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A phylogenetically isolated and endemic Geometridae discovered from montane forests in the Canary Island of Tenerife (Spain) (Lepidoptera: Geometridae, Larentiinae)

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Abstract

The Lepidoptera fauna of Europe is among the best studied in the world, and new species are only rarely discovered that do not fit in the existing classification. We present an unknown Geometridae from the Canary Islands (Spain), which, according to the multi-gene molecular phylogeny and morphology, represents a phylogenetically isolated lineage and does not fit into any known Geometridae genus or tribe. Using an integrative approach, we classify it in the subfamily Larentiinae, in a lineage that is included in the Larentiini complex of tribes. The new taxon, named *Atlanticola mystica* Sihvonen, Skou & Falck (new genus, new species) is an island endemic, occurring in Tenerife only and it is restricted to the montane forests above 500 m AMSL. We also illustrate an unrelated *Herbulotina grandis* (Prout, 1914) for comparison, which has a similar wing pattern, but is structurally different, and it is transferred here from Larentiini to the Xanthorhoini complex of tribes, supporting its original systematic position (original classification revived).
Keywords: Lepidoptera, Geometridae, Larentiinae, new genus, new species, systematics, Tenerife, Spain.

Un Geometridae filogenéticamente aislado y endémico descubierto en los bosques montanos de la isla canaria de Tenerife (España) (Lepidoptera: Geometridae, Larentiinae)

Resumen

La fauna de Lepidoptera de Europa se encuentra entre las mejor estudiadas del mundo y sólo en raras ocasiones se descubren nuevas especies que no encajan en la clasificación existente. Presentamos un Geometridae desconocido de las Islas Canarias (España) que, según la filogenia molecular multigénica y la morfología, representa un linaje filogenéticamente aislado y no encaja en ningún género o tribu de Geometridae conocidos. Utilizando un enfoque integrador, lo clasificamos en la subfamilia Larentiinae, en un linaje que se incluye en el complejo de tribus Larentiini. El nuevo taxón, denominado *Atlanticola mystica* Sihvonen, Skou & Falck (nuevo género, nueva especie) es un endemismo insular, que sólo se da en Tenerife y está restringido a los bosques montanos por encima de los 500 m de altitud. También ilustramos una *Herbulotina grandis* (Prout, 1914) no relacionada para su comparación, que tiene un patrón alar similar, pero es estructuralmente diferente y se transfiere aquí de Larentiini al complejo de tribus Xanthorhoini, apoyando su posición sistemática original (clasificación original revivida).

Palabras clave: Lepidoptera, Geometridae, Larentiinae, nuevo género, nueva especie, sistemática, Tenerife, España.

Introduction

The Lepidoptera fauna of Europe has been studied intensively since mid-1700s (e.g. Linnaeus, 1758), and arguably, it is among the best studied areas in the world. Currently, over 11000 Lepidoptera species are recorded from the continent (https://lepiforum.org Rodeland & Rennwald, 2006-2024). Within the order Lepidoptera, the Geometridae fauna of Europe has been recently revised in the monograph series *Geometrid Moths of Europe* and was concluded to contain about 1000 species (Müller et al. 2019 and references therein). In recent years, few additional, mostly cryptic species or subspecies have been described (e.g. Tautel & Lévêque, 2020; Beshkov, 2022), or taxonomic status has been changed (e.g. Lévêque & Tautel, 2023), and therefore those taxa have been easy to place in the existing classification (Hausmann & Sihvonen, 2019). A notable exception is the discovery of an enigmatic geometrid species from Croatia, *Mirlatia arcuata* Hausmann, László, Mayr & Huemer, 2023, whose classification even on subfamily level is uncertain and it awaits further research (Hausmann et al. 2023).

The Lepidoptera fauna of the Canary Islands was not included in the revision of the European fauna (Müller et al. 2019). The fauna differs from the mainland Europe in the sense that many of its taxa are endemic, occurring only on one or several of its islands. The Canary Islands have been rather intensively studied for more than 100 years (e.g. Rebel & Rogenhofer, 1894; Rebel, 1896-1938; Pinker, 1960, 1963, 1971, 1978), at least partly because the islands are a popular holiday destination. The Lepidoptera fauna of the islands is illustrated by Báez (1998), catalogued by Báez & Martín (2010) and Vives Moreno (2014), and new species are described annually. Based on these, we estimate the fauna consists of about 855 species, of which about 65 species belong to Geometridae. The numbers are indicative only, because in-depth studies on focused taxa have reported notable increases in species diversity and changes in the classifications (e.g. Falck et al. 2019; Falck & Hausmann, 2020; Falck & Karsholt 2022).

In 2018, Peder Skou sent two small, sand-colored male specimens to Pasi Sihvonen for morphological study and DNA barcoding, hoping such information would help to identify the species that did not externally match any western Palearctic taxa. The specimens were collected from the Canary Islands (Spain): Tenerife, Güímar in November 2003. It was noted that several morphological characters supported classification in the subfamily Larentiinae, for instance the long fusion of hindwing veins Sc + R1 with Rs (Meyrick, 1892), the multiple forewing fasciae (e.g. Meyrick, 1892; Minet & Scoble, 1999; Murillo-Ramos et al. 2021), and the hammer-headed tip in tympanal organ's ansa pointed to Sterrhinae + Larentiinae lineages (e.g. Cook & Scoble, 1992). The male genitalia did not match any western Palearctic species. Unfortunately, attempts to extract DNA failed. The studies were paused due to the limited material, and we asked colleagues if they had more specimens on this mysterious species. Per Falck replied that he had found a female of the species from Tenerife: Arona in March 2017. Like the male, the female genitalia did not match any western Palearctic species. Fortunately, a 652 bp COI DNA barcode was recovered from this specimen, but there was no close genetic match on BOLD database (see Results below). Attempts to get nuclear genes from this female specimen by Sanger sequencing failed. The final missing piece was a targeted field trip to Tenerife by Mikael Englund in November 2022. He visited the Güímar area, where the first specimens were found and managed to collect four males and a female by light at around 650 m altitude from the steeply sloping outskirts of coniferous mountain forests covered by dense scrub vegetation (Figure 17). Fresh tissue samples from these specimens yielded high-quality DNA, and several mitochondrial and nuclear genes were successfully extracted and sequenced.

This undescribed species is illustrated on page 30 (Figure 49) without spatial or temporal data in the monograph of Báez (1998), but in our opinion, it is misidentified as *Herbulotina grandis* Prout, 1914.

Here we describe this mysterious, endemic species from Tenerife in the Canary Islands and clarify its relationship against *Herbulotina grandis*. Using an integrative taxonomic approach, including multi-gene molecular phylogeny and morphology, we show that it represents a phylogenetically isolated lineage in the subfamily Larentiinae, and it cannot be classified in any described genus or tribe. It is known only from the scrubby mountain slopes and coniferous montane forests above 500 m AMSL.

Material and methods

Study material, abbreviations, and identification

Altogether, 50 specimens of an undescribed taxon from Tenerife in the Canary Islands were available for study. The oldest specimen is from 2003, and fresh specimens were collected during targeted field trips in 2022-2023, which were used in the molecular studies.

coll. Englund	Research collection of Mikael Englund, Järvenpää, Finland
coll. Falck	Research collection of Per Falck, Årsdale, Denmark
coll. Skou	Research collection of Peder Skou, Ollerup, Denmark
FMNH	Finnish Museum of Natural History, Helsinki, Finland
MNCN	Museo Nacional de Ciencias Naturales, Madrid, Spain
NHMUK	Natural History Museum, London, United Kingdom
ZSM	Bavarian State Museum of Natural History, Munich, Germany

For identification, specimens (including external and internal structures) were compared against relevant literature, online sources, and collections. These include Prout (1912-1916, 1934-1939, particularly North African fauna), Báez (1998) Báez & Martín (2010) and Vives Moreno (2014, Canary Islands), *The Geometrid Moths of Europe* series (Müller et al. 2019 and references therein for previous volumes, Europe), Rodeland & Rennwald, 2006-2024 (Europe and Canary Islands), while DNA barcodes (658 bp region near the 5' terminus of the COI mitochondrial gene) of molecular vouchers ME13 (*Atlanticola mystica*) and PS1529 (*Herbulotina grandis*) processed in the current study were compared against the publicly available genetic material available on Barcode of Life Data Systems BOLD https://v4.boldsystems.org (Ratnasingham & Hebert, 2007; Ratnasingham & Hebert, 2013) and GenBank (Benson et al. 2013). The material in the relevant public and private collections were examined as listed above.

Label data of specimens are presented according to the SHILAP requirements, not verbatim as they appear on the actual labels. A semicolon separate labels, and additional information about specimens or labels is enclosed in square brackets.

Morphological examination

Specimens were first photographed, and following this, male and female abdomens were removed, and the genitalia were dissected following established preparation protocols (e.g. Hardwick, 1950; Robinson, 1976; Sihvonen, 2001, described in detail in Sihvonen, 2005). Some structures were photographed during dissection in situ, to allow an optimal angle for observing and illustrating certain structures. All structures were stained with Chlorazol black. Preparations of genital and abdominal structures were eventually mounted in Euparal. Structural characters were examined and photographed using a Leica S9D stereomicroscope, Leica DM1000 LED microscope and Canon EOS 5D digital camera with MP-E 65 mm EF 100 mm macro lenses. Photos were taken with StackShot automated macro rail and focus stacked in Image Manager software (Zerene Stacker). Image files were edited in Photoshop v. 24 (2023) and the final plates arranged using CorelDraw v. 24 (2023).

Wing venation was studied using non-destructive micro-CT imaging, following the imaging and CT image reconstruction protocols described in Souza Moraes et al. (2023) and Englund et al. (2024), except the imaging parameters, which were different in the current study. Specifically, we used multimetal-target with molybdenum setting, 70 kV beam energy, 100 uA beam current, 500 ms exposure time, and 9998 projections with average of eight frames per projection. Detector binning was set to 1 x 1 and gain to 24 dB and the imaging was conducted using limited dynamic range. X-ray tube warm-up of 15 minutes and shading correction of 5 minutes 23 seconds was performed before the imaging. Total imaging time was 11 hours 6 minutes 40 seconds and the resulting voxel size 8 µm.

Genitalia terminology follows Klots (1970) and Sibatini (1972), wing venation terminology follows McGuffin (1977). In ambiguous cases, descriptive terms were used and were accompanied by illustrations.

Molecular data, techniques, and phylogenetic inference

DNA was extracted from 1-3 legs of dry voucher specimens: an unknown taxon (voucher code ME13: Spain: Tenerife, Güímar, 14-XI-2022, Mikael Englund leg.) and *Herbulotina grandis* (Prout, 1914) (voucher code PS1529: Spain, Tenerife, Adeje, 737 m, 26-XI-2021, Mikael Englund leg.). Genomic DNA was extracted and purified using a QIACEN DNeasy Blood & tissue kit, and QIAcube extraction robot was used, both following the manufacturer's protocols. DNA amplification and sequencing were carried out following protocols proposed by Wahlberg and Wheat (2008) and Wahlberg et al. (2016). PCR products were cleaned enzymatically and sent to Macrogen Europe (Amsterdam) for Sanger sequencing. One mitochondrial gene (cytochrome oxidase subunit I, (COI) and 10 protein-coding nuclear gene regions, carbamoylphosphate synthetase (CAD), Ribosomal Protein S5 (RpS5), wingless (wg), cytosolic malate dehydrogenase (MDH), glyceraldehydes-3-phosphate dehydrogenase (GAPDH), Elongation factor 1 alpha (EF-1alpha), Arginine Kinase (ArgK), Isocitrate dehydrogenase (IDH), sorting nexin-9-like (Nex9), and sarco/endoplasmic reticulum calcium ATPase (Ca-ATPase) were targeted for sequencing. To check for potential misidentifications, DNA barcode sequences (COI) were compared to those in BOLD (Ratnasingham & Hebert, 2007) where references of more than 21,000 geometrid species are available, some 10,000 of them identified to Linnean species names (Ratnasingham & Hebert, 2007). GenBank accession numbers for new sequences used in this study are provided in Table 1.

Table 1. GenBank accession numbers for the new sequences used in this study.

Voucher	COI	RpS5	Wg	EF-1alpha	Ca-ATPase	MDH	ArgK	Nex9
ME13	PP704417	PP707614	PP707616	-	PP707609	-	PP707607	-
PS1529	PP704418	PP707615	PP707617	PP707611	PP707610	PP707612	PP707608	PP707613

Multiple sequence alignments were carried out in MAFFT as implemented in Geneious v.11.0.2 https://www.geneious.com for each gene based on a reference sequence of Geometridae downloaded from the database VoSeq (Peña & Malm, 2012).

We successfully amplified five genes for ME13 (COI, RpS5, wg, CA-ATPase, ArgK) and eight genes for PS1529 (COI, RpS5, wg, EF-1alpha, Ca-ATPase, MDH, ArgK, Nex9). To analyse the data of these two taxa, we added them to the 11 gene geometrid data set of Murillo-Ramos et al. (2019, 2023), having in total 1386 taxa. The dataset included representative taxa of all subfamilies recognized in Geometridae.

We conducted a phylogenetic analysis under a Maximum-likelihood (ML) approach in IQ-TREE2 V2.0.7 (Minh et al. 2020). The dataset was partitioned by genes. The best substitution models that fit our data were selected with ModelFinder (Kalyaanamoorthy et al. 2017). Support for nodes were evaluated with 1000 ultrafast bootstrap (UFBoot2) approximations (Hoang et al. 2018), and SH-like approximate likelihood ratio test (Guindon *et al.*, 2010). To reduce the risk of overestimating branch supports in UFBoot2 test, we implemented the *-bnni* option. We visualized and edited the trees in FigTree v1.4.3 and CorelDraw v. 24 (2023).

Results

Taxonomy

When examining our target taxon from Tenerife, we did not find morphologically similar taxa in the literature, in collections, in DNA barcode reference library on BOLD, and in a multi-gene molecular phylogeny including global taxon sampling, the species did not group inside any included genera. For these reasons, we describe it as a new species in a new genus. However, we refrain from describing a monotypic tribe for it, acknowledging that further taxon sampling may bring clarity to its tribal association inside the Larentiinae: Larentiini complex. Even without a formal tribal description, its phylogenetic position is evident from the phylogenetic hypothesis. The focus of our description is on illustrations, rather than on extensive text, because good illustrations can capture the diagnostic and other features in a more informative way.

Atlanticola Sihvonen, Skou & Falck, gen. nov.

https://zoobank.org/D98AB49C-1D00-4DF2-84F1-6707778A8B06
Type species: *Atlanticola mystica* sp. nov. (by monotypy).

Systematic position and differential diagnosis (Figures 1-12, 14-16): The Larentiinae position is supported by the multi-gene molecular data, the long fusion of hindwing veins Sc + R1 with Rs (Meyrick, 1889), multiple forewing fasciae (e.g. Minet & Scoble, 1999), forewing veins R1-R4 arise from the (second) areole (Õunap et al. 2008), and the socii are absent (Hausmann & Viidalepp, 2012. The new species has a hammer-headed tip in the ansa of the tympanal organ, which is shared by Sterrhinae + Larentiinae (e.g. Cook & Scoble, 1992, see also Murillo-Ramos et al. 2021 for on overview of diagnostic subfamily characters). Multi-gene molecular data places our target taxon in the Larentiini complex of tribes, as sister to Larentiini and an unnamed clade + Ennadini + six other tribes. It represents the only species of an isolated lineage. *Atlanticola* is distinguished from other larentiine genera by the unique wing pattern, vaguely resembling that of *Larentia clavaria* (Haworth, 1809), but the forewings are more sand-colored, fasciae are more pronounced, and postmedial line has a distinct outwards projecting angle in middle (see e.g. Hausmann & Viidalepp, 2012). The genitalia structures do show similarities with *Larentia* Treitschke, 1825, but in *Atlanticola* males the uncus is setose, and valva is without dorsal projection (uncus bare, and valva is with dorsal and setose projection in *L. clavaria*) (Hausmann & Viidalepp, 2012). In *Atlanticola* females, signum is absent (large in *L. clavaria*, weakly developed with diffuse borders in *L. malvata* (Rambur, 1833)) (Hausmann & Viidalepp, 2012). *Atlanticola mystica* is only superficially like *Herbulotina grandis*, as it is shown here to belong in the Xanthorhoini complex of tribes (see below).

Among the European Geometridae, we classify *Atlanticola mystica* in Larentiinae: Larentiini complex of tribes and place it in the linear list of taxa (Hausmann & Sihvonen 2019, the phylogenetic relationships are refined in Õunap et al. 2024) after Larentiini as “Not assigned to tribus”.

Description: See text below.

Etymology: *Atlanticola* refers to the Atlantic Ocean and the suffix -cola refers to “inhabiting”. This indicates the collecting locality of the species on the Canary Islands in the Atlantic Ocean.

Atlanticola mystica Sihvonen, Skou & Falck, sp. nov.

https://zoobank.org/2177288C-058A-4CAB-AFBD-5702FBB0E5B6

Holotype: ♂ [SPAIN] Tenerife, Güímar, Bco. de Badajoz, 705 m, 24-X-2003, leg. O. Czadek L[ight]; Pasi Sihvonen, prep. number 2223; HOLOTYPE, *Atlanticola mystica*, Sihvonen, Skou & Falck [red label]”. Currently in coll. Skou, to be deposited at Zoological Museum, University of Copenhagen, Denmark. Holotype illustrated on figures 1, 11a, 11c-e, 11g, 15b.

Paratypes: Altogether 35 ♂, 14 ♀. [Spain] Tenerife, Güímar, Bco. de Badajoz, 705 m, ♂, 11-X-2003, leg. O. Czadek L[ight] (coll. Skou). Tenerife, Arona 500-700 m, ♀, 1-20-III-2017, P. Falck leg.; Pasi Sihvonen, prep. number 2758 (coll. Falck). [Spain] Tenerife, Arona, 650 m, ♀, 9-21-I-2023, P. Falck leg. (coll. Falck). [Tenerife] Güímar, 700 m, 24 ♂, 7 ♀, 9-24-I-2023, P. Falck leg. (coll. Falck, Skou, MNCN). [Tenerife] La Tierra del Trigo, 500 m, ♂, 19-IX-2-X-2023, P. Falck leg. (coll. Falck). Tenerife: Arona, Ifonce, 28º13’N-16º68’W, alt. 1010 m, 3 ♂ 2 ♀, 2-XI-2023, Mikael Englund leg. (coll. Englund). Tenerife: Arona, Ifonce, 28º13’N-16º68’W, alt. 1010 m, 4 ♂ 2 ♀, 4-XI-2023, Mikael Englund leg. (coll. Englund). Tenerife: Arona, Ifonce, 28.13, -16.68 alt. 1010 m, ♀, 4-XI-2023, Mikael Englund leg. (coll. MNCN). Tenerife: Güímar, 28º30’N-16º44’W, 650 m, ♂, 14-XI-2022, Mikael Englund leg (coll. Englund). Tenerife: Güímar, 28º30’N-16º44’W, 650 m, ♂, 14-XI-2022, Mikael Englund leg (MNCN). Tenerife: Güímar, 28º30’N-16º44’W, 650 m, ♂, 14-XI-2022, Mikael Englund leg.; Sihvonen prep. no. 2894; Mikael Englund DNA # 13; http://id.luomus.fi/GBT.28 (coll. FMNH). Tenerife: Güímar, 28º30’N-16º44’W, 650 m, ♀, 18-XI-2022, Mikael Englund leg.; Sihvonen prep. no. 2895; Mikael Englund DNA # 17; http://id.luomus.fi/GBT.29 (coll. FMNH). All paratypes have red label ”PARATYPE, *Atlanticola mystica*, Sihvonen, Skou & Falck”.

Differential diagnosis: See text above.

Description (Figures 1-12, 15-16): Wings: Wingspan males 20-28 mm (n=34), females 22-30 (n=14). Forewings sand-colored, wing base and medial area darker brown, sub-basal and terminal area lighter brown. Sexes similar, except females slightly paler. Antemedial line rather straight, evenly curved inwards on costa. Postmedial line with distinct outwards pointing angle in middle. Apex with small blackish streak. Terminal lines on fore and hindwings blackish, interrupted. Hindwing paler, rather uniform grey, with suffuse postmedial line. Fore- and hindwings with small, blackish discal spot. Wings below greyish, postmedial line most distinct, bordered with paler area near forewing costa. Blackish, suffuse spot near forewing apex. Frons slightly paler than thorax and abdomen. Male antenna bipectinate, female antenna filiform. Male and female hind tibia with 2 +2 spurs. Tympanal organ large, ansa hammer headed. Sternites and tergites 3-8 of both sexes undifferentiated.

Variation: Wing color varies from pale sand-colored to dark brown, and degree of contrast between medial area and rest of wing can be minor or distinct.

Male genitalia: Uncus long, narrow, setose. Membrane surrounding tuba analis setose. Tegumen dome shaped. Vinculum narrow sclerotized band, slightly angled laterally. Saccus large, rounded, anterior margin medially elongated. Juxta / manica complex densely setose, easily detached when aedeagus removed (in Figure 11d manica partly attached to aedeagus, Figure 11e manica not attached to aedeagus). Each end of transtilla with membranous, inwardly curved, setose lobe. Valva wide, with medial ridge, apex acute and weakly curved inwards. Costa wide, bare, basal part weakly dentate. Ventral part setose apically, margin concave in middle. Aedeagus slightly curved ventrally, narrow, with long caecum. Vesica membranous, narrow at base, wide and rounded in middle. Small batch of needle-like cornute at vesica base.

Female genitalia: Papillae anales massive, round, setose. Apophyses posteriors longer than apophyses anteriores. Lamella postvaginalis sclerotized, with few horizontal striations. Lamella antevaginalis weakly sclerotized on margin. Ductus bursae sclerotized, wide, evenly narrowing anteriorly. Ductus seminalis opens ventrally. Corpus bursae membranous, posterior part narrow and wrinkled, anterior part round. Signum absent.

Distribution and abundance: Known only from three locations in Tenerife in the Canary Islands, Güímar, Arona and La Tierra del Trigo. The first two male specimens of this species were caught from Güímar in 2003. During the recent years several specimens have been caught per night.

Phenology: Adults have been observed from October to March, and majority of those between November and January. Both males and females come to light.

Biology: The host plant of the caterpillars is unknown. By using a headlamp, many specimens were observed just after dark flying actively nearby or disturbed from *Bencomia caudata* (Ait.) Webb & Berthel bushes, indicating a possible host plant. It is endemic to the Canary Islands and known from Gran Canaria, Tenerife, and La Palma.

Habitat: Species has been found in fluvial ravines of open montane coniferous woodland. These habitats are on sandy or rocky soil with rich growth of shrubs and herbs in the upper part of the thermophilus woodland belt and the lower part of the *Pinus canariensis* C. Sm. ex DC. forest belt.

Similar species: No similar species in Europe.

Genetic data: The barcode of *Atlanticola mystica* is represented in BOLD by the BIN BOLD:AEB8667 (n = 2). The uncorrected pairwise distance to the nearest neighbor, *Austrocidaria similata* (Walker, 1862) (BOLD:ACP1376, n = 2) from New Zealand is 7.25 %. Genetic similarity potentially due to long branch attraction, and the lack of assumedly closely related Larentiini taxa from North Africa in BOLD. Therefore, the current nearest neighbor match likely does not reflect true relationship. The external morphology of *A. mystica* and *A. similata* does not support close relationship.

Etymology: Mystica (Latin), feminine form of the adjective mysticus, pertaining to the mysterious nature of the species. It has remained overlooked and undescribed in relatively well-studied Canary Islands for such a long time.

Herbulotina Pinker, 1971

Type species: *Cataclysme grandis* Prout, 1914

The original description of *Cataclysme grandis* is based on external characters only (Prout, 1914 in

Prout, 1912-1916). The original genus combination was questioned by Pinker (1963), in a publication, where he described two additional subspecies: C. *grandis grancanariae* Pinker, 1963 from Gran Canaria and *C. grandis lapalmae* Pinker, 1963 from La Palma. In the same paper, Pinker provided the first illustrations of the male and female genitalia of taxon *grandis*, in addition to the cremaster of the pupa, and reported the caterpillar to feed in captivity on the leaves of *Rubia* L. and *Galium album* Mill., both Rubiaceae. Following this, Pinker (1971) described a new genus *Herbulotina*, and he included two species in it: *H. grandis* with three subspecies and *H. maderae* Pinker, 1971.

In the latest Spanish (Vives Moreno, 2014) and European checklists (Sihvonen & Hausmann, 2019 in Müller et al.), *Herbulotina* was classified in Larentiini, the latter listing five valid species from the Canary Islands, Madeira, Morocco, and Algeria. We show here, using multi-gene molecular phylogeny and morphology, that genus *Herbulotina* is not a Larentiini, but belongs in the tribe Cataclysmini in the Xanthorhoini complex (Figure 16). Our results therefore support the original classification of taxon *H. grandis* being a part of *Cataclysme* group of genera (Prout, 1912-1916) (original classification revived). As regards the DNA barcodes, *H. grandis* (BIN BOLD:AFS5230, n = 1) has as its nearest neighbor *Obila* AH02Ec (BIN BOLD: :AAI3506, n = 6) from Ecuador with 8.49 % (p-dist) genetic difference.

With the respect to morphology (Figures 13-14), the position in Xanthorhoini complex is supported for instance by the presence of the coremata and strongly modified 7th and 8th segments in the male abdomen (Hausmann & Viidalepp, 2012), illustrated by us in Figure 14. Within the Xanthorhoini complex, the Cataclysmini position is supported for instance by numerous thin lines on wings, the paired uncus (see details on Figures 13g-13i), and the entirely sclerotized valva, the pupa cremaster has two curved hooks only (based on comparison of our material against the illustrations in Pinker (1963) (Figures 4, 5) and those of *Cataclysme riguata* and *Phibalapteryx virgata* in Patočka & Turčáni, 2005 (plate 197). Several other synapomorphies, as listed by Hausmann & Viidalepp (2012, p. 41), are not found. Among these, forewing veins R5 and M1 are not stalked in *H. grandis* and it has two areoles (Figure 12), while R5 and M1 are reported as stalked and forewing has only a single areole in the Cataclysmini genera examined by Hausmann & Viidalepp (2012). We illustrate here for the first time the vesica of *H. grandis*, showing it to contain a large, curved diverticulum with a row of massive, sclerotized spikes, the base of vesica is covered with minute "goose bump" like sclerotizations, and the base of ductus ejaculatorius has an elongated, sclerotized plate. The uncus-socii-gnathos complex is unusual, and we illustrate it therefore from ventral, lateral, and dorsal views (Figures 13g-13i).

The three *Herbulotina* species (as classified in Müller et al. 2019) from North Africa are tentatively placed in Xanthorhoini here, but we did have access to authentic material, and highlight that their systematic position needs further study: *H. berberina* (Herbulot, 1981) from Morocco; *H. carolata* (Lucas, 1938) from Morocco; *H. feliciaria* (Rungs, 1950) from Morocco (Herbulot, 1981; Lucas, 1938; Rungs, 1950).

Discussion

The current described fauna of Geometridae comprises about 24000 species, but it has been estimated the true diversity is at least 40000 species (Rajaei et al. 2022). The taxonomic impediment is huge, particularly in the tropics, and our understanding of the phylogenetic relationships and classification varies greatly geographically and by taxon. Our results enforce this message. While the fauna of continental Europe is well studied, the fauna of the adjacent Canary Islands in the Western Palearctic needs more research. *Atlanticola mystica* has been overlooked for a long time and it represents an isolated lineage that may need to be formally described as a tribe, while *Herbulotina grandis* was classified in the recent literature (Müller et al. 2019) in Larentiini, and here we propose Cataclysmini in the Xanthorhoinin complex. We highlight that the exact position of *A. mystica* in the tree of life will be fine-tuned when more extensive molecular and morphological taxon sampling is available.

Of particular interest from the phylogeographic point of view is the Catalysmini clade in Figure 16, where *Herbulotina grandis* from the Canary Islands is sister to a clade containing both North American (*Zenophleps* Hulst, 1896) and Palearctic taxa (*Phibalapteryx* Stephens, 1829 and *Cataclysme* Hübner, [1825]). As regards DNA barcodes, *H. grandis* has its genetically nearest neighbor in BOLD database an *Obila* species from Ecuador (*Obila* AH02Ec, BIN BOLD:AAI3506), further highlighting the potential cross-Atlantic connection. Potential relationship between the lineages of Canary Islands and North America would be exceptional because most geometrid species occurring in the Canary Islands have their closely related taxa in Macaronesia, North Africa, or (western) Palearctic. Tens of such cases are listed in the European checklist of geometrid moths (Hausmann & Sihvonen 2019) and examples include several *Microloxia* Warren, 1893 (Geometrinae); *Crocallis* Treitschke, 1825 (Ennominae), *Menophra abruptaria* Moore, 1887 (Ennominae) and its subspecies; *Oar* Prout, 1913 (Scopulini) and several species of *Idaea* Treitschke, 1825 (Sterrhinae) and *Scopula* Schrank, 1802 (Scopulini). Although our phylogenetic analysis included all Cataclysmini genera of Europe (Hausmann & Sihvonen, 2019 in Müller et al.) and North America (Pohl & Nanz, 2023), and is therefore extensive on genus level, more species are needed from North America, North Africa, and Europe, to test the robustness of our results.

Atlanticola mystica has so far been found from few locations on Tenerife, in high altitude montane habitats only. The current evidence suggests the species is endemic. However, the data on this species are so deficient at the moment that its risk of extinctions cannot be assessed using the IUCN criteria https://www.iucnredlist.org/ (IUCN 2022). We place it in Data Deficient (DD) category. Among the first steps is the identification of the caterpillar's host plant, because this will give indication about its habitat, and whether conservation measures are needed to maintain this phylogenetically isolated species viable and a part of the Canary Islands unique fauna.

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Conflict of Interest

The authors declare that they have no known financial interest or personal relationship that could have influence the work presented in this article.

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Figures 1-10. Adults and egg of *Atlanticola mystica* (new genus, new species). **1.** male (holotype): Tenerife, Güímar, Barranco de Badajoz, 705 m, 24-X-2003 (coll. Skou), dissected (slide # 2223 Sihvonen). **2.** male (paratype): Tenerife, Arona, Ifonce, 1010 m, 4-XI-2023 (coll. Englund). **3.** male (paratype): Tenerife, Arona, Ifonce, 1010 m, 2-XI-2023 (coll. Englund). **4.** male (paratype): Tenerife: Güímar, 650 m, 14-XI-2022 (coll. Englund), dissected (slide # 2894, Sihvonen). **5.** female (paratype): Tenerife, Arona, 500-700 m, 1-20-III-2017 (coll. Falck), dissected (slide # 2758 Sihvonen). **6.** female (paratype): Tenerife, Arona, Ifonce, 1010 m, 4-XI-2023 (coll. Englund). **7.** female (paratype): Tenerife, Arona, Ifonce, 1010 m, 4-XI-2023 (coll. Englund). **8.** female (paratype): Tenerife: Güímar, 650 m, 18-XI-2022 (coll. Englund). **9.** Female adult in situ, Tenerife, 28-XI-2023. **10.** Egg.

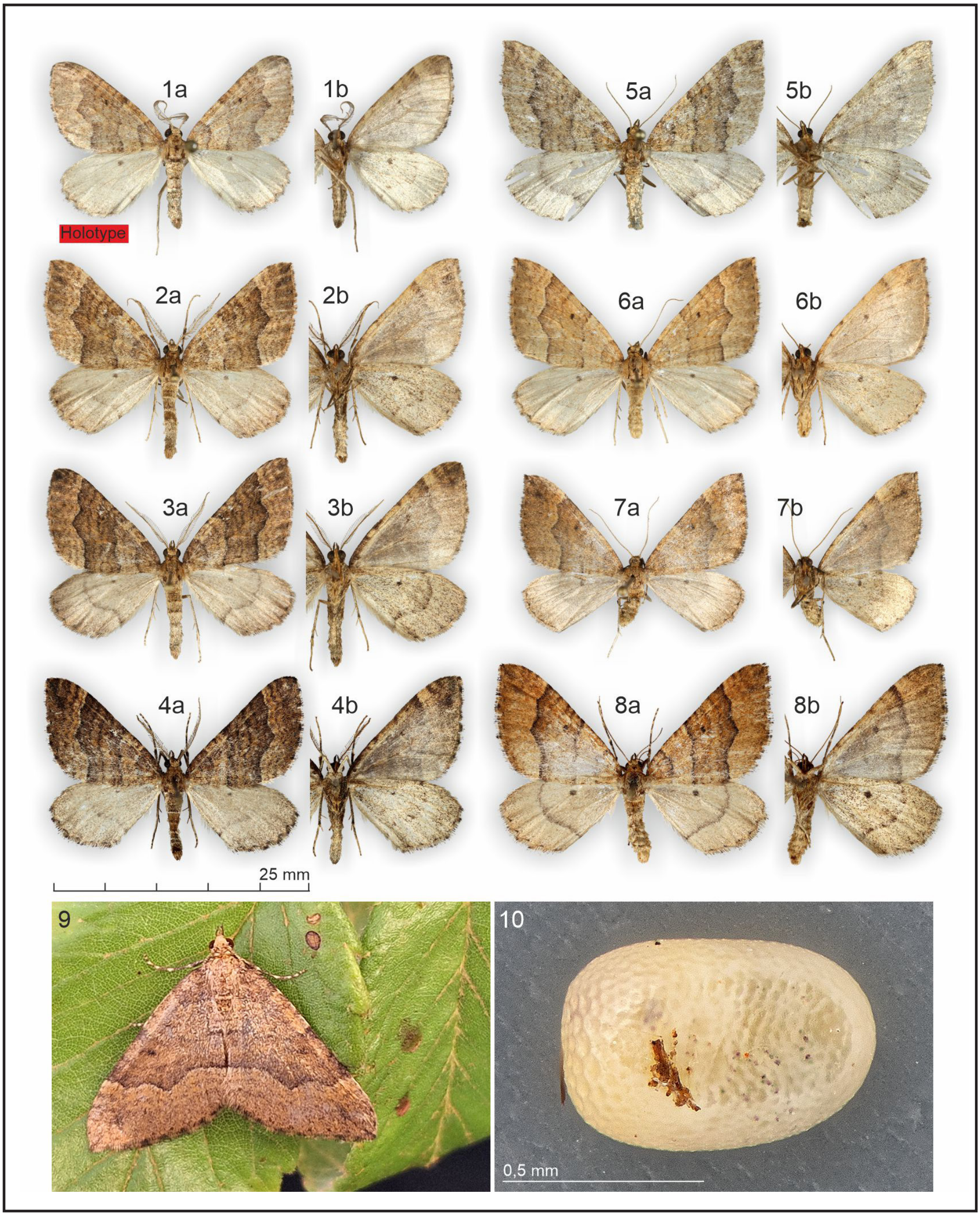


Figure 11. Adults and genitalia of *Atlanticola mystica* (new genus, new species). **a.** adult male (holotype): Tenerife, Güímar, Barranco de Badajoz, 705 m, 24-X-2003 (coll. Skou). **b.** adult female (paratype): Tenerife: Güímar, 650 m, 18-XI-2022 (coll. Engund). **c.** male genitalia (holotype): Tenerife, Güímar, Barranco de Badajoz, 705 m, 24-X-2003 (coll. Skou) (slide # 2223 Sihvonen). **d.** male aedeagus with vesica everted and uneverted with spinose manica attached (paratype): Tenerife: Güímar, 650 m, 14-XI-2022 (coll. Englund) (slide # 2894 Sihvonen). **e.** male aedeagus with vesica everted and uneverted, spinose manica removed (holotype): Tenerife, Güímar, Barranco de Badajoz, 705 m, 24-X-2003 (coll. Skou) (slide # 2223 Sihvonen). **f.** female genitalia, point of origin of ductus seminalis indicated with circle (paratype): Tenerife, Güímar, 650 m, 18-XI-2022 (coll. Englund) (slide # 2895 Sihvonen). **g.** juxta region (holotype): Tenerife, Güímar, Barranco de Badajoz, 705 m, 24-X-2003 (coll. Skou) (slide # 2223 Sihvonen). **h.** uncus, dorsal view (holotype): Tenerife, Güímar, Barranco de Badajoz, 705 m, 24-X-2003 (coll. Skou) (slide # 2223 Sihvonen). **i.** cornuti (holotype): Tenerife, Güímar, Barranco de Badajoz, 705 m, 24-X-2003 (coll. Skou) (slide # 2223 Sihvonen).

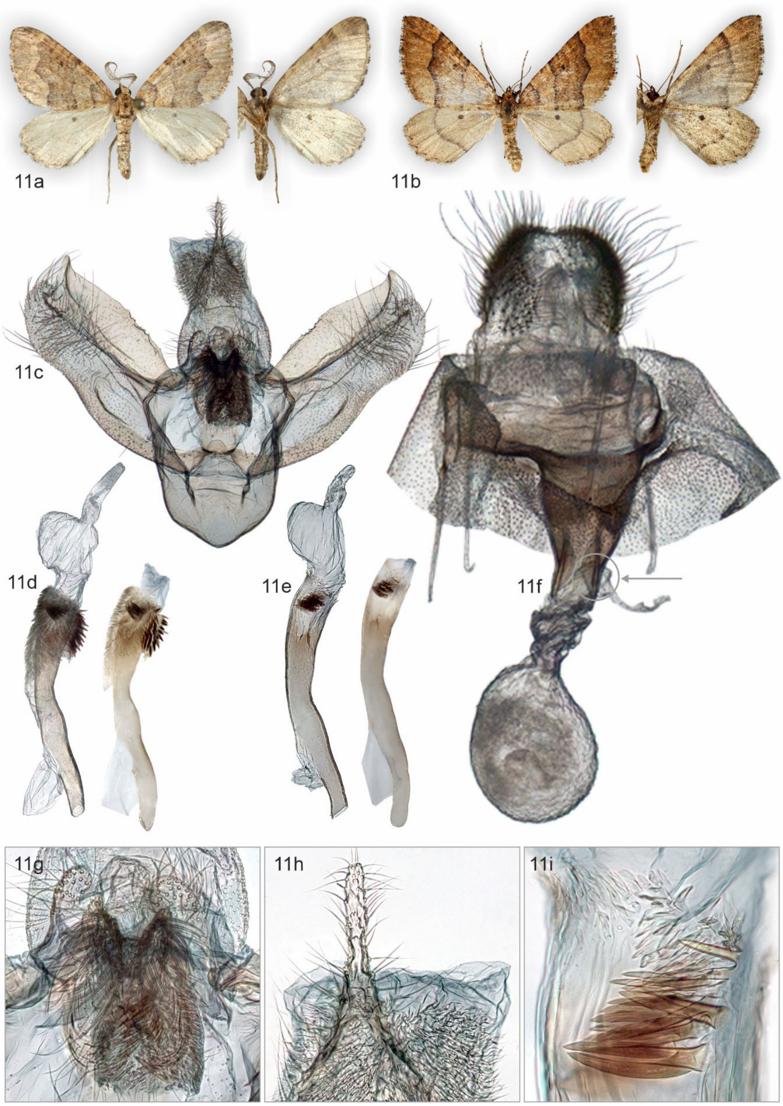


Figure 12. Wing venation of *Atlanticola mystica* (new genus, new species), based on non-destructive micro-CT scan. Male (paratype): Tenerife: Güímar, 14-XI-2022 (coll. Englund) (micro-CT scan # 8 Söderholm).

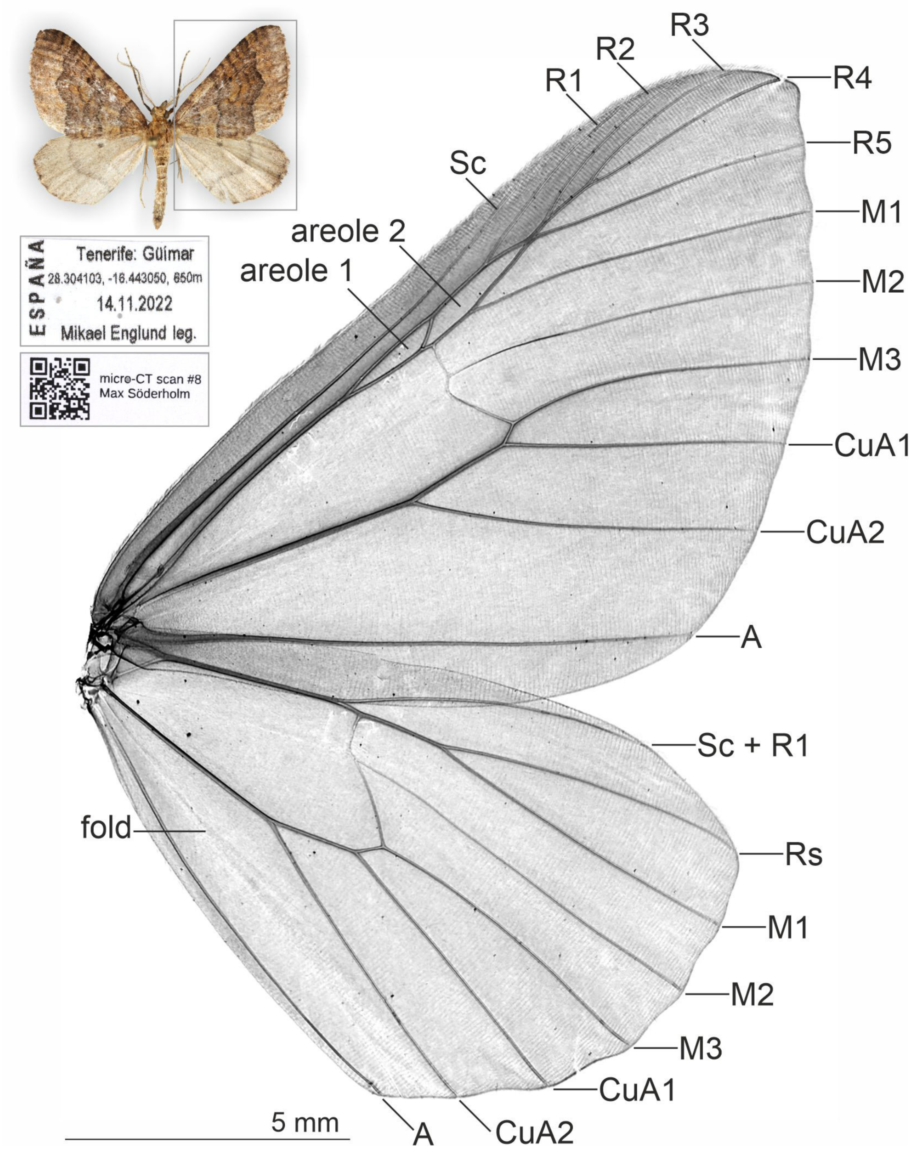
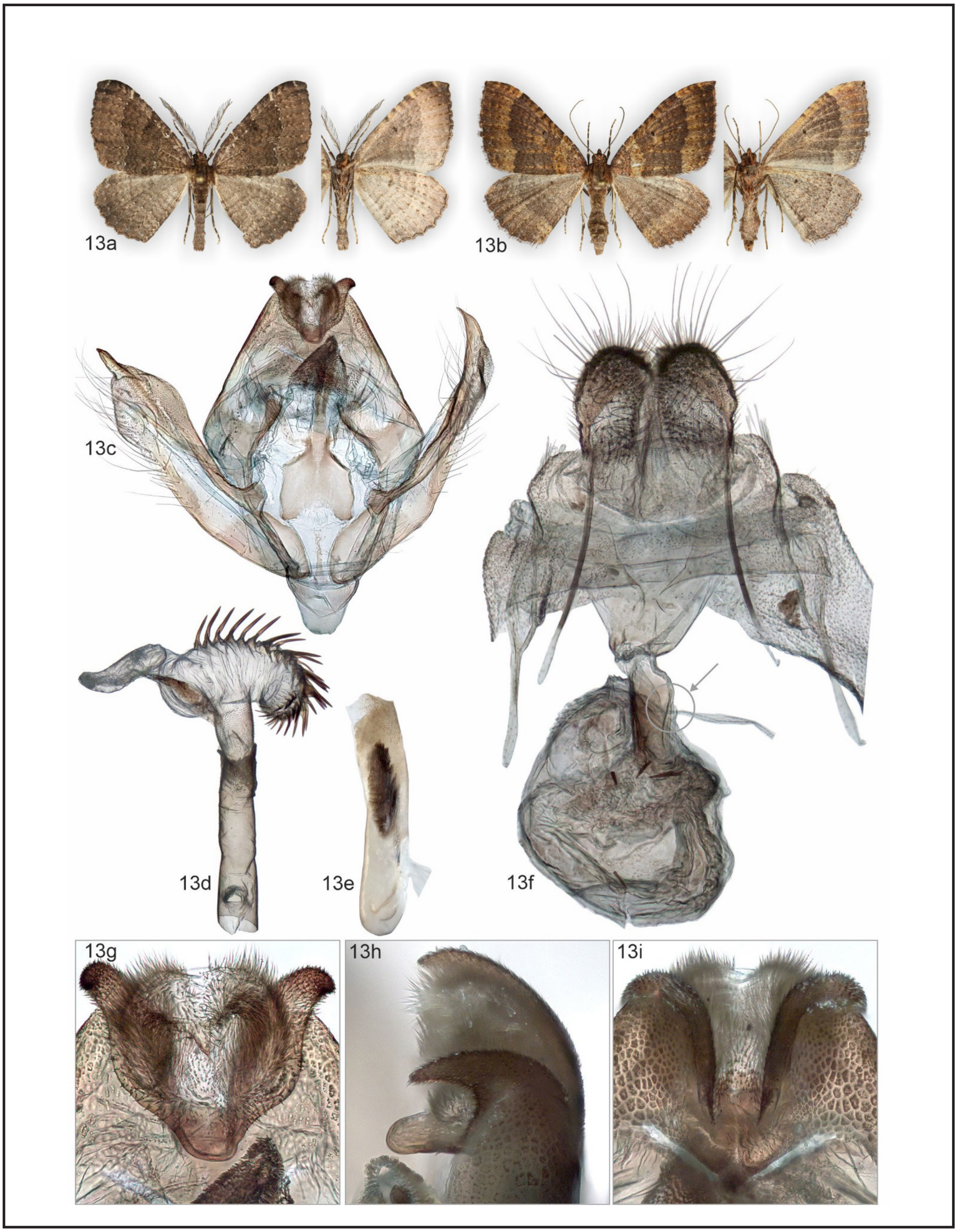


Figure 13. Adults and genitalia of *Herbulotina grandis*. **a.** adult male: Tenerife, Güímar, 650 m, 14-XI-2022 (coll. Englund). **b.** adult female: Tenerife: Adeje, 737 m, 25-XI-2021 (coll. Englund). All male genitalia structures photographed from the same specimen: Tenerife, Güímar, 650 m, 14-XI-2022 (coll. Englund) (slide # 2896 Sihvonen). **c.** male genitalia, **d.** aedeagus with everted vesica, **e.** aedeagus, **g.** uncus region in ventral view, **h.** uncus region in lateral view, **i.** uncus region in dorsal view. **f.** female genitalia, point of origin of ductus seminalis indicated with circle: Tenerife, Adeje, 737 m, 25-XI-2021 (coll. Englund) (slide # 2897 Sihvonen).



Figures 14-15. Structures of descaled male abdomens of *Herbulotina grandis* and *Atlanticola mystica* (new genus, new species). **14a.** terminal segments (A6-A8), showing the paired coremata and reduced sclerites, which are typical in Xanthorhoini: Tenerife, Güímar, 650 m, 14-XI-2022 (coll. Englund) (slide # 2896 Sihvonen). **14b.** Abdomen: Tenerife, Güímar, 650 m, 14-XI-2022 (coll. Englund) (slide # 2896 Sihvonen). **14c.** Tympanal organ's ansa: Tenerife, Güímar, 650 m, 14-XI-2022 (coll. Englund) (slide # 2896 Sihvonen). **15a.** Adbomen (paratype): Tenerife, Güímar, 650 m, 14-XI-2022 (coll. Englund) (slide # 2894 Sihvonen). **15b.** Tympanal organ's ansa (holotype): Tenerife, Güímar, Barranco de Badajoz, 705 m, 24-X-2003 (coll. Skou) (slide # 2223 Sihvonen).

14b *Herbulotina grandis* **15a** *Atlanticola mystica* sp. n.

14c *Herbulotina grandis* **15b** *Atlanticola mystica* sp. n.

Figure 16. Systematic position of the study species based on a maximum likelihood analysis of 1386 taxa and up to 11 genes per sample used in the study. **A.** The condensed phylogenetic hypothesis of Geometridae. Larentiinae (with tribes visible) are highlighted with violet rectangle, and the focus taxa of our study are highlighted with green and shown in detail in Figure 16B

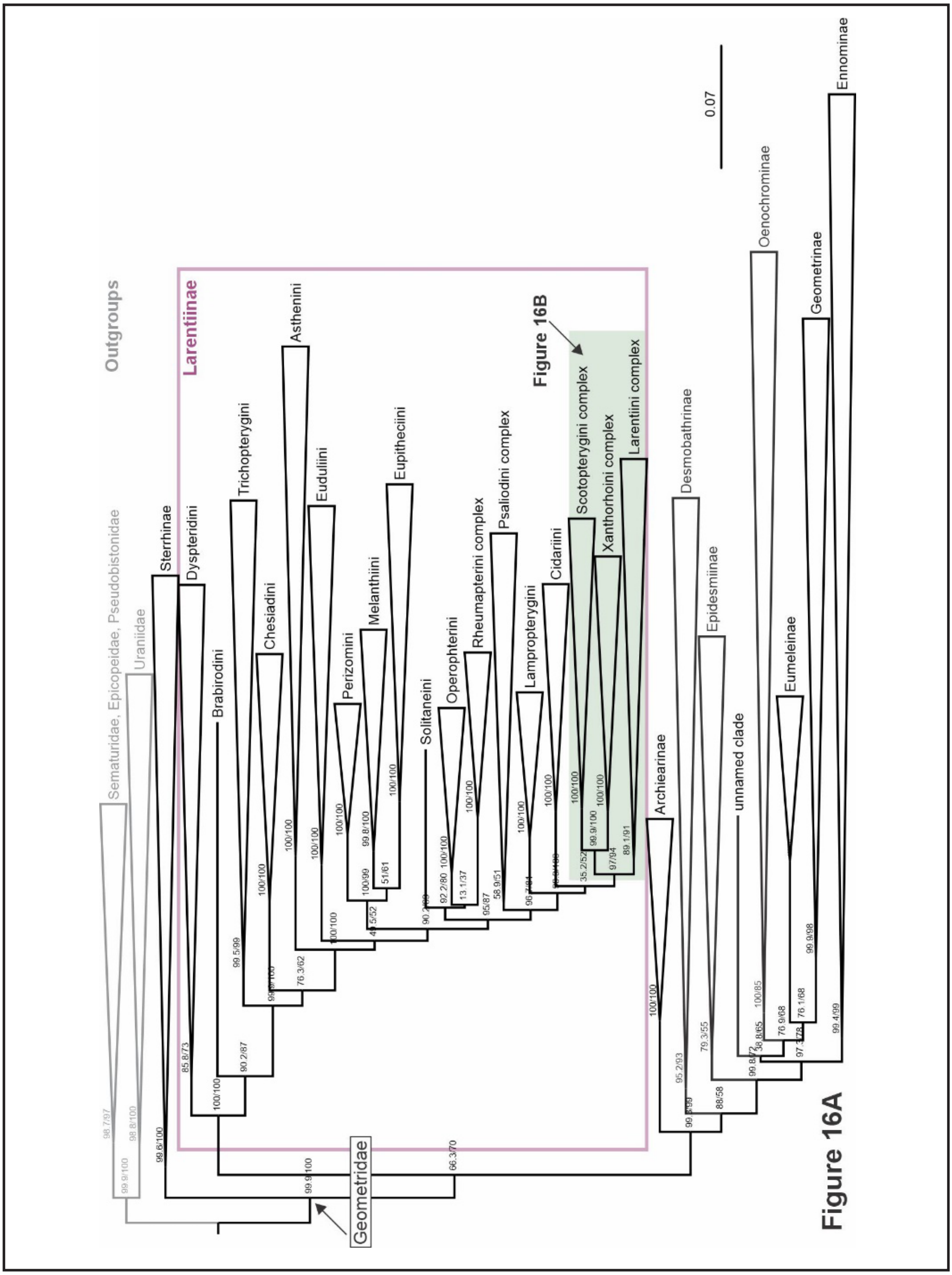


Figure 16B. B. Full phylogenetic hypothesis trimmed to show a part of Larentiinae subfamily. The focus taxa of our study from the Canary Islands are illustrated and voucher numbers are marked with red, showing that *Atlanticola mystica* (new genus, new species) is part of the Larentiini complex of tribes and *Herbulotina grandis* is part of the Xanthorhoini complex of tribes.

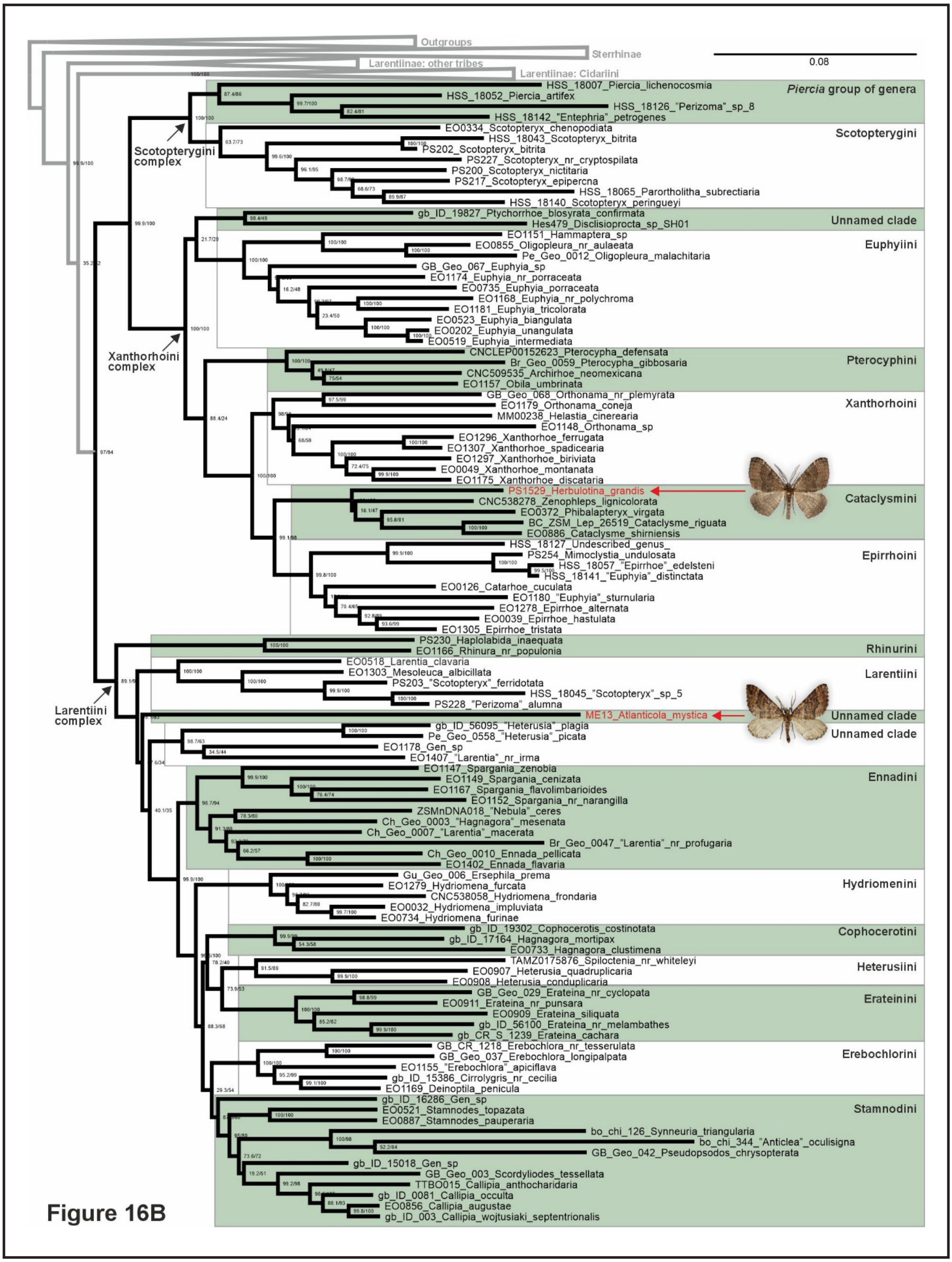


Figure 16B

Figures 17-18. Collecting localities of *Atlanticola mystica* (new genus, new species). **17.** Tenerife, Güímar, 650 m, 20-XI-2022. **18.** Tenerife, Arona, Ifonce, 1010 m, 2-XI-2023.

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