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Short Communication

Lost in hostile lands: moths of conservation concern in cultivated and suburban areas of south Italy

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Abstract

Cultivated and suburban areas are usually considered unfavourable to the vulnerable components of biodiversity and regarded as not interesting from a conservation point of view. However, remnants of semi-natural vegetation can be embedded in such areas, becoming possible refuges for wild biodiversity despite the high anthropogenic pressures. With the present study, we raise awareness that, in some cases, these areas can be regarded as biodiversity treasure chests, even when apparently poor and with low appeal for conservationists. We demonstrate the importance of urbanised and cultivated landscapes by providing new records of two lepidopteran species rare for the Italian Peninsula, namely *Amphipyra* (*Pyrois*) *cinnamomea* and *Boudinotiana notha*. The European range of *A. cinnamomea* has become strongly reduced, seeming extinct in some Central European regions and the few Italian records mostly date back several decades. *B. notha* has very few relict populations in Mediterranean Europe, some of which are in peninsular Italy, where it is threated by urbanisation and reduced precipitations expected in the next decades. Our findings confirm the importance of small and highly fragmented patches of semi-natural vegetation for biodiversity conservation, as they can allow species of conservation interest to persist in hostile lands.

Key words: *Amphipyra cinnamomea*, biodiversity, *Boudinotiana notha*, habitat fragmentation, Lepidoptera

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Introduction

Unveiling the role of non-protected areas in sustaining wild diversity is crucial for biodiversity conservation, as, in most cases, natural parks are surrounded by cultivated lands that represent a barrier to wild diversity (Forman 1995; Conrad et al. 2004) and can rarely lead to a genetic drift in populations of vulnerable species (Britten and Baker 2002). Many countries in Europe and North America have addressed this problem by introducing Agri-Environmental Schemes (AES) as an attempt to reverse declines in farmland biodiversity by providing financial incentives to farmers for adopting less intensive, environmentally sensitive agricultural practices (Fuentes-Montemayor et al. 2011). In addition, a key point of the European Community Agricultural Policy (https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-glance_en) is to maintain the integrity of the ecosystem service of pollination by funding the

monitoring of abundance and diversity of Hymenoptera Apoidea, Diptera Syrphidae and Lepidoptera (Ollerton 2017). Thanks to this policy, the number of studies on species distribution, community composition and abundance of wild pollinators in non-protected areas is rising across Europe (Millard et al. 2021).

During the last decades, knowledge on lepidopteran diversity has increased in Calabria, the southernmost region of peninsular Italy, thanks to several monitoring programmes of forested habitats carried out mostly within natural and protected areas (Ienco et al. 2020; Scalercio et al. 2022). However, the largest part of the regional territory is represented by non-protected urbanised and cultivated areas where only a few studies have been conducted. To fill this gap, some monitoring programmes of nocturnal Lepidoptera were launched in olive groves (Scalercio et al. 2007; Sabatino et al. 2021) and in suburban areas (Zucco and Scalercio 2023).

The complexity of the Calabria territory favours the frequent records of Lepidoptera every time that a new type of habitat is surveyed through monitoring activities (Infusino et al. 2016; Greco et al. 2018). This happens even in suburban and cultivated areas where semi-natural habitats are strongly fragmented in very small patches (Scalercio and Catania 2020), which seem to be large enough to enable wild diversity to permeate hostile environment and maintain populations.

The aim of the present study is to demonstrate that suburban environments that are cultivated and/or subject to anthropogenic interventions can host species richness similar to natural habitats and are, therefore, worthy of attention and protection. The important role of semi-natural vegetation patches in sustaining wild pollinators is confirmed in this paper by new findings of lepidopteran species in a hilly olive grove surrounded by semi-natural vegetation and in a suburban area. During 2022, we found the night-active Noctuidae *Amphipyra* (*Pyrois*) *cinnamomea* (Goeze, 1781), whose populations are declining across Europe (SwissLepTeam 2010; Wachlin and Bolz 2012), and the day-active Geometridae moth *Boudinotiana notha* (Hübner, 1803). For this latter species, the habitat is being strongly reduced by human activities and vulnerable to the expected climatic scenarios (Zaimes 2020), but very little data of its presence in peninsular Italy are available so far. Here we provide new records of these two lepidopteran species in south Italy, the critically revised literature data and the records publicly available on web platforms for Italian fauna, with notes concerning their conservation status at local, national and continental levels.

Material and methods

The sampling sites are located within the Crati Valley, one of the largest plains in the Calabria Region (Fig. 1). Nocturnal samplings of *A. cinnamomea* were carried out in the Coppone locality (Altomonte Municipality, Province of Cosenza) during a monitoring activity of the moth diversity inhabiting an olive orchard and its surroundings. Within and around the selected olive orchard, which extends for 3.1 hectares, we installed a network of ten UV LED light traps (Infusino et al. 2016), weekly activated from July to September 2022 during nights favourable to moth activity, with low wind and little or no rain and temperatures near the mean of the period and not lower than 15 °C. Sampled specimens were sorted and identified in the Laboratory of Faunistic Management and Forest Biodiversity of the Research Centre for Forestry and Wood (Rende, Province of Cosenza) and preserved in the scientific Collection of Lepidoptera of that laboratory.

Diurnal sampling of *B. notha* was done by net in a suburban area near the Research Centre for Forestry and Wood, where urbanised and cultivated lands are dominant and the semi-natural vegetation is mostly represented by remnants of riparian forests. The findings occurred during a monitoring activity of butterflies near an Italian Butterfly Monitoring Scheme transect (https://butterfly-monitoring.net/ebms). One was spotted on the ground, captured and brought to the laboratory for identification. After this first occasional finding on 10 March 2022, daily surveys were organised to find new specimens. However, no other individuals of this species were found despite the occurrence of sunny days optimal for the flight activity of adults (Hausmann 2001). The search during the same period of 2023 in the same area and in other suitable areas along the Crati River near the cities of Rende and Cosenza was unsuccessful.

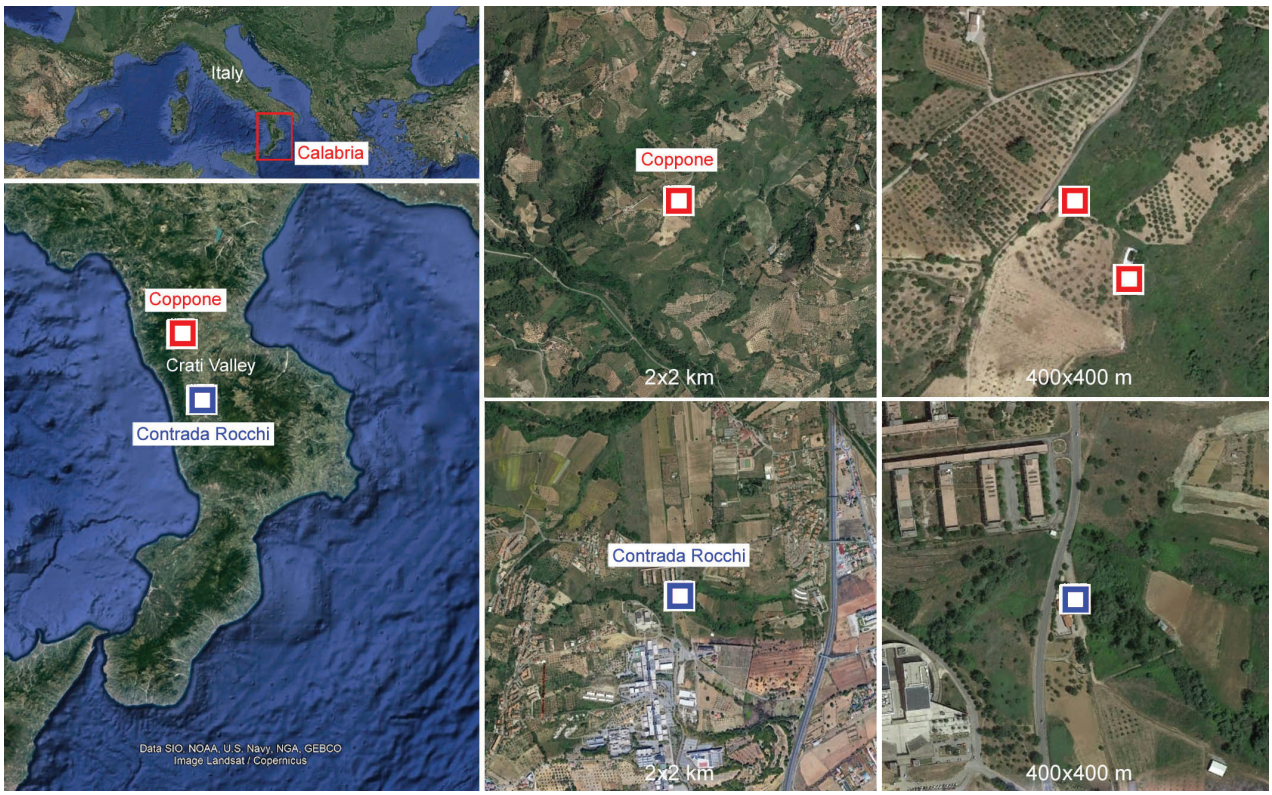

Figure 1. Location of study area. Collecting sites of *Amphipyra cinnamomea* (red and white squares) and *Boudinotiana notha* (blue and white squares) are indicated. Aerial photographs (Google Earth) illustrate the landscape composition around the collecting sites at two different spatial scales.

Results and discussion

***Amphipyra* (*Pyrois*) *cinnamomea* (Goeze, 1781)**
Fig. 2

New records. Calabria: Coppone (Altomonte Municipality, Cosenza Province) 39.689°N, 16.115°E, 5.VII.2022 (1 male), 19.VII.2022 (1 male).

Two adult male specimens, newly emerged, (Fig. 2) were found in July in two out of ten sites monitored in the study area, at the margin of semi-natural patches occasionally burned and near to human artefacts (Fig. 3). No specimens

were collected within the cultivated land and within the best-preserved habitats represented by riparian forests with *Populus*, *Ulmus*, *Lonicera* and others deciduous trees on which the larvae are known to feed (Rákosy 1996).

Other studies report adults from the beginning of spring-time (Fiori 1880) to October (Prola et al. 1978), likely as the result of adult aestivation. In peninsular Italy, the mimetic and elusive *A. cinnamomea* was found in Mediterranean habitats with *Quercus ilex* (Parenzan 1979), in Mediterranean maquis (Nappini and Dapporto 2009) and in areas with sparse *Quercus virgiliana* trees and olive groves (this study). This species has long been considered rare (Bertoloni 1849; Fiori 1880) and only five specimens have been found in Italy during the last century (Fig. 4). Records in Sardinia should be confirmed, as the only available record is the generic citation in the Italian checklist (Raineri and Zilli 1995). Moreover, the citation in Parenzan and Porcelli (2006) is wrong as the mention in Rocci and Turati (1925) refers to *Sideridis cinnamomea* Turati, 1913 that is a form of *Mythimna sicula* (Treitschke, 1835) described from Sardinia (Seitz 1938).

Süssenbach and Fiedler (1999) found that the abundance of species belonging to the genus *Amphipyra* can be underestimated by using light traps only, as they appear to be more abundant when bait traps were used. However, *A. cinnamomea* seems to be very rare in any case as it has never been detected with this method in Italy and it is also absent in the species list gathered from a survey of Lepidoptera carried out with bait traps in an area 20 km around the collecting locality (Scalercio 2006).

A. cinnamomea is considered a Mediterranean species extinct north of the Alps since 2007 (Fibiger et al. 2007). In Germany, it seems to be extinct and last records from Rhineland-Palatinate, Hessen and Baden-Württemberg date back to 1881 (Wachlin and Bolz 2012). It was common near Wiesbaden around the 1880s, becoming rare and lastly recorded in 1898 or 1899 (Steiner 1997). In Switzerland, its range was strongly reduced as it was only recorded in the south-westernmost part of the Central Highlands (SwissLepTeam 2010) as all records after the 1960s were from the vicinity of Valaisan Rhône between Briga and Martigny (Wymann et al. 2015).

General distribution. *Amphipyra* (*Pyrois*) *cinnamomea* is recorded from Andorra, Austria, Bosnia and Herzegovina, Bulgaria, Corsica, Croatia, French mainland, Germany, Greek mainland, Hungary, Italian mainland, North Macedonia, Romania, Slovenia, Spanish mainland, Switzerland, Serbia, Montenegro and doubtfully from Sardinia and Slovakia (Karsholt and Nieukerken 2013). Outside Europe, it is only known for a few specimens collected in Turkey and Iran (Fibiger and Hacker 2007).

Figure 2. *Amphipyra* (*Pyrois*) *cinnamomea*. specimens collected during the present study (Coppone, Altomonte, Cosenza) **a** male, wingspan: 45 mm (19.VII.2022) **b** male, wingspan: 48 mm (5.VII.2022).

Figure 3. Calabrian collecting sites of *Amphipyra* (*Pyrois*) *cinnamomea*.

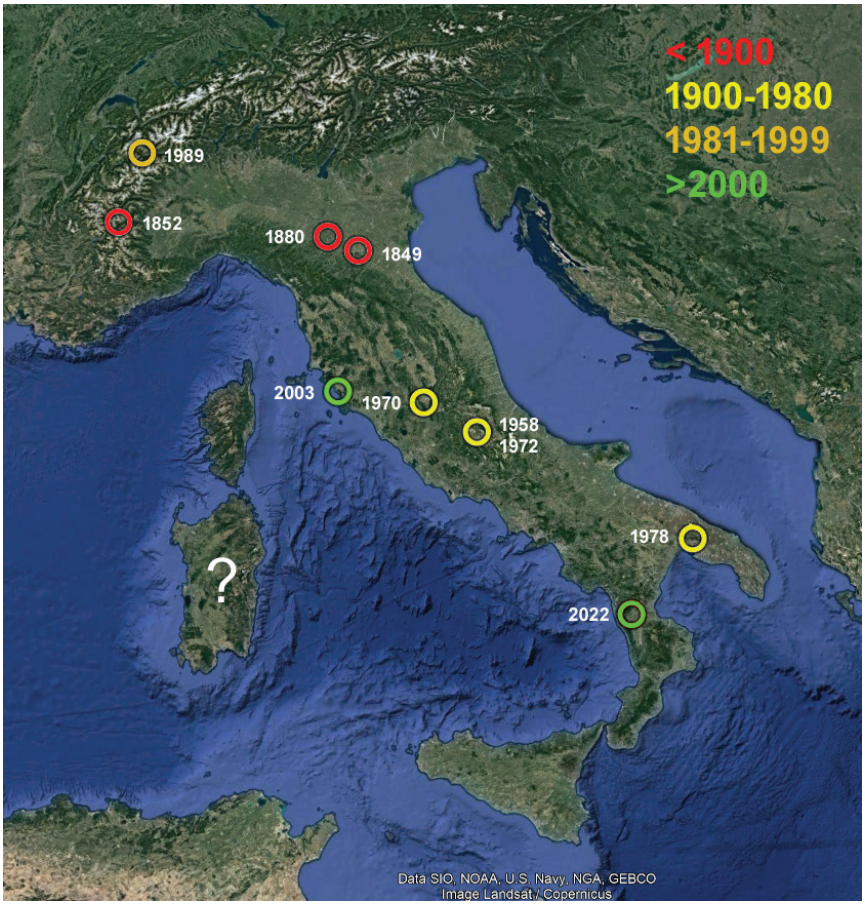

Figure 4. Italian records of *Amphipyra* (*Pyrois*) *cinnamomea*.

Italian distribution. Valle d'Aosta: Vens, Aosta, 1850 m elev., 16.IX.1989 (1 ex.) (Faquaet 1991).

Piemonte: Alpi, Northern Savoia, luglio-agosto (Ghiliani 1852).

Emilia: Bologna Botanic Garden, summer, 1 larva (Bertoloni 1849); San Faustino, Modena, 2 specimens at the beginning of spring-time (Fiori 1880).

Toscana: Collelungo, Parco Regionale della Maremma, Grosseto, VIII.2003 (1 ex.) (Nappini and Dapporto 2009).

Umbria: San Faustino, Terni, 4.X.1970 (1 ex.) (Prola et al. 1978).

Abruzzo: San Potito, L'Aquila, 10.VIII.1958 (1 ex.), 9.X.1972 (1 ex.) (Prola et al. 1978).

Puglia: Pianelle, Taranto, 350–450 m elev., 2.VI (1 male) (Parenzan 1979).

Sardegna: (Raineri and Zilli 1995).

***Boudinotiana notha* (Hübner, 1803)**
Fig. 5

New record. Calabria: Contrada Rocchi (Rende, Cosenza Province), 39.3675°N, 16.2282°E, 10.III.2022 (1 male).

In Calabria, *Boudinotiana notha* was found in a suburban area demonstrating that it can survive also where only remnants of riparian forest grow (Fig. 6), which is the habitat type where the larvae can be found. Preferred habitats are characterised by wind-protected areas, such as glades, valleys, forest-rides usually on wet, peaty or sandy soils near groundwater (Hausmann 2001). It occurs often near pioneer trees of *Populus tremula*, but also old trees. Adults can be attracted by *Salix* and rap runs. It flies exclusively during the day on sunny mornings and, during the afternoon, flies around *P. tremula* or rests on their twigs. It can be found from 0 m up to 1000 m above sea level (Hausmann 2001). For pupation, the *B. notha* caterpillar makes a hole in rotten wood and the pupation tubes are closed by a small cover made of gnawed wood (https://lepiforum.org). The species is univoltine and flies from late February to mid-April in Italy, from early April to mid-May in northern Europe. Larval stages can be found from early May to early July in Italy, from June to July in northern Europe. It overwinters as pupa, sometimes for two or three years (Hausmann 2001).

Several records are available from web platforms of citizen science, whereas published data are very scarce in Italy. It was commonly found from the Po Valley to the Alps, in Piemonte and Lombardia and scattered records are reported from Alpine areas in other regions, with the exclusion of Valle d'Aosta. It is very rare in peninsular Italy where it was recorded in a small area of Tuscany, in one locality of the Circeo National Park in Lazio and in a lowland forest in Puglia (Fig. 7). It was recorded also on other species of *Populus*, for example, *P. nigra* or exceptionally on *Salix* in Europe (Hausmann 2001). Adults were repeatedly observed also in *P. alba* stands (Zdeněk Laštůvka, pers. comm). Despite the field efforts carried out after the first finding in the same location and its neighbouring areas, but also in well-preserved riparian habitats of the Crati Valley during 2022 and 2023, no additional individuals were observed. Adults are very active in sunny days and easy to be detected as demonstrated by the large number of observations available for this species in citizen-science platforms. Then, the lack of additional observations leads us to hypothesise that the presence of very small populations are likely in need of conservation actions. Beside the habitat reduction due to the increasing urbanisation at low altitudes, its habitat is strongly threatened by the reduced precipitations expected in the next decades, more pronounced in the Mediterranean Basin (Brunetti et al. 2012).

General distribution. *Boudinotiana notha* can be found mostly in Europe and in part of Asia, in particular Russia and Japan (GBIF.org). In Europe, it occurs in the central-eastern part of the continent, specifically Austria, Belarus, Belgium, United Kingdom, Bulgaria, Croatia, Czechia, Danish mainland, European Russia, Estonia, European Turkey, Finland, French mainland, Germany, Hungary, Kaliningrad Region, Latvia, Lithuania, Luxembourg, Norwegian mainland, Poland, Romania, Slovakia, Slovenia, Spanish mainland, Sweden, Switzerland, The Netherlands and Ukraine (Karsholt and Nieukerken 2013).

Italian distribution. Piemonte: Eremo, Torino (Giorna 1791–1793); Località Madonnina, Brignano Frascata, Alessandria, 3.III.1997 (Cabella and Fiori 2006);

Ponte Stura Ghiaia Grande, Alessandria, 3.III.2007 (Cabella C., pers. comm.); Gravere, Torino, 18.IV.2018 (Cabella C., pers. comm.); torrente Scrivia, Villa Ivernia, Alessandria, 3.IV.2022 (Cabella C., pers. comm.); Magnano, Biella, 45.4656°N, 8.0298°E, 23.III.2022 (1 male), recorded by Simone Bocca (iNaturalist); Greggio, Vercelli, 45.4586°N, 8.3957°E, 27.II.2022 (1 male), Front, Torino, 45.2628°N, 7.6800°E, 29.II.2021 (1 ex.), recorded by Alessandra Serini (iNaturalist); Rubiana, Torino, 45.1837°N, 7.3479°E, 10.III.2019 (1 male), recorded by Vuillermoz (iNaturalist); Borgone Susa, Torino, 45.1303°N, 7.2406°E, 10.III.2021 (1 male), recorded by Francesca de Leo (iNaturalist); Mompantero, Torino, 45.1477°N, 7.0948°E, 09.III.2020 (1 male), Gravere, Torino, 45.1175°N, 7.0118°E, 30.III.2019 (1 female), Usseaux, Torino, 45.0661°N, 7.0610°E, 17.II.2020 (1 male), Roure, Torino, 45.0567°N, 7.1149°E, 08.III.2019 (1 male), Oulx, Torino, 45.0276°N, 6.8003°E, 01.III.2019 (1 male), Giaveno, Torino, 45.0100°N, 7.3047°E, 10.III.2021 (1 male), recorded by bferrero (iNaturalist); Perrero, Torino, 44.9249°N, 7.1791°E, 16.III.2021 (1 male), recorded by Andrea Pane (iNaturalist).

Lombardia: Colli di San Fermo, Bergamo, mid-March-May (Föhst 1991); Veddasca, Varese, 46.0824°N, 8.7979°E, 22.II.2020 (1 ex.), recorded by giuss91 (iNaturalist); Cantello, Varese, 45.8230°N, 8.8742°E, 13.III.2020 (1 ex.), recorded by Mirko Tomasi (iNaturalist); Malnate, Varese, 2.IV.2021(1 female), recorded by Mirko Tomasi (naturamediterraneo); Cesano Maderno, Monza e Brianza, 45.6274°N, 9.1296°E, 29.III.2019 (1 male), Cesano Maderno, Monza e Brianza, 45.6274°N, 9.1250°E, 16.III.2019 (1 female), Cesano Maderno, Monza e Brianza, 45.6253°N, 9.1228°E, 25.III.2019 (1 male), recorded by alilibere (iNaturalist); Acquanegra Sul Chiese, Mantova, 45.1411°N, 10.4421°E, 08.III.2020 (1 ex.), Acquanegra Sul Chiese, Mantova, 45.1382°N, 10.4361°E, 21.II.2021 (1ex.), 02.II.2019 (1 male) recorded by Francesco Cerere (iNaturalist); Motta Baluffi, Cremona, 45.0342°N, 10.2409°E, 24.II.2019 (1 male), recorded by Fausto Leandri (iNaturalist); Motta Baluffi, Cremona, 45.0311°N, 10.2299°E, 28.II.2019 (1 male), recorded by Matteo (iNaturalist); Casalmaggiore, Cremona, 44.9557°N, 10.4894°E, 13.IV.2017 (1 larva), 19.II.2020 (1 ex.), recorded by Tiziana Dinolfo (iNaturalist); Voghera, Pavia, 45.0344°N, 8.9852°E, 01.III.2019 (1 female), recorded by Associazione Naturalistica Codibugnolo (iNaturalist); Bannio Anzino, Verbanio-Cusio-Ossola, 650 m elev., 28.III.2018 (1 male), recorded by Bantorp (naturamediterraneo); Viadana, Mantova, 26.II.2020 (some specimens), recorded by Tiziana Dinolfo (naturamediterraneo).

Trentino: Südtirol (Kitschelt 1925); surroundings of the Lago di Garda (Wolfsberger 1965).

Alto Adige: Ulten (Hinterwaldner 1867); Sonnenberghang, Naturns (Daniel and Wolfsberger 1957); Taufers/Waalweg, 1250 m elev., 46.657°N, 10.477°E, 14.IV.2013 (2 exx.), Huemer P. leg (BOLD); Bolzano, Bolzano, 46.4792°N, 11.3483°E, 10.III.2021 (1 ex.), recorded by Zenzi Martin (iNaturalist); Bolzano, Bolzano, 46.4788°N, 11.3491°E, 07.III.2021 (1 ex.), recorded by Verena Trockner (iNaturalist); Segonzano, Trento, 46.1896°N, 11.2509°E, 15.V.2020 (1 larva), recorded by Karol Tabarelli de Fatis (iNaturalist).

Veneto: Valdastico, Vicenza, 24.III.2010 (2 males), recorded by Archimede24 (naturamediterraneo).

Friuli: San Leonardo, Udine, 150 m, 12.III.1994 (1 maschio), C. Morandini leg. (Cicerale and Sciarretta 2005).

Venezia Giulia: Strazig, Gorizia, 8.III (1 es.) (Hafner 1910); Salcano, Gorizia, 15–30.III (some specimens) (Hafner 1910).

Figure 5. Collected specimen of *Boudinotiana notha*: Contrada Rocchi, Rende, Cosenza, 10.III.2022, male, wingspan: 32 mm.

Figure 6. Calabrian collection site of *Boudinotiana notha*. Blue and white square indicates the collecting point, where the specimen was found resting on the soil. Photo: Giuseppe Rijllo.

Emilia-Romagna: Modena, 24.III.2010 (1 ex.), recorded by Enrico Ferrari (naturamediterraneo).

Toscana: Torniella, Torrente Farma, Grosseto, 300 m elev., 2.IV.1991 (1 femmina) (Fabiano and Zilli 1998); Iesa, Siena, 350 m elev., II–IV (Dapporto et al. 2005); Bagni di Petriolo, Siena, 160–300 m elev., II–IV (Dapporto et al. 2005); Torniella, Grosseto, 300–400 m elev., II–IV (Dapporto et al. 2005); Carpineto, Siena, 200 m elev., II–IV (Dapporto et al. 2005); Civitella Paganico, Grosseto, 43.0847°N, 11.3131°E, 17.III.1999 (1 ex.), recorded by L. Dapporto (iNaturalist).

Lazio: Parco Nazionale del Circeo, foresta planiziale, 24.III.1995 (1 male) (Fabiano and Zilli 1998).

Puglia: Torre Fantine, Chieuti, Foggia, 27-II-2002 (1 female), T. Cicerale leg. (Cicerale and Sciarretta 2005).

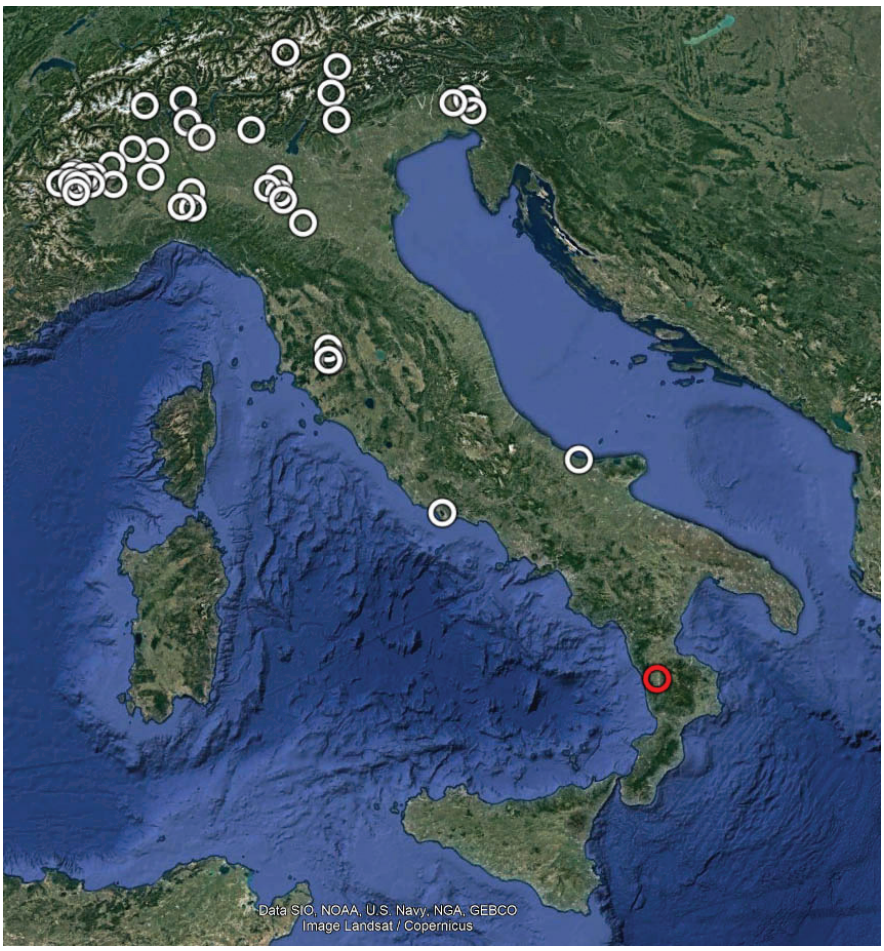

Figure 7. Italian distribution of *Boudinotiana notha*. Red circle: new finding in south Italy.

Conclusions

Our findings confirm the great importance for diversity conservation of semi-natural habitats imbedded within cultivated and urbanised areas. They can represent either primary habitats where the species can complete their biological cycle or corridors enabling the dispersal of species across unsuitable habitats. During our study, we recorded only males, which are usually better fliers than females. This observation led us to hypothesise a primary role of corridors for such remnants, but we cannot exclude the role of primary habitat at least for *Boudinotiana notha* as its larvae feed on trees characterising its sampling site. The finding of one specimen only makes necessary an *ad-hoc* monitoring programme to clarify the role of semi-natural remnants for this species, as well as its range and its population size in the Crati Valley.

Even though our conclusions are based on three specimens only, they refer to very rare species for which also the finding of one specimen is of great importance and deserves to be valorised. In fact, our findings represent the second specimen of *B. notha* and the second and the third specimens of *Amphipyra cinnamomea* ever found in south Italy. As suggested by the high number of records concerning the day-active *B. notha* in north Italy deriving from citizen's observations, *B. notha* in south Italy can be considered very rare and its populations threatened by increasing anthropogenic and climate pressures. On the other hand, the lack of data deriving from citizen's observations concerning

the night-active *A. cinnamomea* could be due to both its rarity and its low detectability also when light traps were used. In fact, it might be better surveyed using sugar-based baits as observed for congeneric species, but there is no evidence of this.

In addition, our records also highlight the need for implementation of monitoring programmes of wild diversity in non-natural areas as well as the need of protection for the remnant patches of semi-natural habitats for both the diversity of species having restricted habitat preferences, as *B. notha* and *A. cinnamomea* documented here and for the maintenance of ecosystem services. The implementation of monitoring programmes with a variety of sampling methods can certainly help to better define the areas of species occurrence and abundance. Moreover, scientific programmes can be profitably integrated by citizen science, which contribute to refine the species distribution patterns, as demonstrated by data concerning *B. notha* for which literature data are very scarce.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

LB, GZ, SS write the manuscript; KG, IM supported field surveys; IM, SS conceived the study; LB, GZ, KG, SS data analysis; LB, GZ studied references.

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Data availability

All of the data that support the findings of this study are available in the main text.

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