



## Revisiting the genus *Diplodoma* Zeller, 1852 in Europe: DNA barcoding reveals the presence of an undescribed species from forested habitats of southern Italy (Lepidoptera: Psychidae)

SARA LA CAVA<sup>1,2,\*</sup>, GIUSEPPE RIJLLO<sup>1,2,3</sup>, GIADA ZUCCO<sup>1,4</sup> & STEFANO SCALERCIO<sup>1,2,5</sup>

<sup>1</sup>Council for Agricultural Research and Economics (CREA), Research Centre for Forestry and Wood, Rende (Cosenza), 87036, Italy

<sup>2</sup>NBFC, National Biodiversity Future Center, Palermo, 90133, Italy

<sup>3</sup>✉ [giuseppe.rijllo@crea.gov.it](mailto:giuseppe.rijllo@crea.gov.it); <https://orcid.org/0009-0007-2266-4237>

<sup>4</sup>✉ [giada.zucco@crea.gov.it](mailto:giada.zucco@crea.gov.it); <https://orcid.org/0009-0000-1119-5737>

<sup>5</sup>✉ [stefano.scalercio@crea.gov.it](mailto:stefano.scalercio@crea.gov.it); <https://orcid.org/0000-0002-5838-1315>

\*Corresponding author: ✉ [sara.lacava@crea.gov.it](mailto:sara.lacava@crea.gov.it); <https://orcid.org/0000-0002-7967-5742>

### Abstract

*Diplodoma* Zeller, 1852 is a Eurasian genus belonging to the family Psychidae Boisduval, 1829 of which three species are known in Europe: *Diplodoma adpersella* Heinmann, 1870, *D. laichartingella* (Goeze, 1783), and *D. taurica* Zagulajev, 1986. Some authors have argued that *Diplodoma adpersella* may be a subspecies or even a form of *D. laichartingella*. The revision of literature and the study of DNA barcoding fragments confirmed the inconsistency of *D. adpersella* as a valid species, and therefore we propose the new synonymy of *Diplodoma adpersella* with *D. laichartingella* (**syn. nov.**). During recent surveys in southern Italy, three specimens of *Diplodoma* were collected. DNA barcoding and morphological analyses showed that COI sequences and male genitalia significantly differ from any previously studied specimen. As a result, we described *Diplodoma giulioregenii* **sp. nov.**, leaving unaltered the number of species belonging to this genus known from Europe.

**Key words:** new species, biodiversity, Mediterranean forests, Naryciinae, Calabria

### Introduction

*Diplodoma* Zeller, 1852 is a Eurasian genus belonging to the family Psychidae Boisduval, 1829 with eight species described from temperate Europe to Far East (Arnscheid & Weidlich, 2017). Three of these have been recorded in Europe: *Diplodoma taurica* Zagulajev, 1986, which is endemic to the Crimean Peninsula, *D. laichartingella* (Goeze, 1783), which is widely distributed throughout Europe except for most Mediterranean islands, and *D. adpersella* Heinmann, 1870, a less common species than the latter but recorded in several European countries (Arnscheid & Weidlich, 2017). In Italy, *Diplodoma laichartingella* was recorded for Valle d'Aosta, Lombardy, Trentino-Alto Adige, Veneto, Piedmont, and Friuli. The congeneric *Diplodoma adpersella* was recorded in central Italy (Emilia Romagna and Abruzzo) and there is a doubtful record in Basilicata (Weidlich, 2015), where only one case was observed (Bertaccini, 2013; Cassidy *et al.* 2021). However, neither species has certainly been recorded for the South.

*Diplodoma laichartingella* and *D. adpersella* are extremely similar both from an ecological and behavioural point of view, as well as in terms of larval development and morphological characters of the adults. The larvae of both species feed on moss, lichens, and fungi and are often found on trunks, walls, and rocky cliffs. Forested habitats (such as beech forests with an abundant layer of green algae and sparse soil vegetation) provide a favorable habitat for *Diplodoma laichartingella* and other related species (Kunz, 1989). The larval cases of the two congeneric species inhabiting central and western Europe exhibit a distinctly triangular section, consisting of two overlapping cases covered by sand, soil, and particles of plant debris and dead small insects (Arnscheid & Weidlich, 2017). Both sexes exhibit fully developed wings, an archaic characteristic of the *Diplodoma* genus (Saigusa, 1962).

The differences between the two species lie in the dimensions of the larval case, which are larger in *Diplodoma adpersella*, in the wingspan, which is 16–18 mm in *D. adpersella* and 10–15 mm in *D. laichartingella*, and in the wing patterns, which are more contrasted and have forewing bands that are less interrupted in *D. adpersella* (Arnscheid & Weidlich, 2017). However, the lack of differences in the morphology of genitalia and wing pattern variability has led some authors to hypothesize that *Diplodoma adpersella* could only be a subspecies or even a form of *D. laichartingella* (Arnscheid & Weidlich, 2017). Other authors have discussed a phylogenetic complex “*adpersella-laichartingella*” (twin species) with at least three different clusters of *Diplodoma laichartingella* in Europe, centred in South Germany, South-East Austria, and North Europe (Bertaccini, 2013).

*Diplodoma taurica*, endemic to the Crimean Peninsula, is the smallest species within the genus. The wingspan of males ranges from 8 to 9.5 mm, while females have a wingspan of 9 mm. Its larvae inhabit the understory layer of mesophilic forests and primarily feed on mosses, lichens, and withered herbs. The larval case is distinctly triangular and elongated, tough, and covered with a soft layer of silk and plant debris, occasionally containing insect particles. *Diplodoma taurica* can be differentiated from *D. adpersella* and *D. laichartingella* by the absence of an intercalary cell on the forewings and its significantly smaller dimensions (Arnscheid & Weidlich, 2017).

The study of Psychidae is quite difficult, primarily because it is difficult to collect adult specimens due to their poor attraction to light (Arnscheid & Weidlich, 2017). During several sampling campaigns conducted over the years in southern Italy with the aim of investigating the lepidopteran biodiversity of forested habitat, three specimens of this genus were unexpectedly collected. DNA barcoding revealed that the obtained sequences are significantly different from any barcoded specimens present in available public repositories and belong to a new undescribed species.

## Material and methods

This paper is based on the study of 33 specimens, 32 of which belong to the genus *Diplodoma* and one to *Narycia duplicella* (Goeze, 1783) as an outgroup (Tab. 1). Three specimens were collected by the authors and deposited in the Lepidoptera research collection of the Wildlife Management and Forest Biodiversity Laboratory, Research Centre for Forestry and Wood (CREA-FL). These specimens were collected using UV LED light traps (Infusino *et al.*, 2017), which were turned on before sunset and turned off after sunrise during nights with no or low wind, temperatures near or above the seasonal mean, no or low precipitations, and near the new moon phase. The sampling details of specimens are as follows:

—1 male: Vallone Argentino, Montalto Uffugo, 565 m a.s.l., 1.VI.2016, latitude 39.4082°N, longitude 16.1209°E, *Castanea sativa* Mill. woodlot;

—1 male: Vallone Tasso, Spezzano Sila (CS), 1376 m a.s.l., 16.VII.2018, latitude 39.332393°N, longitude 16.418499°E, mixed forest of *Pinus nigra* J.F. Arnold subsp. *calabrica* (Delam. ex Loudon) and *Fagus sylvatica* L;

—1 male: Vallone Tasso, Spezzano Sila (CS), 1402 m a.s.l., 9.VII.2018, latitude 39.332823°N, longitude 16.414273°E, *Fagus sylvatica* forest.

Genitalia of one specimen were extracted and slide mounting following the main recommendations outlined by Parenti (2000). The terminology of genitalia traits is according to Arnscheid and Weidlich (2017).

All our specimens were submitted to DNA barcoding analysing of the mitochondrial 5' cytochrome oxidase gene, subunit 1 (COI), following the standard procedures of the Canadian Centre for DNA Barcoding (CCDB). They were successfully barcoded and automatically assigned to a Barcode Index Number (BIN) by The Barcode of Life Data System (BOLD). Three sequences were obtained and compared with those available in BOLD (Ratnasingham & Hebert, 2007) and GenBank (<https://www.ncbi.nlm.nih.gov/genbank/>), using Simple Distance (*p-dist*) as a distance model.

A phylogenetic tree was built using the Neighbor-Joining method (Saitou & Nei, 1987). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (500 replicates) is shown next to the branches (Felsenstein, 1985). The tree is drawn to scale, with branch lengths in the same units as the evolutionary distances (Kimura 2-parameter, K2P) used to infer the phylogenetic tree (Kimura, 1980). All ambiguous positions were removed for each sequence pair (pairwise deletion option). The final dataset comprised a total of 682 positions. Analyses were conducted using MEGA11 (Tamura *et al.* 2021).

## Results

The sequences obtained for our specimens ranged from 653 to 679 bp in length and were assigned to the new Barcode Index Number (BIN) BOLD:AFS5252. The nearest specimen available in BOLD (*p-dist* 6.45%) belongs to *D. laichartingella*. Its sequence is included in the BIN BOLD:AAF5091. This result, coupled with the results of morphological comparison of male genitalia with available iconography (see below), and the critical revision of literature, allowed us to revise the genus *Diplodoma* at the continental level describing a species new to science and proposing a new synonymy.

### *Diplodoma giulioiregenii* La Cava & Scalercio, sp. nov.

<http://zoobank.org/urn:lsid:zoobank.org:pub:46B86E84-20B9-49BD-B241-D2159025F8A2>

(Figs. 1–19)

**Type material.** Holotype. [ITALIA] ♂, CALABRIA,—CC\_C2, V.ne Argentino, Montalto Uff., 565 m—1.VI.2016, 39.4082°, 16.1209°, Scalercio & Infusino leg. [DNA barcode specimen ID LEP-SS-04527]. Paratypes. [ITALIA] 1♂, CALABRIA SL\_AF, Vallone Tasso, Spezzano Sila (CS), 1402 m—9.VII.2018, 39.332823°, 16.414273°, Scalercio S. leg. [DNA barcode specimen ID LEP-SS-04552]; Gen. prep. CREA—0279, Stefano Scalercio; 1♂, ITALIA—CALABRIA SL\_AM, Vallone Tasso, Spezzano Sila (CS), 1376 m—16.VII.2018, 39.332393°, 16.418499°, Scalercio S. leg. [DNA barcode specimen ID LEP-SS-04553], Gen. prep. CREA—0266, Stefano Scalercio.

**Diagnosis.** Male antenna composed by about 35 antennomers as in *D. taurica*, while in *D. laichartingella* is composed by no more than 30 antennomers. Intercalary cell presents as in *D. laichartingella*, lacking in *D. taurica*. In male genitalia (Figs. 5, 10) the length-to-width ratio ( $L-W_{ratio}$ ) of clasper is significantly higher in *D. giulioiregenii* (N=2;  $L-W_{ratio}$  ranging from 1.8 to 2.5) than in available dissected males of *D. laichartingella* (N=9;  $L-W_{ratio}$  min=0.7; mean=1.0±0.2; max=1.3) (Figs. 11–17) and is similar to the picture of the original description of *D. taurica* ( $L-W_{ratio}$ =1.9). Tendon 35 degrees angled upward at about half of its length in *D. giulioiregenii* (Fig.18a), straight in *D. taurica*, (Fig. 18b) and mild curved upward in *D. laichartingella* (Fig.18c). Despite the worn appearance of types, *D. giulioiregenii* does not seem to be significantly different from *D. laichartingella* in terms of wing pattern and wingspan, whereas *D. taurica* is significantly smaller (Arnscheid & Weidlich, 2017).

## Descriptions

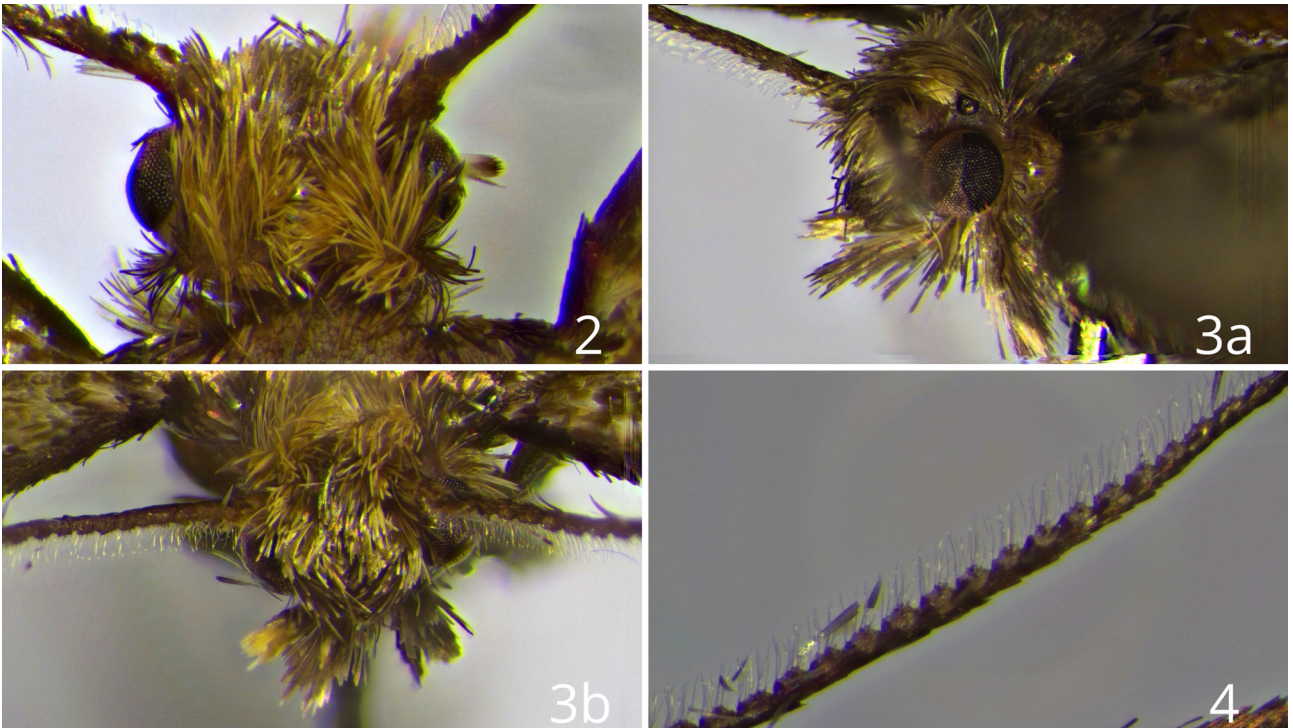
External characters (Figs. 1–4). Adult male, holotype (Fig. 1): wingspan 12 mm; colouration and vestiture: head (Fig. 2) covered in light-brown, shiny, short hairs on frons, with longer light-brown hairs posterior to antennal sockets; labial palpi (Fig. 3, left side (a) and top view (b)) elongated and densely covered with long scales. Round compound eye about 320µm high; distance between eyes about 450µm; a well-developed ocellus present immediately above. The antenna (Fig. 4) thread-like, approximately half-length of the costa, composed by about 35–38 antennomers; dorsally covered by scales and ventrally ciliated with cilia in average 115µm long. The thorax is covered with shiny light-brown hairs. The forewings are elongated and darkish, with shiny light spots that are visible on coastal margin and with shiny yellowish scales visible in the inner margin. Cloaking scales of forewings belong to IV class (Sauter, 1956). The fringe scales are short and compact, with shiny light spots. Venation with 10 veins from discal cell; intercalary and accessory cells present. The hindwings are uniformly brownish, with a few shiny light spots on the proximal margin of the wings. Venation with 6 veins from discal cell. The fringe scales are longer near the proximal margin of the hindwings and shorter toward the distal margin.

Adult female. unknown.

Male genitalia (Figs. 5–9). Valva short and distinctly sclerotized, narrower distally with rounded apex, densely covered with short hairs (Fig. 5). The tendon is short and angled upward by 35 degrees at half of its ventral length. Sacculus long about two-thirds of valva length, roundish caudally with clasper narrower distally, distinctly pointed, and sclerotized. Vinculum and tegumen fused. Pointed saccus 295µm long and 56µm wide at half of its length (Fig. 6). Slightly oval tegumen, distally with two hump shaped appendages (Fig. 7). Phallus 708µm long, thin slightly curved and broader caudally (Fig. 8), bearing distally 4 teeth that become smaller proximally (Fig. 9).



FIGURE 1. *Diplodoma giulioiregenii* sp. nov., male, 1.VI.2016, Montalto Uffugo, Cosenza, Italy (Coll. CREA), holotype.



FIGURES 2–4. head (2); lateral (a) and upper view (b) of palpi; antenna (4), holotype.

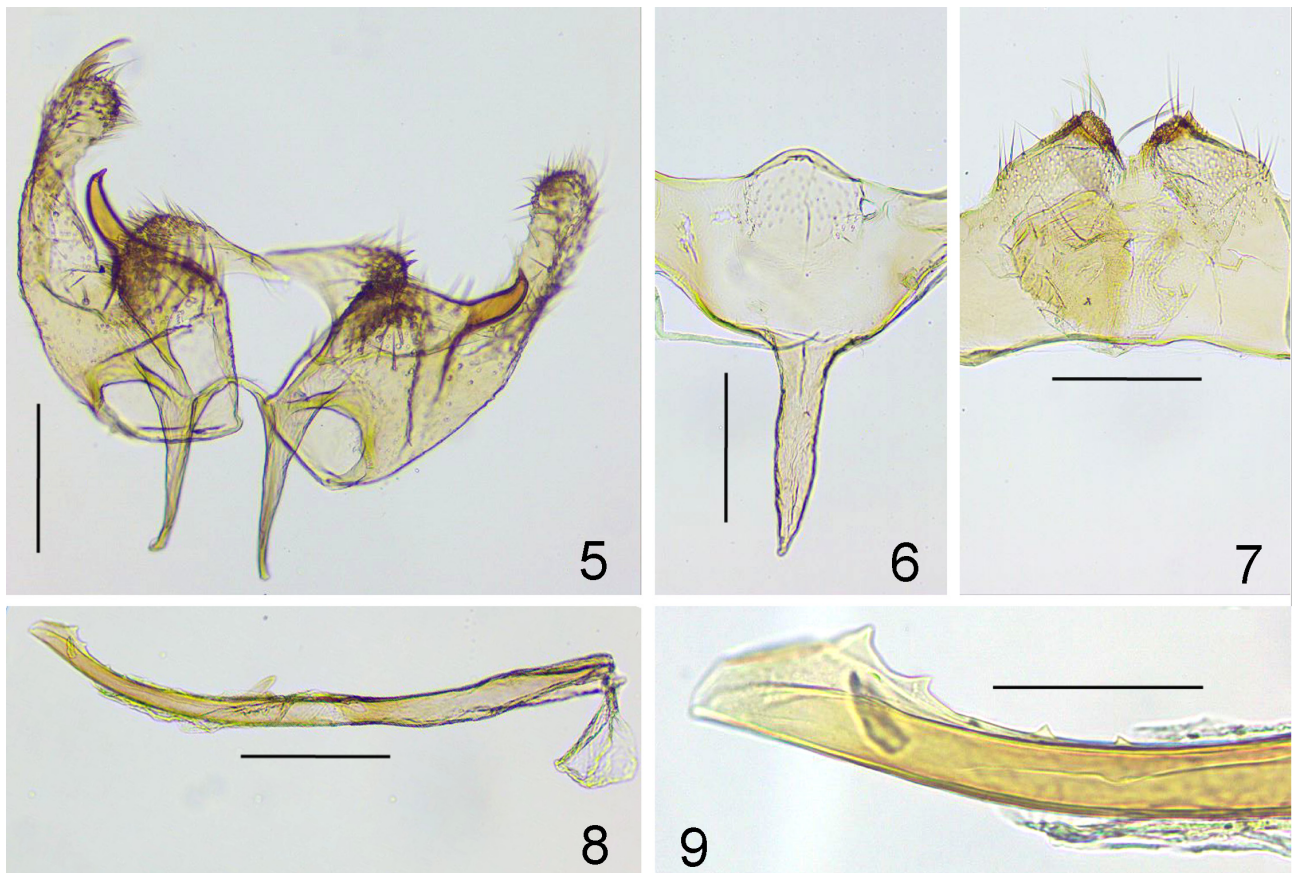
Case. unknown.

Variation. we cannot observe variation in wings pattern because our specimens are worn due to the collecting method. The only observable variation is in wingspan, which ranges between 12 mm and 13 mm (n=3) (Fig. 1, 19), and in phallus length ranging 684 and 708 $\mu$ m in paratypes.

**Genetic data.** the maximum intra-BIN difference is 0.8% with the two paratype identical to each other. The intra-BIN average distance is 0.54% (n=3). The distance from the nearest BIN (BOLD:AAF5091) is 6.25%, and it is composed by European sequences of *Diplodoma laichartingella*. The p-distance from the Nearest Member calculated by the BOLD Identification System is 6.76% for the holotype and 6.45% for the paratypes. The Nearest Member is a specimen from Norway (Sample ID: NHMO-DAR-12513). In the neighbor-joining tree (Fig. 20) resulting from the analyses of available DNA barcoding sequences belonging to the genus *Diplodoma*, eight distinct BINs were present across the European continent and one in Far East Asia. Phylogenetic analysis showed that the cluster of *Diplodoma giulioiregenii* separates earlier than the branches containing *D. laichartingella* and *D. adpersella*.

**Diagnostic SNPs.** we report the 679 bp long DNA barcoding sequence of the holotype compared with the *Diplodoma* sequences utilised in this paper, with the 23 diagnostic SNPs (Single Nucleotide Polymorphism) evidenced in bold:

TTTATATTTTATTTTAGGT**ATTTGATCGGGAATAATTGGAACATCTTTAAGATTATTAATTCGAGTAGAAT**  
**TAGGGATTCC**TAATTCATTTCTTGGAAAGAGATCAAATTTATAATACTATTGTA**ACTGCTCATGCCCTTATT**  
ATAATTTTTTTTATAGTTATACCTATTATAATTGGGGG**ATTTGGAAATTGATTAGTACCTTTAATATTGGGG**  
GCCCCTGATATAGCTTTCCCTCGTATAAATAATATAAGATTTTGACTTCTTCCACCTTCTTTAATAATTTT  
AATTATAAGAAGAATTGTAGAAAATGGAGCAGGAACAGGATGAACAATTTAT**TCCTCCCCTTTCTTCTA**  
ATTAACCCATTCAGGAAGTTCAGTTGATTTAGCAATTTTTCTTTACATTTAGCAGGAATTT**CATCTAT**  
TTTAGGGGCAGTAAATTTTATTACAACAATTATTAATATACGACCATTTAACATATCATTAGATCAAATAC  
CCTTATTTGTATGGTCTGTGGCTATTACTGCAGTACTTTTACTTTTATCTTTACCAGTTT**AGCTGGAGC**  
AATTACTATGTTATTAACCGATCGAAATTTAAATACATCGTTTTTTTGATCCTGCTGGAGGTGGAGACCCT  
ATTTTATTCCAACATTTATTTTGATTTTTTGGT**CACCCTGAAGTT.**



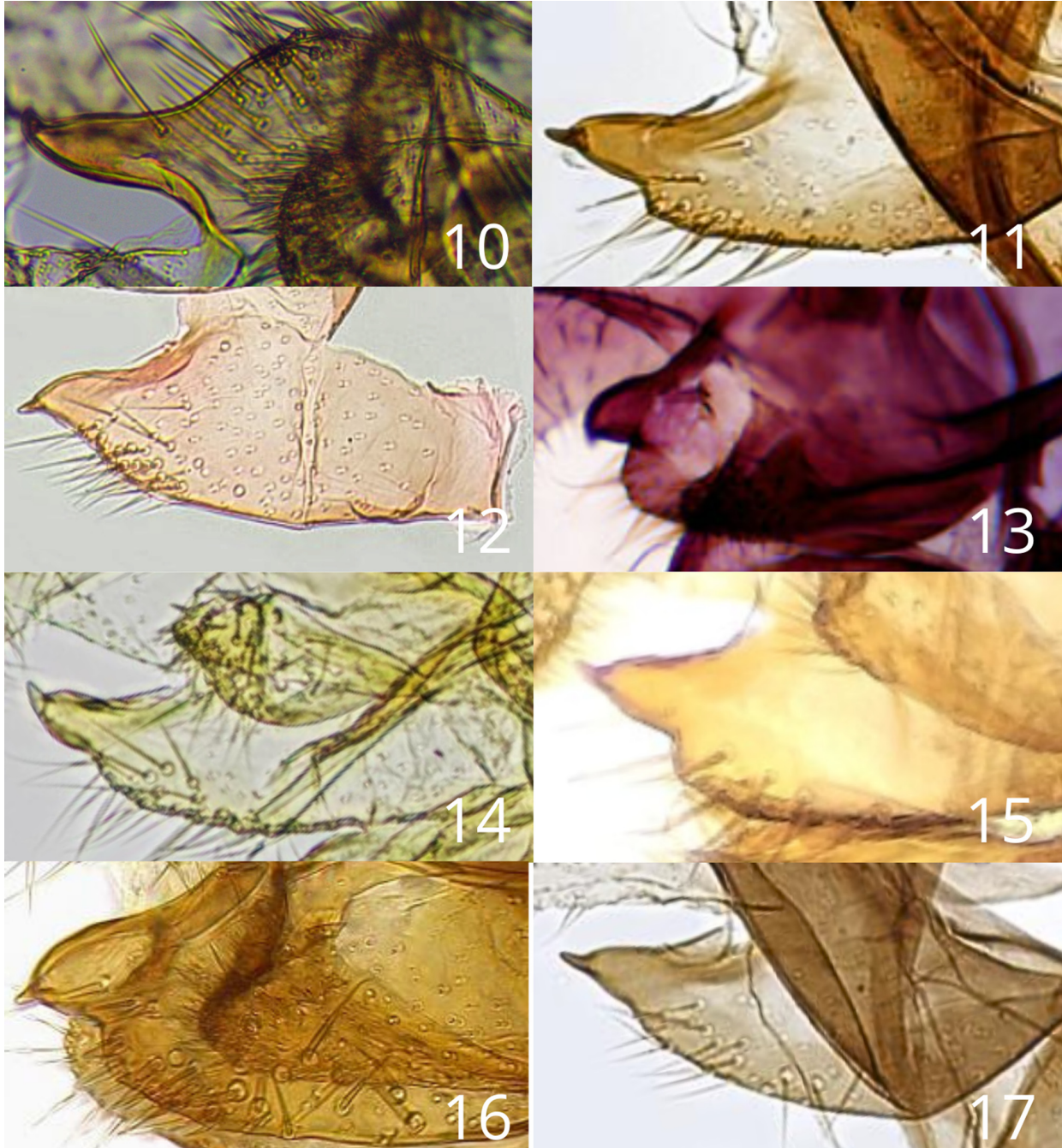
**FIGURES 5–9.** *Diplodoma giulioiregenii* sp. nov., male genitalia, 9.VII.2018, Vallone Tasso, Spezzano Sila, Cosenza, Italy (Coll. CREA), paratype, Gen. prep. CREA-0279. 5: Valvae; 6: Vinculum; 7: Tegumen; 8: Phallus; 9: Distal tip of phallus. Scale bars of figures 5–8 equal to 200µm. Scale bar of figure 9 equal to 60µm.

Biology: unknown.

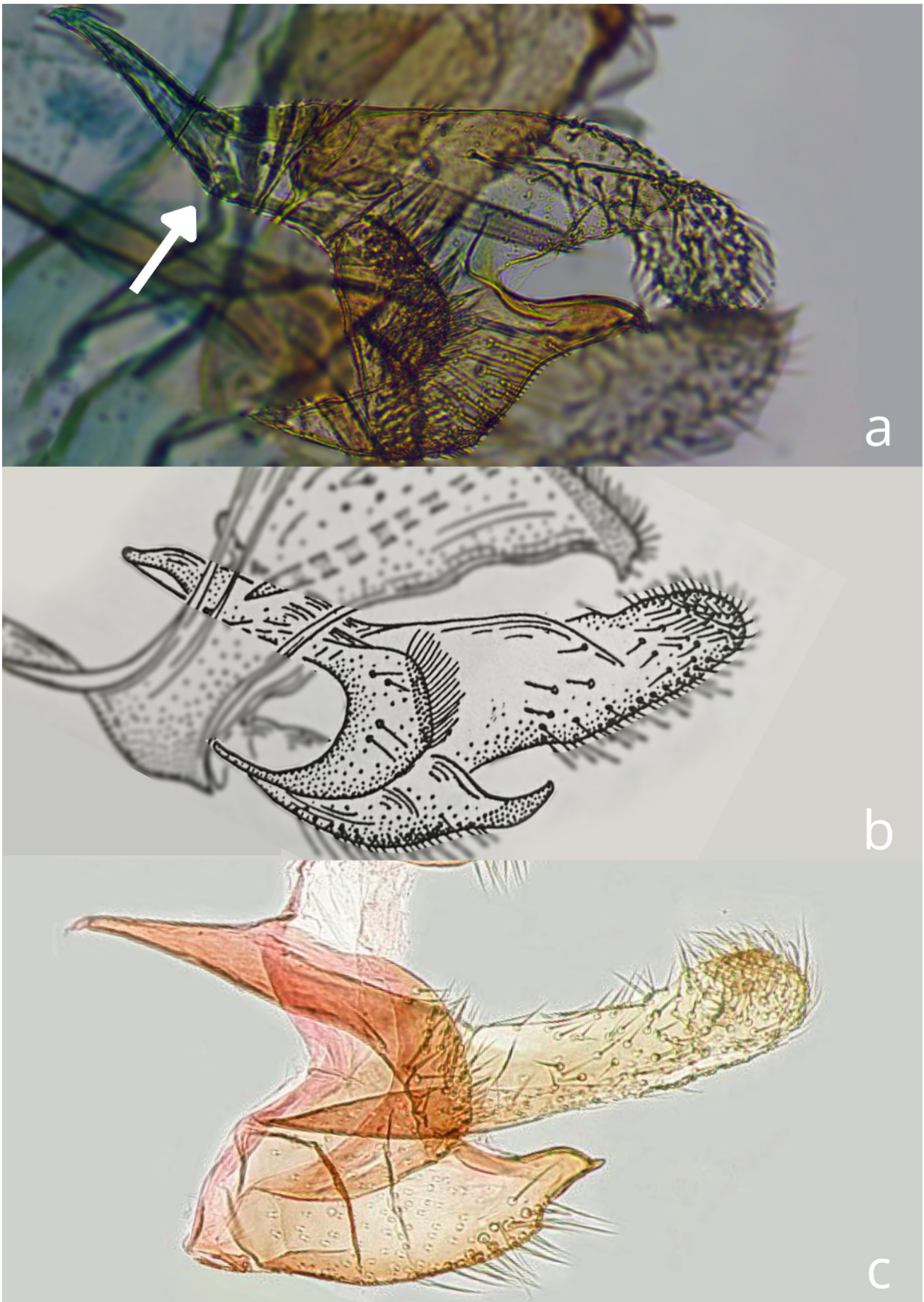
Distribution: endemic of South Italy, with type specimens collected from two different mountainous areas, the Catena Costiera Paolana and the Sila Massif, at a distance of 27 km.

Habitat: all specimens were found in forested habitat, the holotype in a dense chestnut woodlot and the paratypes in a pure beech forest and in a mixed beech-Calabrian black pine forest.

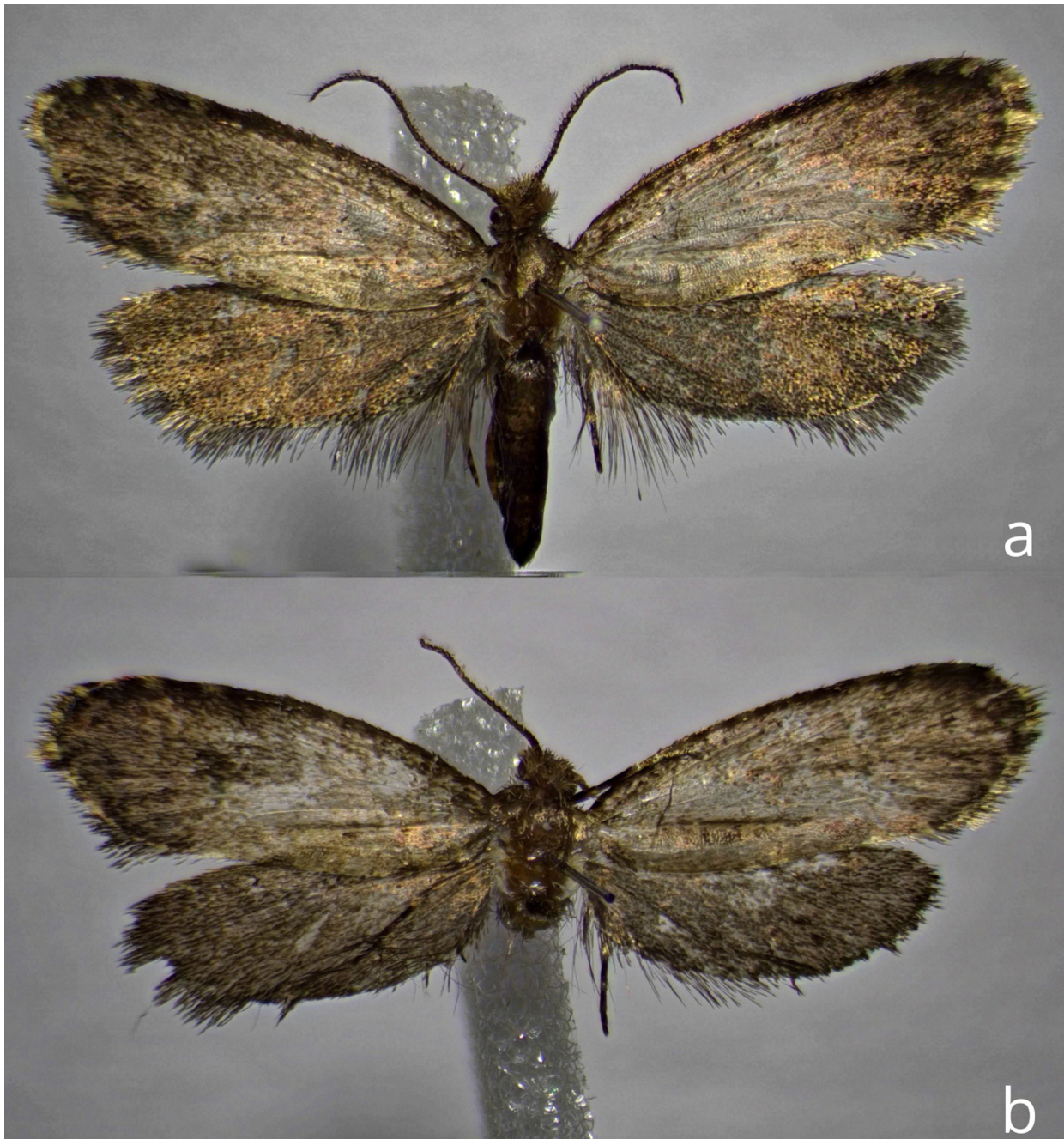
*Derivatio nominis*: in memory of a young Italian researcher murdered by all the evil in the world, waiting for the truth for Giulio Regeni.



**FIGURES 10–17.** Comparison of claspers belonging to *Diplodoma giulioiregenii* **sp. nov.** (10) and the available dissected European specimens of *Diplodoma laichartingella* (11–17). 10: *D. giulioiregenii* **sp. nov.**, Italy (Gen. prep. CREA—0266); 11: *D. laichartingella*, Wales (Psychidae : *Diplodoma laichartingella*—mothdissection.co.uk); 12: Austria (*Diplodoma laichartingella*—LepiWiki); 13: Sweden ([http://www2.nrm.se/en/svenska\\_fjarilar/d/diplodoma\\_laichartingella.html](http://www2.nrm.se/en/svenska_fjarilar/d/diplodoma_laichartingella.html)); 14: England (<https://lc.cx/sk0yIB>); 15: Norway ([www.gbif.org/fr/occurrence/4013009467](http://www.gbif.org/fr/occurrence/4013009467); Observed by Torbjørn Kloster (licence: <http://creativecommons.org/licenses/by-sa/4.0/>)); 16: England (Psychidae : *Diplodoma laichartingella*—mothdissection.co.uk); 17: England (Psychidae : *Diplodoma laichartingella*—mothdissection.co.uk)



**FIGURE 18.** Comparison of valvae of *Diplodoma giulioiregenii* sp. nov. (a), *D. taurica* (b), and *D. laichartingella* (c). The arrow points to the diagnostic difference observed in the tendon shape.



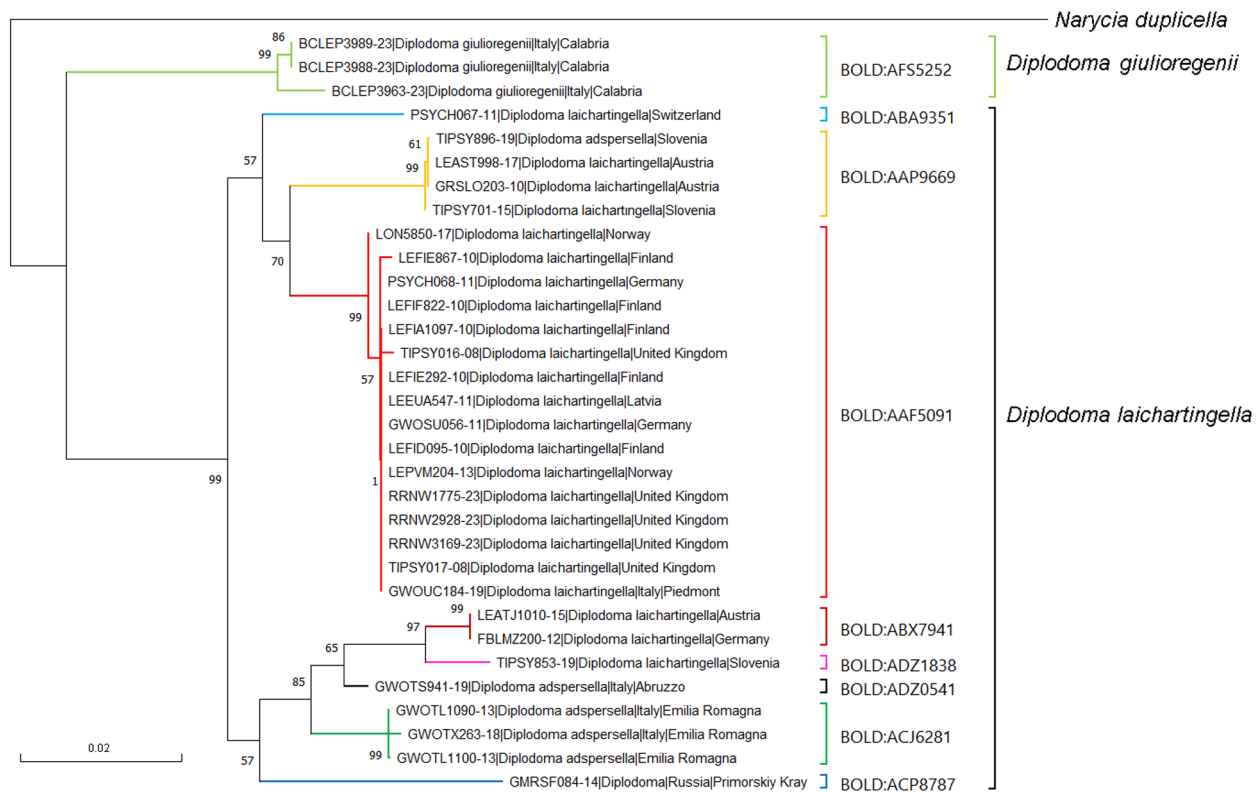
**FIGURE 19.** *Diplodoma giulioiregenii* sp. nov., paratypes, 9.VII.2018 (a), 16.VII.2018 (b) Vallone Tasso, Spezzano Sila, Cosenza, Italy.

***Diplodoma adpersella* Heinemann, 1870 syn. nov.**

DNA barcoding analyses we carried out, highlighted a high COI diversification of *Diplodoma laichartingella* and *D. adpersella* without a clear separation between them. In the Neighbour-Joining tree of European *Diplodoma* (Fig. 20), *D. adpersella* and *D. laichartingella* present in BOLD and identified by the authors on the basis of morphology, are not coherently separated by barcoding. One Slovenian specimen, that refers to a larva and its case, was morphologically identified as *D. adpersella* and included in a BIN (BOLD:AAP9669) together with Slovenian and Austrian *D. laichartingella* specimens identified using wing pattern. In other two cases the name *D. adpersella* has been attributed by wing patterns to all the specimens composing the BINs, but these BINs are intermixed with those of *D. laichartingella*, making a mtDNA-based differentiation of these taxa unlikely. In light



of our genetic analyses, that further weaken the validity of *D. adpersella* questioned by several authors due to the lack of morphological differences, we propose *Diplodoma adpersella* Heinemann, 1870 as a junior synonym of *Diplodoma laichartingella* (Goeze, 1783).



**FIGURE 20.** Neighbour-joining tree derived from sequences of *Diplodoma* specimens available in BOLD. Scale bar indicates a phylogenetic distance of 0.02 nucleotide substitutions per site. Numbers on the branches indicate bootstrap percentage after 500 replications in constructing the tree.

## Discussion and Conclusions

The changes we carried out in the genus *Diplodoma* of western Europe do not affect the number of species known for this geographic area due to the description of *Diplodoma giulioiregenii* **sp. nov.** and the new synonymy of *Diplodoma adpersella* with *D. laichartingella*.

Usually, the specimens of *Diplodoma* were collected as larvae and reared to the adult stage, as they are rarely attracted to the lights commonly used for moth sampling. The specimens of the type series of *D. giulioiregenii* have been collected using UV LED light traps, likely thanks to their low intensity (Infusino *et al.* 2017). It is known that high-intensity light sources are not attractive for several species (Infusino *et al.* 2017), especially for Psychidae (Arnscheid & Weidlich, 2017). Therefore, the use of different kinds of light sources can help to better survey local biodiversity. However, to describe the still unknown preimaginal stages of this new species and to obtain adults with a well-preserved wing pattern (i.e., in a better condition than the type series), field surveys looking for larval cases are needed. The discovery of new species in forested habitats of southern Italy is increasing during the last decade (Scalercio *et al.* 2016; Infusino *et al.* 2018; Govi *et al.* 2022), fostering the role of this geographic area as a biodiversity hotspot.

In the future, some records could be attributed to *D. giulioiregenii* or to other new *Diplodoma* species. In fact, the taxonomy of one specimen tentatively attributed to *D. adpersella* from Samos, Greece (Arnscheid & Weidlich, 2017), and one case tentatively attributed to *D. laichartingella* from Basilicata, South Italy (Weidlich, 2015), must be ascertained.

Kozhanchikov (1956) hypothesized that *Diplodoma adpersella* could be a form of *D. laichartingella*. However, he never proposed a synonymy, as was stated by Sobczyk (2011) and Arnscheid & Weidlich (2017), between the

two species, merely stating that he lacked sufficient material to confirm this hypothesis. The taxonomic status of *D. adpersella* remained unclear until recent years, as some authors stated that it could potentially be a subspecies or a form of *D. laichartingella* (Arnscheid & Weidlich, 2017). Nowadays, the availability of molecular data has allowed us to clarify that *D. adpersella* is a junior synonym of *D. laichartingella*. Further support for this conclusion could be provided by morphological analysis of the genitalia of the specimens belonging to all the observed BINs. However, available iconography concerning the morphology of genitalia attributed to *D. laichartingella* covers all the western European range of the species (Fig. 10–17), showing no appreciable differences between provenances.

**TABLE 1.** For each barcoded specimen of *Diplodoma* available in BOLD, we provide the following information: sample ID, sequence ID, taxonomy, country, region or site (when available), BIN, and sequence length (bp).

Sample ID	Sequence ID	Taxonomy	Country	Region/Site	BIN	Sequence length (bp)
LEP-SS-04553	BCLEP3989-23	<i>Diplodoma giulioiregenii</i>	Italy	Calabria	BOLD: AFS5252	653
LEP-SS-04552	BCLEP3988-23	<i>Diplodoma giulioiregenii</i>	Italy	Calabria	BOLD: AFS5253	653
LEP-SS-04527	BCLEP3963-23	<i>Diplodoma giulioiregenii</i>	Italy	Calabria	BOLD: AFS5254	679
BC TS Psy 0067	PSYCH067-11	<i>Diplodoma laichartingella</i>	Switzerland		BOLD: ABA9351	658
STG805	TIPSY896-19	<i>Diplodoma adpersella</i>	Slovenia	Koroska	BOLD: AAP9669	654
TLMF Lep 24356	LEAST998-17	<i>Diplodoma laichartingella</i>	Austria	Osttirol	BOLD: AAP9669	658
CLV1723	GRSLO203-10	<i>Diplodoma laichartingella</i>	Austria	Osttirol	BOLD: AAP9669	658
STG227	TIPSY701-15	<i>Diplodoma laichartingella</i>	Slovenia		BOLD: AAP9669	643
NHMO-DAR-12513	LON5850-17	<i>Diplodoma laichartingella</i>	Norway	Luster	BOLD: AAF5091	658
MM10121	LEFIE867-10	<i>Diplodoma laichartingella</i>	Finland	Ostrobotnia ouluensis	BOLD: AAF5091	658
BC TS Psy 0068	PSYCH068-11	<i>Diplodoma laichartingella</i>	Germany	Saxony	BOLD: AAF5091	658
MM13096	LEFIF822-10	<i>Diplodoma laichartingella</i>	Finland	Karelia borealis	BOLD: AAF5091	658
MM05826	LEFIA1097-10	<i>Diplodoma laichartingella</i>	Finland	Satakunta	BOLD: AAF5091	658
clv16	TPSY016-08	<i>Diplodoma laichartingella</i>	United Kingdom	England	BOLD: AAF5091	621
MM08640	LEFIE292-10	<i>Diplodoma laichartingella</i>	Finland	Alandia	BOLD: AAF5091	658
MM20606	LEEUA547-11	<i>Diplodoma laichartingella</i>	Latvia	Tal	BOLD: AAF5091	658
BC ZSM Lep 53307	GWOSU056-11	<i>Diplodoma laichartingella</i>	Germany	Saxony	BOLD: AAF5091	658
MM05707	LEFID095-10	<i>Diplodoma laichartingella</i>	Finland	Karelia borealis	BOLD: AAF5091	658

.....continued on the next page

**TABLE 1.** (Continued)

Sample ID	Sequence ID	Taxonomy	Country	Region/Site	BIN	Sequence length (bp)
NorBOL LepVM204	LEPVM204- 13	<i>Diplodoma laichartingella</i>	Norway	Oppland	BOLD: AAF5091	658
RRNW_029_C8	RRNW1775- 23	<i>Diplodoma laichartingella</i>	United Kingdom		BOLD: AAF5091	655
RRNW_040_C4	RRNW2928- 23	<i>Diplodoma laichartingella</i>	United Kingdom		BOLD: AAF5091	655
RRNW_042_E6	RRNW3169- 23	<i>Diplodoma laichartingella</i>	United Kingdom		BOLD: AAF5091	655
clv16.1	TIPSY017-08	<i>Diplodoma laichartingella</i>	United Kingdom	England	BOLD: AAF5091	546
BC ZSM Lep 106925	GWOU184- 19	<i>Diplodoma laichartingella</i>	Italy	Piedmont	BOLD: AAF5091	527
TLMF Lep 18870	LEATJ1010- 15	<i>Diplodoma laichartingella</i>	Austria	Nordtyrol	BOLD: ABX7941	658
BC ZSM Lep 64281	FBLMZ200- 12	<i>Diplodoma laichartingella</i>	Germany	Bavaria	BOLD: ABX7941	658
STG762	TPSY853-19	<i>Diplodoma laichartingella</i>	Slovenia	Stajerska	BOLD: ADZ1838	654
BC ZSM Lep 105307	GWOTS941- 19	<i>Diplodoma adpersella</i>	Italy	Abruzzo	BOLD: ADZ0541	625
BC ZSM Lep 73488	GWOTL1090- 13	<i>Diplodoma adpersella</i>	Italy	Emilia Romagna	BOLD: ACJ6281	658
BC ZSM Lep 103774	GWOTX263- 18	<i>Diplodoma adpersella</i>	Italy	Emilia Romagna	BOLD: ACJ6281	658
BC ZSM Lep 73498	GWOTL1100- 13	<i>Diplodoma adpersella</i>	Italy	Emilia Romagna	BOLD: ACJ6281	654
BIOUG15869- C09	GMRSF084- 14	<i>Diplodoma</i>	Russia	Primorskiy Kray	BOLD: ACP8787	585

## Acknowledgments

We thank the Ufficio Territoriale della Biodiversità (UTB) of the Carabinieri Forestali dello Stato, Cosenza province, and the Sila National Park for supporting this study, and Marco Infusino for help during field surveys. We would like to thank Axel Hausmann (Bavarian State Collection for Zoology, Germany) and Edgardo Bertaccini (Forlì, Italy) for allowing us to use their BOLD private data. We would like to thank Thomas Sobczyk (Germany) for the valuable advice that strongly improved the manuscript and Simon Habermann (Munich, Germany) for the language support. In addition, we would like to thank Raymond A. Watson (England) for the permission to use one image noted as his copyright. Project funded under the National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.4—Call for tender No. 3138 of 16 December 2021, rectified by Decree n.3175 of 18 December 2021 of Italian Ministry of University and Research funded by the European Union—NextGenerationEU; Award Number: Project code CN\_00000033, Concession Decree No. 1034 of 17 June 2022 adopted by the Italian Ministry of University and Research, CUP83D21014060006, Project title “National Biodiversity Future Center - NBFC”.

## References

- Arnscheid, W.R. & Weidlich, M. (2017) *Microlepidoptera of Europe. Vol. 8. Psychidae*. Brill, Leiden, 423 pp.  
<https://doi.org/10.1163/9789004340220>
- Bertaccini, E. (2013) Contributo alla conoscenza degli Psichidi che vivono nel Parco Nazionale delle Foreste Casentinesi, Monte Falterona e Campigna (Insecta Lepidoptera Psychidae). *Quaderno di Studi e Notizie di Storia naturale della Romagna*, 38, 59–89.
- Cassidy, M.M., Raviglione, M. & Bertaccini, E. (2021) Prime segnalazioni certe per la regione Piemonte di *Diplodoma laichartingella* (Goeze, 1783) (Insecta Lepidoptera Psychidae). *Rivista piemontese di Storia naturale*, 42, 93–96.
- Felsenstein, J. (1985) Confidence limits on phylogenies: An approach using the bootstrap. *Evolution*, 39, 783–791.  
<https://doi.org/10.1111/j.1558-5646.1985.tb00420.x>
- Govi, G., Fiumi, G., Barbut, J., Scalercio, S. & Hausmann, A. (2022) An unexpected species complex unveiled in southern European populations of *Phragmatiphila nexa* (Hübner, [1808]) (Lepidoptera, Noctuidae, Noctuinae, Apameini). *Zootaxa*, 5128 (3), 355–383.  
<https://doi.org/10.11646/zootaxa.5128.3.3>
- Infusino, M., Brehm, G., Di Marco, C. & Scalercio, S. (2017) Assessing the efficiency of UV LEDs as light sources for sampling the diversity of macro-moth. *European Journal of Entomology*, 114, 25–33.  
<https://doi.org/10.14411/eje.2017.004>
- Infusino, M., Hausmann, A. & Scalercio, S. (2018) *Ptilophora variabilis* Hartig, 1968, bona species, and description of *Ptilophora nebrodensis* sp. n. from Sicily (Lepidoptera, Notodontidae). *Zootaxa*, 4369 (2), 237–252.  
<https://doi.org/10.11646/zootaxa.4369.2.5>
- Kimura, M. (1980) A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. *Journal of Molecular Evolution*, 16, 111–120.  
<https://doi.org/10.1007/BF01731581>
- Kozhanchikov, I.V. (1956) *Fauna of the USSR. Vol. III. No. 2. Psychidae, (Chekhlonosy - meshecnitsy)*. Izdatel'stvo Akademii Nauk SSSR, Moskva-Leningrad, 517 pp. [in Russian]
- Kunz, H. (1989) Das Vorkommen der *Diplodoma herminata* (Geoffroy in Fourcroy 1785) (Lepidoptera: Psychidae) im Osnabrücker Raum. *Osnabrücker naturwissenschaftliche Mitteilungen*, 15, 215–224.
- Parenti, U. (2000) *A Guide to the Microlepidoptera of Europe*. Museo Regionale di Scienze Naturali, Torino, 426 pp.
- Ratnasingham, S. & Hebert, P.D.N. (2007) BOLD: The Barcode of Life Data System ([www.barcodinglife.org](http://www.barcodinglife.org)). *Molecular Ecology Notes*, 7 (3), 355–364.  
<https://doi.org/10.1111/j.1471-8286.2007.01678.x>
- Saigusa, T. (1962) On some basic concepts of the evolution of psychid moths from the points of view of the comparative ethology and morphology. *Tyo to Ga*, 12, 120–143. [in Japanese, with English abstract]
- Saitou, N. & Nei, M. (1987) The neighbor-joining method: A new method for reconstructing phylogenetic trees. *Molecular Biology and Evolution*, 4, 406–425.  
<https://doi.org/10.1093/oxfordjournals.molbev.a040454>
- Sauter, W. (1956) Morphologie und Systematik der schweizerischen *Solenobia*-Arten (Lep., Psychidae). *Revue Suisse De Zoologie*, 63 (27), 451–550.  
<https://doi.org/10.5962/bhl.part.75469>
- Scalercio, S., Infusino, M. & Hausmann, A. (2016) *Nothocasis rosariae* sp. n., a new sylvicolous, montane species from southern Europe (Lepidoptera: Geometridae, Larentiinae). *Zootaxa*, 4161 (2), 177–192.  
<https://doi.org/10.11646/zootaxa.4161.2.2>
- Sobczyk, T. (2011) *Psychidae* (Lepidoptera). In: Nuss, M. (Ed.), *World catalogue of insects. Vol. 10*. Brill, Leiden, pp. 1–467.  
<https://doi.org/10.1163/9789004261044>
- Tamura, K., Stecher, G. & Kumar, S. (2021) MEGA 11: Molecular Evolutionary Genetics Analysis Version 11. *Molecular Biology and Evolution*, 38 (7), 3022–3027.  
<https://doi.org/10.1093/molbev/msab120>
- Weidlich, M. (2015) Beobachtungen zur Psychidenfauna Italiens mit der Neubeschreibung einer *Dahlica* Enderlein, 1912 (Lepidoptera: Psychidae). *Linzer biologische Beiträge*, 47 (2), 1909–1934.