

Past and current distribution of *Charaxes jasio jasio* (Linnaeus, 1767) (Lepidoptera Nymphalidae) in Sicily in relation to its host plant, *Arbutus unedo* L. (Ericaceae)

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ABSTRACT

The authors provide an updated overview of the past and present regional distribution of the two-tailed Pasha *Charaxes jasio jasio* (Linnaeus, 1767) (Lepidoptera Nymphalidae) and its host plant, the strawberry tree *Arbutus unedo* L. Most of the occurrence data reported in the entomological literature was confirmed, and several new populations have been recently discovered. The distribution pattern of the insect and its host plant overlap almost perfectly. *C. jasio jasio* is more abundant and forms large and stable populations on the Peloritani Mts. and in some areas of the Madonie Mountains. The high number of new records of *C. jasio jasio* suggests that the species is experiencing a spreading phase, but the reasons behind this trend are still unexplained and need further field research and monitoring activities. The recent increase of its populations may depend on the current protection of many forest and pre-forest communities hosting the strawberry trees.

KEY WORDS

Ecology; plant-insect interactions; trophic niche.

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INTRODUCTION

The Two-tailed Pasha, *Charaxes jasio* (Linnaeus, 1767) (Lepidoptera Nymphalidae), is a large and showy butterfly (wingspan 70–80 mm) (Fig. 1) whose distribution range stretches across Africa, Southern Europe and East Mediterranean countries.

Due to the morphological variability of the species across its wide distribution range, the systematic and taxonomic interpretation of *Charaxes*

jasio sensu lato is still lively debated (Aduse-Poku et al., 2009). Many authors distinguish as many as six taxa, i.e., *C. jasio jasio*, widespread across Southern Europe and Northern Africa, and five more subspecies, *C. jasio epijasio* (Reiche, 1850), *C. jasio saturnus* (Butler, 1865), *C. jasio harrisoni* (Sharpe, 1904), *C. jasio pagenstecheri* (Poulton, 1926) and *C. jasio brunnescens* (Poulton, 1926), all of them occurring (and often co-occurring) in Africa, mostly between the tropics.

The type locality of *C. jasio jasio* is “Bar-

baria”, corresponding to today’s Algeria (Honey & Scoble, 2001).

This subspecies is strictly linked to Mediterranean evergreen maquis, and more precisely to the Strawberry tree, *Arbutus unedo* L. (Ericaceae), and mostly occurs between 100 and 700–900 m a.s.l.

The caterpillar is green, cylindrical and bears two yellow ocelli on the back; it is easily recognizable by the presence of four horns on the head turned backwards and feeds on the leaves of the strawberry tree. The adults mostly feed on the sugar-rich liquids of the ripe fruits but may be also attracted by any other sweet fermenting substance. In the Mediterranean Basin, *C. jasius jasius* performs 2 generations per year: the first one in May–June and the second one in August–September; after this last one, it spends the winter in the larval stage, and flickers during the following spring. Under favourable circumstances, a third, incomplete, generation has been recorded in December (southern Spain and northern Africa), with imagos usually larger than those of the second generation. Young caterpillars are the overwintering stage (Verdugo-Páez, 1987; Tarrier & Delacre, 2008).

Charaxes jasius jasius is listed as Least Concern (LC) in the European Red List of Butterflies (van Swaay et al., 2010) and in the Italian Red List of Butterflies (Balletto et al., 2015).

In this paper, an updated overview of the past and present regional distribution of this lepidopteran was provided. An attempt was also made to correlate the distribution and the demographic trend of this species on a regional scale with those of the strawberry tree.

A poorly known, yet interesting feature of *C. jasius jasius* biology is the reported ability of its larvae to occasionally feed on the leaves of *Citrus* species. In fact, Longo (1992, 2016) observed the larvae on lemon tree leaves at Furci Siculo (Messina Province) and on orange tree leaves in Calabria; larvae of *C. jasius jasius* on *Citrus* spp. have been observed on Cyprus Island, too (Morris in Longo, 2002). Indeed, at the end of the 1980s the lepidopterologist B. Giandolfo from Pedara (Catania Province) was able to breed many individuals of Two-tailed Pasha by feeding them with *Citrus* leaves (M. Romano, *pers. comm.*).

In the eastern Mediterranean countries, *C. jasius*

mostly feeds on another strawberry tree, *Arbutus andrachne* L. (Markis, 2003), in Crete it reproduces on *Prunus persica* (L.) Batsch and on *P. armeniaca* (Rosaceae) (Danner, 2001), while it has been observed on *Osyris quadripartita* Salzm. ex Decne. (Santalaceae) in southern Spain and in Balearic Islands (Fernández-Martínez, 2000), on *Annona cherimola* Mill. (Annonaceae) (Muñoz Sario, 2003) and on *Vaccinium corymbosum* L. (Ericaceae) (Molina, 2000).

The tropical African subspecies of *C. jasius* show a wider dietary spectrum. In fact, their eggs and larvae have been found on native hosts belonging to the genera *Rhamnus* (Rhamnaceae), *Bauhinia* and *Lonchocarpus* (Fabaceae), *Gymnosporia* (Celastraceae), as well as on cultivated fruit or ornamental trees belonging to many families, like *Laurus nobilis* L. (Lauraceae), *Prunus persica*, *Nicotiana glauca* Graham (Solanaceae), *Camellia sinensis* (L.) Kuntze (Theaceae), *Annona cherimola*, *Brachychiton* spp. (Malvaceae), and *Citrus* spp. (Rutaceae) (Nel, 1979; Devarenne, 1990; Stefanescu, 1995; Tolman & Lewington, 1997; Longo et al., 2000; Danner, 2001; Mazzei, 2002; Sario, 2003; Bury, 2014).

MATERIAL AND METHODS

Field research

Targeted field trips were carried out in Sicily and the circum-Sicilian islands to search for *C. jasius jasius*, focusing on the most suitable environments, i.e., those characterized by higher frequency and/or cover rate of *A. unedo*. Several Sicilian and Italian public and private entomological collections were also investigated.

Web-sourced data

Photographs of *C. jasius jasius* taken in Sicily were obtained from various web sources. First, we used the web-application Morphic (Leighton et al., 2016), which allows users to specify search terms and retrieves photographs from the search engine Googleimages®. This web application (<http://morphs.io>), free and open source, is based on a perpetual hashing algorithm (Niu & Jiao, 2008) that enables to remove duplicate photographs and



Figure 1. *Charaxes jasio jasio*, Gibilmanna, 7.9.2003 (photo credit: I. Sparacio).

avoids geographical biases using Google's Hummingbird relevance algorithm (Chauntelle & Yazdanifard, 2014). To further reduce the number of duplicates and to identify the original photographic source, we applied the TinEye reverse image search application (<https://tineye.com>). We then supplemented our morphic searches via manual searches from different naturalist and social media sites, Facebook (<https://www.facebook.com/>); and Twitter (<https://twitter.com/>) (see references). As for Facebook, the research was conducted within the following groups: Fauna Siciliana; Farfalle e falene d'Italia - fotografare la natura; Amici delle Farfalle; Il Mondo Delle Farfalle (Lepidotteri); Conservazione Farfalle (e Biodiversità); AFNI Sezione Sicilia; Insetti e altri artropodi - un fantastico mondo da scoprire; Insetti e aracnidi italiani; Insetti e aracnidi; Identificazione ragni e insetti; Riconoscimento Insetti; Aracnidi e Insetti: Official Group; Centro di Educazione Ambientale ODV. These sites were not accessed via morphic tools, as they are not indexed by search engines (Leighton et al., 2016), but we decided to include them in our manual searches as they are very popular in the Sicilian entomological community.

Additional Sources

The data issuing from scientific (entomological, botanical and forestry) literature, from unpublished personal observations or provided by several informants were used to reconstruct the historical and current distribution of both *C. jasius jasius* and *A. unedo* in Sicily. Further useful information on Sicilian phytonyms referred to *A. unedo* were obtained from the specialized literature (dictionaries, lexicons, glossaries) and integrated by consulting ethnobotanical works reporting the popular uses of the strawberry tree. The data obtained are presented in a synthesis map, while the more detailed results of this multidisciplinary ongoing research are not shown here because they will be the subject a forthcoming paper.

Collection abbreviations

MRSNT = Museo Regionale di Storia Naturale e Mostra permanente del Carretto siciliano di Terzasini (Palermo Province, Italy). MSNG = Museo di Storia Naturale di Genova (Italy).

RESULTS

The data presented in text below are also reported in the map of Fig. 2.

Literature data

In Sicily, *C. jasius jasius* was first observed by Ghiliani (1842) in the surroundings of Taormina (Messina Province) and by Zeller (1847), who described for these localities its larva collected on *A. unedo* growing in locality Gravitelli near Messina. Kalchberg (1872) observed the Two-tailed Pasha in the Favorita Park near Palermo. Failla-Tedaldi reported it for two localities near Castelbuono, Miliuni (1877) and Sant'Ippolito (1878). Few years later, Ragusa (1884) wrote some biological notes on the species, mentioning the attraction that sugar-rich substances exert on this butterfly. Based on the observations made by Kalchberg (see Kalchberg, 1872 and Riggio, 1884), Minà Palumbo & Failla-Tedaldi (1887) mentioned the occurrence of the butterfly in the countryside near Palermo. Calberla (1889) observed it on his trip to Sicily but reports no locality, and Ragusa (1905, 1916) reports it from Sicily, with no other indication. Ragusa (1916) observed the species many times in the suburban park of La Favorita near Palermo.

Mariani (1939; 1940–1943) reports the species for Capo d'Orlando (see § *Additional records*). Half a century later, Cernigliaro et al. (1989) report it for locality Curcuraci (400 m a.s.l.) near Messina.

Falci (2004) observed this species in several localities of the Madonie mountain range like Gratteri, Praest (Cefalù), Gibilmanna, Cozzo Carbonara, Ferla and Castelbuono. The species occurrence in Sicily is reported in all the main butterfly catalogues, including the most recent ones (Verity, 1951, 1953; Karsholt & Razowski, 1996; Parenzan & Porcelli, 2007; Pesce et al., 2010; Tolman & Lewington, 2014), as well as in several online articles. For instance, Porto (2001) mention the Two-tailed Pasha for Cefalù and the surroundings of Messina), Saitta (2016) for the Peloritani Mountains in general.

As for the circum-Sicilian islands, *C. jasius jasius* is reported for the Aeolian Islands, namely for Salina (Kudrna & Leigheb, 1988; Biermann, 2005) and Lipari (Favilli, 2017). Recently, it has also been reported for Filicudi (Lo Parrino, 2021). Concerning the occurrence of this species on Pantelleria, see below.

Data from entomological collections

Aeolian Islands

Lipari, 3.X.1976, legit A. Carapezza; idem, Pomiciazzo, 19.VI.1989 (legit/collezione A. Carapezza - MRSNT).

Salina, Monte Fossa delle Felci, 18.VI.1989 (legit/collezione coll. A. Carapezza - MRSNT).

Madonie Mountains

Gibilmanna, 16.IX.1986; 2.IX.1987; 3.IX.1987; 5.IX.1987; 18.VIII.1988; 19.VIII.1988; 24.VIII.1988; 27.VIII.1988; 30.VIII.1989; Gibilmanna, Cozzo Carbonara, 16.IX.1986 (legit/collezione N. Grillo, MSNG). Considering that Gibilmanna is more than 12 km far from Cozzo Carbonara and that the latter is the highest peak (nearly 2000 m a.s.l.) of the Madonie Mountain range, thus totally unsuitable to *A. unedo*, the mention of “Carbonara” probably means that the Two-tailed Pasha was collected “be-

tween” Gibilmanna and Cozzo Carbonara (Authors’ note).

Cefalù: Ferla, 17.IX.1986.

Gibilmanna, Cozzo Carbonara (see previous Authors’ note), 20.IX.1986; 24.VIII.1988.

Gibilmanna, 2.IX.1987; 4.IX.1987; 6.IX.1987; 9.IX.1987; 30.VIII.1989 (legit/collezione F.P. Romano, MSNG).

Peloritani Mountains

Capo d’Orlando (Messina), 16.IX.1933, legit B. Cuva (coll. M. Mariani - MRSNT).

Additional records from field investigations and web sources

Aeolian Islands

Filicudi, one adult individual photographed on 20.IX.2021 (Lo Parrino, 2021a) and in X.2022 (La Spina, 2022).

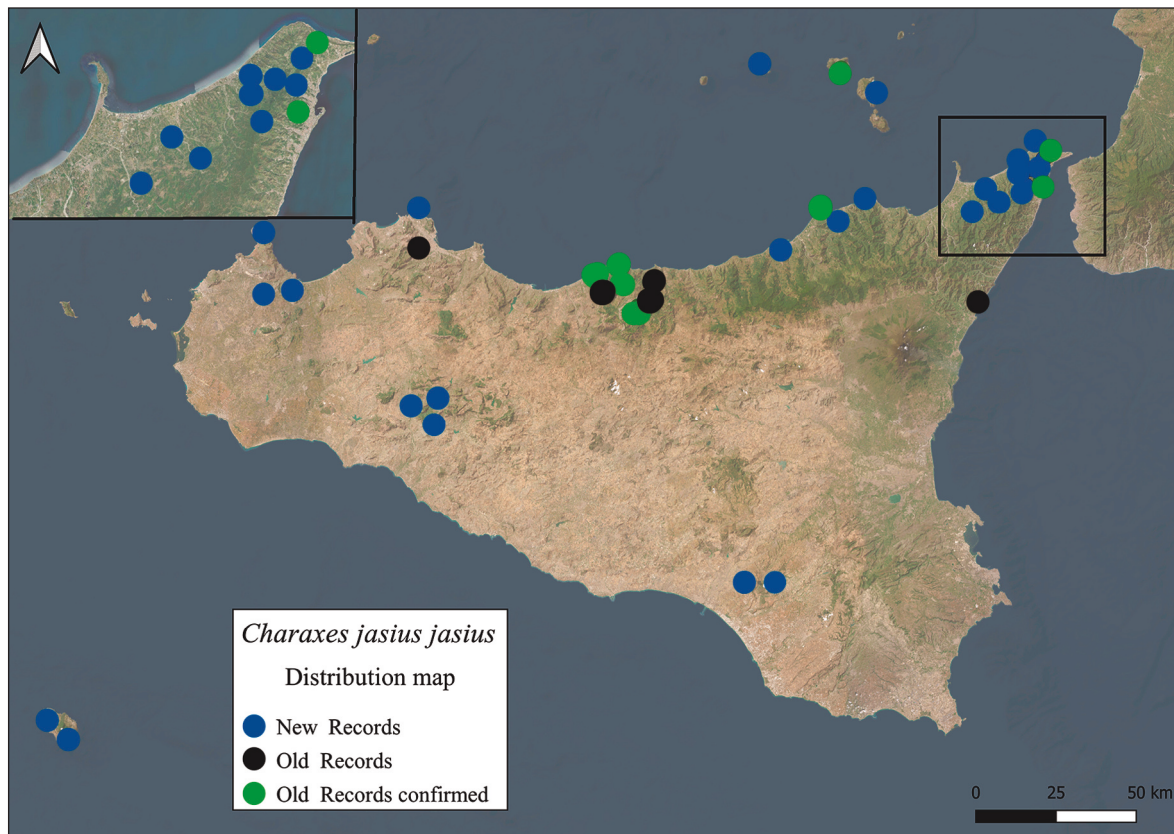


Figure 2. Map illustrating the past and present distribution of *Charaxes jasius jasius* in Sicily and its satellite islands.

Lipari. Regularly observed from July to late September, in recent years until 2021, in different areas of the island like Monte Pilato, Monte Sant'Angelo, Poggio dei Funghi, Monte Chirica, Valone Fiume Bianco (P. Lo Cascio, *pers. obs.*); also recently reported online by De Simone (2021) and Lo Parrino (2021b).

Salina. Regularly observed from July to late September, in recent years until 2021, at Monte Fossa delle Felci and Monte dei Porri (P. Lo Cascio, *pers. obs.*).

Salina, Monte dei Porri, one adult individual photographed in 14.VI.2008, 38°34'21.91"N 14°48'55.59"E, C. Muscarella.

Madonie Mountains

In the last decades fairly stable and numerous populations of *C. jasius jasius* have been observed in the evergreen maquis dominated by strawberry trees near Gibilmanna, on Pizzo Sant'Angelo slopes up to the outskirts of Lascari and Cefalù. Numerous observations have been made in this area since 1985 and up to 2020 by M. Romano, N. Grillo, A. Monastra, V. Aliquò, I. Sparacio (cf. also Monastra's and Romano's collections and sitography).

Peloritani Mountains

Monte di Serro (Francavilla Tirrena), one adult individual, in flight, 28.V.2012 (R. Lo Duca, *pers. obs.*).

Between Tarantonio and Monte Venera, one adult individual, in flight, 2014 (R. Lo Duca & L. Scuderi, *pers. obs.*).

San Jachiddu, one adult individual photographed on 9.VI.2012 (R. Ientile, *pers. comm.*).

Curcuraci, one adult individual photographed on 21.V.2010 (R. Ientile, *pers. comm.*).

San Pier Niceto, one adult individual photographed on settembre 2019 (Gitto, 2019).

Monforte San Giorgio, one adult individual photographed on 23.VIII.2019 (Gitto, 2019b).

Santa Lucia del Mela, one adult individual photographed on 9.X.2016 (Gitto, 2016) and one adult on 28.VIII.2019 (Gitto, 2019c).

Acquedolci, one adult individual photographed on 7.X.2014 (Celi, 2014).

Bosco della Candelara, several observations of caterpillars, 7 and 26.XII.2015, II. 2016, II.2017 (Saitta, 2016).

Portella Chiarino, one adult individual photographed on 2019 (S. Saitta, *pers. comm.*).

Gesso, one adult individual photographed on 23.V.2016 (Cento, 2016).

Gioiosa Marea, one adult individual photographed in August 2015 (D'Amico, 2015) and 1 on 29.VIII.2020 (D'Amico, 2020).

Massa San Nicola, one adult individual photographed on 27.VIII.2022 (Dini, 2022).

Sicani Mountains

Valle del Sosio Nature Reserve (Palazzo Adriano), one adult individual, in flight, 15.VI.2015 (R. Lo Duca, *pers. obs.*).

Rifesi (Burgio), 16.VI.2012 (M. Arnone, A. Carapezza, B. Massa C., Muscarella & M. Romano, *pers. obs.*). 37°36'53.41"N 13°19'52.97"E.

Chiusa Sclafani, one adult individual photographed on 2004 (Grenci, 2004).

Surroundings of Caltanissetta

Sughereta di Niscemi, one adult individual photographed in October 2018 (CEA, 2018) and on 23.X.2022 (Liardo, 2022).

Calatino (= surroundings of Caltagirone)

Bosco di Santo Pietro, one adult individual photographed on 15.V.2020 (P. Galasso, *pers. comm.*).

Surroundings of Palermo

Near the rocky shore at Capo Gallo (Sferracavallo, Palermo) 15.VII. 2000 (A. Carapezza, *pers. obs.*).

Palermo: Villa Sperlinga (within the urban area, Authors' note), 1980s (A. Monastra, *pers. comm.* to M. Romano).

Trapani Mountains

Bosco Scorace (Buseto Palizzolo), 3.9.2012 (A. Gerbino, *pers. obs.*; Fig. 3). Some more individuals have been observed in the same site on 12 September 2016 (Barraco, 2016) and on June 2 and 18, 2020, by I. Sparacio.

Monte Inici (Castellammare del Golfo), one individual observed in flight and photographed near



Figure 3 (below). *Charaxes jasius jasius*, Bosco Scorace, 10.9.16. Photo credit: A. Gerbino.

Figure 4 (above). Caterpillar of *Charaxes jasius jasius*, Pantelleria: Kuddia Attalora, 19.IV.2022. Photo credit: G. Di Giorgio.

the top of Monte Inici, August 2021 (L. Scuderi, pers. comm.).

San Vito Lo Capo, one adult individual photographed on 16.X.2022 (Entling, 2022).

Pantelleria Island

Some individuals of *C. jasius jasius* were observed in flight by T. La Mantia and R. Lo Duca, 03.07.2021 in locality Kannachi. Another dead individual was observed on Montagna Grande (05.07.2021, T. La Mantia and R. Lo Duca) in a wine container. A caterpillar was photographed by G. Di Giorgio on the 19.IV.2022 in locality Kuddia Attalora (Fig. 4) and by Napoletano (2022) on 24.V.2002, 2 individuals photographed by Gerbino (2022) on 10.IX.2022, and one individual photographed by Antinucci (2022) on 25.V.2022 in locality Lake of Venere.

The presence of *C. jasius jasius* on this island has never been reported on previous scientific papers concerning local butterflies (Romano & Romano, 1995; Aistleitner & Aistleitner, 1998, 2001; Romano, 2020); however, many photos of this species taken on the island, especially in recent years, have been published on many naturalistic and travel websites (see sitography).

The Two-tailed Pasha currently appears to be spreading on Pantelleria and is likely to have colonized the island in recent years.

Ecology and distribution of Arbutus unedo L. in Sicily

In Sicily, the strawberry tree grows between 50 and 1050 m a.s.l., but it meets its optimum between 300–400 and 700–900 m a.s.l. This small tree is characteristic to acidophilous forests dominated by evergreen oaks (*Quercus suber* L. and *Q. ilex* L.), but it also occurs in mixed semi-deciduous oak forests related to the alliance *Erico-Quercion ilicis* (Brullo et al., 2009), more rarely in pinewoods (Brullo et al., 2003). At the upper limit of its altitudinal range, *A. unedo* is able to grow together with deciduous broadleaved trees like chestnuts (Schicchi et al., 1991). Thanks to its fast response to fire damages, especially in sites with remarkable air humidity, it sometimes dominates dense species-poor pioneer high shrubland communities, while elsewhere it co-occurs with *Myrtus communis* L.,

brooms and/or with *Erica arborea* L. Under extremely cool and humid conditions it may grow on leached soils deriving from calcareous rocks (Brullo et al., 2009).

The past and present distribution of *A. unedo* is shown in Fig. 5. As for the islands of the Strait of Sicily, *A. unedo* is common only on Pantelleria, while it is rare and almost extinct on the Pelagie and Egadi Islands. The strawberry tree commonly occurs on most of the Aeolian Islands but has never been observed neither at Vulcano nor at Stromboli. Small and scattered populations are present in different hilly areas of Trapani province and in the lowlands of south-western Sicily between Marsala and Sciacca. Common on the central-southern sector of the Sicani mountain range, *A. unedo* also occurs in few localities of the Mounts of Palermo, while it is almost completely absent in the inner part of western Sicily (northern Sicani Mts., Termini and Trabia Mts. and the western Madonie Massif). This species occurs throughout the Madonie territory but is common only in the territories of Castelbuono, Cefalù, Gratteri and Pollina. On the Nebrodi Mountains the strawberry tree is quite common in the coastal and hilly areas up to 600–700 m a.s.l., namely in the municipalities of Tusa and Caronia.

Peloritani Mts. host with no doubt the largest number of stands of *A. unedo*, mostly concentrated on the north-facing mountain ridges where it benefits from cooler and wetter climatic conditions, while it is less common on the Ionian side. Strawberry trees seldom occur on the eastern Hyblaean Mts. (e.g., Noto), on the inner hills of Agrigento, Caltanissetta and Enna territories, whilst it is more common (but subject to fast and continuous shrinkage) in the southwestern sector of Hyblaean territory (e.g., Caltagirone, Niscemi).

DISCUSSION AND CONCLUSIONS

Almost all the Sicilian occurrences of the Two-tailed Pasha reported in the scientific literature were confirmed, and several new ones have been recently discovered. When compared, the distribution pattern of the insect and its plant host show an almost perfect overlap. However, in many areas where *A. unedo* occurs with small and scattered stands or isolated individuals, *C. jasius jasius* has not been

found, perhaps because the chemical signal of the fermenting ripe fruits is too weak, or just because of the lack of observations.

The amount of information and images issuing from non-academic sources, for instance the photos posted on webpages, is continuously growing. *C. jasius jasius* provides a paradigmatic example of species that could be used to test the role of citizen science. In fact, the beauty of this large butterfly attracts even common people, while its peculiar morphology allows quick and unambiguous identification.

The high number of new records of *C. jasius jasius* suggest that the species is experiencing a spreading phase on the regional scale. More in detail, it results more abundant and forms large and stable populations where there are higher concentrations of the host plant, like in the Peloritani Mts. and in some areas of the Madonie Massif. Several

factors may explain the recent increase of observations: this positive trend may depend on a more effective protection of the island's forest and pre-forest communities hosting the strawberry trees; the conservation of these sites, many of which fall within protected areas or within the Natura 2000 network, represents a primary objective to encourage a further growth of *C. jasius jasius* populations and ensure an adequate diversification of the environmental mosaic of our territory.

The reasons behind the positive trend of this butterfly are still unexplained and need further field research and monitoring activities. On this purpose, the case of Pantelleria is particularly intriguing. Considering that *A. unedo* is rather common on this small territory (83 km²) and that the island has been investigated by many entomologists and lepidopterologists during last decades, the fact that *C. jasius jasius* was observed there only recently may

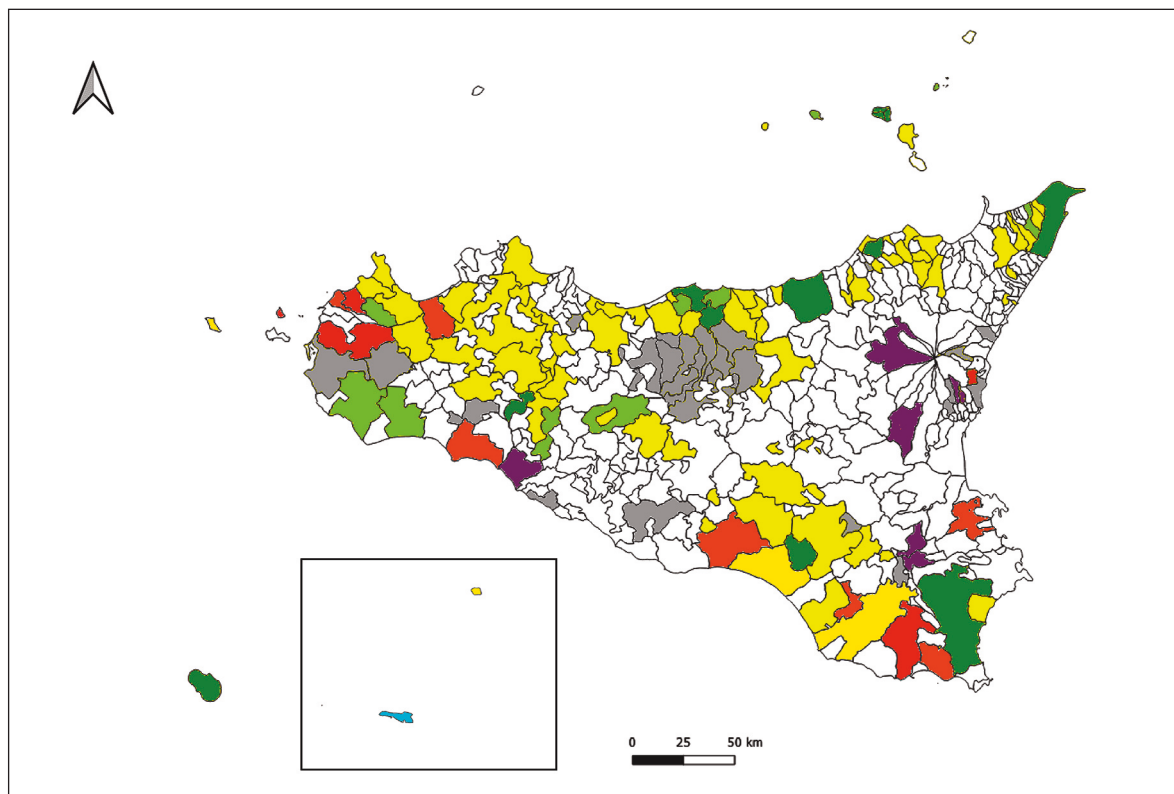


Figure 5. Map illustrating the past and present distribution of *Arbutus unedo* in Sicily and its satellite islands. Occurrence data concerning each satellite island have been reported separately, whilst the information concerning the main island refers to municipalities. Red: verified local extinctions; Orange: probable local extinctions; Yellow = municipalities with less than 3 stands; Pale green = municipality with less than 5 stands; Dark green = municipality with more than 5 stands; Violet = municipality where current occurrence is doubtful; Turquoise = extinct in the wild but recently planted from vegetative material obtained from the last surviving cultivated individual; Grey = possible occurrence (based on local plant names and toponyms).

depend on recent colonization or, like it often occurs to other vagile insects, local population may have experienced a long-lasting period of contraction followed by a sudden phase of expansion.

The observation of an individual resting on the rockpools near the seashore (A. Carapezza, *pers. obs.*) confirms the ability of *C. jasius jasius* to use seawater as salt resource (John & Tennent, 2012).

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