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Faunistic and taxonomic notes on *Phalacropterix apiformis* (Rossi, 1790) and *P. restonicae* (Fiumi & Govi, 2015) from Corsica, France (Lepidoptera, Psychidae, Oiketicinae)

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Abstract. Records of the psychid species *Phalacropterix apiformis* (Rossi, 1790) from Corsica, France are mapped. Information about biology and phenology is also given, as well as a description of the morphological characteristics of this species. We combine this with DNA barcoding results. *P. apiformis* is compared with *P. restonicae*, described in 2015 by Fiumi & Govi from Corsica. We conclude on the basis of this evidence that both taxa are conspecific: we propose *Phalacropterix restonicae* **syn. nov.**

Samenvatting. Faunistische und taxonomische Bemerkungen über *Phalacropterix apiformis* (Rossi, 1790) und *P. restonicae* Fiumi & Govi, 2015 aus Korsika, Frankreich. Nachweise der Psychidae-Art *Phalacropterix apiformis* (Rossi, 1790), von der Insel Korsika, Frankreich, werden auf einer Karte dokumentiert. Ferner werden Informationen über die Biologie und Phänologie gegeben, sowie eine Beschreibung der morphologischen Merkmale dieser Art. Diese verbinden wir mit den Ergebnissen des DNA Barcodings. *P. apiformis* wird mit *P. restonicae* verglichen, die 2015 von Fiumi & Govi von Korsika beschrieben wurde. Auf der Grundlage dieser Ergebnisse kommen wir zu dem Schluss, dass beide Taxa artgleich sind: *Phalacropterix restonicae* **syn. nov.**

Introduction

Phalacropterix apiformis was first described by Rossi (1790) from "Etrusca", Italy. It was placed in the genus "*Bombyx*" and considered as the genotype of *Phalacropterix* (Hübner, 1825) by subsequent designation in Kirby (1892). According to present knowledge, the genus *Phalacropterix* is composed of eight species, which are distributed exclusively throughout the Palaearctic Region (Arnscheid and Weidlich 2017). Apart from *P. graslinella*, which is widespread over large areas of temperate Europe as far as Siberia, the other *Phalacropterix* species show restricted distribution patterns. They occur in southern and south-eastern Europe and through the Anatolian Peninsula to the Middle East. Most species are found in the Mediterranean area (five species in total).

Material and methods

The images of the male genitalia (using the procedure described in Arnscheid and Weidlich 2017) were taken with an Olympus OMD EM10 Mark II digital camera, alongside an Olympus stereo microscope equipped with a photo adapter, and stacked with Combine ZP using Soft Stack, then sharpened and

focused with Neat Image V8 and post-processed with PhotoScape V.37. The DNA barcode sequences published in BOLD (Barcode of Life Data System) are based on a fragment of the mitochondrial COI gene (cytochrome c oxidase 1). DNA extraction, amplification, and sequencing of the barcode region of the mitochondrial cytochrome oxidase I (COI) gene (658 base pairs at the 5' terminus) were carried out following the protocols of deWaard et al. (2008). Levels of interspecific variation of the DNA barcode fragments were evaluated under the Kimura 2 parameter model of nucleotide substitution (Kimura, 1980). Taxonomic and collection data, voucher images, COI sequences and/or GenBank accession numbers are available for all specimens in the BOLD database (http://www.boldsystems.org). The Neighbour-Joining tree as recommended in the barcoding protocol (Ratnasingham and Hebert 2007, 2013) was generated using MEGA 7 (Kumar et al. 2016). The Barcode Identification Number (BIN) BOLD:ABV5577 in the BOLD database comprises the following sequences numbers for *P. apiformis*: GWORB3908-14, TIPSY509-12, GWORB4255-15, TIPSY257-12, GBLAD336-14 and TIPSY233-12. The sequence numbers LEFIA1290-10 and TIPSY047-08 representing the outgroup species *P. graslinella* are accessible by querying BIN BOLD:AAI4339.

Abbreviations

CMW Private collection of Michael Weidlich
CWA Private collection of Wilfried R. Arnscheid
e. o. ex ovum
e. p. ex pupa
e. l. ex larva

The distribution of *P. apiformis* in Corsica

P. apiformis is distributed in the western Mediterranean area. In Italy *P. apiformis* occurs not only on the mainland, but also on the islands of Sardinia and Sicily (Parenzan and Porcelli 2006; Weidlich 2015) as well as on the Island of Capraia in the Tuscan archipelago (Dapporto et al. 2003; Parenzan and Porcelli 2006). In addition the species has also been recorded in Malta, the French mainland and on Corsica. The first author visited Corsica in 1999 sampling Psychidae for one week. In 2010, the second author spent ten days on Corsica, also searching for psychids. Besides *Bankesia montanella* Walsingham, 1899, which is endemic to the island, larval cases of *P. apiformis* were also collected, and several caterpillars were reared to adults. The species was found to be widespread along the coast, up to the high montane region. In addition to their results from fieldwork, the authors searched the literature for hints to the occurrence of *P. apiformis* on Corsica. We excluded general mentions such as "Corse", or "Corsica", in monographs or checklists. Fig. 1 shows the localities numbered from north to south with records colour-coded according to the time of sampling.

Biology and phenology

P. apiformis is found on Corsica from sea level up to 1800 m (Fig. 3). Records from even higher elevations, e.g. at Col de Vergio, Monte Renoso and Monte Incudine we consider to be imprecise. The caterpillars are polyphagous on different herbs and grasses. When pupating they commence spinning exposed on rocks, but also in cracks and clefts on boulders (Fig. 3c). Their period of flight is mainly at the beginning of May but occurred from 24.iv.1999 under laboratory conditions.

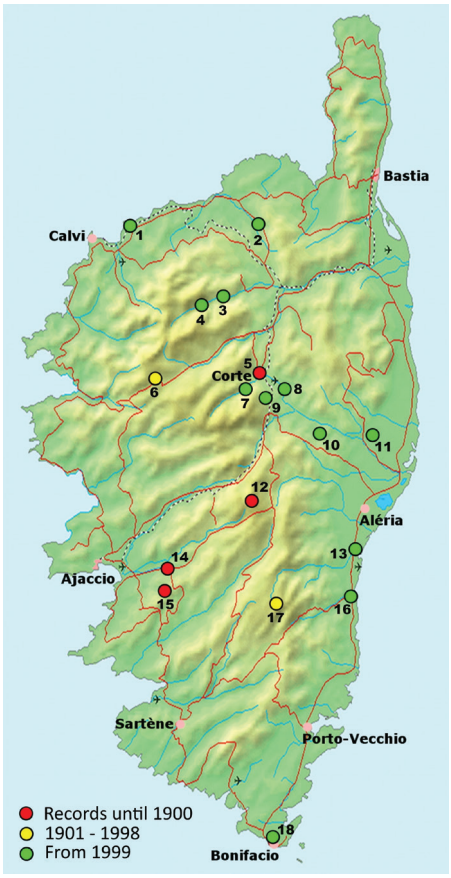

Figure 1. Distributional localities of *Phalacropterix apiformis* on Corsica (France) (https://upload.wikimedia.org/wikipedia/commons/3/3e/Corsica_Map.png, modified). **1**. 1 case, near Calvi NE, Marine di St. Ambrogio, 20 m, 13.iv.1999, leg. Weidlich. **2**. 6 cases, near Bastia SW, Urtaca 4 km NW, 150 m, 9.iv.1999, 1 ♂ e. l. 15.v.1999, leg. Weidlich. **3**. 12 cases, Parc naturel régional de la Corse, Gorges de l´Asco, 330 m, 9.iv.1999, 2 ♂♂ e. l. 5.v.1999, 1 ♂ e. l. 6.v.1999, 1 ♂ e. o. 23.v.2000, 4 ♂♂ e. o. v.2000, leg. Weidlich. **4**. 3 cases, Parc naturel régional de la Corse, near Asco 3 km SW, 950 m, 10.ix.2010, leg. Arnscheid. **5**. Parc naturel régional de la Corse, Corte: "den Case" (Mabille, 1867: 553). **6**. Parc naturel régional de la Corse, near Evisa NE, Col de Vergio: 1 ♀ Case, leg. Reisser (Reisser and Kautz, 1927: 20, Schawerda, 1927: 218). **7**. Parc naturel régional de la Corse, Gorges de la Restonica, cases, leg. Pfister (Pfister, 1982: 86); 7 cases 12.iv.1999, 550 m, 1 ♂ e .l. 7.v.1999, 1 ♂ e. l. 11.v.1999, 1 ♂ e. l. 15.v.1999, leg. Weidlich; 8 ♂♂ e. l. 25.iv.–5.vi.2014, 1400 m (Fiumi and Govi, 2015: 36). **8**. 7 cases, 11.iv.1999, 1 case, 13.iv.1999, Parc naturel régional de la Corse, near Corte, 6 km SE, 300 m, 1 ♂ e. p. 03.v.1999, 1 ♂ e. l. 11.v.1999, leg. Weidlich. **9**. 1 case, Parc naturel régional de la Corse, near Corte S, Casanova 1 km N, 600 m, 10.iv.1999, leg. Weidlich**. 10**. 1 case, Pedicorte di Gaggio, 710 m, 11.iv.1999, leg. Weidlich. **11**. 1 case, near Linguizzetta 2 km S, 250 m, 13.ix.2010, leg. Arnscheid. **12**.Parc naturel régional de la Corse, near Ghisoni SW, Monte Renoso (Mabille, 1868: 638). **13**. 8 cases, near Solenzara, Vix S, 50 m, 10.iv.1999, 1 ♂ e. p. 24.iv.1999, 1 ♂ e. l. 8.v.1999, 1 ♂ e. l. 14.v.1999, 2 ♂♂ e. l. 28.v.1999, leg. Weidlich. **14**. near Ajaccio E, Cavro (= Cauro): cases and e. l. specimen (Mann, 1855: 539). **15**. near Ajaccio E, Pozzo di Borgo: cases and e. l. specimen (Mann, 1855: 539). **16**. 12 cases, River Solenzara, 5 m, 11.iv.1999, 4 ♂♂ e. l. 10.v.1999, 1 ♂ e. l. 15.v.1999, leg. Weidlich. **17**. Parc naturel régional de la Corse, Monte Incudine: 1 case, leg. Schawerda (Schawerda, 1928: 48). **18**. Bonifacio: Kollmorgen (1899: 327); 1 case, 10.iv.1999, leg. Weidlich.

Table 1. The morphological differences between *P. apiformis* and *P. restonicae,* as mentioned by Fiumi and Govi (2015).

Character	*P. restonicae*	*P. apiformis*
wingspan	15–16 mm	15–19 mm
color of abdomen	brownish	brownish and black
forewing veins m2 & m3	one-point-rising	divided
shape of tegumen	more hollow	?
shape of vinculum	triangle-shaped	oval-shaped
saccus	sharp and bent	?
shape of anellus	rounder distally	less round distally
phallus	bent, of genital length	?
sclerite	smaller in size and shape	somewhat broader
cases	smaller	somewhat larger

Morphological diagnosis of *P. restonicae*

As already explained, the existence of *P. apiformis* on Corsica has already been known for a long time (e.g. Mann 1855). Kollmorgen (1899) reported the occurrence of this species as "very common, from the coast (Bonifacio) up to 1800 m." Therefore, it was very surprising that in 2015 Fiumi and Govi described a new *Phalacropterix* species from Corsica, based on the total of eight specimens, which they had collected in 2014 in the area of "Gorges de la Restonica" which is near Corte and an area well researched by lepidopterists for decades. *P. restonicae* was named after this, its type locality. According to Fiumi and Govi (2015), the two taxa differ in the characteristics displayed and compared in Table 1.

Based on a larger number of specimens of both taxa, the authors cannot confirm a significant difference in the wingspan. The males show a wingspan of 15–18 mm, which is in the normal range of wingspan variation of the entire *P. apiformis* population. Nevertheless, the forewing length is more informative than the wingspan because wingspan depends largely on how the specimen has been spread. When compared, these measured values show that there is no significant statistical difference. Even the abdominal colouration of both taxa varies considerably, the observed colouration ranging from a medium brown-yellowish to completely being black (Fig. 2, a–c). The venation was also variable between the two taxa, and was sometimes commonly asymmetric, due to the fact that most taxa of the subfamily Oiketicinae show this characteristic, especially species of the genera *Ptilocephala* and *Oiketicoides* (Arnscheid, unpublished). We found the forewing venation of the *Phalacropterix* population on Corse shows M2 and M3 from one point rising, shortly stalked, or completely divided.

Description of the male genitalia of *P. apiformis* compared with *P. restonicae*

The tegumen of *P.apiformis* is slightly indented medially and show a small pointed process directed downwardly. Valvae short, of one-third of genitalia length, stout, cucullus roundish, distally with short spines. Clasper of sacculus elongate, narrower in the distal half, covered with short spines apically. Anellus short, semicircular and covered with short spines. Vinculum nearly triangular, occasionally slightly vaulted laterally. Saccus of half genitalia length, broad, spatulate caudally. Phallus as long as genitalia, dark sclerotized medially, somewhat enlarged caudally, covered irregularly with fields of short cornuti. Looking closer to the genitalia of *P. restonicae* it appears slightly more compact in general view. The distal end of the tegumen is slightly more elongated in some specimen.

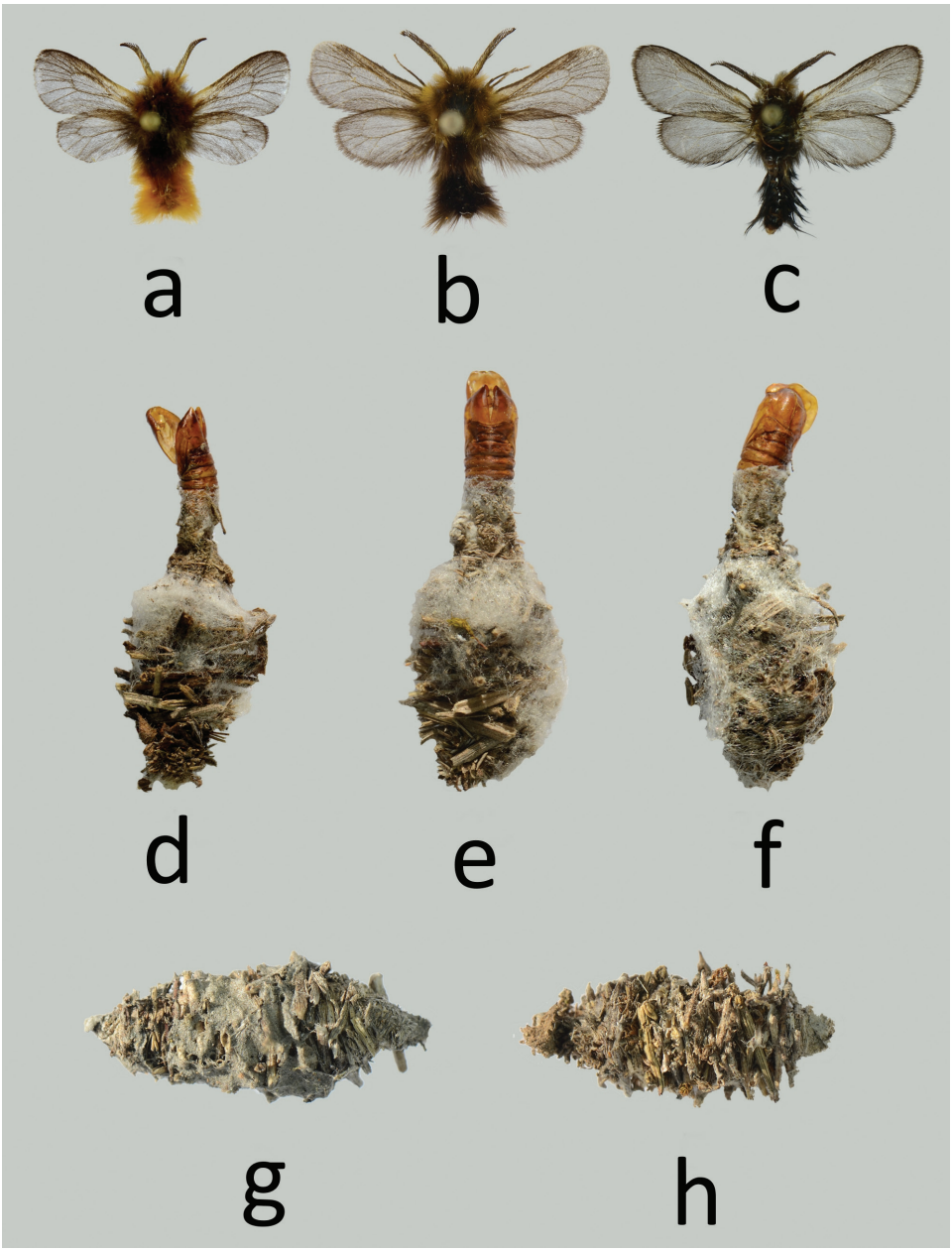

Figure 2. Male adults and larval cases of *P. apiformis* from Corsica. **2a**. ♂ e. l. 14.v.1999, near Solenzara, near Vix S, 50 m, leg. Weidlich (wingspan 14 mm). 2**b**. ♂ e. l. 10.v.1999, Solenzara - river, 5 m, leg. Weidlich (wingspan 16.5 mm). **2c**. ♂ e. l. 9.v.1999, near Solenzara, near Vix S, 50 m, leg. Weidlich (wingspan 16 mm). **2d**. ♂ case, e. l. 14.v.1999, near Solenzara, near Vix S, 50 m, leg. Weidlich (length with exuvia: 21 mm). **2e**. ♂ case, e. l. 10.v.1999, Solenzara - river, 5 m, leg. Weidlich (length with exuvia: 23 mm). **2f**. ♂ case e. l. 9.v.1999, near Solenzara, near Vix S, 50 m, leg. Weidlich (length with exuvia: 22.5 mm). **2g**. ♀ case, 13.iv.1999, near Calvi NE, Marine di St. Ambrogio, 20 m, leg. Weidlich (length 19 mm). **2h**. ♀ case, 9.iv.1999, Parc naturel régional de la Corse, Gorges de l´ Asco, 330 m, leg. Weidlich (length 17 mm) (all CMW). Photo: M. Weidlich.

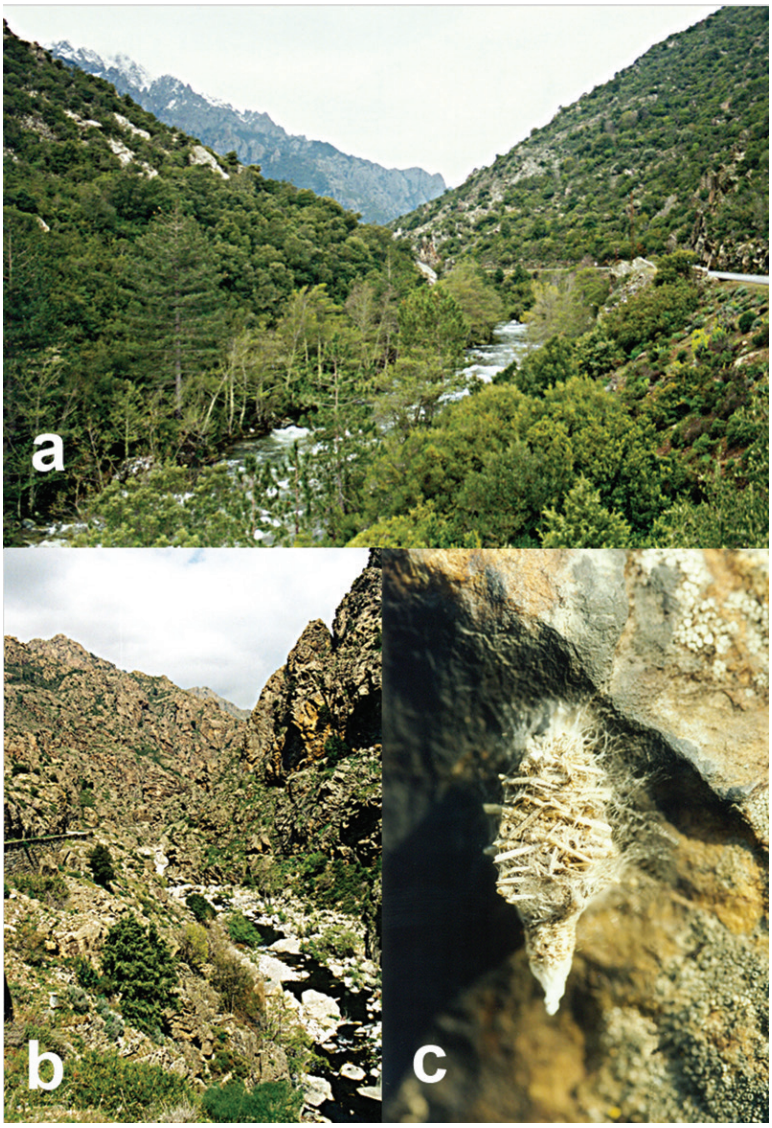

Figure 3. Habitat of *Phalacropterix apiformis* on Corsica. **a**. Landscape in "Parc naturel régional de la Corse", Gorges de l´ Asco, 330 m (10.iv.1999). **b**. Habitat of *Phalacropterix apiformis*, "Parc naturel régional de la Corse", Gorges de la Restonica, 550 m (12.iv.1999). **c**. ♂ Case of *Phalacropterix apiformis* in "Parc naturel régional de la Corse", near Corte 6 km SE, 300 m (11.iv.1999).Photos: M. Weidlich.

The valva length in both taxa is variable, sometimes reaching the distal end of the tegumen or protruding slightly above it. Distally, the anellus of *P. restonicae* appears slightly rounded and somewhat more pointed in *P. apiformis* (Figs 4, 5). Whether this is statistically significant, however, is unclear.

There is no doubt that the variability of the male genitalia in Psychidae is great. This has in the past even led to the (however wrong) assumption that in contrast to most Heterocera the structure of the genitalia plays no part or a very minor role in taxonomic evaluation. As a result, the authors

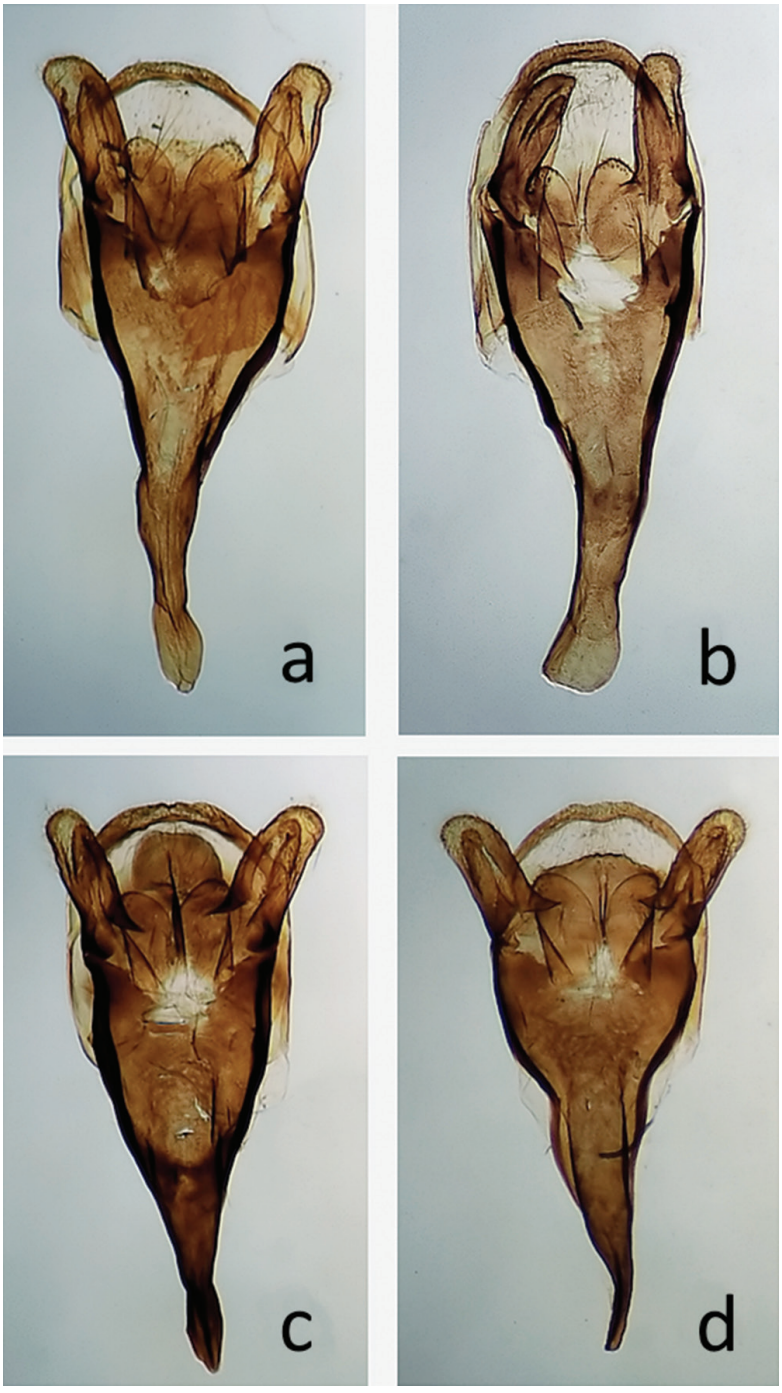

Figure 4. Variability of male genitalia of *P. apiformis* from Corsica and Italy. **4a.** Italy, Liguria, Ville S. Pietro (IM), e. p. 4.v.2006, genital slide 4102. **4b.** Ditto, e. p. 14.v.2002, leg. Arnscheid, genital slide 4103 (CWA). **4c.** Corsica, near Solenzara, Vix S, e. l.1999, leg. Weidlich, genital slide 4100 (CWA). **4d.** Corsica, near Corte, 6 km SE, genital slide 4101 (CWA). Photo: W.R. Arnscheid.

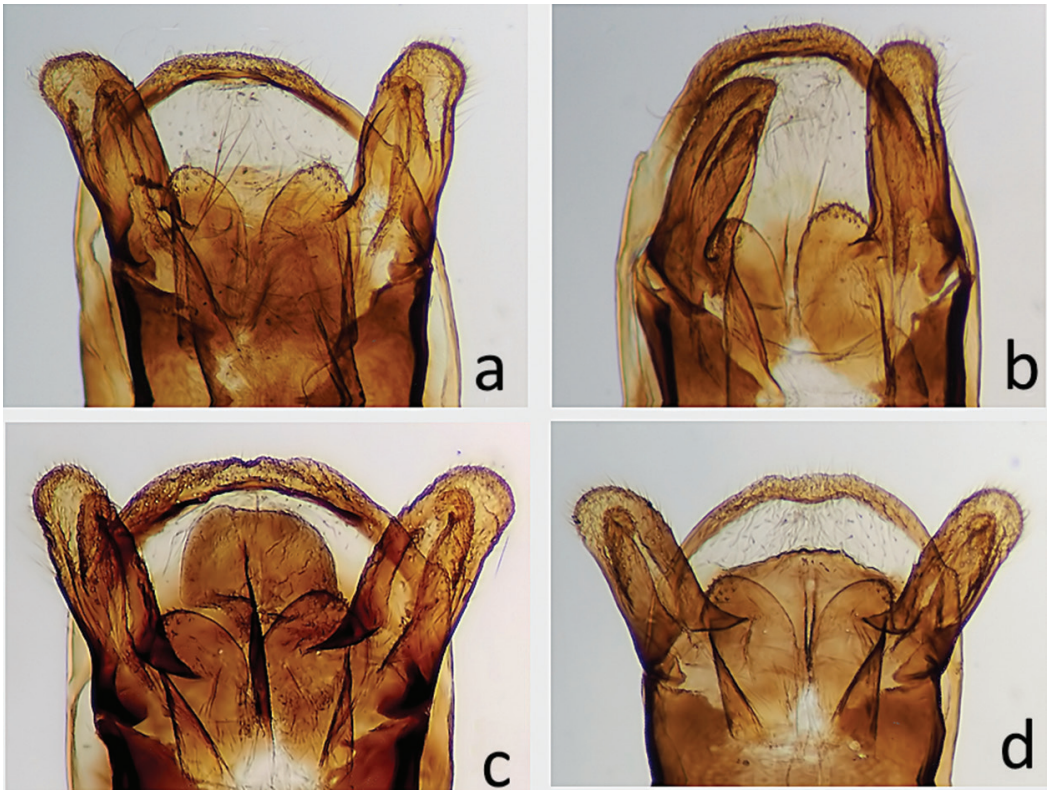

Figure 5. Variability of male genitalia of *P. apiformis* from Corsica and Italy (in detail). **5a.** Italy, Liguria, Ville S. Pietro (IM), e. p. 4.v.2006, genital slide 4102. **5b**. Ditto, e. p. 14.v.2002, leg. Arnscheid, genital slide 4103 (CWA). **5c.** Corse, near Solenzara, Vix S, e. l.1999, leg. Weidlich, genital slide 4100 (CWA). **5d.** Corsica**,** Corte, genital slide 4101 (CWA). Photo: W.R. Arnscheid.

have concluded that *P. restonicae* is in no way morphologically significantly different from *P. apiformis,* as stated previously by Fiumi and Govi (2015). The morphological diagnostic characteristics of species have exhibit little correlation with their genetic characteristics. Altogether, we have to accept that taxonomy based on morphological diagnostic characters is limited in its value for the study of evolution in this group. Therefore, whenever possible, we have also used for our studies molecular data.

Genetic divergences

In the BOLD database a total of six publicly accessible samples forming two BINs were considered, which are identified as *P. apiformis* and *P. restonicae*. The infraspecific pairwise genetic divergence of the samples reaches a maximum of 1.3%. In the absence of other data, this value seems too small for the establishment of a distinct species. Even within the outgroup-species *Phalacropterix graslinella* (Boisduval, 1852) with its widely dispersed populations, intraspecific divergence equals only about 1 %. In contrast, the inter-specific divergence between *P. apiformis/P. restonicae* and *P. graslinella* equals 11 % (Fig. 6, Tab. 2).

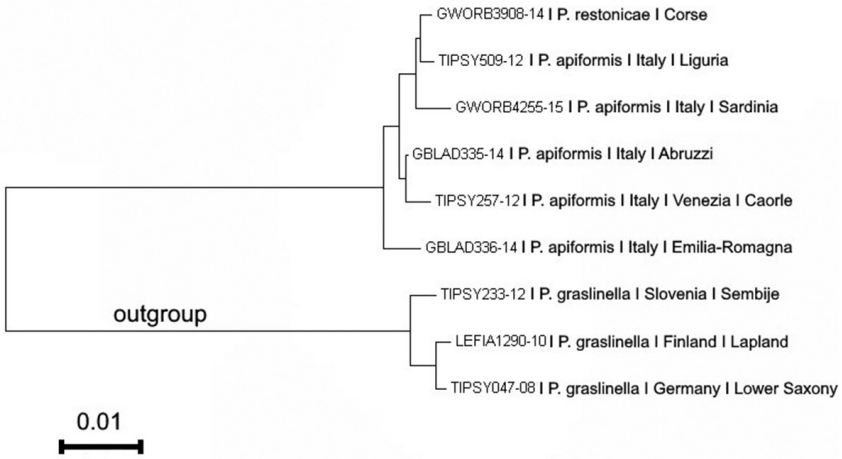

Figure 6. Neighbor-joining tree of DNA barcodes of *P. apiformis*.

Table 2. Matrix of pairwise genetic divergences of several *Phalacropterix* species.

Taxon	Origin	Pairwise divergence (p)							
P. restonicae	France, Corse								
P. apiformis	Italy, Liguria	0.003							
	Italy, Sardinia	0.007	0.007						
	Italy, Abruzzi	0.005	0.005	0.008					
	Italy, Friuli	0.008	0.008	0.011	0.003				
	Italy, Emilia-Romagna	0.011	0.011	0.015	0.007	0.010			
P. graslinella	Slovenia, Sembije	0.121	0.123	0.121	0.121	0.121	0.121		
	Finland, Lapland	0.123	0.125	0.123	0.123	0.123	0.123	0.008	
	Germany, Lower Saxony	0.123	0.125	0.123	0.123	0.123	0.119	0.008	0.003

Conclusion

Traditionally, taxonomists have used morphological diagnostic characters to determine species, but meanwhile, it is now obvious that speciation and establishment of morphological diagnostic characteristics are not often correlated directly especially in allopatry. This is the case here. Because speciation is not always accompanied by morphological change, the true number of biological species is likely to be greater than the current tally of nominal species, most of which are delineated on purely morphological grounds.

Unexpected genetic diversity within species throughout the tree of life prompts several questions about possible regional and taxonomic biases in our estimates of diversity (Bickford et al. 2007). It is typical for island faunas in particular to develop local forms. The extent to which species have evolved apart is assumed to primarily be a matter of time especially in the case of allopatry. In any case, the period of isolation on the island of Corsica for the species *P. apiformis* has likely not been sufficient to allow full speciation on Corsica. Both morphological and genetic characteristics within the framework of the usual variability in these psychids do not provide evidence of such complete speciation. Hence, comparing the similarities both in morphological and molecular characteristics, we do not consider the taxon *P. restonicae* as a separate species but one conspecific with *Phalacropterix apiformis*: *Phalacropterix restonicae* syn. nov.

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