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CEPHALARIA BIGAZZII (*DIPSACACEAE*), A NEW RELIC SPECIES OF THE *CEPHALARIA SQUAMIFLORA* GROUP FROM SARDINIA

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A new species of *Cephalaria*, *C. bigazzii* Bacch., Brullo & Giusso (*Dipsacaceae*), is described and illustrated. It is a typical chasmophyte, exclusive to a small area of SW Sardinia where it grows together with several other rare endemics. It belongs to the *Cephalaria squamiflora* group, showing close relationships with *C. mediterranea* and *C. balearica*. Its ecology, distribution and conservation status are examined. A distribution map of the new species and related species is provided. A new status and combination is proposed for *Cephalaria ebusitana*.

Keywords. Cephalaria, chorology, *Dipsacaceae*, new species, Sardinia, taxonomy.

Introduction

The *Cephalaria squamiflora* (Sieber) Greuter complex (*Dipsacaceae*) is composed of a group of diploid plants growing on the cliffs of many Mediterranean islands (Greuter, 1967; Arrigoni & Mori, 1976; Verlaque, 1985). The populations of the western Mediterranean area (Balearic Islands and Sardinia) and some Aegean Islands (Crete, Karpathos and Ikaria) have been the most studied.

According to the literature (Arrigoni, 1978), the eastern populations should be referred to *Cephalaria squamiflora*, originally collected from Crete (Sieber, 1818), those from Sardinia to *C. mediterranea* (Viv.) Szabó, and those from the Balearic Islands to *C. balearica* Coss. ex Willk.

The populations found in Sardinia and the Balearic Islands are morphologically more similar than the Aegean ones, even though differences, mainly in leaf shape, inflorescence and flowers, allow us to distinguish them easily.

The taxonomic treatment of the *Cephalaria squamiflora* group is quite complex (Szabó, 1922, 1940; Fiori, 1927; Greuter, 1967; Ferguson, 1976; Arrigoni, 1978; Pignatti, 1982; Bolòs & Vigo, 1988; Mus *et al.*, 1990; Bolòs, 1991; Romo, 1994; Rosselló & Sáez, 2000). The taxa belonging to this group have been treated as distinct species or considered subspecies, or sometimes varieties, of *Cephalaria squamiflora*, *C. balearica* and *C. mediterranea*, or more rarely of *C. leucantha* (L.) Roem. & Schult. and *C. rigida* (L.) Roem. & Schult.

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In order to clarify this taxonomic question specimens of the above-mentioned populations were collected on the various islands where they had been recorded (Sardinia, Majorca, Ibiza, Crete, Karpathos and Ikaria). During these field investigations a very peculiar population, well differentiated from the other known taxa, was found in SW Sardinia. It is geographically quite isolated from the other populations occurring in the northeastern part of Sardinia. The SW Sardinia population was previously recorded by Ballero *et al.* (2000) and Maxia & Usai (2004) and identified as *Cephalaria mediterranea*. It has been reported that this population exhibits a unique chloroplast DNA haplotype, differing by up to two mutations in the *trn*L intron from the other Western Mediterranean haplotypes (Rosselló, pers. comm.).

Based on morphological differences obtained from herbarium and literature data, the SW Sardinia population is described as a species new to science and named *Cephalaria bigazzii* Bacch., Brullo & Giusso.

Materials and Methods

This study is based on literature data and herbarium specimens from B, BC, BCF, CAG, CAT, FI, G, M, MAIC, NAP, SASSA, SS, RO, TO, VAL, W and WU, while the morphological analysis is mostly based on living material collected during field investigations carried out in Sardinia, Majorca, Ibiza, Crete, Karpathos and Ikaria. Twenty herbarium specimens (c.10 individuals) were collected from the type locality.

Description

Cephalaria bigazzii Bacch., Brullo & Giusso, **sp. nov. Figs 1–3.**

Differt a *Cephalaria mediterranea* foliis basalibus glabris margine, plerumque simplicibus, limbo rotundato vel ovato, 5–9 cm longo, 3–6 cm lato, calyce 1.3–1.5 mm alto, ciliis margine 0.2–0.3 mm longis, tubo corollae in alabastro 2–2.5 mm longo et 2.5–4 mm diametro, tubo extra piloso superne et subglabrescente inferne, interne piloso superne, lobis subaequalibus, exterioribus pubescentibus peripheriam versus, interioribus glabris peripheriam versus, filamento staminis 5–7 mm longo, staminis fauce insertis, anthera 3 mm longa, stylo 9–10 mm longo, epicalyce 1.5–2 mm longo, coronula 0.6–0.7 mm longa, minute crenata margine, dum differt a *Cephalaria balearica* foliis omnino glabris, limbi dentibus 2.5 mm longis, petiolo 2.5–9 mm longo, inflorescentia max. 3 capitulis praedita, calyce 1.3–1.5 mm alto, ciliis margine 0.2–0.3 mm longis, alabastro 5–5.5 mm longo, tubo corollae 5.5–6 mm longo, extra piloso superne et subglabrescente inferne, lobis 3–3.5 mm longis, interioribus glabris margine, staminis fauce insertis, anthera 3 mm longa, stylo 9–10 mm longo, stigma simplici, 2–4 mm longo, epicalyce 1.5–2 mm longo, coronula 0.6–0.7 mm longa. – Type: Italy, Sardinia, Is Lisandrus, S. Nicolò di Buggerru (CA), 39°25.195′N, 8°25.140′E, 13 vii 2000, *Brullo, Casti & Giusso* s.n. (holo CAT; iso CAG, CAT, FI).

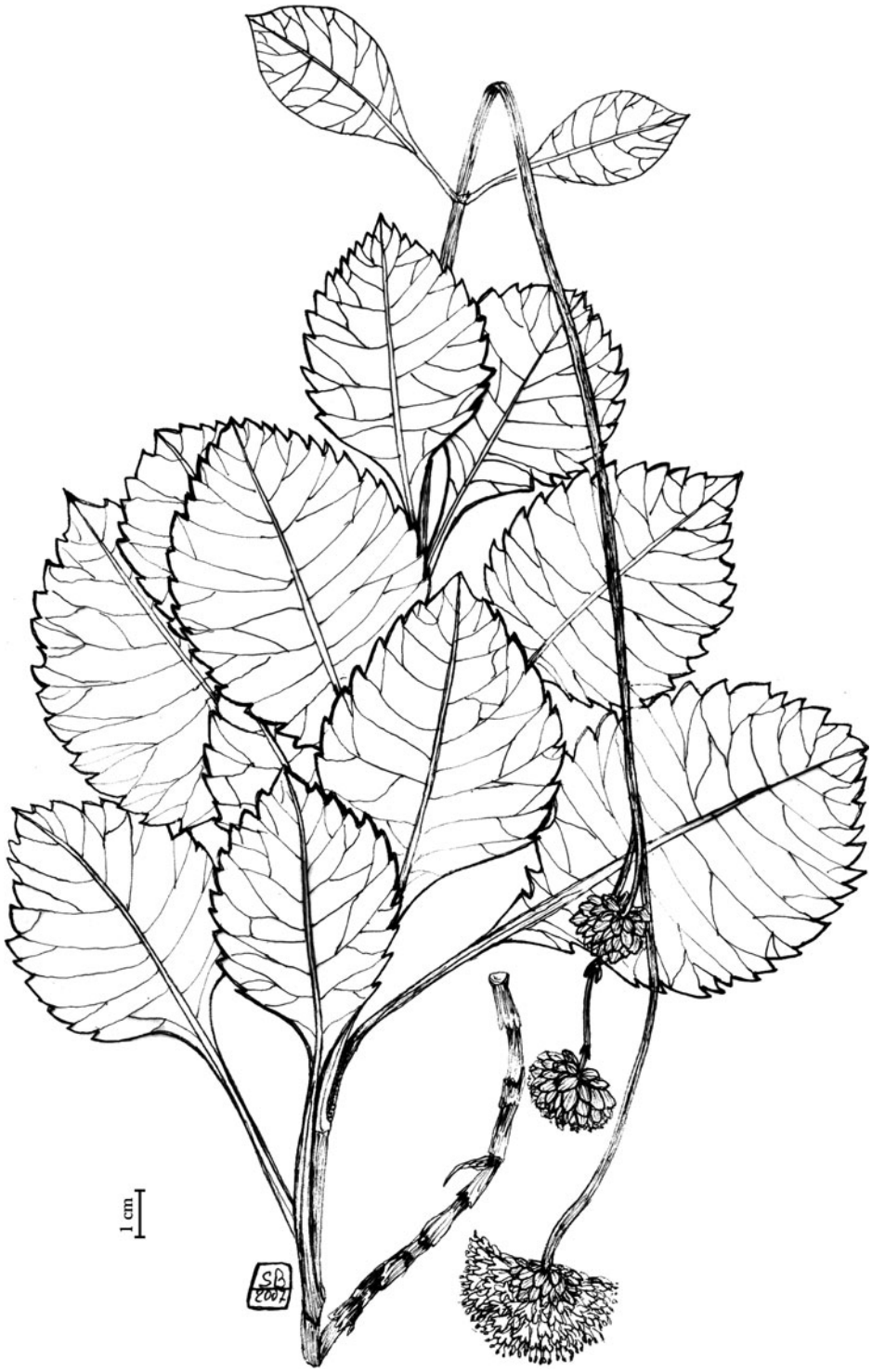

FIG. 1. Habit of *Cephalaria bigazzii* Bacch., Brullo & Giusso.

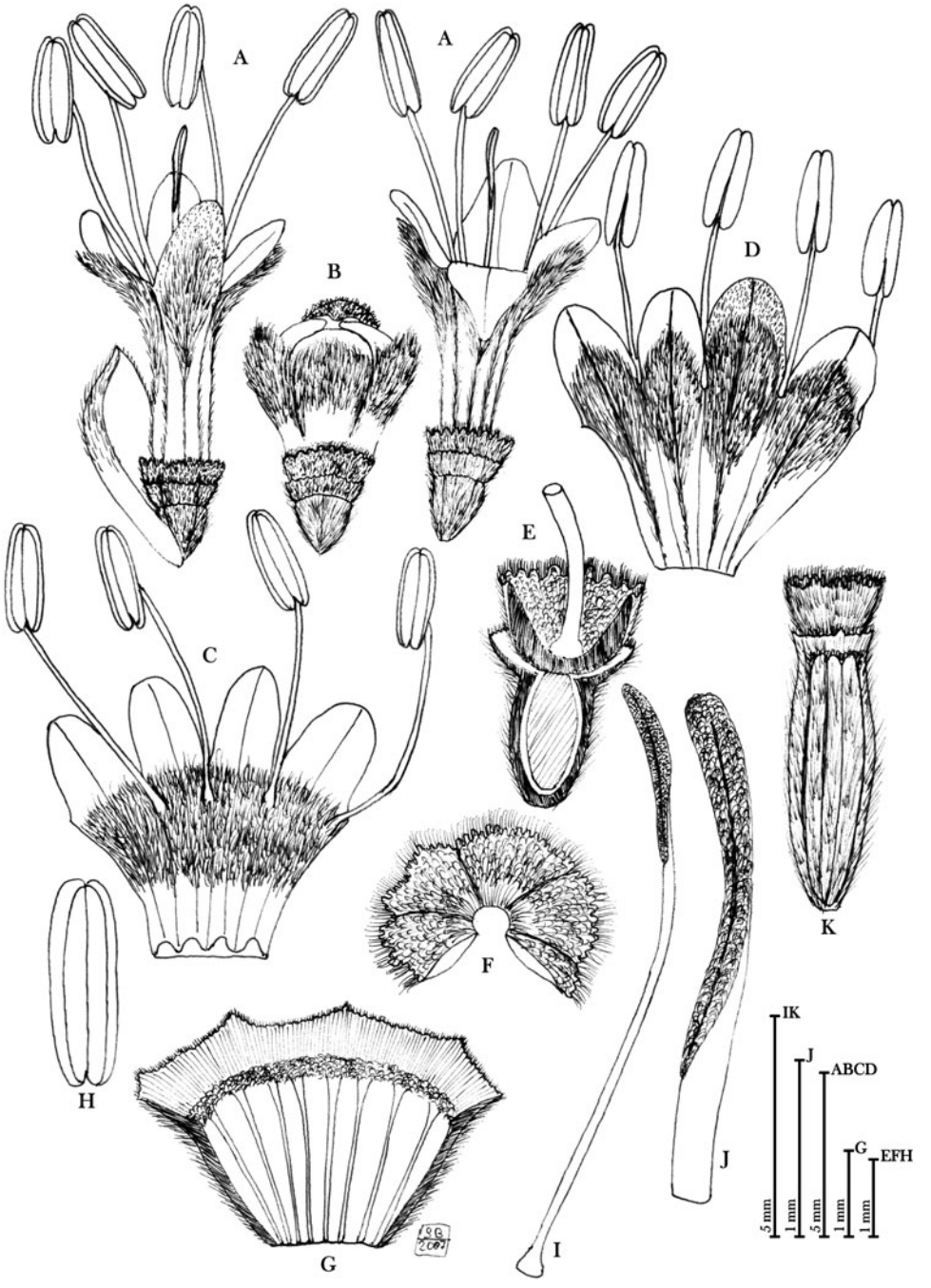

FIG. 2. Morphological characters of *Cephalaria bigazzii*: A, flowers; B, bud; C, open corolla (inner surface); D, open corolla (outer surface); E, calyx and pistil (longitudinal section); F, calyx; G, open epicalyx; H, anther; I, style and stigma; J, stigma; K, fruiting calyx and epicalyx.

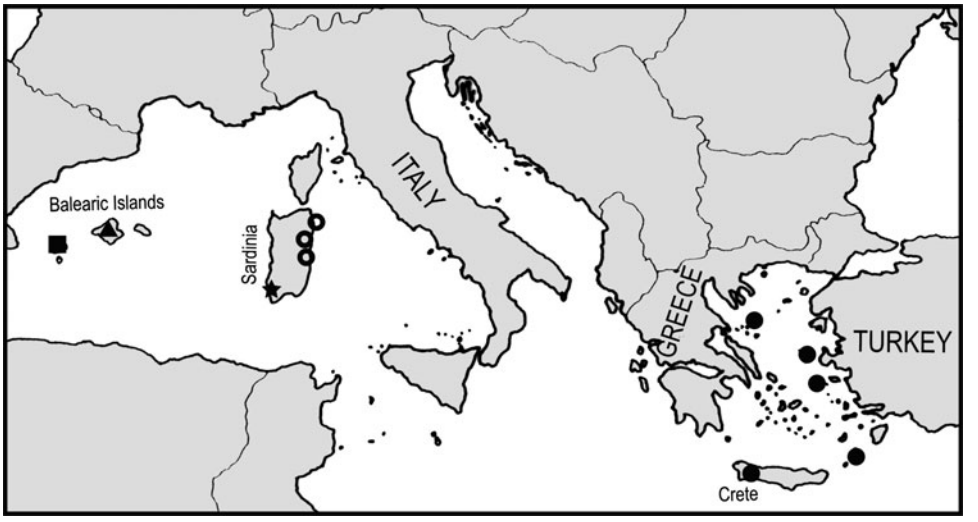

FIG. 3. Distribution map of *Cephalaria mediterranea* (◎), *C. squamiflora* (●), *C. bigazzii* (★), *C. balearica* (▲) and *C. ebusitana* (■).

Subshrub up to 70 cm tall, caespitose with woody basal branches. *Stem* annual, 40–60 cm long. *Basal leaves* dark green, glabrous, 7–18 cm long, simple or rarely with one pair of leaflets and midrib thickened, ivory; limb rounded to ovate, 5–9 cm long, 3–6 cm wide, with apex obtuse to acute-acuminate and margin serrate-crenate to subentire, with teeth 2–5 mm long; cauline leaves simple, 3.5–7 cm long, lanceolate to linear-lanceolate; petiole winged, 2–7 cm long. *Inflorescence* cymose, with 1–3 subglobose to hemispheric capitula, long pedunculate; capitula 2.5–3 cm in diameter in flower; involucral bracts 5–6 mm long, 4–5 mm wide, obovate, rounded at the apex, rigid, several-nerved, membranaceous and pubescent, ciliate at the margin; receptacular scales 6–7 mm long, 3–4 mm wide, linear-obovate, obtuse and violaceous at the apex, rigid, membranaceous and pubescent, ciliate at the margin. *Calyx* coronule-shaped, persistent, 1.3–1.5 cm high, papillose and hairy on both faces, with margin irregularly crenate, ciliate with cilia 0.2–0.3 mm long. *Corolla* 9–10 mm long, white-yellowish; tube 5.5–6 mm long, externally hairy above and only along the principal nerves below, internally hairy above; lobes subequal, 3–3.5 mm long, 2–2.5 mm wide, rounded at apex, villous in the central part, the outer one pubescent peripherally, the inner ones glabrous peripherally. *Stamens* 4, exserted; filaments 5–7 mm long, inserted at the throat; anthers elliptic, yellow, 3 mm long. *Style* 9–10 mm long. *Stigma* simple, 2–4 mm long, max. 1.2 mm wide, rounded at the apex. *Epicalyx* (involucel) hairy, pyramidal-tetragonal, 1.5–2 mm long, with a hairy coronula, irregularly crenate, 0.6–0.7 mm high. *Epicalyx* 5.5–6.5 mm long in fruit, hairy, linear-ellipsoid, tetragonal, with 2 furrows on each side and provided with a coronula 0.7 mm high, irregularly crenate-undulate and minutely ciliate at the margin.

Etymology. The species is named after Prof. Massimo Bigazzi (1953–2006), a distinguished Italian botanist whose research focused on many critical groups of the Mediterranean flora, particularly on the *Boraginaceae* and *Scrophulariaceae*.

Phenology. Flowering: July–September; fruiting: August–October.

Habitat and ecology. Cephalaria bigazzii is a chasmophyte growing on Palaeozoic dolomitic limestones. It is exclusively found on cliffs at 140–260 m altitude. According to Bacchetta (2000), the bioclimate of this area should be referred to Mediterranean pluviseasonal-oceanic, with thermotypes ranging between upper thermomediterranean and lower mesomediterranean, and ombrotypes between upper dry and lower subhumid. The species is a member of a chasmophilous plant community of the class *Asplenietea trichomanis* (Braun-Blanquet in Meier & Braun-Blanquet, 1934; Oberdorfer, 1977), rich in Sardinian and Cyrno-Sardinian endemics, such as *Bellium crassifolium* Moris var. *canescens* Gennari, *Bituminaria morisiana* (Pignatti & Metlesics) Greuter, *Calamintha sandaliotica* Bacch. & Brullo, *Helichrysum saxatile* Moris subsp. *morisianum* Bacch., Brullo & Mossa, *Seseli praecox* (Gamisans) Gamisans, and *Sesleria insularis* Sommier subsp. *morisiana* Arrigoni.

Distribution. This species is extremely rare and found only in the narrow gorge of S. Nicolò and Gutturu Cardaxius, close to Buggerru in SW Sardinia (Fig. 3). This area belongs to the Iglesiente subsector of the Sulcis-Iglesiente biogeographic sector (Bacchetta & Pontecorvo, 2005).

Conservation status. Due to its rarity and scarcity (no more than 50 individuals) at the two currently known sites, as well as the continuous threat from climbers (the sites are very popular for free-climbing and similar outdoor activities), we suggest that *Cephalaria bigazzii* be included in the IUCN Regional Red List as a critically endangered species (CR). In particular, we suggest a category of CR B1ab(ii,iii,v) + 2ab(ii,iii,v); C2a(ii) (IUCN, 2001, 2003, 2006).

Additional specimens examined. SARDINIA. Is Lisandrus, S. Nicolò di Buggerru (CA), 11 vi 1998, *Bacchetta & Brullo* s.n. (CAT); S. Nicolò, Buggerru, 135 m, 3 v 2000, *Bacchetta* s.n. (CAG); S. Nicolò, Buggerru, 175 m, esposizione NNW, 13 vii 2000, *Bacchetta & Brullo* s.n. (CAG, CAT); Lisandrus, Buggerru, su calcari dolomitici, 25 vii 2000, *Maxia & Usai* s.n. (CAG); San Nicolò, Buggerru, su calcari dolomitici, rupi, 11 v 2002, *Ballero & Cara* s.n. (CAG); Lisandrus, Buggerru, su calcari dolomitici, 30 vii 2002, *Usai & Maxia* s.n. (CAG); Is Lisandrus, S. Nicolò di Buggerru (CA), 8 xii 2002, *Brullo, Casti & Giusso* s.n. (CAG, CAT); San Nicolò, s.d., *Ballero, Cara & Loi* s.n. (CAG).

DISCUSSION

With its suffruticose habit and coriaceous leaves, *Cephalaria bigazzii* belongs to the *C. squamiflora* group which occurs on islands of the Mediterranean basin. The small number of individuals in each population, together with their scattered distribution, highlights the relic nature of this group (see Fig. 3). According to Szabó (1922), Greuter (1967), Ferguson (1976), Kamari *et al.* (1988) and Snogerup *et al.* (2001), the

populations growing in the eastern part of the Mediterranean (Crete, Karpathos, Ikaria, Chios and Yioura) should be referred to *Cephalaria squamiflora* (= *C. sieberi* Szabó). For the western Mediterranean populations, those from Sardinia have been attributed by Arrigoni (1978) and Pignatti (1982) to *Cephalaria mediterranea* (= *C. squamiflora* subsp. *mediterranea* (Viv.) Pignatti), those from Majorca (Balearic Islands) have been referred to *C. balearica* (Willkomm, 1876, 1881; Marès & Vigineix, 1880; Mus *et al.*, 1990; Rosselló & Sáez, 2000), while those from Ibiza (Balearic Islands) have been attributed to *C. squamiflora* subsp. *ebusitana* (O.Bolòs & Vigo) Romo (see Bolòs & Vigo, 1988; Romo, 1994) which is considered by Mus *et al.* (1990) a synonym of *C. mediterranea*. From morphological surveys carried out on living and herbarium material remarkable differences among the different populations become apparent. In particular, the eastern populations belonging to *Cephalaria squamiflora* s.str. show an epicalyx structure totally different from that observed in the western ones. In addition, within the western populations, it is quite clear that the morphological differences in the floral and vegetative structures point to more than one taxon. In particular, *Cephalaria bigazzii* seems to be closely related to *C. balearica* based on leaf shape, but it differs in several other features of the leaves, flowers and fruiting epicalyces (see Table 1). Morphological differences in leaf shape and size, calyx, corolla, stamens, pistil and epicalyx are also evident when comparing *Cephalaria bigazzii* with *C. mediterranea*. *Cephalaria squamiflora* subsp. *ebusitana* would appear to be more closely related to *C. mediterranea*, from which it differs in characters of the leaves, floral parts and fruiting epicalyx (see Table 1), than to the rest of *Cephalaria squamiflora*. For this reason, it must be treated as a distinct species and consequently a new status and combination is here proposed:

Cephalaria ebusitana (O.Bolòs & Vigo) Bacch., Brullo & Giusso **comb. et stat. nov.**
Cephalaria squamiflora (Sieber) Greuter var. *ebusitana* O.Bolòs & Vigo, Collect. Bot. (Barcelona) 17(1): 89 (1988 ['1987']). – Type: Spain, Balearic Islands, Ibiza, Cape Jueu, 8 v 1977, *M.A. Cardona & E. Velasco* s.n. (holo BC).

On the whole, the taxa belonging to the *Cephalaria squamiflora* group show some putative archaic characters, such as the suffruticous habit and very isolated and low-numbered populations which are always limited to rocky habitats. Furthermore, their presence on islands, sometimes quite distant from each other, has led to quite long isolations giving rise to geographical vicariants.

Key to the species of the Cephalaria squamiflora *group*

1a. Leaf dark green, rounded to ovate; anthers 3–3.2 mm long _____ 2
1b. Leaf pale green, lanceolate to linear-lanceolate; anthers 2.2–2.5 mm long _____ 3

2a. Leaf margin glabrous, petiole 2.5–9 cm long; stamens inserted in the throat of the corolla tube _____ *C. bigazzii*
2b. Leaf margin ciliate, petiole 1–2.5 cm long; stamens inserted in the middle of the corolla tube _____ *C. balearica*

TABLE 1. Comparison of the features distinguishing *Cephalaria mediterranea*, *C. squamiflora*, *C. bigazzii*, *C. balearica* and *C. ebusitana*

Character	*C. mediterranea* (1)	*C. squamiflora* (2)	*C. bigazzii* (3)	*C. balearica* (4)	*C. ebusitana* (5)
Basal leaves colour	Pale green	Pale green	Dark green	Dark green	Pale green
Basal leaves indumentum	Glabrous	Glabrous	Glabrous	Hairy below	Glabrous
Basal leaves margin	Ciliate	Glabrous	Glabrous	Ciliate	Glabrescent
Leaf teeth length (mm)	(0)2–5	(0)1–4	(0)2–5	1–3	(0)1–1.5
Leaf limb shape	Ovate-lanceolate to lanceolate	Lanceolate	Rounded to ovate	Rounded to ovate	Linear-lanceolate to lanceolate
Leaf limb length (cm)	4–8	3–8	5–9	4–9.5	2–5
Leaf limb width (cm)	1.5–4(5)	1–2.8	3–6	1.5–5	0.5–2.5
Leaf lobe pairs	(0)1–4	0–1	0(1)	0–2	1–3
Petiole length (cm)	1–8	1–5	2.5–9	1–2.5	2–6
Calyx length (mm)	1–1.4	0.8–1	1.3–1.5	1–1.3	1.5–2.2
Calyx cilia length (mm)	0.5–0.7	0.4–0.6	0.2–0.3	0.3–0.5	0.5–0.8
Bud length (mm)	5–5.5	5–5.5	5–5.5	6.5–7	5–5.5
Bud tube diameter (mm)	3–4	3–3.2	3–4	4.4–4.7	4–4.5
Corolla tube length (mm)	4.5–5	7–7.5	5.5–6	5–5.5	8–9
Corolla tube indumentum	Hairy	Hairy	Hairy above and along nerves	Hairy	Hairy
Tube inner face indumentum	Hairy in the middle (2 mm)	Hairy (5.5–6 mm)	Hairy above (3 mm)	Hairy above (2.5 mm)	Hairy above (2.5 mm)
Corolla lobes dimension	Unequal	Unequal	Subequal	Unequal	Unequal
Corolla lobes length (mm)	1.6–3	3–6	3–3.5	3–4.5	5.5–7
Outer lobe margin	Pubescent	Hairy	Pubescent	Pubescent	Pubescent
Inner lobes margin	Pubescent	Hairy	Glabrous	Pubescent	Glabrous
Stamen filament length (mm)	7.5–8	7–7.5	5–7	6–8	8.5–9.5

TABLE 1. (*Cont'd*)

Character	*C. mediterranea* (1)	*C. squamiflora* (2)	*C. bigazzii* (3)	*C. balearica* (4)	*C. ebusitana* (5)
Stamen insertion	In the middle of the corolla tube	In the upper 1/5 of the corolla tube	Throat	In the middle of the corolla tube	In the upper 1/4 of the corolla tube
Anther length (mm)	2.3–2.5	2.3–2.5	3	3–3.2	2.2–2.4
Style length (mm)	4.5–6	7.5–8	9–10	6–6.5	12–14
Stigma shape	Simple	Simple	Simple	Bilobed	Cirrous at apex
Stigma length (mm)	2.8–3	2–2.2	2–4	1–1.5	6–7
Epicalyx length (mm)	2.4–2.5	3–3.5	1.5–2	2.4–2.8	3.5–3.8
Epicalyx coronula length (mm)	0.7–1	0.6–0.8	0.6–0.7	0.8–1	0.7–0.8
Epicalyx coronula margin	Crenate with 4 long points	Dentate with 8 unequal teeth	Crenate with 4 short points	Crenate with 4 long points	Lobed
Fruiting epicalyx length (mm)	5.5–6.2	6.5–7	5.5–6.5	6–6.5	5.5–6.5
Fruiting epicalyx coronula length (mm)	1–1.2	1–1.2	0.7	1–1.2	0.8–1

(1) Based on specimens from Baunei (E Sardinia).
(2) Based on specimens from Lefka Ori, Mavri (W Crete).
(3) Based on specimens from S. Nicolò di Buggerru (SW Sardinia).
(4) Based on specimens from Puig Major (Majorca).
(5) Based on specimens from Ses Roques (Ibiza).

3a. Corolla 8.5–10 mm long with lobes 1.6–3 mm long; stamens inserted in the middle of the corolla tube; epicalyx 2.4–2.5 mm long _____ *C. mediterranea*
3b. Corolla 11–15 mm long with lobes 3–7 mm long; stamens inserted in the upper 1/4 or 1/5 of the corolla tube; epicalyx 3–3.8 mm long _____ 4

4a. Calyx 0.8–1 mm long; corolla tube 7–7.5 mm long, its inner surface hairy; style straight, 7.5–8 mm long; stigma 2–2.2 mm long _____ *C. squamiflora*
4b. Calyx 1.5–2.2 mm long; corolla tube 8–9 mm long, its inner surface hairy above; style curled towards the apex, 12–14 mm long; stigma 6–7 mm long _____ *C. ebusitana*

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