Luca ANSELMO* - Enrico CAPRIO** - Simona BONELLI***

Beyond yellow: host plants of *Anthocharis euphenoides* in NW Italy (Lepidoptera Pieridae)

Abstract: In recent decades, an alarming decline in butterfly populations has been documented in Europe. The main threats include changes in land use, pollution, and climate change. An in-depth understanding of the ecological requirements of species is crucial for developing effective conservation measures to counteract this decline. In this study, we aimed to clarify which plant species serve as host plants for *Anthocharis euphenoides* in the northernmost part of its Italian range. To gather valuable information for this purpose, we conducted an extensive survey of the butterfly, recording the plant species on which adult females were observed laying eggs or where pre-imaginal stages were present, as well as verifying the use of plants reported in the literature as potential host species. Our research revealed a predominant use of *Erucastrum nasturtiifolium*, with only a few cases in which *Biscutella brevicaulis* was used. The former host plant had been reported only in Spain and France, while the use of the latter was previously unknown. In no case was the reproduction of the butterfly associated with *Biscutella laevigata*, which is currently considered the main host plant in Europe, including Italy. The results highlight the need for a more thorough study of the ecological requirements of this butterfly, as misidentification of plants or the spread of unverified information from older literature may lead to inaccuracies in ecological knowledge, which is crucial for planning the conservation of oligophagous butterflies at a local scale.

Riassunto: *Oltre il giallo: piante ospiti di* Anthocharis euphenoides *nel nord-ovest d'Italia (Lepidoptera Pieridae).*

Negli ultimi decenni, è stato documentato un preoccupante declino delle popolazioni di farfalle in Europa. Le principali minacce includono i cambiamenti nell'uso del suolo, l'inquinamento e il cambiamento climatico. Una conoscenza approfondita dei requisiti ecologici delle specie è fondamentale per sviluppare misure di conservazione efficaci volte a contrastare tale declino. In questo studio, ci siamo proposti di chiarire quali specie vegetali fungano da piante ospiti per *Anthocharis euphenoides* nella parte più settentrionale del suo areale italiano. Per raccogliere informazioni utili a questo scopo, abbiamo condotto un'indagine approfondita sulla farfalla, registrando le specie vegetali su cui le femmine adulte sono state osservate durante la deposizione delle uova o dove erano presenti stadi pre-immaginali, oltre a verificare l'uso di piante riportate in letteratura come potenziali specie ospiti. La nostra ricerca ha rivelato un uso predominante di *Erucastrum nasturtiifolium*, mentre in pochi casi in è stata utilizzata *Biscutella brevicaulis*. L'uso della prima pianta era stato riportato solo in Spagna e Francia, mentre l'uso della seconda era finora sconosciuto. In nessun caso la riproduzione della farfalla è risultata associata a *Biscutella laevigata*, attualmente considerata la principale pianta ospite in Europa, inclusa l'Italia. I risultati evidenziano l'importanza di uno studio più approfondito sui requisiti ecologici di questa farfalla, poiché errori nell'identificazione delle piante o la diffusione di informazioni non verificate provenienti da letteratura datata potrebbero causare inesattezze nelle conoscenze ecologiche, fondamentali per pianificare la conservazione delle farfalle oligofaghe a scala locale.

Key words: Lepidoptera, Ecology, Conservation, Susa Valley, Natura 2000, *Erucastrum*, *Biscutella*.

INTRODUCTION

Insects are among the animal groups showing the greatest decline worldwide in recent years (van Klink *et al*., 2020; Wagner *et al*., 2021). Many European butterfly species are experiencing rapid habitat loss, primarily due to changes in land use (van Swaay *et al*., 2010a; Börschig *et al*., 2013; Filz *et al*., 2013; van Strien *et al*., 2019; Warren *et al*., 2021; Rumohr *et al*., 2023). Furthermore, there are clear signs that climate change poses an additional threat, leading to range and phenological shifts in many species (Forister *et al*., 2010; Rödder *et al*., 2021; Kerner *et al*., 2023; Habel *et al*., 2023). Specialist and low-mobility butterflies show greater vulnerability to this threat (Heikkinen *et al*., 2010; Habel *et al*., 2023). Butterflies that feed only on a few plant species are particularly at risk, as several species are shifting upwards faster than their few host plants in the Alps (Kerner *et al*., 2023). Some basic categories of specificity are traditionally recognized: monophagous (feeding on a single host plant species),

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oligophagous (feeding on a few species, usually belonging to the same genus or family), and polyphagous (feeding on a wide range of host plant species, typically from different families) (Courtney, 1948; Wiklund, 1975). The same species may vary its host plant preference primarily based on local availability and phenology at the time of oviposition (Settele *et al*., 2009). Understanding the ecological requirements of each butterfly species must be considered fundamental for planning their conservation (Settele *et al*., 2009). For this purpose, an attempt to gather information from the literature on the host plants of European butterflies has been made (Clarke, 2022, 2024).

The Provence orange tip *Anthocharis euphenoides* Staudinger, 1869 is a monovoltine oligophagous European endemic species (Middleton-Welling *et al*., 2020), with a stable range in Portugal, Spain, France, and Italy (Kudrna *et al*., 2011). The sporadic observations occurring in Switzerland (LSPN 1987) should be referred to a non-stable colony (Balletto *et al*., 2023) or an attempt of introduction (Wermeille *et al*., 2014). In Italy, it exhibits a fragmented distribution, consisting of a main population in the central peninsula (Central Apennines), two smaller populations in the northwest (Cottian and Ligurian Alps), and one in the southern peninsula (Pollino Massif) (Balletto *et al*., 2007; Balletto *et al*., 2023). Other records from the Piedmont, Lombardy, and Tuscany administrative regions have never been confirmed and, therefore, should be considered doubtful (Balletto *et al*., 2023), as this very conspicuous species is unlikely to go unnoticed for a long time (Bollino *et al*., 1996). The host plants indicated throughout their range are all referred to the Brassicaceae family, mainly belonging to the genus *Biscutella* L., while the use of other plants was reported only in a few cases (Tab. 1) (Esper, 1829; Meigen, 1829; Curò, 1874; Duponchel, 1849; Verity, 1905, 1947; Palanca Soler & Galante, 1977; Gomez Bustillo & Fernandez Rubio, 1974; Descimon, 1991; Bollino *et al.*, 1996; Jutzeler *et al.*, 1998; Crozier, 1999; Hellmann & Bertaccini, 2004; Villa *et al.*, 2009; García-Barros *et al*., 2013; Paolucci, 2013; Obregón & Prunier, 2014; Lafranchis *et al*., 2015; Bence & Richaud, 2019; Lafranchis, 2020; Moussus *et al*., 2022; Balletto *et al.*, 2023). According to Balletto *et al.*

Tab. 1. Host plant species of *A. euphenoides* reported in the literature. The species are listed in alphabetical order.

Species	Countries	Reference
Biscutella ambigua DC.	France, Italy	Duponchel (1849), Verity (1905, 1947), Hellmann & Bertaccini (2004), Moussus *et al*. (2022)
Biscutella auriculata L.	France, Spain	Gomez Bustillo & Fernandez Rubio (1974), Obregón & Prunier (2014), Moussus *et al*. (2022)
Biscutella cichoriifolia Loisel.	Italy	Verity (1947)
Biscutella didyma L.	France, Italy, southern Europe	Esper (1829), Meigen (1829), Verity (1905, 1947), Hellmann & Bertaccini (2004)
Biscutella flexuosa Jord.	France	Lafranchis *et al*. (2015), Balletto *et al.* (2023)
Biscutella laevigata L.	France, Italy, Spain	Curò (1874), Verity (1905, 1947), Descimon (1991), Bollino *et al.* (1996), Jutzeler *et al.* (1998), Crozier (1999), Hellmann & Bertaccini (2004), Villa *et al.* (2009), Paolucci (2013), Lafranchis *et al*. (2015), Bence & Richaud (2019), Lafranchis (2020), Moussus *et al*. (2022), Balletto *et al.* (2023)
Biscutella sempervirens L.	Iberian Peninsula	García-Barros *et al.* (2013)
Biscutella valentina (Loefl. ex L.) Heywood	Iberian Peninsula	García-Barros *et al*. (2013)
Erucastrum nasturtiifolium (Poir.) O.E.Schulz	France, Spain	Palanca Soler & Galante (1977), García-Barros *et al*. (2013), Lafranchis *et al.* (2015)
Hirschfeldia incana (L.) Lagr.-Foss.	Spain	Lafranchis (2020)

(2023), *B. laevigata* is the host plant of *A. euphenoides* in Italy. This species, together with *B. ambigua* DC. and *B. didyma* L., was indicated by Hellmann & Bertaccini (2004) as hosts for the population of NW Italy of Susa Valley. Outside of these species, only Dannehl (1929) and Hellmann & Parenzan (2010) mentioned the use of the genus *Alyssum* L. in Italy.

According to the most recent global assessment of the International Union for Conservation of Nature (IUCN) Red Lists, *A. euphenoides* was classified as Least Concern (LC) at EU level (van Swaay *et al*., 2010b). The species was therefore not believed to face significant threats across its range; however, this 15-year-old evaluation should be updated. According to the Climatic Risk Atlas of European Butterflies (Settele *et al*., 2008), this species is classified as at extremely high risk from climate change. More recent IUCN assessments were made at regional and national levels: it was classified as LC in the Mediterranean region (van Swaay *et al*., 2014), LC in France (UICN France *et al*., 2014), and Not Applicable in Switzerland (Wermeille *et al*., 2014). In Italy, it was classified as Near Threatened (Balletto *et al*., 2015; Bonelli *et al*., 2018), as it has experienced a population decline in central Italy of approximately 20-25% in the last 10 years (Balletto *et al*., 2016). The causes of this decline are still unclear, and research activities are needed to obtain more information on the threats (Balletto *et al*., 2016). The number of observations has also decreased since 2000 in the French administrative region of Provence-Alpes-Côte d'Azur (PACA), despite an increase in butterfly data collection during the same period (Bence & Richaud, 2019). With this note, we aim to provide fundamental ecological information collected from the northernmost part of the Italian range of *A. euphenoides* (Susa Valley), which will improve the conservation planning activities for this species.

Materials and Methods

Adults of *A. euphenoides* were extensively searched in the Susa Valley during the central hours of sunny days in May, June, and July 2023, as well as in May and June 2024, starting from the localities where the species had been reported in the past (Fig. 1) and in

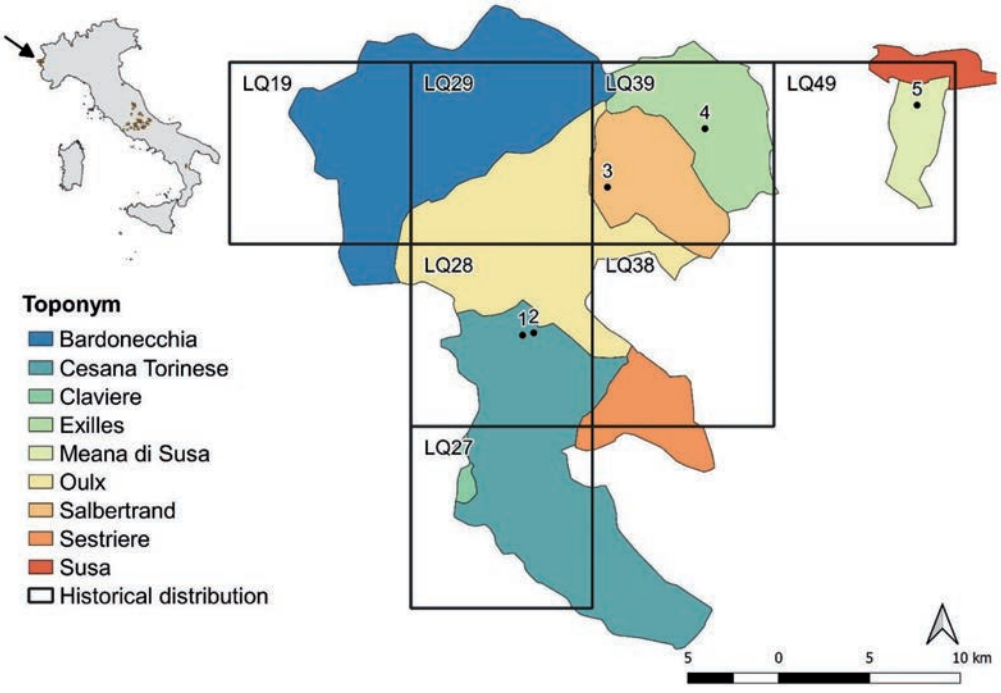

Fig. 1. Map of the geographical information retrieved from literature. The 10×10 km grid provided by Checklist of the Italian fauna is reported (Balletto *et al*., 2007). Colors identify local municipalities, while numbers correspond to more specific toponyms: 1 - Desertes (Cesana Torinese), 2 - Balbiere (Cesana Torinese), 3 - near Forte Pramand (Salbertrand), 4 - San Colombano (Exilles), 5 - Fontana Maubert (Meana di Susa).

additional areas where it had been occasionally observed by the authors in previous years (unpublished data). Adult females were followed to identify the plants on which they were laying eggs. If adults were spotted but no egg-laying females were seen, the flowering plants present in the site were checked for eggs and subsequently revisited after a maximum of two weeks to search for the pre-imaginal stages. Although eggs are highly visible (bright red a few days after being laid), plants with eggs that were not accompanied by the observation of a female laying them or caterpillars were not considered. Indeed, while the caterpillars exhibit distinctive characteristics compared to other species, the eggs of butterflies from the genus *Euchloe* Hübner, [1819], are very similar in shape and color (Balletto *et al*., 2023).

When the species was not found at the historical sites, a search was conducted to check for the possible presence of host plants among those reported in the literature (Tab. 1). Preimaginal stages were identified based on the iconography provided by Paolucci (2013) and Lafranchis *et al*. (2015), as well as descriptions by Balletto *et al*. (2023). Plant species were identified according to Pignatti (2017). The plant nomenclature followed Bartolucci *et al*. (2018).

Results

The presence of *A. euphenoides* was found at 68 sites, between 1026 and 2055 meters above sea level (Fig. 2 and Tab. 2). By monitoring the behavior of adults, several egg-laying females were observed. Adults often used host plants as nectar sources as well. In a large majority of cases, the species used *Erucastrum nasturtiifolium* (Poir.) O.E.Schulz as a host plant (Fig. 3). Only in 11 cases *Biscutella brevicaulis* Jord was recorded as a host plant (Fig. 4). The two plants were found in the same site only in one case (Claviere at 1817 m a.s.l.), in which only the use of *B. brevicaulis* was recorded. Most observations related to the use of *E. nasturtiifolium* occurred in low-density woodland of *Pinus sylvestris* L., particularly in natural river terraces within large floodplains and in calcare-

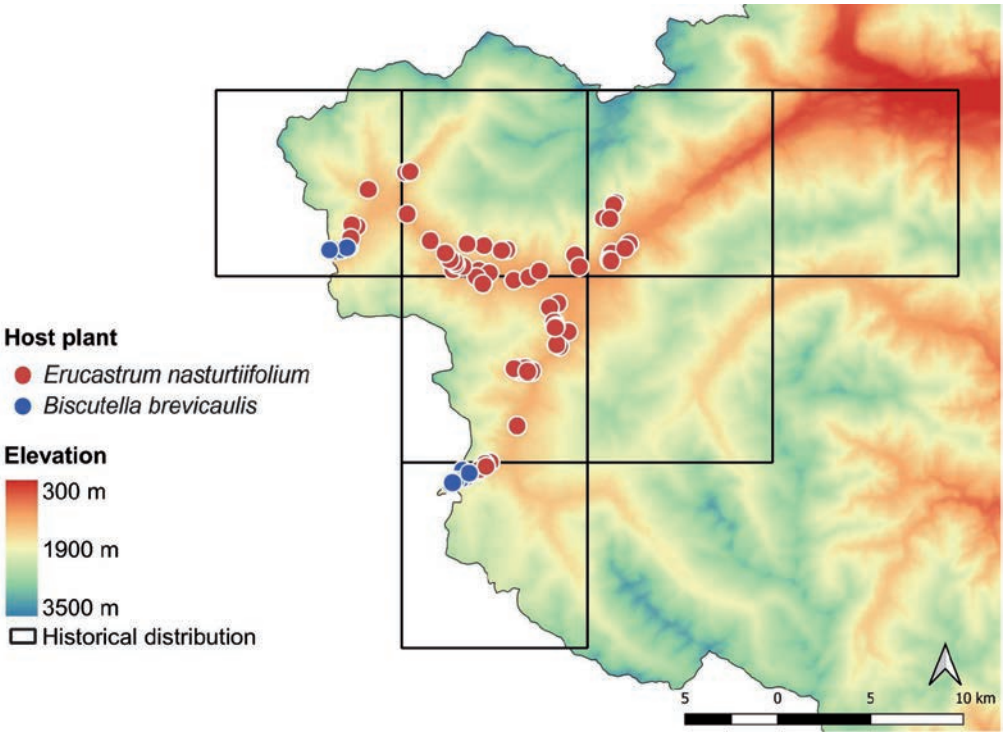

Fig. 2. Occurrences of *A. euphenoides* with associated information on host plant (dots). To compare the previously published distribution with the current one, the 10×10 km grid provided by the Checklist of the Italian fauna was reported (Balletto *et al.,* 2007).

ous sunny slopes. The observations regarding *B. brevicaulis* refer to calcareous stony screes, where the plant grows towards and above the tree line, composed by *Larix decidua* Mill. and *Pinus mugo* Turra subsp. *uncinata* (Ramond ex DC.) Domin. Plants of *B. laevigata* were not found at any of the sites where *A. eu-*

Tab. 2 Altitudinal distribution of observations.

Host plant	N	Elevation (m a.s.l.)		
		Mean	Min	Max
E. nasturtiifolium	57	1363.1 (SD=222.0)	1026	1837
B. brevicaulis	11	1736.9 (SD=183.8)	1453	2063

SD, standard deviation.

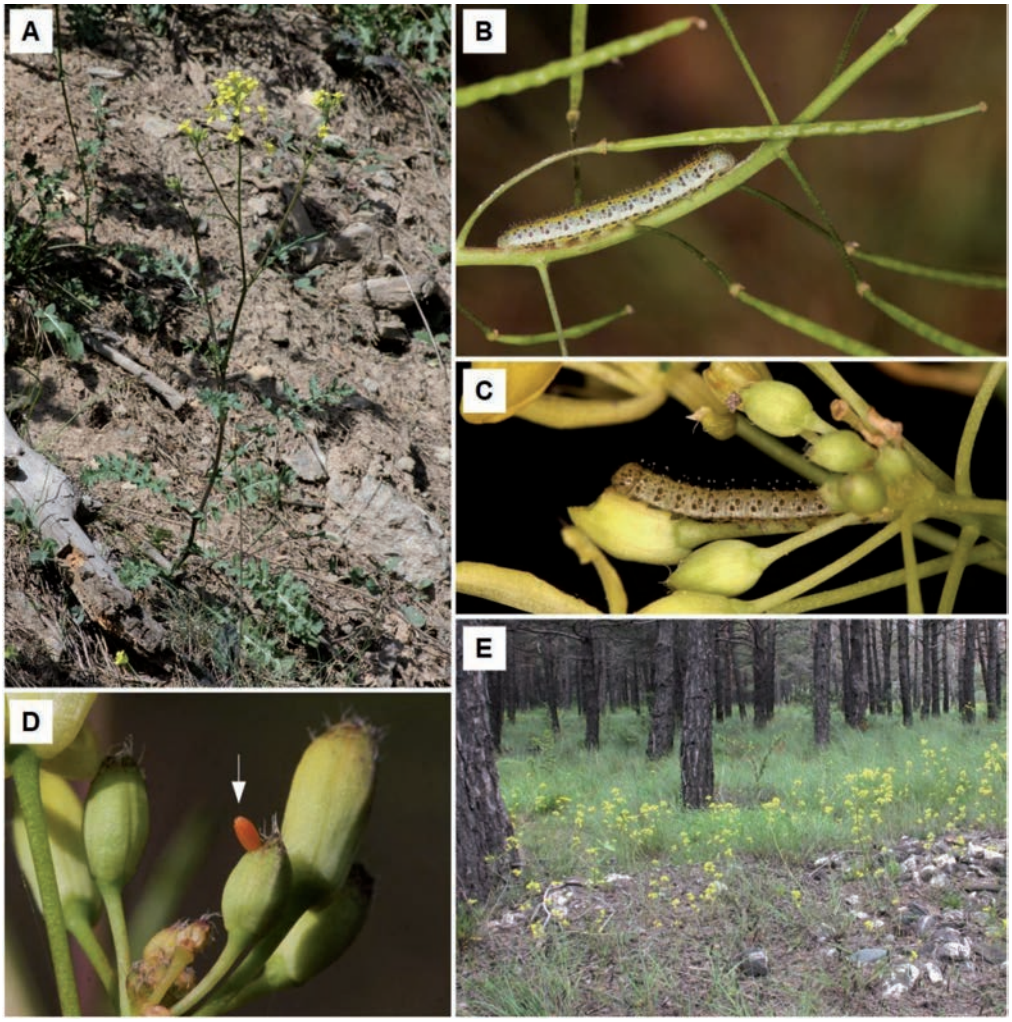

Fig. 3. Reproduction of *A. euphenoides* on *E. nasturtiifolium*. A) Flowering host plant individual (June 11th, 2023); B) mature caterpillar feeding on the raceme, the characteristic elongated siliques are visible (July 2nd, 2024); C) immature caterpillar feeding on a bud (June 26th, 2024); D) egg laid a few days ago (June 16th, 2023); E - habitat consisting of a terrace hosting low-density Scots pine (*P. sylvestris*) woodland, within a large floodplain of the Dora Riparia River (June 7th, 2023).

phenoides was found, despite being quite common in the pastures of the Susa Valley (pers. obs.), and more generally in the Alps (Aeschimann *et al*., 2004). Despite several checks, *A. euphenoides* has never been observed in areas hosting a high number of individuals of this plant.

The presence of *A. euphenoides* was not recorded in two of the seven 10×10 km cells where it had previously been reported (Fig. 2 and Tab. 3) (Giorna, 1791; Ghiliani, 1852: Curò, 1874; Rowland Brown, 1899; Rocci, 1911; Gribodo, 1920, Verity, 19926, 1947; Rocca, 1948; Storace, 1962; Balletto & Toso,1978; Hellmann & Bertaccini, 2004; Balletto *et al*., 2007; Hellmann & Parenzan, 2010). However, few individuals of *E. nasturtiifolium* were present in these cells. For example, 12 plants of this species were recorded in the precise toponym Fontana Maubert (Meana di Susa), indicated by Verity (1947), Rocca (1948), and Balletto *et al.* (2007), in a now dense mixed forest.

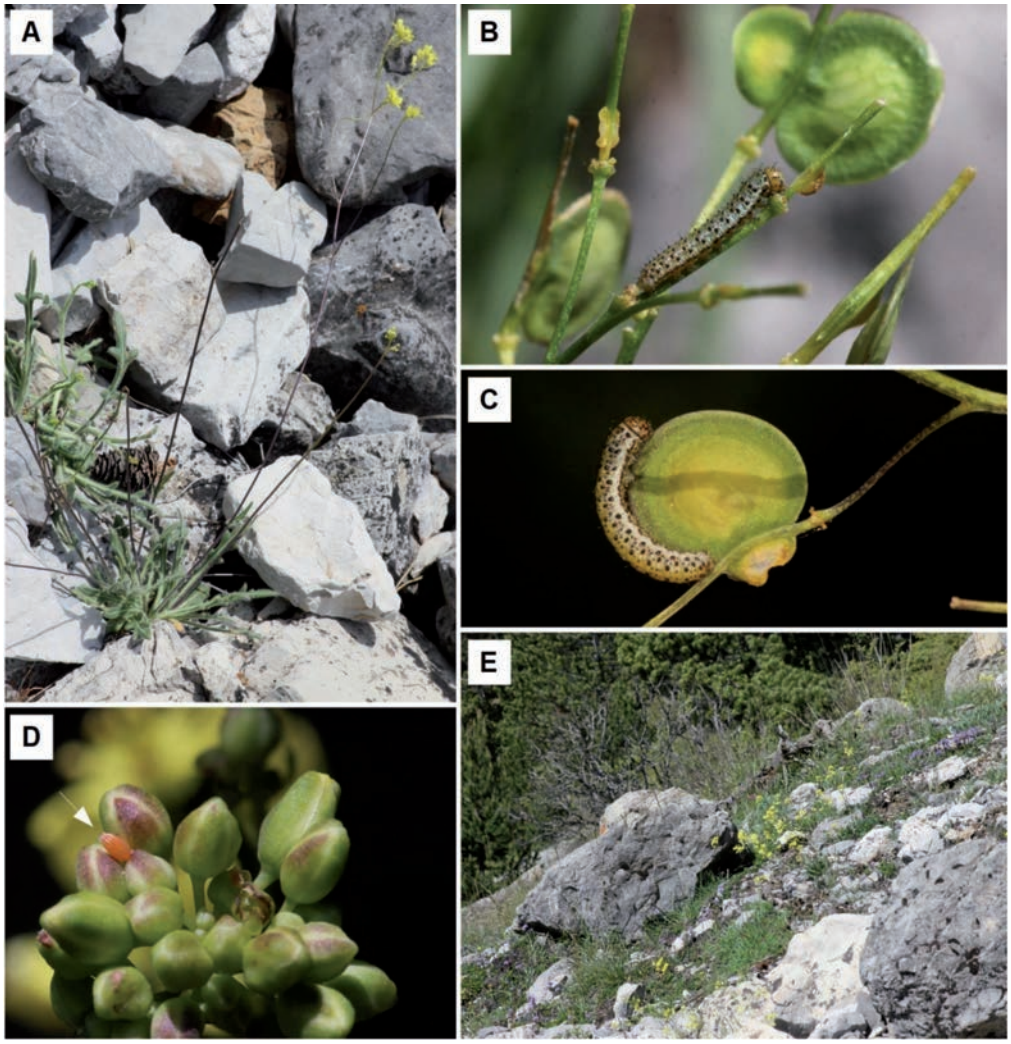

Fig. 4. Reproduction of *A. euphenoides* on *B. brevicaulis*. A) Flowering host plant individual (June 18th, 2024); B) immature caterpillar feeding on the raceme, with the characteristic discoidal siliques (July 15th, 2023); C) immature caterpillar feeding on a silique (July 4th, 2024); D) egg laid a few days ago (June 15th, 2023); E) habitat consisting of a calcareous scree slope colonized by pioneer vegetation (June 15th, 2023).

Tab. 3. Summary of previous records collected from the literature. The included toponyms and corresponding bibliographic references are listed for each 10×10 km grid cell provided by Balletto *et al.* (2007). For each cell, the presence detected during surveys and the associated host plant are reported. Any observed residual presence of host plants is indicated for cells where no presence was detected.

Cell	Toponym	Reference	*A. euphenoides*	Host plant	
				E. nasturtiifolium	*B. brevicaulis*
LQ19	Bardonecchia	Rocci (1911), Verity (1947), Balletto & Toso (1978), Hellmann & Bertaccini (2004), Balletto *et al*. (2007)	x	x	x
LQ29	Bardonecchia	Rocci (1911), Verity (1947), Balletto & Toso (1978), Hellmann & Bertaccini (2004), Balletto *et al*. (2007)	x	x	
	Oulx	Ghiliani (1852), Curò (1874), Rowland Brown (1899)*, Rocci (1911), Verity (1926, 1947), Rocca (1948), Storace (1962), Balletto & Toso (1978), Hellmann & Bertaccini (2004), Balletto *et al.* (2007), Hellmann & Parenzan (2010)	x	x	
LQ39	Oulx	Ghiliani (1852), Curò (1874), Rowland Brown (1899)*, Rocci (1911), Verity (1926, 1947), Rocca (1948), Storace (1962), Balletto and Toso (1978), Hellmann & Bertaccini (2004), Balletto *et al.* (2007), Hellmann & Parenzan (2010)	x	x	
	Salbertrand	Rocca (1948)	x	x	
	near Forte Pramand (Salbertrand)	Hellmann & Bertaccini (2004)	x	x	
	Exilles	Giorna (1791), Rocci (1911), Curò (1874), Verity (1947), Rocca (1948)		x	
	San Colombano (Exilles)	Gribodo (1920); Verity (1947)		x	
LQ49	Susa	Ghiliani (1852), Gribodo (1920), Verity (1947), Giorna (1971),		x	
	Meana di Susa	Gribodo 1920, Verity (1947), Balletto & Toso (1978)		x	
	Fontana Maubert (Meana di Susa)	Verity (1947), Rocca (1948), Balletto *et al*. (2007)		x	
LQ28	Oulx	Ghiliani (1852), Curò (1874), Rowland Brown (1899)*, Rocci (1911), Verity (1947), Rocca (1948), Storace (1962), Balletto & Toso (1978), Hellmann &Bertaccini (2004), Balletto *et al.* (2007), Hellmann &Parenzan (2010)	x	x	
	Cesana Torinese	Verity (1926, 1947), Storace (1962), Balletto & Toso (1978), Hellmann & Bertaccini (2004), Hellmann & Parenzan (2010),	x	x	
	Balbiere (Cesana Torinese)	Hellmann & Bertaccini (2004)	x	x	
	Desertes (Cesana Torinese)	Hellmann & Parenzan (2010)	x	x	

Continua nella pagina seguente

Tab. 3. *Segue dalla pagina precedente.*

LQ38	Oulx	Ghiliani (1852),Curò (1874), Rowland Brown (1899)*, Rocci (1911), Verity (1926, 1947), Rocca (1948), Storace (1962), Balletto & Toso (1978), Hellmann and Bertaccini (2004), Balletto *et al.* (2007), Hellmann and Parenzan (2010)		x	
	Cesana Torinese	Verity (1926, 1947), Storace (1962), Balletto & Toso (1978), Hellmann & Bertaccini (2004), Hellmann & Parenzan (2010)		x	
	Sestriere	Storace (1962), Balletto *et al*. (2007)		x	x
LQ27	Cesana Torinese	Verity (1926, 1947), Storace (1962), Balletto & Toso (1978), Hellmann & Bertaccini (2004), Hellmann &Parenzan (2010)	x	x	x
	Claviere	Gianelli (1890), Rocci (1911), Verity (1947), Rocca (1948), Hellmann & Bertaccini (2004)	x	x	x

*The record states "on the Mont Cenis Road, on June 24th, at about 3500 ft". However, the manuscript incorrectly reports the author crossing the Col du Mont Cenis to reach Oulx from Briançon, whereas the route actually crosses the Col du Montgenèvre. We have therefore attributed this observation to the Montgenèvre road at approximately 1067 m, which falls within the Oulx territory.

The same plant was also present sporadically along some roadsides and along the reaches of the Dora Riparia River in the municipality of Exilles, where *A. euphenoides* was reported in the past by several authors (Giorna, 1791; Curò, 1874; Rocci, 1911; Gribodo, 1920; Verity, 1947; Rocca, 1948). Finally, a few individuals of *E. nasturtiifolium* and *B. brevicaulis* were also present near Sestriere (Storace, 1962, Balletto *et al.*, 2007), but *A. euphenoides* was not found there despite numerous surveys. Overall, 15 observations were recorded within protected areas. The species was reconfirmed in all the protected areas where it had been previously reported, including IT1110049 "Les Arnaud e Punta Quattro Sorelle," IT1110040 "Oasi xerotermica di Oulx - Auberge", IT1110043 "Pendici del Monte Chaberton" and IT1110042 "Oasi xerotermica di Oulx - Amazas" (Sindaco *et al*., 2009). Its presence was also recorded a few hundred meters away from IT1110010 "Gran Bosco di Salbertrand".

Discussion and Conclusions

The reproduction of *A. euphenoides* was recorded at a maximum elevation of 2055 m, which is about 300 m higher than previously reported in the study area (Hellmann & Bertaccini, 2004; Hellmann & Parenzan, 2010). This could be due to either a previous under-sampling of the species or a response to the rising temperatures observed in recent decades in the Alps (Auer *et al*., 2007; Gobiet *et al.*, 2014; Begert & Frei, 2018), which have led many butterfly species to shift their range to higher altitudes (Rödder *et al*., 2021; Habel *et al*., 2023; Kerner *et al*., 2023).

Our findings suggest that *A. euphenoides* in the Susa Valley primarily utilizes *E. nasturtiifolium* as its main host plant. Conversely, the use of *B. brevicaulis* was recorded in few sites (Fig. 2 and Tab. 3). However, gravelly slopes where this latter plant typically grows were more difficult to survey, so its use may only appear less frequent. The reproduction of *A. euphenoides* on *E. nasturtiifolium* in Italy is reported here for the first time. However, Balletto *et al.* (2023), in their recent comprehensive monograph on Italian butterflies, indicated a question mark regarding this plant, suggesting a potential use in Italy as well. Its utilization was already reported in the nearby French Pre-Alps, where Lafranchis *et al.* (2015) documented a pre-imaginal stage on this plant, describing this event as occasional. Palanca Soler & Galante (1977) and García-Barros *et al.* (2013) also mentioned this host plant for Spain. The use of *B. brevicaulis* instead represents unpublished information for the species.

Hellmann & Bertaccini (2004) indicated *B. laevigata* as the host plant for the population of *A. euphe-*

noides object of this research, along with *B. ambigua*, *B. didyma* and *B. dentata*, which probably refer to *Biscutella laevigata* var. *dentata* Gren. & Godr., synonymous with *B. laevigata* (Govaerts, 2024). According to our observations, the use of *B. laevigata* is instead highly unlikely in the study area, as despite it being rather common, this plant has never been observed in presence sites. Regarding the other two plants, their distribution does not include the area covered by this study: *B. ambigua* is found in western Liguria and Provence, while *B. didyma* is present in southern Italy (Pignatti, 2017; Bartolucci *et al*., 2018). Regarding potential sources of confusion, the only shared characteristic between *E. nasturtiifolium* and *B. laevigata* is the bright yellow color of the flowers. In contrast, the overall appearance of the plants is quite distinct, as *E. nasturtiifolium* is notably larger than plants of the genus *Biscutella*, with noticeable differences in the shape of leaves and fruits (Pignatti, 2017). The differences between *B. brevicaulis* and other plants of its genus are instead more subtle, since the latter has a smaller overall size especially of the leaves (Raffaelli, 1986; Pignatti, 2017). We tend to exclude a change in the hosts preferences that occurred over time, as few individuals of *E. nasturtiifolium* were also present even in areas where the species now appears to be locally extinct. Furthermore, it can be excluded that these plants spread in the study area recently. Indeed, in the comprehensive monograph concerning the flora of the Val di Susa written by Re *et al.* (1881), *E. nasturtiifolium* (indicated by the author as *E. obtusangulum* Reich) was reported as present at the end of the 19th century along roads, in sandy areas near water, and in pastures of the study area, *i.e*., in environmental condition that roughly corresponds to what can still be observed today. This work also referred to *B. brevicaulis* (indicated by the authors as *B. coronopifolia* Re-All.) at high altitude near Cesana, which is a toponym that overlaps with what can be also observed today. This species was previously considered endemic to France, then confirmed in Italy only in the upper Susa Valley (Raffaelli, 1986). Its distribution precisely coincides with the areas where the reproduction of *A. euphenoides* has been documented through this study. Overall, the presence of the recorded host plants was already certain at the end of the 19th century in the study area, *i.e.*, a few decades later and before the first records of *A. euphenoides* (Giorna, 1791; Curò, 1874; Ghiliani, 1852; Rocci, 1911; Gribodo, 1920). According to these considerations, we suggest that a genuine misidentification of plant species may have occurred in the past, and that the information was subsequently transcribed without further verification. In this regard, the host plants reported by Hellmann & Bertaccini (2004) coincide with those listed in earlier publications by Verity (1905, 1947), more than half a century before the publication of the identification keys used in this study.

Given its conspicuousness, which makes it unlikely to be overlooked if present, we believe that *A. euphenoides* was not present in historical sites where it was not detected through our specific investigations. The species was not observed in two of the seven 10×10 km cells where it had been previously recorded. Furthermore, a review of the GBIF (www.gbif.org), iNaturalist (www.inaturalist.org), and Observation (www.observation.org) databases revealed no records for these cells. These data suggest a potential contraction in its distribution in the Susa Valley, as recently reported for central Italy (Balletto *et al*., 2015; Balletto *et al*., 2016). In historical sites where the species appears to be locally extinct, but a few individuals of potential host plants persist, we hypothesize that host plant abundance has decreased, reaching a number insufficient to support the persistence of the species, as *A. euphenoides* typically lays only one or a few eggs per plant (Balletto *et al*., 2023). This decrease may have been caused by woody encroachment, a common consequence of land abandonment in mountainous areas (Tasser & Tappeiner, 2002; Tasser *et al*., 2005), which represents one of the main drivers of changes in butterfly communities in the Alps over the past 40 years (Bonelli *et al*., 2022).

From a conservation perspective, the identification of local host plants could constitute a basis for developing management strategies aimed at preserving the *A. euphenoides* population of the Susa Valley. Conservation measures should be applied at least in the protected areas where the species is present. Essential information on the distribution and ecology of host plants is summarized below, along with key recommendations for management aimed at conserving them in suitable habitats for *A. euphenoides*.

- *E. nasturtiifolium*: in Italy, it is distributed in the northern part, where it is more commonly found in riverbanks, gravel deposits, ruins, and railway embankments, between 200 and 2000 m of elevation (Pignatti, 2017). In France, it is distributed from 0 to 2200 m, mainly on the Jura, Alps, and

Pyrenees, where it mainly occupies steppe grasslands, scree, and secondarily in eutrophic wastelands, on calcareous soils (Tison & De Foucault, 2014). According to our observations, this species in the Susa Valley grows on roadside margins, artificial sand accumulations, riverbanks and, overall, in sparse Scots pine woodlands of south-facing slopes and river terraces. In these latter habitats, *A. euphenoides* seems to find higher densities of this host plant. To preserve the plant in these conditions, we suggest avoiding grazing and mowing in presence sites during its vegetative period (April-July), maintaining low-density woodlands by applying forest thinning, and, above all, maintaining the natural dynamics of floodplains to allow the renewal of succession stages suitable for the species.

- *B. brevicaulis*: in Italy, it is exclusively reported from a few areas in the upper Susa Valley, where it selects calcareous scree at altitudes between 1400 and 2700 m of elevation (Raffaelli, 1986, Pignatti, 2017). In France, its range extends southeast, mainly within the PACA and Rhône-Alpes administrative regions, where it occupies mobile to more stable screes and calcareous rocky meadows between 1200-2200 m of elevation (Tison & De Foucault, 2014). Furthermore, it is considered an indicator of calcareous rocky slopes with chasmophytic vegetation, a protected habitat (code 8120) listed in Annex I of the Habitats Directive 92/43/EEC (Bensettiti *et al.*, 2004). According to Raffaelli (1986), it constitutes a pioneer species which tends to become dominant in shifting gravel habitats, while it tends to disappear in increasingly stabilized soils. The sites where we recorded the presence of *A. euphenoides* associated with this plant consisted of rocky calcareous slopes with sparse coniferous tree cover. To preserve the host plant in this condition, we suggest maintaining the mobility of the slopes occupied by the species, avoiding stabilization measures that could lead to the loss of natural renewal of suitable habitats.

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