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CONTRIBUTION TO THE KNOWLEDGE OF THE GENUS *TYPHONIA* (LEPIDOPTERA: PSYCHIDAE) IN SLOVENIA AND CROATIA

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Abstract – New distributional data on *Typhonia melana* (Frivaldszky, 1837) and *T. ciliaris* (Ochsenheimer, 1810) in Slovenia and Croatia are presented. *Typhonia ciliaris* is confirmed here as a new addition to the Croatian fauna. A review of published records for both countries and an examination of historical museum material are provided. Information on distribution, bionomy and larval rearing is summarised, with particular emphasis on the lesser-known *T. melana*. Key external morphological characters distinguishing the two species, together with DNA-based molecular results, are presented. Differences in their geographical and altitudinal distribution are discussed.
KEY WORDS: Lepidoptera, Psychidae, Slovenia, Croatia, *Typhonia*, distribution, bionomics.

Izvleček – PRISPEVEK K POZNAVANJU RODU *TYPHONIA* (LEPIDOPTERA: PSYCHIDAE) V SLOVENIJI IN NA HRVAŠKEM
Predstavljava nove podatke o pojavljanju vrst *Typhonia melana* (Frivaldszky, 1837) in *T. ciliaris* (Ochsenheimer, 1810) v Sloveniji in na Hrvaškem. Vrsta *T. ciliaris* je prvič potrjena za favno Hrvaške. Podani so pregled literature za obe državi ter rezultati pregleda zgodovinskih muzejskih zbirk. Podatki o razširjenosti, bionomiji in gojenju gosenic dopolnjujejo obstoječe poznavanje, z dodatnim poudarkom na slabše poznani *T. melana*. Predstavljene so ključne morfološke razlike med vrstama in rezultati molekularnih analiz DNK, ki potrjujejo njihovo medvrstno ločenost. Razpravljamo o razlikah v geografski in višinski razširjenosti obeh vrst.
KLJUČNE BESEDE: Metulji, Vrečkarji, Slovenija, Hrvaška, *Typhonia*, razširjenost, bionomija.

Introduction

Within the family Psychidae, the genus *Typhonia* Boisduval, 1834 (syn. *Melasina* Boisduval, 1840) is remarkable as one of the few psychid genera that include winged females. Originally placed among the small moths (*Tineidae*), it was later transferred to the Psychidae (Sauter & Hättenschwiler 1991, Sobczyk 2011).

More than 150 species of *Typhonia* are currently recognised worldwide, of which four are known from Europe: *T. ciliaris* (Ochsenheimer, 1810), *T. melana* (Frivaldszky, 1837), *T. lailae* Bertaccini & Zilli, 2017, and *T. christenseni* (Hättenschwiler, 1990) (Arnscheid 2024). According to our research, only *T. ciliaris* and *T. melana* have so far been recorded in Slovenia and Croatia.

Until recently, the genus *Typhonia* remained poorly studied in both countries, particularly in Croatia. *Typhonia melana* was first reported from Croatia by Arnscheid & Weidlich (2017), while Kranjčev (2019) listed several uncertain identifications at the species level. The present study documents *T. ciliaris* as a new addition to the Croatian fauna.

Our observations agree with previously published data on the altitudinal distribution of both species (Arnscheid 2024). *Typhonia ciliaris* typically inhabits alpine environments, whereas *T. melana* is associated with lowland habitats, although it may occasionally occur at higher elevations in Slovenia and Croatia. In Slovenia, *T. melana* has been reliably confirmed from a single upland locality at 1308 m, and in Croatia it has been recorded on Mt Biokovo above Makarska at 840 m.

Distinct interspecific differences between the two taxa were confirmed through the examination of adult external morphology, supplemented by molecular analyses of Slovenian specimens. These complementary approaches provide a robust basis for distinguishing the species in the region.

Materials and Methods

The most effective approach for studying the bionomics of both *Typhonia* species proved to be the collection of larvae followed by rearing them to the adult stage. Larvae of lowland populations of *T. melana* were observed throughout the year, whereas larvae of alpine populations of *T. ciliaris* and *T. melana* were observed between May and October, depending on altitude and snow cover. Fieldwork was conducted between 2009 and 2024.

In the rearing containers, approximate replicas of the natural habitats were created using substrate collected from the respective localities. Several host plants were introduced, including *Taraxacum officinale* Web., *Plantago lanceolata* L., *P. major* L., and grasses of the genus *Festuca*, all of which were readily accepted by the larvae as food sources. The substrate was lightly moistened once daily, or twice daily during the summer months (morning and evening). Moderate watering was applied weekly, and during winter at 12-day intervals.

Rearing was carried out outdoors under natural temperature conditions, with larvae occasionally exposed to direct sunlight for short periods. Limited indoor rearing

during the winter months resulted in increased mortality due to fungal infections. During the emergence period of adults, containers were inspected at least two to three times daily, particularly between 09:00 and 14:30.

During the adult flight period, extending from late June to September, adults of both sexes were observed performing short, rapid flights above larval habitats.

Museum collections of the Slovenian Museum of Natural History (PMSL, Ljubljana), the Natural History Museum Vienna (NHMW, Austria), the Croatian Natural History Museum (HPM, Zagreb), and the Varaždin City Museum (GMV, Croatia) were examined. Only limited material of *Typhonia* was found in these collections.

Specimens were identified through comparative analysis of adult external morphology and molecular data obtained from adults and, in one case, from a larva. At localities where adults could not be successfully reared, species identification (particularly for lowland populations of *T. melana*) was supported by altitudinal data and by recently acquired knowledge of the geographic and vertical distribution of both species.

The nomenclature follows Psychidae of the Palaearctic Region, Part I (Arnscheid 2024), while the delineation of Slovenian zoogeographical regions follows Rdeči seznam ogroženih metuljev (Macrolepidoptera) Slovenije (Carnelutti 1992). Geographical names are adopted from the Atlas Slovenije (Kos 1992).

A total of twelve *Typhonia* specimens were obtained for genetic analysis. Tissue samples (one or two dried legs per specimen) were prepared following standard protocols (Ivanova et al. 2006) and transferred to lysis plates. DNA barcoding analyses targeting a ~648 bp fragment of the mitochondrial cytochrome c oxidase subunit I (COI) gene were carried out at the Canadian Centre for DNA Barcoding (CCDB), Biodiversity Institute of Ontario, University of Guelph, using standard high-throughput protocols. One publicly available COI barcode sequence of *T. melana* and two of *T. lailae* were retrieved from the BOLD Systems database under the corresponding BOLD process ID numbers. A complete list of all COI sequences used in this study is provided in Table 1. Intraspecific and interspecific genetic distances were calculated using the Kimura 2-parameter (K2P) model as implemented in the Barcode of Life Data System (BOLD v4, www.barcodinglife.org) (Ratnasingham & Hebert 2007).

Table 1: List of all COI sequences used in this study.

Species	BOLD sequence ID	Locality	Datasource
Typhonia melana	GRAFW2424-13	Bulgaria, Rila, Iliina	BOLD
	TIPSY288-12	Slovenia, Zidani Most, Gračnica	Our data
	TIPSY699-15	Germany, Basel, Weil a. Rhein	Our data
	TIPSY720-15	Slovenia, Grintovec pri Osilnici	Our data
	TIPSY886-19	Slovenia, Orešje na Bizeljskem, Rupe	Our data
Typhonia lailae	GWORB3911-14	Italy, Liguria, Drego	BOLD
	GWOTL1097-13	Italy, Liguria, dint. Pigna	BOLD
Typhonia ciliaris	TIPSY695-15	Switzerland, Valais, Lac de Moiry	Our data
	TIPSY698-15	Italy, Adamello, Val Salarno	Our data
	TIPSY719-15	Slovenia, Karavanke, Mala Peca	Our data
	TIPSY287-12	Slovenia, Julijske Alpe, Mangart	Our data
	TIPSY887-19	Slovenia, Golte, Požganije	Our data

Abbreviations

General abbreviations:

♂	Male
♀	Female
BIN	Barcode Index Number
BOLD	The Barcode of Life Data System web platform
Cf.	Confer (compare)
COI	A region of the mitochondrial cytochrome C oxidase I (COI) gene
coll.	Collection
DNA	Deoxyribonucleic Acid
ex.l.	Ex larva (collected as larva and reared to the adult)
ID	Identification Number
leg.	Legit (collected)
NHMW	Natural History Museum Vienna
nr.	Number
PMSL	Prirodoslovni muzej Slovenije (Slovenian Museum of Natural History), Ljubljana, Slovenia

Name abbreviations:

AK	Andrej Kapla
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NR	Nejc Rebuza
PT	Peter Tonkli
RK	Radovan Kranjčev
ŽP	Željko Predovnik

Results

Our survey of 63 localities revealed a wide distribution of both *T. ciliaris* and *T. melana* within the study area. We confirmed the presence of *T. ciliaris* at 28 localities and *T. melana* at 23. In addition, *T. ciliaris* was very likely present at a further 11 localities, and *T. melana* at one additional locality. All findings are presented in Figure 1. In total, 134 adults, 199 larval cases and 45 exuviae of *T. ciliaris* were examined, alongside 120 adults, 264 larval cases, 72 exuviae, and two larvae (preserved in ethanol) of *T. melana*.

Typhonia ciliaris (Ochsenheimer, 1810)

Citations. Slovenia: Höfner 1895: 78 (*Typhonia lugubris*); Rebel 1905: 60 (*Melasina lugubris*); Höfner 1911: 88 (*Melasina lugubris*); Galvagni 1910: 162 (*Melasina lugubris*); Thurner 1938: 113 (*Melasina lugubris*); Carnelutti 1958: 511 (*Melasina lugubris*); Carnelutti 1971: 173 (*Melasina lugubris*); Carnelutti 1992: 79 (*Melasina lugubris*); Lesar & Habeler 2005: 23 (*Melasina ciliaris*); Lesar & Govedič 2010: 49 (*Typhonia ciliaris*); Sobczyk 2011:327 (*Typhonia ciliaris*); Arnscheid & Weidlich 2017: 263 (*Typhonia ciliaris*); Bertaccini & Zilli 2017: 140 (*Typhonia ciliaris*); Predovnik 2021: 117 (*Typhonia ciliaris*).

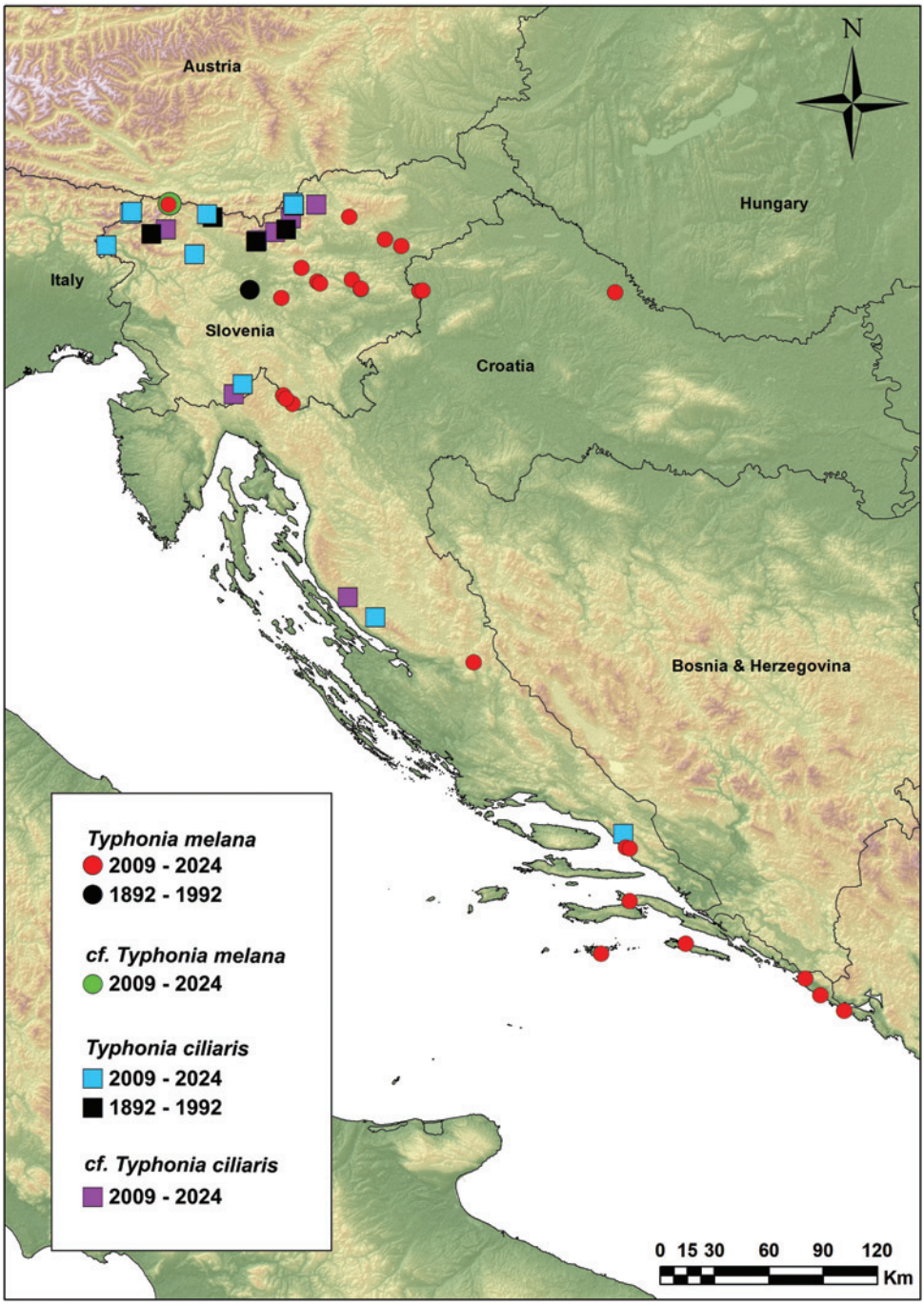


Figure 1. Distribution map of the genus *Typhonia* in Slovenia and Croatia.

Distribution. *Typhonia ciliaris* inhabits alpine and subalpine regions extending from the Pyrenees and western Alps across the Balkans to the western Carpathians, Poland, Slovakia, and Ukraine, where it has been recorded at elevations up to 2500 m (Arnscheid & Weidlich 2017; Arnscheid 2024). The species is regarded as a true glacial relict and occurs much more locally than previously assumed. Due to its frequent confusion with *T. melana*, the precise distribution of *T. ciliaris* remains incompletely resolved.

Carnelutti (1992) and Lesar & Govedič (2010) reported *T. ciliaris* (under the name *Melasina lugubris*) from the Alpine, pre-Alpine, Dinaric (Karst), and Sub-Pannonian zoogeographical regions of Slovenia. During the present investigation, the species was found to be locally common at higher elevations within the Alpine, pre-Alpine, and Dinaric regions. Based on adults reared from larvae, and occasionally on adults observed in the field, *T. ciliaris* was reliably confirmed from the Julijske Alpe (Mangart, Stol, Breginjski Stol, Ratitovec), Kamniško-Savinjske Alpe (Planina Osredek near Kamnik, Raduha, Golte, Smrekovec), Karavanke (Podpeca), and Dinarsko Gorovje (Mali Snežnik), at elevations ranging from 831 to 2012 m.

Larvae collected at Studorski preval below Triglav, Planina Krn, Krvavec, Planina Razor (above Krvavec), Dleskovška planota, Planina Vodol, Tolsti vrh (Raduha), Veliki Razbor, Mala Peca, and Mt Uršlja gora could not be confirmed through rearing due to parasitism, disease, or the presence of only old larval cases. Nevertheless, these records most likely also refer to *T. ciliaris*.

In Croatia, adults were successfully reared from larvae collected on the central Velebit (Visočica, 1500–1550 m) and Mt Biokovo (road to Sv. Jure, 1465 m; Fig. 2a). Considering its occurrence along the Dinarsko gorovje on the Slovenian side (Mali Snežnik), *T. ciliaris* is also expected to inhabit several mountain peaks in northern Croatia (Gorski kotar). Old larval cases collected below Ljubičke grede at Baške Oštarije (Velebit; leg. Predovnik & Kranjčev) could not be reliably identified due to the overlapping altitudinal ranges of *T. ciliaris* and *T. melana*.

Bionomics. *Typhonia ciliaris* is typically associated with sunny alpine habitats, including pastures, screes, roadside embankments, rocky serpentine slopes, and clearings among dwarf shrubs (*Vaccinium* spp.) and heather (Fig. 2b). The species is most commonly recorded on south-facing slopes at elevations ranging from 831 to 2012 m. The optimal period for finding larvae extends from May to late October. Larval cases vary in colour from pale sandy and grey to dark brown or black, occasionally exhibiting intermediate patterns. Considerable variation may occur even among larvae from the same locality. On strongly sun-exposed localities, several larvae were sometimes observed in close proximity. They feed primarily on mosses and low-growing herbaceous plants.

During winter and early spring, larvae enter diapause, concealed within vegetation or attached to the undersides of small stones, which makes them difficult to locate. In natural habitats, in addition to young larvae (mostly in September and October), mature larvae (Fig. 3b) and cases containing prepupae were also observed, confirming that under harsh alpine conditions the species may exhibit both biennial and triennial developmental cycles, as previously reported by Hättenschwiler (1997) and Arnscheid (2024).

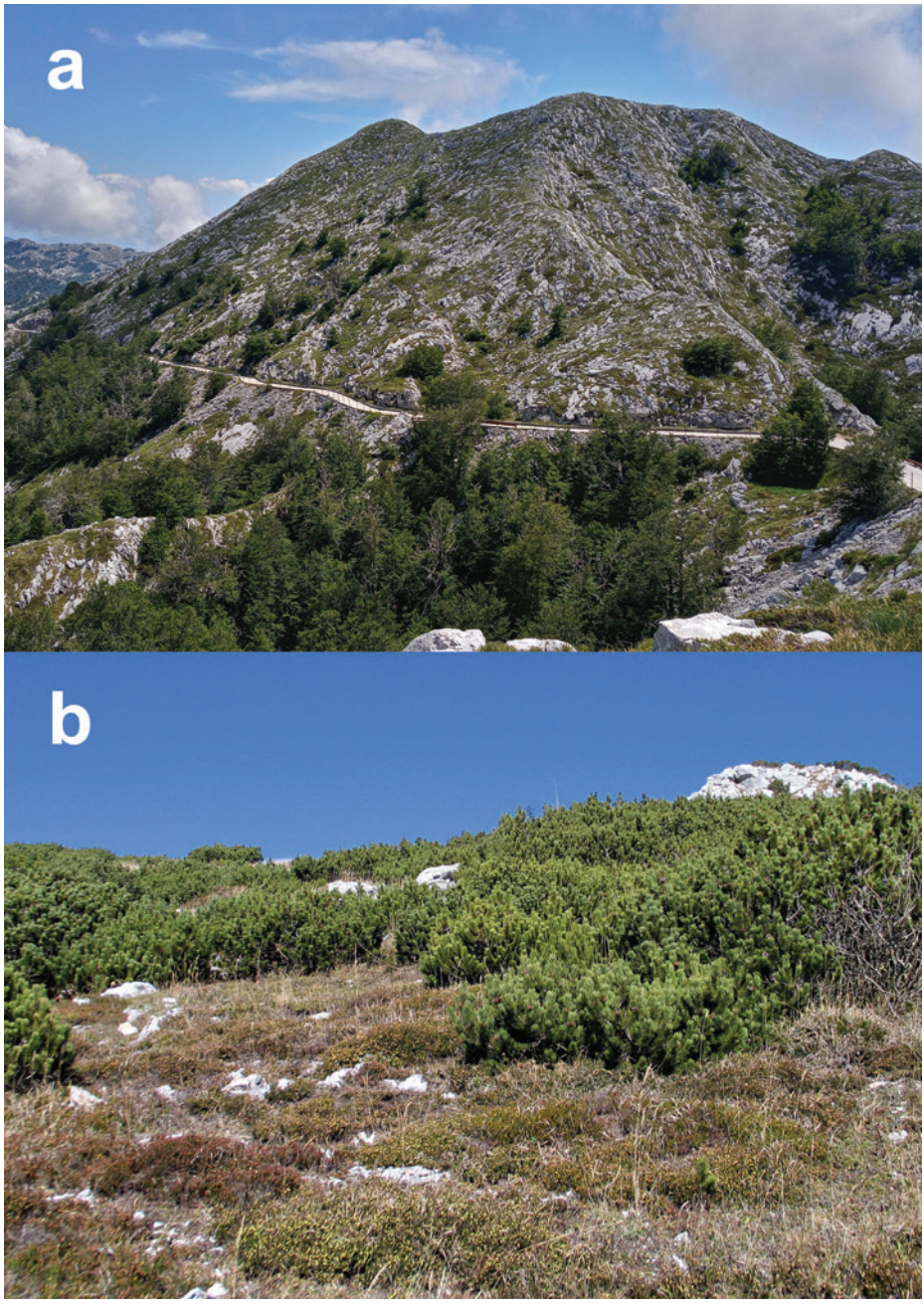


Figure 2. Natural habitat of *T. ciliaris*: **a.** Croatia, Biokovo, road to Sveti Jure, 14.VI.2020, photo: J. Rekelj; **b.** Slovenia, Mali Snežnik, 27.X.2019, photo: Ž. Predovnik.

With a wingspan of up to 33 mm, *T. ciliaris* is among the largest bagworm moths recorded in Slovenia. Adults (Fig. 3a) do not feed and survive for only a few hours to, at most, one day. They are active exclusively in sunny weather, although males are occasionally attracted to artificial light sources. Galvagni (1910) reported numerous males flying around a single female ("*Melasina lugubris*") near the Golica mountain hut. Females lay approximately 300 eggs.

Rearing. Outdoor rearing of larvae under natural conditions was relatively straightforward and yielded good results. Larvae were active on sunny and warm days throughout the year, but entered diapause in late autumn, in contrast to *T. melana*, whose larvae occasionally remained active during winter thaws.

Mature larvae entered the prepupal stage in the second year, between June and August, although a smaller proportion remained active until the following spring. Larval cases were attached to vegetation, or soil, or located beneath stones. Only one female emerged within the same year (year 2), whereas the majority overwintered in the prepupal stage and emerged individually from July to September of the following (third) year. Only a single specimen underwent an additional diapause, emerging only in the subsequent summer (year 4).

Material examined. SLOVENIA: JULIJSKE ALPE • 1♂ Mangartweg [Mangart]; 1909; leg. E. Galvagni; labelled as *Melasina lugubris*; coll. NHMW • 1♂ Raibl, Mangartweg; 24.7.[18]92; leg. Preiss. [Preissecker]; coll. NHMW • 1 larval case;

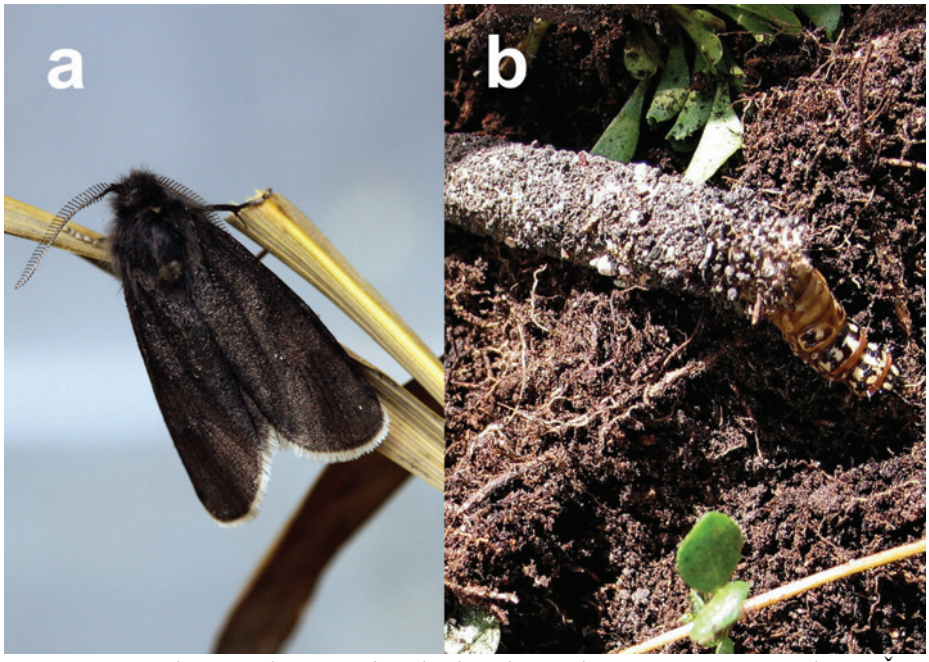


Figure 3. *Typhonia ciliaris*: **a.** hatched male, Podpeca, 9.VII.2019, photo: Ž. Predovnik; **b.** final-instar larva, Ratitovec, 14.9.2020, photo: Ž. Predovnik.

Dolina Triglavskih jezer 15.VII.1949; leg. Michieli; coll. PMSL • 1♀; road to Mangart, 1900 m; 20.VII.2003; leg. et coll. JR • 4♂♂, 5♀♀; road to Mangart, 1800 m; 3.VII.2009, ex.l. 20.–28.VI.2010; leg. ŽP, AK; during the same sampling event several old larval cases and several final-instar larvae were recorded, correction of det. 1♀ (ex.l. 27.VI.2010) confirmed T. Sobczyk; 1♀ (23.6.2010) DNA barcode sample ID: TIPSY287-12 [CLV3386]; coll. ŽP • several old larval cases were recorded; ibidem; 25.IX.2009; leg. ŽP • 3♂♂, 3♀♀; ibidem; 10.VII.2021, ex.l. (4♂♂, 4♀♀) 18.–28.VI.2022; leg. ŽP; during the same sampling event several old cases, several early-instar larvae and 11 final-instar larvae were recorded; coll. ŽP • 1 old larval case; road to Mangart, 1573 m; 27.VII.2013; leg. ŽP, DP, coll. ŽP • 1♀; Mangart, Ilovec peak, 1419 m; 27.VII.2013; leg. ŽP; coll. in free flight in sunshine, 14:12 h; coll. ŽP • 1♀; Mangart, koča na Mangartskem sedlu (below summit), 1995 m; 10.VII.2021; leg. NR; coll. in free flight in sunshine; coll. ŽP • 1 larval case; Vršič, 1400 m; 17.IV.2011; leg. et coll. JR • 1♀ with larval case; Breginjski Stol, 1095 m; 9.V.2020, ex.l. 1.VIII.2020; leg. ŽP, AK, NR; collected as final-instar larva; coll. ŽP.

SLOVENIA: ŠKOFJELOŠKO-POLHOGRAJSKO HRIBOVJE • 1♀ with larval case, 3 old larval cases; Ratitovec, 1381 m; 14.IX.2020, ex.l. 3.VII.2021; leg. ŽP, NR; coll. ŽP.

SLOVENIA: KAMNIŠKO-SAVINJSKE ALPE • 3 larval cases; Krvavec; IV.1952; leg. Michieli; coll. PMSL • 1 ♀; Raduha-Loka; 20.VIII.1992; leg. Tonkli; coll. PMSL • 1♀ with larval case (31 mm), 1 empty larval case with exuvia; Klemenčevo, Planina Osredek, 831 m; 31.XII.2019, ex.l. 12.VII.2020; leg. ŽP; during the same sampling event one larva in prepupal stage and 2 early-instar larvae with length of cases 11 and 9 mm were recorded; coll. ŽP • 1 larval case of early-instar larva, 1 old larval case; Golte, Požganje, 1295 m; 14.XI.2010; leg. ŽP; during the same sampling event one old larval case and 2 early-instar larvae were recorded; coll. ŽP • 1 old larval case, 1 early-instar larva; ibidem; 25.IV.2011; leg. et coll. ŽP • 1 larval case; ibidem; 15.IV.2012; leg. ŽP; larva parasitized, rearing unsuccessful; coll. ŽP • 3♂♂, 2♀, 7 larval cases with exuviae; ibidem; 9.V.2013, ex.l. 1♂, 1♀ 10.VI.2014, 2♂♂ 18.VI.2014, 1♀ 20.VI.2014, 1♂ 22.VI.2014; leg. ŽP; during the same sampling event 6 final-instar larvae were recorded; coll. ŽP • 3 old larval cases; ibidem; 1.X.2013; leg. et coll. ŽP • 5 old larval cases (length 22–30 mm); ibidem; 9.X.2014; leg. ŽP, JR • 1♂ with larval case; ibidem; 20.X.2015, ex.l. 8.VII.2017; leg. ŽP; during the same sampling event several old larval cases and one larva were recorded; 1♂ (20.X.2015) DNA barcode sample ID: TIPSY887-19 [STG796]; coll. ŽP • several old larval cases, 2 early-instar larvae were recorded; ibidem; 31.X.2015; leg. ŽP • 1♂, 1♀ with larval cases and exuviae, 3 old larval cases; Raduha, Planina Arta (pasture), 1582 m; 1.XI.2013, e.l. 1♀ 3.V.2014, 1♂ 5.V.2014; leg. ŽP; during the same sampling event 3 old larval cases and 5 larvae (cases length: 11, 13, 22, 28 and 35 mm) were recorded; coll. ŽP • 1♀ with larval case and exuvia, 1 old larval case; Raduha, Snežna jama, 1454 m; 29.V.2014, e.l. 17.VIII.2014; leg. et coll. ŽP • 1 larval case; Mrzla Gora, 1650 m; 10.VII.2021; leg. et coll. JR.

SLOVENIA: KARAVANKE • 1 larval case, Begunjščica; 1.V.1952; leg. Michieli; coll. PMSL • 2♂♂; Stol, Finžgarjeva skala, 1800 m; 4.VII.1999; leg. JR; in free flight; coll. JR • 6 old larval cases; ibidem; 21.VI.2014; leg. ŽP, JR; during the same sampling event numerous old larval cases and larvae of all developmental stages were recorded; coll. ŽP • several old larval cases, several early-instar and final-instar larvae were recorded; ibidem; 4.VI.2017; leg. ŽP, JR • several old larval cases, numerous early-instar larvae were recorded; ibidem; 20.IX.2020; leg. ŽP • 3 larval cases; Stol, 1900 m; 22.IV.2007; leg. et coll. JR • 1♂, 4♀♀ with larval cases and exuviae; Podpeca, Jakobe, 1356 m; 9.VII.2018, ex.l. 1♂, 4♀♀ 8.–10.VII.2019; leg. ŽP; during the same sampling event several old cases, 1 early-instar larva and 17 final-instar larvae were recorded; coll. ŽP • 5♂♂, 11♀♀ with larval cases and exuviae; ibidem; 15.VII.2018, ex.l. 5♂♂, 11♀♀ 6.–19.VII.2019; leg. ŽP; during the same sampling event several old cases, 1 early-instar larva and 25 final-instar larvae were recorded; coll. ŽP • 1 larval case; Trupejevo Poldne; 5.VII.2021; leg. et coll. JR • 1♀ with larval case and exuvia; 11 old larval cases; Podpeca, Jakobe, 1407 m; 3.V.2013, ex.l. 24.VI.2013; leg. ŽP; during the same sampling event 21 old cases and 6 larvae with the length of 12–23 mm were recorded; 1♀ (3.V.2013) DNA barcode sample ID: TIPSY719-15 [STG 245]; coll. ŽP • 1 old larval case was recorded; ibidem; 19.X.2014; leg. ŽP • 1 old larval case, 2 larvae were recorded; ibidem; 24.V.2015; leg. ŽP • 3 old larval cases; ibidem; 4.XI.2015; leg. ŽP; during the same sampling event 9 old larval cases with length of 27–30 mm and several early-instar larvae were recorded; coll. ŽP • 1 early-instar larva was recorded; ibidem; 18.VI.2016; leg. ŽP, JR • 2 old larval cases; Podpeca (above Planinski dom na Peci) 1684 m; 19.X.2014; leg. ŽP, JR; during the same sampling event several old larval cases were recorded; coll. ŽP • 1♀ with larval case and exuvia; Podpeca (below Tomaževa koča), 1161 m; 15.VII.2018, ex.l. 1♀ 17.VII.2019; leg. et coll. ŽP • 1♀ with larval case and exuvia; Peca, Na Pesku, 1400 m; 20.X.2019, ex.l. 4.VII.2020; leg. et coll. JR • 1♀, with larval case and exuvia, 2 old larval cases; Smrekovec (peak), 1567 m; 16.IX.2020, ex.l. 1♀ 25.VI.2022; leg. ŽP; during the same sampling event several old larval cases and 2 larvae with the length of larval cases 18 mm and 22 mm were recorded; coll. ŽP.

SLOVENIA: DINARIDI • 1 old larval case; Mali Snežnik, 1683 m; 27.X.2019; leg. ŽP; during the same sampling event several old larval cases and 6 early-instar larvae were recorded; coll. ŽP • 2♂♂, 2♀♀ with larval cases and exuviae; ibidem; 23.V.2020, e.l. 1♀ 6.VII.2021, 1♂ 7.VII.2021, 1♂, 1♀ 11.VII.2021; leg. ŽP; during the same sampling event several old cases and 6 larvae were recorded; coll. ŽP • 1♀ with larval case and exuvia; ibidem; 20.VI.2021, ex.l. 1.7.2022; leg. ŽP; during the same sampling event several old larval cases and 2 final-instar larvae were recorded; coll. ŽP.

CROATIA • 1♂ with larval case; Velebit, Visočica, 1500–1550 m; 13.VI.2020, ex.l. 8.VII. 2021; leg. ŽP; during the same sampling event several old cases and 5 larvae were recorded; coll. ŽP • 1 larval case with exuvia, 2 old larval cases; ibidem; 20.III.2022; leg. ŽP; during the same sampling event 28 old cases and 1 early-instar larva were recorded; coll. ŽP •1♂, 1♀ with larval cases; Dalmacija, Biokovo, road to

Sv. Jure, 1465 m; 28.VI.2022, ex.l. 1♀ 25.VI. 2022, 1♂ 2.V.2021; leg. ŽP; during the same sampling event 2 old cases and 4 larvae were recorded; coll. ŽP.

Cf. *Typhonia ciliaris*. SLOVENIA: JULIJSKE ALPE • 2 larval cases; Kobarid, Krn, Prag, 1601 m; 20.VII.2014; leg. ŽP; collected as larvae, rearing unsuccessful; coll. ŽP • 4 old larval cases; Studorski preval, 1797 m; 5.VII.2015; leg. ŽP; during the same sampling event several old larval cases, their remains and 1 early-instar larva were recorded; coll. ŽP.

SLOVENIA: KAMNIŠKO-SAVINJSKE ALPE • 1 larval case; Dleskovška planota, planina Vodole, 1790 m; 11.VII.2016; leg. ŽP; collected as a final-instar larva, adult failed to emerge; coll. ŽP • 1 old larval case; Raduha, planina Vodol, 1281 m; 14.V.2013; leg. et coll. ŽP • 1 old larval case; Raduha,Tolsti vrh, 1227 m; 14.V.2013; leg. et coll. ŽP • several old larval cases, 3 early-instar larvae (length of larval cases 5–12 mm) were recorded; Krvavec, Razor, 1838 m; 22.IX.2019; leg. ŽP • 1 old larval case; Krvavec, 1352 m; 22.IX.2019; leg. ŽP; during the same sampling event 2 old larval cases were recorded; coll. ŽP.

SLOVENIA: KARAVANKE • 1 larval case; Uršlja Gora, 1680 m; leg. ŽP; larva parasitized, rearing unsuccessful; coll. ŽP • 5 old larval cases (length 22–30); Mala Peca, 1684 m; 19.X.2014; leg. et coll. ŽP, JR.

SLOVENIA: DINARIDI • 1 old larval case, 1 larval case of early-instar larva (length 9 mm); Ilirska Bistrica, Zabiče, Veliki Razbor, 1266 m; 12.III.2022; leg. et coll. ŽP.

CROATIA • 1 old larval case; Velebit, Baške Oštarije, below Ljubičke grede, 960 m; 15.VII.2015; leg. ŽP, RK, coll. ŽP.

Typhonia melana (Frivaldszky, 1837)

Citations. Slovenia: Carnelutti, 1978: 114 (*Melasina melana*); Predovnik 2021: 117–120 (*Typhonia melana*); Croatia: Arnscheid & Weidlich 2017: 263 (*Typhonia melana*); Kranjčev, 2019: 124 (*Typhonia melana*).

Distribution. The type locality of *Typhonia melana* is in Sliven, Stara Planina, Bulgaria. It is the most widely distributed European representative of the genus. In southern Europe, the species occurs from sea level up to 2500 m (Arnscheid & Weidlich 2017; Arnscheid 2024), and has been recorded from the Iberian Peninsula, the Rhodopes, Italy, Austria, the Balkans, Romania, Hungary, Slovakia (Arnscheid & Weidlich 2017; Bertaccini & Zilli 2017), and Turkey (Kemal et al. 2019). Additional records are known from North Macedonia (Petkovski 2008; Sobczyk 2011).

In Slovenia, *T. melana* was only recently reported (Predovnik 2021). The species is locally distributed in most regions, between 237 and 1308 m, with the highest density of records in the pre-Alpine area. Targeted field surveys in the Primorska region (Karst margin), in the lowland areas of northeastern Slovenia (Goričko, Pomurje, Prekmurje, Haloze, Slovenske Gorice), and in the Gorjanci Mountains yielded no positive results. On Ratitovec, where Carnelutti (1978) reported "*Melasina melana*", only *T. ciliaris* was found.

Evaluation of older literature (Carnelutti 1971, 1992) in light of new data indicates that *T. melana* was previously encountered in Slovenia but not recognised as distinct from *T. ciliaris* (Predovnik 2021). Carnelutti (1971) mentioned larval cases from Zasavje (Zagorje, Kum, Šklendrovec), Notranje Gorice, and Preserje; given the altitudes of these sites, these records most likely refer to *T. melana*.

Adults reared from larvae confirmed the presence of the species at Boč, Lisca, the surroundings of Zidani Most, Orešje near Bizeljsko, Prežganje near Ljubljana (Fig. 4a), the Kolpa valley, Zasavje (Konjšica, Kolovrat), and Vretov Vrh above Belca in the western Karavanke range. Larval cases and remains were additionally confirmed from Žiče near Slovenske Konjice, Srednji Dolič near Mislinja, Kolovrat (Zasavje), and the Kolpa river valley.

Findings in Austria (Salzburg 1600 m: Kurz & Embacher 2014; Kurz 2014; Arnscheid 2024), in the Julijske Alpe (Cave del Predil: Weidlich 2015), in the Karavanke (Vretov Vrh), and in the Croatian Dinaric Mountains (Biokovo and Velebit) suggest a wider distribution of *T. melana* in high mountains across Slovenia and Croatia.

In Croatia, *T. melana* is widespread, occurring between 4 and 840 m (Predovnik, Rekelj & Kranjčev unpublished; Kranjčev 2019). The species was confirmed by adults reared from larvae collected near Klanjec (Hrvatsko Zagorje) and in the Đurđevački Pijesci reserve (Đurđevac, Fig. 4b). In the Mediterranean region, larval cases were recorded at Šimići above Makarska, on the Pelješac peninsula (Gornji Nakovanj), and on Konavoske Stijene near Radovčići. Near Vitaljina (sea coast, road to Prevlaka), the presence of the species was confirmed by an emerged adult. A particularly illustrative example of the pronounced altitudinal separation of the two species was observed on Mt Biokovo above Makarska, where larvae of *T. melana* were found along the Biokovo road (Topnički put, Vrata Biokova) at 840 m, while *T. ciliaris* occurred at 1465 m on the same date. According to Kranjčev (2019, personal corresp.), larval cases of *T. melana* were recorded at Velji Do in the Konavle Hills, in the Zrmanja River canyon, and on the islands of Lastovo and Mljet (Kozarica), where an adult emerged from a larval case.

Bionomics. Like *T. ciliaris*, *T. melana* is a thermophilous species. It prefers south and southwest-facing habitats, most frequently occurring on sun-exposed southern slopes. Larvae are sometimes locally common and inhabit the margins of abandoned quarries, rocky outcrops, or small clearings on partially vegetated slopes.

The robust larval cases are composed of small stones, fine sand particles, and soil. Compared with those of the genus *Rebelia*, the cases of *T. melana* are larger in the later larval instars, more elongate, and coarser in structure. Their colour varies depending on the locally available material, typically exhibiting light sandy tones. Darker brown to almost black cases predominate in the Kolpa valley, around Mislinja, and near Slovenske Konjice.

Larval cases of early-instar larvae are slightly laterally flattened and strongly taper towards the posterior end, forming a distinctly conical shape. Mature larval cases are cylindrical and gently curved in lateral view; those of females are generally larger, reaching up to 41 mm in length.

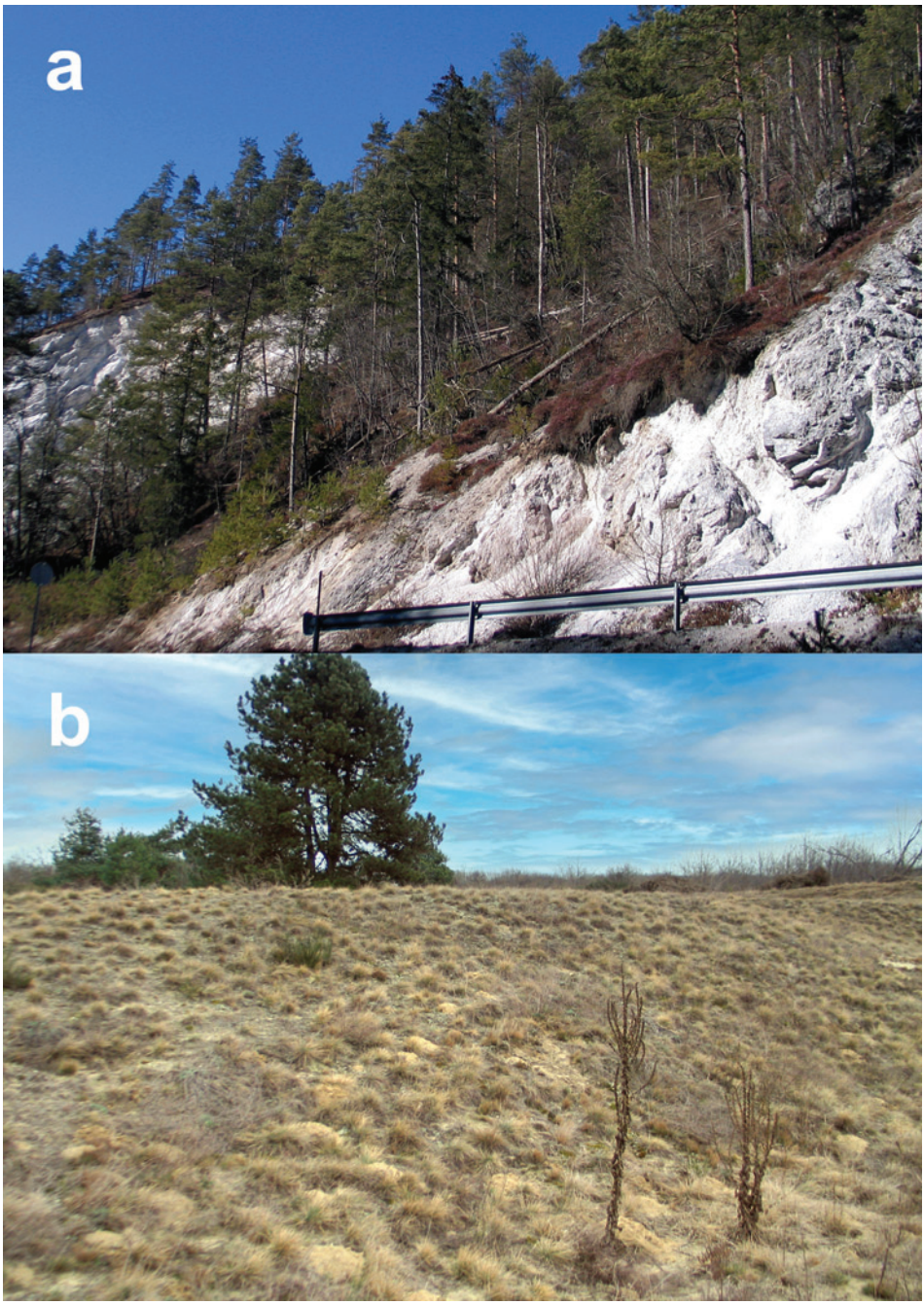


Figure 4. Natural habitat of *T. melana*: **a.** Slovenia, Prežganje, 23.II.2019, photo: Ž. Predovnik; **b.** Croatia, Đurđevački Pijesci, 9.III.2019, photo: Ž. Predovnik.

In autumn, larval cases of all size classes were recorded, including empty cases of already emerged adults, which were often brittle and lying loosely on the soil surface or attached to stones. In strongly sun-exposed sites, mature larval cases were frequently embedded almost entirely within the substrate, with only 5–15 mm protruding above the surface. This confirms Hättenschwiler's (2000) observation that larval cases are positioned deeper in exposed habitats than in shaded ones.

Active larval cases could be assigned to three size classes: (1) nearly mature larvae, (2) intermediate-sized larvae (11–23 mm), and (3) small early-instar larvae (4–14 mm). This size variation was initially interpreted as evidence of multi-year development; however, subsequent observations showed that small larvae grew rapidly in spring and pupated during the same summer as the nearly mature larvae from the previous year, indicating a biennial life cycle in lowland populations. Considering the adult flight period from late June to September, the smallest larvae collected between November and January likely hatched from eggs laid by late-season females.

Larvae feed on various herbaceous plants (Hättenschwiler 2000) and, unlike *T. ciliaris*, remain active until late autumn. At Bizeljsko, larvae were observed feeding even in December and early January during snow-free winters (Fig. 5b).

Females lay 200–250 eggs within approximately two hours, depositing them among stones, beneath bark, or in grass tussocks. At 23–28 °C, larvae hatch after 20–



Figure 5. *Typhonia melana*: **a.** hatched male, Gračnica, 24.VI.2014, photo: Ž. Predovnik; **b.** young larvae in time of feeding, Orešje na Bizeljskem, 21.XII.2014, photo: Ž. Predovnik.

22 days (Hättenschwiler 2000). Development is biennial in lowland and montane regions, but becomes triennial at higher alpine elevations.

In one instance, freshly emerged females attracted males when exposed using methods typically applied in pheromone-based attraction tests for larger bagworm species, i.e. placing the female in an elevated, unobstructed position to allow optimal dispersal of pheromones (Loebel 1941; Štanta 2008; Bertaccini 2017).

Rearing. Rearing of *T. melana* larvae in captivity followed procedures similar to those used for *T. ciliaris*. Larvae readily accepted a range of host plants, including *Plantago lanceolata* L., *Trifolium* spp., *Rumex* spp., leaves and flowers of *Taraxacum officinale* Web., and flowers of *Bellis perennis* L.

During diapause, larvae avoided moisture and selected dry microhabitats, such as within grass tussocks, and occasionally attached their cases to the walls or edges of the rearing containers. Pupation typically occurred within dry grass tussocks, although several larvae were occasionally found embedded vertically in the soil at the same location.

Under outdoor rearing conditions, the first larvae pupated in mid-May, most between late May and mid-June, and sporadically until mid-July. In lowland populations, adults (Fig. 5a) emerged during the same summer, between 6 July and 18 August, with a pronounced peak from 15 to 26 July. In contrast, high-altitude populations (e.g. Vretov Vrh) overwintered in the prepupal stage and emerged the following year, similar to *T. ciliaris*. Adult emergence occurred on sunny days from 08:30 until early afternoon, most frequently between 11:00 and 14:00.

Material examined. SLOVENIA: ZASAVJE • 2♂♂ with larval cases and exuviae, 2 old larval cases; Zidani most, Gračnica 237 m; 15.I.2011, ex.l. 1♂ 12.VI.2011, 1♂ 14.VI.2011; leg. ŽP; 1♂ (12.VI.2011) DNA barcode sample ID: TIPSY288-12 [CLV3387]; during the same sampling event 4 larvae with the length of larval cases 20–22 mm were recorded; coll. ŽP • 2♂♂, 2♀♀ with larval cases and exuviae, 2 old larval cases with remains of exuviae; ibidem; 1.XII.2013, ex.l. 1♀ 14.VI.2014, 1♀ 19.VI.2014, 1♂ 22.VI.2014, 1♂ 24.VI.2014; leg. ŽP; during the same sampling event 1 old larval case (40 mm), 2 old larval cases with remains of exuviae (32 and 37 mm) and 5 larvae with the length of larval cases 18–32 mm were recorded; coll. ŽP • 2♂♂, 4♀♀ with larval cases and exuviae, 7 old larval cases; ibidem; 10.XII.2014, ex.l. 3♂♂, 4♀♀ 15.–24.VII.2015; leg. ŽP; during the same sampling event 4 old larval cases (30–34 mm) and 10 larvae with the length of cases 10–21 mm were recorded; coll. ŽP • 1♂ with larval case and exuviae, 1 additional larval case, 2 old larval cases; ibidem; 25.X.2015, ex.l. 3.VIII.2016; during the same sampling event 4 old larval cases (26–33 mm) and 4 early-instar larvae with the length of cases 22 mm and 24 mm were recorded; coll. ŽP • 1 larva; Lisca, Cerje, 698 m; 19.IX.2014; leg. ŽP • 3♂♂, 1♀ with larval cases and exuviae, 7 old larval cases; ibidem; 27.IX.2014, ex.l. 1♂ 5.VII.2015, 1♀ 12.VII.2015, 1♂ 14.VII.2015; leg. ŽP; during the same sampling event 8 old larval cases and 4 larvae with the length of cases 10–19 mm were recorded; coll. ŽP • 1♀ with larval case and exuvia, 3 old larval cases; ibidem; 5.X.2014, ex.l. 15.VII. 2015; leg. ŽP; during the same sampling event 2 old larval cases (26 and 28 mm), remains of 2 old larval cases and 1 larva with the length of

case 21 mm were recorded; coll. ŽP • remains of 3 old larval cases, 4 early-instar larvae; Lisca, Cerje, 751 m; forest steppe above the quarry; leg. ŽP • 1 old larval case (29 mm); Orešje na Bizeljskem, Rupe, 400–380 m; 12.X.2014; leg. et coll. ŽP • 15 old larval cases (25–34 mm), 82 early-instar larvae (length of cases 4–13 mm), 28 larvae with length of cases 16–30 mm; ibidem; 13.XII.2014; leg. ŽP • 8♂♂, 10♀ with larval cases and exuviae, 26 old larval cases, 14 cases of early-instar larvae; ibidem; 21.XII.2014, ex.l. 1♂ 6.VII.2015, 1♂ 12.VII.2015, 10♂♂, 12♀♀ 13.–25.VII.2015; leg. ŽP; 1♂ (11.VII.2015) DNA barcode sample ID: TIPSY886-19 [STG 795]; during the same sampling event 6 old cases (23–27 mm), 33 early-instar larvae (5–13 mm) and 41 larvae (larval cases 16–25 mm) were recorded; coll. ŽP • several old larval cases (28–35 mm), several early-instar larvae (4 larvae of them parasitized, larval cases 8–14 mm), 42 larvae (larval cases 15–26 mm); ibidem; 7.XI.2015; leg. ŽP • 21 old larval cases (24–35 mm), 32 early-instar larvae (larval cases 6–9 mm) and 12 larvae (larval cases 17–25 mm); ibidem; 13.XII.2015; leg. ŽP • 8♂♂, 16♀♀ with larval cases and exuviae, 2 old larval cases; ibidem; 31.XII.2015, ex.l. 1♂ 11.VII.2016, 2♀♀ 13.VII.2016, 1♀ 17.VII.2016, 2♀♀ 18.VII.2016, 1♂ 20.VII.2016, 1♀ 21.VII.2016, 2♀♀ and 1♂ 23.VII.2016, 1♂ 27.VII.2016, 3♀♀ 28.VII.2016, 1♀ 30.VII.2016, 2♀♀ 31.VII.2016, 2♂♂ 1.VIII.2016, 1♂ 3.VIII.2016, 1♂ 4.VIII.2016, 1♂ 8.VIII.2016; leg. ŽP; during the same sampling event several early-instar larvae and 6 larvae with larval cases (20–28 mm) were recorded; coll. ŽP • 1♂; ibidem; 31.VII.2016; ♂ in flight at 14:18 h over an exposed, newly emerged ♀; leg. ŽP • 14♂♂, 15♀♀ with larval cases and exuviae, 5 old larval cases; ibidem; 1.I.2022, ex.l. 14♂♂ and 15♀♀ 27.VI.–7.VIII.2022; leg. ŽP; during the same sampling event 14 old larval cases (23–28 mm), 56 early-instar larvae (larval cases to 6 mm), 22 larvae (larval cases 16–23 mm) were recorded; coll. ŽP • 29♂♂, 49♀♀ with larval cases and exuviae; ibidem; 2.I.2023, ex.l. 19.VII. –21.VIII.2023; leg. ŽP, JR; during the same sampling event more than 100 larvae of different ages were recorded; coll. JR • 2 larval cases of early-instar larvae, 2 old larval cases; Konjšica, Kumat, 633–750 m; 29.XII.2018; leg. et coll. ŽP • 1♂, 2 old larval cases; ibidem; 1.I.2019, ex.l. 1♂ 14.VII.2019; leg. ŽP; during the same sampling event 4 old larval cases and 1 larva (larval case 22 mm) were recorded; coll. ŽP • 1♂ with 2 larval cases, 6 old larval cases; Konjšica (Pograjc), 676 m; 9.II.2019, ex.l. 1♂ 28.VII.2019, 1♂ 29.VII.2019; leg. ŽP; during the same sampling event 15 old larval cases (28–37 mm) and 5 early-instar larvae (larval cases 4–11 mm) were recorded; coll. ŽP • 2 old larval cases (remains); Kolovrat, Strma Njiva, Na Škalah, 721 m; 3.III.2021; leg. et coll. ŽP.

SLOVENIA: LJUBLJANA VICINITY • 1 larval case; Ljubljana; 25.VII.1950; leg. Michieli; coll. PMSL • 1♂ with larval case and exuviae, 1 old larval case; Zgornja Besnica, Prežganje, (Berce), 491 m; 16.II.2019, ex.l. 1♂ 26.VII.2019; leg. ŽP; during the same sampling event several old larval cases and their remains, 13 early-instar larvae and 4 larvae were recorded; coll. ŽP • 1♀ with larval case and exuviae, 5 old larval cases; ibidem; 23.2.2019, ex.l. 1♀ 23.7.2019; during the same sampling event 7 old larval cases (32–35 mm), several early-instar larvae and 1 old larva (larval case 13 mm) were recorded; coll. ŽP.

SLOVENIA: KOLPA VALLEY • 2 old larval cases; Srobotnik ob Kolpi-Kuželj, Špičasti hrib, 321 m; 1.V.2010; leg. et coll. ŽP • 2 old larval cases, 1 larva; ibidem; 20.IV.2013; leg. et coll. ŽP • 1 old larval case; ibidem; 28.IV.2013; leg. et coll. ŽP • 4♂♂ with 4 larval cases and exuviae, 2 old larval cases; ibidem; 18.IV.2022, ex.l. 3♂♂ 12.VII.2022, 1♂ 18.VII.2022; leg. ŽP; during the same sampling event several old larval cases and 5 early-instar larvae (larval cases 21–30 mm) were recorded; coll. ŽP • 2 old larval cases; Osilnica, Ribjek, 380 m; 1.V.2010; leg. et coll. ŽP • 1 larval case (25 mm); Grintovec pri Osilnici, 334 m; 15.VI. 2010; coll. ŽP • 1 early-instar larva with larval case, 3 old larval cases; ibidem; 4.XII.2013; leg. ŽP; 1 larva (12.IV.2013) DNA barcode sample ID: TIPSY720-15 [STG 246]; coll. ŽP • 3 old larval cases; ibidem; 29.IX.2014; leg. et coll. ŽP • 2 old larval cases; ibidem; 24.X.2015; leg. et coll. ŽP • 1 old larval case, 2 larvae (larval cases 20 and 23 mm); ibidem; 1.I.2017; leg. et coll. ŽP • 1 old larval case (31 mm); ibidem; 29.I.2018; leg. et coll. ŽP.

SLOVENIA: ŠTAJERSKA • 1♂ with larval case, 5 old larval cases; Boč, Galke (rocky cliffs below Galke), 590 m; 25.XII.2018 ex.l. 5.VIII.2019; leg. ŽP; during the same sampling event several old larval cases with the length 23–31 mm and several larvae at different developmental stages, with cases lengths 7–23 mm were recorded; coll. ŽP • 1♂, 2♀♀ with larval cases; ibidem; 8.II.2019, ex.l. 1♀ 25.VII.2019, 1♀ 29.VII.2019, 1♂ 10.VIII.2019, 1♂ 16.VIII.2019, 1♀ 21.VIII.2019; leg. ŽP; during the same sampling event 3 old larval cases with the length 26–33 mm, 2 early-instar larvae with the length of cases 6 mm and 11 mm, 5 larvae with the length of cases 18–23 mm were recorded; coll. ŽP • 1 old larval case; Žiče pri Slovenskih Konjicah, Golo Rebro, 349 m; 20.IX.2014; leg et coll. ŽP • 2 old larval cases; Mislinja, Gornji Dolič, 540 m; 18.IX.2014; leg. et coll. ŽP • 1 old larval case (29 mm); ibidem; 3.X.2014; leg. et coll. ŽP

SLOVENIA: KARAVANKE • 1♂ with larval case and exuviae; Belca, Vretov vrh, 1308 m; 1.XI.2019, ex.l. 1♂ 31.VII.2020; leg. ŽP; during the same sampling event several old cases and 1 larva (larval case 21 mm) were recorded; coll. ŽP • 1♂, 2♀♀ with larval cases and exuviae, 1 old larval case; ibidem; 22.V.2020, ex.l. 1♀, 6.VII.2021, 1♂,15.VII.2021, 1♀,16.VII.2021, leg. ŽP; during the same sampling event several old larval cases, 3 old larvae (larval cases 34 mm, 41 mm and 44 mm) were recorded; coll. ŽP.

CROATIA • 2♀♀ with larval cases and exuviae, 5 old larval cases; Hrvatsko zagorje, Klanjec (Cesarsko brdo), 324 m; 2.XII.2018, ex.l. 1♀ 23.VII.2019, 1♀ 24.VII.2019; leg. ŽP; during the same sampling event several old cases, 13 early-instar larvae and 2 larvae (larval cases 20–26 mm) were recorded; coll. ŽP • 5 old larval cases; Podravina, Đurđevac, Đurđevački pijesci (rezervat), 118 m; 9.III.2019; leg. ŽP; during the same sampling event 7 old cases and 1 larva were recorded; coll. ŽP • 6♂♂, 5♀♀ with larval case and exuviae; ibidem; 25.V. and 25.VII.2019, ex.l. 1♀ 18.VII.2019, 1♂ 19.VII.2019, 1♀ 24.VII.2019, 1♂ 25.VII.2019, 2♂♂,1♀ 26.VII.2019, 1♂,1♀ 27.VII.2019, 1♀ 6.XII.2019; leg. ŽP, RK; during the same sampling event several old cases and 23 larvae were recorded; coll. ŽP • several old larval cases; Kanjon Zrmanje; leg. RK; personal corresp. • 2 old larval cases; Makarska,

Tučepi, Šimići, 270 m; leg. et coll, JR, ŽP • 1♂ with larval cases and exuvia, 5 old larval cases; Biokovo, Topnički put (Vrata Biokova, Biokovo road), 840 m; 1.V.2021, ex.l. 1♂ 7.VIII.2021; leg. ŽP; during the same sampling event 7 final-instar larvae were recorded; coll. ŽP • 1 old larval case; Polotok Pelješac, Gornji Nakovanj, 380 m; 25.III.2011; leg. ŽP, RK; coll. ŽP • 1 old larval case; Konavoske stijene near Radovčići, 310 m; 27.6.2021; leg. et coll. ŽP • 1♂ with larval case and exuvia, 2 old larval cases; near Vitaljina (sea coast, road to Prevlaka), 4 m; 27.VI.2021, ex.l. 1♂ 31.VIII.2021; during the same sampling event several old cases and 1 larva were recorded; coll. ŽP.

Cf. *Typhonia melana*: SLOVENIA • 1 old larval case; Karavanke, Belca, Jurčkov vrh (SE slope), 907–1050 m; 28.III.2010; leg. et coll. ŽP. • 1 old larval case; ibidem; 30.V.2010; leg. ŽP, JR; coll. ŽP.

Morphological differences. Reliable identification of adult *T. ciliaris* and *T. melana* is generally possible by examining their external morphological characters, particularly when supported by comparison with reference specimens. When only larval cases are available and detailed knowledge of the local fauna is lacking, identification is usually restricted to genus level.

In general, males of *T. ciliaris* exhibit a uniform, monochromatic appearance, whereas most males of *T. melana* display a variable pale reticulate pattern on the forewings. Females of *T. ciliaris* differ from those of *T. melana* mainly by their noticeably thinner, filiform antennae and typically more rounded wing shape. Substantial variation in adult body size may occur among populations, as already noted by Arnscheid (2024). Comparable variability is also evident in the size of larval cases. For example, the cases of full-grown *T. melana* from Podravski Pijesci (Croatia) are distinctly smaller than those of larvae from Jurčkov vrh (Slovenia). Additionally, adult males from Podravski Pijesci usually exhibit a more pronounced wing pattern compared with specimens from Jurčkov vrh. The male genitalia of the two species are very similar, and the observed differences fall within the range of normal intraspecific variation (Arnscheid & Weidlich 2017; Arnscheid 2024). Consequently, genital structures are not considered reliable characters for consistent species-level identification.

Several of these characters are summarised as interspecific diagnostic features in Table 2, and are further described and illustrated in Arnscheid & Weidlich (2017), Bertaccini & Zilli (2017), and Arnscheid (2024). Measurements were taken from specimens collected in the field as well as from specimens obtained by rearing, including their larval cases. It should also be noted that the wings of freshly mounted adult specimens gradually fade in museum collections, changing over time from dark black or dark brown to a distinctly lighter brown.

Comparative material examined originated from Slovenian populations. For *T. melana*, 79+ specimens (41 ♂♂, 38 ♀♀) from the following localities were included: Boč, Bizeljsko, Posavje, the vicinity of Ljubljana, and Vretov vrh. For *T. ciliaris*, 41+ specimens (13 ♂♂, 28 ♀♀) were examined from: Mangart, Golte, Raduha, Peca (Podpeca), Stol, Breginjski Stol, Planina Osredek above Kamnik, Mali Snežnik, and Smrekovec.

Table 2. Morphological features of *T. melana* and *T. ciliaris* based on Slovenian specimens.

Diagnostic characters	*T. melana*	*T. ciliaris*
Wingspan	♂♂: 20–25 mm ; ♀♀: 24–31 mm	♂♂:18–28 mm; ♀♀: 22–31 mm.
Wing shape	Elongate	Elongate, apex rounded
♂ **Colour of wings and fringe scales**	Black to black-brown with a pale, variably developed creamy-white pattern, absent in some specimens. Hindwings black, without pattern; fringe scales silvery-white	Uniformly black to black-grey, without pattern; a light grey band along costal margin; fringe scales white to whitish-yellow
♀ **Colour of wings and fringe scales**	Uniformly black to black-brown, without pattern; fringe scales dark	Uniformly black, rarely dark brown; fringe scales blackish
♂ **Antennae**	Covered with pale grey to whitish scales; length slightly exceeding half the forewing length; 28–42 segments	Length equal to half the forewing length; 40–43 segments
♀ **Antennae**	Slightly thickened towards the tip with characteristic protruding scales	Very slender, filiform
♂ **Thorax**	Thorax black, lightly covered with whitish to pale grey scales	Thorax black to brown.
♀ **Thorax & anal hair tuft**	Thorax uniformly blackish; anal hair tuft silvery to silver-grey with black hairs, rarely entirely silvery-grey	Thorax uniformly blackish; anal hair tuft grey-white to light brown
♂♀ **Larval case size**	♀♀ usually distinctly larger than ♂♂; in lowland populations 25–40 mm long, diameter 3.8–5.9 mm; Alpine populations 37–43 mm, diameter 5.5–6.8 mm	26–38 mm, diameter 5.1–7.4 mm; generally thicker than *T. melana*, except for the Alpine population
Altitude range	237–1308 m	831–2012 m

Molecular data. A total of six Slovenian specimens and six specimens from other European countries were included in this study. Together, they yielded four distinct BINs corresponding to three species: *T. melana*, *T. ciliaris*, and *T. lailae*.

For *T. melana*, the minimum K2P divergence from its nearest neighbour (*T. ciliaris*) was 2.3%, and 4.0% from *T. lailae*, values comparable to those reported for interspecific distances within the genus (cf. Bertaccini & Zilli 2017). These results support the expected level of differentiation among the three taxa.

Remarkably, *T. ciliaris* was subdivided into two well-supported barcode clusters, each assigned a separate BIN (Fig. 6). Specimen TIPSY719-15 from Mt Peca clusters with other European sequences and forms the widespread BIN BOLD:AAD9882. In contrast, two Slovenian specimens from the Julijske Alpe and the Kamniško-Savinjske Alpe (TIPSY287-12 and TIPSY887-19) show substantial divergence and constitute a distinct lineage with its own BIN, BOLD:ABU8409, in the phylogenetic analysis. The minimum K2P distance between the two *T. ciliaris* clusters from Slovenia is 4.0%, exceeding typical levels of intraspecific variation reported for the genus.

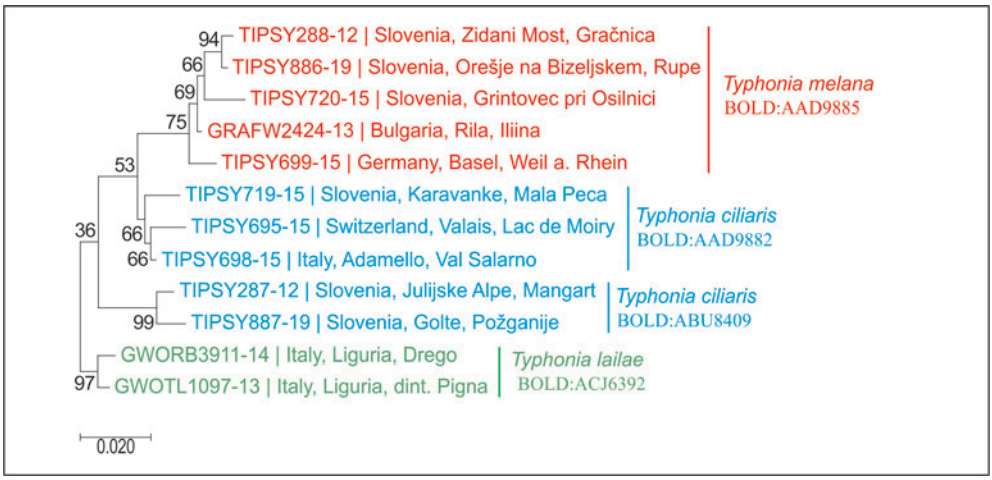


Figure 6. Neighbor-Joining phylogenetic tree for some representatives of the genus *Typhonia* based on COI barcode sequences (K2P model). Samples are labelled with BOLD sequence IDs, species names, and BINs. Numbers at branches indicate bootstrap support (%). Scale bar represents 2% sequence divergence.

Bertaccini & Zilli (2017) noted that the Mangart specimen (TIPSY287-12) "clustered with *T. lailae*" in their analysis. Our results confirm that this specimen is genetically equidistant from *T. ciliaris* (3.3%) and *T. lailae* (3.5%), indicating a level of divergence consistent with a distinct lineage. Morphological data for this specimen clearly exclude conspecificity with *T. lailae* (e.g., comparatively short and slender antennae and broader wings; Bertaccini & Zilli 2017), yet its precise relationship to *T. ciliaris* sensu stricto warrants further investigation, potentially indicating cryptic diversity within *T. ciliaris*.

Table 3. Matrix of pairwise distances in Typhonia used in this study, based on the COI gene barcode region and calculated using the Kimura 2-parameter method.

Sample	Pairwise divergence (p)										
GRAFW2424-13											
TIPSY288-12	0,011										
TIPSY699-15	0,010	0,020									
TIPSY720-15	0,015	0,020	0,023								
TIPSY886-19	0,010	0,005	0,018	0,018							
GWORB3911-14	0,042	0,054	0,042	0,054	0,051						
GWOTL1097-13	0,040	0,052	0,040	0,056	0,049	0,008					
TIPSY695-15	0,032	0,040	0,033	0,044	0,035	0,039	0,037				
TIPSY698-15	0,023	0,032	0,025	0,035	0,030	0,028	0,027	0,011			
TIPSY719-15	0,026	0,032	0,032	0,035	0,030	0,038	0,037	0,021	0,013		
TIPSY287-12	0,044	0,052	0,047	0,060	0,047	0,037	0,035	0,042	0,033	0,040	
TIPSY887-19	0,049	0,058	0,052	0,061	0,054	0,040	0,039	0,049	0,039	0,042	0,013

Discussion

The genus *Typhonia* was originally placed among the microlepidoptera within the family Tineidae (Höfner 1895, 1911; Rebel 1905; Galvagni 1910), and was later transferred to *Melasina*. *Typhonia melana* was first described as *Euprepia melana* Frivaldszky, 1837, but its taxonomic status remained unclear for several decades. Some authors regarded it as a junior synonym of *T. ciliaris* or *T. lugubris* (Kozhanchikov 1956; Sieder 1972; Carnelutti 1958, 1971, 1992). It was subsequently treated as a subspecies of *T. ciliaris* (Sauter & Hättenschwiler 1991; Sobczyk 2011), and only in recent years has it been reinstated as a valid species (Arnscheid & Weidlich 2017; Bertaccini & Zilli 2017).

This historical confusion explains why all earlier records of *Typhonia* in Slovenian literature were attributed to *T. ciliaris*. Carnelutti (1958, 1971, 1992) and Lesar & Govedič (2010) listed all Slovenian material under the synonym *Melasina lugubris*. Carnelutti (1978) even reported *T. melana* from Ratitovec in the Škofja Loka range, although our investigations confirmed the presence of *T. ciliaris* only.

Genetic data indicate that *T. ciliaris* in Slovenia has developed two clearly separated geographically structured lineages. The Julijske Alpe and the Kamniško-Savinjske Alpe, both belonging to the Southern Limestone Alps, differ from other Alpine ranges through their tectonic attachment to the Adriatic microplate and their stronger Mediterranean climatic influence. Combined with repeated Pleistocene climatic oscillations, these factors may have promoted long-term isolation and the formation of distinct genetic lineages, a pattern widely documented among alpine organisms (Schmitt 2009). A comparable pattern of two distinct genetic lineages has been observed in *Dahlica (Brevantennia) triglavensis* (Rebel, 1919), with one lineage occurring in the Julijske Alpe and the other in the Karavanke (Rekelj et al. 2022). Nevertheless, no consistent morphological differences were detected between the analysed populations, and the genetic results are based on only three successfully sequenced specimens (some material failed during processing). Confirmation of a potential cryptic species would therefore require a more extensive study, including a larger number of DNA samples and comparative analyses of juvenile stages.

Our faunistic investigations in Slovenia and Croatia revealed a wide distribution of *T. melana* and a clear geographical and altitudinal separation between the two species, which meet in a contact zone within the Alpine region. As *T. ciliaris* was not recorded below 831 m in our dataset, larval cases and larvae from localities below this threshold can be reliably attributed to *T. melana*, even in the absence of emerged adults. Conversely, larval cases collected above this elevation in the pre-Alpine and Alpine zones cannot be identified with certainty without reared adults, as both species may occur sympatrically. Based on all available faunistic evidence, the majority of such high-altitude records most likely refer to *T. ciliaris*.

Both morphological and molecular data support the distinct species status of *T. melana*, in agreement with previous findings from other European populations (Arnscheid & Weidlich 2017; Bertaccini & Zilli 2017).

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