requiring further study.

***Colostygia sericeata* (SCHWINGENSCHUSS, 1926)**

Larentia multistrigaria var. *sericeata* SCHWINGENSCHUSS, 1926: Verh. zool.-bot. Ges. Wien 74-75: (143) (northern Italy, South Tyrol: Arco, Mori, Monfalcone). Syntypes ♂♀ (NHMW).

Remarks: DNA barcoding confirming species status for this taxon as proposed by SCOBLE (1999) and LERAUT (2009): Sister species *Colostygia multistrigaria* (HAWORTH, 1809) at a genetic distance of 7.8%. In ♂ genitalia valva of *C. sericeata* on average slightly broader, aedeagus longer (1.4-1.5 mm rather than 1.25-1.4 mm). ♂ antennal branches (0.55-0.65 mm) longer than in nominotypical *C. multistrigaria*.

North African populations (*holli* PROUT, 1938) may be a separate species, too, but still lack representance in the DNA barcode library. Populations from southern Italy, similar in habitus to *holli*, at a genetic distance of 3.6% from *C. sericeata*. Comparison of populations from southern Italy (Calabria) and central Italy (Abruzzi), however, showing a similarly large distance of 2.3% (cf. Fig. 2). No significant and constant differences found in ♂ and ♀ genitalia.

***Colostygia aqueata* (HÜBNER, 1813)**

Geometra aqueata HÜBNER, 1813: Samml. Eur. Schmett. 5, Geometrae (1): pl. 68, fig. 353 (Europe). Syntype(s).

Remarks: Populations from central Italy without greenish tinge (A. MAYR, P. HUEMER pers. comm.), reminiscent of ssp. *hercegovinensis* (REBEL, 1901). Several dissected specimens, however, not showing any constant and significant difference from male and female genitalia of nominotypical *C. aqueata*. Genetic distance between central Italian populations and nominate subspecies 1.8% (n=3; P. HUEMER, pers. comm.). In one single central Italian specimen an aberrant haplotype was discovered, being at a genetic distance of 3.2% from syntopic specimens of *C. aqueata* (Mte. Terminillo, P. HUEMER, pers. comm.), and 1.8% from nominate subspecies. The question needs accurate integrative analysis basing on a broad sample. The sister species *Colostygia stilpna* (PROUT, 1924) from the French High Alps (cf. Fig. 2) shows constant differences

in habitus and genitalia (uncus shorter, labides shorter, bundle of cornuti narrower at base). Genetic distance between *C. aqueata* and *C. stilpna* 2.3%.

***Colostygia fezae*, sp. n.** (Fig. 9-10; Gen. figs 23; 29)

Holotype: ♀, Turkey, Dogu Anadolu, Erzurum, Ispir Mescit Daglari, 19km SW Ispir, 1950 m, 24.VII.2001, leg. J. GELBRECHT, R. BUSSE & A. KAZANCI, coll. ZSM, DNA Barcode BC ZSM Lep 8916.

Paratypes: 1♂2♀, Turkey, Karadeniz, Rize, Ikizdere, Dogu Karadeniz, Daglari Ovit Dagi, Sivrikaya bei Ikizdere, 2100 m, 24.VII.2001, leg. J. GELBRECHT, R. BUSSE, A. KAZANCI & E. SCHWABE, coll. J. GELBRECHT, DNA Barcodes BC ZSM Lep 8914, 8915; 1♂1♀ NE Turkey, Prov. Erzurum, Korga Dari, Köprüköy Umgebung bei Ispir, 2000 m, 4.VIII.2001 leg. J. GELBRECHT, R. BUSSE, A. KAZANCI & E. SCHWABE, coll. J. GELBRECHT; 2♀, Turkey, Prov. Erzurum, Umg. Ispir, Mescit Daglari Köprüköy, 2000m, 02.VIII.2001 leg. D. STADIE & H. LÖBEL, coll. D. STADIE; 1♂, Turkey, Prov. Erzurum, Mescit Daglari Gölyurt Gecidi, 27.VII.2002, 2400m, leg. D. STADIE & H. LÖBEL, coll. D. STADIE; 1♂2♀, Türkiye sept. or., Prov. Ardahan, Ilgardagi Gecidi N-Seite, S Posof, 2000m, LF., 11.VIII.2001, leg. et coll. L. LEHMANN.

Further material: coll. ZSM: 2♂8♀, northern Caucasus, various localities; coll. B. MÜLLER: 13♂♀, Russia, Caucasus sept. occ., Teberda valley, Teberda, 1250-1300 m (19.VII.1971, 22.-23.VII.1973, 02.-07.VIII.1976) and Dombai 1600 m (25.-30.VIII.1974).

Description: Wingspan 21-24 mm. Ground colour pale grey, basal and terminal area usually with green tinge quickly fading to yellow or brown. Pattern moss green quickly fading to dark grey brown. Medial area with pale centre towards costa including the blackish discal spot. Distal border of medial area with rounded projection towards termen at centre. Forewing postmedial fascia whitish or pale grey with dark grey dividing line, the latter sometimes diffuse. Postmedial fascia in Caucasian specimens broader and more whitish. Terminal area of forewing comparatively pale, wavy line often dissolved into dots, bordered by greyish shadows, towards apex with three sharp, black dots. Terminal line dissolved to elongate double streaks or spots at both sides of the whitish endings of veins. Hindwing dark, postmedial line double, inconspicuous. ♂ antennae bipectinate, length of branches 0.35 mm, i.e. 3-4 times width of flagellum. Frons flat, whitish, mixed with dark scales. Palpi dark, exceeding frons by 0.5-0.7 mm, i.e. by 0.65-0.75 times diameter of eye.

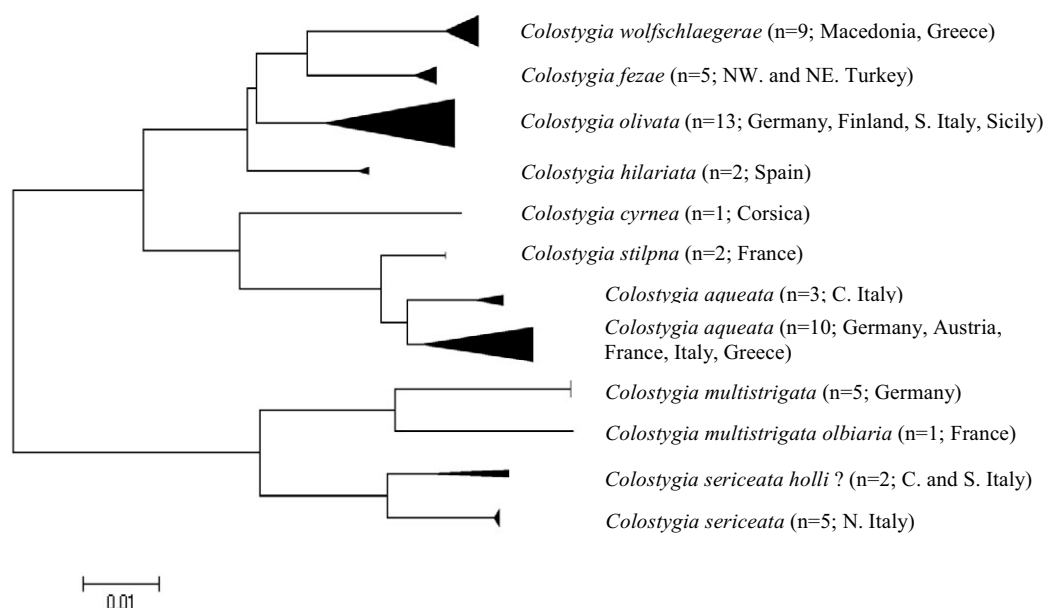


Fig. 2: Neighbor Joining tree (Kimura 2 parameter, built with MEGA 5; cf. TAMURA et al. 2007; 2011) Only barcodes (>500 bp) considered, except for the 407 bp sequence of *Colostygia cyrnea* (see discussion in the text). Width of triangles represent sample size, depth the genetic variation within the cluster. Source: DNA Barcode data from BOLD (Barcode of Life Database, cf. RATNASINGHAM & HEBERT 2007).

Male genitalia: Length of uncus about 0.5 mm. Valva broad, costa convex. Length of aedeagus 1.3-1.4 mm, with two patches of cornuti. Basal patch large, length 0.45-0.5 mm, with numerous stout cornuti. Distal patch 0.5-0.6 mm, length of both patches together (uneverted) 0.8-0.9 mm. Dissected specimens from the Caucasus well corresponding.

Female genitalia: Ductus bursae dilating towards corpus bursae. Length of colliculum 0.1-0.15 mm. Corpus bursae elongate oval or sub-pyriform. Signum developed as an elongate, scobinate patch, length 0.15-0.2 mm.

Differential diagnosis: Closest related species *Colostygia wolfschlaegerae* (PINKER, 1953), and *C. olivata* (DENIS & SCHIFFERMÜLLER, 1775) both at a genetic distance of 3.8%, the latter diverging into at least four regional DNA clusters. In external appearance the new species is reminiscent of *C. wolfschlaegerae*, the latter however with longer ♂ antennal branches (0.5 mm) and one patch of cornuti only in ♂ genitalia. *C. olivata* on average larger and darker, in ♂ genitalia differing by shorter aedeagus (1.2-1.3 mm), shorter cornuti patches (length together 0.6-0.75) and shorter basal patch of cornuti (0.35-0.4 mm), consisting of only 5-7 larger spines. In ♀ genitalia signum of both *C. wolfschlaegerae* and *C. olivata* longer (0.35-0.5 mm).

Distribution: From northwestern to northeastern Turkey and Caucasus. Montane, from 1,700 m up to 2,100 m above sea-level, in the Caucasus from 1,200 m up to 2,000 m. Sister species *C. wolfschlaegerae* at lower altitudes, usually from 0 m up to 800 m.

Phenology: Univoltine mid-July to late August. Flight period of *C. wolfschlaegerae* later, from mid-August to mid-October.

Etymology: The species is dedicated to Dr. Feza CAN, Antakya, Hatay, for her great merits in the study of Turkish Geometridae. The DNA barcodes of some of the paratypes have been generated in one of her research projects on Turkish Geometridae.

***Coenotephria schneideraria* (LEDERER, 1855), comb.n.**

Larentia schneideraria LEDERER, 1855: Verh. zool.-bot. Ges. Wien 5 (Abh.): 214, pl. 3, fig. 8 (Lebanon: Beirut, Dog river). Syntypes 30. Combined with *Xanthorhoe* in WILTSHIRE (1939), with *Nebula* in MÜLLER (1996) and SCOBLE (1999). Herewith transferred to genus *Coenotephria* (comb.n.)

Differential diagnosis: Genetically closest species *Coenotephria florianii* sp. n., at a genetic distance of 7.4% and *C. antonii* at a distance of 7.5% (cf. Fig. 3). All species of the genus *Nebula* at minimum distances of >9.9% (Fig. 4). Morphologically the bipectinate ♂ antennae and the great external similarity with *C. tophaceata* support the position in *Coenotephria*. In male genitalia shape of labides and hamulus more reminiscent of genus *Nebula* but labides are dilated in *C. schneideraria*. In female genitalia the signum shows no transverse ridge which is characteristic for the genus *Nebula*.

Distribution: East-Mediterranean. *C. s. eteocretica* (REBEL, 1906) on Crete island, nominate subspecies on Rhodos and Cyprus, and from coastal southern Turkey to Lebanon, on Tauros mountains replaced by *C. s. taurica* (STAUDINGER, 1901).

Remarks: *C. s. eteocretica* from Crete island at 3.3% genetic distance from West-Asiatic populations of the nominate subspecies. Nominate subspecies with slightly longer ♂ antennal branches (0.7-0.8 mm rather than 0.6-0.7 mm) and slightly stronger bulbed frons. Since no constant and significant differences between both taxa were found in ♂ and ♀ genitalia, the taxon *eteocretica* may better be subordinated under *C. schneideraria* at subspecies rank (cf. Fauna Europaea: HAUSMANN et al. 2010) rather than validated at species rank as postulated by MÜLLER (1996) and SCOBLE (1999).

***Coenotephria antonii* sp. n. (Fig. 11; Gen.fig. 30)**

‡ *Nebula tophaceata*: sensu PARENZAN & HAUSMANN (1992), nec DENIS & SCHIFFERMÜLLER, 1775.

Holotype: ♀, Italia mer., Basilicata mer., Trecchina [Piano dei Peri; 39.9919 N, 15.7931 E], 320m, 15.XI.1987, leg. A.

HAUSMANN, coll. ZSM, gen.prp. ZSM G 4621, DNA barcode BC ZSM Lep 15059.

Paratype: 1♀, id., 29.X.1996, DNA barcode BC ZSM Lep 12926.

Description: Wingspan 27-28 mm. Ground colour whitish. Wing pattern pale grey, diffuse, without any trace of yellow coloration. Hindwing with discal spot close to costa. Frons bulbed.

Differential diagnosis: Closest related species *Coenotephria tophaceata* (DENIS & SCHIFFERMÜLLER, 1775), at a genetic distance of 6.6% (Kimura 2, nearest neighbor analysis, see remarks) and *C. schneideraria* (LEDERER, 1855), at a genetic distance of 7.5%. Central Italian populations of *C. tophaceata* differing from

those of central Europe by 1.5% only. In habitus the new species is reminiscent of *C. tophaceata*, but pattern paler, more diffuse, yellow coloration on forewing completely absent, frons stronger bulbed.

Female genitalia: Similar to those of *C. tophaceata*, but signum much longer (1.6 mm), with spinose invagination at anterior end. Cingulum wider (0.35 mm) than long (0.3 mm).

Distribution: So far known only from southern Italy, probably endemic.

Phenology: Data limited to late October and mid-November, so far. Despite extensive sampling at the type locality in the months from March to June, no specimen of a spring generation could be collected.

Habitat: South-eastern facing slope in a deep river valley at 320 m above sea level, with almost vertical rocky walls and nearby mountain tops up to 1,000 m.

Etymology: The species name refers to the latinized form 'Antonius' (genitive case *antonii*, grammatically formed according to ♂ 31.1.1. and 31.1.2. of the Code, ICZN 1999) of the name of my father-in-law, ANTONIO GUARAGNA (Praia a Mare, Italy) and is dedicated to him for supporting me over so many years in my studies of southern Italian Lepidoptera.

Remarks: The new species was sequenced at a short fragment of 370 bp only, but the direct comparison of this southern Italian specimen with central Italian specimens of *Coenoteophria tophaceata* reveals differences in 24 variable sites across the whole length of the fragment, when examining the trace files and comparing 'manually' aligned sequences of this 370 bp fragment (6.5%).

***Coenoteophria salicata* (DENIS & SCHIFFERMÜLLER, 1775)**

Geometra salicata DENIS & SCHIFFERMÜLLER, 1775: Ankündigung syst. Werkes Schmett. Wienergegend: 109 (not indicated). Syntype(s). Previously combined with *Nebula* (MÜLLER 1996; SCOBLE 1999) transfer to *Coenoteophria* proposed by HAUSMANN et al. (2004; 2010 Fauna of Europe) and SCOBLE & HAUSMANN (2007) anticipating the GME3 revision.

Remarks: Genetically well separated from *Coenoteophria ablutaria* (BOISDUVAL, 1840) (see Fig. 3), confirming species rank for both taxa. Though controversial until recently, species rank was postulated for *C. ablutaria* by various authors (e.g. HAUSMANN et al. 2004; REZBANYAI-RESER 2008) basing on differential features in wing coloration, wing shape and genitalia (e.g. terminal hook 1/8 length of hamulus in *C. salicata*, 1/4 in *C. ablutaria*), such as different ecological niche. In addition, barcode data show two different, intraspecific COI haplotypes within the Central European distribution of *C. salicata* (Fig. 3) without clear correlation with differential features in habitus and/or genitalia. One of the two genetic types was found only in south-easternmost Bavaria, so far. The question is still under research.

***Coenoteophria ablutaria probaria* (HERRICH-SCHÄFFER, 1852) (Fig. 12)**

Larentia probaria HERRICH-SCHÄFFER, 1852: Syst. Bearb. Schmett. Eur. 6 (55): 78 (not indicated, types probably from Croatia (PROUT 1938)). Syntype(s), not traced in MNHU, Berlin (W. MEY, pers. comm.) nor in NHM, London (J. CHAINEY pers. comm.). Neotype herewith designated to gain nomenclatural stability by fixing taxon identity and type locality. Validated here at subspecific rank, as previously proposed by PROUT (1938) and SCOBLE (1999).

Neotype (cf. Fig. 12): ♀, Croatia, Novi Vinodolski, 3.IV.2007, leg. Dr. T. GRÜNEWALD, coll. ZSM, gen.prp. ZSM G 18394, DNA Barcode BC ZSM Lep 31861.

Redescription of western Croatian populations: Wingspan 20-26 mm. Ground colour whitish to light grey, pattern ash grey. Discal spot usually conspicuous and well separate from both bordering fasciae of medial area. Length of ♂ antennal branches 0.5-0.6 mm.

Differential diagnosis: Closest related taxa *Coenoteophria ablutaria hangayi* (VOJNITS, 1986) (see below), at a genetic distance of 1.3% and nominate subspecies at a distance of 2.5% (see Fig. 3). Both nominate subspecies and ssp. *hangayi* with forewing termen and apex more rounded, wings suffused with yellowish or ochreous scales, cell spot often inconspicuous.

Phenology: Bivoltine with sharply defined flight periods: Late March to early May; late September to late October.

Distribution: Western Balkan peninsula, coastal regions of Croatia (Istria and Dalmatia), Montenegro, Albania, western Greece, Corfu. In the west to the valleys of the southern Alps (DNA barcoded from eastern province Lombardia, Alto Adige, Veneto, Friuli) but here with slightly different habitus and increasing ochreous coloration. Delimitation from nominate subspecies requiring further study, populations of central and southern Italy still lacking DNA barcodes, their habitus being characterised by a more ochreous suffusion

and rounded forewings, thus reminiscent of the nominate subspecies. Nominate subspecies from southern France to Sicily and Malta in the south, present on Corsica and Sardinia.

Remarks: PROUT (1938) discussed the taxonomy of “*Cidaria ablutaria*” being strongly in favour of its validity at species rank. The East-Mediterranean populations from southern Balkan countries to southern Levant (Sinai) and northern Iran (Kordestan) form a separate genetic cluster, see below.

***Coenotephria ablutaria hangayi* (VOJNITS, 1986), comb.rev.**

‡ *Larentia salicata* ab. (v.?) *ochrearia* STAUDINGER, 1901: in STAUDINGER & REBEL, Cat. Lep. Pal. 1: 295 (Lebanon: Beirut). unavailable, because not clearly, unambiguously and expressly presented as “var.” (cf. ♂ 45.6.4. Code ICZN 1999).

‡ *Cidaria salicata ochracearia*: PROUT (1938), incorrect subsequent spelling of *ochrearia*; it is unclear whether PROUT intended to raise this taxon to an available (subspecies) rank or not.

Cidaria (Colostygia) salicata hangayi VOJNITS, 1986: Annls hist.-nat. Mus. natn. hung. 78: 221, pl. 1H, fig. 5 (Iran, Fars: Kazeroun-Bouchir Tchoureum). Holotype ♀, gen.prp. VOJNITS 16433 (SMNK). Listed in SCOBLE (1999) at subspecific rank under *Nebula salicata*. Dissected and barcoded material from Iran suggesting transfer to *C. ablutaria* (comb. rev.).

Wingspan of early spring generation 22–26 mm, late autumn specimens 19–23 mm with occasional dwarf forms of 16–18 mm only. Coloration reminiscent of that of the nominate subspecies, i.e. with extended ochreous suffusion. Forewing termen and apex rounded. Pale area around discal spot at the centre of medial area small or absent. Length of ♂ antennal branches 0.5–0.6 mm, in the dwarf forms exceptionally 0.45 mm only.

Differential diagnosis: Closest related taxa *Coenotephria ablutaria probaria* (see above), at a genetic distance of 1.3% and nominate subspecies at a distance of 2.5% (see Fig. 3). In habitus and genitalia almost no constant and significant difference from nominate subspecies, except for the medial area of forewing being narrower on average and often without pale centre. For differences from ssp. *probaria* see above.

Distribution: East-Mediterranean: Bulgaria, Greece including Peloponnes, Egean islands and Crete, Turkey, Levant to Sinai in the south, in the east to northern Iran (Kordestan), see remarks. In northern Greece the subspecies has been collected and DNA-barcoded early September at 1,300 m in province Joannina and late May at 900 m in the western Bulgarian mountains (S. BESHKOV pers. comm.).

Phenology: Bivoltine: In the Levant restricted to the winter months from late October to mid-May with overlap of generations in February. In southernmost Balkan countries and in Turkey north of Taurus late September to early November; late March to mid-May, under good conditions in the lowlands the whole winter through. The northernmost specimens (Joannina, Bulgaria, see under distribution) collected early September and late May, indicating clearly separate generations here, probably due to the high elevation and the longer period of snow coverage. Difference in size between late autumn and early spring moths clearly indicating bivoltinism even in the south where the generations are joined to one long flight period in winter.

Remarks: Within the area of distribution, three different regional genetic clusters can be distinguished: (1) southern Balkan peninsula, Egean islands, (2) Levant and (3) Taurus, eastern Turkey, northern Iran. The genetic distances are at 0.5% (Levant – Iran), 0.8% (Iran – S. Balkan) and 1.4% (S. Balkan – Levant).

***Coenotephria florianii* sp. n. (Figs 13–14; Gen.figs 24; 31)**

Holotype: ♂, Lebanon c., Laqlouq env., h – 1600 m, 4.10.[20]08, leg. I. & A. FLORIANI, A. SALDAITIS, DNA barcode BC ZSM Lep 19604.

Paratypes: 1♀, id., gen.prp. ZSM G 14495, DNA barcode BC ZSM Lep 19607. 1♂, id., gen.prp. ZSM G 14494, DNA barcode BC ZSM Lep 19603. 2♀, id., 29.9.[20]08, DNA barcodes BC ZSM Lep 19608, 19615.

Further material: 1♂, southern Turkey, prov. Sivas, Gürün, 13.–21.9.1975, leg. FRIEDEL, coll. ZSM, very similar in habitus, with ♂ antennal pectination 0.25 mm, excluded from type series because of the large geographical distance of >500 km from the type locality.

Description: Wingspan 22–24 mm. Forewing apex angled. Ground colour whitish, pattern dark grey, almost without brown and ochreous scales. Forewing medial area dark grey, with jagged borders and black discal spot. Postmedial fascia whitish, divided by a grey line. Terminal area grey with wavy line usually conspicuous. Hindwing dark with conspicuous double postmedial fascia. ♂ antennae bipectinate, length of antennal branches 0.35 mm. Frons slightly convex. Palpi slightly exceeding frons, by 0.2–0.3 mm.

Differential diagnosis: Closest related species *C. ablutaria* (BOISDUVAL, 1840), at a genetic distance of 5.6%. In external appearance (habitus) superficially reminiscent of *Epirrhoe galiata*, the latter easily to be

distinguished by its filiform, ciliate ♂ antennae. *Xanthorhoe disjunctaria* and *X. pseudogaliata* similar, too, but differing by quadripectinate or sub-quadipectinate ♂ antennae and strongly differing genitalia. ♂ antennal branches in *C. florianii* much shorter than in both *C. salicata* (DENIS & SCHIFFERMÜLLER, 1775) and *C. ablutaria* (BOISDUVAL, 1840), forewing apex sharper angled, medial area darker and ochreous coloration lacking.

Male genitalia: Uncus curved, narrow, length about 0.75 mm. Labides long (0.85 mm), length of hamulus 0.2 mm, with extremely short hook at tip (1/10 length of hamulus). Valva broad and rounded. Aedeagus strongly sinuous, short (1.2 mm) and broad.

Female genitalia: Colliculum large, V-shaped, length and width 0.2 mm. Ductus bursae broad S-shaped, length 1.5 mm. Signum elongate, scobinate, length about 0.75 mm, with thorn-shaped invagination at the anterior end.

Distribution: High mountains of Lebanon and southern Turkey. In the Lebanese lowlands replaced by *Coenotephria ablutaria hangayi*.

Phenology: Data restricted to late September and early October, so far.

Etymology: The species is dedicated to Mr. ALESSANDRO FLORIANI (Italy), who collected the new species together with AIDAS SALDAITIS (Lithuania).

Remarks: The Lebanese records of “*Xanthorhoe salicata*” in WILTSHIRE (1939) refer to specimens collected in the lowlands and “at middle heights” thus correctly identified as *Coenotephria ablutaria hangayi* very probably.

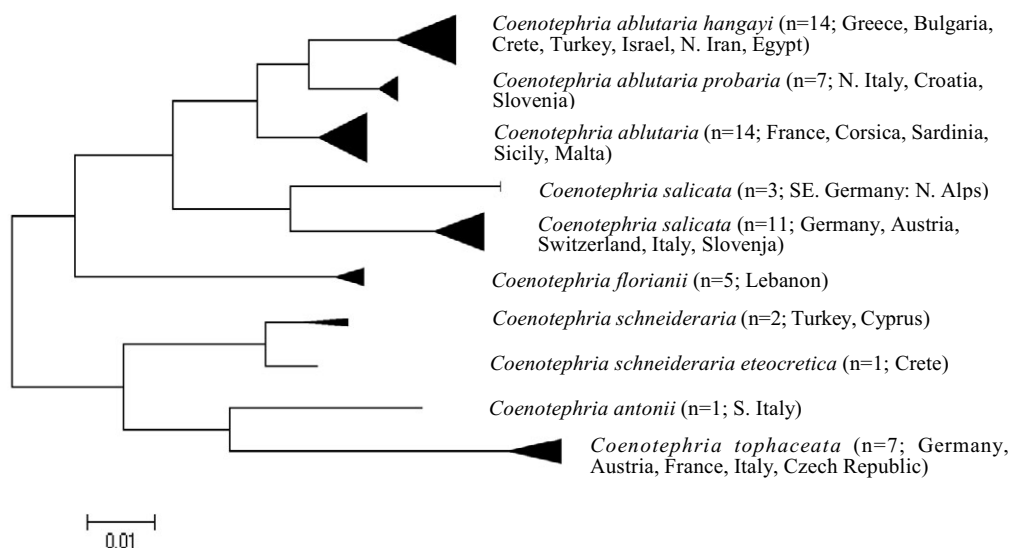


Fig. 3: Neighbor Joining tree (Kimura 2 parameter, built with MEGA 5; cf. TAMURA et al. 2007; 2011) Only barcodes (>500 bp) considered, except for the 370 bp sequence of *Coenotephria antonii* (see discussion in the text). Width of triangles represent sample size, depth the genetic variation within the cluster. Source: DNA Barcode data from BOLD (Barcode of Life Database, cf. RATNASINGHAM & HEBERT 2007).

Nebula pirinica (REISSER, 1936), bona species (Fig. 17)

Cidaria nebulata pirinica REISSER, 1936: Entomol. Rundschau 53 (9): 135, pl. 3, figs A1-6, B1-6. Out of >12 syntypes from Bulgaria, Pirin Mts. and >40 syntypes from Spain (SMNK and ZSM, examined), one ♂ “Holotype” had been selected and labelled as such with the handwriting of H. REISSER (“designated 6/1/1972”). This unpublished act is invalid. Herewith, I designate this ♂ as Lectotype (Fig. 17) to make identity and type locality of this taxon unambiguous: Lectotype ♂, Bulgaria, western Pirin Mts., Spanopole (paralectotypes from the type locality and from

Spain, Sierra de Gredos Mts., Garganta de las Pozas, Laguna de Gredos). Validated at subspecific rank by SCOBLE (1999), herewith raised to species rank.

Redescription: Wingspan 22-26 mm, on Mt. Olympus up to 28 mm. Ground colour creamy white. Transverse lines and fasciae dark grey brown, usually contrasted. Terminal line dissolved to paired dots, sometimes to elongate streaks. Frons bulbed, projecting by 0.25-0.35 times diameter of eye. Palpi not exceeding frons. ♂ antennae filiform, sub-dentate, ciliate-fasciculate, length of cilia 1.0-1.25 times width of flagellum.

Differential diagnosis: Closest related species *Nebula longipennis* (BRANDT, 1941) from the Iran, at a genetic distance of 4.7%, and the European *Nebula nebulata* (TREITSCHKE, 1828) at a genetic distance of 5.8%. Wing pattern and transverse fasciae usually stronger contrasted than in *N. nebulata*, though on Mt. Olympus sometimes occurring in rather similar individual forms. *N. nebulata* on average larger, wingspan 25-30 mm, ♂ antennal cilia slightly shorter, 0.9-1.15 times width of flagellum, frons less bulbed, projecting by 0.2-0.25 times diameter of eye only.

Male genitalia: Uncus stout, curved, length 0.85-0.9 mm. Valva rounded, comparatively broad. Labides with hamulus, the latter bent at the basis and hooked at tip. Length of hamuli 0.5-0.6 mm. Length of aedeagus 1.3-1.5 mm. In *N. nebulata* length of hamuli 0.45-0.5 mm, length of aedeagus 1.25-1.4 mm. The genus *Nebula* is characterised by very small interspecific differences in male genitalia.

Female genitalia: Colliculum V-shaped, length 0.15-0.2 mm. Length of ductus bursae 1.7 mm, Z-shaped. Signum stripe-shaped and scobinate, length 1.1 mm, posteriorly tapering. Colliculum in *N. nebulata* slightly larger, length 0.25 mm, signum longer and slightly broader, length 1.2-1.3 mm.

Distribution: Southern half of the Balkan peninsula, some examined specimens from Caucasus (ZSM) in ♂ and ♀ genitalia well corresponding to *N. pirinica*.

Nebula carlae sp. n. (Figs 15-16; Gen. figs 25; 32)

‡ ? *Nebula nebulata*: sensu PARENZAN (1994), nec TREITSCHKE, 1828. Identity unclear (see remarks).

‡ ? *Nebula achromaria*: sensu RAINERI & ZANGHERI (1995; partim: centre-south Italy), nec LA HARPE, 1853.

Holotype: ♂, Italia mer., Calabria sept., Mte. Pollino, [Colle del] Dragone, 1600m, 3.VI.1998, leg. A. HAUSMANN, coll. ZSM, gen.prp. ZSM G 12058, DNA Barcode BC ZSM Lep add 00119.

Paratypes: 1♂, Italia mer., Basilicata mer., Valle del Noce, Trecchina [Piano dei Peri], 320m, 27.VIII.2000, leg. A. HAUSMANN, coll. ZSM, gen.prp. ZSM G 12059; 1♂, Italia mer., Calabria sept., Mte. Pollino, 5km N Civit , 1000m, 31.VIII.2001, leg. A. HAUSMANN, coll. ZSM, DNA Barcode BC ZSM Lep 12927; 1♂, [Italia mer., Calabria sept.], Massiccio del Pollino, Timpone Castellano, 1000m, 13.IX.1979, leg. P. PARENZAN; 1♀, Italia mer., Basilicata mer., Mte. Sirino, NO. Felswand, 1400m, 26.VIII.1994, leg. A. HAUSMANN, coll. ZSM, gen.prp. ZSM G 18109; 1♂, Italia mer., Basilicata mer., Cristo di Maratea [statua del redentore], 650m, 21.IV.1994, leg. A. HAUSMANN, coll. ZSM, gen.prp. ZSM G 12057.

Further material (coll. ZSM): 1♂1♀, central Italy, Abruzzo, Pescocostanzo; 1♂1♀, central Italy, Mtgna. Grande, 1♂, Gran Sasso.

Description: Wingspan first generation 25-26 mm, second generation 20-22 mm. Ground colour white with slight grey suffusion. Transverse lines sharp, at costa usually with conspicuous spots. Discal spot of forewing well developed. Hindwing dark with pale postmedial fascia. Underside pale with discal spot and distal border of medial area sharply marked. ♂ antennae filiform, sub-dentate, cilia 0.8-0.85 times width of flagellum, in ♀ 0.5 times. Frons distinctly bulbed, projecting by 1/3 to 1/4 diameter of eye.

Differential diagnosis: Closest related species *Nebula achromaria* (LA HARPE, 1853) (barcoded from Austria, northern and central Italy, Greece, Slovakia), at a genetic distance of 3.5%. In *N. achromaria* wing coloration paler, pattern less accentuated, more diffuse, without conspicuous spots at costa, discal spot inconspicuous. Frons less projecting, convex, projecting by 1/5 diameter of eye at maximum. ♂ antennal cilia slightly shorter (0.6-0.8 mm). Habitus of populations from central Italy slightly differing in being paler and pattern less contrasted, thus approaching habitus of *N. achromaria*.

Male genitalia: Length of uncus 0.8-0.95 mm. Length of hamulus 0.4-0.45 mm. No constant and significant difference from ♂ genitalia of *N. achromaria*.

Female genitalia: Lamella antevaginalis with paired dents. Length of colliculum 0.1-0.2 mm. Length of ductus bursae 1.5-1.8 mm, Z-shaped, rectangularly bent twice, slightly dilating towards corpus bursae. The latter globular or elongate in transverse position to ductus bursae. Signum scobinate, large, with long central ridge (0.45-0.5 mm), at anterior margin not bilobous. In *N. achromaria* signum smaller, central ridge shorter (0.25-0.35 mm) and bilobous anteriorly.

Distribution: Type series from southern Italy, populations from central Italy conspecific, judging structure of head and female genitalia (not yet DNA barcoded). Probably endemic to the Apennine peninsula. Montane, usually from 600 m up to 1,700 m above sea-level, in deeply indented valleys sometimes lower. Always collected near cliffs and large vertical rock faces.

Phenology: Bivoltine: late April to early June; mid-August to mid-September.

Etymology: The species name refers to the short form 'carla' of the name of my mother-in-law, GIANCARLA BERNUZZI (Praia a Mare, Italy), and is dedicated to her for supporting me over so many years in my studies of Mediterranean Lepidoptera.

Remarks: PARENZAN's (1994: fig. 9g) figured specimen reminiscent of this new species, with an early collection date of 13.IV.1979 (too early for *N. nebulata*). Occurrence of *N. nebulata* in southern Italy awaiting re-examination and verification.

Nebula ibericata fiumii ssp. n. (Figs 18-19; Gen. figs 26; 33)

Holotype: ♀, [Italy], Sardegna, S[an]. Salvatore [Cabras (OR)], 9.X.[20]08, leg. M. GUIDI, coll. ZSM, gen.prp. ZSM G 14501; DNA Barcode BC ZSM Lep add 00120.

Paratypes: 1♂, id., coll. M. GUIDI (Forlì, Italy); 1♀, [Italy], Sardegna, Cagliari, M.S. Elia, IX.[19]96, leg. et. coll. G. FIUMI (Forlì, Italy); 1♂, [Italy], Sardinia, 3 km NW of Fluminimaggiore, 50 m, 31.III.2002, leg. et coll. P. SKOU (Stenstrup, Denmark), gen.prp. ZSM G 18349, DNA Barcode BC ZSM Lep 35670; 1♂, id., 4.IV.2002, gen.prp. ZSM G 18348, DNA Barcode BC ZSM Lep 35669.

Description: Wingspan ♂♀ 22-23 mm. ♂ forewing termen comparatively straight. Forewing ground pale sand coloured with sharp, brown pattern. Medial area narrow, especially towards termen. Postmedial fascia distally bordered by a row of black dots. ♂ hindwing pale with weak pattern, in ♀ a bit darker. ♂ antennae filiform, sub-dentate, with comparatively long cilia, length 1.2-1.4 times width of flagellum. Palpi not exceeding frons.

Differential diagnosis: Closest related taxon *Nebula i. ibericata* (STAUDINGER, 1871) from Iberian peninsula, at a genetic distance of 1.8% and another, undescribed subspecies from Jordan, at a genetic distance of 1.6%. Subspecies *numidiata* (STAUDINGER, 1892) barcoded in one single specimen from the Canary islands at 2.0% distance from *N. i. fiumii* and 0.9% only from nominotypical Iberian populations of *N. ibericata*. In wing coloration and pattern the new subspecies falls within the large range of variation of the nominate subspecies and ssp. *numidiata* from North Africa, main morphological difference in longer ♂ antennal ciliation, measuring 0.9-1.2 times width of flagellum in both aforementioned subspecies.

Male and female genitalia: No constant and significant differences from those of the nominate subspecies.

Distribution: So far known only from Sardinia, possibly endemic. The question whether the records for Sicily (PROUT 1938; RAINERI & ZANGHERI 1995) refer to this subspecies or to *N. i. numidiata* requires further study.

Phenology: Bivoltine, data from late March, early April, September and early October. Well corresponding to phenology of nominate subspecies.

Etymology: The species is dedicated to the Italian lepidopterologist GABRIELE FIUMI, Forlì for his merits in the exploration of the Sardinian fauna and for multiple support and cooperation regarding the Italian geometrid fauna.

Remarks: The identity of *Nebula juvenilata* (ZERNY, 1933) from the Lebanon requires further study, as there are two completely different DNA barcode haplotypes as 'candidates' for that taxon (not shown in Fig. 4).

Euphyia vallantinaria (OBERTHÜR, 1890) (Fig. 20)

Cidaria vallantinaria OBERTHÜR, 1890: Études ent. 13: 31, pl. 7, fig. 49 (Algeria: near Bône). Syntype(s).

Material examined: 1♀, Spain, Andalusia, Casares, Finca la Molina (Malaga), 320 m, 9.IX.2010, leg. P. HALE, coll. ZSM, DNA Barcode BC ZSM Lep 46968; 1♀, Spain, Andalusia, los reales de Sierra Bermeja (Malaga), 1150 m, 5.VIII.2003, leg. T. GRÜNEWALD & A. SEGERER, coll. ZSM, DNA Barcode BC ZSM Lep 31863, gen.prp. ZSM G 18396. – For comparison 6♂♀ from Algeria (coll. HERBULOT in ZSM).

Distribution: Southern Andalusia, Spain, new for the fauna of Europe (cf. Fauna of Europe, HAUSMANN et al. 2010), Algeria (locus typicus Bône, eastern Algeria).

Remarks: After the first record of a female (leg. THEO GRÜNEWALD & ANDREAS SEGERER) the dissected specimen was tentatively identified as *Euphyia biangulata* (HAWORTH, 1809) because of the great similarity in female genitalia. However, the identification remained doubtful because of some differences in habitus

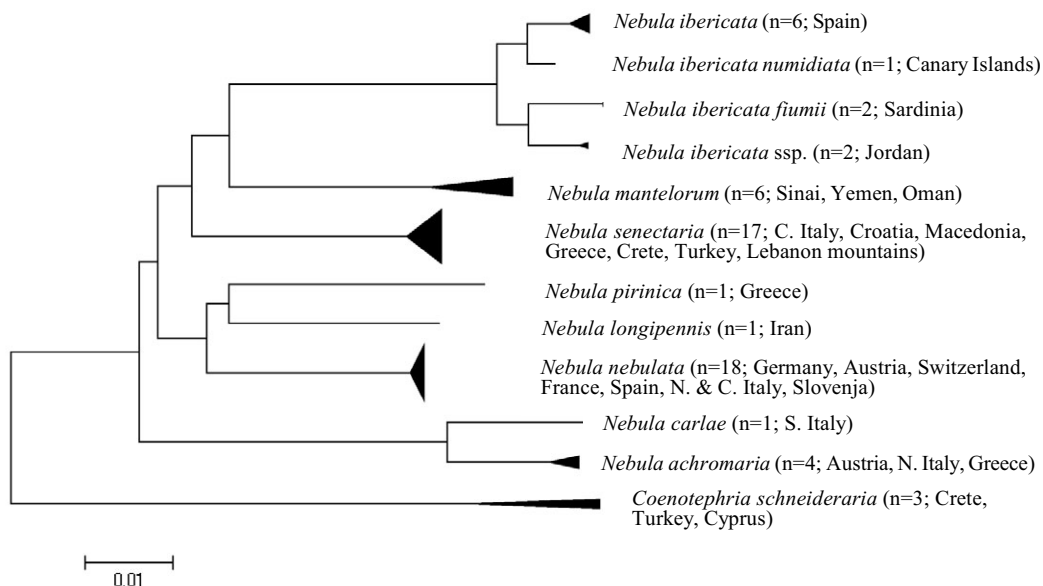


Fig. 4: Neighbor Joining tree (Kimura 2 parameter, built with MEGA 5; cf. TAMURA et al. 2007; 2011) Only barcodes (>500 bp) considered, except for the 370 bp sequence of *Coenotephria antonii* (see discussion in the text). Width of triangles represent sample size, depth the genetic variation within the cluster. Source: DNA Barcode data from BOLD (Barcode of Life Database, cf. RATNASINGHAM & HEBERT 2007).

(hindwings darker, postmedial fascia narrower, forewing terminal area darker with wavy line more contrasting) and the large distributional gap of >600 km between the southernmost known populations of *E. biangulata* (northernmost Portugal, northernmost Spain: REDONDO et al. 2009) and the southern Andalusian populations. Later on one further female was collected by PENNY HALE (Casares, Spain). These two Andalusian specimens were DNA barcoded and revealed large genetic distance from central European *E. biangulata* (5.6%), suggesting separate species rank. Re-examination of the specimens showed their great similarity in habitus with the North African species *E. vallantinaria*, which exactly corresponds also in female genitalia. No significant and constant differential feature in ♀ genitalia could be found between European *E. biangulata* and North African *E. vallantinaria*. The identification of the Andalusian populations as *E. vallantinaria*, however, awaits further corroboration either through DNA barcoding of North African material, or through dissection of a ♂ from southern Spain.

Discussion

A plea for integrative taxonomy

Without any doubt, traditional taxonomy is challenged by the large amount of molecular data gathered in the last few years. In several studies, DNA barcoding proved to be a valuable tool for searching cryptic geometrid diversity (HUEMER & HAUSMANN 2009; HAUSMANN & HEBERT 2009; HAUSMANN et al. 2009a; HAUSMANN et al. 2009b a.s.o.). A minimum of 5% of Bavarian geometrid species showed deep intraspecific divergences of >2% in the COI gene (HAUSMANN et al. 2011a). Similar patterns resulted from the study of the Macrolepidoptera of Germany (HAUSMANN et al. 2011b) and of the Lepidoptera of eastern North America (HEBERT et al. 2009).

Actually, more than 6,000 European DNA barcodes are available for Geometridae, belonging to 778 species (Table 1) and covering 80% of the 976 European species when excluding Macaronesia and Cyprus from the study area (HAUSMANN 2001; cf. FAUNA EUROPAEA 2004; 2010). Out of this data set 590 geometrid species (76%) reveal to be genetically homogenous all over their European distribution area. 130 species (17%) show deep intraspecific splits of more than two per cent, the resulting haplotypes being restricted to clearly allopatric distribution areas. In 58 species (7%) deep sympatric (intrapopulation) splits of >2% were detected (Table 1).

Subfamily	Species in Europe	Barcoded Species	Barcoded Individuals	Splits (regional)	Splits (intra-population)
Sterrhinae	201	143 (71%)	841	26 (18%)	7 (5%)
Larentiinae	414	349 (84%)	2929	55 (16%)	28 (8%)
Archiearinae	5	3 (60%)	28	-	-
Desmobathrinae	4	3 (75%)	4	-	-
Geometrinae	33	23 (70%)	168	10 (43%)	1 (4%)
Ennominae	319	257 (81%)	2133	39 (15%)	22 (9%)
Total	976	778 (80%)	6103	130 (17%)	58 (7%)

Table 1: Barcode coverage in European Geometridae with break-down to subfamilies, and intraspecific divergences ('splits') of more than two per cent. Regional divergences ('splits') with allopatric haplotypes are distinguished from intrapopulation genetic polymorphisms. Multiple splits within one species were counted as one. The analysis is based on traditionally recognized species in Europe excluding Macaronesia and Cyprus (HAUSMANN 2001; cf. FAUNA EUROPAEA 2004; 2010). Source: DNA Barcode data from BOLD (Barcode of Life Database accessed 12 July 2011, cf. RATNASINGHAM & HEBERT 2007).

Probably not all intrapopulation divergences of Table 1 reflect cryptic species diversity referring to extant biological species. The possibility of occasional sequencing of pseudogenes needs to be ruled out carefully. Some of the divergences may be due to genetic polymorphism of functional COI haplotypes going back to separate lineages of diverging evolution in different glacial refugia which later on fused again to one single species. Introgression may be the reason for the polymorphic pattern in *Dysstroma truncata* (HUFNAGEL, 1767) which all over Europe shows two haplotypes of approximately 6% distance. One of both haplotypes corresponds to that of the Scottish *Dysstroma truncata concinnata* (STEPHENS, 1831) which had previously been suggested to be a separate species. Similarly the characteristic barcode for *Epirrita filigrammaria* (HERRICH-SCHÄFFER, 1848) from Ireland and Scotland is found in continental European populations of *E. autumnata* (BORKHAUSEN, 1794), the latter splitting up into several genetic lineages at distances of >3%. Island populations tend to evolve quickly to new COI haplotypes and often the time was not sufficient to develop correlated differential features in external appearance and/or morphology, e.g. in *Scotopteryx bipunctaria* (DENIS & SCHIFFERMÜLLER, 1775) on Sicily, or in *Thera cupressata* (GEYER, 1831) on Sardinia. Sometimes these genetic haplotypes appear also elsewhere on mainland populations as in the above mentioned example of *Dysstroma* or in the case of a separate Sicilian DNA-cluster of *Epirrhoe galiata* (DENIS & SCHIFFERMÜLLER, 1775), with the Sicilian haplotype rarely showing up in the populations north of the Alps, possibly due to occasional migration or transport.

Although if some authors (e.g. COOK et al. 2010) plea for opening taxonomy for descriptions exclusively basing on molecular data (which can include several genetic markers), it has to be emphasized that divergences in the DNA barcode fragment as presented in Table 1 should not automatically lead to premature statements of cryptic diversity at species level. Each single case requires accurate analysis and search for correlated features in morphology ('integrative taxonomy'; cf. TELETCHÉA 2010; PADIAL et al. 2010). On the other hand, even traditional morphometric entomology has limitations and it is not rarely performed on a weak statistical and methodological basis. Many species descriptions base on subtle and debatable 'differences' in genitalia subsequently leading to controversial opinion and confusion. On this background it is a step forward to combine different species concepts from genetic and morphological data in an 'integrative taxonomic' approach that will bring taxonomy to a better harmony with the 'biological species concept'.

Zusammenfassung

Mehrere taxonomische Problemfälle bei mediterranen Larentiinae-Arten werden durch integrativ-taxonomische Analyse unter Kombination molekularer und morphometrischer Methoden gelöst. Sechs neue Arten und eine neue Unterart werden beschrieben: *Xanthorhoe sardisjuncta* sp. n. aus Sardinien, *Xanthorhoe pederi* HAUSMANN & FRIEDRICH, sp. n. aus Zypern, *Colostygia fezae* sp. n. aus der Türkei, *Coenotephria antonii* sp. n. aus Süditalien, *Coenotephria florianii* sp. n. aus dem Libanon, *Nebula carlae* sp. n. aus Süditalien, und *Nebula ibericata fiumii* ssp. n. aus Sardinien. Eine weitere Art wird erstmals für die Fauna Europas nachgewiesen: *Euphyia vallantinaria* (OBERTHÜR, 1890) aus Südspanien. Das Taxon *Larentia adlata* STAUDINGER, 1895 wird zu einem Synonym der ostmediterranen Art *Mattia callidaria* (JOANNIS, 1891) herabgestuft. Für *Cidaria nebulata pirinica* REISSER, 1936 wird ein Lectotypus aus Bulgarien designiert, gleichzeitig wird das Taxon vom Rang einer Unterart von *Nebula nebulata* (TREITSCHKE, 1828) auf Artrang erhöht. Für *Larentia probaria* HERRICH-SCHÄFFER, 1852 wird ein Neotypus aus Kroatien designiert. Das Taxon *Cidaria salicata hangayi* VOJNITS, 1986 aus dem Nordiran, vormals als Unterart von *Coenotephria salicata* betrachtet, wird als Unterart unter *Coenotephria ablutaria* (BOISDUVAL, 1840) gestellt. Das Taxon *Larentia schneideraria* LEDERER, 1855 wird von der Gattung *Nebula* in die Gattung *Coenotephria* umgestellt (comb.n.). Der vorliegende Artikel unterstreicht die Notwendigkeit integrativer Taxonomie unter Kombination molekularer und morphologischer Daten. Im Rahmen des iBOL Projektes wurden bisher 6103 DNA-Barcodes aus 778 Arten europäischer Geometriden generiert. Der Datensatz zeigt 188 Fälle tiefer genetischer, innerartlicher Aufspaltungen, die nun einer sorgfältigen integrativ-taxonomischen Analyse harren.

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Figs 5-10: Holotypes, paratypes.

Figs 5-6: *Xanthorhoe sardisjuncta* sp. n.;

Fig. 5: ♂ paratype; **Fig. 6:** ♀ paratype (photos S. ERLACHER).

Figs 7-8: *Xanthorhoe pederi* HAUSMANN & FRIEDRICH, sp. n.;

Fig. 7: ♂ paratype; **Fig. 8:** ♀ holotype (photos E. FRIEDRICH).

Figs 9-10: *Colostygia fezae* sp. n.;

Fig. 9: ♂ paratype; **Fig. 10:** ♀ holotype (photos A. HAUSMANN/F. CAN).



Figs 11-16: Holotypes, neotypes, paratypes (photos A. HAUSMANN).

Fig. 11: *Coenotephria antonii* sp. n.; ♀ holotype;

Fig. 12: *Coenotephria ablutaria probaria* HERRICH-SCHÄFFER, 1852: ♀ neotype.

Figs 13-14: *Coenotephria florianii* sp. n.;

Fig. 13: ♂ holotype; **Fig. 14:** ♀ paratype.

Figs 15-16: *Nebula carlae* sp. n.;

Fig. 15: ♂ holotype; **Fig. 16:** ♀ paratype.



Fig. 17: *Nebula pirinica* (REISSER, 1936), ♂ lectotype (photo: I. KOSTJUK);



Figs 18-19: *Nebula ibericata fiumii* ssp. n.; Fig. 18: ♀ holotype; Fig. 19: ♂ paratype;



Fig. 20: *Euphyia vallantinaria* (OBERTHÜR, 1890): first record for Europe, southern Spain, Sierra Bermeja (photos A. HAUSMANN).

Figs 17-20: Holotypes, lectotypes, paratypes, new species for the fauna of Europe.

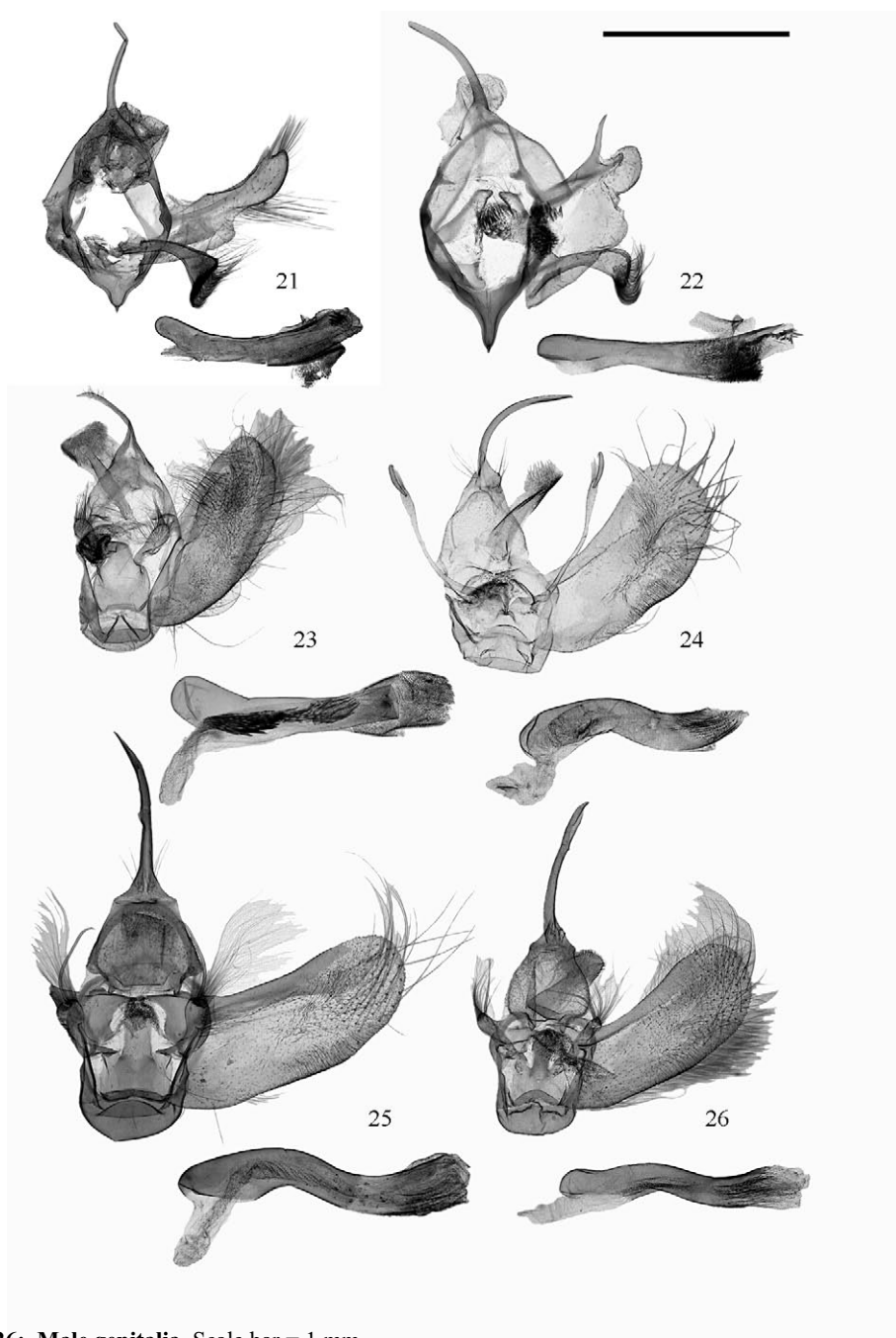


Fig. 21-26: Male genitalia. Scale bar = 1 mm.

- Fig. 21: *Xanthorhoe sardisjuncta* sp. n., paratype, gen.prp. Hausm. 14501;
 Fig. 22: *Xanthorhoe pederi* HAUSMANN & FRIEDRICH, sp. n., paratype, gen.prp. ZSM G 14218;
 Fig. 23: *Colostygia fezae* sp. n., paratype, NW. Turkey, gen.prp. ZSM G 18383;
 Fig. 24: *Coenoteophria florianii* sp. n., paratype, gen.prp. ZSM G 14494;
 Fig. 25: *Nebula carlae* sp. n., holotype, gen.prp. ZSM G 12058;
 Fig. 26: *Nebula ibericata fiumii* ssp. n., paratype, gen.prp. ZSM G 18349 (photos A. HAUSMANN).

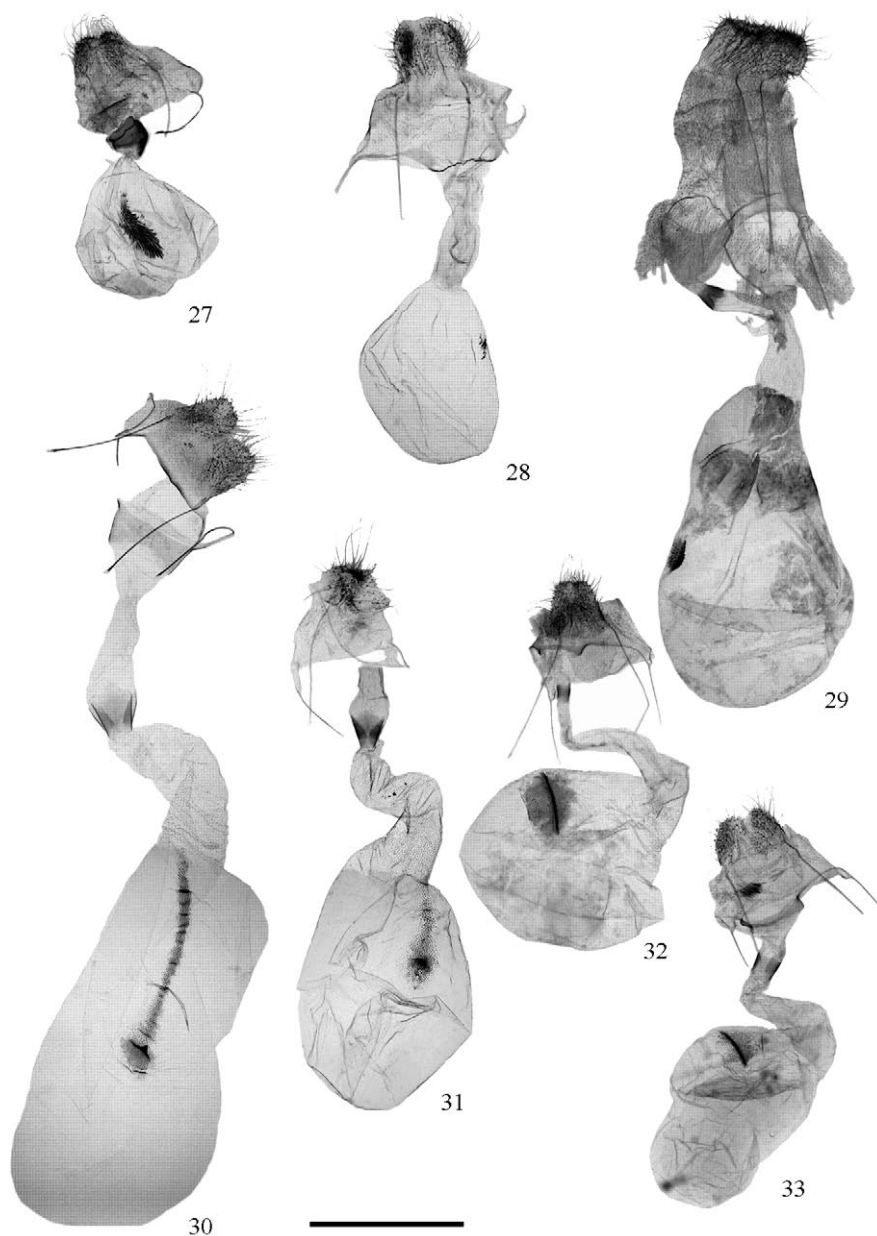


Fig. 27-33: Female genitalia. Scale bar = 1 mm.

- Fig. 27:** *Xanthorhoe sardisjuncta* sp. n., paratype, gen.prp. ZSM G 14511;
Fig. 28: *Xanthorhoe pederi* HAUSMANN & FRIEDRICH, sp. n., holotype, gen.prp. ZSM G 14480;
Fig. 29: *Colostygia fezae* sp. n., paratype, NW. Turkey, gen.prp. ZSM G 18384;
Fig. 30: *Coenotephria antonii* sp. n., holotype, gen.prp. ZSM G 4621;
Fig. 31: *Coenotephria florianii* sp. n., paratype, gen.prp. ZSM G 14495;
Fig. 32: *Nebula carlae* sp. n., paratype, gen.prp. ZSM G 18109;
Fig. 33: *Nebula ibericata fiumii* ssp. n., holotype, gen.prp. ZSM G 14501 (photos A. HAUSMANN).



Figs 34-35: In vivo photographs of *Xanthorhoe pederi* HAUSMANN & FRIEDRICH, sp. n.:

Fig. 34: ♀ holotype; **Fig. 35:** ♀ paratype from Arminou (photos E. FRIEDRICH).



Figs 36-37: In vivo photographs of larvae of *Xanthorhoe sardisjuncta*, sp. n.: Larvae sardisjuncta, Northern Sardinia, San Pantaleo, September 2007, c.o. (photos M. LEIPNITZ).



Figs 38-39: Habitats of *Xanthorhoe pederi* HAUSMANN & FRIEDRICH, sp. n.:

Fig. 38: Scrubland with *Quercus* and *Crataegus* upwards of village Arminou; type locality (photo E. FRIEDRICH, 4 November 2008). **Fig. 39:** rocky steppe habitat, poor of vegetation, close to the top of the 'Adelfoi' massive in the eastern Troodos mountains (photo E. FRIEDRICH, 25 October 2008).



Figs 40-41: Habitats of *Coenotephria antonii*, sp. n. and *Nebula carlae*, sp. n.:

Southern Italy, frontier between Calabria and Basilicata, Valle del Noce, Piano dei Peri, 320m; type locality of *Coenotephria antonii*; at this locality also a paratype of *N. carlae* was collected. **Fig. 40:** collecting site, view to the west, **Fig. 41:** collecting site, view to the east (photos A. HAUSMANN).

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