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R. Vaira (*), A. Carta (**), G. Trombetti (***), G. Bedini (**)

NEWLY DESCRIBED POPULATION OF *CENTAUREA MONTIS-BORLAE* SOLDANO, NARROW ENDEMIC OF APUAN ALPS (NW TUSCANY, ITALY), INCREASES AREA OF OCCUPANCY BUT CONFIRMS STENOECY OF THIS SPECIES

Abstract - The authors report for the first time the extent of a population of the endangered endemic species *Centaurea montis-borlae* Soldano (*Asteraceae*), located on the East ridge of Mount Sagro (Apuan Alps, Tuscany, MS) between 1200 and 1590 m a.s.l. Area, altitudinal range, slope and aspect are discussed and compared with those of the general area to point out ecological preferences. The species is an obligate calciphyte with an exclusive preference for marble and tends to avoid northerly and easterly aspects.

Key words - *Centaurea montis-borlae*, distribution, Apuan Alps, Sagro mountain.

Riassunto - *Una popolazione, descritta per la prima volta, di* Centaurea montis-borlae *Soldano, endemica stretta delle Alpi Apuane (Toscana Nord-occidentale, Italia), aumenta la superficie occupata ma conferma la stenoecia di questa specie*. Viene descritta per la prima volta una stazione di *Centaurea montis-borlae* Soldano (*Asteraceae*), specie endemica minacciata delle Alpi Apuane settentrionali, Toscana, MS, posta sul versante est del monte Sagro tra 1200 e 1590 m s.l.m. Area, intervallo altitudinale, pendenza ed esposizione sono confrontate con quelle dell'area circostante per evidenziare le preferenze ecologiche. La specie è una calcicola obbligata con preferenza esclusiva per il marmo e tende a evitare esposizioni settentrionali e orientali.

Parole chiave - *Centaurea montis-borlae*, distribuzione, Alpi Apuane, Monte Sagro.

Introduction

The Apuan Alps are an isolated mountain massif, adjacent to, but distinctly separated from, the Tuscan Apennines and delimited by the rivers Magra, Aulella and Serchio in the North, East and South, respectively, and by the Versilian plains and the Thyrrhenian Sea in the West. The Apuan Alps occupy an elliptical area of about 55x25 km, the main axis being oriented NW-SE. The highest peaks (Monte Pisanino, Monte Cavallo, Monte Tambura, Pizzo d'Uccello) reach almost 2000 m a.s.l. The area has a great variety of rocks and soils (Carmignani *et al.*, 2001) and has been well known for its marble quarries since Roman times. The climate is very variable, both over the seasons and at the different altitudes and aspects (Rapetti & Vittorini, 1994).
Centaurea montis-borlae Soldano (Fig. 1) is a narrow endemic species of the northern part of the Apuan Alps (Province of Massa-Carrara), recognized as a separate specific unit rather recently (Soldano, 1978; 1978a). The well known population of Foce di Pianza, at the foot of Mount Borla, has a strict ecological preference for marble substrates (Carmignani *et al.*, 2001; Vaira *et al.*, 2004; Ansaldi *et al.*, 2004).
In 1999, during a monitoring campaign undertaken to assess the IUCN risk category of the species (Vaira *et al.*, 2004; Ansaldi *et al.*, 2004), all stations reported by Soldano (1978; 1978a) and Ferrarini (2001) were confirmed, except «Poggio della Signora», where the species was not found despite extensive search, and «East Ridge of Mount Sagro», which was not visited due to the rugged terrain of the area, accessible only to climbers.
The latter report is based on a herbarium specimen kept at the «Liceo Scientifico G. Marconi» Herbarium, Carrara (MS), collected by E. Ferrarini on 29 July 1963, sub *Centaurea jacea* L. var. *nigra* (L.) Fiori, «in meadows, limestone with flint inclusions, at 1600 m».
According to D. Marchetti (*in verbis*), Ferrarini noticed «few individuals» of the plant during a climbing expedition to Mount Sagro via the East Ridge.
Because Ferrarini's report (2001) was never supported by other, successive findings, doubt remained about 1) the consistency of the Mount Sagro population, and 2) the ability of the plant to live on limestone with flint inclusions, which would broaden the substrate preference of the species.
To clarify this matter, we planned a field trip to the East Ridge of M. Sagro with the purpose of:

1. gathering geographic data to update the assessment of the IUCN risk category;
2. ascertaining the substrate type in the Mount Sagro station;
3. defining the ecological preferences of *Centaurea montis-borlae*.

Features of the station

The East Ridge is characterized by alternating geological units, namely – from base to top – «grezzoni» (Norian), megalodon-bearing marbles (Rhaetian), marbles (lower to middle Lias), limestone with flint inclusions (middle to higher Lias) (Carmignani *et al.*, 2001).
Disused marble quarries are present in the vicinity. They had been used for about a century until 1960-1965, when their exploitation became unsustainable due to difficult access to the area (Bradley & Medda, 1995).

(*) Dipartimento di Biologia Evolutiva e Funzionale Sezione di Botanica ed Orto Botanico, viale G.P. Usberti 11, 43100 Parma.
(**) Dipartimento di Biologia, Università di Pisa, via Luca Ghini 5, 56126 Pisa. E-mail: gbedini@biologia.unipi.
(***) Via Silicani 7, 54033 Fossola Carrara (MS).

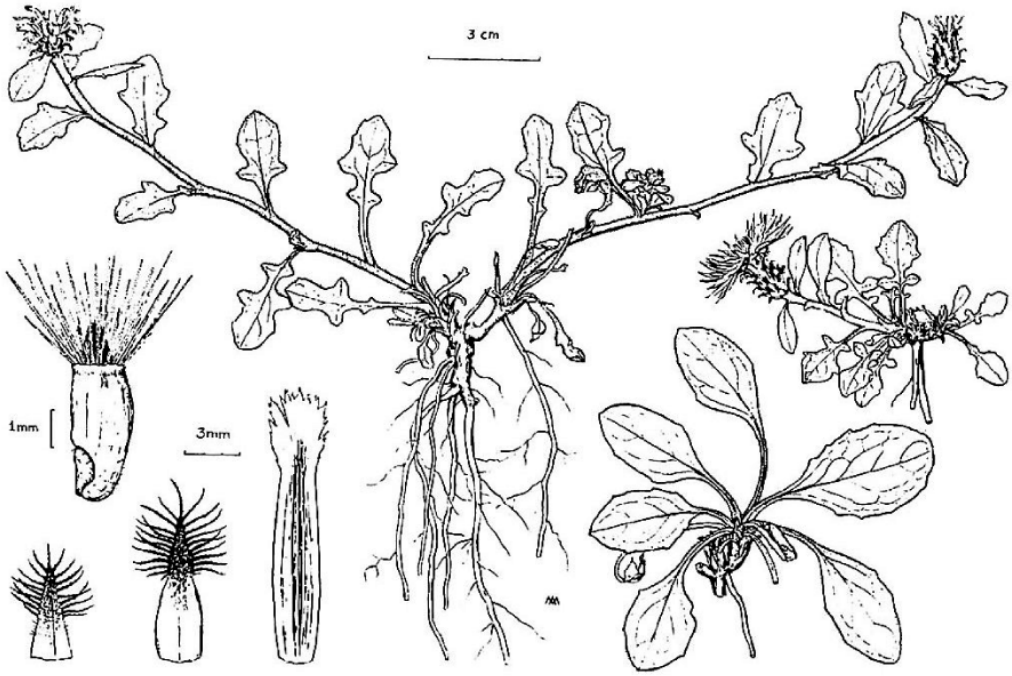

Fig. 1 - *Centaurea montis-borlae* Soldano. Iconography from Bechi *et al.*, 1996.

The slopes are very steep, with sudden changes of aspect.
The zone is colonized by sparse casmophytic vegetation that can be framed in the association *Sileno-Rhamnetum glaucophyllae* (Barbero & Bono, 1973).
From the administrative point of view the station is entirely comprised under the Municipality of Massa (MS). The closest toponym is Fore del Sagro, according to «Carta dei sentieri e rifugi 1:25.000 Apuan Alps F 101-102» (Multigraphic Editions 1990), but other maps report its variants Forre, Borre, or Bore.

Materials and methods

On 11 July 2009 the authors climbed the East ridge of M. Sagro, from Foce del Pollaro, at 1362 m, to the mountain summit at 1752 m (Montagna *et al.*, 1979). Collected specimens were deposited at PI. *C. montis-borlae* population's boundaries were mapped during subsequent visits, by means of a Trimble Pro XR GPS receiver, with sub-metric accuracy, and an Intermec handheld device running ESRI ArcPad 6.0.3. Geodata from the handheld device were then downloaded to a PC for further analysis with ArcView 3.3 (ESRI). The polygons (shapefiles) of a) the East ridge population, b) the marble outcroppings at the East ridge and at Foce di Pianza (provided by the Apuan Alps Natural Park), and c) the Foce di Pianza population (Ansaldi *et al.*, 2008) were superimposed onto a vectorial map of the area (1:10.000). To assess the plant's preference for substrate, altitude, slope, and aspect a Digital Terrain Model (DTM) of the area, with 10x10m cells, was obtained from the contour lines (contour interval = 25 m). Only cells with an altitude > 1000 m were considered in our analyses. For each population (Foce di Pianza and East ridge) we calculated area and maximum, minimum, mean and standard deviation of altitude and slope, and compared them with the same data calculated for the marble outcroppings. Aspect data were grouped into four classes: N (> 292°-67°); E (> 67°-112°); S (> 112°-247°); O (> 247°-292°). For each class, the percentage frequency was calculated as c/C*100, where c = number of cells in a class, and C = total number of cells in each shapefile (East ridge population, East ridge marble outcropping, Foce di Pianza population, Foce di Pianza marble outcropping).

Results and discussion

We found several individuals of *Centaurea montis-borlae* at the East ridge station. Herbarium specimens are deposited in PI.
The population boundaries are shown in Figures 2 and 3.

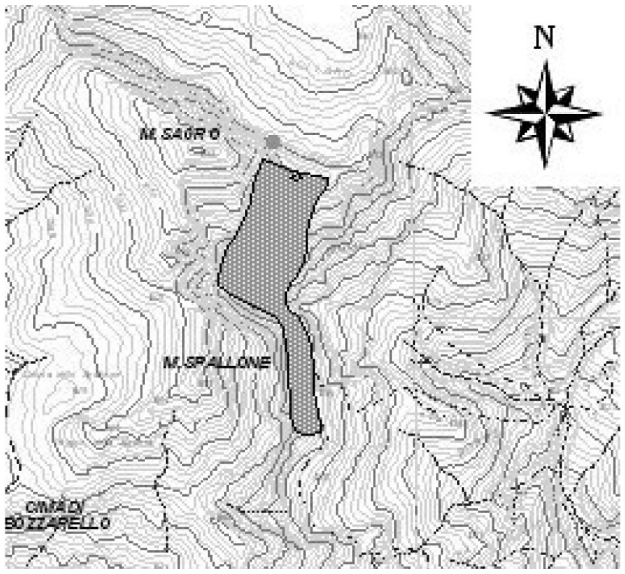

Fig. 2 - Map of the East Ridge of Mount Sagro (Apuan Alps). The shaded area is the station of *Centaurea montis-borlae* Soldano. Map Scale 1:20.000.

Its area and its percentage relative to total area are shown in Table 1, along with the same data for the population of Foce di Pianza. The population of East Ridge occupies a smaller area than that of Foce di Pianza.
Based on the population of Foce di Pianza, the species was categorised as vulnerable (VU) under IUCN (2006) criterium D, subcriterium D2: «Population with a very restricted area of occupancy (Typically Less Than 20 km^2)» (Bedini & Boracchia, 2008).
In spite of the increase contributed by the East ridge station, the species' area of occupancy remains below the threshold value set for the VU (vulnerable) risk category. Therefore, we propose no change to the risk category assessed by Bedini & Boracchia (2008).
The East ridge station falls entirely on marble substrate (Fig. 4). In fact, it closely matches its borders on the southern slope of the ridge, until it reaches its lower limit at about 1200 m a.s.l. (Tab. 2).
This finding is in contrast with the report by Ferrarini (2001) quoted in the Introduction. In this respect, we suggest that Ferrarini's indication of the substrate was based on subsequent georeferencing of his finding on a geological map – see e.g. Carmignani *et al.* (2001) – and not on *in situ* recording. We further speculate that he placed the station on the map at the intersection of the East Ridge trail with the 1600m contour line, based on his *in situ* recording or subsequent estimation of altitude. Given these assumptions, he correctly indicated the substrate as «limestone with flint inclusion». In our observations, we have found the East Ridge plants growing along the trail up to 1590 m, on marble, next to the contact with limestone with flint inclusions. The slight error in Ferrarini's recording of altitude caused him to place the East Ridge station inside the limestone with flint inclusions formation rather than in the adjacent marble one.
We therefore confirm that the plant is stenoecious as regards the substrate, being an obligate calciphyte exclusively adapted to marble substrates, for which we propose the term «marmarophyte» (from the Greek term μάρμαρος = marble).
The results of the analysis of geographic factors (altitude, slope) are shown in Table 2. The data have been calculated for the plant population and for the whole marble outcropping of the East ridge.

Tab. 1 - Area of populations.		
Station	**Area (m^2)**	**% of total**
Foce di Pianza	111.741	63.00%
East ridge	65.754	37,00%
TOTAL	177.495	100.00%

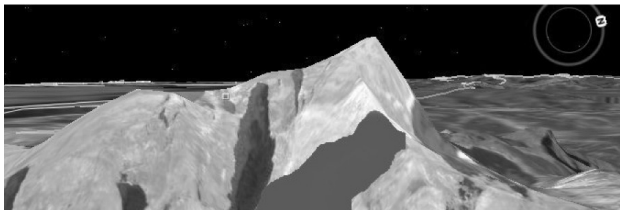

Fig. 3 - 3D view of the East Ridge of Mount Sagro (Apuan Alps). The shaded area is the station of *Centaurea montis-borlae* Soldano.

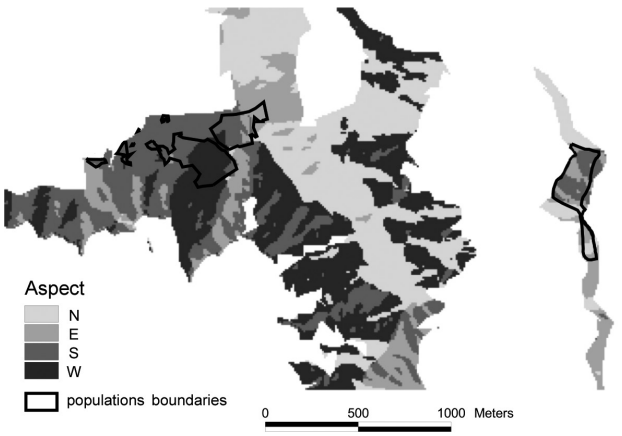

Fig. 4 - Aspect map of marble outcroppings and of *C. montis-borlae* populations at Foce di Pianza (left) and East Ridge (right).

Tab. 2 - Area, altitude, slope and aspect for the plant population (PP) and marble outcropping (MO) at the East ridge station.

	Area (ha)	**Altitude (m)**		**Slope (°)**	
		Min.-max.	Mean ± SD	Min.-max.	Mean ± SD
PP	6.57	1199-1590	1363 ± 95.64	3.55-73.98	46.02 ± 11.15
MO	17.00	1104-1663	1335 ± 117.9	2.84-82.30	44.29 ± 14.37

C. montis-borlae is little selective for altitude and slope. Since its altitudinal limits do not reach those of the marble outcropping, they might reflect an autoecological requirement rather than a substrate limitation. In any case, the population's mean values are slightly higher than those of the whole marble outcropping. On the other hand, the plant is quite selective for aspect. Given that the East Ridge marble outcropping is orientated mainly towards S and E, with a minor part facing N and no W-facing slopes (Fig. 5), *C. montis-borlae* appears to prefer S-facing slopes, and to avoid E- and N-facing ones.
Based on the distribution data reported by Ansaldi *et al.* (2008) for Foce di Pianza, we calculated the same data for the whole *C. montis-borlae* population (Tab. 3; Fig. 6). Again, the plant appears to avoid northerly and easterly aspects, confirming the results obtained for the East Ridge population. This autoecological character, confirming the species' stenoecy, had so far eluded researchers' attention.

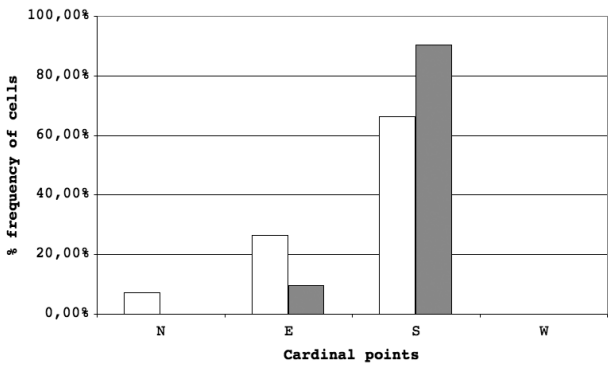

Fig. 5 - Aspect frequency for marble outcroppings (white boxes) and for *C. montis-borlae* populations (grey boxes) at East Ridge.

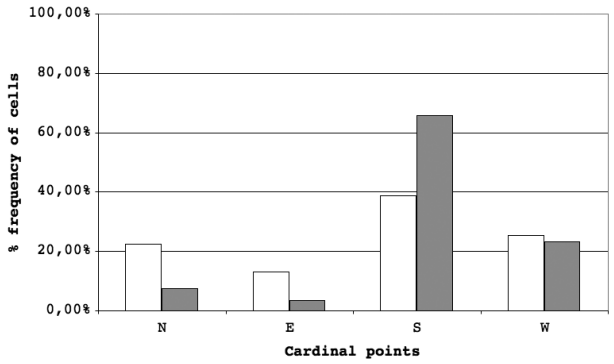

Fig. 6 - Aspect frequency for marble outcroppings (white boxes) and for *C. montis-borlae* populations (grey boxes) in the species' whole range.

Conclusions

We found a sizeable, hitherto undescribed population of the Apuan endemic *C. montis-borlae* at the East Ridge of M. Sagro. Its area was added to that of the known population of Foce di Pianza to update the species' AOO and IUCN risk category (VU). Despite the increase, AOO remains below the threshold value for VU category under criterium D, subcriterium D2. We therefore confirm its classification as VU D2.
The species has a strict preference for marble substrates. Previous reports of it growing on limestone with flint inclusions should be regarded as erroneous. We propose the new term «marmarophyte» to designate it as obligate calciphyte with an exclusive preference for marble (μάρμαρος in Greek).
The species has a further preference for southerly aspects and avoids northerly and easterly aspects, both in the study site and in its whole range. The species' stenoecy is therefore confirmed both for substrate and aspect.
To clarify the exclusive preference for marble, chemical analysis of soil and of whole plants are in progress and will be duly reported. Germination tests are

Tab. 3 - Area, altitude, slope and aspect for the plant populations (PP) and marble outcropping (MO) in the whole range.

	Area (ha)	**Altitude (m)**		**Slope (°)**	
		Min.-max.	Mean ± SD	Min.-max.	Mean ± SD
PP	17.75	1152-1590	1285 ± 88.78	0.00-73.98	32.98 ± 14.74
MO	243.54	1000-1663	1239 ± 110.90	0.00-82.30	30.33 ± 2.94

being conducted both *in situ* and in the laboratory, to check whether the substrate type inhibits germination of seeds. Finally, a comprehensive PVA study is in progress, to evaluate the extinction risk of this species in the next 100 years.

Specimina Visa

Spigolo est del Sagro, nelle cenge erbose su calcare a liste di selce, esp. est, alt. 1600 m 29.VII.1963. *E. Ferrarini* (Herbarium Liceo Scientifico «G. Marconi», Carrara (MS)) *sub Centaurea jacea* L. var. *nigra* (L.) Fiori;
Nelle fessure delle rupi di marmo, a q. 1300 m, esp. Sud, alla Foce di Pianza nelle pendici del M. Borla, Alpi Apuane. 27.VIII.1960. *Ferrarini* (SIENA);
Versante meridionale del Poggio della Signora, nelle pendici del M. Spallone, a q. 1500 m circa. Gruppo del M. Sagro, sopra Carrara. Alpi Apuane. Su calcare a liste di selce. 5.IX.1983. *Marchetti* (SIENA);
Foce di Pianza (gruppo del Sagro: Alpi Apuane. Alt. 1200 m; 3.VIII.1977 (Typus). *Soldano* (FI *sub Centaurea montis-borlae* mihi);
Toscana. Massa. Fivizzano: piedi del Monte Borla alle cave Walton. m 1250. 24.VII.1977.*Soldano* (FI *sub Centaurea montis-borlae* mihi).

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(ms. pres. il 27 marzo 2011; ult. bozze il 12 ottobre 2011)

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