FLORA MEDITERRANEA

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Festschrift for
Francesco Maria Raimondo
on the occasion of his
70th birthday

edited by
Franco Pedrotti
&
Gianniantonio Domina

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FLORA
MEDITERRANEA

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Francesco M. Raimondo & Werner Greuter

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Presentation

This volume is a collection of botanical articles published in honor of Professor Francesco Maria Raimondo to celebrate his 70th birthday and his activity in the field of botany. It contains the contributions of Italian and foreign colleagues on flora and vegetation of the Mediterranean presented at the international conference “Evolution and adaptation of species and plant communities in the Mediterranean environment”, which took place the 26th February 2015 in Florence at the seat of the Italian Botanical Society. The conference was organized by friends, colleagues and students of Prof. Raimondo under the auspices of the Italian Botanical Society and the OPTIMA (Organization for the Phyto Taxonomic Investigation of the Mediterranean Area).

The scientific activity of Prof. Raimondo, who had the good fortune to work in a city like Palermo, situated in the centre of the Mediterranean basin and with an ancient and magnificent botanical garden dedicated to the Mediterranean and tropical plants, was inspired and had as reference the Mediterranean basin.

One of his major scientific interests is the flora, which was investigated by him from the points of view of systematics, chorology, phytogeography and ecology; in particular, he has discovered and described new Mediterranean species, among them one of the first was *Rhamnus lojaconoi*, a little tree confined on the Madonie mountains, followed by several other species of *Brassica*, *Centaurea*, *Hieracium*, *Limonium*, *Pyrus*, etc., including *Ptilostemon greuteri*, a large shrub of *Compositae* that grows on Mt. Inici in a narrow area of the relief along the Tyrrhenian coast. Other research carried out by Prof. Raimondo are related to the biodiversity of Sicily, the vegetation of the Madonie and Nebrodi, with particular regard to wetlands, cartography, geobotany, ornamental flora of parks and gardens, etc..

As a natural corollary of his research, by initiative of Prof. Raimondo the *Herbarium Mediterraneum* was founded in Palermo and three new botanical magazines were launched: “Flora Mediterranea”, “Bocconea” and “Quaderni di Botanica ambientale e applicata”; the first two, being strongly characterized for research in Systematic Botany and Floristics of the Mediterranean Area, were immediately imposed on the international level, the third is targeted mainly to the spreading of the work carried out by the Laboratory of Systematic, Phytogeography and Plant Ecology of Palermo. The “motto” of the Quaderni was taken from the Gymnasium in the Botanical Garden of Palermo, where stands, in the central part of the dome, around the depiction of the goddess Flora: *miscuit utile dulci* (Mixed what is helpful with what is sweet).

Here, then, this “Festschrift”, this volume containing scientific contributions that mainly relate to the themes preferred by Prof. Raimondo, and which is intended to honor him for his scientific and academic dynamism during a long period of years and in which he is still in full activity.

Alongside the scientific research, Prof. Raimondo has always been very involved in various ways also in the promotion of botanical culture in a broad sense, that is oriented to the conservation of flora, botanical gardens, history of Botany, monumental trees, citrus fruits of Sicily, ornamental plants and gardens of Palermo. His interventions (book presentations, reprints of classic works, catalogs of exhibitions, symposia and conferences, and various editions of laudationes at awards and honorary degrees) were joined in the book "*Contributi alla promozione della cultura botanica*" [Contributions to the promotion of botanical culture] (Trento, TEMI, 2015, edited by Franco Pedrotti), presented in occasion of the conference in Florence.

Finally, we cannot forget the public commitments of Prof. Raimondo, as Director of the Department of Botany, the Botanical Garden and *Herbarium Mediterraneum* as well as Dean of the Faculty of Mathematical, Physical and Natural Sciences of the University of Palermo and - finally – Town councillor of green, parks, historic gardens and animal Rights of the City of Palermo, without forgetting his mandates as President of the Italian Botanical Society and of the OPTIMA; in the latter capacity, he organized memorable botanical congresses in the botanical gardens of Palermo. The last of the series is the congress of 30th October 2015 on "*Giardini e paesaggio. La tenerezza filosofica dei giardini*" [Gardens and landscape. The philosophical tenderness of gardens], for the 100th anniversary of the birth of Prof. Rosario Assunto (1915-1994), which he has organized coinciding with the official end of his academic activity.

Friends, students and colleagues of Professor Francesco Maria Raimondo are particularly pleased to dedicate this volume of *Flora Mediterranea* in a sign of respect, friendship and admiration, with the hope that he will continue to cultivate the *Scientia amabilis* in the Botanic Garden of Palermo with profit and advantage to Science and to all of us.

Camerino - Palermo, 18 November 2015

Franco Pedrotti & Gianniantonio Domina

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Pier Virgilio Arrigoni

Contribution to the study of the genus *Armeria* (*Plumbaginaceae*) in the Italian peninsula

Abstract

Arrigoni, P. V.: Contribution to the study of the genus *Armeria* (*Plumbaginaceae*) in the Italian peninsula. — Fl. Medit. 25 (Special Issue): 7-32. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

The taxonomy of the genus *Armeria* depends strictly on its obligate outbreeding mechanism, a key feature of this group of plants that plays a decisive role in their geographical differentiation. With no breeding barriers it is the geographical isolation that operates in the differentiation processes of species (or subspecies when isolation is not complete and morphological differences are less significant). The exsiccata examined, preserved in the Erbario Centrale Italico of the Museo Botanico dell'Università di Firenze (FI), confirm this taxonomical approach. The genus *Armeria* in Italy exhibits disjunct distribution on isolated mountains. There are 12 taxonomically defined species plus 4 subspecies; they include 1 new species (*Armeria garganica*) and 1 new subspecies (*A. arenaria* subsp. *apenninica*).

Key words: Evolution, Taxonomy, Chorology, Italy.

Introduction

The genus *Armeria* is distinguished by notable morphological and biological homogeneity. The plants are perennials, almost always caespitose, multi-cauliculous, scapose with a rosette of basal leaves, pentamerous flowers in capitulum-shaped glomerules.

In almost all of the species, the plants are diploidal with 18 chromosomes. As noted by Baker (1966), these are obligatory allogamous species, due to the existence of a heteromorphous system of self-incompatibility among the various individuals, which ensures a continuous intra-population and inter-population genetic flow among more or less geographically contiguous populations. The evolution and morphological differentiation of the group thus takes place on the geographic and environmental level. Due to the obligatory allogamy, no sympatric species can exist, except for a few cases in which a presumably long period of evolution has determined reproductive isolation. For example, *Armeria morisii* and *Armeria sardoa* in Sardinia, as well as *Armeria gussonei* and *Armeria nebrodensis* in Sicily, present almost contiguous populations without giving rise to populations with intermediate characters. Note also that, due to the population's miscibility, no hybrid (sterile) populations can subsist, but only populations with characters intermediate among the presumable parents.

On the taxonomical level, the absence of reproductive barriers has led, in cases of significant geographical isolation, to a widespread differentiation of populations on the regional scale. Thus Bernis (1953-1956) has interpreted the morphological diversity of the Genus *Armeria* populations on the Italian peninsula as a single species (*Armeria maritima* L.), that is, a great cenospecies (Turesson 1922) or hologamous species (Gilmour & Heslop-Harrison 1954) composed of geographically distinct fractions. On this subject, see Fig. 2 on the distribution of the Genus *Armeria* in Italy in Arrigoni (1988).

Differentiation in the genus is caused not only by geographical isolation but also by the capacity for adaption of the populations to environments having different geological substrata or to extreme environments, such as high mountain meadows having only a brief summer vegetative cycle.

On the taxonomical level, obviously there can exist in nature both geographically isolated species and allopatric populations with gradual differentiation, interpretable on the level of subspecies.

Taxonomic background

In examining the studies of the past, we find notable diversity in the taxonomical interpretation of the Italian populations of *Armeria*. Boissier (1848) was the first to recognize several Italian species of the genus. The first monograph on the group is however the quite old one of Janka (1882), in which 12 species relevant to Italy are recognized.

In the census taken by Fiori (1926), only 3 species, but no less than 14 varieties are reported. A detailed monograph on the genus is the one by Lawrence (1940). This author divides the Italian species into 2 series: *Macrocentron* Boiss. with sola *A. pungens* (Link) Hoffmanns. & Link and *Plagiobasis* Boiss., containing 5 species and 7 heterotypical varieties.

In the extensive monograph of Bernis (1953-1956), 2 species are recognized for the Italian territory: *A. pungens* and *A. maritima* L. with 11 heterotypical varieties. However, for the Italian territory, this contribution shows some inadequacies in the scarcity of the materials examined, and consequently in the in-depth study and delimitation of the morphological and geographical diversities of the species. This situation has stimulated an analysis of some territorial differentiations that have been subjected to local investigation (Arrigoni 1970; Bianchini 1982; Martini & Poldini 1987; Brullo & al. 1997, 2004; Selvi 2009).

Pinto da Silva (1972) recognized 7 species (plus another doubtful one) and 2 heterotypical subspecies. In this work, as can be seen, the geographical diversity of the taxa is partially recorded on the sub-species level. A few years later Zangheri (1976: 493) recognized for the national territory 10 species and 4 heterotypical subspecies. Bianchini (1982) reports 13 species and 2 subspecies.

Greuter & al. (1989: 308) list 15 species and 3 heterotypical subspecies. Lastly, in Conti & al. (2005: 56) 14 species and 2 heterotypical subspecies are recorded.

As can be seen, there is notable diversity of interpretation among the various authors, while the number of taxa recognized has gradually increased due to a more thorough investigation of geographical diversity.

The species in the Italian peninsula

In the territory of the Italian peninsula, several geographically and ecologically isolated species have been described: *Armeria helodes* Martini & Poldini on the fresh marshy soil of lower Friuli - *A. denticulata* (Bertol.) DC. on the Tuscan-Ligurian serpentines - *A. saviana* Selvi, on the calcareous terrain of Mt. Labbro, in southern Tuscany - *A. brutia* Brullo & al., on the siliceous mountains of Sila, in Calabria - *A. aspromontana* Brullo & al., on the Calabrian peaks of Aspromonte.

Most of the *Armeria* populations in the Italian peninsula are found however on the high meadows and rocky peaks of the Alps and the Apennines. On the Alps grows its diffusion *A. alpina* Willd., a south-European orophyte, in the western Alps penetrates the geographically heteromorphic complex of *A. arenaria* (Pers.) Schult., extending as far as the northern Apennines. In the central-southern Apennines, *A. canescens* Host, a species described for Dalmatia, allopatric with *A. gracilis* Ten. and *A. majellensis* Boiss, has been observed. Further south, on the calcareous mountains of Campania and Basilicata, appears *A. macropoda* Boiss.

The distribution of these species is fragmentary due to the discontinuity of the stations, confined to the highest mountain peaks, with more or less partial interruptions of the gene flow and some weak and gradual differentiation on the local scale. The complex diversity found here is complicated still further by the greater or lesser distances existing between the populations on the numerous mountain peaks.

For a more analytical study of the species on the peninsula and their distribution, we have reviewed the abundant material found in the "Erbario Centrale Italico del Museo di Storia Naturale" (FI) of the University of Florence, including various personal collections as well. Based on this research, we have been able to exclude some species (see the following list with the relevant motivations) and to confirm those appearing in the list, which includes some newly described taxa. For clearer definition on the territorial scale, the list runs from North to South of the Italian peninsula.

Analytical keys

1. Plants with homomorphic leaves, linear or linear-lanceolate 2
1. Plants with dimorphic leaves, the outer or vernal ones more or less wide and short, the inner ones ranging from linear to filiform, longer in general..3
2. Sheath 0.8-1.5 cm. Outer bracts of the capitulum oval, obtuse, muticate. Calyx lobes muticate or briefly aristate...***A. alpina***
2. Sheath from 1 to 3.5 cm. Outer bracts of the capitulum oval-oblong, more or less acute. Calyx lobes distinctly aristate...Race ***A. arenaria***
3. Leaf length 10-20 cm, the outer leaves (vernal) 5-6 mm wide, the inner ones (aestival) 3-4 mm wide, multi-veined. Capitula with outer bracts larger than intermediate ones. Calyx 8-10 mm. Hardy plants, height up to 40-60 cm ....Race ***A. macropoda***

3. Leaf length 5-15 cm, outer leaves less than 5 mm wide. Calyx in general less than 8 mm ..4
4. Outer bracts of calyx larger then inner ones, acuminate-aristate 5
4. Outer bracts of capitulum rather short, less than 10 mm 6
5. Calyx 4-6,5 mm with awns 1-1.3 mm. Plant with long, slender scapes with capitulum of 1-1.2 cm. Minutely denticulated vernal leaves.......... ***A. denticulata***
5. Calyx 7.5 mm with ciliate awns 2.2 mm. Outer bracts acuminate-cuspidate .... ***A. saviana***
6. Uninerviate, canaliculated leaves, with narrow hyaline margin. Hemispherical capitula, 2.2-2.8 cm.......... ***A. helodes***
6. Plant with characters not grouped as above 7
7. Short scapes, 5-15 cm, robust. Sub-spherical capitula, 2-3 cm .... ***A. gracilis*** subsp. ***majellensis***
7. Scapes 15-30 cm, fragile or relatively robust. Capitula 1-2 cm..........8
8. Cuspidate outer bracts, 5.5-20 mm, apiculate inner bracts 3.5-6 mm.......... ***A. aspromontana***
8. Outer bracts less than 10 mm, inner ones 2-4 mm..........9
9. Hemispherical capitula. Outer leaves 3-5 mm wide, inner leaves linear or filiform. Scapes generally delicate, thin .... ***A. gracilis***
9. Sub-spherical capitula. Outer leaves linear-lanceolate, 6-10 mm, inner leaves linear 2-3.5 mm... ***A. brutia***

Armeria alpina Willd. (1809) Enum. pl. Hort. Berol., 1: 333.
Armeria maritima subsp. *alpina* (Willd.) P. Silva (1971) Bot. J. Linn. Soc. 64: 376.
Armeria maritima var. *alpina* (Willd.) Lawrence (1940) Gent. Herb., 4(11): 391-418.
Armeria maritima subsp. *maritima* var. alpina (DC.) Bernis (1956) Anal. Inst. Bot. Cavanilles, 14: 335.
Statice armeria var. *alpina* DC. (1805) Fl. Fr., 3: 419.
Armeria elongata var. *alpina* Ces. Pass. Gib. (1886) Comp. Fl. Ital., 2: 289.
Armeria vulgaris var. *alpina* Fiori (1902) Fl. Anal. Ital., 2: 334.
Armeria vulgaris var. *nana* Bolzon (19109 Boll. Soc. Bot. Ital.: 74.

Perennial herb with glabrous scape, 5-25 cm. Homomorphic leaves, linear or sub-lanceolate, 20-80 × 1.5-3(4) mm, flat, glabrous, fleshy, uninerviate, acute, with sub-membranaceous margin. Sheath 0.8-1.5 cm. Capitulum 2-2.5 cm in diameter. Outer bracts of capitulum oval-slightly obtuse, muticate, inner ones largely obtuse, reddish, 9-10 mm. Flowers from pink to purple. Calyx 6.3-8.5 (9) mm, with tube smaller than limb, glabrous in the in the grooves between the ribs.
Iconography – Tab. 1150 in Reichenbach (1855) Icon. Fl. Germ. Helv., 17: 68.
Chromos. Numb. – $2n = 18, 36$.
Chorology – South-European orophye, *Caricetalia curvulae*/Central-eastern Alps.
Note - The species is quite homogeneous in its characters and in the more or less contiguous distribution of its populations.
Specimina visa (Selection by region).

PIEMONTE e VAL d'AOSTA – Pascoli elevatissimi delle Alpi Cozie, Rostan, VII. 1855 - Alpe di Soleva. Val d'Ala, *Beccari*, 7.VIII.1863 - Passo del Bocchino sopra Viozenne, *Ricca*, 19.VII.1867 – Cima Rovelli presso il Mongioie, Alpi Marittime, 2491 m, *Sommier* 26.VII.1902 – Alpi Cozie. Circondario di Pinerolo. Pral (Prali). Falde della Grande Aiguille, versante settentrionale, *R. Gestro*, 11.VIII.1904 - Pragelato, Punta Rognosa di Sestrieres, *Montali*, VII.1913 – Valle Formazza. Salita al Gries tra il Ponticello e il Passo, m 2300-2450, *Oliviero Boggiani*, 24.VIII.1914 - Limone (Piemonte). Tra Maire del Cros (m 1400) e M. Crest (m 1700), *R. Pichi Sermolli* e *A. Contardo*, 20.VII. 1949 – Macereti sul Colle Ciriegia (m2450-2500 m). Val Gesso (A.M.), *P.G.Bono* 6.VIII.1962 – Val di Cogne (AO). Salendo al Passo dell'Invergneux, versante Sud, 2780 m, *Bovio, Broglio, Soldano, Trompetto*, 9.VIII.2011.

LOMBARDIA – Monti della Valtellina, *Moretti*, IX.1842 - Crete di M. Sobretta (2700 m), Val Furva prés Bormio, *E. Levier*, 7.VIII.1870 - Grigna sett. Presso la vetta, vers. di Moncodeno, sopra il nevato, *Provasi* 7.VII.1921 - Valle delle Messi (Sondrio). Passo del Gavia, prati umidi e rive nei dintorni del Lago Negro, m 2386, *C. Steinberg* e *C. Ricceri*, 4.VIII.1969.

TRENTINO-ALTO ADIGE – San Martino di Castrozza: salita alla Rosetta, *P. Bargagli* 25.VII.1892 – Val Gardena: Alto valle del Kedul, m 2400 ca., *A. Chiarugi*, VIII.1923 – Val Gardena. Passo Sella, *A. Chiarugi* 24.VIII.1932 - V. del Brennero. Cima della Stanga, versante Sud. Calcari un po' scistosi, q. 2300-2387 *S. Zenari*, 10.VIII.1950 - Alto Adige, Pascoli dell'Alpe di Zirago, micascisti. *S. Zenari* 17.VIII.1951 - Gruppo del Catinaccio. Dintorni dei rifugi Vajolet ed Heuss (m 1800-2500), *P.V. Arrigoni* 22.VIII.1972 - Trento. Marmolada: dal Rifugio Fedaja (m 2000) al Rifugio Pian Fiacconi (m 2700), *P.V. Arrigoni* 24.VIII.1972 – Prati di Passo Sella (m 2200) *P.V. Arrigoni* 24.VIII.1972 – Dintorni di Passo Pordoi, m 2238, *P.V. Arrigoni*, 26.VIII.1972 - Val di Fassa. Dalla Stazione della Funivia di Col Rodella lungo il sentiero del Sasso Lungo su terreni vulcanici acidi. *C. Ricceri, C. Steinberg*, 8.VII.1974 – Lago Selvaggio (Bressanone) m 2550, pendici esposte a Nord, pend. 35°, pascoli su micascisti, *P. Paiero*, 27.VII.1977.

VENETO – In Baldi montis alpina valle delle Ossa, da *A. Manganotti* 9.X.1845 – In glareosis alpinis supra Passo Siola, *E. Levier* 24.VII.1877 - M. Cavallo, *Siemoni* VII.1882 – M. Posta, in glareosis et rupestribus, *A. Goiran* VIII.1887 - Alpi Carniche. Forcella piccola del M. Antelao, 2000 m, *R. Pampanini* 11.VIII.1899 – M. Cimacuta verso Valmaccon (Carnia) a 1800 m, *Gortani*, 17.VIII.1900 – S. Vito del Cadore, Forcella piccola, 2120 m, *R. Pampanini*, 15.VIII.1907 - Cadore. Dolomiti: Tondi di Faloria (Cortina d'Ampezzo) m 2343, *Chiarugi, Corradi, Bavazzano*, 15.VII.1956.

FRIULI-VENEZIA GIULIA – Alpi Giulie. M. Cren, *D. Marchesetti*, 14.VIII.1899 – F.la Brica (Cimolais), 2000 m, pascolo sassoso a Nord, *P. Paiero*, 22.VIII.1977 – Camporosso (Cimolais) 1900 m s.m., pascolo sassoso a Nord, *Paiero* 22.VIII.1977 – F.la Pregoiane (Claut) m 1700-1900, ghiaioni e macereti calcarei a *S. Paiero* 14.VIII.1977.

Race ***Armeria arenaria*** (Pers.) Schult.

1. Dimorphic leaves, the outer vernal leaves 3-5 cm wide with evident membranous margin ....subsp. ***marginata***
1. Homomorphic leaves, from lanceolate to sublinear, with greater width, 2-4 mm, in the middle or the upper third, attenuated or decurrent in the third basal leaf 2
2. Paucifloroas capitula with precocious white flowers. Outer bracts acuminate, intermediate inner ones mucronate, upper ones muticate ......subsp. ***praecox***
2. Globular aestival capitula with purple-violet flowers 3
3. Sheath 3-3.5 cm. Outer bracts oval extending to acute apex ......subsp. ***arenacea***
3. Sheath progressively reduced to 0.8-1.2 cm. Outer bracts oval-lanceolate ....subsp. ***apennina***

Armeria arenaria (Pers.) Schult. in Roem. & Schult. (1820) Syst. Veg. , ed. 15, 6: 771.

Basion.: *Statice arenaria* Pers. (1805) Syn. Pl., 1: 332.

Armeria alliacea subsp. *plantaginea* (All.) O. Bolos & Vigo (1979) Collect. Bot. (Barcelona), 11: 30, comb. illeg.

Statice plantaginea All. (1785) Fl. Pedem., 2: 90, non A plantaginea Willd.

Armeria vulgaris subsp. *plantaginea* (All.) Syme in Sowerby, comb. illeg.

- subsp. ***arenaria***

Caespitose perennial herb with cylindrical scapes, lightly grooved, up to 60 cm long. Numerous leaves ranging from lanceolate to sublinear, 8-12(18) × 0.2-0.4(0.5) cm wider in the middle or the upper third, attenuated or decurrent in the third basal leaf, with 3(7) principal veins, ciliolate on the margin or along the nervation in the lower part. Sheath 3-3.5(4) cm, lacerated near the bottom. Globose capitula, 1.5-2 cm in diameter, with 2-4 outer bracts, oval-oblong terminating in more or less well-developed acute tip, the others obovate, scarious and obtuse at the apex. Inner bracts obtuse, almost entirely scarious. Calyx 6(7) mm with short tube, 2.5-3 mm and scarious lobes, triangular at the apex, extending in an awn of 1.5-2 mm, with short hairs appressed along the ribs of the tube, none or few in the intercostal space. Violet or bluish flowers. (Description from a topotype existing in FI).

Iconography – Tab. MCLI (I) in Reichenbach (1855) Icon. Fl. Germ. Helv, 5 - Fig. 2314 (Pl. 503) in Bonnier (1990) Reprint Jaca Book.

Chromos. Numb. – $2n = 18$.

Chorology – Western Europe/Piemonte, Lombardy, Liguria up to M. Maggiorasca. Bernis (cit.: 191) considers it "dudoso que esta planta habite tambien el tramo mas septentrional de los Apenninos" [doubtful whether this plant also grows in the northernmost part of the Apennines].

Diagnosis: "*Armeria. 2 arenaria, caul. scapo longo, bract. 2-3 capitulo longioris, fol. lineari b rigidulis glabris. Hab. in arenosis (copiosae prope Fontainebleau). A priore (ß humilis) specie distinta videtur. Hujus loci videtur Statice elongata Hoffm. l.c., qui vero folia dicit irsuta*."

Specimina visa.

LIGURIA – Fra il lago Verde di Fontanalba 2300 m e la vetta di S.a Maria, 2700, *Marchesetti* 19.VII.1908.

PIEMONTE e VAL D'AOSTA – Aosta. Val d'Ayas: Graines, sulle rocce serpentinose nei pressi del Castello, *O. Vergnano Gambi*, 5.VIII.1977 – Aosta. Val d'Ayas: dintorni di Salamon, m 1600-1700, *O. Vergnano Gambi*, 11.VIII.1977 - Aosta. Val d'Ayas: Fra St. Jacques e Resy, m 1800 ca. *O. Vergnano Gambi* 17.VIII.1977 – Alpi Marittime. Lungo il sentiero tra Terme di Valdieri (S. Giovanni) e Pian del Velasco, alt. m 1710, *Aldobrandi G.* e *C. Nepi*, 27.VII.1992 – Alpi Marittime. S. Giacomo, lungo il sentiero per Prà del Rasun, alt. m 1310, esp. Ovest, *Aldobrandi G.* e *C. Nepi* 28.VII.1992 - Val Maira. Al termine della strada provinciale n. 22, prima del tratto sterrato. Esp. Sud, alt. m 1950, *Aldobrandi G.* e *Nepi C.*, 29.VII.1992.

EMILIA – Bobbio, fraz. Coli. Serpentini alla base del Monte dei Tre Abati, *Arrigoni, Raffaelli, Ricceri, Vergnano*, 15.VII.1977 (forma di transizione alla subsp. *apennina*).

- subsp. ***praecox*** (Jord.) Kerguélen (1987) Lejeunia ser. 2, 120: 49.

Basion.: *Armeria praecox* Jord. in Boreau (1857) Fl. Centre France, 1: 537.
Armeria alliacea (Cav.) Hoffmanns. & Link (1813-1820) Fl. Port. 1: 441.
Armeria plantaginea subsp. *praecox* (Jord.) Nyman (1881) Consp. Fl. Eur.: 616.

Hardy plants with long lanceolate leaves, 5-7 veins. Pauciflorous capitula, 1.7-2 cm with white flowers. External bracts acuminate, internal intermediate ones mucronate, upper ones muticate.

Chorology – Western Alps. Not found in Italy for Greuter & al. (1989: 308) and Aeschimann & al. (2004) Fl. Alp., 1: 394.

This finding requires confirmation, however.

- subsp. ***apennina*** Arrigoni, subsp. nova (Fig. 1)
Armeria seticeps auct. Fl. Ital. p.p. non Rchb. (1827).

Typus – Holotypus in FI: "Emilia-Romagna, Corniglio (Parma). Vaccinieti e rupi della cresta rocciosa tra il M.te Marmagna e M.te Braiola, m 1600-1800. Substr. arenaria. *Arrigoni*, *Foggi* e *Ricceri*, 21.VII. 1986".
Diagnosis – *Herba perennis caespitosa, caulibus glabris 20-40 cm altis, foliis basalibus rosulatis. Vagina 0,8-1,2 cm longa. Folia linearia, 3-5(7) nervia, apice subobtusa. Capitula 1-1,5(2) cm diametro. Bracteae esternae ovali-lanceolatae, acutae, margine anguste scariosae, vel ovali-apiculatae, margine late scarioso; internae ovali-rotundatae, muticae, pro maxima parte scariosae. Calix circa 7 mm longus, costis indumento brevi appresso pilosis. Tubus circa 3 mm longus. Lobi scariosi in aristam 1-1,5 mm longam terminantes.*

Caespitose perennial herb with thick woody root often ramified forming on the surface several rosettes and glabrous scapes, 20-40 cm. Sheath 0.8-1.2 cm. Leaves varying in length, 3-10 cm, linear, 3-5(7) veins, sub-obtuse at the apex, at times (e.g., Monte Orsaio) ciliate along the margin and hairy on the veins in the lower parts. Capitula 1-1.5(2) cm. Outers bracts from oval-lanceolate, acute, scarious on the edge, to ovali-apiculate with wide scarious margin, inner bracts oval-rounded, muticate, almost entirely scarious. Calyx approx. 7 mm, briefly hairy, appressed along the ribs. Tube approx. 3 mm. Scarious lobes briefly triangular at the apex, ending in an awn of 1-1.5 mm.
Iconography – Alessandrini and Bonafede (1996) Atl. Fl. Prot. Reg. Em.-Romagna: 34. Our Fig. 1.
Chorology – Endemic to the Tuscan-Emilian Apennines, up to M. Prado to the south. – Orophyte of Apennine meadows and cliffs, above 1200 m.
Note – Taxon intermediate between *A. arenaria* and *A. marginata*, distinguished by the transition of some differential characters typical of the two species:
- transition from leaves that are homomorphic or nearly so to dimorphic leaves, that is, from the vernal outer leaves, in general wider and shorter, to the aestival inner ones, narrower; in particular, by lanceolate leaves with maximum width in the upper half to more or linear, or linear filiform, leaves.
- Progressive reduction in length of the sheath, from 3-3.5 cm to 0.8-1.2.
- transformation of the outer bracts from oval-oblong acuminate to oval, acute or apiculate.
- transformation of the calyx indumentum from short, appressed hairiness to more or less bristling villosity.

Specimina visa:
Pascoli alpini di M. Orsaio presso la Foce di Catelea e la cima. *Parlatore* 21.VII.1838, sub *A. alpina* – Rupi perpendicolari presso la cima del M. Prinzera reg. delle querce. *Parlatore* 3.VIII.1838 - Alpe di Cusna: Appen. di Reggio E.lia. *Fiori* 8.VIII.1888, sub *A. plantaginea* W. var. *seticeps* (Rchb.) - Lago Santo. Sotto il M. Orsaio sul versante Parmigiano. *Sommier* 28.VI.1902, sub *A. vulgaris* W. var. *majellensis* (Boiss.) Fiori Fl. Anal. – Salendo da Pracchiola al M. Orsaio, pascoli verso 1200 m, *Sommier* 28.6.1903, sub *A. majellensis* Boiss. – Emilia. Prov. di Parma, abunde in rupium fissuris montis Prinzera, solo siliceo. *Bolzon* 20.V.1905 n. 620 Sched. Fl. Ital. Exs. sub *A. plantaginea* - Appennino parmigiano sul M. Rogala (m 1710) nelle fessure del serpentino. *Bolzon* 17.VII.1905, sub *A. seticeps* Rchb. – Luoghi erbosi e substrato argilloso-serpentinoso al M. Prinzera (Appennino Parmigiano) a 500-700 m, *P. Bolzon* 24.V.1906, sub *A. plantaginea* - Abbondante sotto

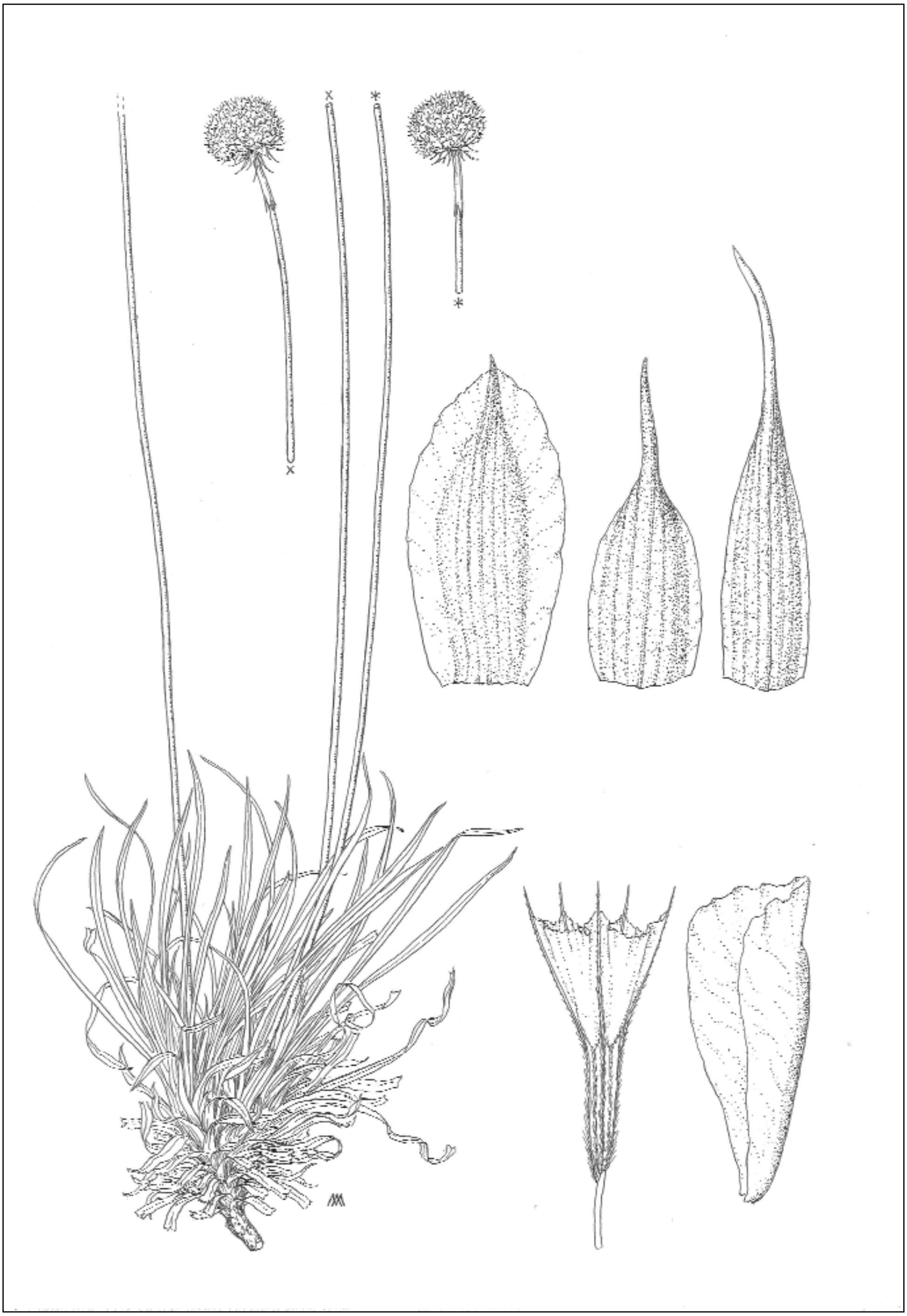

Fig. 1. *Armeria arenaria* subsp. *apennina* Arrigoni × 0.65. Details: Scales and calix × 6.5.

Orsaro (Parma), *Minio* 9.VII.1919 - Reggio Emilia (Prov.), presso il Cusna, m 2000, *Lunardi* 1.IX.1921, sub *A. plantaginea* W. – Emilia, Bobbio, fraz. Coli. Serpentini alla base del Monte dei Tre Abati, *Arrigoni P.V., Raffaelli M., Ricceri C., Vergnano O.,* 15.VII.1977 - Emilia . Ligonchio. M.te Prado. Cresta rocciosa fra lo sprone di Prado e la vetta. Prati e vaccinieti, substrato: arenaria. *B. Foggi, C. Ricceri* 28.VII.1987, sub *A. marginata* – Emilia. Ligonchio. M.te Prado. Pendici rocciose settentrionali fra il Lago di Bargentana e Sella Sprone di Prado. Prati e vaccinieti, alt. M 1800-1950, substrato roccioso: arenaria. *Foggi* e *Ricceri* 28.VII.1987, sub *A. marginata* - Emilia. Ligonchio. M.te Cusna. Prati rocciosi della vetta. Esp. N. Alt. m 2100. Substrato: arenaria. *Foggi* e *Ricceri*, 10.VIII.1988, sub *A. marginata* - Appennino settentrionale. Nella brughiera a mirtilli del M. Marmagna sopra il Lago Santo parmense, alt. 1800 m, *Ferrarini* 30.VII.1991, sub *A. vulgaris* var. *marginata* Fiori - Appennino lucchese reggiano, M. Prado, erbosi sul macigno esposti a Sud vicino alla vetta, alt. 2000 m, *Ferrarini* 20.VIII.1992 – Dintorni di Lagosanto-Orsaio 18.VII.?, *Martelli U.* – M. Rogala. Prato Grande, s. coll. s. d. – M. Bue (Emilia), sine coll., sine d. – Lago Santo Parmense. sine coll., sine d.

- subsp. ***marginata*** (Levier) Arrigoni comb. et stat. nov.

Basion.: *Armeria majellensis* var. *marginata* Levier (1888) Atti Soc. Tosc. Sci. Nat. Proc. Verb., 6: 157.

Armeria marginata (Levier) Bianchini in Pignatti (1977) Giorn. Bot. Ital. 111 (1-2): 49.

Armeria vulgaris var. *marginata* (Levier) Fiori in Fiori e Paol. (1902) Fl. Anal. Ital., 2: 234.

Armeria maritima subsp. *eumaritima* var. *majellensis* subvar. *marginata* (Levier) Bernis (1953) Anal. Inst. Bot. Cavanilles, 11(2): 247.

Armeria plantaginea Bertol. (1832) Mant. Pl. Fl. Alp. Apuan.: 20, num. 30, non Willd. (1809).

Typus - Lectotypus in FI: "*Armeria majellensis* Boiss./var. *marginata* mihi/in monti Libro Aperto, Apennini. Pistoriensis supra Boscolungo, 1700 m, /Jul. 1881 leg. *Levier*", qui designato.

Perennial herb with mediocre scape, 15-40 cm, glabrous or hairy at the base. Flaccid, dimorphic leaves with scarious margin, the outer ones (wintry) ranging from lanceolate to linear-lanceolate, 3-7 cm, 3-5 mm wide, 1-3(multi) veins, with distinct membraneous margin; the inner leaves (aestival) linear, 7-9 cm, 1-5 mm wide. Brown sheath, 1-1.5 cm long. Capitula 1.6-2.5 cm in diameter, with basal bracts oval with acute tip, scarious along the margin, inner bracts oval-rounded with wide scarious margin. Calyxes 6-7 mm, sparsely hairy, with short triangular lobes and awns of 1-1.3 mm. Corolla purple or white.

Iconography - Alessandrini & al. (2003) Fl. Alt. Tuscan-Emilian Apenn.: 49, pro parte.

Chorology - Endemic to the northern and central Apennines, and to some Umbria-Lazio pre-Apennine sectors.

Specimina visa:

EMILIA - Gita del Lago Gradina, *Martelli* 20.VII, sine anno - Ad rupes montis Cimone. Appennino Muticaense, *Fiori* 9.VII.1875 - Sommità del M. Cimone (Appenn. Modenese) *Fiori* 24.VII.1884 - M. te Cimone, *Lunardi* 30.VI.1927 - Appenn. modenese. Libro Aperto, *Cortesi* VIII.1933 - Apenninus Aemilianus M. Cimon in pascuis, alt. 2000 m, *Mori* 27.VIII.1938 - Ligonchio. M.te Cusna. Rocce della vetta. Alt. m 2000-2100, substrato: arenaria, *Foggi* e *Ricceri* 29.VII.1987 - Fiumalbo. M.te Cimone. Da Pian Cavallaro alla vetta. Prati rocciosi Esp. N-NW. Alt. m 1850-2150, substrato arenaria, *Foggi* e *Ricceri* 12.VIII.1988.

TOSCANA - In summo vertice montis sassosi Alpium di Mommio, *Calandrini* VII.1851 - Rupi inizio alla cima del Libro Aperto, 1930 m, *Parlatore*, 9.VII.1863 - Alpi Apuane, route vr. Minucciano à Vinca, Prairies env. 1000 m, *Sommier* 2.VII.1871 - Alpi Apuane. Pisanino, prairies alpines env.

1700 m, *Sommier* 9.VII.1871 - Prati d'Annibale, *Cherici* 30.IV.1873 - In M.te Rotondo (pr. M. Libro Aperto) sopra Boscolungo, in Apennino Pistoriense, *F. Major* 20.VII. 1875 - Fra il Pizzo d'Uccello, *Narducci*, IV.1877 - Cimone di Fanano. App. pistoiese, in rupibus editioribus, *F. Major* 6.6.1882 - Rupi arenarie della vetta a ovest del Libro Aperto. App. pistoiese, *Martelli* 22.VII.1882 - Alpe di Caciaia (sopra il Lago Santo) circ. 1800 m, in rupibus *Sommier* 24.VII.1887 - Alpi Apuane. Ultimi prati sotto la cima del Pisanino, *Sommier* 30.VII.1888 - Uccelliera vers. Prà di Lanna, *Levier* 12.VII.1889 - Spigolino del Libro Aperto. Appenn. Pistoiese, *Sommier* 30.VI.1906 - Camaldoli, Mandrioli, *A. Messeri*, 30-31.VII.1934 - Minucciano, sotto l'Orto di Donna, *B. Lanza*, 28.V.1960 - Massa. Alpi Apuane: dalla Serenaia al Rifugio Donegani, *Baccetti* 19.V.1963 - Foce del Cardeto, versante Nord di Orto di Donna, terreno acido da scisti diasprini, alt. 1600 m, *Ferrarini* 5.IX.1991.
MARCHE (confine Toscana) Prov. Pesaro, Sasso Simoncello, prati sulla cresta rocciosa calcarea sommitale sul ciglio del dirupo,, rara, *F. Selvi* 30.IV.2007, sub *Armeria canescens* (Host) Ebel.

Race ***Armeria denticulata*** (Bertol.) DC.
Comprises two similar reproductively isolated species differentiated on substrates of different nature.

Armeria denticulata (Bertol.) DC. (1813) Cat. Pl. Horti Monsp.: 7.
Statice denticulata Bertol. (1806) Rar. Ital. Pl. Dec. Sec., 1: 34.
Armeria denticulata (Bertol.) Bertol. (1819) Amoen. Ital.: 77.
Armeria vulgaris var. *denticulata* (Bertol.) Fiori in Fiori & Bèg. (1902) Fl. Anal. Ital., 2: 334.
Armeria maritima subsp. *maritima* var. *denticulata* (Bertol.) Bernis (1953-1956) Annal. Inst. Bot. Cavanilles.

Typus: "Lectotypus in BOLO: "Legi prope Sarzanam in montibus Nuda, et Brina di Panzano in rupibus serpentinis", designated by Selvi (2009: 129).

Perennial herb, rosulate, glabrous. Slender scapes, 3-4 per plant, 15-40 cm high. Sheath 1-2 cm, 1-1.2 times the diameter of the capitulum. Dimorphic leaves, lanceolate-spathulate, 20-40 × 4-6 mm, uninervial (rarely with 2 minor veins), outer leaves flat, widened, often serrated, inner leaves slightly convolute, narrow, often erect. Capitulum 10-12 mm. Involucral bracts oval or oval-lanceolate, largely scarious, the outer ones long acuminate-cuspidate, the inner ones mucronate. Sub-sessile spikelets (35-70). Calyx 4-6,5 mm with hirsute tube twice as long as the peduncular tube and 1.3 times as long as the s, awns 1-1.3 mm, hairy primary ribs. Pinkish corolla.
Iconography - Arrigoni & al. (1983: fig.2) - Ferrarini & al. 1997, 2: 192, 197 Fig. 40) - Fig. 2.
Chromos. Numb. - $2n = 18$ (Arrigoni & al. 1980: 141), on material from the Sassi Neri dell'Impruneta (Province of Florence).
Chorology – Endemic to Liguria (*locus classicus* Monti Brina and Nuda of Ponzano Magra) and Tuscany, on serpentinous substrates: M. Ferrato of Prato, Montignoso, Impruneta, Montemurlo and Montauto in Val Tiberina, Monterufoli, M. Pelato of Castiglioncello, Pomarance, etc.
Specimina visa (Selection by region):
LIGURIA – Brina di Ponzano in Val di Magra, *Marcucci*, 28.V.1864 - Gambella, presso Beverino, a q. 160 m. Val di Vara (SP). Liguria, su serpentina, *D. Marchetti* 26.V.2008.
TOSCANA – In **Monte Ferrato** agri Florentini, *T. Caruel* 6.VII.1863 - Monte Ferrato presso Prato,

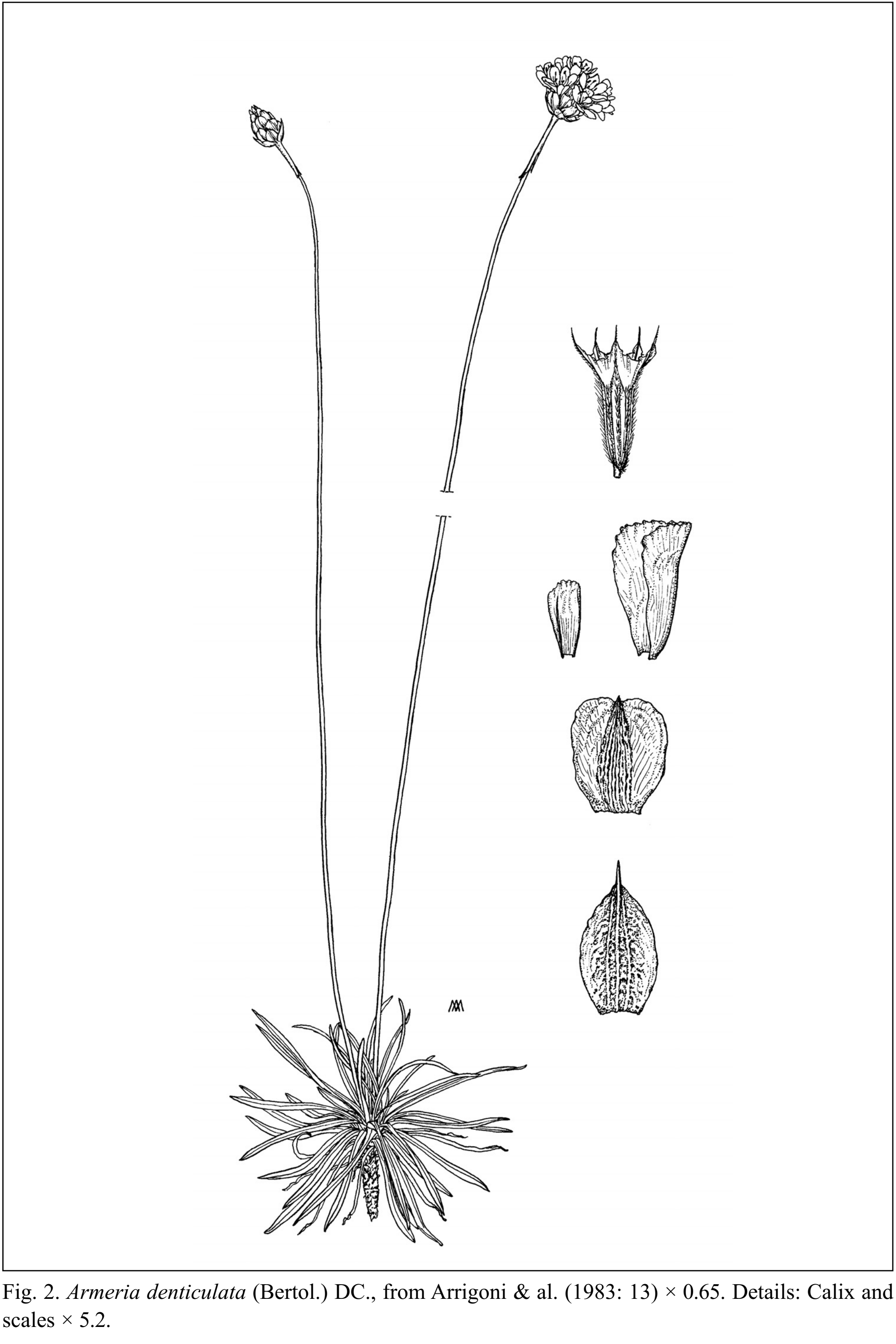

Fig. 2. *Armeria denticulata* (Bertol.) DC., from Arrigoni & al. (1983: 13) × 0.65. Details: Calix and scales × 5.2.

Beccari V.1869 - Prato, Monte Ferrato, serpentino, *R. Pichi Sermolli* 12.XII.1933.
Impruneta - Inveni in gabbratis Imprunetae, *Bechi* VI. 1843 - Impruneta l. d. Sassi Neri, *Pampanini* 25.V.1912 - Impruneta (Firenze) serpentini, *I. Bargoni* 24.V.1938 - Serpentini dell'Impruneta, Cei 23.VI.1939.
Toscana (Prov. Firenze): Montignoso, sui serpentini, *R. Pampanini* 17.VI.1911.
Prov. Di Massa Carrara, Aulla al Castello, suolo serpentinoso, alt. m 100, *A. Fiori* 12.VI.1932.
Alta Val Tiberina. M. Murlo, serpentino, *R. Pichi Sermolli* 25.VII.1932 – Monti Rognosi presso Albiano, serpentino, *R. Pichi Sermolli* 13.VIII.1934 – Pian della Croce, serpentino *R. Pichi Sermolli* 20.XI.1934 - M. Petroso, serpentino, R. Pichi Sermolli 29.XI.1934 – Poggio delle Calbane, ofiolite-serpentina, *R. Pichi Sermolli* 7.VI.1935 - Montauto, *A. Chiarugi, O. Vergnano, R. Corradi*, 23.V.1955.
M. Livornesi, al Gabbro, *Beccari*, 13.VI.1864 – Castiglioncello, *Campana* 30.VII.1865 - M. Pelato (Livorno), *A. Chiarugi* 2.IX.1923.
Prov. di Pisa: Gabbri di Larderello (Volterra), *U. Martelli* 5.VII.1892 - Rocce serpentinose, Orciatico, Al Renajo, *Stefanini* 15.V.1903 - Colli tra Malavolta e Gabbro, serpentino, m 150 ca. *A. Fiori* 9.VII.1913 - Pomarance a M. Gabbri, sul serpentino, m 350-480, *A. Fiori*, 6.VI.1916 – Rocca di Sillano (Pomarance) sul serpentino, m 500, *A. Fiori* 8.VI.1916 - Serrazzano (Pisa). Serpentini ad Est del paese m 500 ca., *A. Chiarugi, O. Vergnano, R. Corradi*, 29.VI.1953 – Chianni (Pisa), serpentini oltre il podere Vitalba sopra la Fattoria Mori (Monti fra la Fine e l'Era), *A. Chiarugi* 25.VIII.1955.
Prov. di Grosseto – Roccatederighi verso Poggio Mozzeta, serpentino, m 600, *A. Fiori* 23.VI.1910.

Armeria saviana Selvi (2009) Nordic J. Bot., 27: 125-133.

Typus - Holotypus in FI: "Toscana, Poggio all'Olmo (Arcidosso, GR), pascoli sassosi, 1030 m, suolo calcareo, 42°51' N, 11°28' E, *F. Selvi* 2.VI.2008".

Caespitose perennial herb with hardy, erect stalks, height up to 45 cm. Sheath 1.6-2.5 cm. Capitula 1.8-2.2 cm in diameter with outer bracts acuminate-cuspidate, 1.5-2.8 × 0.3-0.45 mm, 2-3 often longer than the capitulum, purple-rust-coloured, scarious along the margin. Oval inner bracts, 10-11 × 3.9 mm, carinate, distinctly mucronate at the apex, scarious. Calyx 7.5 mm, with tube of 3 mm, pilous also between the ribs, with scarious lobes terminating in ciliate awn of 2.2 mm. Pink corolla, 8-9 mm.
Iconography – Fig. 1 in Selvi (cit.: 127).
Chromos. Numb. – $2n = 18$ (Selvi, cit.).
Growth form-Habitat - Scapose perennial herb heliophilous and calcicolous growing in mountain meadows.
Chorology - Endemic to the Alta Maremma/Monte Labbro, Poggio Volturaie, M. Aquilaia, M. Buceto, Poggio all'Olmo.
Specimina visa:
In pratis montani mente Labro (M. Amiata Etruria) 1000 m ca., *Arcangeli* VI.1888, sub *A. gracilis* Ten. - In herbidis loco dicto Banditella in M. Labro ad 1000 m alt., *Arcangeli* VI.1888 - In pratis montanis montis M. Selva, *Arcangeli* VI.1888 - Monte Labro presso Santa Fiora, Monte Amiata, *Biondi* 8.VI.1888 - Nei prati della Banditella presso Santa Fiora, *Biondi* 15.VI.1888, sub *A. majellensis* Boiss - Toscana (GR) Arcidosso. M. Labro. 1000-1200 m s.m. ca., *Aldobrandi, Baldini, Nepi*, 25.06.1991 - Toscana (GR) Arcidosso. M. Labro. Settore W, prati-pascolo, 900 m s.m. ca., *Aldobrandi, Baldini, Nepi*, 25.06.1991 - Toscana (GR) Arcidosso. M. Labro. Versante Est, prato-pascolo, 1000 m s.m. ca., *Aldobrandi, Baldini, Nepi*, 26.06.1991.

Armeria helodes Martini & Poldini (1987) Candollea, 42 (2): 537.

Typus – Holotypus in TSB: "Flora Italiae: Province of Udine, flat bogs near the illane of Flambro (Udine), località Roggia dei Molini".

Rosulate perennial herb with erect scapes, 36-52 cm, glabrous. Sheath slighter longer or subequal to the capitulum. Leaves sessile, glabrous, patent or patent-erect, linear, 14-20 × 0.15-0.3 cm, uninerviate, canaliculate with narrow hyaline margin. Capitula 2.2-2.8 cm in diameter, hemispherical. Outer bracts herbaceous, oval-lanceolate, scarious along the margin, mucronulate; inner bracts obovate or obovate-lanceolate, muticate, scarious. Trifoliate spiklets, briefly pedicellate. Calyx pedicellated, 5-7 mm, with lanous ribs. Triangular lobes with awns of 0.2-0.5 mm. Pinkish-white corolla.

Iconography – In Martini and Poldini (cit.: 542).

Chorology – Friuli-Venezia Giulia (Codroipo). Endemic to the karst springs in the lower plains of Friuli. Reported in the past sub *Armeria elongata* (Hoffm.) Koch for the Veneto plains and other Po Valley localities, but its presence in Italy had already ben considered doubtful by Bernis (1953-1956: 256).

Specimina visa:

FRIULI-VENEZIA GIULIA - In turfosis Virco, da *Pirona*, VIII.1861 - Castions di Strada (Friuli) nei prarti paludosi, a 25 m, *L. Gortani* 18.VI.1897 - Paludi di Talmassone, *Marchesetti*, 16.V.1875 - Prov. di Udine: in paludosis prope Castions di strada loco dicto il Molino di Sotto, *Brassica palustris, Scirpus holoschoeno, Cirsio oleraceo* sociis, alt. 15-20 m, *Gortani C.*, 12.V.1905 (Sched. 622) 5 exs. - Friuli. Paludi (risorgive) di Torsa, suolo torboso, m 25, *Fiori* 14.V.1936.

Race ***Armeria gracilis*** Ten.

1. Fragile, elongated, more or less numerous scapes. Leaves 5-20 cm. Sheaths 1.5-2(3) cm. Hemispherical capitula 1.5-2 cm. Short outer bracts, 6-8 mm, scarious on the edge..... ....subsp. ***gracilis***
1. Scape in general short, often only one per rosette. Leaves in general less than 5 cm. Sheaths 0.5-1.5 cm. Sub-spherical capitula 2-.3 cm di diameter. Outer bracts 2-4 mm, reflexed ....subsp. ***majellensis***

Armeria gracilis Ten. (1831) Fl. Neap. Syll.: 158.

Armeria canescens subsp. *gracilis* (Ten.) Bianchini in Pignatti (1977) Giorn. Bot. Ital., 111: 49.

Armeria majellensis subsp. *ausonia* Bianchini (1977) Giorn. Bot. Ital. 111: 49.

Armeria majellensis var. *subalpina* Levier in Arcang. (1888) Atti Soc. Tosc. Sci. Nat., Proc. Verb., 6: 154-158.

Caespitose perennial Herb, multi-stem with erect scape, 30-45 cm, glabrous or pilous (c. humilis) at the bottom. Sheaths approx. 1.5-2(3) cm. Leaves dimorphic, glabrous, 5-20 cm: outer leaves lanceolate or linear-lanceolate, 5 × 0.3-0.5 cm, 3(5) veins, acute; inner leaves ranging from linear, 5-20 × 0.1-0.3 cm, to filiform. Capitula 1.5-2 cm, hemispherical. Outer bracts short, 0.6-0.8 cm, smaller than inner ones, oval-acute or mucronulate, scarious on the edge; inner ones almost entirely scarious. Calyx slightly pediculate, approx. 1 mm, hirsute, 6-7 mm, with tube approx. 4 mm extending into limbus. Scarious limbus with short sub-triangular apex and awn approx. 1 mm. (Description from topotypes of M. Velino, locus classicus).

Chromos. Numb. - 2*n* = 18 (Brullo & al. 1994: 207), on material of M. Pollino (Potenza).

Chorology – Found in general at altitudes lower than 2000 m: Velino, Monte dei Fiori, Campo di Giove alla Majella, M. Corno and Morrone in Abruzzo, M. Coccorello, Monti della Duchessa, M. Sirente, Pizzo di Sivo, Villavallelonga, M. Meta, Piano di Ovindoli, Pollino.

Diagnosis – *"1. Armeria gracilis; scapo tereti basi hirto vel omnino glabro, foliis lanceolato-linearibus trinerviis, involucri foliolis exterioribus cuspidatis, interioribus obtusissimis (nervo ante apicem evanescente) muticis, pedicellis tubi calycis totius villosi longitudine, petalis integris vel subcrenulatis, Ten. A. vulgaris Ten. Fl. Nap. III p. 353, excl. Syn. In pascuis montosis passim C. Velino, Monte Corno in Aprutio; Pollino in Calabria. D. Montevergine; in Hirpinis; Morrone; in Aprutio. Lectotypus* non designato.

Specimina visa (Selection by region):

UMBRIA - Montagna delle Rose presso il Castelluccio, *Batelli*, VI.1888 – M. Subasio (Assisi), calcare, 1000 m, *Fiori* 19.V.1916 – Sigillo. Versante SE di Monte Cucco, pascoli sassosi cacuminali su calcare, *C. Ricceri* e *C. Steinberg* 4.IV.1977

MARCHE – A S. Vicino apennini cingolani, *Narducci*, IX.1844 - In herb. mont. Catria. Prati di Campomiele (da *Piccinini*, I.1864) – Pascoli del monte S. Vicino nelle Marche, 1200 m, 4.VII.1867, da *Bucci* - In pratis apricis subapennini, Limite-lungo-frequens, *R. Ricci*, VI.1877 - Monti di Sarniano, prope Macerata (Marche), *Ricci*, VI.1879 - S. Vicino, IX.1879, *Ricci* - M.te S. Vicino (Marche) in prati, da *R. Ricci*, 1880, sub *A. plantaginea* – M.te Pennino, *Batelli* VI.1886 sub *A. plantaginea* - Montagna delle Rose presso il Castelluccio, *A. Batelli* VI.1888 - Monte della Sibilla (prov. Ascoli Piceno) in pascuis circ. 2200 m, *Sommier* 9.VIII.1895 - Montemonaco, M. Vettore: salendo da Forca di Presta verso il Rif. Zilioli dai ravaneti al Rifugio, m 2000-2215. *C. Ricceri, C. Steinberg* 6.VII.1977 – Montemonaco, M. Vettore: rupi e brecciai ad E del Lago di Pilato, *C. Ricceri, C. Steinberg* 6.VII.1977 – Montemonaco. M. Vettore: salendo nei prati fino ai ravaneti da Forca di Presta verso il Rif. Zilioli. *C. Ricceri, C. Steinberg* 6.VII.1977 – Montemonaco. M. Vettore: vallette nivali e brecciai dal Rif. Zilioli al Lago di Pilato, m 2215-1950, *P.V. Arrigoni*, 6.VII. 1977 – Montemonaco. M.te Porche: falde sassose e prative m 2000-2200. *C. Ricceri, C. Steinberg* 9.VII 1977 - Castelsantangelo. Praterie sotto M.te Bove nei pressi della Funivia m 1900, *C. Ricceri, C. Steinberg* 9.VII.1977 – Visso. Macereti e rocce di M.te Bove, m 1900-2100, *C. Ricceri, C. Steinberg* 9.VII.1977 –

LAZIO - Velletri nei prati, 23.V.sine anno, da *Tanfani* sub *A. elongata* - In collibus Tusculani, *Webb*, 23.V.1848 – Monti Tusculani, *Rolli* 10.VI.1858 - In montosis Campaniae Mainarde, IX,1872, *Tenore* sub *A. denticulata*? - In glareosis Monte Cavallo in Aprutio, 8300 piedi, *H. Groves* VIII.1875 - In collibus Poggi della Pallarispera (?), *Macchiati* 23.V.1880 – Campi d'Annibale presso Albano, *Biondi* V.1886, sub *A. vulgaris* var. *elongata* – Cappuccini di Genzano, sine coll. 30.V.1889 - Rocca di Papa (Frascati) *L. Vaccari*, 15.IV.1902 - M. Guadagnolo. 900-1300, *L. Vaccari*, 1.VI.1902 - Tivoli, fra S. Polo e M. Gennaro, 600-1270, *L. Vaccari* 8.VI.1902 – Cammerata Nuova al fosso Fisis fino allo Stabilimento, 600-800 m, *Vaccari* 28.V.1904 - Dintorni di Tivoli. *L. Vaccari* IV.1907 - Salita Stabilimento di Fosso Fiojo (Lazio), *L. Vaccari* 10.VI.1911 - Da Rocca di Papa al Malepasso, 750 m. Comune nei prati e qua e là al margine del bosco. *L. Senni* 4.VI. 1939, sub *A. vulgaris* var. *plantaginea* W. - Maschis delle Faete. Terreni nudi di crinale. *L. Senni*, 4.VII.1939 – M. Terminillo, colle fra i due coni, sui 1800 m. *Montelucci* 12.VII.1949, sub *A. vulgaris* var. *majellensis* (Boiss) - Faggeta presso la Staz. Infer. Della funicolare del M. Terminillo, *A. Chiarugi, R. Corradi, A. Contardo* 31.VII.1953 – Da Campo Forogna al Terminilletto, *A. Chiarugi, R. Corradi, A. Contardo* 31.VII.1953 - Pascoli calcarei nel Comune di Viticuso (Fr.) ad oltre m 1000 s.m., *Agostini* 10.X.1955.

ABRUZZO:
- ***Majella*** - Majella (Aprut. citer.) Valle Orfenta, supra Caramanico, *Levier* 2.VII.1872 - Majella (Aprut. citer.) in lapidosis ad radicem montis Majellone, supra Caramanico, *Levier* 8.VII.1872 - Fondo di Majella, Abruzzi, *Groves*, VIII.1873 - Campo di Giove, valle di Fonte Majella, 1800-2000 m, *L. Vaccari*, 29.VI.1906 - Caramanico (Majella) salendo al convento di S. Nicola, 600-700 m, *L. Vaccari* 9.VII.1906 - Majella, boscaglia a *Pinus mugo* e rocce del M. Cavallo, m 2000-2171, *Nardi* e *Bavazzano*, 4.VIII.1970 - Caramanico. Prati della Majelletta. Scendendo lungo il sentiero per Caramanico, 2050-1800 m, *Ricceri e Steinberg* 8.VII.1978.
- **Gran Sasso** - Prov. di Teramo: in jugo montis Gran Sasso d'Italia in pratis di Arapietra, alt. 1200 m, solo calcareo, *Andrea Fiori*, 14.VII.1904 - Vive nei prati di Arapietra, G. Sasso, prov. di Teramo, *Baldrati,* 14.VII. 1967 -
- **M. Velino** - In alpinis editioribus montis Velino (Passo del Vertichio), *Levier* 9.VIII.1875 - Abundi in rupestribus subalpinis declivii aridis montis Velino, *Levier* 15.VII.1876 - Monte Velino (Abruzzo), *U. Martelli* 3.VIII.1903 - Velino, Valle di Teve m 1000-1500, *Vaccari* 9.VII.1911.
- **M. Morrone** - In Monte Morrone, *Sommier* 4.VII.1872 - Monte Morrone, supra Sulmonam. In rupestribus vallis di Mala Cupa, m 1500 ca. *Levier* 1.VIII.1873 - Supra Salle, est. 1875, *Profeta* - Monte Morrone (Abruzzi), *Profeta* estate 1891.
- **M. Sirente** - In alpibus editioribus montis Sirente (salendo da Rovere), *Levier* 1.VIII.1870 - In declivibus Montis Sirente in Aprutio, *Groves* VII.1875 - In pascuis saxosis M. Sirente (Cerretto), *Profeta* VII.1876 - In glareosis Monte Sirente in Aprutio, *Profeta*, VII.1877 - Ai prati di Santa Maria sopra Ajelli, 1500 m, *L. Vaccari*, 30.VI.1904 - Prov. d'Aquila, Pescasseroli, calcare, m 1250, *A. Fiori*, 23.VI-1.VII.1926 -
- **Monte Coccorello**, in agro marsico ad orientem montis Velino, *Levier*, 13.VIII.1875 - In alpinis et subalpinis montis Coccorello, in silvo Marsico, *Levier*, 13.VIII.1876.
- Avezzano, salita al Convento di Madonna di Pietracquara, 800-1000 m, *L. Vaccari* 20.V.1911 - Roccaraso, pascoli sassosi e rupi di M.te Greco, m 2000-2285, esp. E-NE, *Bavazzano, Nardi, Ricceri*, 10.VIII.1968 - Piano di Ovindoli (L'Aquila), *Chiarugi* 1.VI.1929 - Ovindoli, Piano di Pezza, *Chiarugi* 2.VI:1929 - Villavallelonga, Taverna degli alpini, *Grande* 29.VII.1904 - Villavallelonga. Monte Serrone. *Nardi* e *Tardelli*, 7.VIII.1977 - Valle Sagittario vers. Scanno, *Levier* 25.VI.1887 - Scanno. Pascoli e rocce di M.te Genzano, m 1850-2170, *Bavazzano, Nardi, Ricceri,* 11.VIII.1968 - Scanno. Pascoli sassosi e rocce esposte a Nord del valico La Genzana e Serra Leonardi, m 1700-1800, *C. Ricceri* e *C. Steinberg*, 11.VII.1978 - Tagliacozzo (Abruzzo). M. Valmintera presso Petrella, *Vaccari* 28.V.1905 - Pizzo di Sivo/Abruzzi/ presso le Macerie della morte, *Gemmi*, 17.VII.1877 - Montagna dei Fiori (Teramo). Pascoli del versante nord del M.te Piselli, alla base della seggiovia (1450-1550), *G. Aldobrandi, G. Padovani, E. Tosi*, 26.V.1987, sub *A. seticeps* Rchb.

MOLISE - M. Capraro a 1700 m ca., *A. Villani* VII.1908 - S. Gregorio Matese, M.te Mutria, faggeta rada e pascoli sassosi da Bocce della Selva q. 1590 a q. 1800 lungo il crinale, *Bavazzano* e *Ricceri*, 6.VIII.1968 - San Gregorio Matese, M.te Mutria, pascoli sassosi cacuminali e doline della vetta, q. 1800-1823, *Bavazzano* e *Ricceri*, 6.VIII.1968 - Capracotta. M.te Capraro: faggeta rada e pascoli de La Crocetta alla vetta, m 1450-1730, *Bavazzano* e *Ricceri*, 7.VIII.1968 - Fra S. Massimo e Campitello Matese (Molise), m 1300, *F. Bianchini* 6.IX.1975.

BASILICATA - M. Volturino in pascuis alpinis, alt. 1800-1836, *Gavioli* sine d. - Pignola. Serramatta 1450 m ca., *Gavioli* VII.1908.
- **M. Pollino**: Monte Pollino, *Biondi* VII.1880 - M. Pollino in pascuis loco Piano del Pollino vocato, alt. 1800-1900 m, *Gavioli* 4.VIII.1929 - M. Pollino in herbosis, loco "Piano Cardoso" vocato, alt. 1800 m, *Gavioli* 4.VIII.1929 - M. Pollino. M. Serra delle Ciavole, in rupestribus calcarei alt. 2000 m, *Gavioli* 4.VIII.1929 - Gruppo del Pollino. Gariga presso il Belvedere a SE del Torrione della Capanna. Alt. 1600 ca. *Nardi, Bavazzano, Posca*, 22.VII.1972 - Gruppo del M. Pollino. Serra del Prete, garighe e pascoli del crinale di SO salendo dal Belvedere tra 1650 e 2000 m, *Nardi, Bavazzano, Posca*, 23.,VII.1972.

CALABRIA - In pascuis elatis Saggio Sibylla (1500-1800 m s.m.) Calabriae, *E.* et *A.. Huet du Pavillon* 28.VI.1856 - Dirupata di Morano a 1300 m, *Fiori* 19.VI.1899 - Gruppo del Pollino. M. Dolcedorme. Valle dei mali venti, in pascuis saxosis, alt. 1800-2000 m, *Gavioli* 23.VII.1935 - Praterie e garighe del circolo glaciale tra il M. Pollino, Serra Dolcedorme e Serra delle Ciavole (Piano di Toscano, Piano di Pollino e Piana del Pollino). Alt. 1800-2000 m ca., *Nardi, Bavazzano, Posca* 25.VII.1972.

- subsp. ***maiellensis*** (Boiss.) Arrigoni, comb. nova

Basion. Armeria majellensis Boiss. in A. DC. (1848) Prodr. 12: 685.
Armeria alpina Ten. (1831) Fl. Neap. Syll.: 160, non Willd. (1809).
Armeria maritima subsp. maritima var. majellensis (Boiss.) Bernis (1953) Anal. Inst. Bot. Cavanilles, 11(2): 247.

Multi-stem perennial herb, in small heads, with erect scapes, 10-25 cm, hairy at the base (glabrous in Boissier), with short sheath, 0.5-1.5. Dimorphic leaves: outer ones linear, short, 2-4 × 0.2-0,4 cm, bending toward the ground, 3-5 veins, with undulated cartilaginous margin; inner leaves linear or filiform, 2-4 × 0.1-0.2 cm. Capitula 2-3 cm in diameter, with short outer bracts, shorter than inner bracts, oblong-acute, 0.2-0.5 cm, briefly scarious along the margin, inner bracts oval, 3-7 mm long, with more or less scarious margin. Sessile or sub-sessile calyxes, approx. 7 mm, with tube of 3 mm, hirsute ribs and apex of the lamina scarious, triangular-acute, with awn of approx. 1 mm. Pinkish-white flowers. (From materials typical of the Majella).

Chorology – Majella (locus classicus). Central-southern Apennines: M. Amaro, Gran Sasso, Monte Morrone, Monte Majellese (Martellese), Monte Sirente, M. Meta, M. Zaffineto (Valle Canneto), M. Cavallo, M. Mucchia, in general at altitudes over 2000 m.

Variability – Stalk sometimes pilous at the base (Majella, Sirente) or glabrous (Gran Sasso), leaves sometimes very short (1-2 cm). Capitula of the Gran Sasso and the Sirente small (1.2-1.5 cm).

Ecology - As correctly noted by Fiori (note to *Armeria gracilis* Ten, no. 1911 Fl. Ital. exs., ser. II) "*majellensis* is the form of the Alpine meadows, *gracilis* that of the meadows and stony places in the sub-Alpine and mountainous zone".

Notes – It is distinguished from *Armeria gracilis* Ten. by the smaller size of the outer bracts of the capitulum (0.2-0.5 cm, slightly acute), by the leaves, by the sheaths and, in general, by the scape. At anthesis, the capitula are sub-spherical (2-3 cm in diameter) while in *Armeria gracilis* they are hemispherical (1.5-2 cm in diameter). *Armeria majellensis* appears as the product of a hypsophyllic evolution of *A. gracilis*.

Specimina visa (Selection by region):

LAZIO - In glareosis alpinis ad radices montis Zaffiretto, supra vallem Canneto (Campania sept., Prov. di Sora) loco: Passaggio dell'Orso, *Levier* 8.VIII.1872 - In lapidosis alpinis montis Meta Campaniae (Valle del Viscuzzo), *Levier*, 9.VIII.1872.

ABRUZZO - **Majella** (Aprut. Citer.) in lapidosis ad medium montis Majellone supra Caramanico, *Levier* 8.VII.1872 - Monte Amaro specialmente verso la cima, 8000 piedi, *Groves* VIII.1875 - Majella: Monte Amaro verso i 2000 m, *Guadagno* VIII.1899 - Majella, tra Pescofalcone e Rapina, 2500-1900 m, *L. Vaccari* 28.IX.1903 - Majella, tra M. Amaro e quota Pesco Falcone, 2800-2600, *L. Vaccari* 28.IX.1903 - Majella, da Grotta Cavata al Rifugio di M.te Amaro, 2500-2800, *L. Vaccari*,

28.IX.1903 - Majella. Stazione di Campo di Giove, *L. Vaccari* 30.VI.1905 - Campo di Giove, fra Fonte Majella e Femmina Morta, 2000-2500 m, *L. Vaccari*, 1.VII.1905 - Majella, *L. Vaccari* 14.X.1909 - Majella, fra Campo di Giove e M.te Amaro, *L. Vaccari*, 18.X.1909 - Majella, *U. Martelli*, 1923 - M.te Majelletta. Dal Rifugio "La Majelletta" al Blockhaus, m 1892-2142, *Nardi* e *Bavazzano*, 12.VII.1969 - Majella. Pietraia del crinale Nord e della vetta del M. Focalone, m 2450-2676, *Nardi* e *Bavazzano*, 6.VIII.1970 - Majella. Praterie e rocce del circolo glaciale fra M.te Focalone e cima delle Murelle, m 2400-2600 ca., *Nardi* e *Bavazzano* 6.VIII.1970.
- **Gran Sasso** d'Italia (2934 m), *Marchesetti* 29.VI.1875 - Gran Sasso d'Italia. Rupi della Traversa di Portella, *Martelli*, 14.VIII.1893 - Pascolo del Gran Sasso presso al Rifugio, *Martelli* 15.VIII.1893 - G. Sasso in Campopericoli, *Andrea Fiori* 30.VII.1898 - Gran Sasso d'Italia, in pratis di Campo Pericoli, alt. 2200 m circ., solo calcareo, *Andrea Fiori*, 18.VII.1907.
In Monte Morrone, *Sommier* 4.VII.1892 - In rupestribus alpinis montis Velino (Passo del Verticchio, 23-2400 metr) *Levier* 9.VIII.1875 - M. Velino (Abruzzi) dai prati di Onsicita alla punta 1800-2476, *Vaccari*, 8.IX.1902 - Sirente sopra Gagliano, m 2800-1500, *L. Vaccari* 29.VI.1910 - Monte Viglio fra la fontana degli Scifi e la vetta, m 1600-2158, *L. Vaccari*, 2.VII.1901.

Race ***A. macropoda*** Boiss.

1. Calyx 8-10 mm. Outer vernal leaves 5-6 mm wide, inner ones 3-4 mm ..***A. macropoda***
1. Calyx 7-8 mm. Outer vernal leaves 2-5 wide, inner ones 1-3 mm................................2
2. Outer bracts lanceolate-acute 0.8-1.5 cm. Inner leaves linear-filiform, 1-2 mm wide..... ....Apulian-Lucanian populations
2. Outer bracts oval-acuminate, 0.8-2 cm. Inner leaves linear-lanceolate, 2-3 mm ....***A. garganica***

Armeria macropoda Boiss. in DC. (1848) Prodr. 12: 688.
Armeria morisii var. *macropoda* (Boiss.) Parl. (1866) Fl. Ital., 8: 600.
Armeria maritima subsp. *maritima* var. *macropoda* (Boiss.) Bernis (1953) Anal. Inst. Bot. Cavanilles, 11(2): 246.
Armeria scorzonerifolia Ten. (1831-1842) Syll. Fl. Neapol.: 160, non Willd.

Caespitose perennial herb with erect, robust scapes, 50-60 cm, with sheath di 3-4 cm, lacerated at the base. Dimorphic leaves, 5-20 cm, basilar leaves as wide as 5-6 mm, inner leaves 3-4 mm, decurrent near the bottom, 5-9 veins, glabrous, with scarious margin. Capitula from 2 to 3 cm in diameter, with 2-4 basilar bracts, oval-lanceolate, larger than the inner ones, acute, the others obovate, obtuse, with scarious margin, the inner interfloral bracts entirely scarious. Spikes with peduncle of 2 mm. Trifloreted spikelets, briefly stipitate, the lower flower with pedicel of 3-4(5) mm. Calyx 8-10 mm long including the awn, tube of 3-4 mm, villous, extending into the lamina. Oval-triangular lobes with awn of 1.5-3 mm. White or slightly pink corolla. (Description from topotypes of the locus classicus: M. Vergine).
Note - On Terminio the outer leaves are also 1-1.2 cm wide. In the materials from Monte Alburno the sheath is reduced to 2-2.5 cm, the leaves and the dimensions of the capitulum (2 cm) are highly reduced (the inner leaves almost filiform).
Chorology - Monte Vergine and Terminio in the Province of Avellino. Monte Alburni, Monti Picentini, on calcareous rock. Bernis (cit.) indicates, in addition to Montevergine,

the localities of Valle Tretta near S. Angelo (Potenza), Jai (Foi?) in Lucania, Pignola and Monte Impiso near Pietrapertosa.

Specimina visa:

LAZIO - Lungo l'Autostrada del Sole. Tra Roma e Napoli all'altezza dell'uscita di S. Cesareo (coltivata), *P.V. Arrigoni* 24.IV.1975 - Lazio: Attigliano, 6,5 Km a Sud di Attigliano sull'Autostrada del Sole (coltivata), *P.V. Arrigoni* 2.V.1975 – S. Cesareo. Autostrada del Sole Roma-Napoli nella scarpata poco dopo S. Cesareo (coltivata), *C. Ricceri* 21.IV.1978 - Lungo l'autostradfa del Sole, tra Anagni e Frosinone (coltivata). *P.V. Arrigoni* 2.V.1995.

CAMPANIA: **Montevergine**: Montevergine, *Pasquale*, VII.1851 - Montevergine pr. Avellino, 1400 m, *M. Guadagno* VII.1900 - Loc. Hirpinia. Prov. di Avellino: communis in saxosis, apricis montis Vergine, alt. 1200 m, solo calcareo, 19.VI.1904, *M. Guadagno* sub 325. *Armeria morisii* Boiss. var. *macropoda* Boiss. (pr. sp.) in DC. Prodr., XII, p. 688 (1848). Schedae Fl. Ital. Exs. – Avellino, Boschi di Montevergine, leg. *G. Pellanda* 12.VII. 1910.

Monte Motola (Salerno) tra Piaggine e Fegiano in pascuis saxosis e 1500 m (flores rosei), *Lacaita* 18.VII.1919 - Monte Motola, interno dell'Abetina, *A. De Philippis*, 9.VI.1948.

Monte Alburno. Da Corleto M. a C. Sierre. Faggeta deteriorata 1200-1420 m, *A. De Philippis*, 12.VIII.1936 - Monte Alburno. Da Sicignano a M.te Panormo. Crinale a 1500, *A. De Philippis*, 16.VIII.1936 - Monte Alburno. Da Postiglione a Campo d'Amore. Cresta rocciosa a 1450 m, *A. De Philippis* 29.VII.1939 - Monte Alburno. Da Sicignano a M.te Tisone. Pascolo roccioso cacuminale (1570 m) *A. De Philippis*, 12.VIII.1941 - Monte Alburno. Da C. Aresta a S. Angelo. Cresta dio Serraventola (1300 m), *A. De Philippis* 14.VIII.1941 - Monte Alburno. Da S. Angelo a C. Farina. Pascolo roccioso (Giammaria), *A. De Philippis* 15.VI.1942 - Monte Alburno. Da S. Angelo a C. Farina. Sopra S. Angelo (fino a 1000 m), *A. De Philippis*, 16.VI.1942 - Monte Alburno. Polla-Vallescura, prato a 800 m, *A. De Philippis*, 7.VI.1948 - Monte Alburno. Lungo la cresta da Costa La Croce a Ottati (600-900 m), 29.V.1951, *A. De Philippis* e *G. Moggi* - Monte Alburno. Pascoli e rocce presso il Figliolo e flora cacuminale, m 1300, 1.VI.1952, *Pichi Sermolli* e *G. Moggi* - Monte Alburno. Pascoli a N di C. Aresta m 1200, 1.VI.1952, *G. Moggi* e *R. Corradi*.

M. Partenio: Terreni calcarei pascolivi del Piano Maggiore (m 1300 s.m.) del M. Partenio (AV), *R. Agostini* 11.VII.1954 -

M. Taburno (Benevento): In montosis Campaniae Taburno, sine coll., sine die - Taburno, *Gussone* X.1849 - Pascoli e rocce del crinale e del versante S tra la Cresta del Taburno e la vetta, m 1150-1394, *Nardi* e *Bavazzano*, 18.VII.1969.

M. Terminio alle rupi Falconara, pascoli sassosi calcarei m 1100-1300, leg. et det. *Moraldo*, 21.VI.1974.

M. Cervialto, pascoli sassosi m 1600-1800, *Moraldo* 16.VII.1975.

- Pomigliano d'Arco, presso la stazione autostradale della Bari-Napoli, coltivata. *P.V. Arrigoni* 2.V.1975.

BASILICATA – Basilicata, Da *Gasparini* in Ottobre 1845, sub *A. denticulata* Bert. - Pignola in pascuis montis Serranetta, *Gavioli* VII.1907 - Sasso Costaldo in pascuis montis Tempa dell'Olmo, solo calcareo humoso, alt. c. 1250 m, 4.VI.1922, *Gavioli* – Sasso Costaldi in herbosis montis Tempa dell'Olmo, solo calcareo alt. 1200 m, *Gavioli* 4.VI.1922 - Sasso Castaldo, in cacuminis montis Serra della Criva, solo calcareo, alt. 1263 m, 4.VI.1922, *Gavioli* - Pignola in cacuminis montis Serranetta, sol. siliceo, alt. 1470 m, *Gavioli* 24.VI.1923 – Pignola. M. Bernardo in pascuis calcareis, alt. 1200 m, *Gavioli* 7.VII.1925 - Potenza. M. Fai, in herbidis, solo siliceo, alt. 1200-1360 m, *Gavioli* 13.VI.1926 - M. Fai, in pascuis editis alt. 1300 m, *Gavioli* 3.VI.1928.

Notes – Lucanian plants are in general more delicate than those of Campania and have shorter pedicels on the calyx (approx. 2 mm). The calyx lobes are modest.

Armeria macropoda is present also in the Apulian Murge but, as in Basilicata, with less highly developed populations. They could be distinguished on the sub-species level, but the few examples we have examined are not sufficiently convincing. However, we will report their description and exsiccata.

Description - Perennial Herb, multi-stem, with erect scapes, 30-40 cm, hardy. Sheath 1.5-3.5 cm. Outer leaves linear-lanceolate, 5-7 × 0.3-0.4 cm, scarious-marginate; inner leaves linear, 6-12 × 0.1-0,2 cm, very acute at the apex. Capitula 2.5-3 cm in diameter, sub-spherical at anthesis. Outer bracts lanceolate-acute, 0.8-1.5 cm, either longer or shorter than the inner ones. Inner bracts oval-oblong, approx. 1 cm, either very scarious on the border or entirely scarious. Spikelets with pedicles of 1.5-2.5 mm. Calyx 8-9 mm with tube of 3 mm, villous on the veins, and very pronounced scarious lobes, ending in a short awn (1 mm at most). Pink corolla crenulate at the apex.

Specimina visa:

PUGLIE - Nel "Pulicchio" di "Fioriti" alle Murgie di Gravina, *A. Palanza* 5.VI.1898 sub *Armeria plantaginea* W. (Palanza alla Flora della Terra di Bari p. 36) - Martina Franca (Terra di Otranto) nelle macchie della Masseria Cobucci; solo calcareo, c. 450 m (flores albi), 10.V.1920 *C. Lacaita* sub *Armeria canescens* (Host) Born. ad *A. macropodam* Boiss vergens.

Armeria garganica Arrigoni species nova (Fig.3)

Herba caespitosa scapis erectis, 25-50 cm altis, cylindricis, robustis. Vaginae 2-3(4) cm longae. Folia primordialia plana, apice acuta, 3-5 × 0,2-0,5 cm, 5(7)-nervia, interna linearia vel filiformia, 5-15 (20) × 0,2-0,3 cm, conduplicata, plerumque trinervia. Capitula 2-2,5 (3) cm in diametro, hemisphaerica vel subsphaerica sub anthesi. Bracteae exteriores interioribus longiores, duae basales ovali-acuminatae, 8-20 mm longae, ceterae ovali-rotundatae apiculatae margine scariosae, vel rotundato-obtusae totae scariosae. Calyces subsessiles, 7(8) mm longi arista inclusa, tubo brevi (circa 3 mm longo), lobis triangularibus, arista 1-1,5 mm longa. Corolla alba vel rosea.

Typus - Holotypus in FI: "Ex Itinere I. italico Portae et Rigoi/*Armeria plantaginea* Willd./Italia austral. Apulia: Gargano in herbidis apricis pr. S. Nicandro sol. calcar. 30/6 1874, *Porta* et *Rigo*."

Caespitose herb with erect scapes, 25-50 cm, cylindrical, hardy. Sheaths 2-3(4) cm. Primordial leaves flat, acute at the apex, 3-5 × 0.2-0.5 cm, 5(7) veins, inner leaves from linear to filiform, 5-15 (20) × 0.2-0.3 cm conduplicate, in general triveined. Capitula 2-2.5 (3) cm in diameter, from hemispherical to sub-spherical at anthesis. Outer bracts longer than inner ones, the two basal ones oval-acuminate, 8-20 mm, the others ranging from oval-rounded, apicolate at the apex, scarious along the edge, to rounded-obtuse, entirely scarious. Sub-sessile calyxes, 7(8) mm with the awn; short tube (approx. 3 mm), triangular lobes and awn of 1-1.5 mm. White or pink corolla.

Chorology – Promontory of Gargano (Apulia).

Note – Simile to *Armeria macropoda* but distinguished from it by narrower leaves, the inner ones ranging from linear to filiform, the basal bracts short and oval, acuminate.

Specimina visa:

GARGANO (Puglie) - Italia austral. Apulia in pascuis circ. M.te St. Angelo Gargani, 1-2000' sol. Calcar, *Porta* e *Rigo*, 21.VI.1875 - Italia austral. Apulia: Gargano in herbidis apricis pr. S. Nicandro sol. calcar. 31.VI.1876, *Porta* e *Rigo* - Coste di Manfredonia presso Cagnano, 15.V.1893, *Martelli* - Monte Sacro, *Martelli*, 31.V.1893 - Falde di Monte Calvo, *Martelli*, 27.V.1893 – Madonna degli Angeli presso Monte S. Angelo, *Martelli* 29.V.1893 – Rupi della Madonna degli Angeli, presso Monte S. Angelo, *Martelli* 29.V.1893 – Gargano a M.te S. Angelo, Fiori 14.VI.1898 – Gargano a M.

Fig. 3. *Armeria garganica* Arrigoni × 0.59. Details: Calix and scales × 5.9.

Nero, *Fiori* 16.VI.1898 - Gargano, M. Sacro, calcare, m 900-950, 21.V.1913, *A. Fiori* – Gargano, M. Sacro, calcare, m 900-950, 21.V.1913, *A. Fiori* – Monte S. Angelo (Italie, prov. Foggia, Peuilles), le long de la Route Nationale n. 528 vers la "Foresta Umbra", prés de la ferme Armillotti, alt. env. 670 m, pâturage de montagne, à esposition Sud-est, 11 juin 1996, *Aldobrandi* e *Baldini*.

Armeria brutia Brullo, Gangale & Uzunov (2004) Bot. Jahrb. Syst., 125(4): 465.

Typus – Holotypus in CAT: " Sila, Silvana Mansio 20.VII.1998, Bartolo, Brullo et Gangale".

Caespitose perennial herb with erect scapes, 10-50 cm, with sheath di 1-2.5 cm. Outer leaves flat, 1.5-3 (5-6) cm, multi-veined, obtuse, inner leaves from linear to filiform, 3-5 veins, from subacute to acute, sometimes as long as 15 cm. Outer bracts from oval-lanceolate to linear-lanceolate, 6-10 mm, scarious on lateral edges, inner bracts from oblong to oval-oblong, triveined, 2-3.5(4) mm wide, with scarious margin. Outer bracts of the spikelets obovate, 7.5-8 × 5-5.5 mm, intermediate ones oblong and obovate-oblong, 5-5.5 × 2.5-3 mm. Calyx 7-8.5 mm with sub-obtuse lobes, with awn of 1 mm. Petals 10-10.5 mm, slightly truncated at the apex.

Chromos. Numb. - $2n = 18$ (Brullo & al., 1994: 207), on material from Sila (Cosenza), sub *A. canescens* (Host) Ebel.

Chorology – Endemic to Sila (Grande and Piccola).

Specimina visa:

CALABRIA – Sila. Habui a Cl. Bivona cui miserat *Thoscos* (?) – Calabria III orient. Distr. Castrovillari in pascuis sylvatic. In M.te Cataracte, solo calc., 900-1000 m, *Huter, Porta, Rigo*, 18.VI.1877 (3 exs.) - Sila al Gariglione, *A. Fiori* 7.IX.1883 - Sila. Fossiata (Longobucco, m 1300, sol. granitico, *A. Fiori* 29.VII-3.VIII.1918 – La Sila (Calabria). Tra Lorica e Bivio Garga, m 1300. *G. Sarfatti* e *R. Renato*, 9.V.1950 – La Sila (Calabria). Camigliatello: dintorni m 1290, 11.V.1950, *G. Sarfatti* e *R. Corradi* - La Sila (Calabria). Ponticelli (S.S. 107 Km 97) m 1300. *G. Sarfatti* e *R. Corradi*, 11.V. 1950 - La Sila (Calabria). Santa Barbara m 1300, *G. Sarfatti* e *R. Corradi*, 12.V.1950 - La Sila (Calabria). Camigliatello: pendii sottostanti verso la piana m 1290, *G. Sarfatti* e *R. Corradi*, 13.V.1950 – La Sila (Calabria). Monte Curcio m 1700, *G. Sarfatti* e *R. Corradi*, 14.V.1950 - La Sila (Calabria), Salita al M. Carlomagno da Silvana Mansio, m 1450-1670, *G. Sarfatti* e *R. Corradi*, 14.VI.1950 - La Sila (Calabria). Neto di Ferrara, m 1300, *G. Sarfatti* e *R. Corradi*, 22.VI.1950 – La Sila (Calabria), Regione Ciricilla zona piana umida, m 1370, *G. Sarfatti* e *R. Corradi*, 27.VI.1950 – La Sila (Calabria). Regione Ciricilla faggeta ad Ovest della zona piana, m 1390, 27.VI.1950, *G. Sarfatti* e *R. Corradi* - La Sila (Calabria). Camigliatello, nei boschi salendo verso M. Curcio, m 1300-1600, *G. Sarfatti* e *A. Contardo* 10-16.VII.1951 - Sila: contrada Giamberga m 1050 (Sila Greca), *Chiarugi A*., *Bavazzano R., Contardo A*., 30.V.1955 - Sila (Camigliatello): Macchia Sacra m 1500 ca., *Chiarugi A., Bavazzano R., Contardo A*., 30.V.1955 - Sila. Bivio di Garga (Cosenza), m 1255 ca. *Chiarugi A., Bavazzano R., Contardo A*., 31.V.1955 – Sila Piccola (Cosenza). Poverella, sui 1150 m. Luogo erboso, aperto, ai margini del bosco, *M. Padula, R. Corti,* 11.X.1960 - Sila Grande: Lago di Cecita, verso Longobucco, *P.L. Di Tommaso* e *E. Ferrarini*, 14.VI.1973.

Armeria aspromontana Brullo, Scelsi & Spampinato (1997) Edinb. J. Bot., 54 (1): 91.

Typus – Holotypus in CAT: "Italy. Aspromonte, Bocca del Lupo, 18.VII.1992, *Brullo, Scelsi* et *Spampinato*".

Caespitose perennial herb with erect scapes, faintly striated, 10-32 cm, with sheaths di 10-16(20) mm. Leaves green-glaucous, glabrous, stiff, dimorphic; outer leaves linear-lanceolate, flat, 2-6 × 0.2-0.4 cm, inner ones linear or filiform, 2-11 x 0.05-0.2 cm. Hemispheric capitula, 12-18 mm wide. Outer involucral bracts from oval-triangular to linear-subulate, 5.5-20 mm, more or less cuspidate, scarious along the edge. Inner bracts from sub-round to oblong, 6-8 × 3.5-6 mm, briefly apiculate at the apex, with wide scarious margin. Sub-sessile spikelets, 2-3 flowers, axcillated by scarious hyaline bracts. Calyx 6-7 mm, with hirsute tube and with limbs and short triangular lobes, with awn of 0.8-1 mm. Pinkish petals, approx. 8 mm.
Iconography – Figs. 1-2 in Brullo & al., (1997: 92-93).
Chorology – Endemic to the Aspromonte, on metamorphic rocks between 1300 and 1900 m.
Specimina visa:
CALABRIA – Calabria I orient. In pascuis petrosis supra Conventum di Polsi ad Montalto, Aspromontes, sol. granit. 1400 m, *Huter, Porta Rigo* ex itinere italico III, 30.V.1879 (4 exs.) – Monte Alto di Aspromonte, *U. Martelli*, 8.VI.1906 - Bocca del Lupo, *Brullo, Scelsi et Spampinato*, 18.VII.1992 (Isotypus).

The genus *Armeria* is completed in Italia by the following taxa of Sicily and Sardinia:

Armeria nebrodensis (Guss.) Boiss. in DC. (1848) Prodr., 12: 685.
Statice nebrodensis Guss. (1842) Fl. Sic. Syn., 1: 366.
Chorology – Eastern Sicily (M. Peloritani). Madonie above Petralia (*locus classicus*), Colma grande, etc.

Armeria gussonei Boiss. (1848) A. DC., Prodr, 12: 687.
Armeria morisii var. gussonei (Boiss.) Parl. (1866) Fl. Ital., 8: 800.
Chorology – Endemic to Sicily (*locus classicus* Rocca Busambra).

Armeria morisii Boiss. in A. DC. (1848) Prodr, 12: 687.
Chorology - Endemic to central-eastern Sardinia.

Armeria sardoa Spreng. (1827) Syst. Veg., 4(2): 127.
Armeria vulgaris subsp. sardoa (Spreng.) Terracc. (1930) Mem. Accad. Sci. Torino, ser. 2, 67: 32.
Chorology - Endemic to the mountains of central-northern Sardinia.

Armedria sardoa subsp. ***genargentea*** Arrigoni (1970) Webbia, 25: 166.
Chorology - Endemic to M. Gennargentu.

Armeria sulcitana Arrigoni (1970) Webbia, 25: 169.
Chorology - Endemic to the mountains of south-western Sardinia, from 800 to 1300 m (*Locus classicus* M. Santo di Pula).

Escludendae

Armeria arenaria subsp. *bupleuroides* (Godr. & Gren.) Greuter & Burdet (1989) Willdenowia, 19: 39.
Armeria bupleuroides Gren. & Godr. (1850) Fl. Fr., 2: 736.
Armeria plantaginea subsp. *bupleuroides* (Gren. & Godr.) Nyman (1881) Consp. Fl. Eur.: 616.
Armeria plantaginea var. *bupleuroides* (Gren. & Godr.) Lawrence (1940) Gent. Herb., 4(11): 391-418.

Plant woody at the base, delicate with scapes of 20-30 cm, and capitula di 1.2-1.8 cm. Triveined glaucose-green leaves, with wavy margin, 4-8 mm wide. Capitula approx. 1.5 cm in diameter. Outer involucral bracts pale, distinctly shorter than capitulum, i.e., not surpassing the flowers. Calyx with lamina having short, triangular lobes, almost obtuse lobes, abruptly contracted in an awn longer than the lobe. Corolla white, at times pinkish-white.
Chorology – Alpine-Pyrenean/Western Alps, in general on calcareous substrates: Frejus, Toulon, Marseille, Gap. Not in Italy according to Greuter & al. (1989: 308) and Aeschimann & al. (2004, 1: 394).

Armeria canescens (Host) Ebel (1840) Gen. Armeria: 28.
Statice canescens Host (1827) Fl. Austr., 1: 407.
Armeria canescens (Host) Boiss. in DC. (1848) Prodr., 12: 686.
Armeria maritima subsp. *maritima* var. *canescens* (Host) Bernis (1953) Anal. Inst. Bot. Cavanilles, 11(2): 246.
Armeria dalmatica Beck (1898) Ann. K.K. Naturhist. Hofmus., 13: 16.
Armeria canescens subsp. *dalmatica* (Beck) Trinajstic (1980) Suppl. Fl. Anal. Jugosl, 7: 6.
Chorology – Balkan species: Dalmatia, Montenegro. Indicated with doubt in Greece.
Chromos. Numb. - $2n = 18$ (Brullo & al. 1994: 207), on material from Sila (Province of Cosenza), but the report is certainly to be referred to Armeria brutia Brullo, Gangale et Uzumov.

Both Host and Boissier described this species for Dalmatia, to which Ebel later added Montenegro and others, Greece. Its presence on the Italian peninsula was hypothesized by Levier (1888) Atti Soc. Tosc. Sci. Nat.: 157) in reference to the var. "gracilis d pallida" of Tenore. This hypothesis was accepted by Arcangeli (1894, Comp. Fl. Ital., ed. 2: 461) for Lucania, but the report did not convince Fiori (1902) Fl. Anal. Ital., 334 who, in a note, pointed out diversities in some existing characters between Boissier's description and the southern populations of Calabria. "The var. "*gracilis* d *pallida*" is the same, according to Levier (1888: 157) as the *Statice canescens* Host, or *Armeria canescens* Boiss. of Dalmatia and Montenegro; the latter, however, according to Boissier's description (in DC: Prodr., 12: 686), should have the pedicles of the flower three times shorter than the calyx, and the corolla always white (while in the Calabria plant it is pale purple). Although these characters are relatively unimportant, considering the different geographical areas, they can suffice to consider the two plants as different forms. The same can be said of *Armeria undulata* Boiss. (= *Statice* Bor. & Chaub.) of Greece, which Levier deems synonymous with his *Ameria majellensis* var. *elatior*, while according to Boissier's diagnosis (l.c.) it differs in having snow-white outer bracts and the pedicles of the flower a little shorter than the calyx tube; the elatior var. corresponds instead to the typical *A. gracilis* Ten., as is clearly evident by the localities specified by Tenore for this species". Subsequently, however, Fiori (1926, 2: 236), accepted this report, but equating the species with *Armeria gracilis* Ten., inclusive of *Armeria majellensis* var. *elatior* Levier (1888).

The name *A. canescens* was subsequently utilized by many florists for peninsula populations having different characters and provenance. Specifically, it has been used for populations of *A. canescens* with sturdy scapes, well-developed leaves and rather large capitula, in sharp contrast to the diagnoses of Host and Boissier and the following description based on original Dalmatian material (in FI).

Diagnosis – *"4. S. floribus capitatis, foliis linearibus scapisque glabris, calycibus aristatis. In Dalmatiae montibus. J. Host, Portenschlag. Fl. Aestate. Per."Radix multiceps. Scapus teres, glabre. Folia lineria, canescentia, striata. Bracteae exteriores acuminatae, in membranam, superiorem scapi partem vestientes, decurrentes; interiores obtusae. Calyx pilosus, quinquangulatus: angulis in aristam scabram procurrentibus*.

Multicipite caespitose perennial herb, with erect scapes, 30-40 cm. Sheath 10-15 mm. Dimorphic leaves: outer leaves linear, short (2-3 cm) flat, 2-4 mm wide, 3-7 veins, with wavy cartilaginous margin; inner leaves ranging from linear, a little wider in the upper half, to filiform (3-10 × 0.05-0.2 cm), 1-3 veins, with brief scarious margin in general revolute toward the inside. Capitulum 1.7-2 cm in diameter. Outer bracts of capitulum oval, 3-4.5 mm, acute or apicolate at the apex, scarious on the margin, inner bracts ranging from oval, emarginate and with wide scarious border to oval-rounded, muticate, entirely scarious. Short pedicels, 0.5-2 mm. Calyx 7-8 mm, with tube approx. 3.5 mm, hirsute on the ribs, and scarious lobes, triangular at the apex, terminating in an awn of 1-1.5 mm. "*Corolla constanter alba*" (Boissier).

Note – Bernis (cit.: 246) reports a single Italian sample of this species, coming from the Montagna della Duchessa (leg. *Martelli*, 1903), "with slight tendency to the var. macropoda".

Armeria elongata (Hoffm.) Koch (1826) in Roehl., Deutsch Fl., ed. 3, 2: 487.
Statice elongata Hoffm. (1800) Deutschl. Fl.: 150.
Armeria maritima subsp. *elongata* (Hoffm.) Bonnier in Bonnier & Douin (1927) Fl. Compl. Fr., 9: 54.
Statice armeria var. *elongata* DC. (1805) Fl. Fr., 3: 419.
Armeria vulgaris var. *elongata* (Hoffm.) Fiori (1926) Nuova Fl. Anal. Ital., 2: 235, pro parte.

Chorology - Reported in the past for the Veneto plains and other Po Valley localities, but its presence in Italy had already been considered unproven in Bernis (cit.: 11(2): 256). See *A. helodes* Martini and Poldini.

Armeria majellensis subsp. *ausonia* Bianchini (1977) Giorn. Bot. Ital. 111: 49.

The subspecies does not appear significantly distinct since, as shown by the diagnosis, its characters fall within the intra-specific diversity of *A. gracilis*. Moreover, some exsiccata (FI!) from Monte Coccorello (*locus classicus* of the subspecies) have been attributed by Bianchini himself to *A. gracilis*.

Diagnosis – *"Folia 0,5-2,2 mm lata, 40-70 mm longa, esteriore valde latiora. Scapi editi 13-40 cm, capituli subsphaerici (17-23 mm) vagina 2/3 longa et 50-60 spiculis praediti; calix brevibus aristis ornatus".*

Typus – Holotypus in FI: "In Monte Coccorello, 13.VIII.1875, *Levier*".
Chorology – Reported on Monte Vettore, Sirente, Majella, M. Meta, etc.

Armeria seticeps Rchb. (1827) Iconogr. Bot. Pl. Crit, 5: 54.

From the diagnosis it can be seen that the species presents "foliis lineari-lanceolatis, erectis, acutis, trinervibus, ciliatis, scape omnino pubescente", characters that lead us to exclude its presence in Italy, especially in the northern Apennines and the Apuan Alps, territories in which it has been reported by several authors.

Armeria seticeps Rchb. fil. (1855) Fl. Germ. Excurs., 17: 68, nom. illeg., non Rchb. (1827).

This is a name attributed to species differing from *A. seticeps* Rchb. (1827). In synonomy appears *Armeria plantaginea* var. *brachylepis* Boiss. in DC. (1848: 683), a taxon faintly characterized by leaves that are narrower and shorter than *A. arenaria* (Pers.) Schult. (*A. plantaginea* Willd.) and by more modest scapes (Iconography in Reichenbach, 1855, Icon. Fl. Germ. Helv., Tav. 1151, II). The *brachylepis* variety has been reported on the Maritime Alps (Tenda) and at Valdieri.

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Avinoam Danin

Rocks supporting endemic plant species in East Mediterranean deserts

Abstract

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East Mediterranean deserts of Israel, Jordan, and Sinai have a few endemic species which firmly occur on specific rocks. The extent of these rocks and the size of their outcrops have a profound impact on the distribution of certain narrow endemics. The aim of the present article is to deal with examples of distribution of a few endemic plants as related to their specific rock types.

Key words: Endemism, Ecology, Desert Flora.

Introduction

East Mediterranean deserts of Israel, Jordan, and Sinai have a few endemic species which firmly occur on specific rocks (Shmida 1984). The extent of these rocks and the size of their outcrops have a profound impact on the distribution of certain narrow endemics. Of the many rock types which occur in the study area three chemically rare rock types are selected – Triasic gypsum in the Ramon depression, Negev Highlands, Tertiary sandstone, and Senonian silicified chalk found in the Judean Desert between Jerusalem and the Dead Sea valley. The fourth rock type are smooth-faced limestone and dolomite and smooth-faced hard sandstone. Much of the rocks smoothness is caused by the protection from weathering of epilithic lichens developing on north-facing limestone, dolomite, and sandstone. The aim of the present article is to deal with examples of distribution of a few endemic plant related to the various rock types.

Capparis ramonensis on Triasic gypsum

Capparis ramonensis Danin is an endemic (Danin 2011) species found only on outcrops of Triasic gypsum in the Negev Highlands, Makhtesh Ramon (in Fig.1: No. 1; for color images of all plants mentioned here see: http://www.flora.org.il). The most common rock types surrounding the gypsum outcrop are limestone of various eras. The geologists consider the palaeo-environment forming these gypsum sediments a “product” of a palaeo-

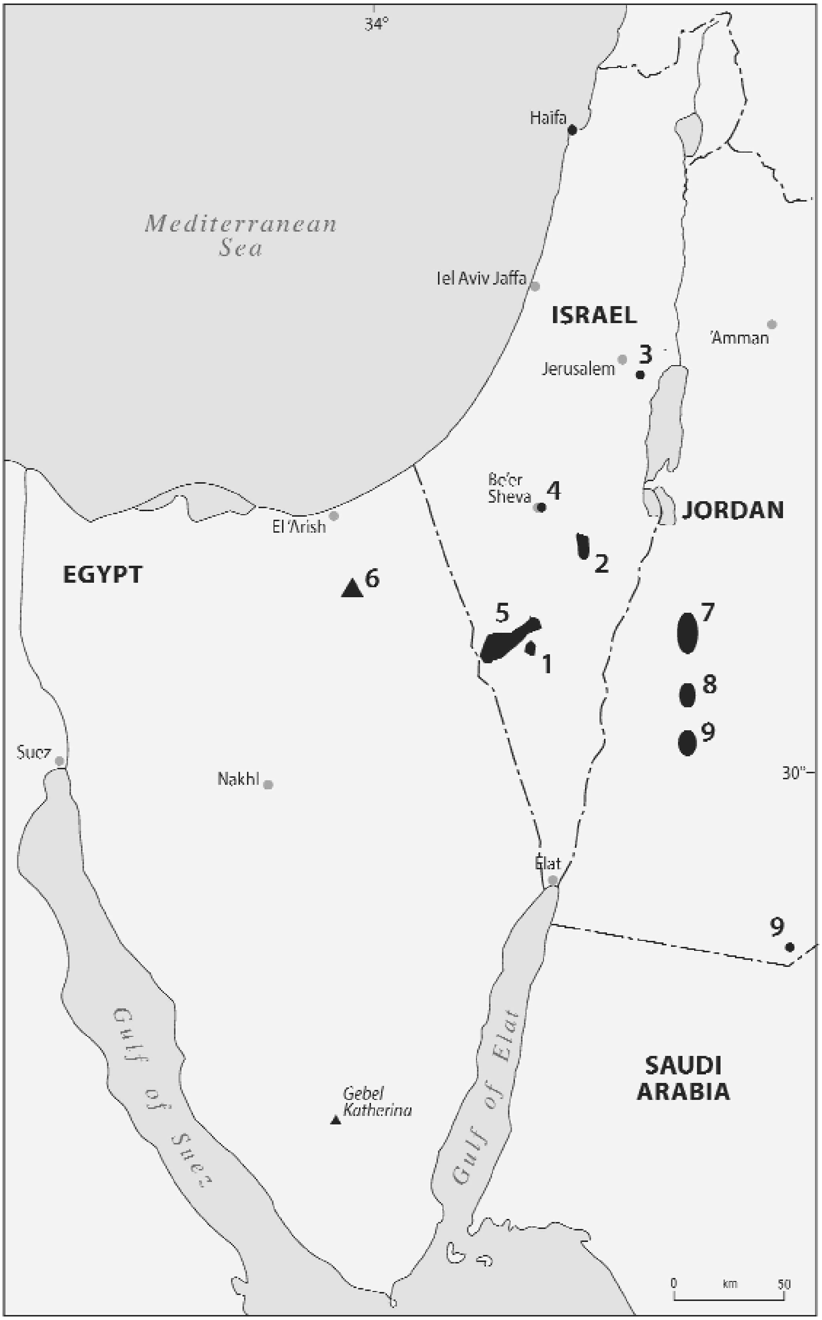

Fig. 1. Distribution map of a few endemic species in Israel, Jordan and Sinai. 1.*Capparis ramonensis,* 2.*Hormuzakia negevensis*, 3. *Satureja thybrifolia*, 4. *Origanum dayi,* 5. *O. ramonensis*, 6. *O. isthmicum*, 7. *O. punonense,* 8. *O. petraeum*, 9. *O. jordanicum.*

lagoon of the Triasic era at the margins of the Tethys Ocean. The rock is exposed only in the erosion crater of Makhtesh Ramon in an area of 3.35 km^2. The thickness of the gypsum layers is several hundred meters.

The mean annual rainfall in this area is 70 mm. Such gypsum rock outcrops are unique and do not occur anywhere else in the entire area of the East Mediterranean deserts. Until found in additional locations *Capparis ramonensis* should be considered as a narrow endemic with less than 200 specimens.

A few psammophytic species of the extreme desert accompany *Capparis ramonensis*. These are *Hammada salicornica* (Moq.) Iljin and *Salsola cyclophylla* Baker (=*Caroxylon cyclophyllum* (Baker) Akhani & Roalson). The association in which this caper grows is not defined yet phytosociologically, but it is evident that it belongs to the vegetation class *Anabasietea articulatae* (Danin & Orshan 1999).

Hormuzakia negevensis on Neogene sandstone

The Yamin-Rotem syncline of the Negev Highlands is filled up with terrestrial sandstone and claystone deposited there some 3 to 20 million years ago during the Neogene. The Tertiary rocks passed a long period of weathering leading to reworking of sands through short distance transportation in that valley. *Hormuzakia negevensis* (Danin) Danin & Hilger (= *Anchusa negevensis* Danin) is a perennial herbaceous plant and observed so far only at the "locus classicus". It grows in a minute population with less than 20 individuals. It is one of the group of psammophytic *Boraginaceae* which have the property of vegetative reproducing by producing roots-derived shoots (Danin 1996). The other plants in that group, which are not endemics are *Echiochilon fruticosum* Desf., and *Moltkiopsis ciliata* (Forssk.) I. M. Johnst. The latter accompany *H. negevensis* in the Negev. Of the most important environmental factors associated with the occurrence of this narrow endemic is its constant exposure to wind erosion being a SW facing gentle slope. The particular type of Neogene sandstone occurs in Israel only in the Rotem – Yamin plane (Fig. 1: No. 2), and Yerokham – Dimona plane.

Satureja thymbrifolia on Hatrurim Formation

Satureja thymbrifolia Hedge & Feinbrun is endemic to a small area of ca. 45 km^2 around Biqa'at Horkania in the northern Judean Desert (between Jerusalem and the Dead Sea, Fig.1: 3). It is confined within this area to outcrops of a rare rock type known as Hatrurim Formation. It is a silicified chalk and marl and regarded as a result of natural heat metamorphosis (pyrometamorphic rocks). More than 130 rare minerals (Gross 1977) are listed from the Hatrurim Formation and discussed by Sokol & al. 2008. In Jebel Harmun (12 km SW of Jericho; Fig. 1: No. 3), the northernmost location of the endemic *Satureja thymbrifolia* Hedge & Feinbrun, it grows only on the upper half of the mountain; below it the rock is a soft chalk and marl populated by *Suaedetum asphalticae* (Fig. 2). There is a rather sharp borderline between the two rocks formations. I hope future researchers will investigate the chemical composition of *S. thymbrifolia* and its relationship with the unique

Fig. 2. Jebel Harmun in the Judean Desert with *Suaedetum asphalticae* on the soft chalk and marl (with prominent dark *Suaeda* shrubs) and the harder overlying rock populated with *Saturejo thymbrifoliae – Salsoletum vermiculatae*.

rock type. The phytosociological position of the association where *S. thymbrifolia* grows is the *Saturejo thymbrifoliae – Salsoletum vermiculatae* (Danin & Orshan 1999: p. 125).

Origanum **species on smooth-faced hard calcareous rocks and sandstones**

Limestone and dolomite rock outcrops support three endemic species of *Origanum* from the section *Campanulatocalyx*. *O. dayi* Post grows in crevices of limestone and dolomite outcrops and adjacent wadis in the Negev Highland and southern Judean Desert (Fig. 1: No. 4), elevation 300 m below sea level to 600 m above sea level. In higher elevation (900 to 1200 m a.s.l.) *O. ramonense* Danin (Fig. 1: No. 5) occupies the same habitat. *O. isthmicum* Danin (Fig. 1: No. 6) grows in the same habitat in a small area of Gebel Halal, Northern Isthmic Desert, and Sinai. Additional species of *Origanum* from the same section grow in SW Jordan on outcrops of hard sandstone. These are *O. punonense* Danin, *O. petraeum* Danin and *O. jordanicum* Danin & Kuenne (Fig. 1: No. 7, 8, 9 accordoingly). All the above listed six species of *Origanum* are accompanied by plant communities from the vegetation order *Artemisio sieberi – Chiliadentalia iphionoidis* (Danin & Orshan 1999). They develop in crevices and soil pockets enjoying enrichment of their moisture regime by run-off water from the exposed rocks. These plants enjoy in fact moisture regime of less arid areas. This fact may be clearer by listing several companions sharing their habitat; such are: *Juniperus phoenicea* L., *Lonicera etrusca* Santi, *Sarcopoterium spinosum* (L.) Spach, *Narcissus tazetta* L., and *Sternbergia clusiana* (Ker Gawl.) Spreng. Smooth-faced rock outcrops function in the deserts a Mediterranean refuge to plants which arrived to their isolated locations in a period when the extent of the Mediterranean zone was much southern than it is today (Danin 1999a, 1999b). Genomic investigations may enable us to follow the path of speciation in *Origanum* section *Campanulatocalyx*.

One may lump the 6 species mentioned above into two groups following flower morphology and scent of crushed green leaves. The 4 species having exerting corolla 3-4 times longer than calyx are *Origanum dayi, O. ramonense, O. punonense,* and *O. petraeum*. Their stamens are two times longer than corolla, thus exerting. These species have similar scent and differ easily from the other 2 species *O. isthmicum* and *O. jordanicum* which have the scent of "za'atar" (in Arabic) due to high content of thymol and carvacrol. *O. isthmicum* and *O. jordanicum* have corolla as long as calyx.

The distribution map of the 6 species (Fig. 1 number 4-9) looks like a map of "islands" of moist Mediterranean microhabitat in the "ocean" of deserts. Additional narrow endemic species belonging to other genera are described recently from the rocks of Edom (SW Jordan); such are *Pycnocycla saxsatilis* Danin, Hedge & Lamond (*Apiaceae*), *Silene danaensis Danin* (*Caryophyllaceae*), *Micromeria danaensis* Danin and *Satureja nabateorum* Danin & Hedge (*Lamiaceae*). There are many more taxa belonging to that group.

Conclusions

There are two groups of endemic plant species in the East Mediterranean deserts; the large group is of relicts inhabiting smooth-faced limestone, dolomite, and sandstone. They are assumed to have been derived from a Mediterranean flora which penetrated the area in the past. When the climate became drier, Mediterranean taxa survived in soil crevices where due to run-off the microclimate continues to be Mediterranean. The other group is of species which are confined to rocks of rather local occurrence. Such are gypsum rocks, silicified chalk and marl, and tertiary soft sandstone under deflation.

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Guests and gatecrashers in a New World's banquet: Old World plant species introduced from the Mediterranean Basin enriched the flora of grasslands and croplands in the Pampas of Argentina

Abstract

Poggio, S. L., Perelman, S. B., Mollard, F. P. O., León, R. J. C.†: Guests and gatecrashers in a New World's banquet: Old World plant species introduced from the Mediterranean Basin enriched the flora of grasslands and croplands in the Pampas of Argentina. — Fl. Medit. 25 (Special Issue): 39-54. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

Exchange of domesticated plants between Europe and the Americas has been a paramount episode of World History, which transformed agriculture and food habits at both sides of the Atlantic Ocean. However, many plant species have been inadvertently introduced mostly as contaminants of crop seeds, causing important changes in the flora. Here, we present a brief description of the floristic enrichment of the Pampa grasslands of Argentina due to the naturalisation of plant species from the Mediterranean Basin. Since the European colonisation in the 16th century, Old World plant species have been continuously introduced, intentionally or not, in the Pampas, especially during the expansion of agriculture in the late 19th century. Four botanical families comprised the highest numbers of species (*Asteraceae, Poaceae, Fabaceae,* and *Brassicaceae*), which have been recognised for having the largest contribution to the total number of alien species in local floras. Some families were only present in the Pampas by Mediterranean species occurring as weeds in croplands. The flora of the Pampas was also enriched with life-forms that were poorly represented in the pristine grasslands, such as species from *Fabaceae* and short-lived species vegetating during the cool season. Finally, seed trade from South America to Europa provided a vector for the dispersion of Neotropical and Pampean species naturalised in Mediterranean ecosystems. While the long term impact of alien naturalization in the evolutionary history of life-forms in the Pampas and the Mediterranean basin is difficult to elucidate, some naturalised Mediterranean plants are involved in providing ecosystem services in the intensively managed croplands in the Pampas or are seen as a threat to native flora.

Key words: aliens, arable weeds, biodiversity, invasions, non-natives, phytosociology, naturalisation.

Introduction

The development of Western agriculture and trade has been fostered historically by the exchange of domesticated plants between Europe and the Americas (Crosby 2003). This historical process, termed as the Columbian Exchange, has been a paramount episode of

World History that had important ecological and socioeconomic impacts at both sides of the Atlantic Ocean, especially concerning both agriculture and culinary traditions in the Western hemisphere. For instance, wheat, barley and flax were introduced in the Americas by the Spanish conquistadors, who also brought potatoes, maize and tomatoes to Europe. Moreover, plants native to Europe are recognised as highly invasive species worldwide for reason that are both historical and ecological (Pyšek 1998). Thus, propagules of many weedy and invasive plant species were also inadvertently transported by humans, for instance, as contaminants of crop seeds (Pyšek 1998; Mack & al. 2000). Some of these non-invited plants became weeds, whereas others invaded natural and disturbed habitats currently being more widespread than in their origin regions.

Pristine grasslands in the Rolling Pampa, the Pampa's region with the longest history of continuous cropping, have been almost entirely converted into intensively managed croplands. Grasslands were ploughed to sow annual crops (wheat, flax, and maize) and pastures (alfalfa, fescue, and ryegrass). Mediterranean species have been therefore introduced into the Pampas, intentionally or not, since the European colonisation in the 16th century. Many species have naturalised to the recipient environments, while some species become common as weedy plants in grasslands and croplands (Azara 1809; Darwin 1845; Hauman 1927; Söyrinki 1991). Thus, landscape transformation by human activities promoted the introduction and naturalisation of many exotic plant species, which nowadays constitute the major component of the weed flora (de la Fuente & al. 1999; Ghersa & León 1999; Poggio & al. 2004, 2010a). On the contrary, there are large areas still occupied by semi-natural grasslands in the Flooding Pampa, as soil quality and the recurrence of floods has limited land use to extensive rangeland grazing and prevented it from being replaced by crops. The long history of livestock grazing after European colonisation has promoted the introduction of exotic species, mainly those favoured by grazing: 74% of exotic species are annuals, 75% are forbs, while 85% of native species are perennials, and 79% of the grasses are native perennials (Perelman & al. 2001, 2007). Agriculture is restricted to well-drained soils which cover less than 20% of the area in the Flooding Pampa, while croplands occupy nearly the 60% of the area in the Rolling Pampa (Baldi & al. 2006).

Our aim is to develop a brief portrayal of the floristic enrichment of the Pampa grasslands of Argentina due to the introduction and naturalisation of plant species from the Mediterranean Basin. We first present a physiographic description and an historical account of both landscape transformations and land use changes in the Pampas of Argentina. We then describe the main floristic changes observed in Pampa grasslands and in the flora of both rangelands and croplands. We will focus our study on the Flooding and the Rolling Pampas. As aforementioned, the former region is covered by semi-natural grasslands mostly devoted to extensive cattle grazing, because soil quality and periodic flooding restrict farming to the scarce well-drained areas (León & al. 1984; Soriano & al. 1991), while intensively managed croplands predominate in the latter region (Hall & al. 1992). We highlight here that many Old Word plants, which are nowadays adventive in the Pampas, represents novel life-forms that were previously absent in the pristine grasslands. Interestingly, some naturalised plants are currently involved in sustaining ecosystem services in Pampean agro-ecosystems, such as thistles providing resources to flower visiting insects (Torretta & Poggio 2013).

The Pampas

The Pampas are a large grassland region in the central-eastern part of Argentina, in the southern cone of South America (Fig. 1). This region is a vast plain that spreads from the sea level, on its eastern limit with the Río de la Plata and the Atlantic Ocean, to up to c. 1200 m a.s.l. in the low sierras on the southwest. The northern limit is set by a xerophytic forest known as 'espinal', whereas the region is bounded westward by a shrub land named 'monte' (Cabrera 1976). Pristine vegetation corresponded to mesic tussock grasslands dominated by a rich mixture of C3 and C4 grass species (Parodi, 1930, 1947; Ghersa & León 1999; Burkart & al. 2011).

Climate and soils - Climate is temperate sub-humid in the northeast to dry sub-humid in the west and southwest. Winters are mild, whereas summers are warm and slightly dry (Burgos & Vidal 1951). Mean annual rainfall ranges from 1100 mm in the northeast to 600 mm in the south-west (Soriano & al. 1991). Temperature varies between the mean annual isotherms of 17ºC to the north and the 14ºC and 15ºC to the south (Soriano & al. 1991). Rainfall is relatively well distributed among seasons and incipient water deficit may occur during summers, though significant inter-annual variations are not uncommon (Hall & al. 1992). Snowfall is a rare event and frosts are not severe, frost-free period ranges between 180 and 260 days (Burgos & Vidal 1951). Soils are mainly Mollisols, characterised by their top horizon rich in organic matter, fertile and porous that determines the outstanding aptitude for agriculture (Soriano & al. 1991). Topography in the Rolling Pampas is gently undulated and crossed by shallow streams (Soriano & al. 1991). Conversely, the Flooding

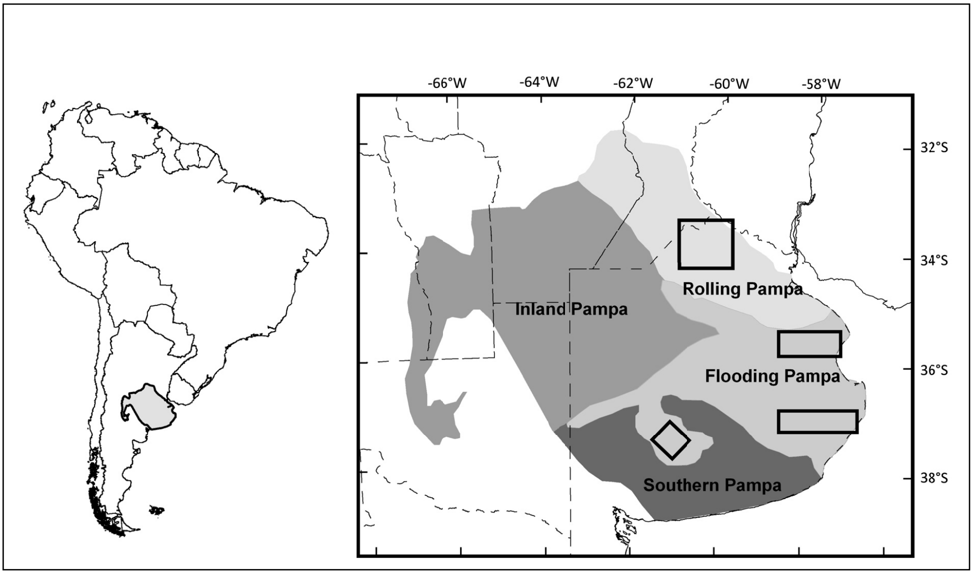

Fig. 1. The Pampas of Argentina with its four sub-regions. Squares indicates the study areas where phytosociological surveys in grasslands in the Flooding Pampa and in croplands in the Rolling Pampa were carried out.

Pampa, which was formed during an arid paleoclimatic period, has a minimal overall slope that has prevented the development of a hydrologic network in balance with their present humid conditions. Thus, groundwater remains near the soil surface for long periods in winter and spring (Paruelo & Sala 1990).

Historical land use changes - The Pampas of Argentina, thanks to their favourable climate and fertile soils, have become one of the most extensive and productive areas of agricultural commodities in the world. Extensive treeless grasslands and open, flat horizons characterised the Pampas when Spanish conquistadors arrived in the 16th century. European settlers introduced large domestic ungulates, such as cows and horses, which escaped, became feral and form large herds, because there were neither native ungulates in the Pampas as large as cows and horses nor large carnivores that could regulate their growing populations. South American megafauna, including ungulates and carnivores, became extinct in the Pampas during the Pleistocene (Soriano & al. 1991; Ortíz Jaureguizar & al. 1995). Early European towns and dwellings have been mainly concentrated in the Rolling Pampa, on a 200 km strip along the southern bank of the Río de la Plata. Rural populations considerably increased due to European immigration and the agricultural frontier was extended hundreds of kilometres to the west since late 1870's (Scobie 1964). Agriculture then rapidly expanded between 1880 and 1914. Grassland habitats were ploughed to sow row-crops, especially wheat. Landscapes were fragmented by intricate networks of railways and roads, which promoted the settlement of many towns and villages along them. Seeds from field crops and forage species were introduced during that period, mainly in alfalfa seeds imported from Western Europe (Poggio & al. 2010b). After several intervals of expansion and stagnation during the 20th century, agriculture has been increasingly intensified since the early 1970's, which was accelerated after the widespread inceptions of no-tillage and herbicide-tolerant, genetically modified soybean varieties during the 1990's.

Mediterranean plants enriched the flora diversity of grasslands and croplands in the Pampas

We listed a total of 94 Old World species originated from the Mediterranean basin (Table 1), after compiling phytosociological surveys in mesophytic grasslands in the Flooding Pampa (Perelman & al. 2001), and in croplands in the Rolling Pampa (de la Fuente & al. 1999; Poggio & al. 2004; R. J. C. León unpublished). Although both hydrophytic and halophytic grasslands cover larger areas than mesophytic grasslands in the Flooding Pampas, we focused on the latter grassland type because occur in depth, well-drained soils that are similar to cropland habitats in the Rolling Pampa. Seventy Mediterranean species were surveyed in mesophytic grasslands in the Flooding Pampa, which represents the 26.2% of the regional species richness (a total of 267 taxa including natives). Mesophytic grasslands are suitable for annual cropping because they are placed in positive topographic positions and well drained soils (Ghersa & al. 2007). Old World arable weeds surveyed in field crops in the Rolling Pampa totalised 50 taxa, which were 44.6% of the weed flora surveyed in this region (a total of 112 taxa including natives).

Seventeen botanical families were listed. *Asteraceae* (24 taxa) and *Poaceae* (20) comprised the highest numbers of species, followed by *Fabaceae* (14) and *Brassicaceae* (6)

Table 1. Latin binomial names and botanical families of species surveyed in grasslands and croplands in the Pampas. Species are classified according to their life-forms and growing seasons. Nomenclature follows Zuloaga & al. (2008). Values of constancy are grouped in classes[1].

				Grasslands[2]	**Croplands**	
					Cool-season[3]	**Warm-season**[4]
		Number of samples		202	74	102
Latin name	**Family**	**Life-form**	**Season**			
Lolium multiflorum Lam.	*Poaceae*	Annual grass	Cool	IV[1]	III	I
Medicago polymorpha L. var. *polymorpha*	*Fabaceae*	Annual forb	Cool	III	I	I
Ammi majus L.	*Apiaceae*	Annual forb	Cool	IV	I	I
Trifolium repens L.	*Fabaceae*	Perennial forb	Cool	I	II	I
Cynodon dactylon (L.) Pers. var. *dactylon*	*Poaceae*	Perennial grass	Warm	II	II	II
Taraxacum officinale G. Weber ex F.H. Wigg.	*Asteraceae*	Perennial forb	Cool	II	II	I
Capsella bursa-pastoris (L.) Medik.	*Brassicaceae*	Annual/Biennial forb	Cool	III	I	I
Anagallis arvensis L.	*Primulaceae*	Annual forb	Cool	I	I	I
Medicago sativa L.	*Fabaceae*	Perennial forb	Warm	I	I	I
Ammi visnaga (L.) Lam.	*Apiaceae*	Annual/Biennial forb	Cool		I	I
Brassica rapa L.	*Brassicaceae*	Annual/Biennial forb	Cool	I	I	I
Cirsium vulgare (Savi) Ten.	*Asteraceae*	Annual/Biennial forb	Cool	IV	III	
Carduus acanthoides L.	*Asteraceae*	Annual forb	Cool	III	IV	
Hypochaeris radicata L.	*Asteraceae*	Perennial forb	Cool	III	I	
Lactuca serriola L.	*Asteraceae*	Annual/Biennial forb	Cool	II	I	
Anthemis cotula L.	*Asteraceae*	Annual forb	Cool	I	I	
Poa annua L.	*Poaceae*	Annual grass	Cool	I	II	
Avena sativa L. var. *sativa*	*Poaceae*	Annual grass	Cool	I	I	
Sonchus asper (L.) Hill	*Asteraceae*	Annual/Biennial forb	Cool	I	I	
Melilotus albus Desr.	*Fabaceae*	Annual/Biennial forb	Cool	I	I	
Festuca arundinacea Schreb.	*Poaceae*	Perennial grass	Cool	I	I	

Table 1. continued.

Trifolium pratense L.	*Fabaceae*	Biennial/Perennial forb	Cool	I	I	
Medicago lupulina L.	*Fabaceae*	Annual/Biennial forb	Cool	II		I
Dactylis glomerata L.	*Poaceae*	Perennial grass	Cool	I		I
Cichorium intybus L.	*Asteraceae*	Annual/Biennial forb	Cool	I		I
Centaurium pulchellum (Sw.) Druce	*Geraniaceae*	Annual forb	Warm	IV		
Bromus hordeaceus L.	*Poaceae*	Annual grass	Cool	IV		
Cynara cardunculus L.	*Asteraceae*	Perennial forb	Cool	III		
Centaurea calcitrapa L.	*Asteraceae*	Annual forb	Cool	III		
Briza minor L.	*Poaceae*	Annual grass	Cool	III		
Carthamus lanatus L.	*Asteraceae*	Annual forb	Cool	III		
Silene gallica L.	*Caryophyllaceae*	Annual forb	Cool	III		
Gaudinia fragilis (L.) P. Beauv.	*Poaceae*	Annual grass	Cool	II		
Crepis setosa Hallier f.	*Asteraceae*	Annual forb	Cool	II		
Mentha pulegium L.	*Lamiaceae*	Perennial forb	Cool	II		
Leontodon saxatilis Lam.	*Asteraceae*	Perennial forb	Cool	I		
Bupleurum tenuissimum L.	*Apiaceae*	Annual forb	Warm	I		
Melilotus indicus (L.) All.	*Fabaceae*	Annual forb	Cool	I		
Trifolium dubium Sibth.	*Fabaceae*	Annual forb	Cool	I		
Phalaris coerulescens Desf.	*Poaceae*	Perennial grass	Cool	I		
Parapholis incurva (L.) C.E. Hubb.	*Poaceae*	Annual grass	Cool	I		
Geranium dissectum L.	*Geraniaceae*	Annual forb	Cool	I		
Centunculus minimus L.	*Primulaceae*	Annual forb	Cool	I		
Anthoxanthum odoratum L.	*Poaceae*	Perennial grass	Cool	I		
Trifolium fragiferum subsp. *bonanni* (C. Presl) Soják	*Fabaceae*	Perennial forb	Cool	I		
Lotus tenuis Waldst. & Kit. ex Willd.	*Fabaceae*	Perennial forb	Cool	I		
Echium plantagineum L.	*Boraginaceae*	Annual forb	Cool	II		
Carduus thoermeri Weinm.	*Asteraceae*	Annual forb	Cool	II		

Table 1. continued.

Carduus nutans L.	*Asteraceae*	Annual/Biennial forb	Cool	II		
Silybum marianum (L.) Gaertn.	*Asteraceae*	Annual forb	Cool	I		
Geranium molle L.	*Geraniaceae*	Annual forb	Cool	I		
Hordeum murinum subsp. *leporinum* (Link) Arcang.	*Poaceae*	Annual grass	Cool	I		
Medicago arabica (L.) Huds.	*Fabaceae*	Annual forb	Cool	I		
Sisymbrium officinale (L.) Scop.	*Brassicaceae*	Annual forb	Cool	I		
Rapistrum rugosum (L.) All.	*Brassicaceae*	Annual forb	Cool	I		
Picris echioides L.	*Asteraceae*	Annual forb	Cool	I		
Erodium cicutarium (L.) L'Hér. ex Aiton	*Geraniaceae*	Annual/Biennial forb	Cool	I		
Torilis nodosa (L.) Gaertn.	*Apiaceae*	Annual forb	Cool	I		
Leucanthemum vulgare Lam.	*Asteraceae*	Perennial forb	Cool	I		
Atriplex prostrata Boucher ex DC.	*Chenopodiaceae*	Annual forb	Warm	I		
Carduus pycnocephalus L.	*Asteraceae*	Annual/Biennial forb	Cool	I		
Centaurea melitensis L.	*Asteraceae*	Annual forb	Cool	I		
Foeniculum vulgare Mill.	*Apiaceae*	Perennial forb	Cool	I		
Marrubium vulgare L.	*Lamiaceae*	Perennial forb	Warm	I		
Phalaris canariensis L.	*Poaceae*	Annual grass	Cool	I		
Prunella vulgaris L.	*Lamiaceae*	Perennial forb	Cool	I		
Trifolium fragiferum L. subsp. *fragiferum*	*Fabaceae*	Perennial forb	Cool	I		
Centaurea solstitialis L.	*Asteraceae*	Annual/Biennial forb	Cool	I		
Melilotus officinalis (L.) Lam.	*Fabaceae*	Annual forb	Cool	I		
Digitaria sanguinalis (L.) Scop.	*Poaceae*	Annual grass	Warm	I	IV	V
Chenopodium album L.	*Chenopodiaceae*	Annual forb	Cool		IV	IV
Sonchus oleraceus L.	*Asteraceae*	Annual forb	Cool	I	III	II
Stellaria media (L.) Cirillo	*Caryophyllaceae*	Annual forb	Cool		III	III
Rumex crispus L.	*Polygonaceae*	Perennial forb	Cool		II	II
Veronica persica Poir.	*Plantaginaceae*	Annual forb	Cool		II	II

Table 1. continued.

Polygonum convolvulus L.	*Polygonaceae*	Annual forb	Cool		II	I
Lamium amplexicaule L.	*Lamiaceae*	Annual forb	Cool		II	I
Convolvulus arvensis L.	*Convolvulaceae*	Perennial vine	Warm		I	I
Matricaria recutita L.	*Asteraceae*	Annual forb	Cool		I	I
Raphanus sativus L.	*Brassicaceae*	Annual/Biennial forb	Cool		I	I
Vicia sativa L.	*Fabaceae*	Annual forb	Warm		I	I
Avena fatua L.	*Poaceae*	Annual grass	Cool		I	
Avena sterilis L.	*Poaceae*	Annual grass	Cool		I	
Fumaria agraria Lag.	*Fumariaceae*	Annual forb	Cool		I	
Senecio vulgaris L.	*Asteraceae*	Annual forb	Cool		I	
Urtica urens L.	*Urticaceae*	Annual forb	Cool		I	
Veronica arvensis L.	*Plantaginaceae*	Annual forb	Cool		I	
Veronica polita Fries.	*Plantaginaceae*	Annual forb	Cool		I	
Viola arvensis Murray.	*Violaceae*	Annual forb	Cool		I	
Viola odorata L.	*Violaceae*	Annual forb	Cool		I	
Eragrostis cilianensis (All.) Vignolo ex Janch.	*Poaceae*	Annual grass	Warm			I
Hirschfeldia incana (L.) Lagr.Foss.	*Brassicaceae*	Annual/Biennial forb	Cool			I
Setaria verticillata L. P. Beauv.	*Poaceae*	Annual grass	Warm			I
Setaria viridis (L.) P. Beauv.	*Poaceae*	Annual grass	Warm			I
		Number of species		70	43	30

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[1] Constancy classes. I: 0.1 – 20% (rare); II: 20.1 – 40% (low); III: 40.1 – 60% (intermediate); IV: 60.1 – 80% (moderately high); V: 80.1 – 100% (high); (Mueller-Dombois & Ellenberg, 1974).

[2] Grassland data correspond to mesophytic grassland surveys published in Perelman & al. (2001).

[3] Cool season crops, wheat and field pea, were published in Poggio & al. (2004).

[4] Warm season crops are soybean and maize. Soybean data were published in de la Fuente & al. (1999), while maize data are unpublished (R.J. C. León).

(Table 2). These four families have been recognised for having the largest contribution to the total number of alien species in local floras worldwide (Pyšek 1998). Other families that are conspicuous in the Old World flora were represented by fewer species (*Apiaceae*: 5, *Lamiaceae*: 4, *Caryophyllaceae*: 2, and *Chenopodiaceae*: 2). Some families only occurred in either grasslands or croplands. Species from two families only occurred in grasslands (*Boraginaceae*, *Geraniaceae*), while six families were only surveyed in croplands (*Convolvulaceae*, *Fumariaceae*, *Plantaginaceae*, *Polygonaceae*, *Urticaceae*, *Violaceae*, Table 2). Many of these families are scarcely represented in the native flora of the Pampa grasslands (Cabrera & Zardini 1978). Conversely, species from *Papaveraceae* were not surveyed in either grasslands or croplands (Poggio & Mollard 2010), even though many species belonging to this family has been recognised as weeds and highly invasive plants (Pysek 1998; Weber & Gut 2005). For instance, *Papaver dubium* and *P. rhoeas* did not become widespread weeds in croplands as in Europe, even though both species were documented as casual in cereal crops in the Pampas in the early 20th century (Spegazzini 1905).

Asteraceae, which is recognised as a botanical family including many wind-dispersed species, have enriched the floras of grasslands and croplands in the Pampas (Table 1). Strong westerly winds, along with both the absence of trees and the flat topography that characterise the Pampas, would have promoted the spread of anemochorous species. Moreover, areas in agricultural landscapes that are not ploughed, such as grasslands, may

Table 2. Number of species listed for each botanical families in grasslands and croplands in the Pampas. Percentages are also shown for each family.

	Total		**Grasslands**		**Croplands**	
Family	**Taxa number**	**(%)**	**Taxa number**	**(%)**	**Taxa number**	**(%)**
Asteraceae	24	25.5	22	31.4	11	22.0
Poaceae	20	21.3	15	21.4	12	24.0
Fabaceae	14	14.9	13	18.6	7	14.0
Brassicaceae	6	6.4	4	5.7	4	8.0
Apiaceae	5	5.3	5	5.7	2	4.0
Lamiaceae	4	4.3	3	4.3	1	2.0
Chenopodiaceae	2	2.1	1	1.4	1	2.0
Caryophyllaceae	2	2.1	1	1.4	1	2.0
Primulaceae	2	2.1	2	2.9	1	2.0
Geraniaceae	4	4.3	4	5.7	-	-
Boraginaceae	1	1.1	1	1.4	-	-
Plantaginaceae	3	3.2	-	-	3	6.0
Polygonaceae	2	2.1	-	-	2	4.0
Violaceae	2	2.1	-	-	2	4.0
Fumariaceae	1	1.1	-	-	1	2.0
Urticaceae	1	1.1	-	-	1	2.0
Convolvulaceae	1	1.1	-	-	1	2.0
Total	94	100.0	70	100.0	50	100.0

function as sources of anemochorous weeds dispersed towards fields (Moyer & al. 1994). Regarding *Poaceae*, tussock perennial grasses were the prevalent life-form in the mesophytic grasslands, whose dominance was importantly reduced by grazing and trampling and the opportunistic planting of pastures with more palatable grasses and legumes of Mediterranean origin (Ghersa & al. 2007). Perennial grasses were thus introduced as forage crops in the Pampas during the agricultural expansion between 1880 and 1914 (*Cynodon dactylon*, *Festuca arundinaceae*, *Sorghum halepense*), but some of these species became conspicuous invasive plants few decades later of their introduction. Other annual forage grasses, such as ryegrass (*Lolium multiflorum*), already naturalised before agricultural expansion (Hernández 1884), have been continuously sown in pastures, albeit this species is also recognised as weed in cereal crops (Scursoni & al. 2014). Conversely, abundance of cool-season native grasses was undermined by cattle grazing because their greater sensitivity to grazing and trampling than Old World grasses (Chaneton & al. 1988; Longo & al. 2013). Species from *Fabaceae* are underrepresented in the native pampa grasslands in comparison to the European flora (Cabrera & Zardini 1978; Burkart & al. 2011). Most Old World species from this family have been deliberately introduced in the Pampas as forage plants to sown pastures, principally *Medicago sativa*, followed by *Trifolium repens* and *T. pratense*, and into a lesser extent *Lotus tenuis* and *Melilotus albus* (Table 1). Many other species, due to their seed sizes and shapes were highly similar to that of forage legumes, were inadvertently introduced as seed contaminants, mostly alfalfa seeds imported from Europe during the early period of agricultural expansion (Poggio & al. 2010b). All species from *Brassicaceae* were short-lived species growing during the cool season (Table 1). Species from this family usually have low constancy in both grasslands and croplands (Perelman & al. 2001; Poggio & al. 2004). *Brassicaceae* species were observed in early stages in post-agricultural fields (D'Angela & al. 1986; Tognetti & al. 2010).

Old World plant species occurring in grasslands and croplands in the Pampas are mostly short-lived forbs vegetating during the cool season (Fig. 2). Short-lived species are proportionally more numerous in croplands than in grasslands (80% vs. 71.6%, Fig. 2), including more forbs (*Chenopodium album*, *Polygonum convolvulus*, *Stellaria media*, *Sonchus oleraceus*, *Veronica persica*) than grasses (*Digitaria sanguinalis*, *L. multiflorum*, *Poa annua*). In addition, short-lived grasses growing during the cool season were numerous in grasslands (e.g. *Bromus hordeaceus*, *Briza minor*, *Gaudinia fragilis*, *L. multiflorum*). Life cycles of plants occurring in grasslands and croplands are thus reflecting the influence of environmental filtering on plant functional traits, which may favour or discriminate against the establishment of species having particular traits (Díaz & Cabido 2001). Annual ploughing creates highly unstable conditions within arable fields, where the occurrence of long-lived species is usually much lower than ephemeral species, which arrive to complete the growth cycle and reproduce early during the growing season and thus thrive to persist in fallows (i.e. the uncultivated period between two consecutive crops in rotation; a common practice to recover fertility in Pampas croplands before the inception of no-tillage practices). However, perennial species are also frequent in croplands when farming practices contribute to spread species having vegetative propagation, such as through rhizomes or sprouting roots (*Convolvulus arvensis*, *C. dactylon*, *Sorghum halepense*).

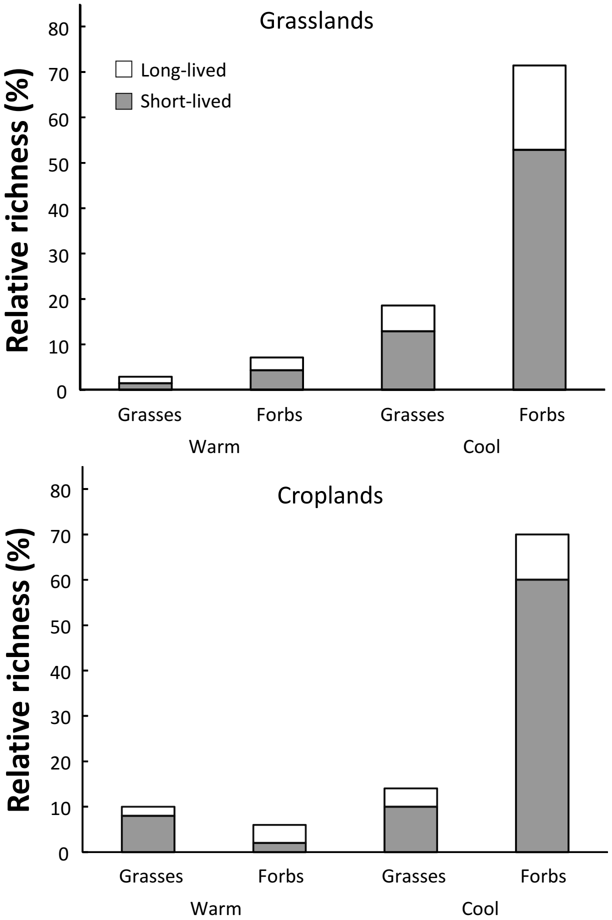

Fig. 2. Proportional contribution to the total species richness of different plant life-forms from Mediterranean flora occurring in grasslands and croplands in the Pampas. The bars show the percent number of grass and forb species (short- and long-lived) vegetating in either cool or warm growing seasons. Short-lived plants include annuals and annual-biennials, while long-lived plants include biennials, biennial-perennials and perennials.

Many Old World arable weeds naturalised in the Pampas have also found refuge in habitats other than grasslands and croplands. Hence, Old World species were also cited as inhabiting livestock handling facilities in ranches and farms (i.e., corrals, fencerows, water troughs, and reservoirs) create places where cattle is brought or spontaneously gather generating fertility spots and habitat for ruderal, nitrophyllous species, such as *Urtica urens*. Water troughs in extensive paddocks with high stocking rates also brought about overgrazed spots where some ruderal species such as *Plantago lanceolata* and *Leontodon taraxacoides* may thrive (León & al. 1984; Sala & al. 1986). Overgrazing or heavy cattle trampling also increase the abundance of unpalatable ruderals, such as *Centaurea* sp.pl., which prosper along cattle paths. Other Old World species, usually found as weeds in croplands, were also found in less disturbed sites, such as fencerows, railway and roadside embankments, as well as in small woodlots surroundings abandoned rural settlements (locally named as "taperas"). In addition, the large introduction and planting of exotic trees for cattle shelter, surrounding dwellings and along roads, paved the way for the thriving of Mediterranean sciophytes or sciophyte-facultative species, for instance *Galium aparine*, *Viola arvensis*, *Malva parviflora*, *Marrubium vulgare*, and the Rhubarb-like leaved *Arctium minus*. Moreover, flowers of many Mediterranean weedy plants occurring in fields and along field margins, such as *Ammi majus*, *Brassica rapa*, *Carduus acanthoides*, *S. oleraceus*, and *T. repens*, are visited by insects, which provide ecosystem services for agriculture, such as pollination and biotic regulation of crop pests (Torretta & Poggio 2013).

Returning the kindness: Neotropical aliens naturalised in the Mediterranean Basin

The Pampas and Mediterranean floras not only share weeds native from the Mediterranean Basin, or alien in both regions, but also there is an extensive list of Neotropical species native from the plains of Argentina, Brazil, Paraguay and Uruguay that have become alien in Mediterranean ecosystems. The list includes many Asteraceae species, such as *Baccharis articulata* (Lam.) Pers., *Galinsoga parviflora* Cav., *Bidens pilosa* L., *Conyza bonariensis* (L.) Cronquist (= *Erigeron bonariensis* L.), *C. blakei* (Cabrera) Cabrera (= *E. blakei* Cabrera), *Senecio grisebachii* Baker and *Symphyotrichum squamatum* (Spreng.) G.L. Nesom (= *Aster squamatus* (Spreng.) Hieron.), which behave as synanthropic species as they proliferate in uncultivated fallows in Pampean croplands, or disturbed sites and became naturalised in Spain, Italy and France encroaching on similar habitats than those in the Pampas (Pignatti 1982; Celesti-Grapow & al. 2010; R. J. C. León personal observation). Perennial bunchgrasses from the tribe Stipeae that are also representative of Pampa grasslands, such as *Nassella neesiana* (Trin. & Rupr.) Barkworth, *N. trichotoma* (Nees) Hack. ex Arechav., and *Jarava brachychaeta* (Godr.) Peñailillo, are found as aliens in embankments and uncultivated croplands in northern Italy, Spain and France (Pignatti 1982; Euro+Med database, 2006). Some Neotropical Paniceae also found the way to became alien in Mediterranean countries: *Paspalum quadrifarium* Lam. (in Italy), *P. urvillei* Steud., *P. vaginatum* Sw., *P. notatum* Flüggé, and *P. distichum* L. With respect to rangelands, *Ambrosia tenuifolia* Spreng. and *Setaria parviflora* (Poir.) Kerguélen are increaser species which rapidly encroach on overgrazed Pampean grasslands, also managed to establish in disturbed lands in Spain, France and Italy.

As many of these species thrive in the Pampas the following question arises: Have the Pampas backfired and supplied Mediterranean countries with members of its own flora? The question is enticing as the Pampas were one of the major producers of crop and farm seeds (e.g. linseed, alfalfa), which have been traded and exported to European countries. These exported seed lots were known to be rich in arable weed seeds as contaminants (Poggio & al. 2010b). While the putative vector exists, the possibility that the current

Mediterranean genotypes have originated from Pampas accessions is difficult to corroborate because the above-mentioned species (and other not mentioned here) have a broad native range which encompasses different regions in South America. One exception is *Solanum bonaeriense* L., which has a narrower native range in the Pampas of Argentina and Uruguay. A detailed study of herbarium records of the Mediterranean specimens from the above-mentioned Pampean species may shed light into the probable origin and naturalization process of New World species naturalized in the Mediterranean.

Concluding remarks

Many plant species of Mediterranean origin are currently documented as adventive or naturalised species in the flora of the Pampean grasslands and croplands (Zuloaga & Morrone 1996, 1999). Four botanical families comprised the highest numbers of taxa (*Asteraceae, Poaceae, Fabaceae, and Brassicaceae*), which have been also recognised for having the largest contribution to the total number of alien species in local floras worldwide (Pysek 1998). The Pampas were enriched with species mostly found in croplands, which belong to a group of families widely known as arable weeds in the Old World, such as *Fumaria agraria*. Interestingly, species from *Papaveraceae* were absent in both grasslands and croplands, even though many species are widely recognised as weeds in European croplands, such as *P. dubium* and *P. rhoeas*. However, the introduction of Mediterranean species, intentionally or accidentally, have greatly contributed to increase the species diversity of the Pampean flora, as well as enriched with life-forms poorly represented in the pristine pampa grasslands.

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Benito Valdés

Xenophytes in the Doñana territory (SW Spain)

Abstract

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The Territory of Doñana covers c. 230,000 ha mainly to the West side of the Guadalquivir river mouth. It includes the National and Natural Parks of Doñana and two other protected areas: Estero de Domingo Rubio and Laguna de las Madres, as well as the surrounding unprotected areas. A checklist published in 1980 covering the National park and part of the Natural Park listed 15 naturalized species. A checklist published in 2007 that covers the territory of Doñana, increased this number to 86. But new naturalized xenophytes have since been recorded in this territory raising the number to 99, 38 of which are native to the Old World and 61 to America. One of them, *Carpobrotus edulis*, is a harmful invader and at least two more, *Cortaderia selloowiana* and *Lantana strigocamara*, may become invaders in this area in the near future. The continuous population increase in the cities and villages around the territory, the presence of two tourist resorts within the territory (Matalascañas and Mazagón), the annual pilgrimage to El Rocio chapel and the increase in the roads net-work in the territory likely constitute the main factors responsible for this increased naturalization of introduced plants.

Key words: Alien flora, naturalized plants, invaders.

Introduction

The territory of Doñana, as defined in Valdés & al. (2010: 11), covers c. 230,000 ha mainly between the Guadalquivir river mouth and the Tinto river basin in Western Andalusia (SW Spain). The area comprises three well-characterized ecosystems: sweet and salt water marshes, stabilized sands and moving sand dunes (Castroviejo 1993; García Novo 1997).

To protect migrating birds, the Spanish Council for Scientific Research (C.S.I.C.) and the World Wildlife Fund acquired 6,794 hectares in 1964 to establish the Doñana Biological Reserve. This was gradually enlarged to form Doñana National Park (54,252 ha) and Doñana Natural Park (53,835 ha), which together were declared by UNESCO as the Doñana Biosphere Reserve in November 1980 (Pinilla 2006).

A recent floristic study of this territory (Valdés & al. 2007) indicates that the floristic richness of this territory includes 1,368 taxa (species and subspecies) of vascular plants of which 6.2% are naturalized xenophytes. But the number of xenophytes has since increased at a rate of c. two new naturalized species per year, to complete the 99 taxa listed in this paper.

Material and methods

The basis of this study was a floristic checklist of the vascular plants of the Doñana territory (Valdés & al. 2007), along with the subsequently published papers addressing xenophytes in this territory, which will be given below.

The limits of the territory are those adopted by Valdés & al. (2007, 2011; see Fig. 1).

Results

The publication of the *Flora Vascular de Andalucía Occidental* (Valdés & al. 1987) was preceded by an appropriate study of the vascular plants of the four provinces of W Andalusia (Huelva, Córdoba, Sevilla and Cadiz). The main Spanish herbaria were revised and over 80,000 gatherings were collected. The floristic knowledge of W Andalusia was

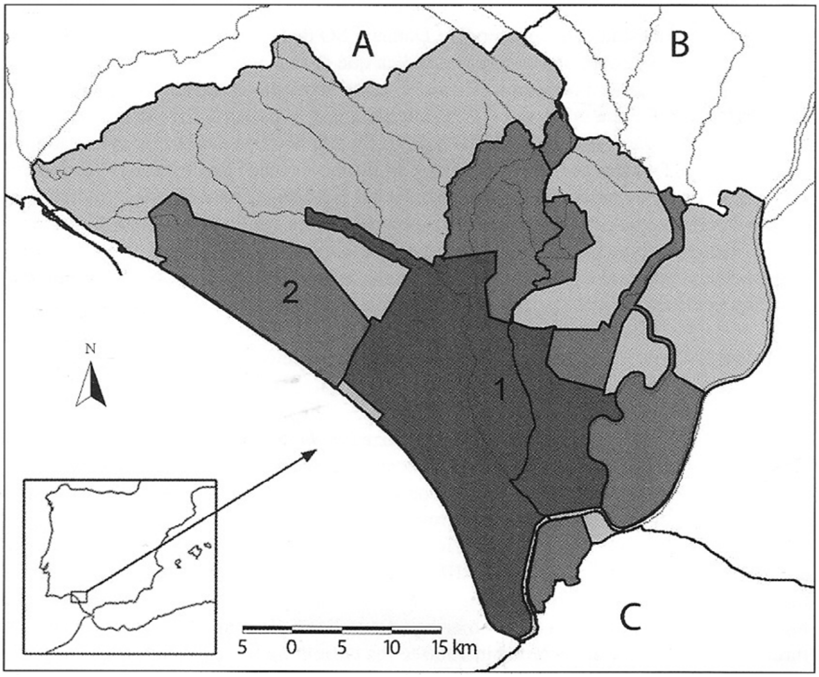


Fig. 1. Localization of the Doñana territory in the Iberian Peninsula and limits of the territory. The hydrographic network and main protected areas are indicated: 1, Doñana National Park; 2, Doñana Natural Park. The limits of the provinces of Huelva (A), Sevilla (B) and Cadiz (C) are added.

consequently considered to be highly accurate. Within the areas covered by the Doñana territory, 50 species were recorded as being naturalised xenophytes. But the floristic knowledge of a territory is never complete. Peinado & al (1990) recorded *Bergia capensis* L. and *Ammania coccinea* Rottb. as weeds in the rice fields of Isla Mayor, and Roales (1997) also recorded in these fields *Leptochloa uninervia* (Presl.) Hichc. & Chase. Sánchez Gullón & Rubio (1999) recorded *Chloris gayana* Kunth on roadsides near Mazagón, *Bidens pilosa* L. at the beach near the Parador Nacional (also in Mazagón) and *Diplachne fascicularis* (Lam.) Beauv. in Estero de Domingo Rubio. Medina (2003) recorded *Hydrocotyle verticillata* Thunb. in Laguna del Hondón, within the National Park, which has also been found in other parts of Doñana.

In 2005, Dana & al. (2005) mentioned *Bidens frondosus* L., *Paspalum dilatatum* Poir. and *Carpobrotus edulis* (L.) N.E. Br. as invaders in the territory of Doñana, Cobo & al. (2005) found *Ipomoea imperati* (Vahl) Griseb. in sand dunes at Matalascañas and Valdés & al. (2005a, 2005b) recorded four new naturalized taxa: *Abutilon teofrastii* Medik in the marshes of Hinojos, *Kikuyuochloa clandestinum* (Chiov.) H. Scholz (=*Pennisetum clandestinum* Chiov.) in the laguna de las Madres, not far from Mazagón, and other coastal areas of Huelva province where it starts to behave as an invader, *Galenia secunda* (L. f.) Sond. in salty areas of Monte Algaida (Cadiz province) and *Eclipta prostrata* (L.) L. in Dunas del Odiel, between Mazagón and the estuary of the rivers Tinto and Odiel.

Sánchez Gullón & al. (2006a, 2006b) recorded *Guizotia abysinica* (L. F.) Cass. within Doñana National Park, *Sporobolus indicus* (L.) R. Br. near Mazagón and *Oenothera speciosa* Nutt. also in Mazagón on coastal sand dunes and roadsides.

In 2007, seven new naturalized xenophytes were added. Fernández Zamudio & al. (2007) recorded *Cucumis myriocarpus* Naudin on roadsides and nitrified areas around Laguna de las Madres. López Albacete & al. (2007) gave *Chamaesyce maculata* (L.) Small for ruderalized areas near the Palacio de Doñana. Sánchez Gullón & al. (2007) recorded *Cyperus eragrostis* Lam. for the Doñana territory and *Chasmanthe aethyopica* (L.) N.E. Br. and Valdés & al. (2007) *Cyperus involucrata* Rottb. and *Eucaliptus camaldulensis* Dehn. This last species merits particular comment. This Australian species has been widely planted in Spain, first as an ornamental and subsequently mainly for timber, and it was never considered to be naturalized. But many seedlings produced from seeds have been observed at Dunas del Odiel, which indicates that this species has indeed become naturalized, at least in this locality.

When a checklist of the territory of Doñana was published by Valdés & al. (2007) the number of naturalized xenophytes had increase to 86, 34 of which are native to the Old World and 52 to the New World. All known previous records had been included in this checklist, but the number of naturalized xenophytes in the territory of Doñana has continue to increase.

In 2008 Verloove & Sánchez Gullón (2008) recorded *Dysphania pumilio* (R. Br.) Mosyakin & Clements (*Chenopodium pumilio* R. Br.) at Matalascañas' Rocío Playa campsite, *Eragrostis mexicana* (Hornem.) Link in Mazagón, close to the lighthouse, *Eragrostis frankii* Steud. in irrigated fields at Laguna de la Madres and *Eragrostis pectinacea* (Michx.) Nees at several ruderalized sites in Matalascañas. The following year *Spartina patens* (Ait.) Muhl. was recorded by Sánchez Gullón & Verloove (2009) in el Asperillo, between Matalascañas and Mazagón. In 2010 *Cyperus retrorsus* Chapman was recorded in Mazagón, close to the lighthouse by Verloove & Sánchez Gullón (2010) and *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn. and *Lantana strigocamara* R.W. Sanders (*L. camara* auct., non L.) in Estero de Domingo Rubio by Sánchez Gullón & al (2010). In 2011 *Tragus racemosus* (L.) All. was recorded on the roadsides between Matalascañas and Mazagón (Cuesta de Maneli) by Sánchez Gullón & al (2011). *Stenotaphrum secundatum* (Walter) O. Kuntze was later recorded in Matalascañas and other localities of Huelva province by Verloove & Sánchez Gullón (2012), and Sánchez Gullón & al. (2014) added *Opuntia pilifera* F.A.C. Weber, recorded at Dunas del Odiel, and Sánchez Gullón & Galán de Mera (2014) *Lemna minuta* Kunth, a potential invader collected at Laguna de las Madres, not far from Mazagón.

Consequently, the current number of naturalized xenophytes in the Doñana territory is 99, 38 of which are native to the old World and 61 native to America, as listed in tables 1 an 2.

Table 1. Old World taxa naturalized in the Doñana territory. *Already recorded in 1980 (Rivas Martínez & al. 1980).

TAXA	ORIGING
Aizoaceae	
Carpobrotus edulis (L.) N.E. Br.	S Africa
Galenia secunda (L. f.) Sond.	S Africa
Asclepiadaceae	
*Gomphocarpus frut*icosus (L.) W.T. Aiton	S Africa
Asteraceae	
* *Arctotheca calendula* (L.) Levins	S Africa
* *Cotula coronopifolia* L.	S Africa
Guizotia abyssinica (L. F.) Cass.	S Africa
Chenopodiaceae	
Chenopodium pumilio R. Br.	Australia
Cucurbitaceae	
Cucumis myriocarpus Naudin	S Africa
Cyperaceae	
Cyperus involucratus Rottb.	Tropical Africa
Cyperus retrorsus Chapman	Old Wold tropics
Elatinaceae	
Bergia capensis L.	Old World tropics
Euphorbiaceae	
Ricinus communis L.	Tropical Africa
Fabaceae	
Medicago sativa L.	Black Sea coasts
Iridaceae	
Chasmanthe aethiopica (L.) N.E. Br.	S. Africa
Freesia refracta (Jacq.) Katt.	S. Africa
Iris albicans Lange	Yemen, Arabia
Iris germanica L.	Hybrid origin
Liliaceae	
Asparagus officinalis L.	Euro-Siberian region
Malvaceae	
Abutilon theophrastii Medik	S Asia
Moraceae	
Ficus carica L.	Mediterranean
Myrtaceae	
Eucaliptus camaldulensis Dehn.	Australia
Oxalidaceae	
* *Oxalis pes-caprae* L.	S. Africa
Poaceae	
Arundo donax L.	Asia
Chloris gayana Kunth	S Africa
* *Digitaria debilis* (Desf.) Willd.	Tropical Africa
Echinochloa colonum (L.) Link	O & N Worlds tropics
Echinochloa oryzoides (Ard.) Fritsh	C & S Asia
Ehrharta calycina Sm.	S Africa
Eragrostis curvula (Schrad.) Nees	S Africa
Kikuyuochloa clandestina (Chiov.) H. Scholz	Old World tropics
Panicum miliaceum L.	Asia
Sorgum halepense (L.) Pers.	Mediterranean
Sporobolus indicus (L.) R. Br.	Old World tropics
Stenotaphrum secundatum (Walter) O. Kuntze	Pantropical
Tragus racemosus (L.) All.	Tropical Africa
Scrophulariaceae	
Cymbalaria muralis P. Gaertn., B. Mey. & Scherb.	S Europe
Simaroubaceae	
Ailanthus altissima (Mill.) Swingle	China
Solanaceae	
Solanum linnaeanum Hepper & P.-M. L. Jaeger	S Africa

Table 2. New World taxa naturalized in the Doñana territory. * already recorded in 1980 (Rivas Martínez & al. 1980).

TAXA	ORIGING
Agavaceae	
Agave americana L.	N. A.
Amaranthaceae	
Amaranthus albus L.	N A
**A. blitoides* S. Watson	N A
**A. deflexus* L.	S A
A. hybridus L.	T
A. hypochondriacus L.	N A
A. muricatus (Moq.) Hieron.	S A
A. retroflexus L.	N A
Asteraceae	
Bidens aureus (Aiton) Sherff	C A
B. frondosus L.	N A
Eclipta prostrata (L.) L.	T
**Erigeron bonariensis* L.	S A
E. canadensis L.	N A
E. sumatrensis Retz.	S A
**Gnaphalium antillanum* Urb.	T
G. pensylvanicum Willd.	T
**Soliva stolonifera* (Brot.) Sweet	S A
**Symphyotrichum squamatum* (Spreng.) G.L. Nelson	T
Xanthium orientale L. subsp. *italicum* (Moretti) Greuter	N A
X. spinosum L.	S A
Boraginaceae	
Heliotropium curassavicum L.	T
Brassicaceae	
**Coronopus didymus* (L.) Sm.	S A
Cactaceae	
Opuntia dillenii (Ker-Gawl.) Haw	N A
O. maxima Mill.	N A
O pilifera F.A.C. Webber	C A
Chenopodiaceae	
Chenopodium ambrosioides L.	S A
Ch. multifidum L.	S A
Convolvulaceae	
Cuscuta campestris Yunck.	N A
Ipomoea imperati (Vahl) Griseb.	N A
Euphorbiaceae	
Chamaesyce maculata (L.) Small	N A
C. serpens (Kunth) Small	C A
Lemnaceae	
Lemna minuta Kunth	T
Liliaceae	
Nothoscordum borbonicum Kunth	S A
Lythraceae	
Ammania coccinea Rottb.	T
Onagraceae	
Oenothera drummondii Hook. subsp. *drumondii*	S A
O. speciosa Nutt.	N A
O. stricta Link subsp. *stricta*	S A
Oxalidaceae	
Oxalis articulata Savigny	S A
Papaveraceae	
Eschscholzia californica Cham.	N A
Phytolaccaceae	
Phytolacca americana L.	N A
Poaceae	
Ceratochloa cathartica (Vahl) Herter	S A
Cortaderia selloana (Schult. & Schult. f.) Asch. & Graebn.	S A
Eragrostis frankii Steud.	N A
E. mexicana (Hornem.) Link	S A
E. pectinacea (Michx.) Nees	N A
Leptochloa uninervia (J. Presl.) Hitch & Chase	T
Diplachne fascicularis (Lam.) P. Beauv.	N & S A
Paspalum dilatatum Poir.	S A
**P. distichum* L.	T
P. notatum Flugge	T
**P. vaginatum* sw.	T
**Spartina densiflora* Brogn.	S A
S. patens (Ait.) Muhl.	N A
Solanaceae	
Datura inoxia Mill.	C A
D. stramonium L.	S A
Nicotiana glauca R.C. Graham	S A
Solanum eleagnifolium Cav.	S A
Umbelliferae	
Hydrocotyle verticillata Thunb.	T
Verbenaceae	
Lantana strigocamara R.W. Sanders	S A
Phyla filiformis (Schard.) Meikle	T

Moreover, the 21 taxa listed in table 3, both from the Old and New Worlds have been detected in the territory of Dañana either as adventives or as having escaped from cultivation.

Discussion

In 1980 Rivas Martínez & al. (1980) published a study of the vegetation of Doñana. It covered the National Park and part of the Natural Park. The checklist included in this study includes 15 naturalized species. The *Flora Vascular de Andalucía Occidental* (Valdés & al. 1987) increased this number to 50. The checklist of the Doñana territory published by Valdés & al (2007) increased this number even further to 86 naturalized taxa.

Data given in tables 1 and 2 indicate that currently there are 99 naturalized taxa in the territory of Doñana, 38 of which are native to the Old World and 61 to the new World. Furthermore, 21 taxa listed in table 3 are recorded as adventitious or escaped from cultivation. The data listed in the three tables indicate that the number of xenophytes from the New World is higher that the figure for the Old World, most likely due to intense trade between Spain and America over the last five centuries.

The main reason for this increasing number of naturalized xenophytes appears to involve the increase in population in the villages surrounding the territory (see table 4) as well as the presence of two tourist resorts within the territory, the subsequent increase in gardening and agricultural activities (mainly strawberry and rice fields) and the continuous growth of the roads network, as indicated in Fig. 2, a fact that very much facilitates mobility in the territory of Doñana.

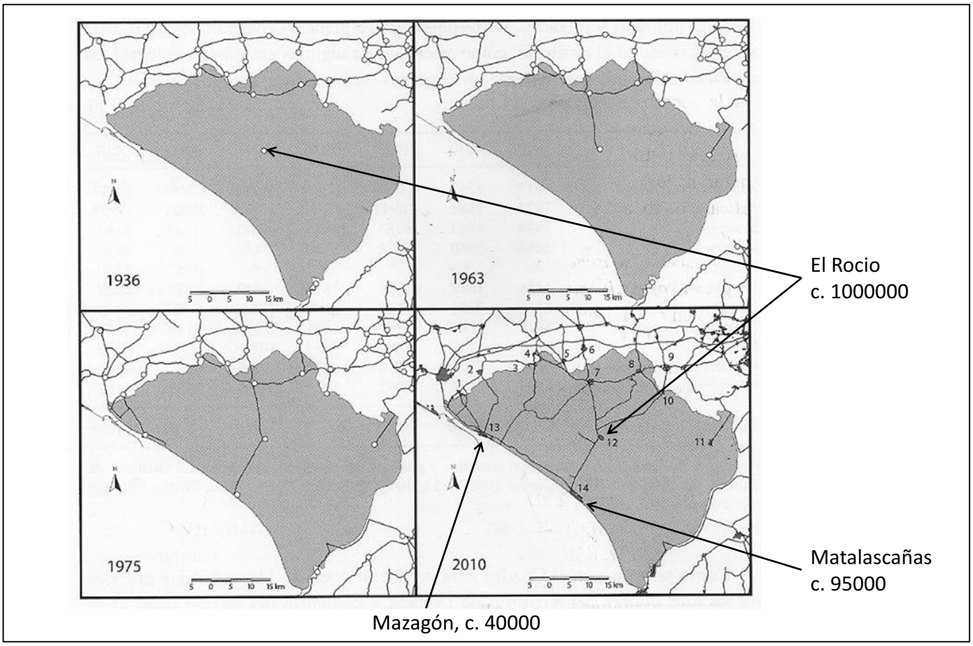
Data included in table 4 indicate that from 1981, when 15 xenophytes were recorded (Rivas Martínez & al. 1980) to 2013, the population of the area almost doubled, and this figure shows a big increase in summer in two important tourist resorts: Mazagón and

Table 3. Old and New Worlds taxa that are adventitious or have escaped from cultivation in the Doñana territory.

Asclepiadaceae	
Asclepias curassavica L.	Tropics of America
Asteraceae	
Gaillardia aristata Pursh	N America
Brassicaceae	
Brassica juncea (L.) Czern	Asia
Brassica napus L.	?
Brassica oleracea	Atlantic Europe
Raphanus sativus L.	E Mediterranean
Caryophyllaceae	
Silene pseudoatocion Desf.	Ibero-Maghrebian
Cistaceae	
Cistus populifolius L.	Iberian Peninsula [Fr.]
Cyperaceae	
Cyperus aggregatus (Willd.) Endl.	America
Cyperus croceus Vahl	C & 5 America
Kyllinga brevifolia Rottb.	America
Fabaceae	
Lupinus a/bus L.	Balcans?
Linaceae	
Linum usitatissimum L.	Cult.
Onagraceae	
Oenothera affinis Cambess.	S. America
Oenothera glazioviana Micheli	Cult. hybrid
Poaceae	
Axonopus fissifolius (Raddi) Kullm.	Tropics of America
Pennisetum ciliare (L.) Link	Old World tropics
Zoysia matrella (L.) Merr.	Tropics of Asia
Scrophulariaceae	
Linaria maroccana Hook.	Morocco
Vitaceae	
Vitis vinifera L. subsp. *vinifera*	SW Asia

Table 4. Permanent population in cities and villages inside and around the Doñana territory from 1900 to 2013 (Anonymous 1902, 1932, 1962, 2015; INE 1981, 1991, 2000, 2010). *No available data.

	1900	1930	1960	1981	1991	2000	2010	2013
Almonte	6917	8287	11538	12959	16350	17444	22204	22964
Bollullos del Condado	7922	8881	10947	11862	12465	12822	13959	14394
Bonares	3928	4848	4783	4815	4900	5122	6145	6282
Hinojos	2058	2660	3278	3130	3434	3556	3926	3904
Isla Mayor	*	*	*	*	*	6057	5930	5948
Lucena del Puerto	1456	1658	1703	1870	2049	2237	2659	2600
Moguer	8455	7051	7222	10004	12193	14389	20040	21209
Palos de la Frontera	1621	2201	2540	5901	7335	7115	9167	10196
Pilas	4251	5755	8604	9835	10503	11289	13509	14058
Rociana del Condado	4291	5705	6016	5777	6095	6292	7362	7673
Villamanrique de la Condesa	3079	3154	3392	3225	3460	3805	4162	4359
TOTAL	43978	50200	60023	69378	78784	90128	109063	113587



El Rocio
c. 1000000

Matalascañas
c. 95000

Mazagón, c. 40000

Fig. 2. Roads network in the Doñana territory from 1936 to 2010 (Spanish Instituto Geográfico and Instituto Geográfico y Catastral). and Summer population in El Rocío, Mazagón and Matalascañas. 1; Palos de la Frontera; 2, Moguer; 3, Lucena del Puerto; 4, Bonares; 5, Rociana del Condado; 6, Bollullos del Condado; 7, Almonte; 8, Hinojos; 9, Pilas; 10, Villamanrique de la Condesa; 11, Isla mayor (Villafranco del Guadalquivir between 1956 and 2000); 12, El Rocío; 13, Mazagón; 14, Matalascañas.

Matalascañas. It is estimated that in Mazagón (n. 13 in Fig. 2) the summer population may exceed 40,000 people and in Matalascañas (n. 14 in Fig. 2) 100,000 during July and August. But the village of El Rocío must be included. El Rocío, right in the middle of the Doñana territory (n. 12 in Fig, 2), concentrates over one million people for one week, during a famous pilgrimage which takes place in May. More than 100 brotherhoods arrive in El Rocío on foot, or by horse or horse and cart from the main cities and from many villages in Andalusia, following old unpaved roads.

Gardening constitutes an important activity for plant introduction and many naturalized species found in the territory of Doñana in the last two decades were recorded in Matalascañas (*Ipomoea imperati*, *Dysphania pumilio*, *Eragrostis pectinacea*, *Stenotaphrum secundatum*), Mazagón (*Sporobolus indicus*, *Eragrostis mexicana*, *Cyperus retrorsus*) and the Parador Nacional (*Bidens pilosa*). *Diplachne fascicularis*, *Cortaderia selloana* and *Lantana strigocamara*, recorded in Estero de Domingo Rubio, may have escaped from the gardens of the neighbouring Technical University of La Rábida.

Agricultural practices within and around the territory of Doñana is another factor responsible for the introduction of xenophytes in the area. The presence in the area of la Laguna de las Madres of *Kikuyuochloa clandestina*, *Cucumis myriocarpus* and *Eragrostis frankii*, at least, could be related to the extensive strawberry fields in the vicinity, and *Bergia capensis*, *Ammania coccinea* and *Leptochloa uninervia* are indeed weeds from the rice fields.

Roads are excellent pathways for penetration of exotic plants (Brisson & al. 2010; Gelbard & Belnap 2003; Harrison & al. 2002; Mortensen & al. 2009). This has been confirmed in the Doñana territory, where some species, both exotic and native, spread along the roads. The gradual growth of the roads network in the territory may have contributed to this alarming increase in naturalized xenophytes, as an increase occurs in nitrogen deposition due to human and animal activity, particularly along the roads (Forman & Alexander 1998), while nitrogen enrichment also results from burning petrol derivatives (Pasari & al. 2011). This increase can favor the establishment and propagation of exotic plants (Dukes & Mooney 1999). Indeed, many naturalized species behave as nitrophylous and ruderal ones, as is the case, for instance, of the species of *Amaranthus*, *Erygeron*, *Xanthium*, *Solanum* and *Eragrostis*. *Tragus racemosus*, *Chloris gayana*, *Oenothera speciosa* and *Cucumis myriocarpus* were recorded in this habitat as being new to the territory.

Unfortunately, the naturalization of exotic plants in the territory of Doñana is an ongoing process, as many other xenophytes have already become naturalized in some coastal areas in the provinces of Huelva and Cadiz (for references see Valdés & al. 2011) and their introduction into the Doñana territory is only a matter of time. Furthermore, some of those already recorded as adventives in the territory will, undoubtedly become established in the near future.

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The Mediterranean floristic element in the flora and vegetation of Romania

Abstract

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The aim of this study was to select a list of Mediterranean taxa (*sensu stricto*) from the vascular flora of Romania as well as to reveal the vegetation types in which these species occur and the community types in which they are dominant. A total of 139 Mediterranean taxa were selected, of which 121 were recorded in phytosociological releves and 18 were considered as subspontaneous i.e., escaped cultivation. The relatively high proportion (up to almost 9%) of Mediterranean taxa in the flora of some regions of Romania suggests the potential role of calcareous, open habitats in their establishment. Most community types that host Mediterranean species were described in Dobrogea (the Black Sea coast included), the Danube Plain and adjacent calcareous mountains, a pattern suggesting that the dispersal of these plants followed the Illyric route and then the fluvial corridors across the south Carpathians.

Key words: calcareous habitats, dominant species, floristic proportion, host communities, Illyric route, subspontaneous species.

Introduction

It’s known that chorological analyses give interesting information regarding the climatic influences, the migration ways in the post-glacial period, but also the possible genetic interferences between the extant plant populations within a certain area.

The Mediterranean chorotype in the Romanian floristic literature is regarded either in a broad sense (Eurimediterranean) or in a narrow sense (Stenomediterranean), but most often is subdivided in 5-6 categories, especially following Adamović’s (1933) system.

In our study, we started from the premise that the following statements are true: “*The most numerous and typical among our Mediterranean elements grow in the south-western part of the country ... and in Dobrogea*” (Călinescu 1946, p. 62), and “... *the influence of the Mediterranean climate is present mostly in the south (Banat and Oltenia) and south-east (Dobrogea)*” (Pop 1979, p. 178).

Rexhepi (1997), in his study concerning the Mediterranean, Submediterranean and Illyric floristic elements in Kosovo region, distinguished six subtypes within the Mediterranean element: Widespread Mediterranean, East Mediterranean, West Mediterranean, Subatlantic-Mediterranean, Mediterranean-Pontic and Central-European Mediterranean.

Jovanović (1997) stated that he revealed in the ruderal flora of Belgrad city area "... *the presence of 397 different floristic elements belonging to 17 area groups and 7 basic area types*" (p. 441), which in our opinion means an inoperational, excessive subdivision of the floristic chorotypes (such as Mediterranean-Pontic-South-Siberian group, Mediterranean-South-Siberian-Oriental-Turanian group, Mediterranean-Oriental-Turanian group, and so on). Drawing pertinent and reliable inferences by employing such chorotypes is very difficult.

Quite often, the same plant species was assigned by different authors to two or three chorotypes, sometimes rather separate. Therefore, we think that, the cluster analysis performed on about 20% of the European vascular flora by Finnie & al. (2007) who distinguished 18 floristic elements, can represent a way to clarify the phytogeographic status of each taxon (species or subspecies).

Mediterranean taxa (*sensu stricto*) in the Romanian vascular flora

Taking into account the last two monographs on the chormophytes of Romania (Ciocârlan 2009; Sârbu & al. 2013), we selected those taxa on which there is a consensus as being considered Mediterranean, as well as some taxa that were treated slightly different in the two mentioned monographs but were assigned to the Eumediterranean chorotype by Adamović (1933). Accordingly, we ended up with a list of 145 Mediterranean taxa (*sensu stricto*), of which 127 were recorded in different phytosociological releves (Table 1) and 18 were considered subspontaneous, as the latter escaped cultivation and have survived sporadically in various plant communities.

The proportion of Mediterranean taxa in the flora of some regions of Romania (Table 2) suggests possible dispersal routes and the potential role of calcareous, open habitats in their establishment and subsequent integration into communities.

Table 1. Mediterranean species and subspecies (*sensu stricto*) in the vascular flora of Romania (from Cocârlan 2009 and Sârbu & al. 2013).

No.	Taxon	Vegetation types (in italics, associations in which the taxon is dominant)
1.	*Dryopteris pallida* (Bory) Maire & Petitmengin [rare]	?
2.	*Ranunculus muricatus* L.	Bidention tripartiti
3	*R. millefoliatus* Vahl	Agrostion stoloniferae
4.	*Aristolochia clematitis* L.	*Convolvulo-Aristolochietum clematitis* Convolvulo-Agropyrion repentis
5.	*Glaucium corniculatum* (L.) Rudolph	Caucalidion lappulae
6.	*Hypecoum procumbens* L.	Elymion gigantei
7.	*Hypecoum torulosum* A. E. Dahl.	Elymion gigantei
8.	*Celtis australis* L.	*Celto-Juglandetum regiae* Syringo-Carpinion orientalis
9.	*Castanea sativa* Mill. [cultural relict]	*Castaneo-Quercetum*
10.	*Glinus lotoides* L.	Chenopodion glauci, Nanocyperion
11.	*Scleranthus perennis* subsp. *marginatus* (Guss.) Nyman	*Polytricho piliferi-Scleranthetum perennis* *Sclerantho-Erysimetum cuspidatae* *Sclerantho-Teucrietum polii*

Table 1. continued.

12.	*Silene italica* (L.) Pers. subsp. *italica*	Fraxino orni-Cotinion
13.	*S. thymifolia* Sm.	Polygono-Chenopodion
14.	*Lychnis coronaria* (L.) Desr.	*Lychnio coronariae-Qercetum cerris* Quercion frainetto, Syringo-Carpinion orientalis
15.	*Amaranthus graecizans* L.	Polygono-Chenopodion, Amarantho-Chenopodion albi
16.	*Suaeda splendens* (Pourr.) Gren. & Godr. [very rare]	Thero-Salicornion
17.	*Plumbago europaea* L.	Festucion valesiacae
18.	*Polygonum maritimum* L.	Bidention tripartiti
19.	*Rumex pulcher* subsp. *woodsii* (De Not.) Arcang.	Sisymbrion officinalis
20.	*Sedum ochroleucum* Chaix [rare]	?
21.	*S. caespitosum* (Cav.) DC.	Festucion pseudovinae, Pimpinello-Thymion zygoidi
22.	*S. cepaea* L.	Quercion petraeae, Quercion frainetto
23.	*Potentilla pedata* Willd.	? Festuco-Brometea
24.	*Sanguisorba minor* subsp. *polygama* (Walst. & Kit.) Holub	? Festuco-Brometea
25.	*Crataegus monogyna* subsp. *azarella* (Griseb.) Franco	Fraxino orni-Cotinion
26.	*Sorbus graeca* (Spach) Schauer	Quercetalia pubescentis
27.	*Psoralea bituminosa* L.	Festuco-Brometea
28.	*Trigonella gladiata* M. Bieb.	*Trigonello gladiatae-Orlayetum* Festucion valesiacae, Festucion rupicolae
29.	*Medicago orbicularis* (L.) Bartal.	Festucion valesiacae, Sisymbrion officinalis
30.	*M. rigidula* (L.) All.	Chrysopogono-Festucion pseudodalmaticae, Bromo-Festucion pallentis
31.	*Trifolium patens* Schreb.	Arrhenatheretalia
32.	*T. pallidum* Waldst. & Kit.	*Lolio-Alopecuretum pratensis trifolietosum pallidi* Deschampsion caespitosae
33.	*T. echinatum* M. Bieb.	*Agrostetum stoloniferae-Trifolietosum echinati* *Trifolio echinati-Agrostietum stoloniferae* Sisymbrion officinalis, Festucion pseudovinae
34.	*T. angustifolium* subsp. *intermedium* (Guss.) Kožuharov [rare]	?
35.	*T. purpureum* Loisel.	Chrysopogono-Danthonion
36.	*T. resupinatum* L.	*Lolio-Alopecuretum pratensis trifolietosum resupinati* *Caricetum gracilis-trifolietosum resupinati* Deschampsion caespitosae, Potentillion anserinae
37.	*T. suffocatum* L. [rare]	?
38.	*T. michelianum* Savi	*Lolio-Alopecuretum pratensis trifolietosum micheliani*
39.	*T. hybridum* subsp. *elegans* (Savi) Asch. & Graebn.	Calthion, Agropyro-Rumicion
40.	*Astragalus depressus* L.	Chrysopogono-Festucion pseudodalmaticae
41.	*Coronilla scorpioides* (L.) W. D. J. Koch	Asparago verticillati-Paliurion, Festucion rupicolae
42.	*C. emerus* subsp. *emeroides* (Boiss. & Spruner) Hayek [rare]	?
43.	*Vicia amphicarpa* Dorthes [rare]	?
44.	*V. peregrina* L.	Caucalidion lappulae
45.	*V. ervilia* (L.) Willd.	Caucalidion lappulae
46	*V. narbonensis* L.	Festucion valesiacae, Caucalidion lappulae
47.	*Lathyrus aphaca* L.	*Consolido-Polygonetum convolvuli lathyretosum aphacae* *Apero-Lathyretum aphacae* Atriplicion nitentis, Veronico-Euphorbion, Potentillion anserinae
48.	*L. latifolius* L.	Geranion sanguinei, Quercion petraeae
49.	*L. setifolius* L.	Bromo-Festucion pallentis
50.	*L. cicera* L.	Caucalidion lappulae
51.	*L. sphaericus* Retz.	Asparago verticillati-Paliurion, Chrysopogono-Festucion pseudodalmaticae, Festucion rupicolae, Seslerio-Festucion pallentis

Table 1. continued.

52.	*Pisum elatius* Steven	Caucalidion lappulae, Veronico-Euphorbion
53.	*Paliurus spina-christi* Mill.	*Asphodelino luteae-Paliuretum spina-christi* Prunion spinosae, Asparago verticillati-Paliurion
54.	*Euphorbia chamaesyce* L. subsp. *chamaesyce* [rare]	?
55.	*E. myrsinites* L.	Pimpinello-Thymion zygoides
56.	*Bifora radians* M. Bieb.	*Stachyo annuae-Setarietum pumilae biforetosum radiantis* Veronico-Euphorbion, Scleranthion annui, Panico-Setarion, Caucalidion lappulae
57.	*Smyrnium perfoliatum* L.	Galio-Alliarion
58.	*Myrrhoides nodosa* (L.) Cannon	Galio-Alliarion
59.	*Scandix pecten-veneris* L.	Caucalidion lappulae
60.	*Pimpinella tragium* Vill.	Pimpinello-Thymion zygoides
61.	*Cnidium silaifolium* (Jacq.) Simonk. subsp. *silaifolium*	Cynosurion, Bromo-Festucion pallentis, Geranion sanguinei
62.	*Viola alba* Besser ssp. *dehnhardtii* (Ten.) W. Becker [rare]	?
63.	*V. hymettia* Boiss. & Heldr.	*Violo hymettiae-Cynodontetum* Festucion vaginatae, Festuco-Mollugion
64.	*Clypeola jonthlaspi* L.	Festucion valesiacae
65.	*Eruca vesicaria* subsp. *sativa* (Mill.) Thell. [cultural relict]	Sisymbrion officinalis
66.	*Iberis saxatilis* L. [rare]	?
67.	*Myagrum perfoliatum* L.	Caucalidion lappulae, Sisymbrion officinalis, Atriplicion nitentis, Panico-Setarion
68.	*Sisymbrium irio* L.	Sisymbrion officinalis
69.	*Diplotaxis viminea* (L.) DC.	Veronico-Euphorbion
70.	*Rapistrum rugosum* subsp. *orientale* (L.) Arcang.	Caucalidion lappulae, Sisymbrion officinalis
71.	*Reseda alba* L. [rare]	?
72.	*R. phyteuma* L.	Alysso-Sedion, Artemisio-Agropyrion
73.	*Ecbalium elaterium* (L.) A. Rich.	*Cynodonto-Atriplicetum tataricae ecballietosum elaterii* Atriplicion nitentis, Scolymion hispanici
74.	*Primula veris* subsp. *columnae* (Ten.) Lüdi	Seslerion rigidae, Festuco saxatilis-Seslerion bielzii, Asplenio septentrionalis-Festucion pallentis
75.	*Periploca graeca* L.	Alno-Ulmion
76.	*Asperula arvensis* L.	Caucalidion lappulae
77.	*A. laevigata* L. [rare]	?
78.	*Galium divaricatum* Lam.	Thero-Airion, Corynephorion canescentis
79.	*G. debile* Desv.	Filipendulion, Agrostion stoloniferae
80.	*G. purpureum* L.	Thero-Airion, Bromo-Festucion pallentis
81.	*Valerianella coronata* (L.) DC.	Chrysopogono-Festucion pseudodalmaticae, Festucion valesiacae
82.	*V. pumila* (L.) *DC* subsp. *pumila*	Festucion rupicolae
83.	*Jasminum fruticans* L.	*Rhamno catharticae-Jasminetum fruticantis*
84.	*Calystegia silvatica* (Kit.) Griseb.	Alno-Ulmion
85.	*Cuscuta planiflora* Ten.	Panico-Setarion, Dauco-Melition
86.	*Cynoglossum creticum* Mill.	Robinion pseudacaciae
87.	*Bellardia trixago* (L.) All. [rare]	?
88.	*Kickxia elatine* subsp. *crinita* (Mabille) Greuter [rare]	?
89.	*Teucrium scordium* subsp. *scordioides* (Schreb.) Maire & Petitm.	Magnocaricion elatae, Agrostion stoloniferae, Potentillion anserinae
90.	*Salvia sclarea* L.	Bromo-Festucion pallentis, Festucion valesiacae
91.	*Hyoscyamus albus* L.	Onopordion acanthii
92.	*Scolymus hispanicus* L.	*Lolio-Scolymetum hispanici*; *Cakileto euxiniae-Salsoletum ruthenicae scolymetosum hispanicae*

Table 1. continued.

		Secali sylvestris-Brometum tectori scolymetosum hispanici *Cynodonto-Atriplicetum tataricae scolymetosum hispanici* Amarantho-Chenopodion albi, Malvion neglectae, Euphorbion peplis
93.	*Anthemis triumfettii* (L.) DC.	Achnatherion calamagrostis
94.	*Cirsium acarna* (L.) Moench	Onopordion acanthii
95.	*C. creticum* (Lam.) D'Urv. subsp. *creticum*	Arction lappae, Dauco-Melilotion
96.	*Centaurea solstitialis* L. subsp. *solstitialis*	*Carduo acanthoidis-Onopordetum acanthii centauretosum solstitialis* Amarantho-Chenopodion albi, Sisymbrion officinalis, Malvion neglectae, Atriplicion nitentis, Jurineo arachnoideae-Euphorbion steposae, Cynosurion, Onopordion acanthii, Dauco-Melilotion, Arction lappae, Convolvulo-Agropyrion
97.	*Sonchus asper* subsp. *glaucescens* (Jord.) Ball [rare]	?
98.	*Crepis nicaeensis* Pers.	Bromo-Festucion pallentis
99.	*Allium sphaerocephalon* subsp. *arvense* (Guss.) Arcang.	Agropyro-Kochion, Prunion spinosae, Prunion fruticosae, Stipo-Festucetalia pallentis
100.	*A. moschatum* L.	Festucion valesiacae, Festucion vaginatae
101.	*Asphodeline lutea* (L.) Rchb.	*Asphodelino luteae-Paliuretum asphodelinetosum* Prunion spinosae, Prunion fruticosae, Asparago verticillati-Paliurion
102.	*Gagea granatelii* (Parl.) Parl.	Pimpinello-Thymion zygoides, Quercion pubescentis-petraeae
103.	*Muscari commutatum* Guss.	Festucion valesiacae
104.	*Gladiolus illyricus* W.D.J. Koch	Chrysopogono-Festucion pseudodalmaticae
105.	*Orchis papilionacea* L.	Danthonio-Brachypodion
106.	*O. coriophora* subsp. *fragrans* (Pollini) Sudre	Molinion caeruleae
107.	*Juncus hybridus* Brot. (*J. bufonius* subsp. *mutabilis* (Cavi) I. Grinţ.)	Nanocyperion, Scorzonero-Juncion gerardii
108.	*Sorghum halepense* (L.) Pers.	*Setario pumilae-Sorghetum halepensis* *Cynancho acuti-Sorghetum halepensis* Malvion neglectae, Amarantho-Chenopodion albi, Atriplicion nitentis, Panico-Setarion, Caucalidion lappulae
109.	*Psilurus incurvus* (Gouan) Schinz & Thell.	Festucion valesiacae, Alysso petraei-Sedion
110.	*Dasypyrum villosum* (L.) P. Candargy	*Trifolio molinerii-Dasypyretum villosae* Thero-Airion, Festucion valesiacae, Amarantho-Chenopodion albi, Sisymbrion officinalis, Chrysopogono-Festucion pseudodalmaticae, Matricario matricarioidis-Polygonion arenastri
111.	*Gastridium ventricosum* (Gouan) Schinz & Thell.	Festucion valesiacae
112.	*Sclerochloa dura* (L.) P. Beauv.	*Sclerochloo durae-Polygonetum avicularis* Amarantho-Chenopodion albi, Sisymbrion officinalis, Malvion neglectae, Jurineo arachnoideae-Euphorbion steposae, Caucalidion lappulae
113.	*Sporobolus pungens* (Schreb.) Kunth	Elymion gigantei
114.	*Lolium multiflorum* Lam.	Arction lappae
115.	*Vulpia ciliata* Dumort. subsp. *ciliata*	Thero-Airion
116.	*Cynosurus echinatus* L.	Festucion valesiacae, Sisymbrion officinalis
117	*Elymus panormitanus* (Parl.) Tzvelev	Syringo-Carpinion orientalis
118.	*Bromus rigidus* Roth [rare]	?
119.	*B. scoparius* L. [rare]	?
120.	*Aegilops geniculata* Roth	Onopordion acanthii, Festucion valesiacae
121.	*A. neglecta* Bertol.	*Medicago minimae-Aegilopsetum triaristati* Onopordion acanthii, Festucion valesiacae, Sisymbrion officinalis, Chrysopogono-Festucion pseudodalmaticae
122.	*A. triuncialis* L. [rare]	Festucion vaginatae, Festucion valesiacae

Table 1. continued.

123.	*A. lorentii* Hochst. [rare]	?
124	*Phleum subulatum* (Savi) Asch. & Graebn. subsp. *subulatum* [rare]	?
125.	*Secale strictum* (C. Presl) C. Presl	Moehringion muscosae, Asplenion septentrionalis
126.	*Hordeum bulbosum* L. subsp. *bulbosum*	Sisymbrion oficinalis
127.	*Tragus racemosus* (L.) All.	*Tribulo-Tragetum racemosi* Puccinellio limosae-Halimionion verruciferae, Bassio laniflorae-Bromion tectorum, Amarantho-Chenopodion albi, Salsonion ruthenicae, Malvion neglectae, Atriplicion nitentis, Festucion vaginatae, Sisymbrion officinalis

Apart from these 127 taxa, several subspontaneous Mediterranean species, like *Trigonella foenum-graecum* L., *Papaver somniferum* L., *Ficus carica* L., *Morus nigra* L., *Silene pendula* L., *Mespilus germanica* L., *Cercis siliquastrum* L., *Spartium junceum* L., *Ornithopus sativus* Brot., *Salvia officinalis* L., *Chrysanthemum coronarium* L., *Calendula officinalis* L., *Vicia sativa* L., *V. articulata* Hornem., *Sinapis alba* L. subsp. *alba*, *Melissa officinalis* L., *Consolida ajacis* (L.) Schur, *Adonis annua* L., occur sporadically.

Table 2. Number and proportion of Mediterranean taxa (*sensu stricto*) in the vascular flora of various geographic areas of Romania.

Region	**Total no. taxa**	**Mediterranean taxa (no./%)**	**Reference**
Dobrogea	1911	46/2.4	Skolka & al. (2005)
Romanian Back Sea coast	594	36/6.0	Făgăraş (2008)
Prut valley	1360	35/2.4	Tofan-Burac & Chifu (2002)
Milcov drainage basin	1093	23/2.1	Coroi (2001)
Gurghiu valley	1194	7/0.6	Sămărghiţan (2005)
Crişul Alb valley	1249	20/1.6	Ardelean (1999)
Crişurilor Plain	787	70/8.8	Pop (1968)
Sadu drainage basin	1106	4/0.5	Drăgulescu (1995)
Luncavăţ upper basin	933	24/2.6	Niculescu (2006)
Piatra Craiului Mountains	991	20/2.0	Mihăilescu (2001)
Stânişoarei Mountains	1408	11/0.8	Oprea & Sîrbu (2009)
Pădurea Craiului Mountains	856	19/2.2	Groza (2008)
Siriu Mountain	880	23/2.6	Dihoru (1975)
Ţarcu, Godeanu and Cernei Mountains	1630	72/4.5	Boşcaiu (1971)

Coenotic integration of the Mediterranean floristic element (*sensu stricto*)

The peculiar edaphic and climatic conditions extant in certain regions have promoted the local abundance of 23 Mediterranean species that have become dominant or co-dominant in 18 plant associations and 14 subassociations, of which (*nota bene!*) three are forest communities and two are scrubs.

The syntaxonomic framework of those plant associations in which one or two Mediterranean taxa are dominant is given below (the distribution of these community types is roughly indicated through the names of localities, geographic regions or provinces):

CAKILETEA MARITIMAE R. Tx. & Prsg. 1950
  Euphorbietalia peplis R. Tx. 1950
    Cakilion euxiniae Morariu 1967 corr. Rodwell & al. 2002
      1. *Cakileto euxiniae-Salsoletum ruthenicae* Vicherek 1971
        – *scolymetosum hispanicae* (Pop 1969) Coldea 2012: Vama Veche

PHRAGMITETEA R. Tx. & Prsg. 1942
  Phragmitetalia W. Koch 1926
    Magnocaricion W. Koch 1926
      2. *Caricetum gracilis* Almquist 1929
        - *trifolietosum resupinati* Dihoru & al. 1973: Mehedinţi

KOELERIO-CORYNEPHORETEA Klika in Klika & Novák 1941
  Festucetalia vaginatae Soó 1957
    Bassio laniflorae-Bromion tectorum (Soó 1957) Borhidi 1996
      3. *Secali sylvestris-Brometum tectori* Hargitai 1940
        – *scolymetosum hispanici* (Pop 1970) Coldea 2012: Vama Veche, Mamaia, Năvodari
    Festucion vaginatae Soó 1938
      4. *Violo hymettiae-Cynodontetum* Cîrţu 1973: Oltenia, southern Moldavia
  Sedo-Scleranthetalia Br.-Bl. 1955
    Thero-Airion R.Tx. ex Oberd. 1957
      5. *Trifolio molinerii-Dasypyretum villosae* Boşcaiu & Resm. 1969: Danube Gorge, Mehedinţi Plateau, Olt lower basin, Ţarcu-Godeanu-Cernei Mountains
    Alysso alyssoidis-Sedion albae Oberd. & Th. Müller in Th. Müller 1961
      6. *Scierantho-Erysimetum cuspidata*e Csűrös & al. 1968: Caraş-Severin
      7. *Polytricho piliferi-Scleranthetum perennis* Moravec 1967: Ţarcu-Godeanu-Cernei Mountains
      8. *Sclerantho-Teucrietum polii* Andrei & Popescu 1967: Pricopanu, Popina Island

FESTUCO-BROMETEA Br.-Bl. & R. Tx. ex Klika & Hadač 1944
  Stipo pulcherrimae-Festucetalia pallentis Pop 1968
    Chrysopogono-Festucion pseudodalmaticae Coldea & Sârbu 2012
      9. *Medicago minimae-Aegilopsetum triaristati* Roman 1974: Mehedinţi Plateau
  Festucetalia valesiacae Br.-Bl. & R. Tx. ex. Br.-Bl. 1949
    Festucion valesiacae Klika 1931
      10. *Trigonello gladiatae-Orlayetum* Dihoru (1969) 1970: Dobrogea, Siriu Mountain

MOLINIO-ARRHENATHERETEA R.Tx. 1937
  Molinietalia caeruleae W. Koch 1926
    Agrostion stoloniferae Soó (1933) 1971
      11. *Agrostetum stoloniferae* (Ujvarosi 1941) Burduja & al. 1956
        - *trifolietosum echinati* Morariu & al. 1973: Moldova Veche

Potentillo-Polygonetalia R.Tx. 1947
Potentillion anserinae R. Tx. 1937
12. *Lolio-Alopecuretum pratensis* Bodrogközy 1962
- *trifolietosum pallidi* Păun (1964) 1966: Oltenia
- *trifolietosum resupinati* Păun (1964) 1966: Oltenia
- *trifolietosum micheliani* Păun (1964) 1966: Oltenia
13. *Trifolio echinati-Agrostietum stoloniferae* Morariu & al. 1973: Eforie Sud, Moldova Veche
– *trifolietosum resupinati* Păun (1964) 1966: Banat, Oltenia

PLANTAGINETEA MAJORIS R. Tx. & Preising 1950
Plantaginetalia majoris R. Tx. & Preising 1950
Scolymion hispanici Morariu 1967
14. *Lolio-Scolymetum hispanici* Morariu 1959: Dobrogea

ARTEMISIETEA VULGARIS Lohmeyer & al. in R. Tx. 1950
Onopordetalia Br.-Bl. & R.Tx. ex Klika & Hadač 1944
Onopordion acanthii Br.-Bl. & al. 1936
15. *Carduo acanthoidis-Onopordetum acanthii* Soó ex Jarolinek & al. 1997
- *centauretosum solstitialis* (Coroi & Coroi 1998) Sanda & al. 2001: Moldavia
Agropyretalia repentis Oberd. & al. 1967
Convolvulo-Agropyrion repentis Görs 1966
16. *Convolvulo-Aristolochietum clematitis* Ubrizsy 1967 em. Coldea & Ştefan 2012: Moldavia

POLYGONO ARENASTRI-POETEA ANNUAE Rivas-Martinez 1975 corr. Rivas-Martinez & al. 1991
Polygono arenastri-Poetalia annuae R.Tx. in Géhu & al. 1972 corr. Rivas-Martinez & al. 1991
Matricario matricarioidis-Polygonion arenastri Rivas-Martinez 1975 corr. Rivas-Martinez & al. 1991
17. *Sclerochloo durae-Polygonetum avicularis* Soó ex Kornek 1969 corr. Mucina 1993: Dobrogea, Romanian Black Sea coast, Prut valley, Milcov basin

STELLARIETEA MEDIAE R. Tx., Lohmeyer & Preising in R.Tx. 1950
Papaveretalia rhoeadis Hüppe & Hoffmeister ex Manthey in Dengler & al. 2003
Caucalidion lappulae (R.Tx. 1950) von Rochow 1951
18. *Consolido-Polygonetum convolvuli* Morariu (1943) 1967
- *lathyretosum aphacae* (Spiridon 1970) Oprea & Sârbu 2012: Bucharest, Danube Plain, Oltenia
19. *Stachyo annuae-Setarietum pumilae* Felfoldy 1942 corr. Mucina 1993
- *biforetosum radiantis* Viţalariu 1974: Crasna basin
Atriplici-Chenopodietalia albi (R. Tx. 1937) Nordhagen 1940
Panico-Setarion Sissingh in Westhoff & al. 1946
20. *Setario pumilae-Sorghetum halepensis* Ştefan & Oprea 1997: southern Moldavia
Scleranthion annui (Kruseman & Vlieger 1939) Sissingh in Westhoff & al. 1946
21. *Apero-Lathyretum aphacae* R. Tx. & von Rochow 1951: Maramureş, Oltenia
Eragrostietalia J. Tx. ex Poli 1966
Amarantho-Chenopodion albi Morariu 1943

22. *Cynancho acuti-Sorghetum halepensis* Ştefan & Oprea 1997: Vrancea
23. *Tribulo-Tragetum racemosi* Soó & Timár in Timár 1954: Dobrogea, Romanian Black Sea coast, Prut valley

Sisymbrietalia J. Tx. in Lohmeyer & al. 1962

Atriplicion nitentis Passarge 1978

24. *Cynodonto-Atriplicetum tataricae* Morariu 1943
    – *ecballietosum elaterii* (Morariu 1959) Oprea & Sârbu 2012: Dobrogea (Constanţa and Vama Veche)
    – *scolymetosum hispanici* (Morariu 1959) Oprea & Sârbu 2012: Constanţa

QUERCO-FAGETEA Br.-Bl. & Vlieger 1937 em. Borhidi 1996

Qercetalia roboris R. Tx. 1931

Castaneo-Quercion Soó 1962 em. Soó 1971

25. *Castaneo-Quercetum* Horvat I. 1938: Baia-Mare

QUERCETEA PUBESCENTI-PETRAEAE (Oberdorfer 1948) Jakus 1960

Fraxino orni-Cotinetalia Jakus 1960

Syringo-Carpinion orientalis Jakus & Vida 1959

26. *Celto-Juglandetum regiae* Jovanović 1957 em. Roman 1974: Mehedinţi Plateau

Quercion frainetto I. Horvat 1954

27. *Lychnio coronariae-Qercetum cerris* Sanda & al. 2003: Giurgiu, Oltenia, Muntenia, Banat, Crişurilor Plain

Asparago verticillati-Paliurion Sanda & Popescu 1999

28. *Asphodelino luteae-Paliuretum spina-christi* Sanda & Popescu 1999: Dobrogea
    - *asphodelinetosum* Sanda & Popescu 1999: Dobrogea
29. *Rhamno catharticae-Jasminetum fruticantis* (Mihai & al. 1964) Mititelu & al. 1993: Dobrogea

Most of the above plant (sub)associations were described in Dobrogea, southern Moldavia, Oltenia, Mehedinţi Plateau and the Danube gorge, which suggests that the dispersal of the Mediterranean plants followed the Illyric route and then the fluvial corridors across the south Carpathians. Regarding the presence of such Mediterranean taxa (*sensu stricto*) in the composition of different vegetation types, one can note that:

- six species occur in (semi)-halophilous habitats, but none is (co)dominant in any community type (according to Pop 2002);
- 36 species, representing about 6% of the regional vascular flora, occur along the Black Sea coast (within Romanian borders) and some of them are dominant in six plant associations (Făgăraş 2008); at the scale of the whole Dobrogea region, the number of such species and community types increases to 46 and 10, respectively (Skolka & al. 2005);
- within the area of Cluj-Napoca city, Filipaş (2007) found a total of 1058 species, of which 1.8% were Mediterranean (*sensu stricto*); most of the latter occur in ruderal communities, where their proportion can reach 4% (i.e., in *Polygono avicularis-Matricarietum matricarioidis*) and even 6.2% (i.e., in *Setario-Stachyetum annuae*);
- in the forest (co)dominated by *Quercus cerris* or *Q. frainetto*, the proportion of the Mediterranean floristic element varies between 2 to 6% (Pop & Cristea 2002), which

is an argument for the inclusion of the regions Banat and Oltenia into the Dacian-Illyric floristic province;

- an evidence for considering the Cerna valley as " … *the richest and most interesting in the entire Europe* … " (Călinescu 1946, p. 41) comes from the data published by Boşcaiu (1971), as in both herbaceous and forest communities installed on calcareous shallow soils and outcrops, the proportion of the Mediterranean floristic element reaches the highest values: *Asplenio-Ceterachetum* – 15.9%, *Achnateretum calamagrostis* – 17.8%, *Festucetum xanthinae* – 13.3%, *Geranio robertianae-Fagetum* – 9.0%, *Syringo-Carpinetum orientalis* – 19.4%;
- in the colline and montane forests of Cluj county, the proportion of Mediterranean species varies between 0.5 and 1%, but on limestone habitats it can reach 3.6% (i.e., *Melampyro bihariensi-Carpinetum*) and sometimes 5% (i.e., *Quercetum robori-petraeae*) (Pop & al. 2002);

In conclusion, we agree with Boşcaiu's (1971) statement according to which the positioning of the south Carpathian-Danubian region"… *at the crossing of so different migration waves in terms of origin and intensity has developed the phylogenetic potentialities of the Carpathian massifs* " (p. 484).

A more detailed study based on historical data could reveal the variation in the distribution of Mediterranean species that is presumably due to climate change.

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E. Biondi, M. Allegrezza, S. Casavecchia, D. Galdenzi, R. Gasparri, S. Pesaresi, P. Soriano, G. Tesei & C. Blasi

New insight on Mediterranean and sub-Mediterranean syntaxa included in the Vegetation Prodrome of Italy

Abstract

Biondi, E., Allegrezza, M., Casavecchia, S., Galdenzi, D., Gasparri, R., Pesaresi, S., Soriano, P., Tesei, G. & Blasi, C.: New insight on Mediterranean and sub-Mediterranean syntaxa included in the Vegetation Prodrome of Italy. — Fl. Medit. 25 (Special Issue): 77-102. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

The Italian Vegetation Prodrome (IVP), implemented on behalf of the Ministry of the Environment and Protection of Land and Sea (also known as MATTM) on the basis of two agreements entrusted to the Italian Botanical Society, has been drawn up to the lower level of suballiance. In the current paper, the syntaxonomical choices adopted in the description and the typification of the new syntaxa are explained through eight main conceptual issues. Among these, there are several Mediterranean and sub-Mediterranean syntaxa, which contribute to improve knowledge of the phytocoenosis biodiversity of these biogeographic areas. Indeed, these Mediterranean and sub-Mediterranean territories are the most important European areas in terms of flora, vegetation and habitats. In the past, the syntaxa of these bioclimatic and phytogeographic areas were mainly included in classes widespread over Europe and in hierarchical levels that are, in our opinion, inappropriate for describing their floristic and phytocoenotic richness. Therefore, we decided, in some cases, to raise their hierarchical level in order to promote a better and more appropriate syntaxonomical classification. The definition of such syntaxa is the result of a research carried out on various aspects of the flora, ecology and dynamic features of the plant communities; they have often considered large geographical territories, wider than Italy and, sometimes, even Europe. The case study of some syntaxa belonging to the classes *Euphorbio paraliae-Ammophiletea australis, Sarcocornietea fruticosae*, *Festuco valesiacae-Brometea erecti*, *Trifolio medii-Geranietea sanguinei*, *Rhamno catharticae-Prunetea spinosae* are shown.

Key words: bioclimatology, sand dune vegetation, wetland vegetation, ecotone vegetation, dry grassland vegetation, Italy, plant ecology, syndynamic, syntaxonomy, methodological classification.

Introduction

The aim of this paper is to highlight the logic and conceptual lines leading to the implementation of the Italian Vegetation Prodrome (IVP) in the current state of the art (available on the Italian Botanical Society (IBS) website in a special forum that is still partly upgradeable:

http://www.prodromo-vegetazione-italia.org). The IVP project has been carried out in the framework of two agreements entrusted to the Italian Botanical Society by the Ministry of the Environment and Protection of Land and Sea (also known as MATTM) and coordinated by Edoardo Biondi and Carlo Blasi. The first of these agreements, which began in 2012 and ended in 2013, involved the implementation of the prodrome up to the syntaxonomical level of alliance (Biondi & al. 2014b). The second agreement, started in 2014 and ended in April 2015, concerned the addition of suballiances and the improvement of what had been produced during the first phase through changes and updating of syntaxa, some of them newly described and recently typified in accordance with the ICPN rules.

Currently the prodrome consists of 75 classes, two subclasses, 175 orders, eight suborders, 403 alliances and 89 suballiances; the state of the art of the prodrome is available on the fore-mentioned website of the Italian Botanical Society.

The IVP is the first comprehensive survey of the vegetation of Italy involving the entire country. It is a checklist of syntaxa whose valid names and synonyms are provided.

For the upper syntaxonomic hierarchical levels, a synthetic diagnostic sentence is provided while for the alliances and suballiances 482 original sheets are provided that give insight on the ecology, geographical distribution, floristic composition, syndynamic features, connections to habitats of Community interest, conservation status and management, presence in National Parks, and specific literature. The work ends with a rich glossary that helps the reader to understand the technical and scientific terms used.

The Mediterranean and sub-Mediterranean syntaxa, often newly described or lately reassessed, play a very important role in the IVP because they contribute to improve knowledge of the phytocoenosis biodiversity of these biogeographic areas. Indeed, the Mediterranean area is one of the world's major hotspots for plant diversity, where 10% of the world's higher plants occurs in an area representing only 1.6% of the earth's surface (Medail & Quezel 1997). The prominent role played by these areas as reservoirs for plant biodiversity has been emphasized by Myers (1990). The flora of the Mediterranean basin in a broader sense includes more than 25,000 species of flowering plants, making it the third richest in the world. More than 30 Mediterranean plants are considered to have become extinct during the last century. It has been estimated that nearly 25 % of the Mediterranean flora may be threatened in the decades to come (Leon & al. 1985). In the Mediterranean biogeographical region (northern part of the basin), the number of species for a certain area (areal richness) may be twice the number found in corresponding areas in northern Europe (Ozenda 1994).

The Mediterranean and the Temperate macrobioclimates, *sensu* Rivas-Martínez & al. (2011), occupy about 14% and 53% of the European territory, respectively. In Italy, the Mediterranean and the Temperate macrobioclimates occupy 43% and 57% of the territory; 40% of the Temperate macrobioclimate (equivalent to 25% of the national territory) belongs to the sub-Mediterranean variant (Fig. 1 and Table 1). Therefore, the sub-Mediterranean variant of the Temperate macrobioclimate extends for a large portion of the Italian territory and shows a high variability in bioclimatic terms particularly with regard to summer drought. This variability is classified into different submediterraneity levels (Rivas-Martínez & al. 2011) (Table 2 and Fig. 1).

The Italian Adriatic sectors of the sub-Mediterranean variant have different bioclimatic characteristics as compared with the Tyrrhenian ones due to their geographical position:

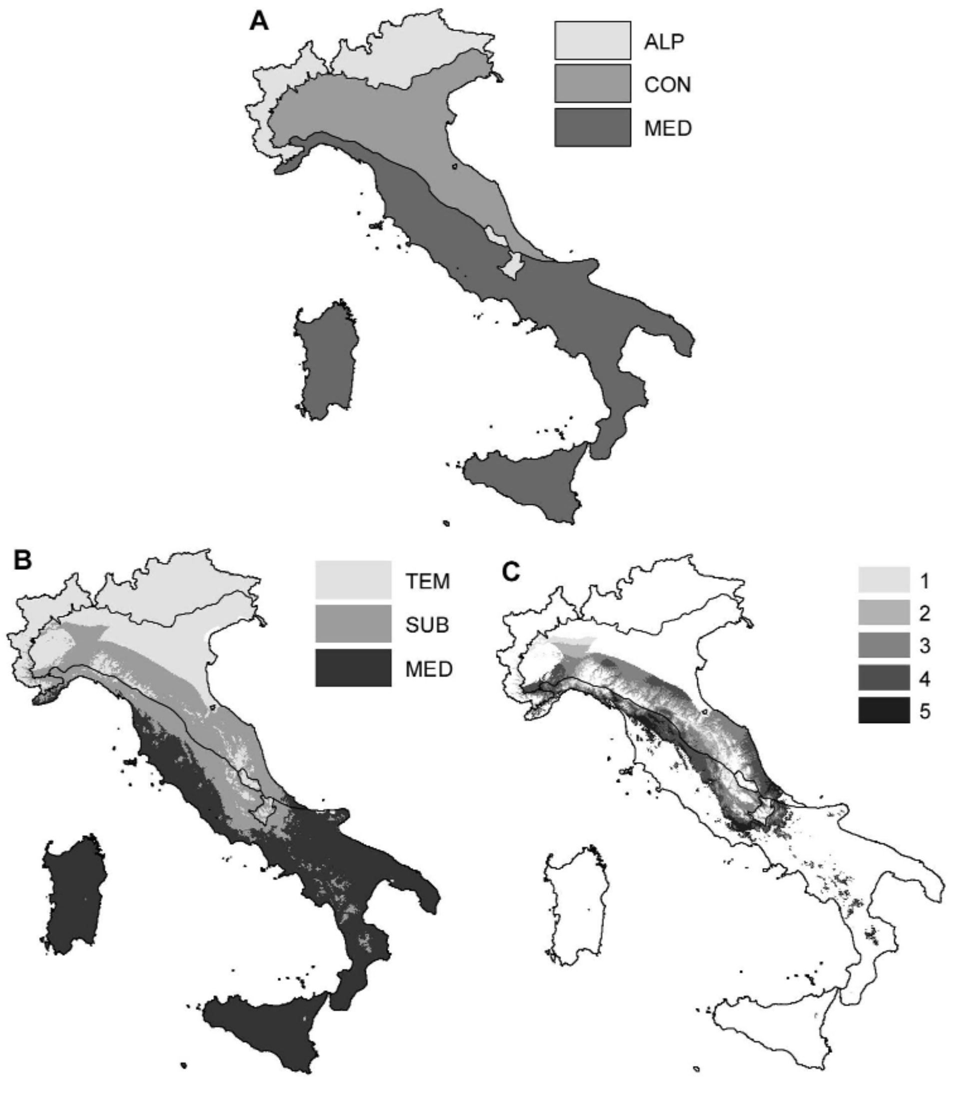

Fig. 1. A) Map of the EU biogeographical regions. ALP-Alpine; CON-Continental; MED-Mediterranean. B) Map of Macrobioclimates of Italy. TEM-Temperate; SUB-Temperate sub-Mediterranean variant; MED-Mediterranean. The black line represents the boundaries of the EU biogeographical regions. C) Map of the sub-Mediterranean levels of Italy.1 - Extremely weak; 2 - Highly weak; 3 - Weak; 4 - Strong; 5 - Highly strong. The black line represents the boundaries of the EU biogeographical regions. The bioclimatic data are *sensu* Rivas-Martínez & al. (2011) derived from Pesaresi & al. (2014).

Table 1. Pivot table of the EU biogeographical regions and macrobioclimates of Italy. Columns are the macrobioclimate regions *sensu* Rivas-Martínez & al. (2011) derived from the bioclimatic map of Italy (Pesaresi & al. 2014). Rows are EU biogeographical regions. Values are percentage of the whole Italian territory. Temp - Temperate; Submedit - Temperate sub-Mediterranean variant; Medit - Mediterranean; Alp - Alpine; Cont - Continental; Medit -Mediterranean.

	Temp	**Submedit**	**Medit**	***Total***
Alp	0.17	0.01	0.00	0.18
Cont	0.16	0.13	0.00	0.29
Medit	0.00	0.10	0.43	0.53
Total	*0.33*	*0.24*	*0.43*	

lower annual rainfall, less summer drought and thus lower sub-Mediterraneity levels, colder winters, and a slightly higher continentality.

Furthermore, the new vegetation syntaxonomy of the Italian peninsula (IVP) establishes a better relationship with the coarse biogeographic classification proposed by the EU.

In Italy, according to the European biogeographic classification, Alpine, Continental and Mediterranean biogeographical regions extend for 18%, 29%, and 53% of the territory, respectively. The comparison with the bioclimatic map of Italy shows that about 45% of the Continental biogeographic region and 19% of the Mediterranean biogeographic region fall within the Temperate macrobioclimate sub-Mediterranean variant (Table 1). Consequently, the attribution of a habitat to a certain biogeographic region made on the basis of the Interpretation Manual of European Union Habitats - EUR28 is more administrative than scientific and, therefore, not fully comprehensive and adequate.

Table 2. Sub-Mediterraneity levels *sensu* Rivas-Martínez & al. (2011) of Italy. The first column shows the occurrence of the sub-Mediterraneity level in percentage relative to the entire territory. The second column is the occurrence of the sub-Mediterraneity level in percentage relative to the sub-Mediterranean variant of the Temperate macrobioclimate. The data are derived from the bioclimatic map of Italy (Pesaresi & al. 2014).

Sub-Mediterraneity levels		
Extremely weak	3	12
Highly weak	5	18
Weak	8	30
Strong	7	27
Highly strong	3	13

The Apennines are defined as a biogeographic crossing area as its flora is made up of a mixture of elements of different origins such as northern Europe, eastern and western species, and relatively few endemic species.

The phytogeographic element known as the Apennine-Balkan element, described by Pezzetta (2010), is also important from a bioclimatic point of view as discussed above. In fact, this element perfectly justifies the relationship between the Apennine territories of the Adriatic and Ionian side with the southern Balkan Peninsula, as proposed with respect to the bioclimatic conditions of the Italian peninsula.

These are the bioclimatic and biogeographical conditions that led over time to establish a significant correlation, in syntaxonomical terms, of many vegetation types, such as forests, meadows, montane chamaephytic formations as well as coastal communities and shrublands, to the eastern system of classification (Cutini & al. 1996; Blasi & al. 2004; Košir & al. 2008; Allegrezza & Biondi 2011; Biondi & Galdenzi 2012; Košir & al. 2013). Therefore, a major change occurred over time in the syntaxonomy of the Italian vegetation, which was previously almost exclusively driven by the central and western Europe syntaxonomical classifications, except for the north-easternmost areas (Poldini 1989). In this way, the Italian peninsula, because of the different biogeographical regions that it encloses, plays the role of biogeographical joint. In fact, the geographical position that it occupies places Italy at the center of the Mediterranean.

About one-third of the Mediterranean biogeographic regions is used for agriculture, including grasslands. Forests and other wooded lands, scrub and heathlands with dwarf shrubs together dominate more than half of the region. Abandonment of agricultural practices and fires lead spontaneously to scrub formations and from that to secondary forests. In the Mediterranean region of EU-27, 425 species and sub-species (Annex II of Habitats Directive) and 147 habitat types are of Community importance (Annex I Habitats Directive). Of these, 37 are EU-27 priority habitat types, and 26 types occur only in the Mediterranean region (European Environment Agency, http://www.eea.europa.eu).

According to Habitats Directive (92/43/CEE) habitats are defined through syntaxa, so allowing an easy recognition of them. Often, however, Mediterranean habitats are not as clearly recognizable as the Continental and Atlantic ones because of the lack of clear syntaxonomic references. This is a very important issue because the phytosociological science, with its concepts and methods, allows the interpretation of all habitat features, beyond their mere identification. In fact, phytosociology helps to understand habitat transformations linking them to a dynamic landscape view of territories in their own biogeographic regions. Human activities have played a crucial role on the vegetational successions that phytosociologists have long since understood and used to direct conservation measures and to compile the impact assessment requested by Habitats Directive. Phytosociological and syntaxonomic knowledge also plays an important role in the projects promoted by the European Commission (LIFE projects, Horizon 2020, etc.) concerning the reintroduction and reinforcement of threatened species and, specially, for restoration and recovery of habitats assessed as unsatisfactory.

Guiding concepts in the Prodrome implementation

The IVP, coherent with the concepts partially explained in the introduction of this paper, aims to combine the current needs of a syntaxonomic classification that should be:

1. - consistent with the physiognomic and structural uniformity of plant communities classified in hierarchical levels;
2. - consistent with the ecology, because plant community structure and function, like that of species, are strictly linked;
3. - consistent with the biogeographical context where plant communities occur. In fact, just as species vary among different individual biogeographic areas, vegetation typologies also vary with significant effects on the hierarchical levels of the plant communities;
4. - most appropriate, in hierarchical terms, to express the high phytocoenotic biodiversity of Mediterranean and sub-Mediterranean plant communities. This can be achieved, for example, by raising to the order level a number of alliances or creating new suborders and suballiances, so as to obtain a more articulated and, therefore, more precise and easily usable classification;
5. - most appropriate to represent the dynamic processes, no longer considered to be marginal aspects in the study of plant communities. In fact, they are fundamental in the transformation of the plant landscape because they promote a classification that pays closer attention to the ecology of vegetation edges (*Trifolio medii-Geranietea sanguinei*) and forest mantles (*Rhamno catharticae-Prunetea spinosae*) playing a key role in the dynamics of the plant landscape;
6. - complying with vegetation classes that are already universally accepted even if they do not always respect the rules of the International Code of Phytosociological Nomenclature (ICPN). It is, therefore, necessary that in the same code, under review by a competent committee, an article be included on *nomina conservanda*, so that the phytosociological classifications of different countries can match, at least for the highest hierarchical levels (see also Willner & al. 2015);
7. - more easily accessible even to non-specialists, e.g., by inserting definitions of each syntaxonomical rank, so that syntaxa and their practical applications can be better understood;
8. - more appropriately applicable. For example, *via* recognition and classification of habitats *sensu* Directive 92/43/EEC and of the transformations of the same habitats in relation to global change and thus to their preservation.

Some significant examples are reported below, showing how syntaxonomic conceptions of some syntaxa can be improved by applying the above-mentioned rules. These examples are representative of the overall knowledge gained through years of research carried out by a group of phytosociologists, including the authors of this article.

Materials and methods

The manuscript relies on previously published articles concerning the IVP, especially those describing new Mediterranean and sub-Mediterranean syntaxa (Biondi & al.

2014b). For the bioclimatic references, the classification of Rivas-Martínez & al. (2011) and the bioclimatic map of Italy (Pesaresi & al. 2014) were followed. For the coding of new syntaxa, the ICPN was consulted (Weber & al. 2000). Regarding the taxonomic nomenclature, we followed Pignatti (1982), Conti & al. (2005) and Conti & al. (2007) and the following websites: http://www.anarchive.it and http://www. theplantlist.org. Finally, the new syntaxa proposed here have been surveyed following the phytosociological method (Braun-Blanquet 1928; Braun-Blanquet 1932; Tüxen 1979; Géhu & Rivas-Martínez 1981; Theurillat 1992; Rivas-Martínez 2005; Géhu 2006; Biondi 2011; Blasi & Frondoni 2011; Pott 2011).

Coastal vegetation

The coastal vegetation is the one most exposed to the effects of climate change due to the sea level rise worldwide, particularly evident in the Mediterranean Sea and, even more, in the Adriatic Sea because of its small size and shallow waters in the northern part. The flora of the Mediterranean dunes is essentially made up of endemic species and subspecies, which in turn are distributed in different areas of the regions belonging to the Mediterranean macro-region. As found in many parts of the world, the Mediterranean dunes perform multiple functions simultaneously, such as coastal defense, and protection from erosion resulting in stabilization of the dune system. Human activities supported are: reforestation, agriculture, tourism and urbanization, recreation, information, and education (van der Meulen & Salman 1996).

The decline in Mediterranean dunes has been severe: it is estimated that since 1900 more than 70% of them has been lost. Most of the former dune areas has been used for urbanization, not least for tourism. Thus, only few areas remain untouched.

Dunes are the exclusive habitat of many plant and animal species and many dune species are endemic. Animal life (snails, arthropods, insects, lizards, tortoises, rabbits) is often not very visible. An accurate and in-depth knowledge of the vegetation and its dynamic aspects at the level of dune systems and halophilous and hyperhalophilous habitats is, therefore, extremely important for the reconstruction of the protective systems of the coastal micro-habitats recognized by the Habitats Directive. They are, in fact, extremely threatened.

Seventy percent of the Italian coasts are represented by low, sedimentary, sandy or gravelly coasts. They extend over a length of 3,270 km and an area of 120 km^2 and are particularly vulnerable to the effects of global warming. A model based on predicted climate change over this broad area (Prisco & al. 2013), despite the limitations of the simulation, indicates that, without proper management, the habitats of the fixed and mobile dunes may even disappear in the short term. These changes may have important implications for biodiversity conservation, as well as for long-term predictions of the effects of global climate change (Heijmans & al. 2008).

In Italy, a large number of coastal plant communities still occur resulting in a high biodiversity, despite the strong alteration that habitats have suffered from the negative factors indicated. Therefore, it is necessary to carry out a recovery strategy that would allow the preservation of ecosystems and thus the improvement of natural areas of Italian coasts

(Biondi & Zivkovic 2014). For this purpose, careful management of these habitats is needed. It is certainly a priority for Italy, as shown by the diachronic analyses carried out in some Italian coastal areas (Brachetti & Conti 2014; Del Vecchio & al. 2015).

Coastal dune vegetation

The first complete syntaxonomic study of the Italian sedimentary coasts and retrodunal salt environments was the result of a phytosociological excursion led by J.-M. Géhu and J. Géhu-Franck in 1982 with a group of Italian and Spanish researchers. In the publication of the relevés collected during that excursion, a rather exhaustive syntaxonomic scheme was proposed (Géhu & al. 1984).

Previously, studies on this part of the Italian territory had a more regional or strictly local character. Amongst these, a study characterised by greater precision and originality for its times was performed by Pignatti (1952, 1953) on the eastern plain of the Veneto Region. Further investigations on this area allowed to adjust some syntaxonomical aspects and take a census of the conservation status of the vegetation growing in this extremely important sector of the Mediterranean basin (Buffa & al. 2007; Sburlino & al. 2013).

The syntaxonomic scheme concerning plant communities growing on the Italian side of the Adriatic basin has been, since then, used and updated by Géhu & Biondi (1996) and later by Biondi (1999) with a review of all the vegetation of the Italian sandy coasts and cliffs. Again, Biondi (2007) expanded the vision to the entire Mediterranean basin and proposed successional schemes of sandy coasts and cliffs including new important syntaxa. These schemes have recently been followed and modified by Pirone & al. (2014) in a review of the Ionian and Adriatic coastal vegetation, whereas Acosta & al. (2009) and Stanisci & al. (2014) have dealt with the monitoring of the dune coastal habitats.

In the IVP, the vegetation dominated by perennial grasses growing on the coastal sandy dunes of the Mediterranean areas was recently referred to the class *Euphorbio paraliae-Ammophiletea australis* Géhu & Rivas-Martínez in Rivas-Martínez & al. 2011. This class replaces the class *Ammmophiletea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946 as it groups the vegetation of Atlantic and Mediterranean dunes in a single class (Biondi & Galdenzi 2014). The correct definition of the class is: "Psammophilous perennial vegetation from coastal sandy and fine-pebbly dunes with a Mediterranean, Atlantic, Macaronesian and north African coastal distribution, which is important in the dune construction and stabilisation processes" (*errata corrige* of the article by Biondi & Galdenzi (2014) published in June 2015 in the journal Plant Sociology vol. 52 (1), p. 64).

The separation between the Atlantic and the Mediterranean and thermo-Atlantic dune vegetation is performed at the level of order by recognizing the order *Elymetalia arenarii* Br.-Bl. & Tüxen 1943 for the Atlantic north-European coasts and the order *Ammophiletalia australis* Br.-Bl. 1933 for the Mediterranean and thermo-Atlantic ones. In this way, if the role of basic rank for grouping phytocoenoses according to the biogeographical macro-units Region and Subregion (Rivas-Martínez 2007) is assigned to the order, the alliance can represent the ecologically-based hierarchical level, while the suballiance can represent the rank in which the biogeographical and ecological features are better described (Biondi & Galdenzi 2014). With regard to the Mediterranean dune vegetation, order *Ammophiletalia australis* includes three alliances that group phytocoenoses making up the geosigmeta of the dune landscape: *Ammophilion australis* for the mobile dune formations, *Agropyrion juncei* (R. Tüxen in Br.-Bl. & R. Tüxen) Géhu, Rivas-Martínez & R. Tüxen 1972 in Géhu & al. 1974 for the embryonic dune formations, and *Elymion gigantei* Morariu 1957 for communities that colonize Pontic dunes. This classification, defined at the level of alliance, has been recognized since a long time and is, therefore, maintained (Géhu & al. 1984; Géhu 1986; Géhu & Franck 1988; Géhu & al. 1994; Géhu & Biondi 1996).

As part of the alliance *Ammophilion australis*, suballiance *Ammophilenion australis* Br.-Bl. 1933 is recognized. It describes the psammophilous perennial, herbaceous communities that colonize the mobile dunes in Mediterranean and European Thermo-Atlantic littoral areas. As far as the alliance *Agropyrion juncei* is concerned, five suballiances are recognized: (i) *Sporobolenion arenarii* Géhu ex Biondi & Galdenzi 2014, which includes the first perennial vegetation of the first part of the embryonic dune, directly reachable by seawater; (ii) *Elymo farcti-Otanthenion maritimi* Biondi & Galdenzi 2014, which groups the vegetation of the inner part of the embryonic dune characterised by reduced mobility of the sandy substrate; (iii) *Echinophoro spinosae-Elymenion farcti* Biondi & Galdenzi 2014, which groups the communities of the central-eastern Mediterranean up to Greece; (iv) *Agropyrenion farcti* Rivas-Martínez, Costa, Castroviejo & Valdés 1980 of the communities of the western Mediterranean; (v) *Sileno succulentae-Elymenion farcti* Biondi & Galdenzi 2014, which includes the communities of the Mediterranean coast of North Africa.

The full syntaxonomical scheme for this vegetation type is found on the website (http://www.prodromo-vegetazione-italia.org/).

Halophytic vegetation of coastal wetlands

Wetlands are directly interconnected to sandy coastal environments and represent highly threatened habitats in the European part of the Mediterranean basin. These habitats are linked to those sandy and gravel coastal ones where topographic variations are sometimes very limiting. Erosion in a dune system may favour the establishment of salt marshes provided that artificial barriers have not been created to safeguard beaches. Thus, the fate of coastal wetlands is perhaps more intrinsically linked to the complex economic and sociological decisions determining the creation of coastal infrastructure rather than to the effect of climate change itself (Kirwan & Megonigal 2013).

Studies carried out in different parts of the Mediterranean region have dealt not only with the perennial hyperhalophilous vegetation but also with the annual one corresponding to the 1420 “Mediterranean and thermo-Atlantic halophilous schrubs (*Sarcocornietea fruticosae*)” and 1310 “*Salicornia* and other annuals colonizing mud and sand” habitats. The IVP innovations mostly concern the vegetation of the genus *Halocnemum*, for which, in recent years, many taxonomic and ecological aspects and, therefore, phytosociological and syntaxonomical issues, have been clarified.

The vegetation of *Halocnemum*: taxonomy, ecology, phytosociology and syntaxonomy

In the IVP, this vegetation has been assigned to the *Sarcocornietea fruticosae* class which includes the perennial halophilous vegetation within which the order *Halocnemetalia cruciati* Biondi, Casavecchia, Estrelles & Soriano 2013, defined as "Woody and semi-woody, succulent, hyper-halophilous vegetation that spreads along the Mediterranean coasts, even as far as the Middle East, and marginally found in the Eurasian inlands" (Biondi & al. 2013), has been included.

Taxonomic aspects and distribution in Italy

The proposal of this new order is a part of the research conducted on the taxonomy of the genus *Halocnemum* based on the fact that, in the Mediterranean basin and in Europe, authors of the phytosociological studies have referred in the past to a single species: *Halocnemum strobilaceum* (Pallas) M. Bieb. (Biondi & al. 2013). Nevertheless, the fact is that two morphotypes, that have been identified as "nano-phanerophytic" and "chamaephytic morphotype" (Biondi & Casavecchia 2010), are clearly evident. DNA analyses allow us to hypothesize that these two morphotypes may correspond to different taxa (Papini & al. 2004) as acknowledged in taxonomic terms. Indeed, the "nano-phanerophytic" morphotype can be identified as *Halocnemum cruciatum* (Forssk.) Tod. (Syn*: H. drepanensis* Lojacono, *Salicornia drepanensis* Tin., *Salicornia cruciata* Forssk., *H. strobilaceum* var. *cruciatum* Moq., *H. yurdakulolii* Yaprak & Kadereit) (Bacchetta & al. 2012; Biondi & al. 2013). This species grows exclusively in the warmest European Mediterranean central-western area (eastern Spain and Tyrrhenian Italy), as well as in North Africa, the Sinai Peninsula, and the Middle East. In Italy, both species of *Halocnemum* can be found, *H. cruciatum* grows in southern Sardinia in the Santa Gilla lagoon, near Cagliari (Mossa & Biondi 1992) and on the island of Sant'Antioco (De Marco & al. 1980), and in western Sicily in the salt marshes of Trapani (Brullo & Di Martino 1974). In the case of *H. strobilaceum,* two populations have been found in the Italian peninsula, one in the northern Adriatic coast, in the State Nature Reserve of Sacca di Bellocchio, close to Ravenna and in the Valli di Comacchio (Corbetta 1976; Cortichelli & al. 1999; Piccoli & al. 1999). The other is located on the northern Tyrrhenian coast in the Maremma Regional Park (Arrigoni & al. 1985; Biondi & al. 2013). Recently, a new locality of *H. strobilaceum*, situated in the southern part of the Italian Adriatic basin, at the mouth of River Carapelle in northern Apulia (Sciandrello & Tomaselli 2014), has been described. However, by observing the photos appearing in the publication it seems that it could be attributed to *H. cruciatum*. In fact, when this species grows in predominantly sandy soils with low clay content, it does not reach large dimensions. It is still recognizable by its branches that stem directly from the soil, and, in some cases, as can be observed in Tunisia, it can create microdunes in areas near the sea where sea water reaches them frequently. The two localities of *H. strobilaceum* in peninsular Italy are in the area of transition between the Temperate and the Mediterranean macrobioclimatic conditions, rather than in the sub-Mediterranean variant of the Temperate macrobioclimate. Indeed, the phenotype having a smaller size occurs in ecological and bioclimatic conditions that are more similar to those of continental Europe (Biondi & al. 2013).

Vegetation and syntaxonomy

The syntaxonomic interpretation of hyperhalophilous woody or semi-woody vegetation with *Halocnemum* M. Bieb. along the coasts of the Mediterranean basin has been described by Biondi and co-workers (2013, 2014b). A brief summary (Fig. 2) and the syntaxonomic scheme are presented below.

SARCOCORNIETEA FRUTICOSAE Br.-Bl. and Tüxen ex A. and O. Bolós, 1950 em. Biondi, Casavecchia, Estrelles & Soriano 2013

SARCOCORNIETALIA FRUTICOSAE Braun-Blanq. 1933 nom. mut. prop. Rivas-Martínez & al. 2002

HALOCNEMETALIA CRUCIATI Biondi, Casavecchia, Estrelles & Soriano 2013
Halocnemion cruciati Biondi, Casavecchia, Estrelles & Soriano 2013
Communities with a European and African Mediterranean littoral distribution, including the Middle East with penetrations into the Sinai Peninsula and growing in the semi-arid to hyperarid Mediterranean.

Halocnemion strobilacei Biondi, Casavecchia, Estrelles & Soriano 2013
Communities occurring along European coasts of the Mediterranean Basin and growing in

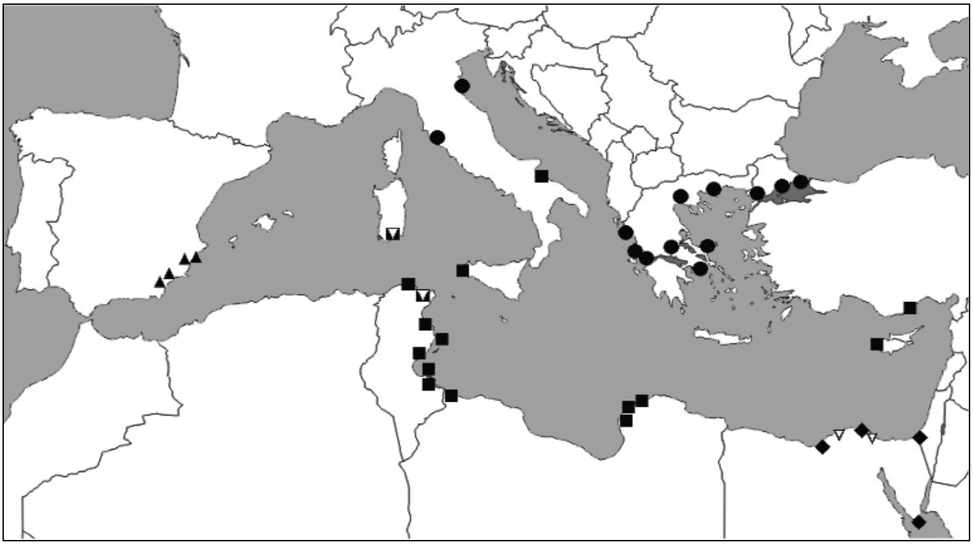

Fig. 2. Distribution of plant communities with *Halocnemum strobilaceum* and *H. cruciatum* along the coasts of the Mediterranean basin. ▲ *Frankenio corymbosae-Halocnemetum cruciati*; ■ *Arthrocnemo macrostachyi-Halocnemetum cruciati*; ● *Arthrocnemo glauci-Halocnemetum strobilacei*; ▽ *Halocnemo cruciati-Sarcocornietum fruticosae*, ◆ *Zygophyllo albi-Halocnemetum cruciati* (modified from Biondi & al. 2013).

Temperate sub-Mediterranean macrobioclimate or Mesomediterranean thermotype of Mediterranean macrobioclimate (Biondi & al. 2013).

The complete syntaxonomic scheme for Italy is present on the IBS website: http://www.prodromo-vegetazione-italia.org.

According to the results of the ecological analyses on bioclimatic conditions and soil features carried out on the two populations: Sacca di Bellocchio (Ravenna, Italy) for *H. strobilaceum* and El Hondo (Crevillente, Spain) for *H. cruciatum*, the two species of the genus *Halocnemum* grow in completely different environments. The first grows in the sub-Mediterranean variant of the Temperate macrobioclimate, with a mean annual temperature of 13.7 C° and a mean annual rainfall of 584.2 mm in the Mesotemperate upper dry (Andreucci & al. 2000) and the second in the Mediterranean xeric-oceanic climate (Thermo-Mediterranean semiarid), with a mean annual temperature of 18 C° and an average annual precipitation of 286 mm (Estrelles & al. 2015). This study also provided information on the germination behaviour related to divergent environmental conditions, demonstrating that water availability affects the germination response of *Halocnemum* seeds. Germination strategies of the two populations with contrasted rainfall regimes and soil aridity, were evaluated in relation to soil salinity and features, especially texture and conductivity. The *H. cruciatum* population (El Hondo) and that of *H. strobilaceum* (Sacca di Bellocchio) grow on sandy loam to clay loam soils and on clay soils, respectively. In the case of the *H. strobilaceum* population, waterlogging is much more favoured in comparison to the other population. These soil features, combined to a decrease in the mean annual temperature and greater annual rainfall, result in a longer flooding period and lower salinity in the dry period in Sacca di Bellocchio (Andreucci & al. 1999) as compared to El Hondo (Fig. 3).These ecological data are of great help in order to spatialize species and communities in the Mediterranean region and to plan how to reinforce them or recreate their environments where they have been destroyed (Estrelles & al. 2015).

Ecotone vegetation

Historical data related to the dynamic processes occurring in vegetation is one of the most important chapters of phytosociology in the more than 100 years since its foundation (Biondi 2011). Phytosociological studies in ecotonal areas between forest formations and the herbaceous meadows and pastures are particularly important for the understanding of the dynamic processes occurring in this area for the shrub vegetation class *Rhamno-Prunetea* and the herbaceous vegetation class *Trifolio-Geranietea* (Tüxen 1979; Géhu 1979; Géhu & Rivas-Martínez 1981; Géhu 1988; Theurillat 1992; Rivas-Martínez 2005; Biondi & al. 2006; Biondi 2011). The recognition of shrubs communities surrounding the forest and of those that are projected outside of these when the grasslands are no longer used in the agronomic or pastoral sense was the first major step forward in the understanding of natural phenomena triggered independently in the vegetation. Long-term observations conducted in the ecotonal area have also led to the discovery that along the forest margin, where shade is produced by the tree canopy, a sciaphilous vegetation develops, consisting of nemoral herbaceous species that tend to emerge naturally in this area. In the illuminated part, that of the grassland, a similar process takes place after abandonment, leading to concentration of heliophilous species in the same ecotonal area, which is con-

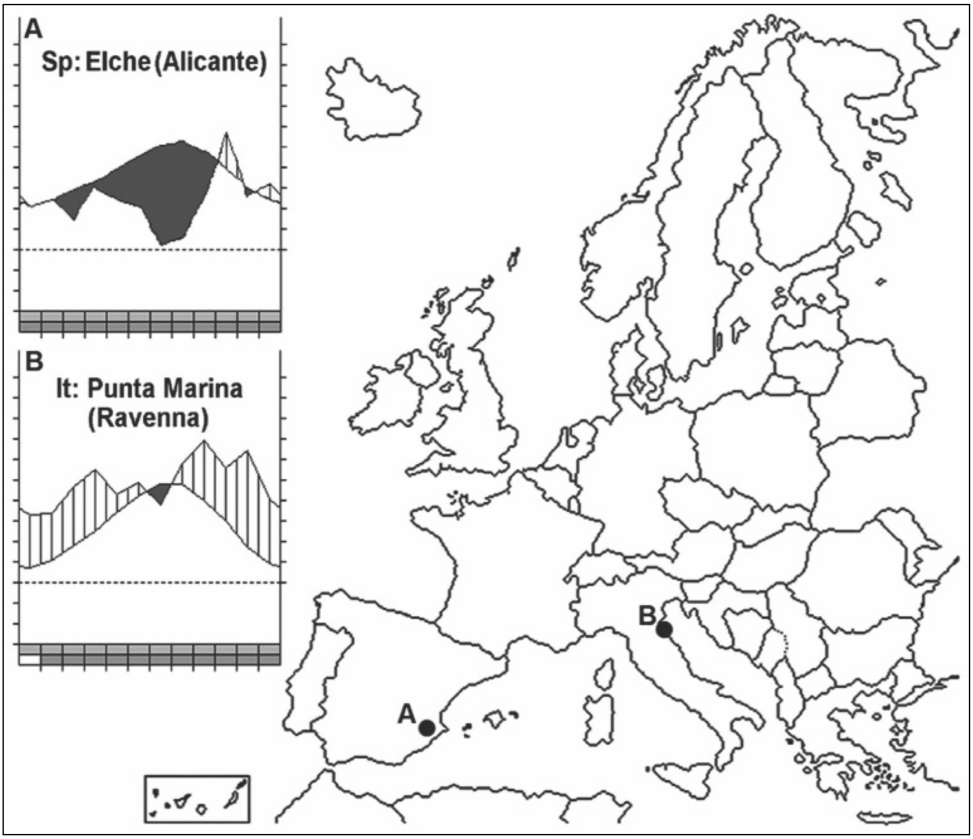

Fig. 3. Bioclimatic diagrams from nearby thermopluvial stations: El Hondo, Alicante, Spain (A) and Sacca di Bellocchio, Ravenna, Italy (B) (from Estrelles & al. 2015).

tinuous with the sciaphilous part. Sciaphilous and heliophilous vegetation edges are, therefore, the elements that define a dynamic process in which research, currently very active, helps to better define the dynamic processes. In the IVP, with the insertion of the *Asphodeletalia macrocarpi* order within the class *Trifolio-Geranietea*, these dynamic processes, such as those concerning the sciaphilous edges and mantles of vegetation, have been given greater attention. All these aspects contribute to enrich and refine the field of synphytosociology in Italy, according to the concepts of syntaxonomy (Bouzille & De Foucault 1988; Biondi & al. 2001; Dengler & al. 2003; Vagge & Biondi 2004; Čarni 2005; Mucina & al. 2009; Biondi & al. 2014a; Biondi & al. 2014c; Allegrezza & al. 2015).

Forest edges

In the IVP, the new alliance *Digitali australis-Trifolion medii* has been included in the order *Origanetalia vulgaris* (Biondi & al. 2015). It groups communities of the pre-forestal mesophilous edges and replaces, in Italy, the alliance *Trifolion medii* Müller 1962 with a predominant central-European and Alpine distribution. Earlier, the alliance *Digitali australis-Helleborion bocconei* had been inserted in the IVP. That name certainly better expresses the floristic composition of species that characterise the Apennine sciaphilous edges. In fact, in these types of vegetation, the species and subspecies belonging to the genera *Digitalis* and *Helleborus* play an important role, specifically in differentiating edge associations (Biondi & al. 2014a). Previously, Čarni (2005) had proposed the suballiance *Digitali-Trifolienion* of the alliance *Trifolion medii* using the same association *typus* of the alliance *Digitali australis-Helleborion bocconei* Biondi, Vagge & Galdenzi in Biondi & al. 2014 (*Digitali australis-Helleboretum bocconei* Biondi & al. 2001). For this reason, the suballiance *Digitali-Trifolienion* Čarni 2005 was raised to the rank of alliance (Biondi & al. 2015) in order to restore the most appropriate syntaxonomic level. The classification proposed by Čarni (2005), in fact, does not appear to be more suitable because the plant communities included in the suballiance *Digitali-Trifolienion* show a higher diversity than those typical of the alliance *Trifolion medii*. Table I in Čarni (2005) shows that the species that characterise and differentiate the suballiance *Digitali-Trifolienion medii* form a very different group of stands from that of the alliance *Trifolion medii* as they are endemic and typical of the floristic contest of the Apennines. Moreover, the ordination and the synoptic table (Fig. 3 and Table II in Čarni 2005) highlight the inadequate connection between the Apennine communities and the others being compared (Biondi & al. 2015).

Several associations described for the Italian vegetation are related to this alliance (*Digitali australis-Trifolion medii*) and express the diversity of the Apennine populations studied so far (Biondi & al. 2001; Vagge & Biondi 2004) and of the eastern ones, belonging to the Balkan area, which show a high affinity.

In the IVP, the alliance *Geranio nodosi-Digitalion luteae* has also been included. It is defined as a group of communities that occurs in the central-northern Apennine mountains, on the Tyrrhenian side, and on marly arenaceous and Flysch substrates. It occurs in the Temperate macrobioclimate, sub-Mediterranean variant, meso- and supratemperate thermotypes and replaces the alliance *Digitali australis-Trifolion medii* (Čarni 2005) Biondi, Vagge & Galdenzi 2015 in Biondi & al. 2015 on acid soils.

Heliophilous edges

In the IVP, heliophilous edges have been included, like the sciaphilous ones, in the class *Trifolio-Geranietea sanguinei* Müller 1962 since they affect not only the forest edge but also the heliophilous edges. To this end, the order *Asphodeletalia macrocarpi* Biondi & Allegrezza 2014 in Biondi & al. 2014, which brings together heliophilous communities that develop in the same altitudinal zone following the abandonment of agricultural and pastoral activities, was added to the order *Origanetalia vulgaris* Müller 1962 that brings together communities of mesophilic forest edges, growing on mature soils rich in humus. *Asphodelus macrocarpus* communities, included within syntaxa related to the class *Festuco-Brometea* and showing a specific, clearly autonomous combination related to different dynamic stages, are to be referred to this order as well (Allegrezza & al. 2014; Biondi & al. 2014a; Biondi & al. 2014c). Based on the critical review of the herbaceous communities dominated by *A. macrocarpus* in the Apennines (Allegrezza & al. 2015) and assigned by the authors to different syntaxa of the *Festuco-Brometea* and *Nardetea strictae* classes, three alliances for the *Asphodeletalia macrocarpi* order have been recognized: (i) *Cyano triumfettii-Asphodelion macrocarpi* (all. *typus*), (ii) *Thalictro aquilegifolii-Asphodelion macrocarpi* for the upper supratemperate and lower supratemperate thermotype, respectively of the central Apennines (Allegrezza & al. 2014; Biondi & al. 2014a; Allegrezza & al. 2015), and (iii) *Hyperico calabricae-Asphodelion macrocarpi* for the southern Apennines (Biondi & al. 2014c). Finally, with the inclusion of heliophilous edge communities dominated by *Brachypodium genuense* (Allegrezza & al. 2014), the order *Asphodeletalia macrocarpi* has been subdivided into two suborders (Biondi & al. 2015): *Asphodelenalia macrocarpi* (subord. *typus*) and *Senecio scopolii-Brachypodienalia genuensis* (*Luzulo sieberi-Brachypodion genuensis* alliance *typus*). It brings together the communities of heliophilous, mesophilous, and sub-acidophilous to acidophilous edges, dominated by *Brachypodium genuense*, occurring in the supratemperate thermotype of the Apennines with an optimum in the upper supratemperate thermotype, mainly on calcareous substrata, on sites with a prolonged snow cover. Indications on the environmental characteristics and preferential dynamic relationships for each syntaxon (Allegrezza & al. 2015; Biondi & al. 2015) contribute to the definition and clarification of the ecological, biogeographical and landscape ranges of the order *Asphodeletalia macrocarpi*, thus completing the main landscape units for the central-southern Apennines (Blasi 2010; Blasi & al. 2014).

Shrubland and forest mantle vegetation

Shrub forest mantle formations and shrublands are very widespread in Mediterranean and sub-Mediterranean territories. In particular, shrublands are long-lasting successional stages in the recolonization dynamics of deforested areas and abandoned grasslands and fields. These continuously changing ecotone communities are rich in biodiversity with pioneer plant formations in the initial stages that are replaced over time by more and more complex and demanding coenoses.

In Italy, research on the mantle vegetation developed faster than research on the vegetation of edges because these communities exhibit much more evident dynamic aspects and are, therefore, more easily interpretable.

The first complete revision of the Italian shrublands of the class *Rhamno catharticae-Prunetea spinosae* Rivas Goday & Borja ex Tüxen 1962 was carried out by Poldini & al. (2002) with the inclusion of all the associations and alliances in the order *Prunetalia spinosae* Tüxen 1952 of the above mentioned class. Actually, both the dendrogram and the ordination achieved by elaborating all the relevés (Poldini & al. 2002, Fig. 1-2) clearly show a strong separation of the most thermophilous Mediterranean and sub-Mediterranean relevés from the others. At that time, those relevés were classified within the alliance *Pruno-Rubion ulmifolii* and the suballiance *Pruno-Rubenion ulmifolii* specific for edapho-meso-hygrophilous aspects. Currently, these syntaxa are included in the order *Pyro spinosae-Rubetalia ulmifolii* Biondi, Blasi & Casavecchia in Biondi & al. 2014, recently described by Biondi & al. (2014a). This new syntaxon was achieved by raising the hierarchical level of the alliance whose chorological range was too broad to distinguish different vegetation aspects. Within the new order, two new alliances were recognized that refer to distinct floristic and bioclimatic aspects.

The alliance *Pruno spinosae-Rubion ulmifolii* O. Bolòs 1954 includes thermophilous shrubs and mantles occurring on wet soils and characterized by the presence of a large contingent of Mediterranean species while the alliance *Arundo plinii-Rubion ulmifolii* Biondi, Blasi, Casavecchia & Gasparri 2014 in Biondi & al. 2014 refers to communities dominated by *Rubus ulmifolius* that grow on soils - from clay to pelitic, arenaceous and marly-arenaceous - with variable water retention capacity and organic matter content (Biondi & al. 2014a).

The order *Lauro nobilis-Sambucetalia nigrae* Biondi, Blasi, Casavecchia, Galdenzi & Gasparri 2014 in Biondi & al. 2014*,* widespread in southern Europe in Mediterranean and Temperate bioclimatic contexts, is particularly abundant in the sub-Mediterranean macrobioclimate. It relates to the nitrophilous micro-forests characterised by *Sambucus nigra*, that are differentiated by species like *Laurus nobilis, Rubus ulmifolius, Rhamnus alaternus, Rubia peregrina* subsp. *longifolia* and *Hedera helix.* The *Sambucus nigra* vegetation occurs throughout Europe, from central to Mediterranean regions, in different bioclimatic belts and, consequently, in different ecological conditions and biogeographic areas. For this reason, the alliance *Lauro nobilis-Sambucion nigrae* Biondi, Blasi, Casavecchia, Galdenzi & Gasparri 2014 in Biondi & al. 2014, distributed in sub-Mediterranean and Mediterranean regions, has been identified in Italy. Among the shrublands displaying a strong dynamic capacity in the Mediterranean and south-Mediterranean macrobioclimate, formations of *Paliurus spina-christi* occupy a significant position. They are particularly frequent in central-eastern Europe, but they also occur in Mediterranean France and in north-eastern Spain. Because of the bioclimatic and biogeographic diversification contexts in which the *Paliurus* vegetation develops, we consider it useful to include the different Italian communities in different alliances and suballiances. Shrublands dominated by *Paliurus spina-christi* occurring within the Mediterranean macrobioclimate of the lower meso-Mediterranean thermotypic horizon with humid ombrotype are coenoses of recovery on abandoned or burned areas that belong to the reconstitution series of thermophilous evergreen forests and olive groves, sometimes with some deciduous trees. Therefore, they are included in the order *Pistacio lentisci-Rhamnetalia alaterni* Rivas-Martínez 1975 of the class *Quercetea ilicis* and in the order *Oleo sylvestris-Ceratonion siliquae* Br.-Bl. ex Guinochet & Drouineau 1944.

Compared to the maquis formations that this alliance includes, the *Paliurus* formations can be distinguished floristically by the higher presence of edaphic humidity. For this reason, the suballiance *Oleo sylvestris-Paliurenion* Biondi, Casavecchia, Biscotti & Pesaresi 2014 with an eastern European Mediterranean distribution that groups meso-Mediterranean and thermo-Mediterranean copses and scrublands, and is in dynamic successional series with sclerophyllous and evergreen woods of the Adriatic and eastern Ionian coasts, has been described. It is currently known for the Gargano coast (Apulia) and on the south-eastern coast of Sicily (Casavecchia & al. 2015).

With regard to the order *Prunetalia spinosae*, Italian alpine and Apennine communities of pre-forest mantles linked to mesophilous woods of temperate bioclimates are included in the alliances *Berberidion vulgaris* Br.-Bl. 1950, *Salici elaeagni-Hippophaeion fluviatilis* de Foucault & Julve 2001, *Salici cinereae-Viburnion opuli* (Passarge 1985) de Foucault 1991 and *Humulo lupuli-Sambucion nigrae* de Foucault & Julve 2001. The first Italian endemic alliance described was *Cytision sessilifolii* Biondi in Biondi, Allegrezza &

Guitian 1988 that was proposed for classifying mantles of Apennine thermo-xerophilous woods. Later, the alliance *Berberido aetnensis-Crataegion laciniatae* Gianguzzi, Caldarella, Cusimano & Romano 2011 was described in Sicily.

In the Apennine intramontane territories and for the Friulan Karst areas, where the overall bioclimatic and continental conditions are clearly known, we recognize the presence of the order *Paliuretalia spinae-christi* Trinajstić 1978, which groups together shrub formations of mixed deciduous and evergreen forests that are the recovery stages of the sub-Mediterranean deciduous and semi-deciduous woods occurring in the eastern Mediterranean area on carbonate substrates. Thus, the distribution range of this order includes both the Italian and Balkan peninsulas.

In this order, the alliance *Rhamno saxatilis-Paliurion* Biondi, Casavecchia, Biscotti & Pesaresi 2014 is recognized in Italy. It has a western Adriatic distribution and, sometimes, also occurs in Tyrrhenian inland areas. Currently, the alliance is recognized for Karst areas and in the Apennine intramontane lowlands.

Xerophilous and semi-mesophilous secondary grasslands

The history of research on xerophilous secondary grasslands reflects the path followed by phytosociological and syntaxonomic knowledge of most of the syntaxa occurring in Italy. In the 1960s, the leading experts in this field came from central Europe (France, Germany and Austria) and the syntaxonomic classifications they made were used as a reference for the Italian vegetation. Over time, both Spanish and Balkan phytosociological research underwent rapid progress leading to a revision of syntaxonomic classifications by arranging the syntaxa of peninsular and insular Italy in the correct biogeographical and bioclimatic context.

In this historical context, the paper describing the alliance *Crepido lacerae-Phleion ambigui*, the first alliance for xerophilous secondary grasslands of the Apennines (Biondi & Blasi 1982), occupies a special place. It includes the communities described in previous studies on dry grasslands (Bruno & Covarelli 1968; Avena & Bruno 1975; Hruska-Dell'Uomo 1976; Avena & Blasi 1979, 1980; Hruska 1982; Ballelli & Biondi 1982, Biondi & Ballelli 1982) (Fig. 4). In fact, the first association of Apennine xerophilous grasslands was described by Volk (1958) with the name *Xerobrometum apenninum* and included in the alliance *Xerobromion* (Br.-Bl. & Moor 1938) Moravec in Holub, Heijny, Moravec & Neuhäusl 1967. The name of this association was later changed (Castelli 1995) into *Cleistogeno serotinae-Brometum erecti* (Volk 1958) Castelli 1995.

Subsequent research on the Apennine grasslands made a large amount of data available for further elaborations, which then led to the description of the alliance *Phleo ambigui-Bromion erecti* (Biondi & al. 1995) and allowed to clarify the relationship between xerophytic grasslands and chamaephytic garrigues in those mountains (Biondi & al. 2005).

In the most recent syntaxonomic revision, the xerophilous and semi-mesophilous secondary grasslands from the supra-Mediterranean to the mesotemperate thermotypes have been included in the order *Phleo ambigui-Brometalia erecti* Biondi, Allegrezza, Blasi & Galdenzi in Biondi & al. 2014 (Biondi & al. 2014a). In this way, communities whose floristic and phytogeographic autonomy is characterised by a large number of endemic and

Fig. 4. Distribution range of the alliance *Crepido lacerae-Phleion ambigui* and its associations derived from Biondi & Blasi (1982). Gray area, *Crepido lacerae-Phleion ambigui*; X, *Seslerio nitidae-Brometum erecti*; *, *Pimpinello lithophilae-Astragaletum syrinici*; Δ, *Asperulo purpureae-Brometum erecti*; ●, *Trigonello monspeliacae-Sideritetum syriacae*; ▲, *Saturejo montanae-Brometum erecti*.

sub-endemic taxa typical of secondary Apennine grasslands are grouped together and can be distinguished from conenoses of the order *Scorzonero-Chrysopogonetalia*.

Previously, in Biondi & Galdenzi (2012) these grasslands were attributed to the Illyrian order *Scorzonero-Chrysopogonetalia.* This scheme had been applied for the Friuli Venezia Giulia grasslands (Poldini 1989; Feoli Chiappella & Poldini 1993) and for the *Stipa austroitalica* communities growing on the Adriatic slopes of sub-Apennine areas [Apulia, Basilicata, Molise (Forte & al. 2005; Biondi & Guerra 2008; Terzi & al. 2010)]. In these studies, the grasslands were attributed to the order *Scorzonero-Chrysopogonetalia* rather than to the order *Brometalia erecti*. This attribution was based on the succesional dynamics of the forest vegetation and, of course, on the chorology of the species that make up these grasslands having an eastern range. A similar approach was used for the Appenine grasslands whose flora composition is well characterised by amphi-Adriatic species with an eastern and southeastern range centroid. The scheme proposed in Biondi & Galdenzi (2012) was a concrete attempt to separate the Appennine grasslands from the central-western European ones belonging to the order *Brometalia erecti*. Later studies (Di Pietro 2011; Terzi & Di Pietro 2013; Biondi & al. 2014a) highlighted the need to propose a new endemic order for the grasslands of the Italian peninsula that could be distinguished both from the central and western order of *Brometalia erecti* and from the eastern one of *Scorzonero-Chrysopogonetalia*. For these reasons, (Biondi & al. 2014a) the new order *Phleo ambigui-Brometalia erecti* (= *Euphorbietalia myrsinites* Ubaldi 2011 nom. inv. arct. 5) was proposed in which the alliance *Phleo ambigui-Bromion erecti* Biondi, Ballelli, Allegrezza & Zuccarello ex Biondi & Galdenzi 2012 and all its associations were included and considered as *typus* of the order. Following the conclusions of Terzi and Di Pietro (2013) also *Stipa austroitalica* communities, belonging to the alliance *Hippocrepido glaucae-Stipion austroitalicae* Forte & Terzi in Forte, Perrino & Terzi 2005, were included in the order *Phleo ambigui-Brometalia erecti* so that the order *Scorzonero-Chrysopogonetalia* is confined in north eastern Italy, while the order *Brometalia erecti* widespreads in the north western part of the Peninsula and in the Apennines where it characterises the more mesophilous pastures belonging to the alliance *Bromion erecti* Koch 1926. Finally the continental order *Festucetalia valesiacae* Br.-Bl. & Tüxen ex Br.-Bl. 1949 is mainly present in the continental part of the Alps.

As shown in Fig. 5, the boundary among the vegetation of the orders *Phleo ambigui-Brometalia erecti*, *Brometalia erecti* Koch in 1926, *Scorzonero villosae-Chrysopogonetalia grylli* Horvatić & Horvat in Horvatić 1963 and *Festucetalia valesiacae* Br.-Bl. & Tüxen ex Br.-Bl. 1949 and their alliances is not always clear.

Conclusions

The main objective of this article is to highlight how the research efforts necessary to achieve the IVP are based on a logical scheme that can be summarised in eight main points. Implementation of the IVP, besides being, as far as possible, a comprehensive checklist of the vegetation syntaxa of Italy, is also the starting point for a more general process of adjustment of phytosociology 100 years since the foundation of this discipline (Biondi 2011; Pott 2011). Therefore, some significant recently described syntaxa are presented and discussed. The studies carried out in different sectors that led to the decisions proposed in the IVP are described.

It is no coincidence that these syntaxa refer mainly to Mediterranean and sub-Mediterranean areas. The implication of this localisation has been discussed from different points of view, bio-climatic and phytogeographical, and by references to the history of the spread of phytosociological knowledge in Europe and specifically in Italy (Biondi 1996). The result of this process of adaptation of different syntaxa is the current version of the IVP (http://www.anarchive.it and http://www. theplantlist.org).

Fig. 5. Distribution range in Italy of the orders *Phleo ambigui-Brometalia erecti*, *Brometalia erecti*, *Scorzonero villosae-Chrysopogonetalia grylli* and *Festucetalia valesiacae*.

The southern part of Europe has the greatest diversity of flora and phytocoenoses as compared to the rest of the continent. Therefore, the adjustment of national prodromes of southern countries requires a different concept of syntaxonomic classification allowing the full expression of the biodiversity existing from the Iberian Peninsula to Turkey.

A recent review on the phytosociological classification of floodplain forests in Europe (Douda & al. 2015) shows as the need to produce a continental scale synthesis can unfortunately underestimate the value of researches made by local specialists and can lead to significant reductions in the knowledge of plant communities biodiversity. This is even more serious if it is compared with the aim clearly expressed by its authors to support the European strategy for biodiversity conservation with this synthesis. Indeed, this strategy aims at better evaluate the local specific features expressed in terms of ecosystem services and green infrastructures. In fact, in that review the high degree of vegetation biodiversity of the southern part of Europe is neglected and the extreme physiognomic simplification it is clear. The review of Douda & al. (2015) deals with 148 associations whose, after the numerical elaboration only 30 are recognized as real by the authors while 118 are considered as synonyms. Therefore, the result of this drastic synthesis is clear: the basic aspects like the biogeographical value and ecological modelling (the topics of the modern phytosociology) are minimized. Furthermore, the Authors do not take into account the historical progress of phytosociology. In our opinion, these large reviews require a revision also on methods of the syntaxonomic classification, at least on the basis of the eight points mentioned in this manuscript that are the foundations of the IVP. On the contrary, it would be useful to invite phytosociologists to produce national revisions and to use the alliance level as the limit for revision at continental scale. This would avoid the production of syntaxa unrelated to the more general continental pattern, but leaves to local experts the definition of syntaxa strongly correlated with the specific bio-geographical, ecological and syndynamic features of different countries. Only in this way, the ecological and phytogeographical modelling (made at the "association" level) may be useful for the European aims like the evaluating the economic value of the nature services (economic accounting) that by definition must be necessarily incurred with a local detail full syntaxonomic scheme.

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Mediterranean botanic gardens and the introduction and conservation of plant diversity

Abstract

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The botanic gardens of the Mediterranean have played an important role in the study of the plant life of the region through exploration, taxonomic and ecological studies, introduction of new material and more recently in the conservation of germplasm in genebanks, living collections and conservation, recovery and reintroduction of threatened species. Many gardens still house important germplasm of early introductions such as citrus fruits. The region houses a large number of botanic gardens but their distribution and range of facilities is very uneven and proposals are made for actions to remedy these problems.

Key words: Mediterranean, botanic garden, conservation, germplasm.

Introduction

For 700 years Mediterranean botanic gardens have had a major influence on the architecture, culture, sociology, science and economy of the region and their buildings, museums, libraries herbaria and collections represent a rich and important heritage. Celebrated botanists such as A. J. Cavanilles, A. P. de Candolle and F. Parlatore have been directors of these gardens while many others spent part of their careers there. Many new genera and species were described and classic national and local Floras were written by the botanists at these Gardens. In addition, large numbers of plants of scientific, ornamental and economic importance were introduced into cultivation by them and disseminated to other parts of the Mediterranean and beyond. The Gardens have also played an innovative role in the history of plant science: for example, the celebrated naturalist Luca Ghini (1490-1566) who instituted the first botanic gardens in Pisa and Florence between 1543 and 1545 at the behest of Cosimo I de' Medici, also created the plant press, first herbarium and instituted the formal teaching of medicinal botany and laid the foundations for modern pharmacognosy (von Engelhardt 2012). In recent years many of these gardens have changed their emphasis away from taxonomy and systematics and have made important contributions to the conservation of the Mediterranean flora through living collections and seed banks and their participation in species recovery and reintroduction programmes.

It is difficult to state unequivocally when the first botanic gardens in the Mediterranean were established. The forerunners were medicinal, physic or herbal gardens and the transition between them and the first botanic gardens as we recognize them today was gradual. There are records of medicinal plant gardens such as the *pomarium* or *viridarium novum* in Rome, Italy, created in 1277/8 by Pope Nicholas III, part of which was devoted to the cultivation of medicinal plants. In the Muslim period of El Andalus in Spain, there are historical records of what was probably the first introduction and acclimatization garden attached to the Al-Rusafa Palace of the Emir Abd al-Rahman in the 8th century. The Al-Rusafa garden was used to grow plants that were brought from Syria and other regions at the instigation of Abd al-Rahman so that they could be acclimatized and then distributed them to other parts of the country. This garden had many of the characteristics of what we consider to be a botanic garden today and has claims to be the earliest botanic garden in the Mediterranean and Europe (García Sánchez 1992; Ruggles 2000; El Faïz 2007; Montero 2014).

The first botanic gardens in the western tradition were founded as medicinal plant gardens of universities in the Mediterranean, particularly in Italy (Raimondo & Garbari 1986). A public medicinal and pharmaceutical garden – the Giardino de la Minerva was created in 1317-20 in Salerno in the oldest university. This would appear to be the earliest European botanic garden and although it still exists today there is little if anything remaining of the original foundation. In Venice a medicinal plant garden was created in 1333 by Gualtiero and it is reported that in the Middle Ages, and until the 18th century, Venice was the city boasting most botanical gardens in the world. Allegedly there were more than 500 botanical gardens![i]

From the 16th century onwards in Italy and other countries the first academic university botanic gardens were founded such as those of Pisa (1544) , Padua[ii] (1545), Firenze (1545), Bologna (1547), Ferrara (?1577), Zurich (1560), Leiden (1577), Paris (1579), Leipzig (1597), Montpellier (1598) and Valencia (1567). Many further botanic gardens were created in the European Mediterranean zone in the following centuries.

Calculus of Botanic Gardens in the Mediterranean

Today, the Mediterranean region houses a large number of botanic gardens but their distribution across the region and their range of facilities are very uneven. The number of botanic gardens in each country of the Mediterranean region is given in Fig. 1 but only those gardens that occur in the Mediterranean climate zone[iii] of the countries concerned have been included. The total number is approximately 170. It is not possible at this stage to give fully accurate figures.

The numbers of Gardens given for each country are subject to several caveats: the lists of botanic gardens given in BGCI's GardenSearch[iv] for individual countries does not agree with various national lists (e.g. for France GardenSearch lists 96 botanic gardens, arboreta and other institutions (accessed 10 January 2015) while the Wikipedia's List 'of all significant botanical gardens and arboretums in France' has nearly 300, including a large number of arboreta, as at 16 December 2014 (accessed 10 January 2015); and the CBD list of botanic gardens in France lists 104 botanic gardens (accessed 10 January 2015 but the list dates from 2001); many arboreta are listed and it is often not clear whether they should be included; and it is very difficult in some cases to ascertain if a listed botanic garden or arboretum is operational in any meaningful sense. The appellation ‘botanic garden’ has been applied to a wide range of institutions, reflecting the diversity of factors that are used to define them, and in a number of cases, it is difficult to decide if a garden is a private establishment or should be regarded as a botanic garden.

Of the 170 botanic gardens listed (Table 1), by far the largest number (57) are found in Italy where most of the country occurs in the Mediterranean climate zone. Although France as a whole has as many if not more botanic gardens than Italy, most of them are in the non-Mediterranean zones where only some 20 occur. In Spain most botanic gardens occur in the Mediterranean zone which covers much of the country: 21 out of a total number of 29.

In contrast, with few exceptions, botanic gardens have not played an important role in the countries of the southern and eastern Mediterranean. The number of botanic gardens in North Africa and the Levant is relatively small, and often with limited resources and facilities and with species- poor living collections; and in the countries of SW Asia, with few exceptions, botanic gardens have not been developed either as scientific or educational establishments. More than half of the countries have one or two botanic gardens or none at all. Most of those that do exist are small and report few activities.

The botanic garden estate in the Mediterranean is remarkably dynamic. Many botanic gardens that were founded in the past have ceased to function and often little trace if any) remains of them while many new ones have been founded. In some cases, some or all of the original structure and location remains although little if any scientific or academic activity continues. In Granada, Spain, for example, the university botanic garden (Jardín Botánico Histórico de la Universidad), dates from 1783 and has undergone many changes and closures during the course of its history but much of the later walls and layout remains together with several trees (Fernández-Carrión & al. 1993). It was restored and brought

Tab. 1. Number of botanical gardens in the Mediterranean climate zone.

Albania	1	Lebanon	0
Algeria	3	Libya	0
Bosnia & Herzegovina	2	Malta	1
Croatia	7	Montenegro	0
Cyprus	1	Morocco	4
Egypt	8	Palestine	1
France	20	Portugal	9
Gibraltar	1	Spain	21
Greece	10	Syria	0
Israel	12	Tunisia	3
Italy	57	Turkey	8
Jordan	1		
Total		**170**	

back into use in 1998 as a botanic garden but is largely of historical interest, retaining the layout of the botanical school (systematic beds), corresponding to the 14 classes of the old Jussieu taxonomy (as rectified by De Candolle)![v]

Today, many of the Mediterranean's botanic gardens are under great financial pressure and have suffered severely from the recent economic crisis with their staffing and operating budgets cut. Others have never managed to establish themselves fully as modern botanic gardens and their capacity and functions are severely restricted. If one also takes into to account the imbalance in the distribution of Gardens across the region, and the large numbers of threatened endemic species in the region, it is evident that there is a lack of capacity to undertake the necessary conservation actions to maintain this unique biodiversity.

The N-S, E-W imbalance in the distribution of gardens

Although the reasons for the current imbalance between the number of botanic gardens on the northern shores and the eastern and southern shores are largely historical and economic, the problem still needs to be addressed if the necessary capacity for conservation and other action in these areas is to be provided. To alleviate these problems, much more effective cooperation and networking is needed as was already pointed out decades ago (Heywood 1990; Walters 1979). Several botanic garden networks or associations exist for the countries in the region. Until the late 1980s, the European-Mediterranean Division of the International Association of Botanic Gardens (IABG) provided a forum for discussion between the botanic gardens of the Mediterranean region. It went into abeyance when the European Botanic Gardens Consortium[vi] was established in 1994 under the aegis of IABG and BGCI which took over many of its activities for European Gardens but not those of the whole Mediterranean region. Regional networks such as the Ibero-Macaronesian Association of Botanic Gardens (Asociación Ibero-Macaronésica de Jardines Botánicos – AIMJB) and national associations exist but there is no specifically pan-Mediterranean network. The organization Med-O-Med as taken some initial steps to starting a botanic gardens network for the region in recognition of the fact that the 'number of Botanic Gardens in the Mediterranean and the Middle East is currently insufficient to carry out, on site and off, the necessary tasks for the conservation of local flora and phytogenetic resources'[vii] but progress is very limited.

It has been suggested that the formal 'western' model is not appropriate for the Levant region and that a local community-centred approach would be better. Perhaps by deconstructing the various roles that botanic gardens occupy today we might find a solution. Various kinds of botanic garden have developed over the centuries in response to the different conditions and needs of the times and new models may need to be developed in response to the rapid changes we are currently experiencing and already there are several examples.

Specifically, as regards conservation activities, many of the botanic gardens in the Mediterranean are too small in extent to accommodate substantial conservation collections of growing plants but several have established or house seed banks, some of which are substantial such as that at the Jardín Botánico de Córdoba, Spain which is the Germplasm Bank of the Environmental Agency of Andalucía (Banco de Germoplasma Vegetal

Andaluz de la Consejería andaluza de Medio Ambiente) and stores more than 7,000 accessions or propagules, mainly seeds, of more than 1500 different species of Andalusian plants and about 500 other Iberian endemic species.

It is notable that about half of the members of the EU-funded European Native Seed Conservation Network (ENSCONET), which ran from 2004 to 2009, were from the Mediterranean region and they are also well represented in the ENSCONET Consortium developed from it[viii]. GENMEDOC[ix] was an interregional network of seedbanks of the Mediterranean regions aimed at facilitating the exchange of technical information and adoption of common protocols for the genetic conservation of the Mediterranean flora and more especially those that occur in habitats included in the EU Habitats Directive. It was co-financed by the EU through the programme INTERREG IIIB MEDOCC and 2004-2006 and of the eleven participating institutions (botanic gardens, institutes, seeds banks), all but one (Tunisia) were in the European part of the region. GENMEDOC was succeeded by the project SEMCLIMED (SEMences CLImat MEDiterranée) which ran from 2006 to 2008 whose aim was to study the impacts of climate change on Mediterranean plants habitats and propose methods for their effective conservation, especially species with recalcitrant seeds for which *ex situ* conservation is problematic. Later these initatives led to the creation of GENMEDA[x], a network of plant conservation centres. It publishes the magazine *Odissea Seminum*. It is unfortunate these initiatives are all ephemeral when what is needed is a stable long term organization.

An innovative approach to plant life conservation has been developed in France where the Fédération des Conservatoires botaniques nationaux (FCBN), a network of 11 botanical conservatories (three in the Mediterranean region) has been created aimed at the conservation of the wild plant species of France and its overseas territories (Fig. 1; Nardin & Buord 2015). The model of the Conservatoire botanique national is that under an agreement with the Ministry of the Environment each Conservatoire is responsible for the knowledge and conservation of the wild flora and natural and semi-natural habitats of a territory made up of a number of Departments with a biogeographical coherence. Their conservstion programmes include *ex situ* (seed banking, cultivation of threatened species) and *in situ* actions in collaboration with protected area managers.

Another novel conservation network is the Andalusian Network of Botanical and Mycological Gardens in Natural Spaces (Red Andaluza de Jardines Botánicos y Micológicos en Espacios Naturales – RAJBEN) initiated in 2001. It consists of 12 botanic gardens in located in natural vegetation communities in different biogeographic zones and their role is the study, cultivation, conservation and display of the flora and vegetation of the areas, especially of rare and endangered plant species. By growing in their natural wild habitats, the plants are able to develop with minimum of human intervention.

Mention should be made of the unique Nezahat Gökyiğit Botanic Garden of Istanbul, Turkey is now well established. The latter is a unique 50ha (125 acre) Botanic Garden is situated in a busy motorway intersection in a residential area of Istanbul. Originally started in 1995 by Mr A. Nihat Gökyigit as a Memorial Park in memory of his late wife, Nezahat Gökyigit, its aim was to restore the environment in an area which had been severely destroyed by major motorway construction. On April 30th 2003, the Park became the ‘Nezahat Gökyigit Botanic Garden’. It occupies 32ha and grows some 2000 species. Over 50,000 trees and shrubs species have been plant-

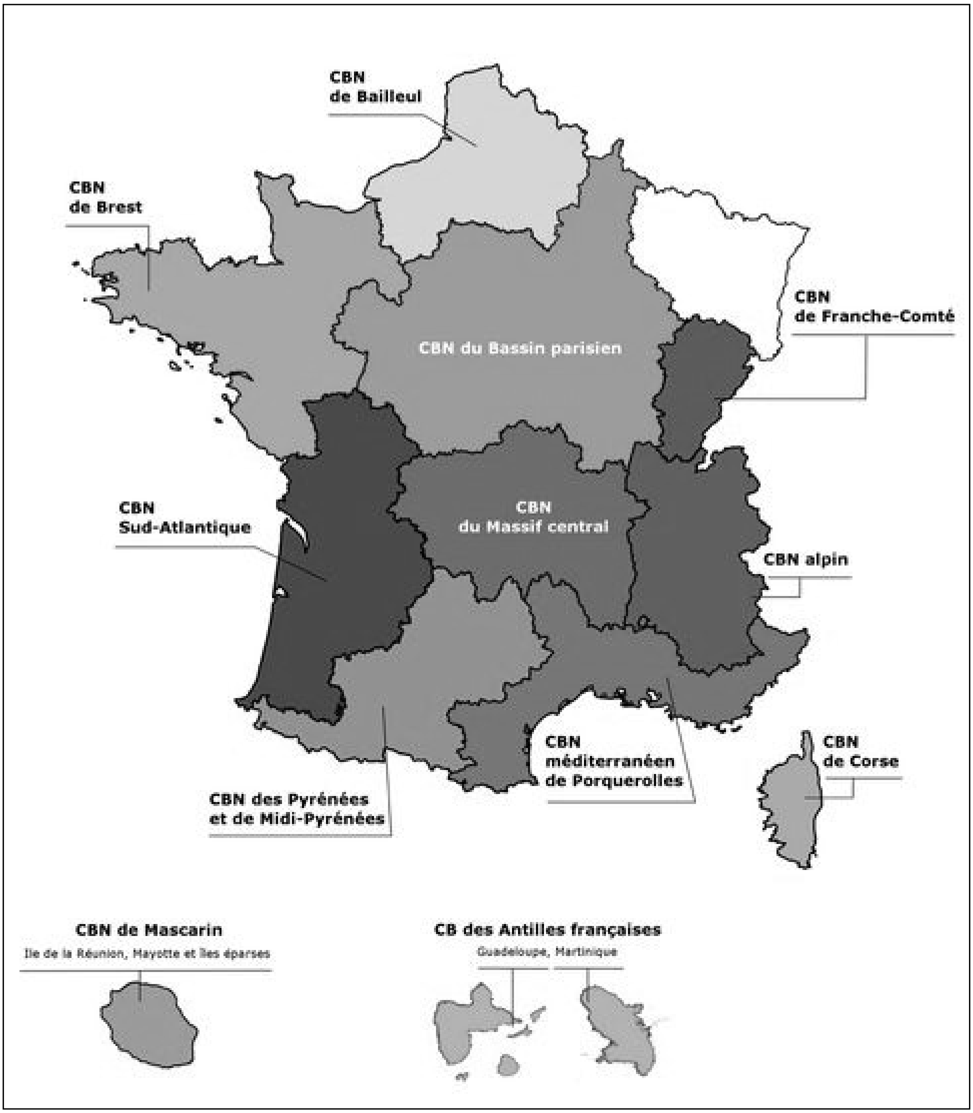

Fig. 1. The French Conservatoires botaniques nationaux (FCBN) network.

ed and it houses a seed bank, herbarium, library, a teaching and training centre, conservation collections of bulbous monocotyledons.

Also remarkable is the number of privately founded botanic gardens in the coastal areas of France, Italy and Spain, such as the Giardino botanico Hanbury (Muratorio & Kiernan 1992; Agostini 2007), the Jardín Botánico Marimurtra, the Jardin botanique privé Marnier-Lapostolle ‘Les Cèdres’ at Saint-Jean-Cap-Ferrat and the Val Rhameh botanical garden in Menton.

In addition, there are many important private gardens in the Mediterranean region, especially in Italy, France and Spain, some of which hold important collections of plants, a tradition that goes back at least to the days of Cosimo I de Medici. Although the early botanic gardens were responsible for many of the plant introductions, and were directed by academics, they were largely dependent on their patrons such as the Pope and the Medici family who also arranged for material to be collected for their own private gardens. As Attlee (2006) observes, in 16th century Italy, many of the most important plants collections were to be found in private gardens in Rome which became a leading centre of botanical study and research.

To shield some of the exotic introductions from the cold, especially citrus fruits, various forms of protection were introduced including cold frames, *stanzone per I cidri*, initially using windows or walls of thin sheets of mica, a tradition going back to Roman times, and later panes of glass, limonaie and orangeries (Saudan & Saudan-Skira 1998). Some of these lemon and orange houses developed as major architectural structures both in private and botanic gardens across Europe such as the limonaia of the Boboli gardens in Florence, Italy, La Gardette Orangerie, Jardin des Plantes, Montpellier and the Pabellón de Villanueva in the Real Jardín Botánico of Madrid.

Although limonaie and orangeries were the precursors of the spectacular development of greenhouses and conservatories in more northern countries with cooler climates and later across much of the temperate world, Mediterranean botanic gardens are not celebrated for their greenhouses. On the other hand some of the shade houses that were built are of considerable architectural merit such as the spectacular umbraculum of the Jardín Botánico, Valencia, Spain, dating from 1900.

Many original introductions of citrus species and cultivars are still found in both private and botanic gardens of the Mediterranean, especially in Italy (Attlee 2014) and although detailed records of their provenance are not always available, they represent an important germplasm collection and a proper survey and catalogue should be undertaken as a matter of urgency while the plants are still extant.

The dilemma of the old historic botanic gardens

Many of the Mediterranean botanic gardens, especially the historic ones such as Florence, Madrid, Paris, Pisa, Padua, Valencia, are small and exist like islands in large conurbations. These urban botanic gardens often face severe restrictions in their activities because of the lack of space: they are unable to set aside large enough areas for conservation collections and other activities of a modern botanic garden and since they cannot grow physically they have to grow qualitatively. They can, however, grow by proxy by establishing satellite gardens at some distance from the urban centre. Urban botanic gardens are often threatened with encroachment, peripheral tall buildings, water supply problems, expropriation for development, pollution, access and car parking problems, visitor pressure. Some may be forced to move because of pressure of development or for climatic reasons. Yet some manage to acquire additional land even within the city limits. The best form of defence by urban botanic gardens against encroachment or closure is to develop a major role in the local community – as a public educational centre, advice centre, training centre, scenario for cultural and social activities and as a tourist attraction.

At the same time, cities and other levels of government are increasingly, turning attention to naturalization of urban green space and returning ecological function to parks, greenbelts, and other open areas. Botanic gardens have been involved in this process as active partners, providing expertise, plant material, and even interpretive signage and educational programming. In addition, botanic gardens have a very special part to play in the urban context: they house a wide array of plant (and often also animal) diversity and afford the only opportunity many people will ever get of appreciating something of the variety of plant life.

Botanic gardens as centres of plant introduction and acclimatation

The introduction of new plants of agricultural, horticultural or economic importance has been an important activity of Mediterranean botanic gardens over the centuries (Heywood 2011). Large number of species were introduced into cultivation by Mediterranean botanic gardens over the past 700 years including many tropical and subtropical ornamental trees and shrubs that have become characteristic features of Mediterranean landscapes and townscapes.

Curiously, botanic gardens played a negligible role in the first introductions of plants from the New World after 1492 during the so-called Columbian Exchange (Crosby 2003), for the simple reason that hardly any of them had been established by that time (Heywood 2012). It was only in the following centuries that acclimatization gardens were established in the Mediterranean, mainly in Spain, France, Portugal and Italy. Acclimatization gardens created in Spain for the plants brought from overseas – in Cartagena, Cordoba (although short-lived), Barcelona, Aranjuez, Madrid, Burgos, Sevilla, Carmona, Cádiz, La Orotava (Tenerife), Valencia (see detailed discussion by Puerto Sarmiento 2002).

The term and indeed the concept of acclimatization is somewhat ambiguous and has been defined in markedly different ways. As I have noted elsewhere (Heywood 2102) 'the concept of acclimatization in the sense of gradual adjustment of plants or animals to new climatic or other ecological conditions other than those to which they are accustomed is highly debatable. It is in effect essentially a selection process (albeit often very idiosyncratic[xi]) rather than any physiological adaptation of individual plants or animals although some plants can be hardened off through gradual exposure to colder temperatures (this is sometimes distinguished as 'acclimatation' as opposed to acclimatization) while others succumbed to the cold…'

Many of the botanic gardens and private gardens of the Mediterranean acted *de facto* as acclimatation centres and plants that could not be maintained in the open were grown in cold frames, limonaie, orangeries or greenhouses. The Giardino botanico Hanbury was largely conceived of as a garden for the acclimatation of exotic species (Agostini 2007) and many of the 3500 species listed in its first catalogue of plants cultivated in the garden in 1889 were novel introductions.

Other gardens were specifically aimed at the acclimatation of alien introductions and one of the most celebrated is the Jardin botanique de la villa Thuret which has been engaged in the introduction and acclimatation of plants for over 150 years (Ducatillion & Blanc-Chabaud 2010).

Colonial and trial gardens

In addition, a number of so-called colonial gardens were established in some parts of the Mediterranean. In Italy, a number of gardens were opened in the 20th for the introduction of plants from their colonies. The Giardino Botanico Tropicale, Florence, managed by the Istituto Agronomico per l'Oltremare, is a garden primarily devoted to the cultivation of tropical plants. Opened in 1904, the garden has around 300 species of tropical plants primarily from Africa and America. Also in Florence, the Boboli Gardens included a botanic garden, Giardino Botanico Superiore, later transformed by the Italian botanist Filippo Parlatore into the Giardino degli Ananassi (Pineapple Garden) (Volpi 2003).

In Palermo, the Giardino Coloniale (founded 1903) which was developed alongside the Orto Botanico introduced and undertook experiments on many plants of economic importance. It was responsible for the introduction to and spread through the Mediterranean of species such as the Mediterranean mandarin (*Citrus deliciosa*) and Loquat (*Eriobotrya japonica*) as well as the reintroduction of cotton (*Gossypium* spp.), and the first European trials of ramie (*Boehmeria nivea*), candlenut (*Aleurites moluccana*), soya (*Soja hispida*) and more recently, sweet sorghum (*Sorghum bicolor*. Information on the introductions were published in the *Bollettino del R. Orto botanico e Giardino Coloniale di Palermo* (e.g. Borzi (1911).

In North Africa, the 16 ha Jardin d'Essais Botaniques (JEB), Rabat (Morocco) which opened officially in 1928 was an experimental garden that undertook trials on fruit trees and ornamental species. It fell into disrepair and has recently been restored and with a broader remit, including the conservation of Moroccan endemic species. In 2012, the garden was recognized by UNESCO as a World Heritage Site. An earlier foundation is the Jardin d'Essai du Hamma of Algiers, established under French rule in 1832, which today covers 38 ha of gardens and 20 ha of arboretum. It started life as a model farm and a trial garden, then became the government central nursery and later the Jardin d'acclimatation. In its day it was one of the most important acclimatization and trial gardens in the Mediterranean but later fell into disrepair and was eventually closed for some years. It re-opened in May 2009 after a major five year restoration in cooperation with the Ville de Paris.

Another North African garden that was of major importance for plant introductions is the experimental garden of El Saff about 50 km south of Cairo. Also in Egypt were the experimental gardens of Zohriya (today the Zohira Trial Gardens) Gezireh west of Cairo, in which Delchevalerie in 1870 established the first station for acclimatization of plants. Particular attention was paid to the propagation of tropical fruits such as the breadfruit tree (*Artocarpus altilis*), the sapodilla plum (*Manilkara achras*) and the mango (*Mangifera indica*) (Hamdy & al. 2007)

A trial Garden (Jardin d'essai) was opened in Paris in 1899 to undertake trails of potentially useful agronomic plants from the French colonies. After a varied history the site was acquired by the City of Paris which undertook a programme of restauration and the garden is now the Jardin tropical du Bois de Vincennes, Paris.

In Portugal, the Jardim Botânico Tropical (JBT) in Lisbon, was founded in 1906 as the Jardim Colonial with the aim was of bring into cultivation a diverse collection of plants from tropical and subtropical regions and to support the teaching of agronomy.

In the post-war years in the latter half of the 20th century, the role of botanic gardens as introduction centres in the Mediterranean (as elsewhere) was greatly diminished, partly due to a shift in priorities and partly due to a saturation effect: so many species of trees, palms, succulents and other ornamentals had been introduced in the previous centuries that there was little demand for additional species and as regards agricultural and forestry species, specialized agencies or institutes had taken over this role. The recent growth in the development of garden centres and nurseries (already common in more northern countries in Europe and in the USA) led to a demand by the public for novelties but botanic gardens have been slow to capitalize on this opportunity. Another recent demand for new plant introductions comes from the greening of cities movement and the growing use of green roofs, living walls and xeriscaping and the need for plants that are adapted to a warming and drier climate in parts of the region.

Conclusions

- Mediterranean botanic gardens have had a glorious past. Many gardens today are poorly financed and resourced and unable meet public expectations.
- Today many gardens have changed their focus are now engaged in active conservation and education programmes.
- Many gardens contain important germplasm of introduced cultivars such as *Citrus* and these need to be catalogued.
- Gardens need to renew themselves to meet the economic and societal challenges of the modern world and seek to establish a new compact with society. This may involve considering new models or structures.
- The imbalance in the present day distribution of Mediterranean botanic gardens needs to be tackled and much more effective north-south networking is is required.
- The possibility of developing a network of Mediterranean botanic gardens should be explored.

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[i] A Garden in Venice, 2015http://www.gardeninvenice.com/2013/02/ow-exotic-plants-came-to-venice-our.html

[ii] UNESCO added Padua's Botanical Garden to its World Heritage List in 1997.

[iii] The delimitation of the Mediterranean climate zone adopted here is that of Médail & Quézel (1997).

[iv] http://www.bgci.org/garden_search.php

[v] The University of Granada's Botanic Gardens. www.coimbra-group.eu/uploads/2012/Granada-botanic%20gardens.pdf

[vi] http://www.botanicgardens.eu/

[vii] http://medomed.org/category/network-of-botanic-gardens/directory-of-botanic-gardens/

[viii] http://www.kew.org/science-conservation/research-data/science-directory/projects/european-native-seed-conservation-0

[ix] www.genmedoc.org

[x] http://www.genmeda.org/en/home.php

[xi] In their manual of acclimatising plants, Naudin & Müller (1887) note that the process often begins with a packet of seeds, which when sown produce a diversity of plants from which only the most vigorous or best adapted to their new environment, or the most attractive in the eyes of the collector, are selected and then propagated by seed or vegetatively.

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M. Privitera, R. Galesi, L. Arato & M. Puglisi

Bryophyte diversity in Augusta-Priolo territory (South-Eastern Sicily)

Abstract

Privitera, M., Galesi, R., Arato, L. & Puglisi, M.: Bryophyte diversity in Augusta-Priolo territory (South-Eastern Sicily). — Fl. Medit. 25 (Special Issue): 115-126. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

The bryophyte flora of two areas adjacent to the petrochemical pole of Augusta-Priolo in the South-Eastern Sicily was investigated: Punta Cugno and the Nature Reserve Saline di Priolo. A biological and ecological analysis was made, showing: the predominance of species of the Mediterranean phytogeographical element, with prevailing life strategy colonist and life form turf; the low occurrence of species sensitive to pollutants and the high occurrence of species tolerant human impact. The occurrence of some species of phytogeographical interest, deserving protection, was detected. They are *Didymodon sicculus*, *Ditrichum pusillum*, *Tortula solmsii*, *Tortula viridifolia*. For these species the IUCN category for Sicily is proposed too.

Key words: Bryophytes, Biological/ecological analysis, Environmental quality, Augusta-Priolo territory.

Introduction

In the last times an increasing rate of extinction was both recorded for animal and plant species; this is quite worrying especially considering that the causes of this loss are mainly linked to human activity (Manes & Capogna 2005). These threats lead to a deterioration and impoverishment of the ecosystems and local extinction of species, primarily the most sensitive and vulnerable, such as the endemic and rare species (Blasi & al. 2010). The biodiversity conservation often conflicts with the needs of man and the efforts to reconcile them converge in appropriate International Conventions, agreement and strategic plans, as the Bern Convention, the CBD and the Directive 92/43/EEC with the Natura 2000 network.

In this context a study, addressed to the knowledge and conservation of the bryophyte diversity of the South-eastern Sicily, was carried out. In particular, the survey was aimed to investigate the bryoflora of two neighboring coastal areas adjacent the petrochemical complex district of Augusta-Priolo: the area of Punta Cugno and the Nature Reserve Saline di Priolo, a Site of Community Importance and a Special Protection Area within the Natura 2000 Network (Fig. 1). Both areas are localized within the industrial triangle of

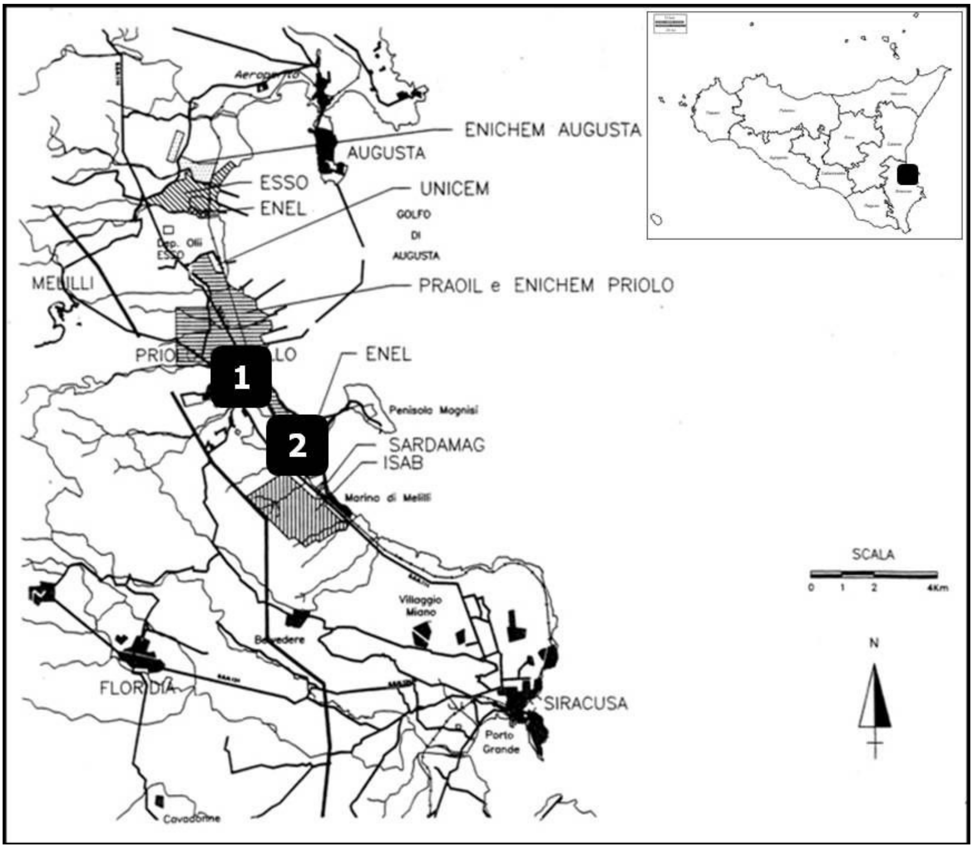

Fig. 1. Location of the investigated areas. 1: Punta Cugno; 2: Nature Reserve Saline di Priolo.

Augusta-Melilli-Priolo (Syracuse province), a territory with a particularly fragile ecosystem balance due to the rate of environmental pollution.

The investigated territory falls within the margin of the northeastern Hyblaean plateau; this constitutes a carbonate Meso-Cenozoic massif, with volcanic intercalations, lying on the African continental crust. The lithostratigraphic sequence of the area consists of alternating layers of sedimentary deposits and volcaniclastic levels lying on a Miocene carbonate base (Lazzari 2011).

The area is included in the Mediterranean climatic region and is characterized by a Mediterranean pluviseasonal oceanic bioclimate (Rivas Martínez & al. 2004). For the climatic data we refer to the meteorological station of Augusta (70 m a.s.l.). In particular, the thermotype is thermomediterranean with mean annual temperature of 18.4°C and the ombrotype is dry with mean annual precipitations of 538.1 mm.

PUNTA CUGNO - The site includes lands previously occupied by a traditional agricultural mosaic, now uncultivated, with the recolonization of maquis with *Ceratonia siliqua* L., *Myrtus communis* L., *Pistacia lentiscus* L., *Prasium majus* L., *Rhamnus alaternus* L., prevailing. The surrounding area is characterized by agricultural terrains mostly characterized by the presence of arable crops, citrus and olive groves.

NATURE RESERVE SALINE DI PRIOLO - The Reserve consists of a large coastal pond corresponding to the ancient reservoirs of seawater. The wetland is separated from the sea by a narrow dune cordon extending, in the middle part, in a short isthmus connected with the Peninsula Magnisi, of calcareous origin . As regards the flora, along the sandy coastline it is possible to observe the presence of some psammophytes, e.g. *Achillea maritima* (L.) Ehrend. & Y. P. Guo, *Cakile maritima* Scop., *Calystegia soldanella* L., *Echinophora spinosa* L., *Eryngium maritimum* L., *Pancratium maritimum* L., *Salsola soda* L. In the salterns it is possible to find *Ruppia maritima* L., *Sarcocornia fruticosa* (L.) A. J. Scott, *Suaeda maritima* (L.) Dumort. The reeds, not very dense, are mainly constituted by *Phragmites australis* (Cav.) Steud.

Material and methods

The field work was carried out in the spring of the years 2010 and 2013 with excursions during maximum sporification period (March, April).

The analysis of the bryoflora was made by using the next data:

-the chorological elements, following Hill & Preston (1998); each element is specified by the major biome (Mediterranean, Southern-temperate, Temperate, Wide-temperate, Boreo-temperate, Boreal-montane, Wide-boreal, Boreo-arctic montane, Arctic-montane) and eastern limit category in Eurasia (Circumpolar, Eurasian, Eurosiberian, European, Suboceanic, Oceanic, Hyperoceanic);

-three ecological indices, following Hill & al. (2007): moisture (F) with values ranging from 1 (indicator of extreme dryness) to 12 (normally submerged); substrate acidity (R), with values ranging from 1 (indicator of extreme acidity) to 9 (on substrata with free calcium carbonate, mainly chalk and limestone); Nitrogen (N) with values ranging from 1 (indicator of extremely infertile sites) to 7 (plant often found in richly fertile places);

-the life strategy according the classification of During (1979) and Frey & Kürschner (1991);

- the life form follows the concept in Mägdefrau (1982) and the classification of Hill & al. (2007);
- the sensibility to SO_2 according to the classification of Rao (1982);
- the sensibility to human impact taken from Dierßen (2001), gathered in three groups according to Kürschner & al. (2007) and Puglisi & al. (2012): species showing a low human impact (ahemerobic, oligohemerobic, a-oligohemerobic species, oligo-mesohemerobic), species showing a moderately strong human impact (mesohemerobic and meso-euhemerobic species), species showing strong human impact (euhemerobic, polyhemerobic, eu-polyhemerobic and hemerophilous species). The species with a wide range (i.e. a-euhemerobic, oligo-euhemerobic, meso-polyhemerobic) were not considered for their insignificance.

The nomenclature of the species follows Ros & al. (2013) for the mosses and Ros & al. (2007) for the liverworts. The distribution in the Italian regions is taken from Aleffi & al. (2008).

The specimens are kept in CAT Herbarium.

Results and discussion

In the study areas a total of 39 *taxa* (Tab. 1) were found with the ratio liverwort/mosses very low (0.03), with the prevalence of the *Pottiaceae* family (60%). The high incidence of this family is due to the high number of species adapted to dry climates and therefore tolerant of long droughts, such as the Mediterranean coast territories and the urban areas, where there is a considerable rate of pollution. The second most numerous family is represented by the *Bryaceae* (13%), a large acrocarpous moss family. The other moss families are: *Brachytheciaceae* (8%) *Grimmiaceae* and *Fissidentaceae* (5% each), *Dicranaceae*, *Ditrichaceae* and *Funariaceae* (3% each).

As regards the phytogeographical analysis, the Mediterranean element, including Oceanic Mediterranean, Suboceanic Mediterranean and Eurasian Mediterranean species, prevails (59%), in agreement with the geographical position of the investigated areas. The Mediterranean element is followed by the Southern-temperate element (17.9%), with European, Eurosiberian and Circumpolar species, the Wide-temperate element (12.8%), with European and Circumpolar species, the Circumpolar Boreo-temperate (7.8%) and Circumpolar Temperate species (2.5%).

The ecological analysis overall reveals a xerophytic bryoflora with the occurrence of many species indicators of dry and extremely dry sites, (F values ranging from 1 to 3) e.g. *Aloina aloides*, *Bryum radiculosum*, *Dicranella howei*, *Didymodon acutus, D. sicculus*, *D. vinealis*, *Grimmia pulvinata*, *G. trichophylla*, *Microbryum rectum*, *M. starckeanum*, *Pseudocrossidium hornschuchianum*, *Ptychostomum torquescens*, *Tortella nitida*, *Tortula brevissima*, *Tortula muralis, Weissia condensa*. Regarding the values of the reaction to substrate acidity (R), the flora is mostly composed by species typical of basic or strongly basic substrata (corresponding to R values ranging from 6 to 8). As the values for Nitrogen (N), that are a general indication of fertility, the bryoflora overall reflects a site with medium nutrient content (N values 4-5).

As concerns the life strategy a strong occurrence of colonist species is observed (69.2%), including colonist with sexual reproductive effort (Bg) which are predominant, pauciannual colonist (Ba), colonist with asexual reproductive effort (Bv), colonist with asexual and sexual reproductive effort (Bv,g), colonist with basitonic innovations; these species can be regarded as pioneers colonizing hard environments prevailing in dry and sun-exposed sites or underlying a strong disturbance (Frey & Kürschner 1991; Kürschner & Erdağ 2008; Kürschner & Frey 2013; Puglisi & al. 2012, 2015). The colonist life strategy is followed by the perennial stayers (17.9%), which are typical of undisturbed stable environments (Kürschner & Erdağ 2008; Kürschner & Frey 2013; Puglisi & al. 2013a, 2013b, 2014); they include in the investigated areas the perennial stayers with high sexual reproductive effort (Ag), high asexual reproductive effort (Av), high asexual and sexual reproductive effort (Av,g), low asexual and sexual reproductive effort (Ap). The other life strategies are the annual shuttle (10.3%) and short-lived shuttle (2.6%). The shuttle species are found in habitat with seasonal fluctuations that can be tolerated as spore stage (Kürschner & Parolly 1999; Lo Giudice & Bonanno 2010; Kürschner & Frey 2013). An analysis carried out in the Natural Reserve Cava Grande del Cassibile (SE Sicily) has emphasized a lower percentage of colonist species (38%) and higher percentage of perennial stayers (33%, unpublished data).

Table 1. List of species found in both studied areas, indicating for each of them, chorotypes, ecological indices, life strategy, life form, sensibility to SO_2, and human impact tolerance.
Abbreviations. Ecological indices - F: value for moisture; R: value for substrate acidity; N= value for Nitrogen. Life strategies - Ba: pauciennial colonist; Bg: colonist with sexual reproductive effort; Bi: colonist with basitonic innovations; Bv: colonist with asexual reproductive effort; Bv,g: colonist with high sexual and asexual reproductive effort; Ag: perennial stayers with high sexual reproductive effort; Ap: perennial stayers with low sexual and asexual reproductive effort; Av: perennial stayers with high asexual reproductive effort; Av,g: perennial stayers with high sexual and asexual reproductive effort; Pe: annual shuttle; Pk: short-lived shuttle. Life forms: Cu: cushion; Mr: mat, rough; Sc: solitary creeping; Tf: turf; Ts: turf, scattered. Sensibility to SO_2 - S: sensitive; Txp: toxiphilous; Txt: toxitolerant.

Taxa	**Saline di Priolo**	**Punta Cugno**	**Chorotypes**	**Ecological indices**			**Life strategy**	**Life forms**	**Sensibility to SO_2**	**Human impact**
				F	R	N				
Aloina aloides (Koch ex Schultz) Kindb.	-	●	European Southern-temperate	3	8	3	Bg	Ts	Txt	oligo-euhemerobic
Aloina ambigua (Bruch & Schimp.) Limpr.	●	-	European Southern-temperate	4	7	3	Bg	Ts	Txt	oligo-mesohemerobic
Barbula convoluta Hedw.	●	●	Circumpolar Wide-temperate	4	7	5	Bv	Tf	Txp	eu-polyhemerobic
Barbula unguiculata Hedw.	●	●	Circumpolar Wide-temperate	5	7	5	Bg	Tf	Txp	meso-polyhemerobic
Bryum dichotomum Hedw.	●	●	European Wide-temperate	5	7	7	Bv,g	Tf	Txp	a-euhemerobic
Bryum radiculosum Brid.	●	●	Suboceanic Mediterranean	3	8	5	Bv	Tf	Txt	meso-euhemerobic
Dicranella howei Renauld & Cardot	●	●	Suboceanic Submediterranean	3	-	-	Bg	Tf	Txt	meso-euhemerobic
Didymodon acutus (Brid.) K.Saito	-	●	Circumpolar Southern-temperate	3	8	2	Bv	Tf	Txp	meso-euhemerobic
Didymodon luridus Hornsch.	-	●	Suboceanic Mediterranean	4	8	4	Bg	Tf	Txp	meso-euhemerobic
Didymodon sicculus M.J.Cano, Ros, García-Zamora & J.Guerra	●	-	Eurasian Mediterranean	3	-	-	Ba	Tf	Txt	-
Didymodon vinealis (Brid.) R.H.Zander	●	●	European Southern-temperate	3	8	4	Bg	Tuft	Txp	meso-euhemerobic
Ditrichum pusillum (Hedw.) Hampe	-	●	Circumpolar Boreo-temperate	5	4	3	Av,g	Ts	Txt	meso-euhemerobic
Entosthodon attenuatus (Dicks.) Bryhn	●		Oceanic Mediterranean	7	5	3	Pe	Ts	Txt	oligo-mesohemerobic
Fissidens bryoides Hedw. var. *bryoides*	●		Circumpolar Temperate	5	5	5	Bg	Tf	Txt	oligo-euhemerobic
Fissidens viridulus (Sw.) Wahlenb. var. *viridulus*	-	●	Circumpolar Wide-temperate	5	7	6	Bg	Tf	Txp	oligo-euhemerobic

Table 1. continued.

Fossombronia caespitiformis De Not. ex Rabenh.	-	•	Eurasian Mediterranean	6	5	4	Pe	Sc	Txt	meso-euhemerobic
Grimmia pulvinata (Hedw.) Sm.	●	●	Circumpolar Southern-temperate	1	8	4	Ba	Cu	Txt	meso-euhemerobic
Grimmia trichophylla Grev.	-	●	Circumpolar Wide-temperate	1	2	2	Av	Cu	S	oligo-mesohemerobic
Gyroweisia reflexa (Brid.) Schimp.	-	●	Oceanic Mediterranean	5	7	3	Bv,g	Tf	Txt/S	oligo-mesohemerobic
Microbryum rectum (With.) R. H. Zander	●	●	Oceanic Mediterranean	3	7	3	-	Ts	Txt	meso-euhemerobic
Microbryum starckeanum (Hedw.) R. H. Zander	●	-	Suboceanic Mediterranean	3	7	3	Pe	Ts	Txt	meso-euhemerobic
Oxyrrhynchium schleicheri (R. Hedw.) Röll.	●	-	Suboceanic Mediterranean	5	6	4	Ap	Mr	S	oligo-mesohemerobic
Pseudocrossidium hornschuchianum (Schultz) R. H. Zander	●	-	Eurosiberian Southern-temperate	3	7	5	Bi	Tf	Txt	mesohemerobic
Ptychostomum capillare (Hedw.) D. T. Holyoak & N. Pedersen	●	●	Circumpolar Boreo-temperate	4	7	4	Bv,g	Tf	Txp	oligo-euhemerobic
Ptychostomum imbricatulum (Müll. Hal.) D. T. Holyoak & N. Pedersen	●	●	Circumpolar Boreo-temperate	4	6	5	Bv	Tf	Txp	meso-euhemerobic
Ptychostomum torquescens (Bruch & Schimp.) Ros & Mazimpaka	●	●	Oceanic Mediterranean	3	7	3	Bv,g	Tf	Txt	oligo-euhemerobic
Rhynchostegiella tenella (Dicks.) Limpr. var. *tenella*	-	●	Suboceanic Mediterranean	4	8	5	Ag	Mr	S	a-oligohemerobic
Rhynchostegium megapolitanum (Blandow ex F.Weber & D.Mohr) Schimp.	●	●	Suboceanic Mediterranean	4	7	5	Ag	Mr	Txt	Mesohemerobic
Timmiella barbuloides (Brid.) Mönk.	-	●	Suboceanic Mediterranean	4	8	-	Ag	Tf	Txt	a-euhemerobic
Tortella flavovirens (Bruch) Broth. var. *flavovirens*	●	●	Suboceanic Mediterranean	5	7	4	Bg	Tuft	Txt	oligo-mesohemerobic
Tortella nitida (Lindb.) Broth.	-	●	Oceanic Mediterranean	2	9	2	Ap	Tuft	Txt	meso-euhemerobic
Tortula brevissima Schiffn.	-	●	Eurasian Mediterranean	2	-	-	Ba	Tf	Txt	mesohemerobic
Tortula marginata (Bruch & Schimp.) Spruce	●	●	Oceanic Mediterranean	4	8	5	Ba	Tf	Txp	euhemerobic
Tortula muralis Hedw.	●	●	Circumpolar Southern-temperate	2	8	5	Ba	Tf	Txp	meso-polyhemerobic
Tortula solmsii (Schimp.) Limpr.	-	●	Oceanic Mediterranean	5	6	4	Ba	Tf	Txt	euhemerobic
Tortula viridifolia (Mitt.) Blockeel & A. J. E. Sm.	●	-	Oceanic Mediterranean	5	6	4	-	Tf	Txt	meso-euhemerobic
Trichostomum brachydontium Bruch	●	●	Suboceanic Mediterranean	5	7	3	Pk	Tf	Txt	a-mesohemerobic
Trichostomum crispulum Bruch	-	●	Circumpolar Southern-temperate	4	8	3	Bi	Tf	S	a-mesohemerobic
Weissia condensa (Voit) Lindb. var. *condensa*	-	●	Suboceanic Mediterranean	2	9	2	Bg	Tf	Txt	meso-euhemerobic

The life form turf is strongly predominant (61.5%), followed by a much lower percentage of turf scattered (15.4%), tuft and mat rough (7.7% each), cushion (5.1%) and solitary creeping (2.6%). The high percentage of turf, a life form typical of man-disturbed habitat (Lo Giudice & al. 1997; Gueli & al. 2004; Lo Giudice & Bonanno 2010), is due to the high presence of *Pottiaceae* adapted to dry and sunny habitats (Lo Giudice & al. 1997; Werner & al. 2004). In the Natural Reserve Cava Grande del Cassibile, the percentage of the life form turf is lower (40%, unpublished data).

Respect to the sensibility to SO_2, the toxitolerant species prevail (61.5%), followed by the toxiphilous (28.2%); the sensitive are represented only by a percentage of 10.2%. Apart from the percentage of the toxitolerant species, normally represented even in degraded and anthropic areas, the occurrence of the toxiphilous contingent and above all the low percentage of sensitive are an indication of a disturbed territory with a rate of disturbance stronger than that detected in other Sicilian protected areas, e.g. in the Natural Reserve Cavagrande del Cassibile (toxiphilous 22%, sensitive 34%), in the Integral Natural Reserve Grotta Monello (toxiphilous 23.5%, sensitive 32.4%), (Corradino & al. 2013; Privitera & al. 2010). Moreover, an exclusive presence of markedly and moderately resistant to pollution species was detected at Milazzo and surroundings (N Sicily) where a thermoelectric power plant and an oil refinery are localized (Privitera & Puglisi 1995).

Likewise, in relation to the hemerophobous-hemerophilous gradient, expressing the intensity of human impact to which the species underlie, the species showing a moderately strong human impact prevail (62.9%), followed, with a considerable distance, by species with low (25.9%) and strong human impact (11.2%). A comparison with the Natural Reserve Cavagrande del Cassibile shows in this area a bryoflora with a higher percentage of species with low human impact (33%, Corradino & al. 2013).

SPECIES OF PHYTOGEOGRAPHICAL INTEREST

In the frame of this research some interesting species were found *Didymodon sicculus*, *Ditrichum pusillum*, *Tortula solmsii*, *Tortula viridifolia*; they are added to the valuable bryophyte flora of Sicily pointed out in many studies (e.g. Privitera & Puglisi 2002, 2009; Campisi & al. 2006; Dia & Campisi 2006, 2009; Puglisi 2009; Puglisi & al. 2013c).

Tortula viridifolia - A subneutrophytic, psammophytic and halophytic species, typical of salt meadows and upper saltmarsh, subject to at most only very occasional tidal inundation or of cliffs receiving some salt spray (Dierßen 2001). *Tortula viridifolia* was found at Nature Reserve "Saline di Priolo" in low loose tufts along the dune cordon together with *Microbryum starckeanum* (Hedw.) R. H. Zander and *Tortella flavovirens*,. *Tortula viridifolia* is, as indicated in Table 1, an Oceanic Mediterranean species, signaled in Italy from Sardinia and Sicily and with a single old report by Zodda (1909) in the Campania region in the southern peninsula (Ros & al. 2013); in Sicily it is a rare species, occurring only in the Island of Lipari (Aeolian archipelago), in the islet of Lachea (eastern coast), at Pace del Mela (Messina territory) and the hinterland of the Catania province (Lo Giudice & Privitera 1989; Privitera & Puglisi 1995; Gueli & al. 2004; Privitera & al. 2008). It is included in the Red List of bryophytes of Spain and considered as a Vulnerable species (Brugués & González Mancebo 2012). In Italy it was considered Endangered (Cortini Pedrotti & Aleffi 1992). Following the new 2012 IUCN *criteria* we propose to consider this species as Vulnerable (D2) in Sicily.

Tortula solmsii (Schimp.) Limpr. - A subneutrophytic-basiphytic, hygrophytic-xerophytic species (Dierßen 2001) found at Punta Cugno in rock crevices. *Tortula solmsii* is a Mediterranean-Atlantic species restricted to countries fringing the Mediterranean Sea, the Atlantic Islands (Canary Islands, Madeira and Azores), reaching its northernmost stations on the southern coast of England (Porley 2013). In Italy it is signaled only from the Campania region, Sardinia and Sicily, where it is fairly diffused. The species, considered Vulnerable in Italy (Cortini Pedrotti & Aleffi 1992), is listed as Rare in Europe (ECCB, 1995). Considering the phytogeographic importance, we propose for Sicily the attribution of the IUCN category LC-att.

Didymodon sicculus – It is a subneutrophytic, highly xerophytic and photophytic species, well adapted to the peculiarity of the Mediterranean climate (Dierßen 2001). The species was found on trodden soil at Saline di Priolo together with *Aloina ambigua* (Bruch & Schimp.) Limpr. and *Dicranella howei*. Despite *Didymodon sicculus* is a rather recently described species (Cano & al. 1996), it is signalled in a lot of localities of the Mediterranean region (Ros & al. 2013). In Italy it is reported only from few localities of central and southern peninsula and from Sicily, where it was found in the island of Linosa of the Pelagian archipelago and the hinterland of the Catania province (Gueli & al. 2004; Puglisi & al. 2004). It seems that the saline habitat is an important factor for the establishment of this species and for this reason it could be considered a facultative halophyte or halotolerant (Dierßen, 2001; Papp & al., 2012). The finding of the species in the Saline of Priolo on saline soil should confirm this hypothesis. For the phytogeographic interest of the species we propose for Sicily the IUCN category LC-att.

Ditrichum pusillum (Hedw.) Hampe - An acidophytic-subneutrophytic, mesophytic species found in disturbed sites on sandy soil, especially along roadsides (Dierßen 2001). In the investigated area, it was collected at Punta Cugno along a trodden path where it grew in short scattered turfs together with *Didymodon luridus* Hornsch. and *Dicranella howei*. It is a Boreo-temperate species, not widespread in the Mediterranean region. In Italy it is signaled in many northern and central regions, while in the South only old reports from the Calabria region are known; in Sicily it is only signaled from the Egadi archipelago (Carratello 2001, 2004, 2007). The new record represents the first for the Sicily Island. It is included in the Red List of bryophytes of Spain and considered as Vulnerable (Brugués & González Mancebo 2012). For Sicily we propose the IUCN category Vulnerable (D2).

Conclusion

The analysis of the results shows in the investigated areas a typically Mediterranean, xerophytic bryophyte flora characterized by species with prevailing life strategy colonist, life form turf, markedly or moderately resistant to pollution. On the whole the floristic composition reflects an anthropic disturbance to which the close petrochemical complex contributes. This is confirmed by the comparisons with other areas where no industry is present, such as the Natural Reserves Cava Grande del Cassibile and Grotta Monello, both located in south-eastern Sicily. Instead, it shows some affinities with the bryoflora of Milazzo and surroundings, located close to a thermoelectric power plant and an oil refinery.

Nevertheless, some species of phytogeographical interest, such as *Didymodon sicculus*, *Ditrichum pusillum*, *T. solmsii* and *Tortula viridifolia* were found. Thus, the task of the scientific community is the conservation of these species over time by appropriate measures of protection and safeguard, already adopted with the institution of the Nature reserve and to be extended in the surrounding territory. The naturalistic interest of the investigated areas could partially redeem the degradation of an area already too penalized by industrial settlements.

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Karyomorphological study of some Cretan archeophytes

Abstract

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A karyological study of six characteristic archeophytes from the island of Crete is presented, along with comments concerning their taxonomy and IUCN conservation status, whenever appropriate. For *Leontice leontopetalum* subsp. *leontopetalum* the chromosome number $2n = 16$ is given for the first time in material from Greece. Additionally, new chromosome numbers for *Geranium tuberosum* and *Ranunculus asiaticus* var. *sanguineus* are reported. Karyotype microphotographs and karyological features for all taxa examined are provided and their karyotype morphology is also discussed.

Key words: chromosome numbers, conservation, distribution, karyotype morphology, taxonomy.

Introduction

Changes from traditional to modern agricultural practices on the island of Crete, during the 20th century, have adversely affected the non-invasive Mediterranean weed flora. Many of these species were presumably originally introduced by humans (such plants are termed archeophytes), since the island was cultivated more than 9000 years ago (Phitos & Kamari 2009), and they often exhibit peculiar restricted distributions, reflecting the isolation under which the traditional agriculture developed (Turland & al. 2004). The declining populations of archeophytes are an important but overlooked issue in the conservation of Mediterranean biodiversity. Since insufficient comparative historic data exist for the last century, it is currently difficult or sometimes impossible to measure population decline or threat levels of Cretan weeds. This is at least partly because weeds tend to be undercollected during botanical excursions.

In spring of 2003, a research project took place entitled "Threatened weeds in the traditional agriculture of Crete" and financially supported by the National Geographic Society. The project was a collaboration between the Missouri Botanical Garden, St. Louis U.S.A. (MO) and the Botanical Institute of the University of Patras, Greece (UPA). The goal of this project was to carry out a thorough floristic survey of weeds in sites of traditional agriculture of Crete, Greece (Turland & al. 2004).

During this project, living material was collected for cytological investigation. As a result of this study, the chromosome number, karyotype morphology and geographical distribution of some endemic, rare and interesting archeophytes of Crete are presented along with issues of taxonomy, phytogeography and conservation.

We are pleased to have the opportunity to publish this work as a tribute to our distinguished friend Prof. Francesco M. Raimondo, as recognition of his efforts and achievements.

Materials and methods

During the fieldwork in Crete, fifty cultivated localities (fields, vineyards and olive groves) were surveyed in detail for vascular plant taxa. The presence of 'traditional agriculture' was inferred from (1) a rich weed flora, (2) the absence or non-dominance of the highly invasive S African geophyte, *Oxalis pes-caprae* L., (3) the absence of herbicidal spraying, (4) the absence of irrigation pipe systems (Turland & al. 2004).

Living plants for karyological study were collected from several regions and cultivated in the experimental botanical garden of the Botanical Institute of Patras University. Chromosome counts were obtained from root tip metaphases, using the squash technique (Östergren & Heneen 1962) with some small modifications. Root tips of *Leontice leontopetalum* L. subsp. *leontopetalum, Tulipa doerfleri* Gand., *T. saxatilis* Sieber ex Spreng., *Anemone hortensis* subsp. *heldreichii* (Boiss.) Rech. f. and *Ranunculus asiaticus* var. *sanguineus* (Mill.) DC., were pretreated for 6 h in an 1:1 mixture of 8-hydroxyquinoline (0.002% w/v):colchicine 0.2% w/v. For *Geranium tuberosum* L. an aqueous solution of 8-hydroxyquinoline (0,002% w/v) was used. Fixation in Carnoy (3:1 (v/v) absolute ethanol:glacial acetic acid) was implemented for 24 h at 0-4 °C. Afterwards, the root tips were hydrolyzed in 1N HCl for 12 min at 60 °C and placed in Feulgen's stain (Darlington & La Cour 1969) for ca. 4 h.

At least five photomicrographs of each population were examined, taken with a Zeiss Axiophot photomicroscope. Chromosome terminology follows Levan & al. (1965), Stebbins (1971) and Kamari (1976), taking into consideration comments and suggestions by Sybenga (1959), Bentzer & al. (1971) and Favarger (1978). For the characterization of the karyotypes the following chromosome features were calculated: (1) total chromosome length (TLC); (2) mean arm ratio (MAR); (3) centromeric index range (CIR); and (4) arm difference ratio range (ADR); (5) relative length range (RLR). Moreover, following Paszko's (2006) method the additional parameters are given: (1) shortest (SC) and longest (LC) chromosome length; (2) longest to shortest chromosome ratio (LC/SC); (3) mean long-arm length (p); (4) mean short-arm length (q); (5) mean chromosome length; (6) mean centromeric index (CI) (Table 1).

Table 1. Chromosome characteristics of the studied taxa.

Taxon	Ploidy level	Range SC-LC (µm)	Ratio LC/SC	p (µm) Mean (±SD)	q (µm) Mean (±SD)	CL (µm) Mean(±SD)	TLC (µm)	ARR (µm)	MAR (µm) (±SD)	CIR (µm)	CI (µm) Mean (±SD)	ADR (µm)	RLR (µm)	Karyotype morphology
Leontice leontopetalum subsp. *leontopetalum*	2x	5.06-14.95	2.95	6,44 (±1.45)	3.93 (±1.67)	10.37 (±2.65)	165.99	1.00-4.00	1.89 (±0.81)	0.50-0.80	0.63 (±0.09)	0.00-0.60	3.25-9.01	8m + 6sm + 2st-SAT
Geranium tuberosum	2x	1.45-5.07	3.50	1.75 (±0.60)	0.81 (±0.24)	2.55(±0.55)	51.09	1.01-4.00	2.27 (±0.76)	0.50-0.80	0.68 (±0.07)	0.00-0.60	3.10-8.38	4m + 14sm + 2st-SAT
Tulipa doerfleri	3x	3.66-7.98	2.18	4,27 (±0.94)	1.37 (±0.46)	5.63(±1.04)	202.82	1.60-8.00	3.51 (±1.54)	0.62-0.89	0.76 (±0.07)	0.23-0.78	1.81-3.92	21sm + 15st
Tulipa saxatilis	2x	4.86-10.23	2.11	5.49 (±1.34)	1.71 (±0.67)	7.19(±1.48)	172.69	1.50-8.67	3.65 (±1.69)	0.60-0.90	0.76 (±0.08)	0.20-0.79	2.76-6.02	12sm + 10st + 2t
Anemone hortensis subsp. *heldreichii*	2x	6.02-11.54	1.92	5.69 (±0.44)	3.17 (±2.01)	8.86(±2.06)	141.75	1.05-12.00	3.92 (±3.82)	0.51-0.92	0.68 (±0.17)	0.02-0.85	4.25-8.14	10m + 2st + 2st-SAT + 2t
Ranunculus asiaticus var. *sanguineus*	2x	4.26-8.55	2.01	4.15 (±0.66)	2.26 (±0.95)	6.71 (±1.31)	102.59	1.01-3.50	2.14 (±0.85)	0.50-0.83	0.66 (±0.12)	0.00-0.56	4.15-8.33	6m + 6sm + 4st
Ranunculus asiaticus var. *sanguineus*	3x	4.53-9.62	2.12	4.46 (±0.57)	2.45 (±1.27)	6.41 (±1.15)	165.82	1.00-4.75	2.42 (±1.30)	0.50-0.78	0.65 (±0.10)	0.00-0.65	3.10-10.62	12m + 3sm + 9st

Abbreviations: (SC) shortest and (LC) longest chromosome length; (p) mean long-arm length; (q) mean short-arml ength; (CL) mean chromosome length; (TLC) total chromosome length; (ARR) arm ratio range; (MAR) mean arm ratio; (CIR) centromeric index range; (CI) mean centromeric index; (ADR) arm difference ratio range; (RLR) relative length range; (SD) standard deviation.

Results and discussion

Berberidaceae

Leontice leontopetalum L. subsp. ***leontopetalum*** (Fig. 1). — 2*n* = 2x = 16 (Fig. 7).

Gr: Nomos Irakliou, Prov. Pirgiotissis: 1 km N of Kamilari, 35° 02’ 45.8” N, 24° 47’ 37.6” E, alt. 55 m, level open olive groves, area 2100 m^2, surrounded by young and older olive groves and a few small fields with cereal crops, 16 Apr 2003, *Kyriakopoulos & Turland* sub *Turland 1215* (MO, UPA).

Leontice leontopetalum is a conspicuous geophytic, obligate weed of traditional agriculture with a tough, deeply rooted tuber. According to Coode (1965) the taxon is divided into three subspecies: *L. leontopetalum* subsp. *leontopetalum* is found from the E Mediterranean area to N Iraq and N Iran; *L. leontopetalum* subsp. *ewersmannii* (Bunge) Coode is distributed in Turkestan, Iran and W Pakistan; and *L. leontopetalum* subsp. *armeniacum* (Boivin) Coode grows in Jordan, Syria and Armenia. The two subspecies found in the E parts of this large distribution area grow in semi-natural, steppe-like vegetation, while the typical subspecies has probably evolved as an ecotype with the development of agriculture (Phitos & Strid 2002). *L. leontopetalum* subsp. *leontopetalum* grows in clayey soils sticky in spring and compacted in summer at attitudes up to 1100 m, with other characteristic taxa of similar habitats such as *Ornithogalum nutans* L., *Geranium tuberosum* L., *Aegilops triuncialis* L., *Consolida regalis* Gray, *Cerastium semidecandrum* L., *Brassica geniculata* (Desf.) Ball, *Papaver rhoeas* L., *Delphinium peregrinum* L., *Ranunculus muricatus* L., *Centaurea calcitrapa* L., *C. solstitialis* L. subsp. *solstitialis*, *Mantisalca salmantica* (L.) Briq. & Cavill., *Scolymus hispanicus* L., *Reseda lutea* L., *Eryngium campestre* L., *Hypericum triquetrifolium* Turra.

Due to the relatively limited distribution range of the subspecies, the scattered and small size of the populations, the specificity of the habitat, the gradual decline of the older populations and changes associated with the use or intensive cultivation of agricultural land the taxon has been characterized as Vulnerable (VU) according to the IUCN (2001, 2003, 2006) criteria A4(c); B1b(iii)c(iii); C2a(i) (Krigas & al. 2009).

In Crete it is very rare and has been decreasing over the last century. During our fieldwork it was found at only three localities. The chromosome number 2*n* = 16 is given by several authors from elsewhere (Toren 1962, 1965; Markova 1969; Kosenko 1977). Moreover, Toren (1962) reported the gametophytic count *n* = 9, which, however is considered doubtful (Phitos & Strid 2002). The chromosome number 2*n* = 16 given in the present study is, to the best of our knowledge, counted for the first time from Greece. The karyotype, which has the following formula 2*n* = 8m + 6sm + 2st-SAT = 16, consists of mostly long chromosomes, varying in size from 5.06-14.95 μm. The total chromosome length is 165.99 μm, while the mean arm ratio is given as 1.89 (Table 1). The satellites of the acrocentric chromosomes are small, spherical and not always visible.

Geraniaceae

Geranium tuberosum L. (Fig. 2). — 2*n* = 2x = 20 (Fig. 8).

Gr: Crete, Nomos Lasithiou, Prov. Lasithiou: Lasithi plain, 500 m S of Agios Konstantinos, 35° 10' 14.8" N, 25° 30' 03.5" E, alt. 850 m, level field with a few fruit trees, 3/4 fallow, 1/4 with cereal crop, area 1200 m^2, many similar fields in area, 7 Apr 2003, *Bareka & Turland* sub *Turland 1080* (MO, UPA).

— Crete, Nom. Irakliou, Prov. Monofatsiou: Ahendrias, within village, 34° 59' 27" N, 25° 13' 25" E, alt. 685 m, field with cereal crop and many weeds, 15 Apr 2003, *Kyriakopoulos & Turland* sub *Turland 1199* (B, BM, MO, UPA).

Geranium tuberosum is one of the most reliable indicators of traditional agriculture, in that it is restricted (obligate) to such habitats. The taxon is distributed in S Europe, from SE France to the Aegean region, extending E to Crimea, Caucasia, the Syrian desert, N Iraq and N Iran (Webb & Ferguson 1968). It is a rare archeophytic weed of cultivated and fallow fields (Lasithi plain and Ahendrias in the eastern Asterousia mountains) (Fielding & Turland 2005).

The chromosome number 2*n* = 28 for *Geranium tuberosum* has been previously reported for this taxon in material from Sterea Hellas (Van Loon & Oudemans 1982). However, our counts from both studied populations in Crete revealed the chromosome number 2*n* = 20. The karyotype consists of small mostly submetacentric (sm) chromosomes varying in size from 1.45-5.07 µm (Fig. 8). The arm ratio varies from 1.01 to 4.00 and the centromeric index from 0.50 to 0.80. The mean chromosome length is given as 3.50 µm, while the total chromosome length is 51.09 µm. Only one chromosome pair is acrocentric and bears big spherical satellites (st-SAT) longer than the short arms. The karyotype formula is given as: 2*n* = 4m + 14sm + 2st-SAT = 20 chromosomes.

Liliaceae

Tulipa doerfleri Gand. (Fig. 3). — 2*n* = 3x = 36 (Fig. 9).

Gr: Nom. Rethimnis, Prov. Amariou: Gious Kambos plain ESE of Spili, beside stream on W part of plain, 35° 12' 50.4" N, 24° 33' 47.3" E, alt. 755 m, fallow field, partly with deep soil over limestone, partly with very stony soil on schist, area 1600 m^2, many similar fields in area, some fallow, some with cereal crops, 21 Apr 2003, *Phitos, Kamari & Turland* sub *Turland 1306* (B, BM, MO, UPA).

Tulipa doerfleri is an endemic taxon to WC Crete, from Angouseliana (Prov. Agiou Vasiliou) to Moni Asomaton (Prov. Amariou). It is an obligate weed of traditionally cultivated land (the only endemic weed in the Cretan flora) occurring in cultivated and fallow fields, and persisting in abandoned fields, at altitudes of 330-750 m (Turland 2009). It grows with other weeds of cultivation, including the geophytes *Allium nigrum* L., *Gladiolus italicus* Mill., *Muscari comosum* (L.) Mill., *Ranunculus ficaria* subsp.

chrysocephalus P. D. Sell and *Smyrnium perfoliatum* subsp. *rotundifolium* (Mill.) Hartvig and a wide variety of annuals including *Anagallis arvensis* L., *Eruca vesicaria* (L.) Cav., *Glebionis segetum* (L.) Fourr., *Papaver rhoeas* L. and *Scandix pecten-veneris* L.

Tulipa doerfleri has been treated as *T. orphanidea* Boiss. & Heldr. (e.g. by Grey-Wilson & Matthews 1980), which occurs in S Greece (Peloponnisos and Attiki) and W Turkey (Persson 1991). According to Zonneveld (2009) in his revision of the genus, based on nuclear genome size measurements, *T. doerfleri* has been included in *T. orphanidea* as a subspecies [*T. orphanidea* subsp. *doerfleri* (Gand.) Zonn.].

Whereas *Tulipa orphanidea* has an orange to brick-red or rarely yellow perianth, *T. doerfleri* has a deep red perianth. Moreover, *T. orphanidea* is characterized by several ploidy levels from diploid with $2n = 2x = 24$ chromosomes (Southern 1967; Fedorov 1969; Blakey & Vosa 1981; Zonneveld 2009) to tetraploid with $2n = 4x = 48$ chromosomes (Athanasiou 1988; Persson 1991), with triploid karyotypes being the most common (Athanasiou 1988; Tzanoudakis & al. 1991; Başak & Özhatay 1997; Zonneveld 2009). *Tulipa doerfleri*, on the other hand, is always triploid with $2n = 3x = 36$ chromosomes (Sonderhousen 1977; Tzanoudakis & al. 1991 as *"T. orphanidea"*). Based on the present authors' observations, *T. doerfleri* appears to be completely sterile, spreading vegetatively by subterranean stolons but never forming viable seeds. This biology is compatible with a sterile triploid.

Changes to traditional agricultural practices, such as abandonment of cultivated fields or deep-ploughing with modern machinery, threaten the survival of *Tulipa doerfleri*. For that reason the category Vulnerable (VU) was proposed in the Red Data Book of Rare and Threatened Plants of Greece (Turland 2009) based on criteria B1ab(iii,v)c(iv)+2ab(iii,v)c(iv); D2 (IUCN 2001).

The karyological features of the taxon are given in Table 1. The karyotype comprises of $2n = 3x = 21sm + 15st = 36$ chromosomes, ranging in size from 3.66 to 7.98 µm.

Tulipa saxatilis Sieber ex Spreng. (Fig. 4). — $2n = 2x = 24$ (Fig. 10).

Gr: Nom. Lasithiou, Prov. Lasithiou: Lasithi plain, between Agios Konstandinos and Koudoumalia, N side of road, 35° 10’ 08.5” N, 25° 29’ 24.4” E, alt. 835 m, ploughed field without crop, area 600 m^2, surrounded on 3 sides (N, W, S) by similar fields with some fruit trees, 7 Apr 2003, *Bareka & Turland* sub *Turland 1085* (B, BM, MO, UPA).

— Nom. Hanion, Prov. Selinou: N part of Omalos plain, near Omalos village, 35° 20’ 26.8” N, 23° 54’ 06.4” E, alt.1055 m, more or less level fallow field, area 3500 m^2, several similar fields on plain, 1 May 2003, *Karakitsos & Turland* sub *Turland 1380* (B, BM, MO, UPA).

Tulipa saxatilis grows on ledges and in crevices of calcareous cliffs, rocky slopes and screes, stream banks in scrub, flat clayey and cultivated, fallow or abandoned fields, often on mountain plains such as those of Lasithi and Omalos. The species is scattered around Crete and also occurs in Karpathos, the E Aegean island of Rodos and SW Turkey (Fielding & Turland 2005).

Figs 1-4. Photos of: **1,** *Leontice leontopetalum* subsp. *leontopetalum*; **2,** *Geranium tuberosum*; **3,** *Tulipa doerfleri*; **4,** *Tulipa saxatilis*.

This taxon was considered as "normally triploid" since most of the chromosome counts reported revealed a triploid chromosome number (Southern 1967; Yoshida 1980; Blakey & Vosa 1981; Tzanoudakis & al. 1991; Raamsdonk & Vries 1992). However, most of the Cretan populations examined previously by Tzanoudakis & al. (1991) were diploid with the exception of one triploid population.

Both populations studied during this project are diploid and their karyotype consists $2n = 2x = 12sm + 10st + 2t = 24$ chromosomes, varying in size between 4.86-10.23µm. The total length of the chromosome complement is 172.69 µm and the mean chromosome size is 7.19 µm. The mean arm ratio is given as 3.65 while the relative length of the chromosomes ranges from 2.76 to 6.02 (Table 1).

Ranunculaceae

Anemone hortensis subsp. ***heldreichii*** (Boiss.) Rech. f. (Fig. 5). — $2n = 2x = 16$ (Fig. 11).

Gr: Nom. Lasithiou, Prov. Mirambellou: S of Katharo plain, on road to Giannitsi, 35° 07' 48.6" N, 25° 33' 56.0" E, alt.1140 m, small field inaccessible to tractors, schist substrate, without obvious crop, inorganic fertilizer applied, area 700 m^2, surrounded by phrygana on schist, 6 Apr 2003, *Bareka & Turland* sub *Turland 1068* (B, BM, MO, UPA).

Anemone hortensis L. s. l. is a tuberous C Mediterranean species, extending E to the S Aegean region, belonging to *A.* subg. *Anemone* and to the "*Coronaria* group" together with all tuberous anemones from the Mediterranean region and SC USA with one disjunct species in South America (Mlinarec & al. 2006). It is divided into two subspecies: *A. hortensis* subsp. *hortensis* is distributed throughout most of the range of the species, while *A. hortensis* subsp. *heldreichii* is an endemic taxon of the islands of the Crete-Karpathos area, where it grows in phrygana, open calcareous woods, olive groves garigue and rocky places at an altitude from 0 to 1850 m (Fielding & Turland 2005).

The somatic number $2n = 16$ counted here for *A. hortensis* subsp. *heldreichii* has been previously given for *A. hortensis* s.l. by several authors (Tzanoudakis 1986 in material from Crete probably referring to *A. hortensis* subsp. *heldreichii*, Druskovic & Lovka 1995; Lovka 1995; Mlinarec & al. 2006 in material from elsewhere). It is the most common somatic number in all representatives of *A.* subg. *Anemone*. The karyotype is symmetrical, consisting of $2n = 2x = 10m + 2st + 2st\text{-}SAT + 2t = 16$ chromosomes, ranging in size from 6.02 to 11.54 µm. The morphometric analysis of the taxon (Table 1) gave similar results to those given by Mlinarec & al. (2006) in material from Croatia. It is also noteworthy that the satellites observed in an acrocentric chromosome pair are longer than the short arm of the homologues.

Ranunculus asiaticus var. ***sanguineus*** (Mill.) DC. (Fig. 6). — $2n = 2x = 16$ (Fig. 12a) & $2n = 3x = 24$ (Fig. 12b).

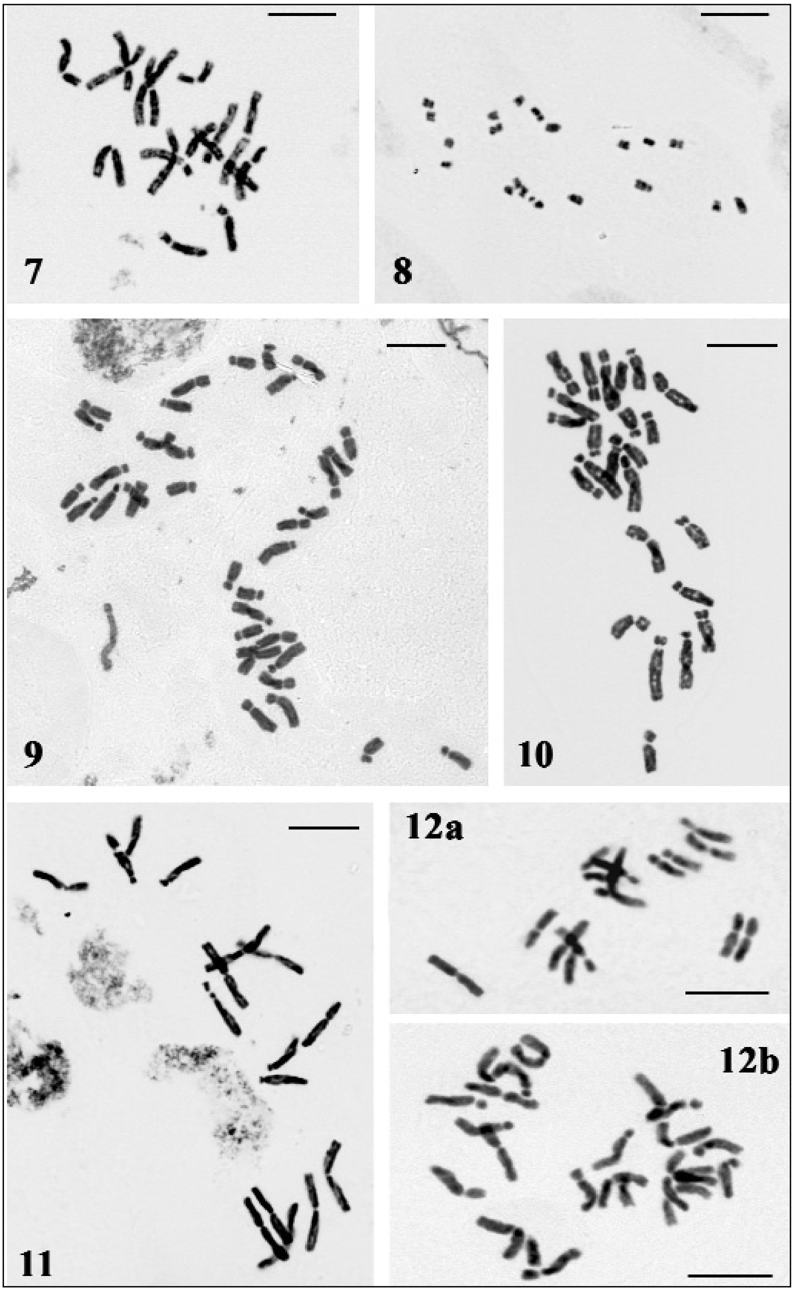
Gr: Nom. Hanion, Prov. Apokoronou: S of Vrises on road to Hora Sfakion, 4.4 km by road from river in Vrises, 35° 20' 59.2" N, 24° 12' 08.8" E), alt. 280 m, terraced olive grove with various fruit and nut trees, area 650 m^2, surrounded by similar olive groves, 19 Apr 2003, *Phitos*, *Kamari & Turland* sub *Turland 1272* (B, BM, MO, UPA).

— Nom. Rethimnis, Prov. Amariou: N part of Fourfouras village, SW of road junction to Platania, 35° 12' 53.0" N, 24° 42' 40.1" E, alt. 430 m, open olive grove, area 1000 m^2, surrounded by similar olive groves and small fields with cereal crops, 20 Apr 2003, *Kamari & Turland* sub *Turland 1280* (B, BM, MO, UPA).

— Nom. Hanion, Prov. Sfakion: W edge of Anopoli village, S side of road to Aradena, 35° 13' 10.0" N, 24° 04' 53.9" E, alt. 585 m, small level stony fallow field, area 300 m^2, surrounded by fallow and cultivated (with cereals) fields, vineyards and olive groves, 22 Apr 2003, *Kamari & Turland* sub *Turland 1375* (MO, UPA).

Ranunculus asiaticus L. s. l. is a very variable species occurring mainly in the E Mediterranean area, e.g. Libya, Egypt, the Aegean area, Cyprus and through Anatolia to Syria, W Iraq &W Iran (Strid 2002). The red-flowered variety of this tuberous geophyte in Crete, var. *sanguineus*, has a completely different ecological niche to the plants with yellow flowers (var. *flavus* Dörfl.) and white or pink flowers (var. *albus* Hayek) (Turland & al. 2004). The red-flowered variety occurs exclusively in cultivated ground, while the other two grow in

Figs 5-6. Photos of: **5**, *Anemone hortensis* subsp. *heldreichii*; **6,** *Ranunculus asiaticus* subsp. *sanguineus*.



Figs 7-12. Microphotographs of mitotic metaphase plates of: **7**, *Leontice leontopetalum* subsp. *leontopetalum*, $2n = 2x = 16$; **8**, *Geranium tuberosum*, $2n = 2x = 20$; **9**, *Tulipa doerfleri*, $2n = 3x = 36$; **10**, *Tulipa saxatilis*, $2n = 2x = 24$; **11**, *Anemone hortensis* subsp. *heldreichii*, $2n = 2x = 16$ and **12**, *Ranunculus asiaticus* subsp. *sanguineus*, **12a**, $2n = 2x = 16$; **12b**, $2n = 3x = 24$. – Scale bars = 10 µm.

semi-natural phrygana and garigue habitats. According to Turland & al. (2004) the collected plants have underground stolons, by which they were spreading vegetatively.

The chromosome number 2*n* = 2x = 16 found here in var. *sanguineus* has also been reported for *Ranunculus asiaticus* s. l. and *R. asiaticus* var. *albus* (Montmollin 1984; Tzanoudakis 1986; Tak & Wafai 1996; Chen & al. 2003; Baltisberger & Widmer 2004, 2005). However, within the studied populations of *R. asiaticus* var. *sanguineus* we also found triploid individuals with 2*n* = 3x = 24 reported here for the first time. The karyotype features for both diploid and triploid individuals are given in Table 1. The main difference between diploid and triploid karyotypes is the number of submetacentric and acrocetric chromosomes. The diploid karyotype consists of 2*n* = 2x = 6m + 6sm + 4st = 16 chromosomes, while the morphology of the triploid karyotype is given as 2*n* = 3x = 12m + 3sm + 9st = 24 chromosomes. The karyotype morphology reported by Tzanoudakis (1986) for *R. asiaticus* s.l. is 2*n* = 2x = 6m + 10st = 16 chromosomes. Baltisberger & Widmer (2005) reported the karyotype formula 2*n* = 2x = 6m + 6sm/st + 4st = 16 chromosomes for *R. asiaticus* var. *albus*, which is quite similar with the karyotype morphology reported here for *R. asiaticus* var. *sanguineus.*

Concluding remarks

In the present study a detailed karyotype analysis of six characteristic representatives of archeophytes in the island of Crete (Greece) was implemented, focusing specifically on the determination of the chromosome number and the morphology of the karyotype with the use of classical karyological methodology (squash technique, followed by Feulgen staining). A detailed karyotype analysis with twelve different karyological features is given for the studied taxa. Additionally, data on the distribution, systematics and ecology of the taxa are given.

The chromosome number (2*n* = 16) of *Leontice leontopetalum* subsp. *leontopetalum* is given for the first time from Greek material.

For *Geranium tuberosum* a new chromosome number (2*n* = 20) is reported for the first time.

For *Ranunculus asiaticus* var. *sanguineus* triploid (2*n* = 3x = 24) individuals have been found for the first time; this is together with diploid (2*n* = 2x = 16) individuals as previously reported.

The majority of the investigated taxa are diploid: *Leontice leontopetalum* subsp. *leontopetalum* (2*n* = 2x = 16), *Tulipa saxatilis* (2*n* = 2x = 24), *Anemone hortensis* subsp. *heldreichii* (2*n* = 2x = 16) and *Ranunculus asiaticus* var. *sanguineus* (2*n* = 2x = 16).

For the genus *Geranium* several different basic chromosome numbers have been reported: x = 10, 12, 13, 14, 16 (Petrova & Stanimirova 2001, 2003) The most common basic chromosome number is x = 14 (Albers 1990). All individuals and both populations of *G. tuberosum* studied revealed the new chromosome number 2*n* = 20, instead of 2*n* = 28 which has been previously reported. This is not a very common phenomenon for the genus. On the contrary, several species of the genus have a diploid together with a tetraploid chromosome number in the same individual (Petrova & Stanimirova 2001, 2003). The phenomenon is noted as endomitosis (Geitler 1939) conducting to endopolyploidy (Löve & Löve 1975).

Polyploidy in the genus *Tulipa* is very common and it seems to play a significant role in the speciation of the genus (Zonneveld 2009), where diploid species are the most common (2*n* = 2x = 24). However, triploid (2*n* = 3x = 36) and tetraploid forms (2*n* = 4x = 48) have been reported (Southern 1967; Zonneveld 2009). Pentaploid forms (2*n* = 5x = 60) are recorded only in *T. clusiana* Redouté, and Kroon & Jongerius (1986) found a hexaploid karyotype (2*n* = 6x = 72) in *T. polychroma* Stapf.

Both *Tulipa doerfleri* (2*n* = 3x = 36) and *T. saxatilis* (2*n* = 2x = 24), examined here, belong to *T.* subg. *Eriostemones*. As already mentioned here, Zonneveld (2009) included *T. doerfleri* sub *T. orphanidea*, as *T. orphanidea* subsp. *doerfleri*. However, the morphological and karyological differences between these two taxa, as well as the polymorphism in the *T. orphanidea* group make urgent the need for further study in order to resolve any taxonomic question. For all the above reasons we prefer now to maintain *T. doerfleri* as a separate species.

Fluorescence in situ hybridization (FISH) is an excellent tool for chromosome identification and studies of chromosome evolution and genome organization (Bareka & al. 2012). Many studies, have been published on the distribution, organization, and activity of ribosomal RNA (rRNA) genes for studying the evolutionary relationship within many genera and elucidating many taxonomical issues, e.g., in the genera *Artemisia* L. (Garcia & al. 2007), *Bellevalia* Lapeyr. (Bareka & al. 2012), *Cedrus* Trew (Bou Dagher-Kharrat & al. 2001), *Hypochaeris* L. (Cerbach & al. 1998; Weiss-Schneeweiss & al. 2003), *Lilium* L. (Siljak-Yakovlev & al. 2003; Muratovič & al. 2005), *Quercus* L. (Zoldoš & al. 1999) and *Reichardia* Roth (Siljak-Yakovlev & al. 1998). We believe that a molecular cytogenetic study on the representatives of this group could answer questions concerning the taxonomic relationships between Greek representatives of *Tulipa*.

In the Mediterranean *Anemone* species, two distinct karyotypes have been found so far: one with three acrocentric and five metacentric to submetacentric chromosomes (*A. coronaria* L., *A. pavonina* Lam.) and another with four acrocentric and four metacentric chromosomes (*A. blanda S*chott & Kotschy, *A. palmata* L.) (Marks & Schweizer 1971; Medail & al. 2002). The karyotype morphology of *A. hortensis* studied from Croatia (Mlinarec & al. 2006) is in accordance with the karyotypes of *A. coronaria* – *A. pavonina* group. Those three species have also the same heterochromatin banding pattern (Marks & Schweizer 1971) and they differ only by a variable telomeric DAPI banding pattern of the fourth-in-size chromosome pair (Mlinarec & al. 2006). The karyotype morphology found here for *A. hortensis* subsp. *heldreichii* is also in accordance with the results given by Mlinarec & al. (2006).

The present study of these six characteristic archeophytes from Crete can be regarded as a small but significant contribution in the effort to further advance the biosystematic study of the non-invasive Mediterranean weed flora.

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The genus *Pleurotus* in Italy

Abstract

Venturella, G., Gargano, M. L. & Compagno, R.: The genus *Pleurotus* in Italy. — Fl. Medit. 25 (Special Issue): 143-156. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

On the basis of personal observations, herbarium specimens and, data reported in the literature the authors report morphological, ecological and distributive data on *Pleurotus* taxa from Italy. New descriptions are here provided based on the most distinctive-discriminating eco-morphological characters of twelve *Pleurotus* taxa.

Key words: oyster mushrooms, descriptions, ecology, distribution.

Introduction

In modern taxonomy the genus *Pleurotus* (Fr.) P. Kumm is placed under the family *Pleurotaceae* Kühner (*Agaricales*, *Basidiomycota*). The *Pleurotaceae* are a family of small to medium-sized mushrooms which have white spores including 6 genera and 94 species (Kirk & al. 2008).

The genus *Pleurotus* is a cosmopolitan group of fungi which comprises ca. 30 species and subspecific taxa also known as oyster mushrooms. The genus *Pleurotus* also represents the second main group of cultivated edible mushrooms in the world (Zervakis & Labarère 1992). The *Pleurotus* species are efficient colonizers and bioconverters of lignocellulosic agro-industrial residues into palatable human food with medicinal properties (Philippoussis 2009). Some white-rot fungi of the genus *Pleurotus* are able to remove lignin with only minor attack on cellulose (Cohen & al. 2002). Besides *Pleurotus* species demonstrates significant nutritional values (La Guardia & al. 2005; Venturella & al. 2015a) and their bioactive compounds (mainly polysaccharides) possess antibacterial (Schillaci & al. 2013), antibiotic, antitumor, hypocholesterolemic and immunomodulation properties (Wasser 2002). *Pleurotus* species establish a wide range of interactions with plants, animals and other microorganisms (Tsuneda & Thorn 1995). *Pleurotus* species are also nematophagous and they derive nutrition by consuming nematodes (Thorn & al. 2000). This is made possible by hyphae that may have drops or adhesive knobs that attach to passing nematodes and secrete nematotoxic compounds (Koziak & al. 2007).

In past times the assessments of *Pleurotus* diversity in Europe supported by biochemical, molecular and compatibility studies revealed the existence of eleven species, i.e. *P. abieticola* R.H. Petersen & K.W. Hughes, *P. calyptratus* (Lindblad ex Fr.) Sacc., *P. cornucopiae* (Paulet) Rolland, *P. dryinus* (Pers.) P. Kumm., *P. eryngii* (DC.) Quél., *P. ferulaginis* Zervakis, Venturella & Cattarossi, *P. fuscosquamulosus* D.A. Reid & Eicker, *P. opuntiae* (Durieu & Lév.) Sacc., *P. nebrodensis* (Inzenga) Quél., *P. ostreatus* (Jacq.) P. Kumm. and, *P. pulmonarius* (Fr.) Quél. (Zervakis & al. 2001).

P. abieticola, *P. fuscosquamulosus* and, *P. opuntiae* are infrequent to very rare species. The former was collected from east Russia (Petersen & Hughes 1997) whereas *P. opuntiae* is distributed in Mediterranean Europe and, particularly, in southern Italy (Venturella 1991). *P. fuscosquamulosus* was reported for the first time in Greece by Zervakis & al. (1992).

This paper deals with the distribution and ecology of *Pleurotus* species growing in Italy on the wood of broadleaved trees, on trunks of *Agavaceae* and on the fiber of fallen cladodes of *Cactaceae* and, as weak parasites on the roots of herbaceous plants of family *Apiaceae*.

Materials and Methods

In the last ten years field collections on lignicolous and saprotrophs *Pleurotus* species, combined with observations on several herbarium specimens belonging to *P. calyptratus*, *P. cornucopiae*, *P. dryinus*, *P. eryngii* var. *elaeoselini*, *P. eryngii* var. *eryngii*, *P. eryngii* var. *ferulae*, *P. ferulaginis*, *P. nebrodensis*, *P. opuntiae*, *P. pulmonarius*, *P. ostreatus*, and *P. thapsiae*, and kept in the Italian universities (AQUI, BOLO, CAT, FI, GDOR, GE, PAL, PAV, PERU, RO, SAF, and TO) and the herbaria of the main Italian mycological amateur groups (Associazione Micologica Bresadola and Unione Micologica Italiana) allowed the macro- and micromorphological characterization of twelve *Pleurotus* taxa in the Italian territory. The macro-morphological characteristics of the basidiomes were evaluated with a Leica MS5 binocular microscope while the microscopic features were evaluated with a Leica DLMB microscope using tap water. In particular we observed the habit and the habitat, the color, the odor, the shape and the size of pileus and stipe, the cuticle of pileus, the type of lamellae, the stipe position, the hyphal system (monomitic or dimitic), the type of wall, the shape and the size of basidia and basidiospores, the pileipellis, the presence of pileocystidia, the hymenophoral trama combined with a well developed subhymenium, the reaction of basidiospores in Melzer's solution. The nomenclature of vascular plants follow The Euro+Med PlantBase - The Information Resource for Euro-Mediterranean plant diversity (http://www.emplantbase.org/home.html) while the nomenclature of fungi is referred to Zervakis & al. (2014).

Species distribution and ecological notes

The Checklist of Italian Fungi (Onofri & al. 2005) listed eleven taxa (8 species and 3 varieties): *P. calyptratus* (Lindbald) Sacc., *P. cornucopiae* (Paulet) Rolland, *P. dryinus*

(Pers.) P. Kumm., *P. eryngii* (DC.) Quél. var. *eryngii*, *P. eryngii* var. *elaeoselini* Venturella, Zervakis & La Rocca, *P. eryngii* var. *ferulae* Lanzi, *P. eryngii* var. *thapsiae* Venturella, Zervakis & Saitta, *P. nebrodensis* (Inzenga) Quél., *P. opuntiae* (Durieu & Lév.) Sacc., *P. ostreatus* (Jacq.) P. Kumm. and, *P. pulmonarius* (Fr.) Quél.

P. ferulaginis Zervakis, Venturella & Cattarossi was recently described as new species for Italy (Zervakis & al. 2014) increasing the number of *Pleurotus* species in Italy to twelve.

The updated distribution in Italy of the taxa mentioned above is shown in Figs. 1-3.

The lignicolous *Pleurotus* species mainly grows in broadleaved and conifer woods, on cultivated and ornamental plants, on living and dead trees, branches and logs.

P. calyptratus (Fig. 4) is currently reported only from Trentino Alto Adige (Vigo di Ton, Trento) on dead fallen trunks of *Populus tremula* L. The period of fructification is spring-summer and the altitude range of 350 and 910 m a.s.l. On the contrary, *P. cornucopiae* is widely distributed in Italy and it can be observed from summer to autumn, and in different altitudinal levels, on stumps and trunks of different broad-leaved trees (i.e. *Ulmus* ssp., *Fagus sylvatica* L.). Even *P. dryinus* is widely collected in Italy, from summer up to winter and in different altitudinal levels, on living trees, dead trees, and trunks of *Abies alba* Miller, *Acer negundo* L., *Alnus glutinosa* (L.) Gaertn., *Betula pendula* Roth, *Fraxinus ornus* L., *Picea abies* (L.) H. Karst., *Populus termula* L., *Quercus ilex* L., *Q. pubescens* Willd., *Salix alba* L. and, *Yucca aloifolia* L. *P. ostreatus* have a wider distribution and can be collected all year round from 0 to 1450 m a.s.l. in large tufts on living broad-leaved trees, logs, stumps, or fallen trunks of various broadleaved trees [*A. alba*, *Castanea sativa* Miller, *Fagus sylvatica*, *Morus nigra* L., *P. alba* L., *P. tremula*, *Q. pubescens*, *Q. petraea* (Matt.) Liebl., and *S. alba*].

A more restricted distribution is that of *P. pulmonarius* (Fig. 5) which can be collected, from 400 to 1600 m, from late summer up to autumn, on trunks, stumps and logs of various deciduous trees (i.e. *Populus alba*, *P. tremula*, *Sorbus aucuparia* L.), in Piedmont, Trentino Alto Adige, Veneto, Friuli Venezia Giulia, Emilia Romagna, Abruzzo, Basilicata and, Calabria.

P. opuntiae is an interesting and infrequent mushroom from southermost Italian regions (Calabria and Sicily), growing as parasite or saprotroph, from 0 to 500 m, on fibers of fallen cladodes of *Opuntia ficus-indica* Haw., and on trunks of *Agave americana* L. and *Yucca elephantipes* Hort ex Regel. (Venturella 1991).

Other *Pleurotus* species grows as weak parasites on the roots of herbaceous plants of family *Apiaceae*. *P. ferulaginis*, recently collected in northeast Italy (Campoformido, province of Udine, 78 m a.s.l.), is associated with *Ferulago campestris* (Besser) Grecescu. This is a vernal species which can be observed in dry meadows, cliffs, rocky and calcareous areas, at an elevation of 0-900 metres. The basidiomes of *P. eryngii* var. *eryngii* grows in all the Italian regions in autumn, on calcareous soils and sandy shores, on root residues of *Eryngium campestre* L. and *E. maritimum* L., from 0 to 1500 m (Venturella & al. 2015a). *P. eryngii* var. *elaeoselini* can be collected in autumn and spring, in different Italian regions, in pasture and meadows of calcareous soils and a nutrient-rich substrate, at an altitude of 0-2100 metres, on *Elaeoselinum asclepium* (L.) Bertol. subsp. *asclepium*, *Laserpitium latifolium* L. and, *L. siler* L. *P. eryngii* var. *ferulae* grows in Tuscany, Lazio, Molise, Campania, Basilicata, Apulia, Calabria, Sicily and, Sardinia, in pastures and meadows of arid and calcareous soils on *Ferula communis* L., at an altitude of 0-1200 metres.

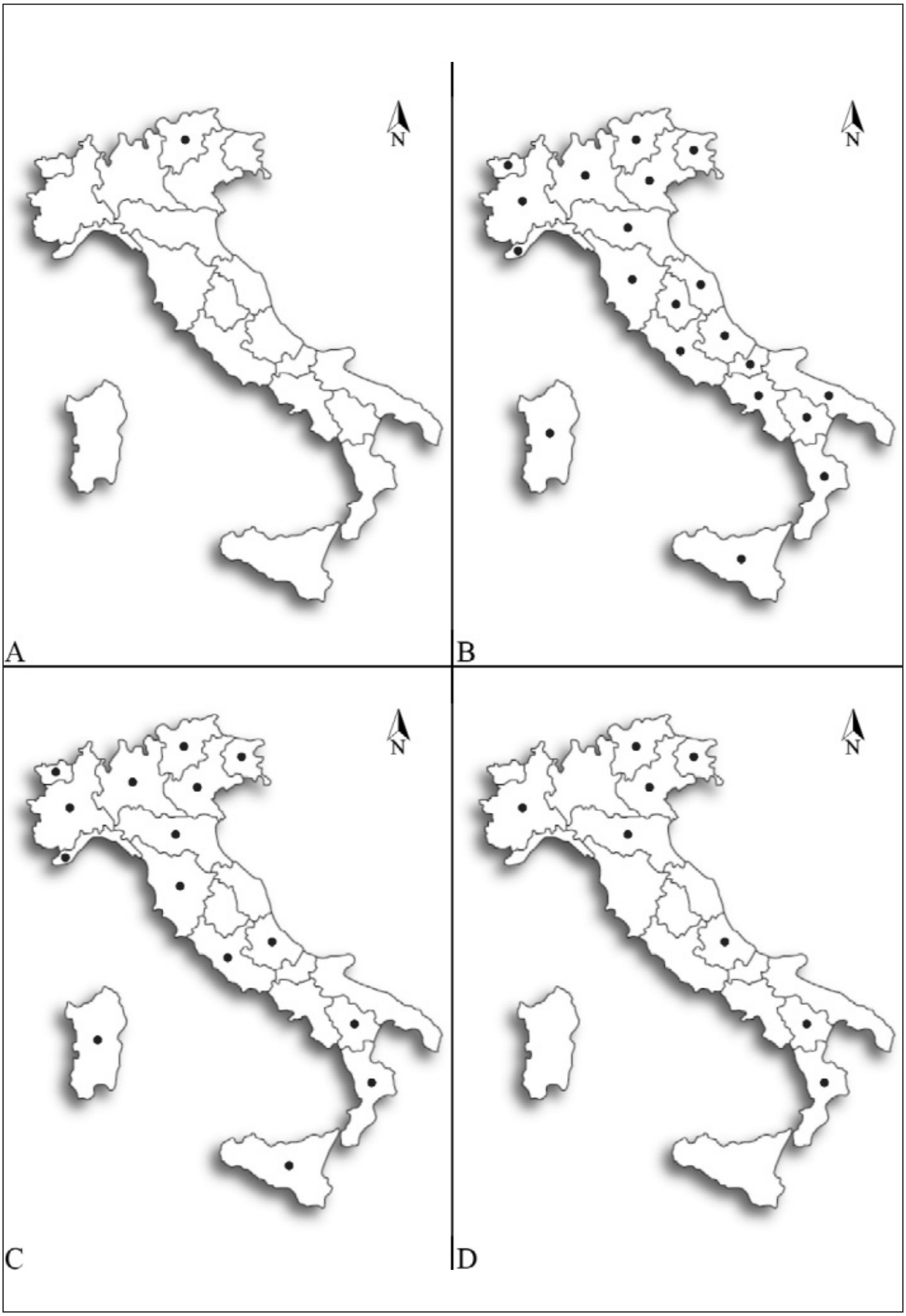

Fig. 1. **A.** *Pleurotus calyptratus*; **B.** *P. cornucopiae*; **C.** *P. dryinus*; **D.** *P. pulmonarius*.

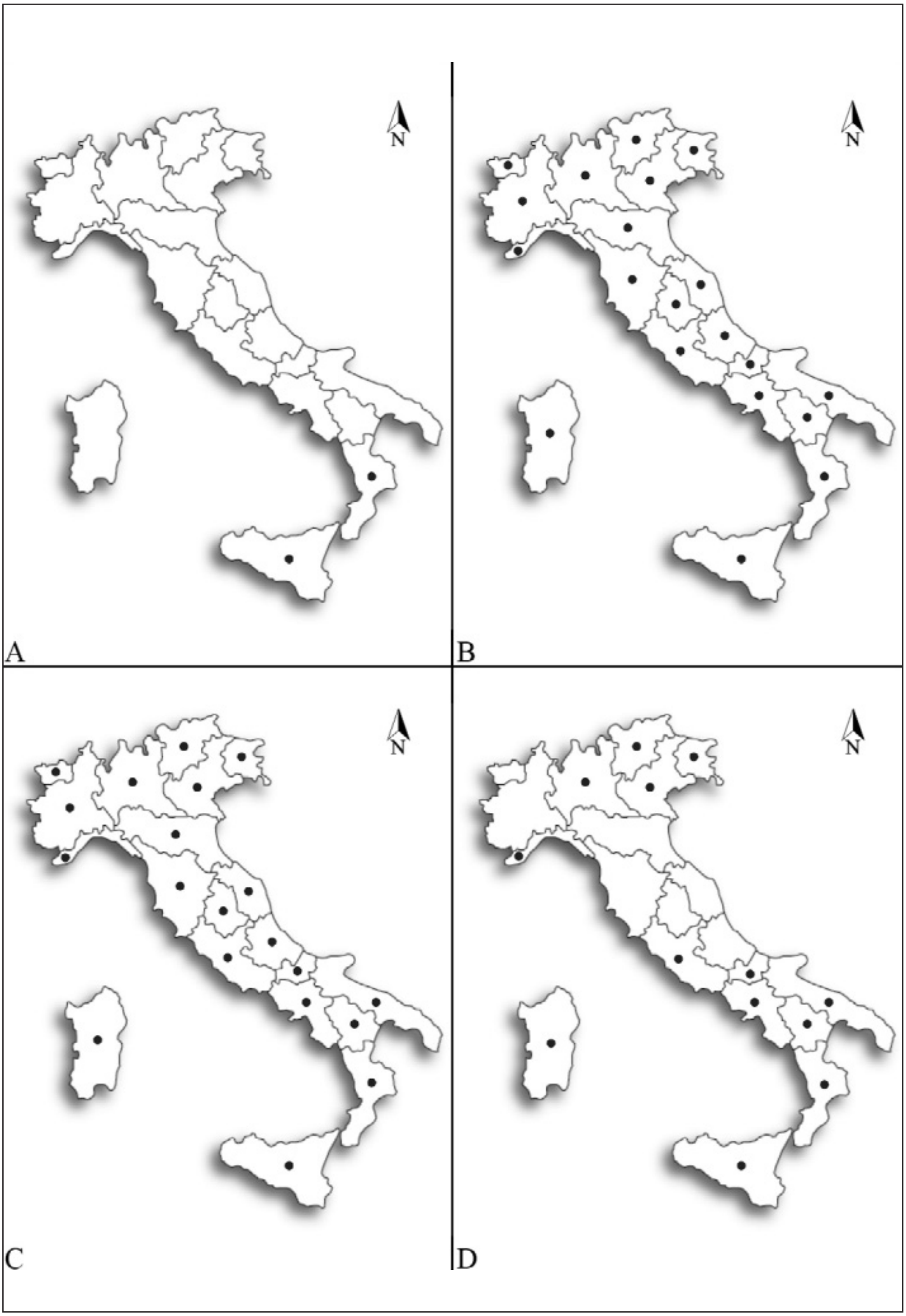

Fig. 2. **A.** *Pleurotus opuntiae*; **B.** *P. ostreatus*; **C.** *P. eryngii* var. *eryngii*; **D.** *P. eryngii* var. *elaeoselini*.

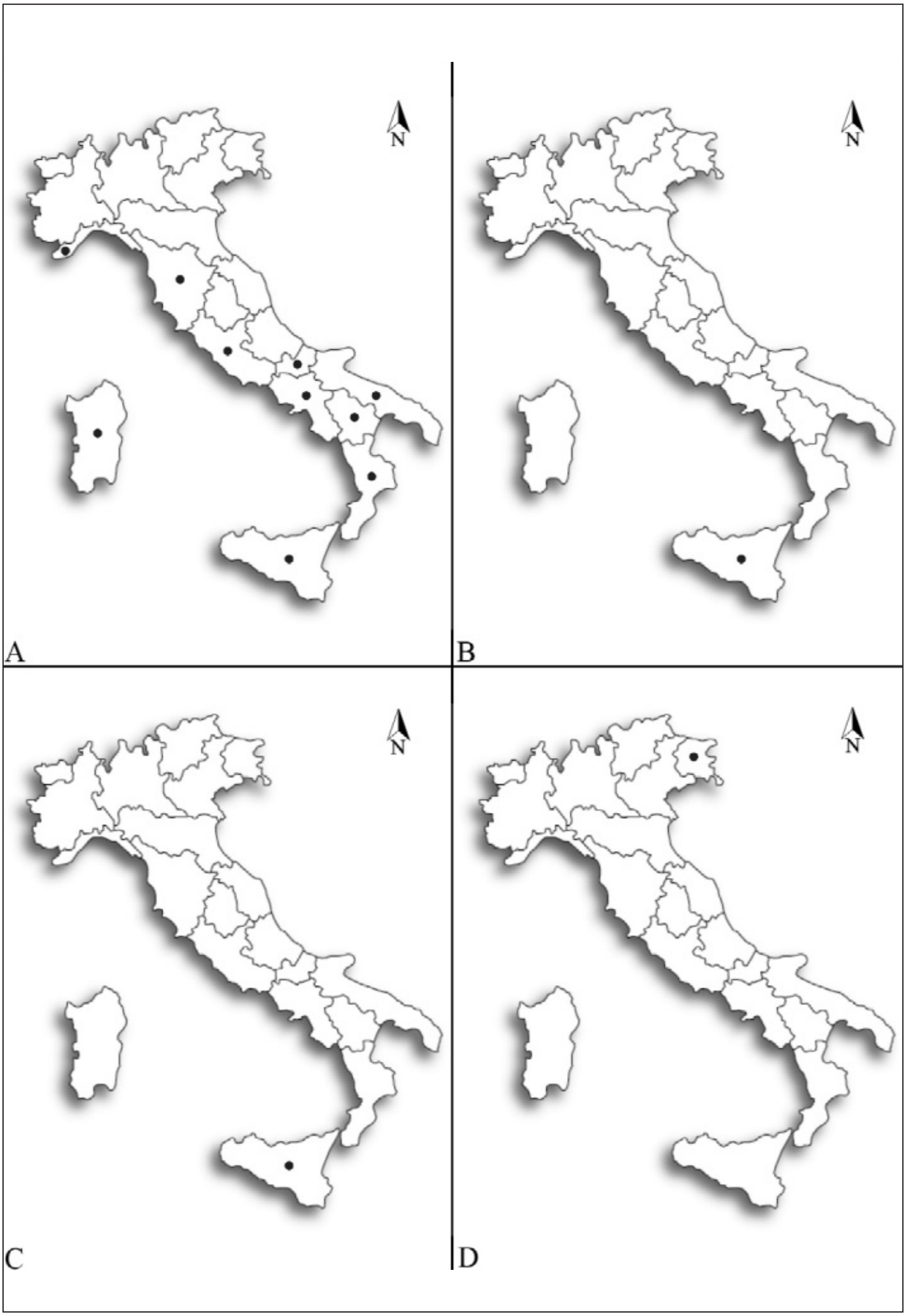

Fig. 3. **A.** *Pleurotus eryngii* var. *ferulae*; **B.** *P. eryngii* var. *thapsiae*; **C.** *P. nebrodensis*; **D.** *P. ferulaginis*.

The main period of fructification is from summer to autumn. In winter the appearance of basidiomes is less frequent and then it resumes in early spring. *P. eryngii* var. *thapsiae* is an infrequent species currently reported only from Sicily, on root residues of *Thapsia garganica* L., in pastures on calcareous soils, at an altitude of 0-1500 m a.s.l. *Pleurotus nebrodensis*, a rare species at risk of extinction (Rossi & al. 2014), growing in Sicily in arid pastures, is associated only with *Prangos ferulacea* (L.) Lindl. and its fructification period is restricted from the middle of April to the first ten days of June. Recently many reports of *P. nebrodensis* in Italy were re-identified as *P. eryngii* var. *elaeoselini*, a taxon with a much wider distribution in Europe than was previously assumed (Chinan & Venturella 2012).

Systematic arrangement and descriptions of taxa

The first references on the systematics of the genus *Pleurotus* in Italy are attributed to Saccardo (1915) and Baglietto (1972). Saccardo provided a systematic arrangement based on the position of the cap compared to the stipe. In particular, the species of *Pleurotus* were distinguished in three main groups: resupinate, dimidiate (shield-like) and, excentric. The systematic arrangement proposed by Baglietto was based instead on the ecology of the species with a clear separation between lignicolous species and the species growing on dead roots of plants of the family *Apiaceae*.

A modern systematic arrangement was recently proposed for *Pleurotus* taxa, including those growing in Italy, and new taxa were described and new investigations have been carried out by combining the traditional identification techniques with molecular analysis (Zervakis & al. 2014).

In this paper we propose new descriptions for the species of *Pleurotus* growing in the Italian territory based on the most distinctive-discriminating eco-morphological characters:

Lignicolous fleshy species, saprotrophs or weak parasites, on living and dead trunks, deciduous and coniferous trees, solitary, imbricate, gregarious, in large clusters or in small groups.

Pleurotus calyptratus

Pileus 4-11 cm, hygrophanous grayish-blue, grayish-brown to brown, then beige to light beige, cream to almost white, convex or semicircular to kidney-shaped then circular. Cuticle smooth, silky-fibrillose, slightly viscid. Veil fleeting. Lamellae thin, crowded, decurrent to the top of the stipe, entire, without anastomoses but with numerous lamellulae and often forked, at first white then cream to light beige. Stipe absent, rudimentary or lateral. Trama homogeneous. Basidiospores cylindric to elliptic, thin-walled, with a small and broad apiculus, containing yellow oily drops and granules, 10.0-15.5 × 4-5.5 µm. Solitary or in small groups, on dead fallen trunks of *Populus tremula*.

Pleurotus cornucopiae

Pileus 4-15 cm, cream to pale yellowish brown, ivory sometimes grayish, convex, smooth to velvet-like centre, circular to kidney-shaped, distinctly depressed at the centre in mature specimens, with inrolled margin. Cuticle smooth, slightly viscid. Lamellae thin,

Fig. 4. *P. calyptratus* on fallen trunks of *Populus tremula* (Photo M. Floriani).

Fig. 5. *P. pulmonarius* on wood of *Sorbus aucuparia* (photo M. Donnini).

wide, crowded, deeply decurrent up to the base of the stipe, with conspicuous anastomoses below. Stipe 3.0-11.0 × 1.0-2.5 cm, central to eccentric, rarely almost lateral, broader at top. Basidiospores 7.0-11.5 × 3-5.5 µm, subcylindric to ellipsoid, thin-walled. Imbricate often in large clusters with several pilei, on stumps and trunks of different broad-leaved trees.

Pleurotus dryinus

Pileus 4.5-16 cm, cream to light or darker gray, convex to cap-shaped in unripe basidiomes then plane. The margin inrolled when young, hung with partial veil remnants. Cuticle dull, fibrillose-tomentose, squamose in ripe basidiomes. Lamellae white then cream-colored to yellowish. Stipe eccentric, 2-6.5 × 1.5-4 cm. Trama homogeneous. Basidiospores cylindric to cylindric-elliptic, smooth, hyaline, with drops, 9.8-14.0 × 3.8-4.2 µm. Solitary to imbricate, in forests and parks, on living trunks of broad-leaved trees.

Pleurotus ostreatus

Pileus 4-20 cm, lingulate to spatulate, convex then conchate to hemicircular or flabellate. Cuticle smooth, dull silky, very variable in color from cream-beige to lilac-blackish. Lamellae whitish to cream, decurrent. Stipe rudimentary, laterally attached. Hymenophoral trama not completely irregular, thin-walled, 2.5-4-2 µm diam. Basidiospores broadly elliptic, smooth, hyaline, 6.2-8 × 4-6.5 µm. Solitary to gregarious, in forests and parks, on stumps, fallen trunks and living broad-leaved trees.

Pleurotus pulmonarius

Pileus 3-11, convex then flat, spathulate to kidney-shaped. Cuticle light brown, beige-brown, beige-buff, orange-brown, margin inrolled. Lamellae thin, crowded, decurrent to the top of the stipe and often intervenose along its entire length, with rare anastomoses, white to cream to ivory. Stipe absent or short, 1.5-2.0 × 2-4 cm, eccentric to lateral cylindrical to connate. Hymenophoral trama completely irregular, with clamped sclerified hyphae, 5.2-7.8 µm diam. And thin-walled hyphae 3.5-10.4 µm diam. Basidiospores 7.5-14.5 × 2.5-5.0 µm, subcylindrical to cylindrical to bacilliform, thin-walled. Solitary or usually in clusters and groups, on trunks, stumps and logs of various deciduous trees.

On trunks of Agavaceae *and on the fiber of fallen cladodes* of Cactaceae

Pleurotus opuntiae

Pileus 5-15 cm, sub-globose then shell-shaped. Cuticle smooth, thin, white, cream, yellowish in ripe basidiomes: Lamellae white-cream, narrowed, decurrent, with numerous lamellulae. Stipe 1.5-3 × 1.0-1.5 cm, lateral, hard, white and felted. Basidiospores 7.5-10 × 3-5.5 µm, oval and elongated. Solitary or in clusters, on fiber of fallen cladodes of *Opuntia ficus-indica* and on trunks of *Agave americana* and *Yucca elephantipes*.

Associated with plants of family Apiaceae

Pleurotus eryngii* var. *eryngii

Pileus 5-15 cm, fleshy, convex then depresse, brown to red-brown, warm brown, light beige to beige-brown. Cuticle velvety, pruinose, with pigments and terminal club-like cells. Lamellae decurrent, cream to light beige, anastomoses at stipe. Stipe 2.0-4.0 × 1.0-3.0 cm, central to eccentric. Basidiospores 9.0-13.5 × 4.5-6.5 µm, cylindric-elliptic, smooth, hyaline, with drops. Basidiomes appearing from autumn to late winter, occurring mostly in groups, from 0 to 1500 m, in pastures and sandy shores, on limestone soils. Associated with *Eryngium campestre* and *E. maritimum*.

Pleurotus eryngii* var. *elaeoselini

Pileus 5-15 cm, fleshy, convex then flat, whitish to white-cream, sometimes light beige, with alutaceous tones. Cuticle smooth, thick, velvety, opaque, lacerated in small appressed areolae. Lamellae deeply decurrent, whitish to pale yellow. Stipe 4.0-8.0 × 1.0-3.0 cm, central to eccentric, radicating. Basidiospores 10.0-14.0 × 5.2-7.0 µm, cylindric-elliptic, smooth, hyaline, with drops. Basidiomes appearing in spring and autumn (March-May, October-November), occurring mostly in clusters, from 0 to 1200 m, in pastures and meadows, on limestone and silicaceous soils. Associated with *Elaeoselinum asclepium* subsp. *asclepium*, *Laserpitium latifolium* and, *L. siler*.

Pleurotus eryngii* var. *ferulae

Pileus 5-25 (-30) cm, fleshy, convex then flat, dark brown to chestnut brown to grey brown. Cuticle with innatae fibrillae, thick, velvety, pruinose, heavily pigmented. Lamellae decurrent, cream to light beige, anastomoses at stipe. Stipe 3.0-10.0 × 1.0-4.0 cm, central to eccentric. Basidiospores 9.6-13.8 × 4.5-7.0 µm, cylindric-elliptic, smooth, hyaline, with drops. Basidiomes appearing almost all year round, from 0 to 1200 m, in garrigues, pastures and meadows, on limestone, silicaceous and, volcanic soils. Associated with *Ferula communis*.

Pleurotus eryngii* var. *thapsiae

Pileus 3-5 cm, fleshy, convex, dark brown to warm brown. Cuticle with scattered squammules, thin, with pigments, velvety, pruinose. Lamellae deeply decurrent, grayish white, anastomoses at stipe. Stipe 3.0-5.0 × 1.0-3.0 cm, central. Basidiospores 9.6-13.8 × 4.5-7.0 µm, cylindric-elliptic, smooth, hyaline, with drops. Basidiomes appearing in spring and autumn (March-May, October-November), from 0 to 1500 m, in garrigues, pastures and meadows, on limestone and silicaceous soils. Associated with *Thapsia garganica*.

Pleurotus ferulaginis

Pileus 3-15 cm, fleshy, circular to kidney-like with wavy edges and often inrolled margin, fleshy, convex then almost flat and later infundibuliform, white to cream to ivory to light brown to beige-brown to beige-buff to warm brown to brown. Cuticle smooth, then often unevenly fibrillose or with small brown squamules towards the outer half. Lamellae crowded, thin, entire, broad, and dense, decurrent to the top of the stipe, without anastomoses, white to cream to ivory. Stipe 2.5-10.5 × 1.0-3.0 cm, central and rarely subcentral, robust, cylindric to spindle-shaped and often rounded towards the base, white to cream to ivory. Basidiospores 11.0-16.0 × 4.0-6.0 µm, cylindrical to bacilliform, smooth, thin walled, hyaline, with one or more drops. Basidiomes appearing singly or in small groups, in May and June, from 0 to 700 m, in meadows, on limestone and silicaceous soils. Associated with *Ferulago campestris*, distribution restricted to NE Italy.

Pleurotus nebrodensis

Pileus 4-20 cm, fleshy, convex, white-cream to white ochraceous with alutaceous tones. Cuticle smooth, cracked in ripe basidiomes, thin, velvety, opaque. Lamellae deeply decurrent, whitish to pale yellow. Stipe 4.0-9.0 × 2.0-4.0 cm, central to eccentric, radicating, with a small reticulum at stipe. Basidiospores 12.2-17.4 × 5.5-8.2 µm, cylindric-elliptic, smooth, hyaline, with drops. Basidiomes appearing usually singly during spring or early summer, in altitudes from 1200 to 2000 m, in pastures of *Prangos ferulacea* on limestone soils. Distribution restricted only to Sicily.

Discussion and Conclusions

The *Pleurotus* species show an high level of diversity in the Italian territory. Some *Pleurotus* species (i.e. *P. ferulaginis*, *P. nebrodensis*) are endemic to restricted territories of southern regions some others are organisms of significant importance not only for the crucial roles they undertake in nature but also for many human activities that are strictly dependent on them. As white-rot fungi *Pleurotus* species are actively involved in wood decomposition, as weak parasites and saprotrophs they actively degrade the herbaceous plants residues while as edible mushrooms are also involved and/or exploited in forestry, pharmaceutical industry and food production. Furthermore, some *Pleurotus* species for their valuable organoleptic qualities are much appreciated by mushroom hunters. In addition, most of these species are suitable for cultivation and can be proposed to farmers as an alternative to traditional crops nowadays unprofitable. Apart from *P. ostreatus* that is already cultivated throughout the Italian territory and has an economic importance equal to that of champignon, a rapid spread, especially in southern Italy, is having the cultivation of “cardoncello” mushrooms (*P. eryngii* var. *eryngii*) (Venturella & al. 2015b). Tests of cultivation were also carried out in Sicily on other *Pleurotus* saprotrophs species such as *P. eryngii* var. *elaeoselini*, *P. eryngii* var. *ferulae* and, *P. eryngii* var. *thapsiae* and in other regions (Basilicata, Piedmont, Friuli Venezia Giulia) on the lignicolous *P. cornucopiae* (Venturella & Ferri 2001). Also *P. nebrodensis* is a potential cultivated species but most of the fungal strains currently available for cultivation are referable to *P. eryngii* var. *elaeoselini* and therefore they require a more precise morphological and genetic characterization (Venturella & al. 2015c). Recently some *Pleurotus* species were also tested for their anticancer and antibacterial activities (Schillaci & al. 2013). For all the reasons mentioned above we believe that the modern descriptions of *Pleurotus* taxa growing in Italy here reported is appropriate in order to provide an easier field identification by mycologists and mycological amateurs and for a more precise identification of fungal strains for molecular analysis and medicinal uses.

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Occasional Papers from the Herbarium Greuter – No 2

Werner Greuter

Roxburgh's *Cynoglossum marifolium* (*Boraginaceae*) – reassessment and typification of a long forgotten name[1]

Abstract

Greuter, W.: Roxburgh's *Cynoglossum marifolium* (*Boraginaceae*) – reassessment and typification of a long forgotten name. — Fl. Medit. 25 (Special Issue): 157-166. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

Cynoglossum marifolium was described and validly named in 1824, in a posthumous publication of Roxburgh. Clarke in 1885 unaccountably relegated it to the synonymy of *Heliotropium marifolium* Retz., where it has since remained, even though the original description forbids such placement. No original specimen is known to exist, but an original watercolour drawing inscribed "*Cynoglossum marifolium* R.", commissioned by Roxburgh from an unknown Indian artist, was recently offered for sale and has been acquired for the Palermo Herbarium (PAL-Gr). It is here designated as lectotype. An almost identical drawing exists at Kew. Roxburgh's plant's correct identity is *Bothriospermum marifolium* (Roxb.) DC., a species that has so far been confused with the closely related *B. zeylanicum* (J. Jacq.) Druce.

Key words: *Heliotropium marifolium*, *Bothriospermum zeylanicum*, Roxburgh, lectotypification.

Introduction

When nomenclaturally and taxonomically reassessing *Cynoglossum* sensu lato with a view to establish a complete inventory of names and taxa (Hilger & al. 2015), one of the problems that surfaced was the identity of *Cynoglossum marifolium* Roxb., a name all but unused in recent botanical literature. We found that Catalogue of Life (http://www.catalogueoflife.org/col/), in its dynamic catalogue, treats it as a synonym of *Heliotropium marifolium* Retz., member of a different subfamily if not family – a disposition that appeared to be incompatible with Roxburgh's solid botanical reputation. I decided to take a closer look at the case and, chance assisting, have been able to solve it and confirm Roxburgh's credibility. The details are the subject of the present note.

Historical digest

William Roxburgh (3 Jun 1751 to 18 Feb 1815), British botanist of Scottish origin, stands foremost among the fathers of (East) Indian botany. Aged just 15 he set out on his

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[1] Dedicated to my illustrious friend Francesco Maria (Franco) Raimondo on the occasion of his seventieth birthday.

first travel to India, on a ship of the East India Company (EIC). In alternation with his studies of botany and medicine at Edinburgh University, he completed several voyages to India until he settled there in 1776, initially to work as a surgeon in Madras (Chennai) but never neglecting his botanical interests. In the early 1780s he founded and ran an experimental botanical garden at Samalkot (Samarlakota), sharing his time between botanical studies in the field and the introduction and multiplication of foreign useful plants. This qualified him for the post of naturalist in the Madras Presidency, which he obtained in 1790. Three years later he was appointed superintendent of the Royal Botanic Garden in Calcutta (Kolkata, West Bengal) and moved from the south of India to the country's north-eastern edge. Plagued by ill health, which forced him twice to take breaks for recovery in South Africa and Britain, he left India for good in 1813, spending 10 months on St. Helena Island on his way back (Beatson 1816: 295), to die in Edinburgh in February 1815, half a year after his final return home (Desmond 2004; see Desmond 1992 for additional information).

During his Indian stay of close to a lifetime, Roxburgh collected and studied assiduously the country's flora but published relatively little. His only major work were the "Plants of the coast of Coromandel", published in 3 volumes (12 parts) over a time span of 25 years (Roxburgh 1795-1820) under the care of Sir Joseph Banks, the three last parts posthumously. When Roxburgh finally left India he entrusted the manuscript of his catalogue of the Calcutta botanic Garden as well as a copy of his to-be "Flora Indica" to a friend: the Baptist missionary William Carey, who little by little managed to have them printed. The catalogue came out first, still during its author's lifetime, under the title "Hortus bengalensis" (Roxburgh 1814). One third of the Flora followed, in two volumes (Roxburgh 1820, 1824), with many added contributions by Nathaniel Wallich, botanist of Danish origin who had succeeded Roxburgh as superintendent of the Calcutta Garden. Finally, the complete "Flora Indica" (Roxburgh 1832), from which the Wallich additions had been expunged, was published in three volumes – bar the cryptogams, which had to await publication a dozen years more.

The first half of Roxburgh's Indian activities took place in the Madras Presidency in the south-east of the subcontinent, to which the Coromandel Coast belongs. Roxburgh soon started to write up descriptions of the native species available to him, numbering them sequentially as the work proceeded; a habit that he maintained faithfully after his move to Bengal. A Roxburgh manuscript at Kew has the descriptions arranged in their original numerical sequence, which obviously reflects chronology. These descriptions served as the basis for Roxburgh's treatment in the Flora itself (manuscript at BM), allowing for the fact that "sometimes … the published account is much abbreviated from that in the MS" (Sealey 1957).

Roxburgh did of course collect specimens of the plants he described, but seems not to have attached the same value to voucher material as other botanists. He did not apparently build a herbarium of his own, and indeed, "very few of Roxburgh's specimens are to be found in the Calcutta Garden at present" (Anonymous 1964: 2). Instead, he "distributed specimens freely, but does not appear to have kept a set for himself… Moreover, Roxburgh specimens are often poor and scrappy" (Sealey 1957; Sealy also provides information on several specimen sets known to him, with their present and former whereabouts).

The unique feature in Roxburgh's way of working is the importance he attached to the pictorial record of the plants he described. "At the same time that he wrote his description, he nearly always had a life-size painting of the plant … made by a native artist. In all he described about 2,600 species and had paintings made of more than 2,500 of them" (Sealy 1957). He availed himself of the skilled services of an unknown number of Indian artists of cryptic identity, trained and supervised by him. The illustrations were given numbers matching those of the concomitant descriptive text. Most of these illustrations exist in two or more near identical versions, done in parallel or (more likely) copied one from the other, but in essence all are originals, as it is not possible to tell with certainty which version is the earliest. It is often assumed (e. g. by Clarke 1874; Sealey 1957; Anonymous 1962) that the set housed in Calcutta comprises the originals and other sets consist of copies, but this is an unwarranted assumption, not only in view of the above considerations but also because it is sensible to assume that the version judged to be best (which need not be the earliest) was chosen for the "original" set.

The Calcutta set is stated to comprise 2,533 plates measuring about 44 × 29 cm, bound in 35 volumes (Anonymous 1964). Clarke (1874) mentions "plants 2,542 in number" – the slight difference being perhaps due to the presence of plates on which more than one plant is represented. Presumably due to the unfavourable conditions of the Bengal climate, the Calcutta plates have deteriorated to some extent: the colour of the paper "has deteriorated considerably", having become "somewhat yellowish and often foxed"; and the colouring of the plates has also deteriorated, "having become dim or dull with age" (Anonymous 1964).

What has been considered a "duplicate set" was sent to the East India Company and is now kept at Kew. It comprises 2,512 numbered plates of drawings – only 69 less than the number of descriptions. Their inventory has been published by Sealey (1957; Sealy also refers to the fate and location of several other runs of Roxburgh plates that are known to exist). All can be admired on the apposite Website of Kew Gardens (Anonymous 2006), funded by the A. W. Mellon Foundation, which also brings much additional information on Roxburgh and his work.

Only part of the Roxburgh plates, this unique pictorial monument so eminently useful for the interpretation of Roxburgh's species (many of which were first described and named by him), has been published in print. Exactly 300 plates were included in Roxburgh's (1795-1820) "Plants of the coast of Coromandel"; about 400, re-drawn, were used to illustrate Wight's (1844-1853) "Icones"; and 201, slightly reduced in format and drawn anew from the originals, appear as colour prints in the "Icones Roxburghianae" (Anonymous 1964-1978), a serial publication that was unfortunately discontinued long before the self-set goal, to make public the illustrations of "all the species described by Roxburgh in his *Flora Indica* as new" (Santapau in Anonymous 1964), was attained. Allowing for some duplication, this corresponds to approximately one third of the total number of the known, numbered illustrations.

***Cynoglossum marifolium* and its fate**

In Roxburgh (1814: 13), where *Cynoglossum marifolium* first appears, it is a nomen nudum for a not yet described, diffuse annual species found by Roxburgh's son William ("Mr. W. R."; see Desmond 2004) at Chittagong (Bangladesh) and cultivated since 1801 in the Calcutta Garden. Its original description (in Roxburgh 1824: 8; repeated identically in Roxburgh 1832, 1: 457-458) runs as follows:

Annual, diffuse. *Leaves* bifarious oblong, hairy. *Flowers* solitary between the leaves; *corol* half the length of the calyx; *seed* round, rough.

A native of the eastern parts of Bengal; flowering time the cold season; soon after which the seed ripens, and the plants perish.

Root annual.—*Stem* none, but several, ramous, slender, round, hairy branches spread on the ground.—*Leaves* alternate, bifarious, subsessile, elliptic, hairy underneath; half an inch in length, and about half that in breadth.—*Flowers* axillary, or between the leaves, short-peduncled, solitary, very small, of a pale whitish blue.—*Calyx* five-leaved; leaflets lanceolate, hairy on the outside, nearly twice as large as the corol.—*Corol,* the tube very short, the *throat* contracted by five emarginate scales alternate with the stamens.—*Filaments* short; *anthers* large, half hid in the mouth of the tube of the corol.—*Style* short, clavate; *stigma* emarginate.—*Seeds* rough, round, almost hid in the calyx, affixed to a very short columnar receptacle.

Subsequent authors mentioning *Cynoglossum marifolium* found little to add. Don (1837-1838: 353), who accepted the species, used a shortened version of the original description. The Candolles (in Candolle 1846: 116), also relying entirely on Roxburgh's description, tentatively transferred the species to *Bothriospermum* Bunge as *B. marifolium* (Roxb.) DC. & A.DC. None of them, nor any later author as far as I am aware, saw an original specimen, and it is doubtful whether any ever existed.

Clarke (1885: 152) held a completely different view. He assigned *Cynoglossum marifolium,* with *Bothriospermum marifolium,* to the synonymy of *Helotropium marifolium* Retz., member of a different subfamily if not family. He did not mention the reasons for such change, nor did he claim to have examined any original Roxburgh element, but blandly asserts: "Anthers ovate with linear twisted tips (as in allied species) described by Roxburgh as 'scales' between the corolla lobes which error has misled A. DC." The authority of Clarke has since prevailed and his conclusion has not been challenged. The Catalogue of Life (Anonymous 2015) still accepts synonymy of *C. marifolium* with *H. marifolium*.

Clark's assessment left me nonplussed. After all, Clarke himself (1874: v) had professed his admiration of Roxburgh, qualifying his work as "excellent" and his species as "well conceived". He even wrote (l.c.), to shame some of Roxburgh's detractors: "many … of his species have been impertinently reduced by various hands to well-known species (themselves described by Roxburgh) on the assumption that Roxburgh had made two species out of one, the true explanation being that Roxburgh's second species was unknown to the man who reduced it as a mere synonym". So, when Clarke himself, a decade later, took very similar action he must, one supposes, have had very solid reasons. Accusing Roxburgh to have mistaken apical anther appendages for "emarginate scales alternate with the stamens" [not with the corolla lobes!], and, by implication, bracteate flower spikes with "solitary flowers, axillary, or between the leaves", is pretty harsh. The obvious assumption was that Clarke, then still based at Calcutta and familiar with the Roxburgh plates there, must have seen a Roxburgh illustration of *Cynoglossum marifolium* that in fact represented the heliotrope.

The Roxburgh watercolour

Searching for illustrations of *Cynoglossum marifolium* on the Internet, much to my surprise I came across an offer for sale of a Roxburgh original, made in the following terms: “A superb original watercolour drawing of *Cynoglossum marifolium* Roxburgh, a small delicate plant, with detailed vignette of the flower and seed, captioned in pencil; by an unnamed local Indian artist, commissioned by William Roxburgh. Single leaf, wove paper watermarked J. Whatman (sheet size: $16\frac{4}{8} \times 10\frac{6}{8}$ inches).” That sheet (Fig. 1) was purchased at my behest by the Foundation Herbarium Greuter. It has been incorporated as accession No. 62676 into the Greuter Herbarium in Palermo (PAL-Gr), to serve as the **lectotype (designated here) of the name *Cynoglossum marifolium* Roxb.** A high-resolution digital image has been placed online at the Website of the Herbarium Mediterraneum Panormitanum (http://147.163.105.223/zoomify/view_img.asp?ic=62676_GR).

The leaf is one of a set of 75, kept disbound in a modern clamshell case. The set was auctioned by Christie’s London on 31 Oct 1991, as lot 226, and acquired by W. G. Arader of New York. Some of the plates have the red ink library stamp of the East India Company on the verso. The present one shows traces of an erased such stamp, with its oval red outline still visible. It is therefore a safe assumption that the set consists of plates that had at one time been considered as surplus duplicates by the East India Company (or their successors) and, by consequence, placed on sale. The J. Whatman watermark is incomplete and does not show the date (if it ever had one), but there is no reason to doubt that the plate was part of the original consignment sent by Roxburgh to London, presumably in 1803 (see below). The techniques and materials used by the artists working for Roxburgh are described in Anonymous (2006), in the chapter “The Roxburgh artists”.

The PAL-Gr plate is captioned “*Cynoglossum marifolium* R.” in pencil, in Roxburgh’s handwriting (see, for comparison, Van-Steenis Kruseman 1950: CLI, and Steinberg 1977: 14). It does not bear the sequential number [1348] of the description to which it belongs, but instead a small, pencilled number (100 or 10a) in a different hand, the signification of which is unknown. One of several decumbent stems is shown, connected to the root and with the remaining stems and lower branches cut off, the whole in life-size, as is normal for Roxburgh’s plates. The details however are enlarged (contrary the general rule for “dissections”, if Sealey 1957: 301 is correct): the fruiting calyx enclosing the base of the globular fruit, with its four mericarps, about 2×; the opened flowering calyx, showing the pistil, and on its right the flattened-out corolla from within, both about 5×.

The Kew set of Roxburghian drawings includes an exact match of the Palermo plate. It is captioned in ink, at the right margin, “1348 *Cynoglossum marifolium* R.”, also in Roxburgh’s handwriting but in a neater script. As to the drawing itself the two versions are almost indistinguishable. Their date of origin can be placed between 1801 (year of introduction into the Calcutta Botanic Garden, according to Roxburgh 1814: 13) and 1803[-1804], when drawing No. 1463 was sent to London (Sealey 1957: 300, footnote).

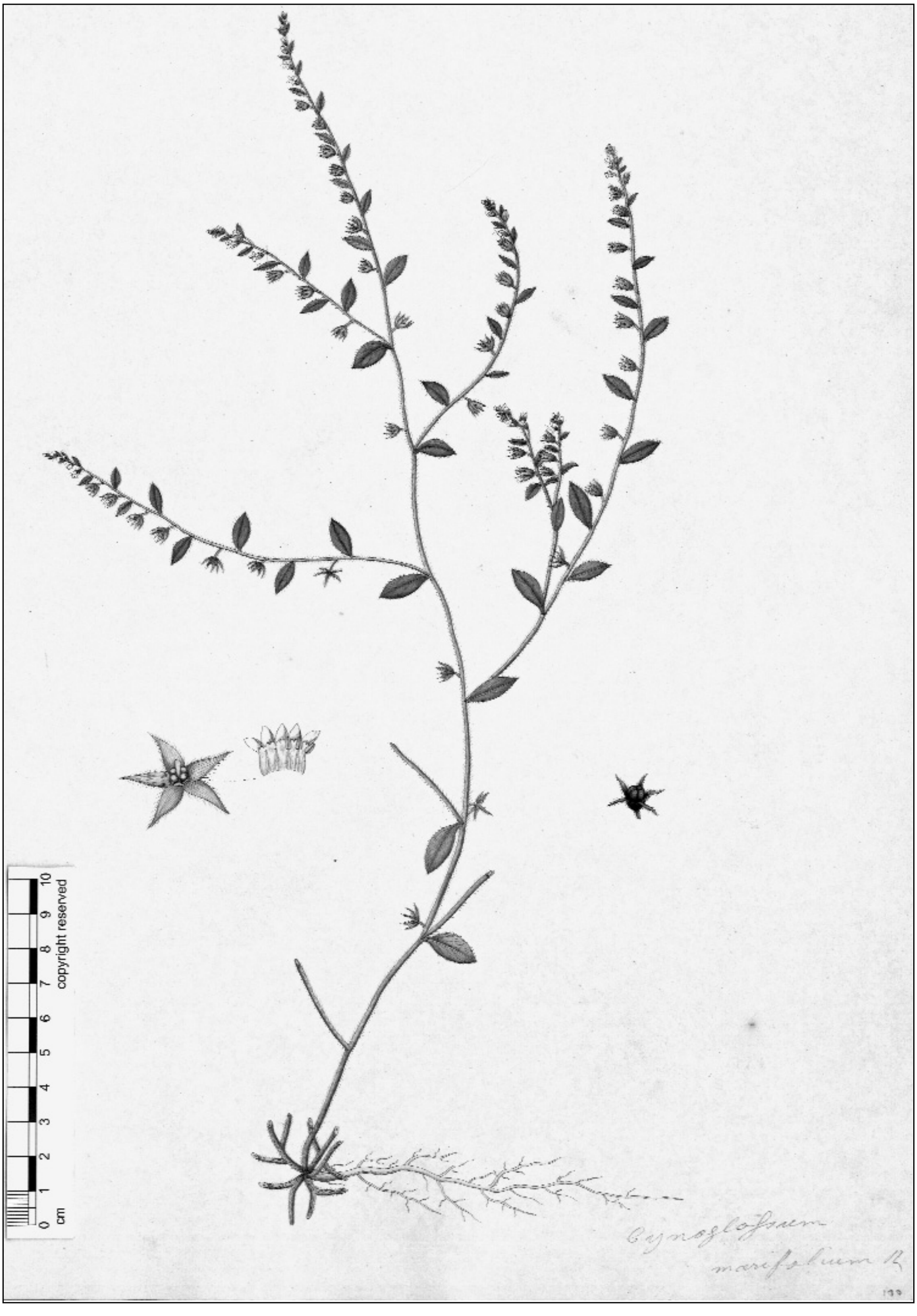

Fig. 1. Lectotype of *Cynoglossum marifolium* Roxb. (PAL-Gr No. 62676). Scanned from the original by R. Rankin Rodríguez.

The taxonomic identity of *Cynoglossum marifolium*

The plate is in good agreement with Roxburgh's original description of the species. In particular it shows single flowers spaced along the branches, alternating with or ± opposite to the leaves (none is axillary); and emarginate scales alternating with the stamens in the throat of the corolla (Fig. 2a). How Clarke came to attribute the features of *Heliotropium marifolium* (Fig. 2c) to this plant remains a mystery: the blame he placed on Roxburgh and the younger Candolle falls back on himself.

The described and depicted features leave no doubt as to generic affiliation. The Candolles (in Candolle 1846) were correct in placing *Cynoglossum marifolium* in *Bothriospermum.* At this point, however, certainty ends: Roxburgh (1824) described two *Cynoglossum* species, *C. marifolium* and *C. diffusum* Roxb., both of which belong in *Bothriospermum;* but only one species of that genus is currently believed to occur on the Indian subcontinent: *B. zeylanicum* (J. Jacq.) Druce, of which the more widely used *B. tenellum* (Hornem.) Fisch. & C. A. Mey. is a synonym. The Candolles already considered *C. diffusum* a synonym of *B. tenellum* (i.e., *B. zeylanicum*), and they are probably correct. Where, then, is *B. marifolium* to be placed?

Roxburgh recognised two species and saw both alive, growing side by side in the Cacutta Garden. He distinguished them as follows: *Cynoglossum diffusum* has petiolate lower leaves; small, white flowers with a tinge in the throat; stamens hidden in the "gibbous" [inflated] corolla tube; and obovate mericarps affixed "by the base, and on the inside to the stigma"; whereas *C. marifolium* has [all] leaves subsessile; pale whitish blue flowers; stamens alternating with the scales and large anthers hidden only for one half in the mouth of the corolla tube; and round mericarps partly hidden in the calyx and affixed to a very short columnar receptacle.

Of these alleged differences I discount flower colour, because it is contradicted by the illustrations: in both versions of the *Cynoglossum marifolium* plate (1348) the corolla is shown as white with a yellowish throat, whereas in the Kew image of the *C. diffusum* plate (1211; see Anonymous 2006) the corolla is whitish blue. Whether this is due to variability of the character or to colour being accidentally switched between the descriptions I cannot tell. The difference in the lower leaves is borne out by the plates but may well lie with-

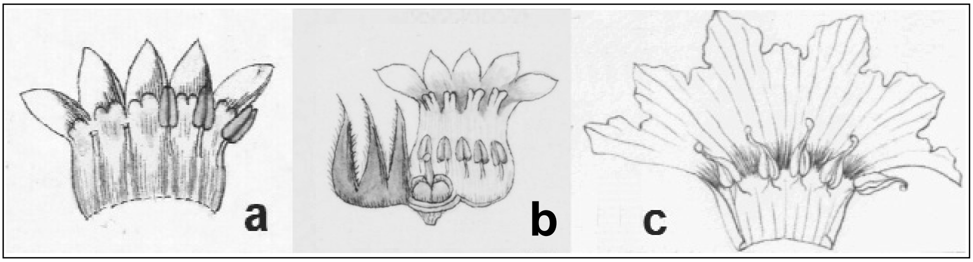

Fig. 2. Details showing flattened-out corollas from the inside (not to scale). – **a,** *Cynoglossum marifolium* (from the lectotype); **b,** *Cynoglossum diffusum* (from the Roxburgh plate No. 1211, K: Anonymous 2006 [© Copyright The Board of Trustees of the Royal Botanic Gardens, Kew]), including pistil and part of calyx; **c,** *Heliotropium marifolium* (reproduced from Wight 1844-1853: pl. 1390. 1848).

in the range of variation of a single species. Mericarp attachment is an important character but is not described in clear, comparable terms and cannot be observed on the illustrations, where the main difference shown is the enclosure of the proximal half of the fruit in the calyx, in *C. marifolium.*

The difference of size, insertion and position of the stamens, however, is quite clear (Fig. 2a and 2b). *Cynoglossum diffusum* has filaments inserted near the base of the corolla tube, with anthers half the size of those of *C. marifolium,* situated halfway up the obese tube and not reaching the base of the scales; whereas the anthers in *C. marifolium,* sitting on longer filaments inserted toward the middle of the cylindrical tube, are placed at the same level as the scales which they exceed by their tips, becoming part exserted. The latter situation conflicts with the published generic and species descriptions of *Bothriospermum* as a whole and, if found to be constant within populations, would well justify acceptance of two species in Bengal.

Bothriospermum is currently believed to consist of one widespread species, *B. zeylanicum,* plus half a dozen narrow endemics of China and Korea (Zhu & al. 1995, Anonymous 2014). *B. zeylanicum* itself is extremely polymorphic, and a critical revision will probably result in the recognition of several discrete taxa. As a first step, I would like to encourage Bangladesh botanists to reassess the taxonomy of the Bangladesh populations of *Bothriospermum,* bearing Roxburgh's two-centuries-old observations in mind. In the most recent floristic digest of their flora, Khatun (2008) describes a single species under the name *B. tenellum,* in terms that are compatible with Roxburgh's *Cynoglossum diffusum* (and with *B. zeylanicum*), with a colour photograph showing two quite different plants of which only the left one corresponds to the taxon described.

Meanwhile, I propose that *Bothriospermum marifolium* (Roxb.) DC. & A. DC. be considered as the correct name of an insufficiently known and documented species endemic to Bangladesh.

Acknowledgements

I am indebted to Ms Kate Hunter of the rare book department of Arader Galleries, New York, for useful information on William Roxburgh and the plant illustrations that were made under his care, and for providing details on the acquisition of the Roxburgh watercolours by W. G. Arader. Thanks are due to Ms. Lynn Parker, Kew, for providing the plate from which Fig. 2b was taken.

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Life forms, life strategies and ecological indices of bryophytes for bioindication in wood areas: a case of study in the "Bosco della Ficuzza, Rocca Busambra, Bosco del Cappelliere e Gorgo del Drago" Oriented Nature Reserve (West Sicily)

Abstract

Dia, M. G. & Campisi, P.: Life forms, life strategies and ecological indices of bryophytes for bioindication in wood areas: a case of study in the "Bosco della Ficuzza, Rocca Busambra, Bosco del Cappelliere e Gorgo del Drago" Oriented Nature Reserve (West Sicily). — Fl. Medit. 25 (Special Issue): 167-178. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

Life forms, life strategies and ecological indices of bryophytes which live in evergreen and deciduous *Quercus* woods as well as in a *Pinus halepensis* artificial system within the "Bosco della Ficuzza, Rocca Busambra, Bosco del Cappelliere e Gorgo del Drago" Oriented Nature Reserve are analysed and compared. The study highlights that in the same local climatic conditions the *Quercus* and *Pinus* trees select different bio-ecological types in the bryophyte communities. They appear to be especially useful to detect physionomic-structural differences in the woods, integrating the information provided by the ecological indices.

Key words: Bryophytes, life forms, life strategies, bioindication, Sicilian woods.

Introduction

As bryophyte life forms and life strategies make it possible to bring together unrelated taxa on base of adaptive traits, they are known as functional types which provide better information of habitat conditions than species composition (Gimingham & Birse 1957). For this reason they have been studied by several authors in very different environments ranging from polar to tropical ones, to high-altitude (alpine and Mediterranean) habitats, to deserts (e.g. Longton 1988; Nakatsubo 1994; Frey & Kürschner 1991a, 1991b; Kürschner 1999; Kürschner & al. 1999; Puglisi & al. 2013a, 2013b, 2014).

In this work life forms, life strategies and ecological indices of bryophytes which live in evergreen and deciduous *Quercus* woods as well as in a artificial arboreal system within the "Bosco della Ficuzza, Rocca Busambra, Bosco del Cappelliere e Gorgo del Drago" Oriented Nature Reserve were analysed and compared. We wanted to evaluate the effects of the change in dominant tree species on adaptive ecological characters of bryophytes within the same forest area. The aim was to understand if at similar altitudes and in the same local climate conditions, bio-ecological types can provide further specific information, other than that of ecological indices, which express the climate and substrate requirements of taxa in their distribution range. Namely we wondered if life forms and life strategies, since their selection in a community mostly depends on the microenvironment types, can provide indication on physionomic-structural conditions of woods.

The Study area

The nature reserve "Bosco della Ficuzza, Rocca Busambra, Bosco del Cappelliere e Gorgo del Drago ", located in western Sicily, covers a total area of 7,397.49 hectares. After the great regional parks, it is the largest protected area of the island.

Morphology and hydrography of the area are significantly influenced by the presence of the great limestone massif of Rocca Busambra. In fact, it is the natural watershed of three important river basins of western Sicily: Belice Sinistro, San Leonardo and Eleuterio.

The reserve is part of the Apennine-Maghrebian chain and the geomorphological landscape is quite varied, including limestone formations, but also shales, clays, marls and quartzarenites (Gianguzzi & La Mantia 2004).

With reference to the climate the area is characterized by the following termotypes and ombrotypes: mesomediterranean (T = 13-16 ° C) with upper dry (P = 450-600 mm), lower sub-humid (P = 600-800 mm) or upper sub-humid (P = 800-1000 mm) ombrotypes; supramediterranean (T = 8-13 ° C) with upper sub-humid (P = 800-1000 mm) or lower wet (P => 1000 mm) ombrotypes (Gianguzzi & al. 2004).

Inside the reserve, different aspects of forest vegetation occur. The north side of the Rocca Busambra hosts: *Quercus ilex* L., *Q. suber* L., *Q. virgiliana* (Ten.) Ten., *Q. leptobalanos* Guss. and also the endemic *Q. cerris* var. *gussonei* Borzì woods.

Afforestation measures introduced mainly *Fraxinus angustifolia* Vahl., *Eucalyptus globulus* Labill., *Pinus halepensis* Mill. and *Castanea sativa* Mill.

The area is almost entirely subject to grazing activities.

Material and methods

The study focused on three different forest communities located in four sites in the Reserve. In particular, the surveys were conducted in two *Quercus ilex* woods, at Cima Cucco and Pizzo Nero, two *Q. leptobalanos* woods at Cima Cucco and Casa del Fanuso and at last in an artificial arboreal system with *Pinus halepensis* at Piano della Tramontana, on the northern slope of Rocca Busambra (Fig. 1).

The sites chosen are all located between 900 and 1100 m a.s.l. and have mesomediterranean upper sub-humid climate. The lithologic substrate ranges from Numidian Flysch of Casa del Fanuso to limestone-dolomite substrates of the other sites.

At each site the bryophyte flora was studied in three sample areas of about 150 m^2, away from forest edges, paths and water bodies.

For bioindication indices we referred to Hill & al. (2007), as regards the light, temperature, water, pH of the substrate and its content of nitrogenous salts. For each site, the mean

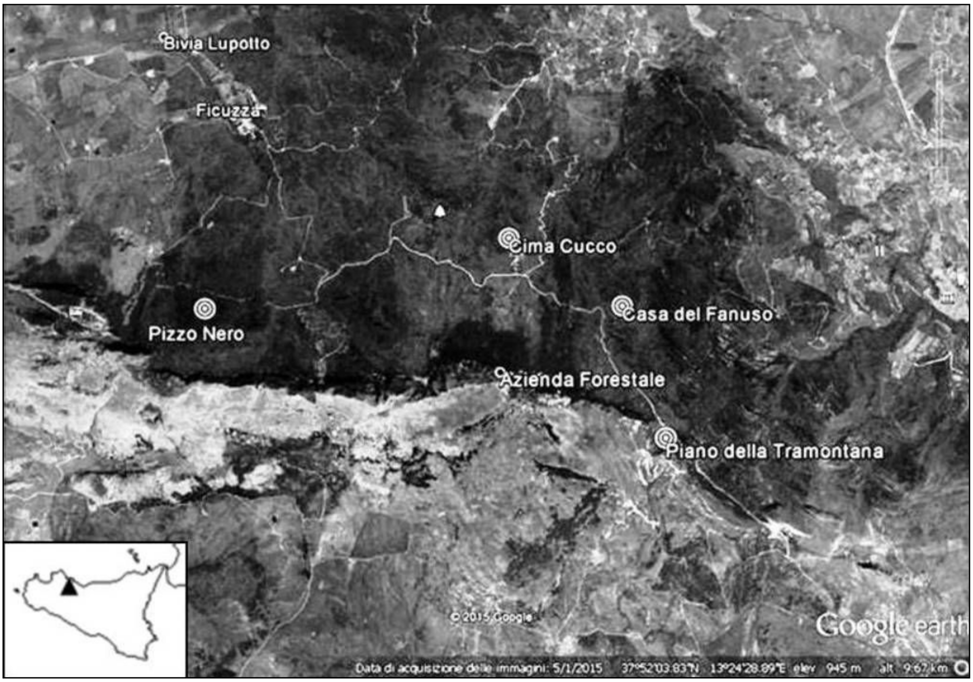

Fig. 1. Localization of the study sites.

values of indices ofthese five major ecological factors were calculated to draw radar diagram. Also life forms data have been drawn by Hill & al. (2007), while life strategies data (*sensu* During 1979, 1992) are those reported by Dierßen (2001).

In order to carry out synthesis evaluations life forms, short turf and tall turf were joined in the main category Turf, while "Mats, rough" and "Mats, smooth" have been grouped together in the category Mats.

Similarly, with reference to the life strategies, colonists and pioneer colonists were gathered in the category Colonists (C) and perennials, perennials competitive, stress-tolerant perennials and long lived shuttel were joined in the category Perennials (P).

The nomenclature of bryophytes, reported in Appendix 1, follows Ros & al. (2007) and Ros & al. (2013), while that of tracheophytes follows Giardina & al. (2007).

Results

Altogether 58 taxa were found (10 liverworts and 48 mosses) in the five studied sites (Table.1).

Bryophyte flora shows diverse consistence and taxa composition in different sites. The oak wood of Pizzo Nero has the richest flora (31 taxa), while the deciduous oak wood of Cima Cucco is among the studied sites one that has the lowest number of species (16). The number of taxa present in the artificial pinewood is rather high (20).

Table 1. List of taxa collected in the study sites.

	Dominant tree species				
	Pinus halepensis	***Quercus ilex***	***Quercus ilex***	***Qercus leptobalanos***	***Qercus leptobalanos***
	Locality				
Taxa	**Piano della Tramontana**	**Cima Cucco**	**Pizzo Nero**	**Cima Cucco**	**Casa del Fanuso**
Musci					
Aloina ambigua (Bruch & Schimp.) Limpr.	+				
Barbula unguiculata Hedw.	+				
Bartramia pomiformis Hedw.			+		
Brachythecium rutabulum (Hedw.) Schimp.	+	+		+	
Bryum dichotomum Hedw.	+				
Dicranella howei Renauld & Cardot	+		+		
Didymodon insulanus (De Not.) M.O.Hill					+
Didymodon luridus Hornsch.			+		
Didymodon sinuosus (Mitt.) Delogne			+		
Didymodon tophaceus (Brid.) Lisa	+				
Encalypta ciliata Hedw.			+		
Encalypta streptocarpa Hedw.		+			
Eurhynchium striatum (Hedw.) Schimp.		+			
Fissidens taxifolius Hedw.			+	+	
Fissidens viridulus var. *incurvus* (Starke *ex* Röhl.) Waldh.	+				
Grimmia lisae De Not.	+				+
Habrodon perpusillus (De Not.) LIndb.		+	+	+	
Homalothecium sericeum (Hedw.) Schimp.		+		+	+
Hypnum andoi A.J.E.Sm.		+			
Hypnum cupressiforme var. *lacunosum* Brid.	+	+	+	+	+
Hypnum cupressiforme Hedw.		+			
Hypnum cupressiforme var. *filiforme* Brid.				+	
Isothecium alopecuroides (Lam. *ex* Dubois) Isov.			+		
Leptodon smithii (Hedw.) F.Weber & D.Mohr		+	+	+	+
Leucodon sciuroides (Hedw.) Schwägr.	+	+	+	+	+
Nogopterium gracile (Hedw.) Crosby & W.R.Buck		+		+	
Orthotrichum affine Schrad. *ex* Brid.	+	+	+	+	+
Orthotrichum diaphanum Schrad. *ex* Brid.	+		+		
Orthotrichum lyellii Hook. & Taylor	+	+	+	+	+
Orthotrichum striatum Hedw.	+				
Orthotrichum tenellum Bruch *ex* Brid.	+				
Oxyrrhynchium praelongum (Hedw.) Warnst.			+		
Polytrichum juniperinum Hedw.			+		+
Pterigynandrum filiforme Hedw.		+	+		
Ptichostomum capillare (Hedw.) Holyoak & N. Pedersen	+	+	+	+	+
Racomitrium aciculare (Hedw.) Brid.			+		
Rhizomnium punctatum (Hedw.) T.J.Kop.					+
Rhynchostegiella litorea (De Not.) Limpr.	+				
Rhynchostegiella tenella (Dicks.) Limpr.			+		
Rhynchostegiella teneriffae Dirkse & Bouman				+	

Table 1. continued.

Syntrichia laevipila Brid.	+	+	+	+	+
Syntrichia ruralis (Hedw.) F.Weber & D.Mohr		+			
Syntrichia virescens (De Not.) Ochyra	+				
Thamnobryum alopecurum (Hedw.) Gangulee		+	+		
Tortella nitida (Lindb.) Broth.			+		
Tortella squarrosa (Brid.) Limpr.		+			
Tortula inermis (Brid.) Mont.	+				
Zygodon rupestris Schimp. *ex* Lorentz		+	+	+	
Hepaticae					
Fossombronia angulosa (Dicks.) Raddi					+
Frullania dilatata (L.) Dumort.		+	+		
Lejeunea cavifolia (Ehrh.) Lindb.					+
Lophocolea heterophylla (Schrad.) Dumort.					+
Metzgeria furcata (L.) Dumort.					+
Porella obtusata (Taylor) Trevis.			+		
Radula complanata (L.) Dumort.			+		
Reboulia hemisphaerica (L.) Raddi					+
Scapania compacta (A. Roth) Dumort.			+		

No liverwort was found in deciduous oak woods at Cima Cucco as well as in the pinewood.

High diversification was observed between the five floras, as it is shown in the dendrogram of Fig. 2. The highest similarity is found between the floras of *Quercus ilex* and *Q. leptobalanos* woods at Cima Cucco. The distance factor in this case seems to have a greater incidence than the dominant tree species on the floristic diversity. The similarity between these two floras, however, does not reach 50%. The oak forest of Pizzo Nero is then linked to this cluster with a similarity of 30.1%.

The flora that differs most is that of artificial pine forest that though having a high species number, no less than that of almost all other sites, shows a similarity of only 23.4% compared to the whole group of oaks.

In the graph of Fig. 3, which takes into account the main life forms, the categories that have the highest incidences are Turfs and Mats both in the areas dominated by native oaks and in the pinewood. However, significant differences are observed between the areas. The life form Mats, that usually prevails in sites rather humid and with good lighting (Kürschner 2004), has a stronger presence at Cima Cucco especially in deciduous but also in evergreen oak woods. The Turf which together with the Cushions dominate in dry areas have significantly higher relative abundance in the pinewood.

Dendroid species, which live in sites with high moisture levels (Gimingham & Birse 1957), and that, as well as the weft, are very sciaphilous, are little represented in the studied woods. Similar results are observed by analyzing the incidences of life forms on different substrates, as shown in Fig. 4. In fact the Mats are always prevalent on bark, rock and soil in oak woods, while in pinewood the Cushions (followed by turfs) prevail on the bark, the turfs are the most abundant on other two substrates.

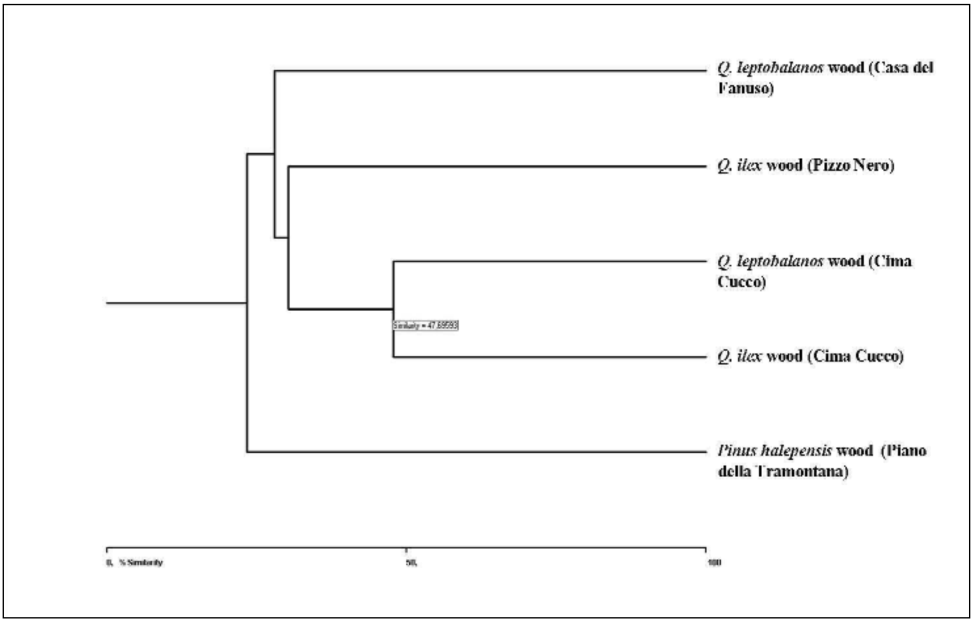

Fig. 2. Similarity and classification of floras of study sites.

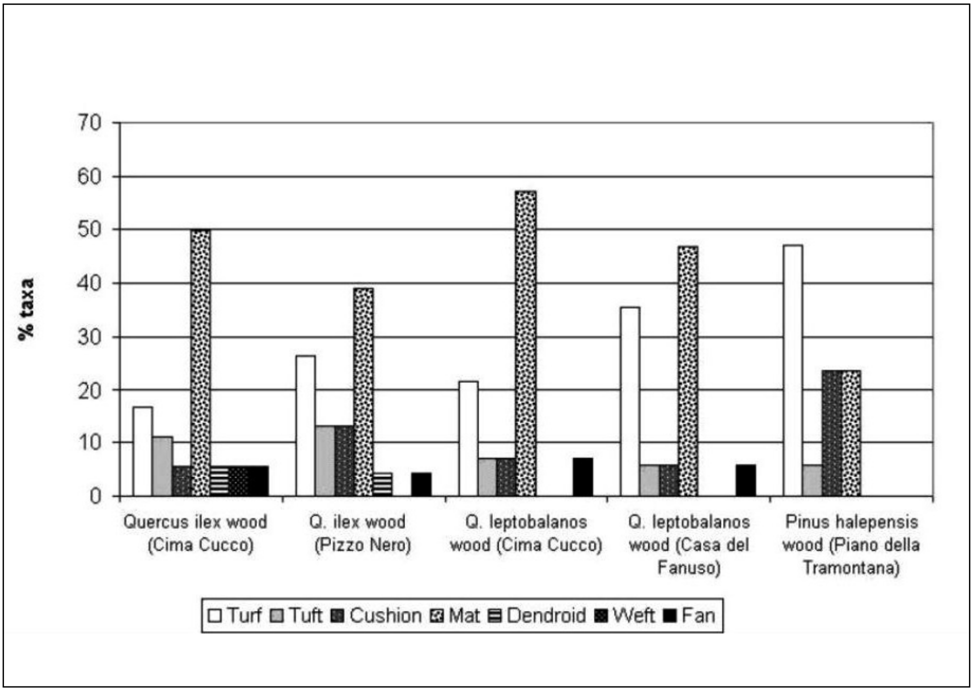

Fig. 3. Percentage incidence of life forms.

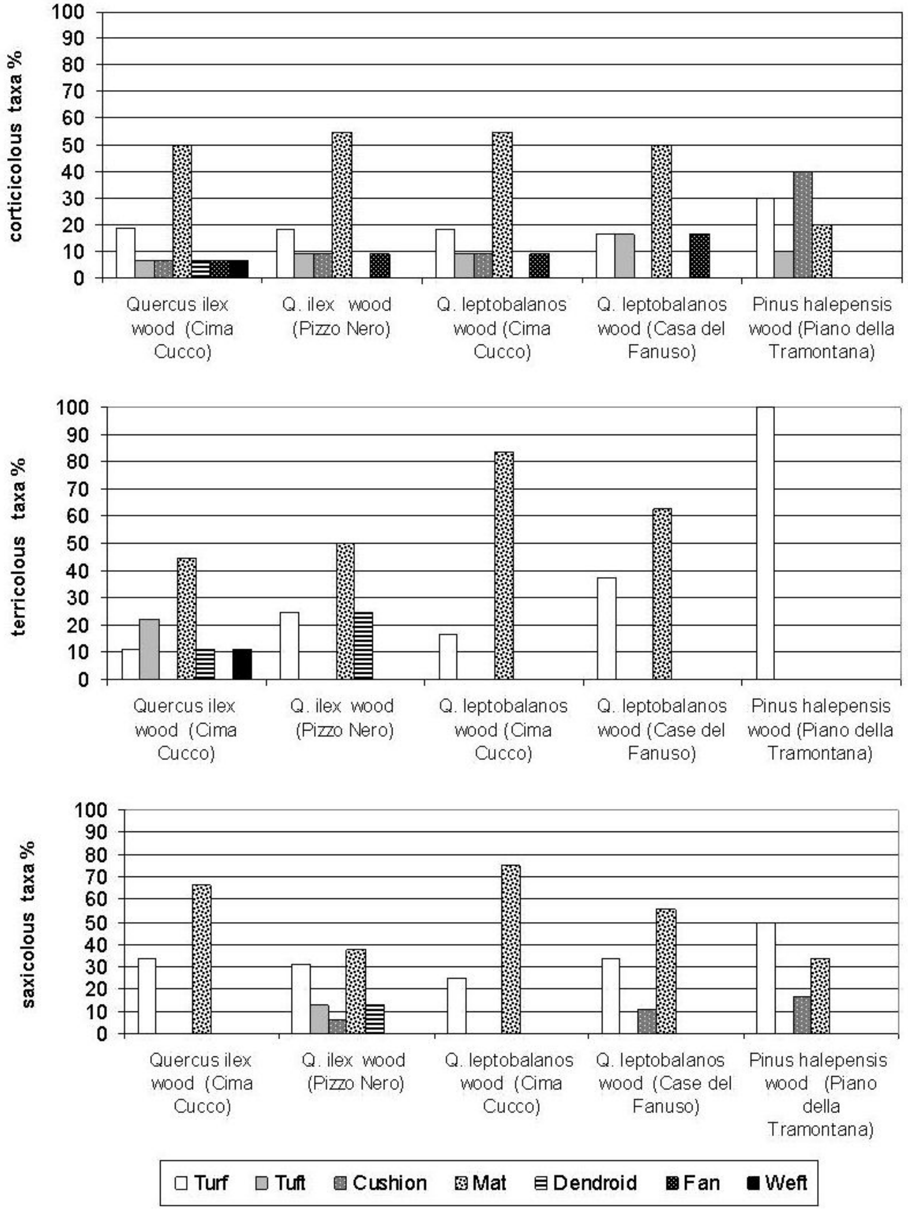

Fig. 4. Percentage incidence of life forms on bark, soil and rock.

With regard to life strategies, in the graph of Fig. 5 in which all colonizing species were joined between them and likewise all the perennial species, it is observed that the Perennials have a higher percentage than the Colonists in all four oak woods while the Colonists are the most represented in the pine forest reaching 75%.

The same result is obtained by taking into account the flora on different substrates, as shown in Fig. 6. The Colonists, in fact, are always dominant in the pinewood, on the trunks of trees, on the ground and on boulders and this character contrasts with the condition of the oak wood floras where Perennial species are always prevalent in all substrates.

Although, as was noted above, the bryophyte floras show a low floristic similarity (always less than 50%) in the different sites, the diagram constructed on the basis of the average values of the indexes of bioindication not show a significant ecological differentiation (Fig . 7). In fact, all floras have a mesophotophilous, mesoterm, mesophilous, rather oligotrophic and almost neutrophilous connotation.

The only differences concern the pinewood and deciduous oak woods of the Casa del Fanuso. In the first, bryophytes show a slightly greater nitrophily, in the second they indicate a weakly acidophilic condition of the substrates and an environment a bit cooler.

Discussion and conclusions

The study shows that within the same protected area in about the same altitudinal and climatic conditions, but in different types of forest vegetation, diverse bryophyte floras with different incidence of bio-ecological types are selected.

Among the analyses conducted, the one based on indices of bioindication provides a

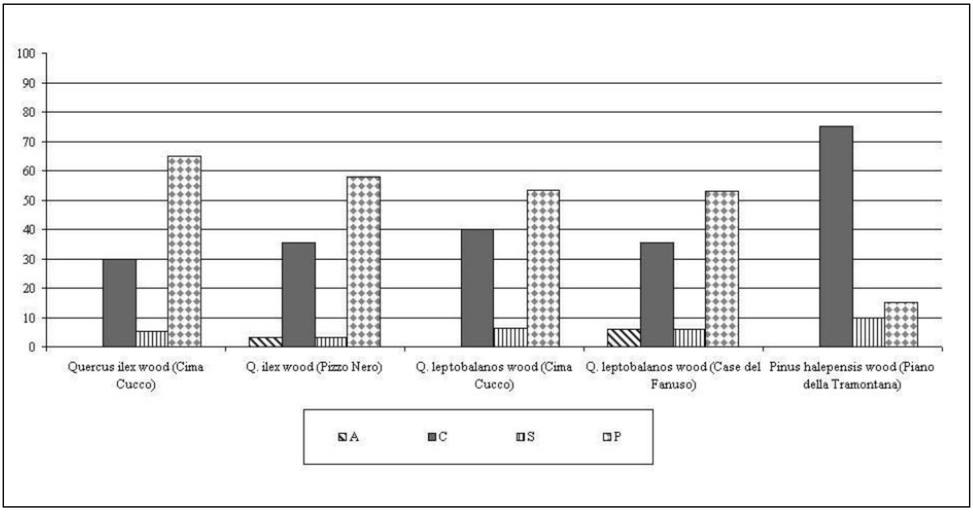

Fig. 5. Percentage incidence of life strategies.
A: annuals; C: colonists and pioneer colonists; S: short-lived species; P: perennials, perennials competitive, stress-tolerant perennials and long lived shuttle.

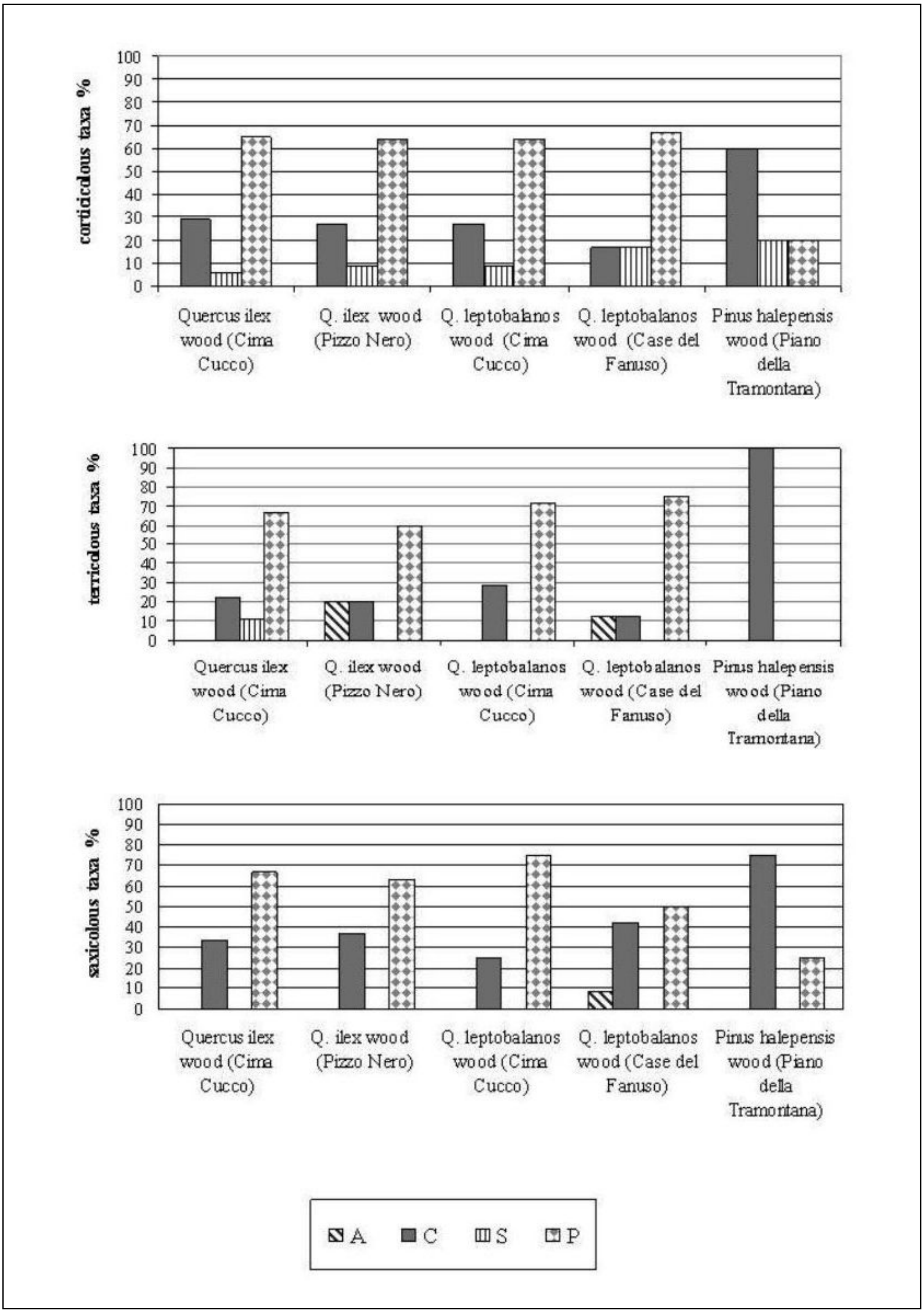

Fig. 6. Percentage incidence of life strategies on bark, soil and rock (Abbreviations for life strategies are given in the caption of Fig. 5).

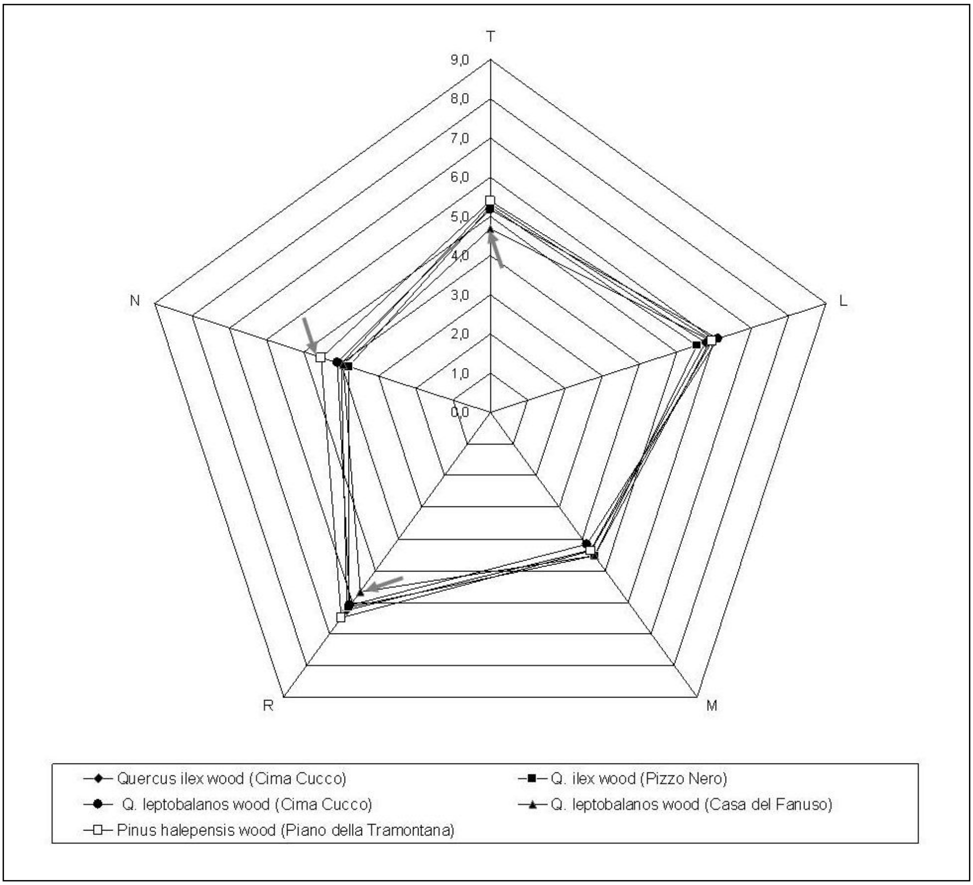

Fig. 7. Radar diagram based on the average values of bioindication indices at the study sites.

profile ecologically quite uniform of these floras. The only detected differences concern the pinewood and deciduous oak woods of Casa del Fanuso. The slightly higher nitrophily of the flora in the former can be explained in greater frequentation of animals, as the area is adjacent to an intensively grazed grassland. The slightly greater acidophily of Casa del Fanuso flora can be related to a different lithological nature of the site.

The analysis of the life forms and life strategies highlighted more sharply the difference between the wooded areas dominated by native tree species and artificial system. In the latter bryophyte flora is highly modified and the distribution of the life forms and life strategies highlights in all substrates the presence of poorly developed communities constituted by colonies which have the growth form best suited to drought conditions and lighting rather high. The eco-physiological character of the pines, remarkably heliophilous, results in a low density of trees and hence an open cover; this enhances the stressful conditions of habitat corticicolous and saxicolous. Furthermore, the accumulation of needles to the soil determines the maintenance of rather bare soils. These conditions together with the attendance of grazing animals make the pinewood habitat unsuitable for perennial species.

In conclusion, the present study further confirms the validity of the indexes of bioindication to characterize the environment with reference to the main ecological factors, but stresses especially the importance of bio-ecological types for acquiring useful information to understand the overall environment status. This study, in fact, suggests that these types, depending on microenvironment conditions on the different growth substrates, are able to point to the physionomic-structural differences of the woods. It does not seem, however, that they can highlight the seasonal variations that characterize deciduous than in evergreen forests.

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João Domingues de Almeida

A new association and a new vegetal community for continental Portugal

Abstract

Domingues de Almeida, J.: A new association and a new vegetal community for continental Portugal. — Fl. Medit. 25 (Special Issue): 179-184. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

A new association, *Trisetarietum hispidae*, belonging to the class of perennial pratense herbaceous vegetation *Stipo giganteae-Agrostietea castellanae*, dominated by Iberian endemic grass *Trisetaria hispida* (*Gramineae*), from the Eastern Beira-Duriense mountains (province of Beira Alta) is described here for the first time. A vegetal community dominated by the exotic species *Watsonia meriana* (*Iridaceae*), from the coastal region of SW Portugal (provinces of Algarve and Baixo Alentejo) is also described.

Key words: Grasses, Portugal, vegetation.

Introduction

A new association and a new vegetal community are described here for the first time for continental Portugal. These two communities are not cited in the reference works about the vegetation of Portugal (Rivas-Martínez & al. 2001, 2002a, 2002b; Costa & al. 2012).

I. *Trisetarietum hispidae*, a new association of hemicryptophitic grassland from the Beira-Duriense mountains (Portugal, Beira Alta)

A new association, ***Trisetarietum hispidae***, belonging to the class of perennial pratense herbaceous vegetation ***Stipo giganteae-Agrostietea castellanae***, from the Eastern Beira-Duriense mountains, discovered during the field work for the author's PhD thesis (Almeida 2009: 698) as ***Trisetarietum hispidae*** inéd., is described here for the first time:

Trisetarietum hispidae J. D. Almeida, assoc. nova hoc loco (Table 1, *holotypus assoc.* relevé 2) (*Agrostio castellanae-Stipion giganteae*, *Agrostietalia castellanae*, *Stipo giganteae-Agrostietea castellanae*)

Hemicryptophitic grassland characterized by the large Iberian endemic perennial grass *Trisetaria hispida* (Lange) Paunero [=*Trisetum hispidum* Lange] –the most abondant species in this association–, the Iberian endemic species *Centaurea herminii* subsp. *lusitana* (Arènes) Franco, *Conopodium majus* subsp. *marizianum* (Samp.) López Udias & G. Mateo, *Digitalis thapsi* L. and *Quercus pyrenaica* Willd. (as a shrub), the common species *Andryala integrifolia* L., *Hypochaeris radicata* L., *Jasione montana* L. and *Senecio sylvaticus* L.; and without the very common high perennial grass *Celtica gigantea* (Link) F. M. Vázquez & E. M. Barkworth [=*Stipa gigantea* Link], Iberian endemic *Armeria beirana* Franco or the strict endemism from the neighbour mountain Serra da Estrela *Centaurea rothmaleriana* (Arènes) Dostál.

It occurs in mesomediterranean to supramediterranean subhumid to humid, on cambisols derived from granites, in the Eastern Beira-Duriense mountains (Penedono, Sernancelhe, Trancoso, Meda).

Its a subseral association of *Holco mollis-Quercetum pyrenaicae* oakwoods.

Table 1. *Trisetarietum hispidae* J. D. Almeida, assoc. nova hoc loco (holotypus assoc. relevé 2).

Ordinal number of relevé	1	**2**	3
Altitude (m above sea level)	780	**870**	750
Rock	granite	**granite**	granite
Surface (m^2)	20	**24**	20
Number of species	18	**24**	20
Characteristic species			
Trisetaria hispida	4	**5**	3
Andryala integrifolia	1	**1**	+
Conopodium majus subsp. *marizianum*	1	**+**	+
Digitalis thapsi	2	**1**	1
Hypochaeris radicata	1	**+**	+
Jasione montana	2	**1**	+
Quercus pyrenaica (*frutex*)	2	**1**	+
Senecio sylvaticus	+	**1**	+
Companion species			
Agrostis × fouilladei		**1**	+
Anarrhinum bellidifolium		**1**	+
Arrhenatherum elatius subsp. *baeticum*		**1**	+
Centaurea herminii subsp. *lusitana*	+	**1**	
Cytisus multiflorus	2	**2**	1
Cytisus striatus	2		1
Hypericum linariifolium		**+**	+
Micropyrum tenellum	1	**1**	
Neoschischkinia truncatula subsp. durieui	+	**2**	
Rumex angiocarpus	2	**1**	
Spergula morisonii	+		+
Umbilicus rupestris		**+**	+

Other companion species: relevé nº 1: 1 *Briza maxima*, 1 *Cistus psilosepalus*, + *Raphanus microcarpus*; **relevé nº 2**: + *Anthemis arvensis*, + *Bromus diandrus*, 1 *Campanula lusitanica*, + *Centranthus calcitrapae*, 1 *Corynephorus canescens*, + *Echium lusitanicum*, + *Lupinus gredensis*, + *Tolpis barbata*; **relevé nº 3**: 1 *Avenula lodunensis*, 1 *Dianthus lusitanus*, + *Linaria saxatilis*, 2 *Pteridium aquilinum*.

Localities: relevé nº 1: BA: Trancoso: near Sebadelhe, granitic place, 780 m, UTM: 29TNF345247, 14.VI.2007; **relevé nº 2** (*holotypus assoc.*): BA: Sernancelhe: near Arnas, granitic place, 870 m, UTM: 29TPF365278, 19.VI.2001; **relevé nº 3**: BA: Meda: Chãos, granitic place, 750 m, UTM: 29TPF410293, 2.VII.2008.

II. *Watsonia meriana* (L.) Mill. communities in Baixo Alentejo and Algarve (Portugal)

This South-African Iridaceae can be classified as a ruderal and arvense epecophyte in Portugal (Almeida 1999: 101), according to the classification of synanthropic species established by Kornas (1990). It forms extended and compact populations at the Capense Region, where it is native.

Introduced as an ornamental plant for its beautiful flowers, *Watsonia meriana* is known in Portugal as a subspontaneous plant for more than a hundred years, since the begining of the XX century, when it was found in the margins of a creek in the county of Odemira (Pinto da Silva & Rainha, 1956: 22; Almeida 1999: 101).

Watsonia meriana is a perfectly naturalized species in Southern Portugal, having vegetative reproduction and also producing viable seeds, and it forms dense densas populations on cultivated or wasted lowlands, rich in clay, with the presence of water, where the freatic level allows its growth (Ramos Lopes & Pinto da Silva 1980: 8; Franco, 1994: 139).

Flowering period: from March to July (III-VII).

Distribution: Minho Baixo Alentejo and Algarve, between 50 and 200 m (Ramos Lopes & Pinto da Silva 1980: 10; Buira & Calvo, 2013: 478).

Having visited the provinces of Baixo Alentejo and Algarve, where *Watsonia meriana* is subspontaneous (counties of Odemira e Aljezur), we compiled six phytosociological relevés: four in the Algarve (districto of Faro, county of Aljezur, parishes of Aljezur and Odeceixe) and two in the Baixo Alentejo (districto of Beja, county of Odemira, parish of São Teotónio). These relevés, from 2001, 1 and 2 of May, are resumed at Table 1.

It's a plant community dominated by the exotic herbaceous capense species *Watsonia meriana*, an "watsonial", which can cover quite large areas, forming dense populations densas in low lands with a fair amount of water, as Ramos Lopes & Pinto da Silva (1980: 8) already had noted.

Table 2. *Watsonia meriana* community.

Relevé nº	**1**	**2**	**3**	**4**	**5**	**6**
Altitude (m)	80	100	100	80	150	150
Surface covered (%)	100	80	80	80	90	80
Area (m^2)	900	10	20	20	20	10
Geological substract	aluvion	aluvion	aluvion	aluvion	aluvion	aluvion
Declive (%)	-	-	-	-	-	-
Characteristic species						
Watsonia meriana	4	4	5	4	5	4
Rubus ulmifolius	1	3	2	2	1	1
Andryala integrifolia	1	1	+	+	+	+
Companion species						
Dittrichia viscosa subsp. *revoluta*	2	2	.	1	.	1
Briza maxima	1	+	.	.	2	1
Briza minor	+	.	.	.	1	.
Galactites tomentosa	+	.	.	.	+	1
Avena sp.	.	1	.	.	2	+
Cistus salviifolius	+	.	3	.	.	.
Vicia benghalensis	+	.	.	.	1	.
Vicia lutea	+	.	.	.	.	+
Vicia sativa	+	.	.	.	+	.
Oxalis pes-caprae	+	+	.	.	.	.
Linum bienne	+	.	.	.	+	.
Tolpis barbata	+	.	.	.	+	.
Trifolium angustifolium	+	.	.	.	+	.
Dipsacus comosus	2	.	.	.	.	.
Pistacia lentiscus	1	.	.	.	.	.
Phlomis purpurea	1	.	.	.	.	.
Scolymus hispanicus	1	.	.	.	.	.

Other companion species: relevé nº 1: *Ranunculus* sp., *Cerastium* sp. +, *Rumex* sp. +, *Cistus ladanifer* 1, *Tuberaria* sp. +, *Tamarix* sp., *Genista hirsuta* 1, *Medicago murex* +, *Trifolium campestre* +, *Euphorbia* sp. +, *Geranium dissectum* +, *Olea europaea* +, *Daucus* sp. +, *Oenanthe crocata* +, *Galium* sp. +, *Stachys arvensis* +, *Bellardia trixago* +, *Scabiosa atropurpurea* +, *Centranthus calcitrapae* +, *Centaurea* sp. +, *Crepis* sp. +, *Leontodon* sp. +, *Juncus acutus* +, *Bromus* sp. +, *Dactylis glomerata* +, *Carex divulsa* 1, *Serapias* sp. +; **relevé nº 2**: *Pelargonium* sp. 2; **relevé nº 5**: *Silene gallica* 1, *Rumex bucephalophorus* 1, *Daphne gnidium* +, *Parentucellia viscosa* +, *Plantago lanceolata* +, *Conyza* sp. +, *Coleostephus myconis* 1, *Urospermum picroides* +, *Bromus hordeaceus* +.

Localities: relevé nº 1: Aljezur, Picão, near the road from Arrifana and Vales, 29SNB132272; **relevé nº 2**: Aljezur, Maria Vinagre, margin of the road, near the village, 29SNB1939; **relevé nº 3**: Aljezur, Maria Vinagre, margin of the road, close to the village, 29SNB201400; **relevé nº 4**: Aljezur, Odeceixe, near the road between Odeceixe and Odeceixe Beach, 29SNB189424; **relevé nº 5**: Odemira, S. Teotónio, near the road, 29SNB236481; **relevé nº 6**: Odemira, S. Teotónio, by the road, near the village, 29SNB252536.

The presence of *Genista hirsuta* and *Cistus ladanifer* (relevé nº 1) may possibly indicate a presence of the association *Genisto hirsutae-Cistetum ladaniferi*, at the fringe of the *Watsonia meriana* community.

It is worth to note the presence of *Medicago murex* Willd. in Picão, Aljezur, Algarve (relevé nº 1), a rare species in Portugal.

Fig. 1. *Trisetarietum hispidae*, Beira Alta, near Trancoso, June 2007.

Fig. 2. *Watsonia meriana* community in Algarve, near Aljezur, May 2003.

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G. Nakhutsrishvili, N. Zazanashvili, K. Batsatsashvili & C. S. Montalvo Mancheno

Colchic and Hyrcanian forests of the Caucasus: similarities, differences and conservation status

Abstract

Nakhutsrishvili, G., Zazanashvili, N., Batsatsashvili K. & Montalvo Mancheno C. S.: Colchic and Hyrcanian forests of the Caucasus: similarities, differences and conservation status. — Fl. Medit. 25 (Special Issue): 185-192. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

Along with high degree of vascular plant endemism (more than 25%) the existence of two refugia of the Tertiary flora – Colchic and Hyrcanian – are the most unique features of the Caucasus ecoregion. Likewise, Colchic and Hyrcanian forests are classified as temperate rainforests.There are certain physical-geographical and biological similarities and even more differences between Colchic and Hyrcanian regions, reflected on compositions of flora, types of vegetation zonation, as well as spectrums of vegetation formations. An “individualities” of these two unique nature phenomena definethe necessity of their equal and effective conservation. Currently, the Colchic forests are better protected: almost half a million hectares, or 16.5% of Colchic region, is covered by protected areas, but there are still some evident gaps to be filled with regard to improve spatial structure of protected areas system and properly cover the most vulnerable ecosystems. More problematic situation is observed in case of Hyrcanian forests, particularly in Iranian part: lack of high categories of protected areas (IUCN categories I-IV), in terms of both number and territory, is the main obstacle for development of protected areas system in Hyrcanian region.

Key words: Colchis, Hyrkan, Caucasus, forests, conservation.

Introduction

The Caucasus ecoregion, which historically is interpreted as the isthmus between the Black and the Caspian seas, covers a total area of some 580,000 km^2 that extends over the nations of Armenia, Azerbaijan and Georgia, the North Caucasus portion of the Russian Federation, the north-eastern part of Turkey, and a part of north-western Iran (Williams & al. 2006). One of the most biologically rich regions on Earth, especially in the temperate context, the Caucasus ranked among the planet’s 34 most diverse and endangered Biodiversity Hotspots (another temperate Hotspots included in the list is the Mediterranean) (Mittermeier & al. 2004).

Along with high degree of vascular plant endemism (more than 25%) the existence of two refugia of the Tertiary flora – Colchic and Hyrcanian – are the most unique features of the Caucasus ecoregion. Likewise, Colchic and Hyrcanian forests are classified as temperate rainforests (Nakhutsrishvili & al. 2011). Consideration of Colchic and Hyrcanian forests as subtropical (Rikli 1943; Gulisashvili & al. 1975) does not have enough justification. Colchic and Hyrcanian rainforests cannot be considered subtropical climatically or structurally in terms of plant communities: first of all, air temperature (especially in winter) is lower and there are no broad-leaf evergreen forests as in subtropical regions.

In this article, we discuss biophysical and biological similarities and differences between these two most diverse forest refugia in the Western Eurasia (Dolukhanov 1980), as well as status of their conservation.

Location and physical-geographic characteristics

The Colchic region, which took shape mainly from the end of the Middle Sarmatian, i.e. 11-12 million years ago (Kolakovsky 1961; Shatilova & al. 2011), is located in the catchment basin of the Black Sea. Most scientists incline to consider Upper Miocene as the formation time of Hyrcanian region too (Safarov 1979). It is located at the extreme south-eastern end of the Caucasus, covering the eastern slopes of the Talysh Mountains and northern slopes of the Alborz Mountains at the southern coastal area of the Caspian Sea. The Hyrcanian biogeographic region goes beyond Caucasus borders: distribution of components of Central Asiatic flora and vegetation in the eastern part of this region is already substantial, but for purpose of this article we show whole south Caspian/Hyrcanian forest area (Fig. 1). The total area of all forests of the Colchic region, estimated by the GIS unit of WWF Caucasus using Google images, is ~ 3 million hectares, whereas the total estimated area of Hyrcanian rainforests, which covers all types of forests of Talysh and Alborz mountains, is around 1.96 million hectares.

As it was already mentioned, these unique forests can mostly be classified as temperate rainforests due to the same reasons as for other temperate rainforest regions: relevant slopes of barrier-mountains located along coastlines that trap a large portion of the humidity from oceanic/sea air masses. In the Caucasus, these barriers are formed by a topographical triangle created by the intersection of the western part of the Greater Caucasus Mountain Range (Georgia, Russia), western part of the Lesser Caucasus Mountain Chain (Turkey and Georgia) and Likhi ridge (bridge ridge between Greater and Lesser Caucasus, Georgia) at the Black Sea; and by the Talysh-Alborz Mountain Range at the southern-south-western coast of the Caspian (Iran and Azerbaijan). Montane barriers also contribute to a warm and humid climate that has been present since the late Tertiary and is the primary reason that the Caucasus has acted as a shelter for hygro-thermophilous (Doluchanov & Nachucrišvili 2003) relicts during the Quaternary ice ages. Consequently, Colchic and Hyrcanian forests are the oldest forests in Western Eurasia in terms of their origin and evolutionary history, the most diverse in terms of relict and endemic woody species and tree diversity, and the most natural in terms of transformation of historic structure (Ministry of Ecology and Natural Resources of Azerbaijan & Iranian Cultural Heritage-Handicrafts and Tourism Organization 2009).

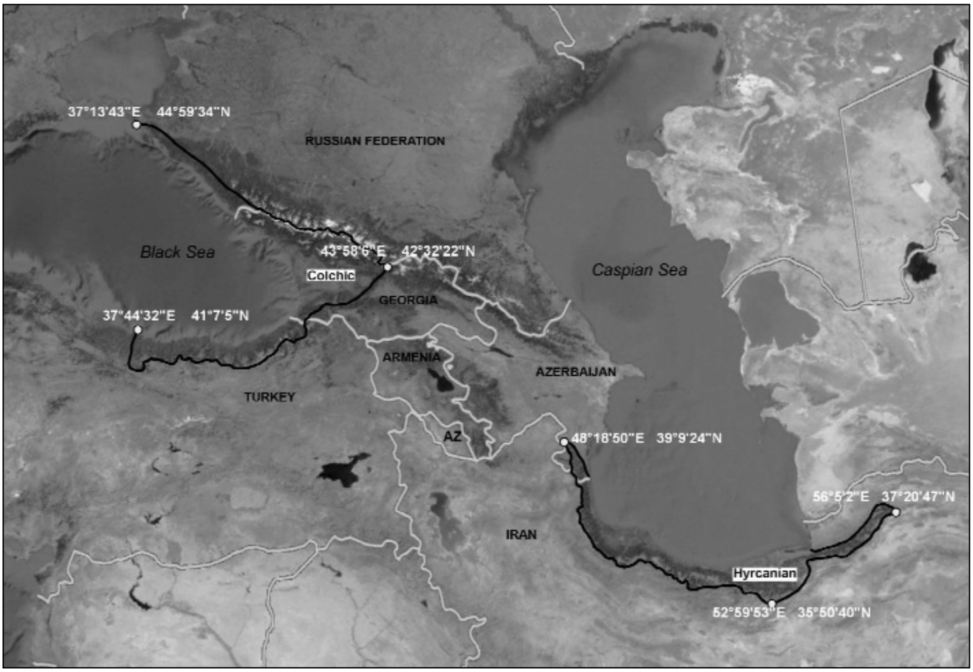

Fig. 1. Location of Colchic and Hyrcanian forest areas.

In addition to a common barrier effect, there are other biophysical similarities: in both areas, yellow soils are distributed (in Colchis – red soils too) in submontane zone up to 500-600 m above sea level, which together with high annual precipitation (in average 1200-1400 mm in Hyrcanian and 1800-2000 in Colchic) and warm climate (mean annual air temperature at the sea level in both regions is around +14oC) create convenient conditions for cultivation of some subtropical crops (tea, mandarin, lemon, orange, grapefruit, kiwi, and some others).

Differences are even more apparent between both areas: Colchic area, which is generally located further north than Hyrcan, is much more humid (with maximum mean annual precipitation >4500 mm, when maximum for Hyrcan is around 2200 mm); apart from this, precipitation in Colchis is more or less equally distributed during a year/seasons, whereas summer minimum is recorded in Hyrcan. There is also significant difference in altitudinal distribution of precipitation: in Hyrcanian area with increasing of altitude not only temperature is decreased, but also precipitation, in average on 80 mm/100 m. This is why typical Hyrcanian forests are concentrated within boundaries of high precipitation area, i.e. up to 500-600 m. Relict Hyrcanian vegetation still occurs up to 1000 m, but above these altitudinal limits it is changed by common Caucasian type of beech forest (*Fagus orientalis*), and then by dry *Quercus macranthera* woodlands and/or different types of steppes at the timberline and in subalpine zone: mean annual precipitation above 1800-2000 m is decreased to 300-400 mm (Safarov 1979).

Opposite to Hyrcan type of mountain zoning, precipitation with increasing of altitude does not decrease in Colchic area, and Colchic type of forest occurs along whole altitudinal profile of vegetation formations including lower subalpine belt up to 2200 m (Dolukhanov 1980; Nakhutsrishvili 2013; Zazanashvili 1999).

Table 1. Comparison of vegetation zones.

Altitude (m above sea level)	**Main vegetation formations**	
	Colchis	**Hyrcan**
0-1000	(a) Mixed broad-leaved forests with *Quercus hartwissiana, Q. imeretina, Castanea sativa, Fagus orientalis, Zelkova carpinifolia, Alnus barbata, Carpinus caucasica(=C.betulus)* (b) Chestut and beech-chestut forests (*Castanea sativa, Fagus orientalis*)	(a) Mixed broad-leaved, mostly oak-irontree, irontree-horbeam-oak, oak-azad/oak-hornbeam-azad (*Quercus castaneifolia, Parrotia persica, Carpinus caucasica(=C.betulus), Zelkova carpinifolia, Albizzia julibrissin*) (b) Oak forests (*Quercus castaneifolia*) (c) beech/beech-hornbeam forests (*Fagus orientalis, Carpinus caucasica =C..betulus*)
1000-1500	(a) Beech forests (*Fagus orientalis*) (b) Spruce-fir forests (*Abies nordmanniana, Picea orientalis*)	(a) Beech forests (*Fagus orientalis*)
1500-2000	(a) Spruce-fir forests (*Abies nordmanniana, Picea orientalis*) (b) Beech forests (*Fagus orientalis*) (c) Beech (*Fagus orientalis*), oak (*Quercus pontica*) and birch (*Betula medwedewii, B. litwinowii*) krummholz	(a) Steppes (b) *Quercus macranthera* (c) *Fagus orientalis*
2000-2500	(a) Birch/ash-birch (*Betula litwinowii, Sorbus aucuparia = S.caucasigena*) krummholz (b) *Rhododendron caucasicum* thickets (c) Subalpine meadows	(a) Steppes (b) *Quercus macranthera* woodlands

Vegetation and flora

There are even more differences than similarities in structure and composition of flora and vegetation. When comparing spectrums of main vegetation formations of these two refugia, only *Fagus orientalis* forest is clearly common (Table 1).

Main physiognomic difference creates wide distribution of evergreen, among them, broad-leaf species (mostly sub-prostrate shrubs) in Colchic forests and particularly within understory: relict species such as *Rhododendron ponticum*, *Rh ungernii, Rh smirnowii*, *Laurocerasus officinalis*, *Ilex colchica* often form high (up to 4 m), dense underwood. Evergreens also create separate communities outside forest canopy. Meanwhile, participation of evergreens generally, and particularly broad-leaved evergreen species in Hyrcanian forest, is insignificant. Apart from this, there are limited areas occupied by dark conifers and no "Krummholz"formations due to probably lack of precipitation in higher altitudes.

Also, flora of Colchic and Hyrcanian forests quite differs. In table 2, principal differential woody species of these two refugia are included.

Common woody relicts include: *Alnus barbata*, *Zelkova carpinifolia, Pterocarya fraxinifolia*, *Diospyros lotus*, *Vaccinium arctostaphylos*, *Laurocerasus officinalis*, *Daphne pontica*, *Arachne colchica*, *Hypericum androsaemum*, *H. inodorum*, *Philadelphus caucasicus*; taxonomically very close species are *Buxus colchicus* and *B. hyrcana*, *Ruscus colchicus* and *R. hyrcanus*, *Ilex colchica* and *I. hyrcana*. In addition, following widespread Caucasian species are common: *Fagus orientalis*, *Quercus iberica*, *Carpinus caucasica* (*C. betulus*), etc.

Tab. 2. Principal differential woody species of Colchic and Hyrcanian regions.

Life form	**Principal differential woody species**	
	Colchis	**Hyrcan**
Trees	*Abies nordmanniana, Quercus hartwissiana, Q. imeretina, Q. pontica, Betula medwedewii, Sorbus subfusca, Castanea sativa, Staphylea colchica*	*Quercus castaneifolia, Parrotia persica, Albizzia julibrissin, Gleditcia caspica, Acer velutinum, A. insigne, Alnus subcordata*
shrubs	*Rhamnus imeretina, Corylus colchica, Daphne alboviana, Rhododendron ponticum, Rh. ungernii, Rh. smirnowii, Rh. caucasicum, Epigaea gaultherioides, Viburnum orientale*	*Danae racemosa*
Lianas	*Hedera colchica, Dioscorea caucasica*	*Hedera pastuchovii*

We will not discuss further reasons of differences between Colchic and Hyrcanian regions, as the above mentioned ones depict the "individualities" of these two unique nature phenomena in order to underline the necessity of their equal and effective conservation.

Conservation

The first protected areas in Colchic region were established mostly in 50th of the last century. At present, there are: 9 Strict Nature Reserves (Georgia: Kintrishi, Kobuleti, Sataplia, Adjameti, Pskhu-Gumista, Pitsunda-Myusera, Ritsa; Turkey: Djamili-Efeler, Djamili-Gorgit, Orumcek Forest, Turkey), 7 National Parks (Russia: Sochinsky; Georgia: Kolkheti, Mtirala, Machakhela, part of Borjomi-Kharagauli; Turkey: Kachkar Mountains, Hatila Valley, Altindere Valley) and 1 Biosphere Reserve (Djamili, Turkey). By country, they equal to 208,455 ha in Georgia, 99,691 ha in Turkey and 190,000 ha in Russia.

Thus, almost half a million hectares, or 16.5% of Colchic region, is covered by protected areas, which is considerable figure. Protected areas include representative territories of almost all Colchic ecosystems, except submontane polydominat forests (up to 500-600 m), which are largely replaced by settlements and agricultural lands, and high mountains. It is obvious the need for additional conservation of remnant submontane forest areas and high mountain ecosystems, especially timberline crumholtz forests of relict and Colchic endemic species, such as *Quercus pontica* and *Betula medwedewii*. There are also some evident spatial gaps: (1) there are no protected areas in Racha and Samegrelo regions of Georgia, i.e. in limestone part of south-western slope of the Greater Caucasus mountain range, extremely rich in endemic species; (2) insufficient coverage is observed in quite large area, south-west from city Trabzon/Altindere Valley National Park in Turkey. Filling in these gaps will contribute to creation of future Colchic ecological network of protected areas.

Much more problematic situation is observed in case of Hyrcanian forests: forest decline has been dramatic over nearly five decades of logging and other uses. For instance, in 1963, the Hyrcanian forests of Iran totaled some 3 million ha, but nowadays roughly 1.8 million ha remain, which means a drop of over 40% (Ministry of Ecology and Natural Resources of Azerbaijan & Iranian Cultural Heritage-Handicrafts and Tourism Organization 2009). There is still lack of high categories of protected areas (IUCN categories I-IV) in Iranian part. In Azerbaijan's part of Tallish Mountains, although Hyrcan National Park and Sanctuary cover around 40,000 ha or 37% of Azerbaijan's Tallish forests, Azerbaijan's part of Hyrcanian region itself is 108,000 ha or just 5.5% of total area of Hyrcan.

In conclusion, development of conservation activities in both refugia, and especially in Hyrcanian one, is evident, which requires urgent attention from governments and conservation organizations to guarantee the survival of these unique forests.

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M. Puglisi, P. Campisi, M. G. Dia & M. Privitera

New or interesting regional bryophyte records for Italian bryoflora

Abstract

Puglisi, M., Campisi, P., Dia, M. G. & Privitera, M.: New or interesting regional bryophyte records for Italian bryoflora. — Fl. Medit. 25 (Special Issue): 193-198. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

Based on recent bryophyte collections five records are added to the bryophyte flora of some Italian regions. The hepatic *Riccia beyrichiana* is new to Campania, *Archidium alternifolium*, *Campylopus introflexus* and *Hedwigia stellata* are new mosses to Lazio and *Hylocomium splendens* to Basilicata. In addition, the presence of *Campylopus atrovirens* and *Pleuridium acuminatum* in Lazio is confirmed after more than half a century.

Key words: Italian bryoflora, new records, mosses, liverworts.

Introduction

During some investigations aimed at improving the knowledge of the Italian bryophyte flora and vegetation some interesting *taxa* not previously known in some regions of central and southern Italy (Aleffi & al. 2008) were found. These include the first finding of the hepatic *Riccia beyrichiana* Hampe ex Lehm. (*Ricciaceae*) in Campania, as well as of the mosses *Archidium alternifolium* (Hedw.) Mitt. (*Archidiaceae*), *Campylopus introflexus* (Hedw.) Brid. (*Leucobryaceae*) and *Hedwigia stellata* Hedenäs (*Hedwigiaceae*) in Lazio and, lastly, *Hylocomium splendens* (Hedw.) Schimp. (*Hylocomiaceae*) in Basilicata. In addition, reports of *Campylopus atrovirens* De Not. and *Pleuridium acuminatum* Lindb. (*Ditrichaceae*) allow us to confirm the presence of these *taxa* in Lazio after more than half a century.

The nomenclature followed is that of Ros & al. (2007) for liverworts and Ros & al. (2013) for mosses. The specimens are kept in the *Herbarium Mediterraneum Panormitanum* (PAL) and the Vegetal Biology Section of the Department of Biological, Geological and Environmental Sciences of University of Catania (CAT), as specified below for each species.

Riccia beyrichiana Hampe ex Lehm

Italy, Campania, Palinuro al Faro (Cilento and Vallo di Diano National Park), 169 m a.s.l., 40° 01’ 34” N, 015° 16’ 45” E, *M. Privitera* (CAT).

Riccia beyrichiana grows on acidic soils and rocks in Mediterranean forests, on cliff tops, in wetlands and in grasslands. In the new locality it was found on damp, acidic soil of temporary ponds, together with *Archidium alternifolium*, *Trichostomum brachydontium* Bruch and *Epipterygium tozeri* (Grev.) Lindb.

Known in North America, it is widely distributed in the Mediterranean Europe and more rare in eastern part of this continent (Hodgetts 2015). Also in Italy it is quite rare; in particular, in the South it was known only in Apulia (Aleffi & al. 2008).

In the Red list of the Italian bryophytes, it was considered Critically Endangered (Cortini Pedrotti & Aleffi 1992).

Archidium alternifolium (Hedw.) Mitt.

Italy, Lazio, Bosco della Cerasella (Circeo National Park), 40 m a.s.l., 41°20’58”N, 13°02’54”E, together with *Riccia glauca* L. var. *glauca* and *Trichostomum brachydontium*, *M. Privitera & M. Puglisi*; Bosco di Foglino (Nettuno) 40 m a.s.l., 41°28’20”N, 12°42’54”E, together with *Pleuridium acuminatum, Epipterygium tozeri* and *Scapania compacta* (A. Roth) Dumort., *S. Brullo;* Castel Porziano (Rome) 60 m a.s.l., 41°45’05”N, 12°25’58”E, together with *Epipterygium tozeri, S. Brullo* (CAT).

It grows on sandy or clay soils, disturbed or subjected to periodic immersion, especially in damp open habitats at the edge of stretches of water but also in forest areas. In the finding localities it was collected on damp soil along the edge of some shallow ponds in the ambit of the Priority Habitat “Mediterranean temporary ponds “(code 3170, Habitats Directive 92/43/ EC).

Archidium alternifolium is present in America, Europe, N Africa, Atlantic islands (Spence 2007). In Europe, it is widely distributed although is rare and considered threatened in several countries (Hodgetts 2015). In Italy, it is not very common (Cortini Pedrotti 2001).

Campylopus introflexus (Hedw.) Brid.

Italy, Lazio, Castel Porziano (Rome), 65 m a.s.l., 41°44’39”N, 12°25’33”E, *S. Brullo*, together with *Campylopus atrovirens*; Bosco di Foglino (Nettuno), 45 m, 41°28’22”N, 12°42’56”E, *S. Brullo*, together with *Campylopus atrovirens*, *Hypnum cupressiforme* Hedw. var. *cupressiforme* (CAT).

It is a widespread species in the Southern hemisphere, in the Southern part of South America, Africa, Australia, islands in the Pacific, Atlantic and Indian Ocean (Gradstein & Sipman 1978; Söderström 1992; Klinck 2009). In 1941 was discovered in Europe in the Southern part of Great Britain (Richards 1963). After it continued its spread through Europe until now (Klinck 2010) and moreover its presence was registered as a neophyte in California, USA in 1975 (Frahm 1980). In Italy it is known in few northern and central regions and it has also been reported for Campania and Sardinia. In the new sites it was found on acidic, seasonally moist soil.

Campylopus introflexus is considered an invasive alien species; it shows a high ecological tolerance, as well as other species of the genus *Campylopus* (Spagnuolo & al. 2014), growing on sandy soils, on cliff, along paths and forest edges as well as on dunes and in wet areas (Hallingbäck & al. 1985).

Hedwigia stellata Hedenäs

Italy, Lazio, Bosco di Foglino (Nettuno), 45 m, 41°28'22"N, 12°42'56"E, *S. Brullo* (CAT).

It grows on acidic or weakly basic rocks, usually in open mountain habitats. It occurs in North America, Chile, Asia, Atlantic Islands, Morocco and Europe (Jiménez & al. 2002; Smith 2004; Eckel 2012). In Italy it is mostly known in the southern part and also in Piedmont, Tuscany and Liguria (Aleffi & al. 2008, Puglisi & al. 2013). In the Lazio it grows on acid rocks covered by soil together with *Hypnum cupressiforme* var. *cupressiforme*.

Hylocomium splendens (Hedw.) Schimp.

Italy, Basilicata, Monte Viggiano (Lucano Apennine Val D'Agri Lagonegrese National Park), 1500 m a.s.l., 40°22'38" N, 15°51'25" E 09.07.2014, *E. Di Gristina* and *F. Scafidi* (PAL).

Hylocomium splendens is a common *taxon* that usually lives on acidic substrate, soil and decaying wood or rocks in mostly forest environments. In the new locality it was collected from carbonate rocks.

It is widely distributed in the northern hemisphere and is also known in New Zealand (Schofield 2014). Due to sensitivity to air pollution it for some time shows signs of regression in Europe (Dierβen 2001). It is known in almost all Italian regions, even if it is rarer in the South (Aleffi & al. 2008).

Campylopus atrovirens De Not.

Italy, Lazio, Castel Porziano (Rome), 65 m a.s.l., 41°44'39"N, 12°25'33"E, *S. Brullo*, together with *Campylopus introflexus*; Bosco di Foglino (Nettuno), 45 m, 41°28'22"N, 12°42'56"E, *S. Brullo*, together with *Campylopus introflexus*, *Hypnum cupressiforme* var. *cupressiforme* (CAT).

This *taxon* lives on wet rocks and soils in oceanic-montane belt. It is distributed in Asia, Europe, where it is included in some *red lists* (Hodgetts 2015), and North America. In Italy, it is known especially in the north and central part, mostly by reports dating back more than half a century ago (Aleffi & al. 2008). The finding in Lazio allows confirm its presence in this region.

Pleuridium acuminatum Lindb.

Italy, Lazio, Bosco di Foglino (Nettuno), 40 m a.s.l., 41°28'20"N, 12°42'54"E, *S. Brullo* (CAT).

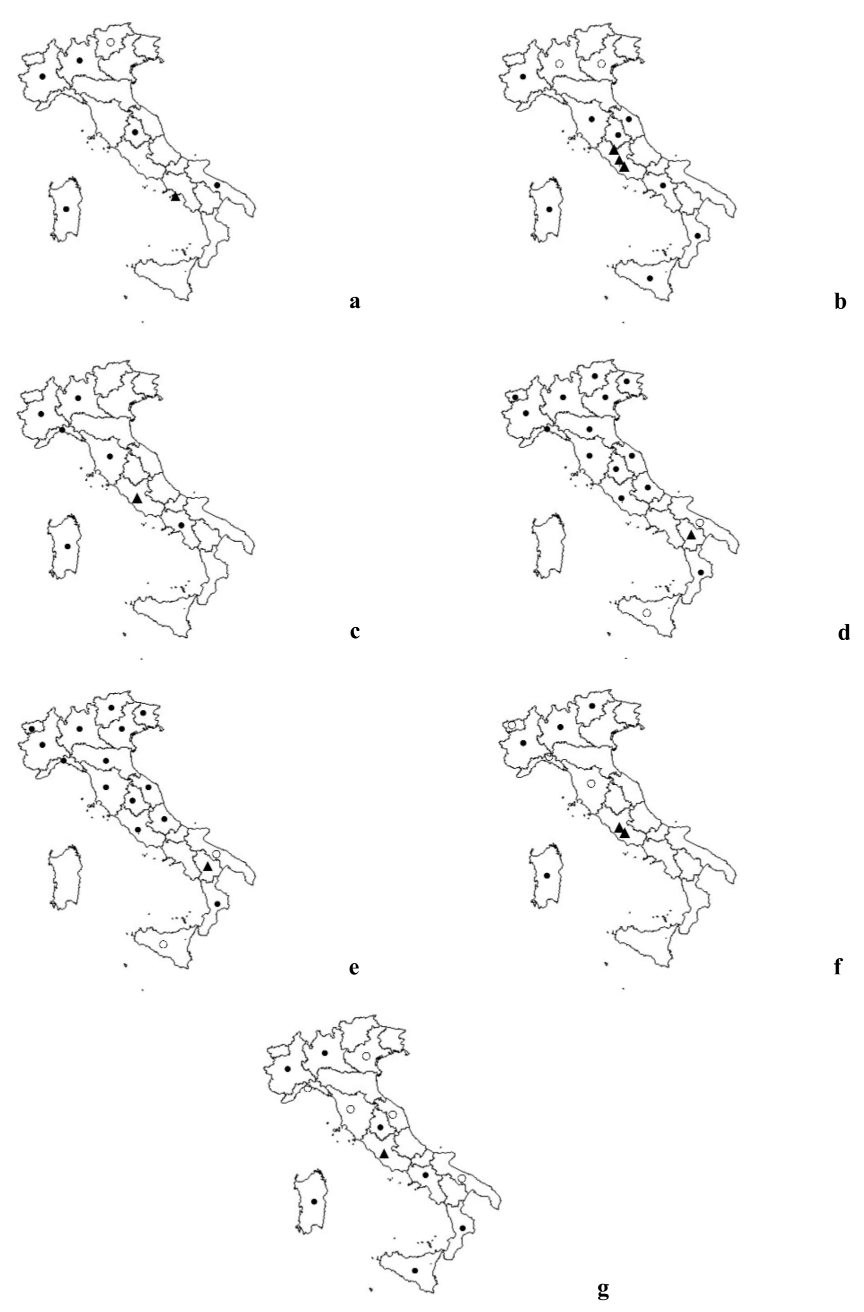

Fig. 1. Italian regional distribution of: a) *Riccia beyrichiana* Hampe ex Lehm; b) *Archidium alternifolium* (Hedw.) Mitt.; c) *Campylopus introflexus* (Hedw.) Brid.; d) *Hedwigia stellata* Hedenäs; e) *Hylocomium splendens* (Hedw.) Schimp.; f) *Campylopus atrovirens* De Not.; g) *Pleuridium acuminatum* Lindb. ● reports published before 1950; ○ reports published after 1950; ▲ new record.

It grows on open and disturbed soil in fields, pastures or slopes in woods, at low to moderate elevations. It is distributed in Europe, Asia (China), S Africa; Atlantic Islands, New Zealand (Seppelt 2007). In the new site it was found along the edge of some temporary ponds in the ambit of the Priority Habitat "Mediterranean temporary ponds", together with *Archidium alternifolium*, colonizing the same type of habitat.

In Italy, the species is known throughout the peninsula but in some regions, including Lazio, by old reports. Its presence in this region, recorded more than half a century ago, is here confirmed (Aleffi & al. 2008).

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N. Özhatay, R. Wallis, R. B. Wallis & M. Koçyiğit

A new *Fritillaria* species from Mediterranean region of Turkey; *Fritillaria asumaniae*

Abstract

Özhatay, N. Wallis, R., Wallis, R. B. & Koçyiğit, M.: A new *Fritillaria* species from Mediterranean region of Turkey; *Fritillaria asumaniae*. — Fl. Medit. 25 (Special Issue): 199-208. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

Fritillaria asumaniae R. Wallis, R. B. Wallis & N. Özhatay from Antalya province, situated in the Mediterranean region of Turkey is described as a new species. Approximately 20 species of the genus *Fritillaria* occur in Mediterranean region of Turkey, nearly 50% of which are endemic. In habit and shape of the perigone, the new species is reminiscent of *F. forbesii* Baker, a Turkish endemic species distributed around Muğla province and *F. elwesii* Boiss. scattered throughout SW Turkey and Aegean Islands. It differs from *F. forbesii* in its very dark brownish or blackish flowers, anthers and pollen grains. It also differs from *F. elwesii* in its undivided style, lack of green fascia on the perigone segments, the dark colored pollen grains and absence of bulbils. Description of the new species, taxonomic relationships, anther and pollen grain characteristics with color photographs are given.

Key words: *Fritillaria*, SEM, Mediterranean, Turkey.

Introduction

Approximately 156 taxa of the genus *Fritillaria* are accepted worldwide (Rix 2001). In Turkey the genus is represented by 35 species and 6 subspecies totaling 41 taxa, of which 16 are endemic. 15 new species have been collected for the first time in Turkey and their type specimens preserved therein (Rix 1984; Özhatay 2000; Tekşen 2012). The Mediterranean region is a particularly important area for the genus in Turkey (Fig. 1). Herein we describe a further new taxon from the region: *Fritillaria asumaniae.*

Whilst walking in the forest in the foothills of Tahtalı Dağ, near Antalya, on November 8th 2008, R. & R. B. Wallis noticed a large number of *Fritillaria* capsules in the dense undergrowth. Enquiries made of others who had been there before, informed us that the flowers were predominantly black and that, in spite of the colour, this could be a disjunct site for *F. forbesii*. Further investigation on April 7th 2011, whilst the plants were in flower, made us realise that there were significant differences from the latter and that we had found an undescribed species growing

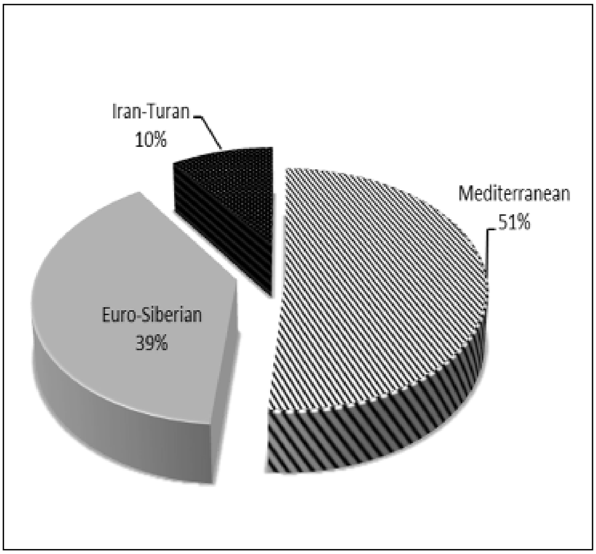

Fig. 1. The distribution of *Fritillaria* species within the three floristic region of Turkey (Tekşen 2012).

within a km of a popular tourist resort. It is widespread in and around the Olimpos Beydağları National Park and along the Lycian Way and it is a surprise that it has not been reported before.

Materials and methods

The specimens were collected during flowering time and were checked with the relevant literature (Tutin 1980; Rix 1984, 2001; Townsend 1985; Rechinger 1990; Özhatay 2000; Wallis & Wallis 2003; Tekşen & Aytaç 2008; 2011; Tekşen 2012) and compared with the herbarium specimens in ISTE (Istanbul University, Faculty of Pharmacy Herbarium).

Other examined species kept in ISTE:

F. forbesii; C2 Muğla, Babadağ,Fethiye-Ölüdeniz, Ocakköy,*Pinus brutia* forest ,limestone rocks,500 m, 19.03. 1992, *N.Özhatay, A.Byfield, S.Atay* (ISTE 64040)!

F. elwesii; C3Antalya:Manavgat-Topraktepe, near Taşkesiği, 100 m, 30.03.1975, T. Baytop (ISTE 31386)!, around Akseki, 04.1987, *A. Attila*. (ISTE 57760)!

Pollen samples were taken from herbarium materials for palynological studies. Pollen grains of specimens for LM investigations were prepared according to the method proposed by Wodehouse (1935) in Istanbul University, Faculty of Pharmacy, and Department of Pharmaceutical Botany and coated with gold for scanning electron microscope (SEM) studies. The SEM micrographs were taken with a JEOL 6510-LV JSM microscope. The descriptive terminology of Faegri and Iversen (1992) was used. The general pollen description was based on the SEM investigation.

Fritillaria asumaniae R. Wallis, R. B.Wallis & N. Özhatay, **sp. nov.** — Fig. 2, 3.

Type: C3 Antalya. Kemer, west of Göynűk, forest in deep leaf soil amongst limestone rocks under tall pine woodland, 250 m. 29.ııı.2012, *N. Özhatay and A. Kavgacı* (Holotype: ISTE 106610!).

Other examined specimen C3 Antalya, Kemer, Tahtalıdağ, Peynirlik-Kızılalan 800-1600 m, 04.05.1979, *H.Peşmen 4628, A. Güner* (ISTE 52595)!

Etymology: The species is named after Asuman Baytop (1920 – 2015) who was a well known Türkish botanist and sadly passed away this year.

Bulb spherical without bulbils. Stem 25-60 cm smooth. Leaves glaucous, 4-5 (7), alternate, linear-lanceolate, lowest 9.5 × 1.2 cm, with a single bract leaf, 4.5 × 0.3 cm. Leaves on unflowered bulbs ovate-lanceolate up to 6.5 × 3.5 cm. Flowers single, narrowly conical, segments dark brown-black with occasional small light spots, sometimes with a yellowish distal margin, untessellated, 20 × 8 mm. Nectary indistinct, greenish, at the base of the perigone, 3-4×2 mm. Filaments greenish white, 10 mm. Anthers dark brown. Style clavate, trifurcate, undivided, 8 × 1.5 mm papillose. Capsule unwinged.

Growing in partial to deep shade of large *Pinus brutia* Ten. trees, in deep leaf mould soil amongst limestone rocks. 225-500 m.

Ecology and distribution: *Fritillaria asumaniae* is quite a tall (up to 60cm) compared to other species probably because of its environment of tall undergrowth under the shade of pine trees in Antalya Province (Fig. 4). It shares this environment with beautiful mature trees of *Arbutus andrachne* L. and several species of deciduous shrubs which are only just coming into leaf when the new species is flowering. The area has a number of orchids of which we only noted *Orchis anatolica* Boiss. in flower at the same time. There are also a large number of *Cyclamen graecum* subsp *anatolicum* Ietsw. and *Galanthus peshmenii* A.P.Davis & C.D.Brickell which occupy the lower and the upper forest respectively and both of which overlap the altitude range of *F. asumaniae.*

Fritillaria asumaniae shows little variation and about half of the flowers observed are entirely dark brown with small white dots and the other half have a small yellow mark in the centre of the tip of both inner and outer tepals. After considerable searching we found just one specimen, amongst approximately 100 others, with dingy yellow flowers.

Anther and pollen morphology of the new species was compared with *F. forbesii* and *F. elwesii* (Fig. 3). The general description can be given as follows:

The anthers of *F. elwesii* are 5-8 × 0.9-1 mm and those of *F. forbesii* are 4-8 × 0.8-0.9 mm, whereas *F. asumaniae* has the smallest anthers among the three species (4-6 × 0.9-1 mm). Those of all the investigated species are apiculate at apex. The inner and outer surfaces are fossulate, with irregular grooves.

The main features of the investigated pollen are summarised in Table 1. *Size and shape;* The shape of pollen grains in the investigated *Fritillaria* is radially symmetrical, heteropolar, prolate according to the LA/SA ratio. The long axis (LA) 42.46-56.31 μm and short axis (SA) 30.46-41.85 μm based on LM. *F. asumaniae* has the largest pollen grain. *Aperture;* All the investigated pollen grains are operculate, monosulcate. *Fritillari forbe-*

Fig. 2. *Fritillaria asumaniae*: A) Perigone, B) In the field.

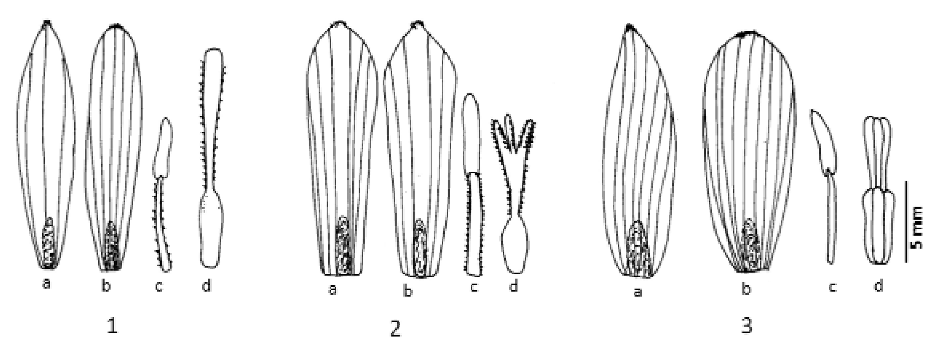

Fig. 3. The main morphological features of *Fritillaria forbesii* (1), *F. elwesii* (2), *F. asumaniae* (3): a. Outer tepals; b. Inner tepals; c. Stamen; d. Pistil.

sii has the longest and the widest sulcus, its length is 41.54 µm and its width is 10.77 µm based on LM. The sulcus membrane is verrucate in all three *Fritillaria* species investigated. *Exine, intine;* The exine is tectate and 1.08-1.69 µm thick. Intine thickness ranges from 0.91 to 1.24 µm. The thickest exine and intine are observed on the new species, *F. asumaniae*. The ornamentation is reticulate, rugulate-reticulate, reticulate-perforate. Reticulate-perforate sculpturing is observed in *F. forbesii*, rugulate-reticulate sculpturing is observed in *F. elwesii* and reticulate sculpturing is observed in the new species.

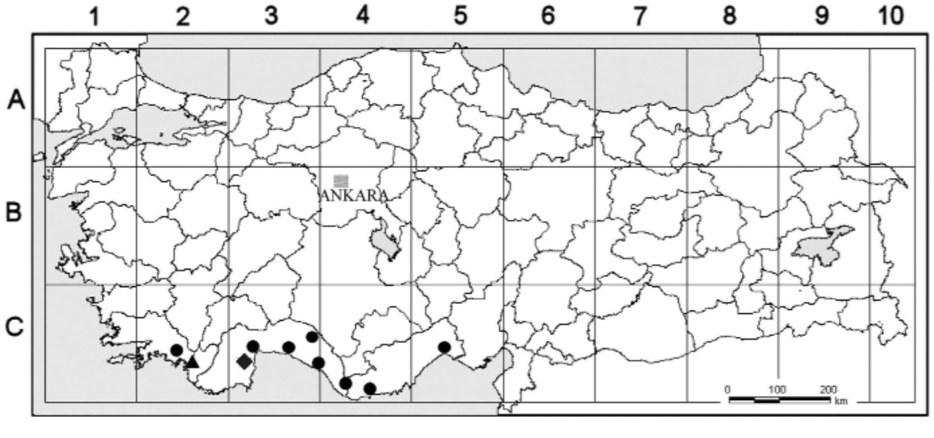

Fig. 4. Distribution of *F. forbesii*▲ , *F. elwesii* ●, *F. asumaniae* ♦ .

Table1. Pollen morphological parameters of *Fritillaria forbesii*, *F. elwesii* and *F. asumaniae* (values in µm, sd; standard deviation).

	Long axis (LA) mean±sd	**Short axis (SA) mean**	**LA/SA ratio, shape**	**Exine**		**Intine**	**Aperture type**	**Sulcus**		
				thickness	**ornamentation**			**length mean**	**width mean**	**ornamentation**
F. forbesii	47.38±1,39	32.01±1,56	1.48 prolate	1.08±0.25	reticulate-perforate	0.91±0.23	Monosulcate	41.54±1,97	10.77±1,42	Verrucate
F. elwesii	42.46±1,24	30.46±1,14	1.39 prolate	1.23±0.21	rugulate-reticulate	0.92±0.20	Monosulcate	24.62±1,63	09.23±0,98	Verrucate
F. asumanae	56.31±1,28	41.85±1,43	1.35 prolate	1.69±0.16	reticulate	1.24±0.24	Monosulcate	55.38±1,81	06.15±0,78	Verrucate

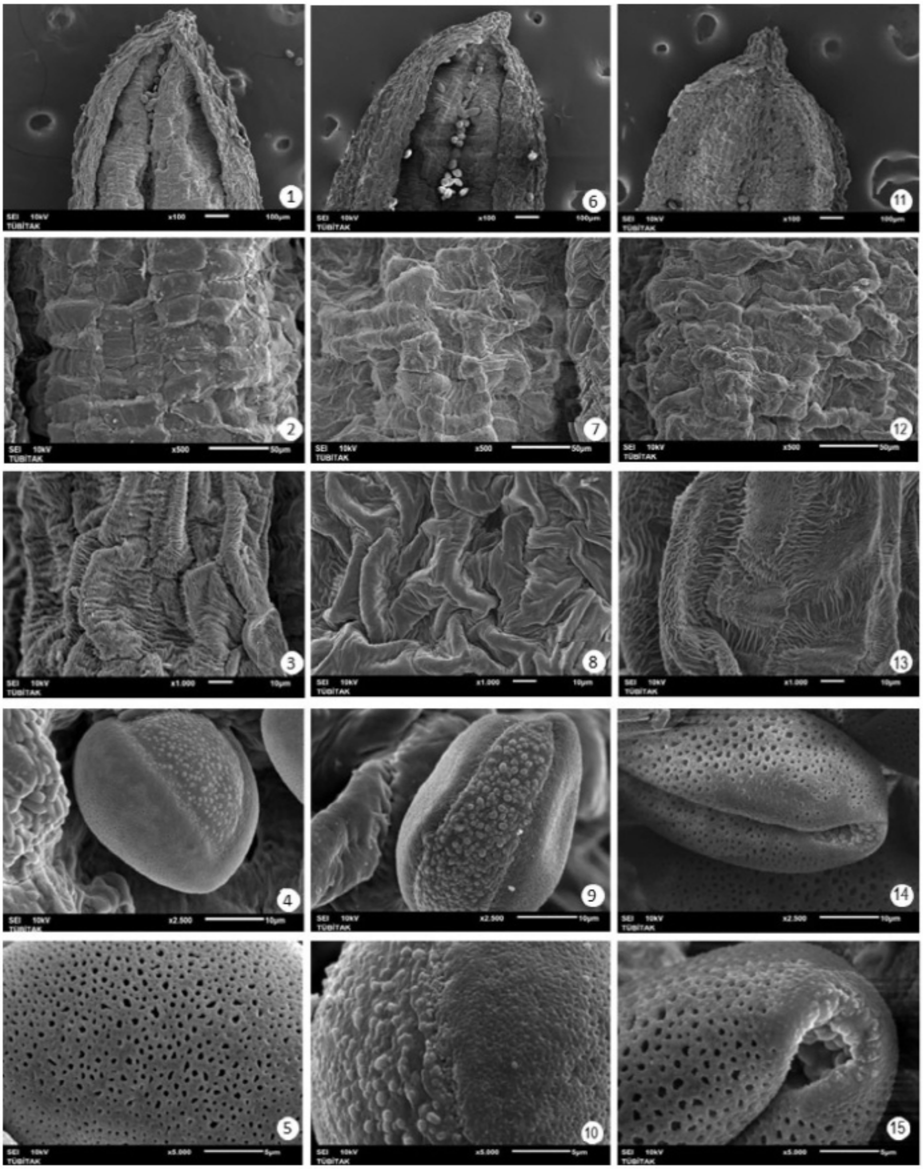

Fig. 5. Scanning electron micrographs of anthers (SEM × 100, 500, 1000) and pollen grains (SEM × 2500, 5000): 1-5. *F. elwesii*, 6-10. *F. forbesii*, 11-15. *F. asumaniae*. Anther apex (1, 6, 11), inner surface of anther (2, 7, 12), outer surface of anther (3, 8, 13), pollen grains (4, 9, 14), exine surfaces (5, 10, 15).

Discussion and Conclusions

Fritillaria asumaniae differs from *F. forbesii* Baker in several respects. With just the single exception described above, the flowers are very dark brown (greenish yellow in *F. forbesii*). The anthers and pollen are dark brown (yellow in *F. forbesii*). The stigma is markedly clavate and becomes very thick (1.5 mm) (linear and less than 1 mm in *F. forbesii*). The stem leaves are more than 10 mm wide (less than 5 mm wide in *F. forbesii*), a feature which is even more marked in the single leaves of unflowering seedlings (*F. asumaniae* = 35 mm, *F. forbesii* = 4 mm). *Fritillaria forbesii* is found on Baba Dağ and adjacent mountains, some 120 km to the west and has not been found in the intervening area.

According to Tekşen & al. (2010), *Fritillaria* species were divided into 7 pollen types according to sulcus membrane (psilate, verrucate, verrucate-granulate, granulate, granulate-striate, rugulate, gemmate). Pollen grains of *F.asumaniae* and *F. forbesii* are type II, but the pollen of *F.elwesii*'s is of type I.

Several other species of *Fritillaria* are known in the general area of Olimpos Beydağları National Park. *Fritillaria acmopetala* Boiss. is common especially on the south and east sides of the Tahtali Dağ ridge but differs in that it has narrower leaves and broader flowers. Plants named *F. lycica* were collected and described by Boissier nearby but it is clear that this is just a small form of *F. acmopetala* and is not the same as *F. asumaniae* (Baker 1874; Stapf 1928), *F. asumaniae* is easily separated from *F. acmopetala* by the shape of the flowers which is narrowly conical (campanulate with rounded shoulders *in F. acmopetala*) and particularly, by the stigma which is narrow and divided into three clear branches of at least 3 mm long in *F. acmopetala* and thickly clavate and undivided in *F. asumaniae.*

The difference between *F. asumaniae* and *F. elwesii* Boiss. is less straightforward and requires a combination of characters to be determined in order to distinguish the two species. The type locality of *F. elwesii* in the Dalaman River basin is 160 km to the south west and since it occurs near Kaş and throughout the southern Taurus mountains, one might expect it also to occur in Tahtali Dağ region, although it has never been reported there. Like *F. acmopetala*, *F. elwesii* usually has a divided stigma, lacking in *F. asumaniae*. However, in some specimens found near near Kaş, the stigma is undivided (E.M. Rix personal communication). It is however narrower than that of *F. asumaniae*. *Fritillaria elwesii* generally has flowers with marked green fascia (absent in *F. asumaniae*). Both species have brown anthers but the pollen is yellow in *F elwesii* and brown in *F. asumaniae.* Moreover the inner segments are markedly broader than the outer segments in *F. elwesii*, yet similar or only slightly broader in *F. asumaniae. Fritillaria elwesii* is often a prolific producer of bulbils which result in quite large colonies of leaves whereas we have not observed bulbils on plants of *F. asumaniae.*

There is also one report of *F. latakiensis* Rix (Rix 1984) from near Kaş but again, although superficially similar to *F. asumaniae* it has a narrow, divided style.

For these reasons we consider *F. asumaniae* to be a new species and a surprising new addition to the flora of Turkey. *F. asumaniae* has been seen in several places in the forests of Tahtalı Dağ where it flowers in March and early April.

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S. Brullo, P. Pavone & C. Salmeri

Biosystematic researches on *Allium cupani* group (*Amaryllidaceae*) in the Mediterranean area

Abstract

Brullo, S., Pavone, P. & Salmeri, C., W.: Biosystematic researches on *Allium cupani* group (*Amaryllidaceae*) in the Mediterranean area — Fl. Medit. 25 (Special Issue): 209-244. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

Allium cupani Raf. is a species complex of the subgenus *Allium* L., which is taxonomically quite critical mainly for its marked karyological and morphological variability. In the present study, karyo-taxonomic characterization of some peculiar populations of this group from Italian, N African, Balcan and Aegean territories has been performed, using both living plants collected in the field and herbarium material. As a result, ten new species have been recognized and described within the *A. cupani* complex. They are *A. panormitanum* from N Sicily, *A. samniticum* from C Italy, *A. mauritanicum* from N Morocco and NW Algeria, *A. balcanicum* from mountains of Balkan Peninsula, *A. tzanoudakisanum* from Aegean area, *A. cephalonicum* from Cephalonia island, *A. meikleanum* from Cyprus, *A. pelagicum* from Lampedusa island, *A. maghrebinum* from Tunisia and NE Algeria, and *A. tingitanum* from N Morocco and NW Algeria. A comprehensive description and detailed illustration, together with significant notes on karyology, phenology, ecology, geographic distribution, and taxonomic relationships are provided for each species.

Key words: biogeography, karyology, Mediterranean, *Allium* sect. *Cupanioscordum*, taxonomy.

Introduction

As a result of extended biosystematic studies carried out on the genus *Allium* L. in the Euro-Mediterranean countries over the last thirty years (Brullo & al. 1982, 1993, 1996, 1997a, 1998, 2001, 2003a, 2003b, 2004, 2008a, 2008b, 2009, 2010, 2013, 2014; Bogdanovič & al. 2008, 2009, 2011a, 2011b; Giusso & al. 2015), this contribution on a critical and poorly known group of taxa currently attributed to the *A. cupani* Raf. complex is presented.

Populations belonging to this species complex are distributed in the whole Mediterranean area, spreading eastward to the Irano-Turanian region. They are usually very scattered and geographically quite isolated, often restricted to small surfaces with few individuals. This biogeographical pattern has been interpreted as a consequence of ancient segregation processes, probably dated back to the Miocene (De Wilde-Duyfjes 1976; Garbari & al. 1979; Brullo & al. 1995, 2008c).

Based on literature (Rafinesque 1810; Kunth 1843; Boissier 1882; Vvedenskii 1935; Palau 1953; Stearn 1978; Garbari & al. 1979; Llorens 1979; Brullo & Pavone 1983, 1988; Pastor & Valdes 1983; Kollmann 1984; Miceli & Garbari 1987; Pogosian 1989; Brullo & al. 1989, 1990, 1995, 1997b, 2008c; Andersson 1991; Iatrou & Tzanoudakis 1995) and vast herbarium surveys, several taxa reported for the Mediterranean area and the Middle East should be referred to this group, some of which actually having a doubtful taxonomic status. They are: *A. cupani* Raf., *A. callidictyon* C.A. Meyer ex Kunth, *A. hirtovaginatum* Kunth, *A. lacerum* Freyn, *A. incisum* Fomin, *A. araxanum* Fomin ex Grossh., *A. fimbriatum* Schischkin, *A. peroninianum* Azn., *A. antonii-bolosii* P. Palau, *Allium cupani* Raf. subsp. *cyprium* Meikle, *A. cupani* subsp. *anatolicum* Stearn, *A. greuteri* Brullo & Pavone, *A. eivissanum* Garbari & Miceli, *A. pentadactyli* Brullo, Pavone & Spamp., *A. karistanum* Brullo, Pavone & Salmeri, *A. ritsii* Iatrou & Tzanoudakis, *A. balcanicum* Brullo, Pavone & Salmeri nom. nud., *A. panormitanum* Brullo, Pavone & Salmeri nom. nud., *A. pelagicum* Brullo, Pavone & Salmeri nom. nud.

A characteristic feature of the taxonomic history of the *Allium cupani* complex is the inclusion in many different sections of the subgen. *Allium*, such as sect. *Schoenoprasum* Dumort. (Regel 1875; Vvedenskii 1935; Martinoli 1955), sect. *Macrospatha* G. Don (Maire 1958), sect. *Codonoprasum* Reichenb. (Garbari & Senatori 1976; De Wilde-Duyfjes 1976), sect. *Scorodon* C. Koch (Wendelbo 1971; Stearn 1978, 1980; Tzanoudakis 1983; Tzanoudakis & Vosa 1988; Özhatay 1990), sect. *Brevispatha* Valsecchi (Garbari & al. 1979; Kollmann 1984; Tzanoudakis 1992; Özhathay 1993; Brullo & al. 1995), and sect. *Cupanioscordum* Ceschm. (Cheschmejiyev 1975; Brullo & al. 2008c; Salmeri & al. 2014, 2015).

Some morphological traits of *Allium cupani*, as for istance spathe often shorter than the inflorescence, simple stamen filaments, included into the perigon, and ovary with well-developed nectariferous pores, indeed characterize various members of sect. *Scorodon* s. l., but many other taxonomically important characters, including outer bulb coats always reticulate-fibrous, sheathing spathe with 1 or 2 valves always connate at base, usually unilateral inflorescence, and 2-4 bostryces clearly distinguish *A. cupani* populations from sect. *Scorodon* s. l. The inclusion within sect. *Codonoprasum* should also be excluded, since all members of this section show membranaceous or coriaceous bulb tunics (the outermost ones sometimes only slightly fibrous), more or less large leaves, never filiform, spathe with 2 very long valves, splitted or slightly welded, ovary with inconspicuous nectariferous pores. These evidences are well supported by many phylogenetic studies, which place *A. cupani* s. l. in a distinct clade sister to the monophyletic sect. *Codonoprasum*, within the subgenus *Allium*, while sect. *Scorodon* s.str., typified by *A. moscatum* L., is included in the subgenus *Polyprason* Radić. (Fritsch & Frisen 2002; Frisien & al. 2006; Nguyen & al. 2008; Li & al. 2010; Hirschergger & al. 2010). Despite some affinities based on sheathing spathe, few-flowered inflorescence and 2 bostryces (Valsecchi 1974; Brullo & al. 1982), *Allium cupani* does not properly fit even within sect. *Brevispatha,* which is typified by *A. parciflorum* Viv., species markedly differing from *A. cupani* in a combination of relevant diagnostic features, such as only slightly fibrous outer bulb coats and coriaceous inner ones, 2-valved spathe always associated with 2 bostryces, and ovary with inconspicuous nectariferous pores.

It must be stressed that taxonomic diacritic characters of *Allium* species can be properly detected only on living plants, because most traits, especially the floral ones, become altered and not recognizable in dry specimens so as to be unsuitable for a correct identification (Brullo 2009). This is probably one of the main reasons why many critical species and groups of this genus are still poorly investigated or misclassified, as in the case of *A. cupani*.

All populations of the *Allium cupani* complex are morphologically well differentiated from the other *Allium* species by a distinctive combination of diagnostic features, comprising brown outer bulb tunics, fibrous and more or less markedly reticulate, filiform leaves, with cylindrical to semicylindrical outline, subglabrous to densely hairy leaf indumentum, persistent spathe, with 1 or 2 valves basally connate, partially sheathed the flower pedicels, inflorescence few-flowered, fastigiate and usually unilateral (rarely hemispherical), arranged in 2 or 4 bostryces when the spathe is 1-valved or 2-valved respectively, perigon cylindrical to urceolate, white-pinkish to pink-purplish, simple stamen filaments included into the perigon, ovary with well-developed nectariferous pores, covered by a membranous plica, capsule included into the perigon.

This combination of morphological features, together with many other anatomical, ultra-structural and biogeographical peculiarities (Garbari & al. 1979, 1991; Tzanoudakis & Vosa 1988; Brullo & al. 1995, 2008c, 2012; Celep & al. 2012), indeed suggests a more appropriate inclusion of the *A. cupani* group in the autonomous sect. *Cupanioscordum* as proposed by Cheschmejiyev (1975). Recent phylogenetic studies supported the monophyletic status of this group, whose species usually form a distinct clade in sister-relationship to other sections of subgenus *Allium*, especially sect. *Codonoprasum* (Friesen & al. 2006; Li & al. 2010; Salmeri & al. 2014, 2015).

In addition, the *Allium cupani* group is characterized by a significant variation both in the chromosome number and karyotype structure amongst different taxa and populations, as clearly highlighted in the current literature (Garbari & al. 1979; Tzanoudakis 1983; Brullo & Pavone 1983; Miceli & Garbari 1987; Tzanoudakis & Vosa 1988; Pogosian 1989; Brullo & al. 1989, 1990, 1995, 1997b; Tzanoudakis & al. 1991; Iatrou & Tzanoudakis 1995). These studies pointed out that the ancestral chromosome complement in the *A. cupani* group was diploid ($2n = 16$), with a basic number $x = 8$, as common in the whole subgenus *Allium* (Garbari & al. 1979; Narayan 1988; Özhatay 1993; Brullo & al. 1995; Hanelt 1996; Ohry & al. 1998). Populations of *A. cupani* s. l. also exhibit a tetraploid chromosome number $2n = 32$, derived by autopolyploidy or allopolyploidy processes. From these euploid chromosome complements, other two hypo-aneuploid counts $2n = 2x = 14$ and $2n = 4x = 30$ directly derived, due to mutational events.

This study aimed to clarify some of the taxonomic and nomenclatural problems within the *A. cupani* complex, using morphological, karyological, phenological, ecological, and chorological data, mostly obtained from living plants collected in various Mediterranean localities. As a result of these investigations, some species have been discovered and here described as new to science.

Materials and Methods

The morphological study was based on living plants collected in many localities of the Mediterranean area (Aegean area, Anatolia, Bulgaria, Crete, Cyprus, European Turkey, Greece, Baleares, Italy, Libya, Morocco, Sicily, Tunisia), then cultivated in the Botanical

Garden of Catania. Living plants specifically coming from the type locality were surveyed whenever possible. Furthermore, many herbarium collections from various botanical museums were examined for taxonomic comparison (B, BM, BOLO, C, CAT, FI, FI-W, G, G-BOIS, HUJ, ISTE, K, M, MA, MPU, NAP, OXF, P, PAL, PI, RO, UPA, W, WU). Qualitative and quantitative morphological traits were examined and recorded under a Zeiss Stemi SV11 Apo stereomicroscope at 6–66× magnification from fresh material (about 10 individuals). Both vegetative and reproductive characters, together with some anatomical and ecological features, were chosen according to their diagnostic value for discriminating among the investigated populations. Herbarium specimens and available literature data were also employed to better define the range of intra-specific variability.

Karyological analyses were performed on mitotic plates obtained from root meristematic cells of cultivated bulbs (at least five), pre-treated with 0.3% (w/v) colchicine at room temperature for 3 h, fixed in Farmer's fixative (3:1 v/v, absolute ethanol: glacial acetic acid) for 12 hours, and hydrolyzed with 1N HCl for 7 min at 60°C. Chromosomes were stained using the Feulgen method (Feulgen & Rossenbach 1924). The somatic chromosome number was established and karyotype details were defined from 10 representative metaphase plates (2 per individual). Metaphase chromosomes were measured using the image analysis systems IKAROS 4.6 (Metasystem) and Zeiss Axiovision 4.6. Karyotyping was performed using software Cromolab© 1.1 (Brullo 2002) for the recognition and ordering of homologues. Chromosome classification and karyotype formulas followed Levan & al. (1964) and Tzanoudakis (1983).

Results

1. *Allium cupani* Raf., Caratteri: 86, 1810 – Figs. 1A, 3A, 5A, 6A, 7A, 8A.

Type: Sicily, Nasce sopra il Monte Etna e le Madonie, Rafinesque (types destroyed).

Lectotype: *Moly alpinum minus, capillaceo folio, floribus purpureo-rubris*, vol. 2, T. 201, Cupani (1713), here designated.

Epitype: Sicilia, Madonie, Quacella, 30.7.1991, *S. Brullo s. n.* (CAT!), here designated.

Bulb ovoid, sometimes bulbilliferous, 15-18 × 7-11 mm, with brown tunics, reticulate-fibrous, attached to the base of the bulb, covering the stem up to 2.5 cm. *Stem* erect or erect-ascending, flexuous, 12-18 cm high, covered by the leaf sheaths from 1/2 to almost total length. *Leaves* 4-5, shorter than the inflorescence, filiform, semicylindrical, sometimes canaliculate, 1.5-8 cm long, subglabrous or sparsely hairy with patent hairs 0.15-0.2 mm long. *Inflorescence* fastigiate, unilateral, with 4-10 flowers on pedicels 12-30 mm long. *Spathe* 1-valved, shorter than the inflorescence, 3-nerved, sometimes with 2 additional incomplete nerves, 12-20 mm long, with an appendage 1-3 mm long. *Bostryces* 2. *Perigon* cylindrical-campanulate, 6-7.5(8) mm long; tepals white-pink or pink with a purplish mid-vein, the outers oblong-lanceolate, entire, obtuse, 2-2.2 mm wide, the inners linear-oblong, rounded and gnawed-undulate at the apex, 1.6-1.8 mm wide. *Stamens* with white filaments, unequal, the outers subulate-triangular, 0.7-1.7 mm long and 0.5-0.7 mm wide at the base, the inners subulate above and broadened below, 1.5-2.5 mm long and 1-1.2 mm wide at the base, below connate with tepals into an annulus 1.2-1.5 mm high; anthers white-straw coloured, linear-elliptical, rounded at the apex, 1.6-1.8 × 0.6-0.8 mm.

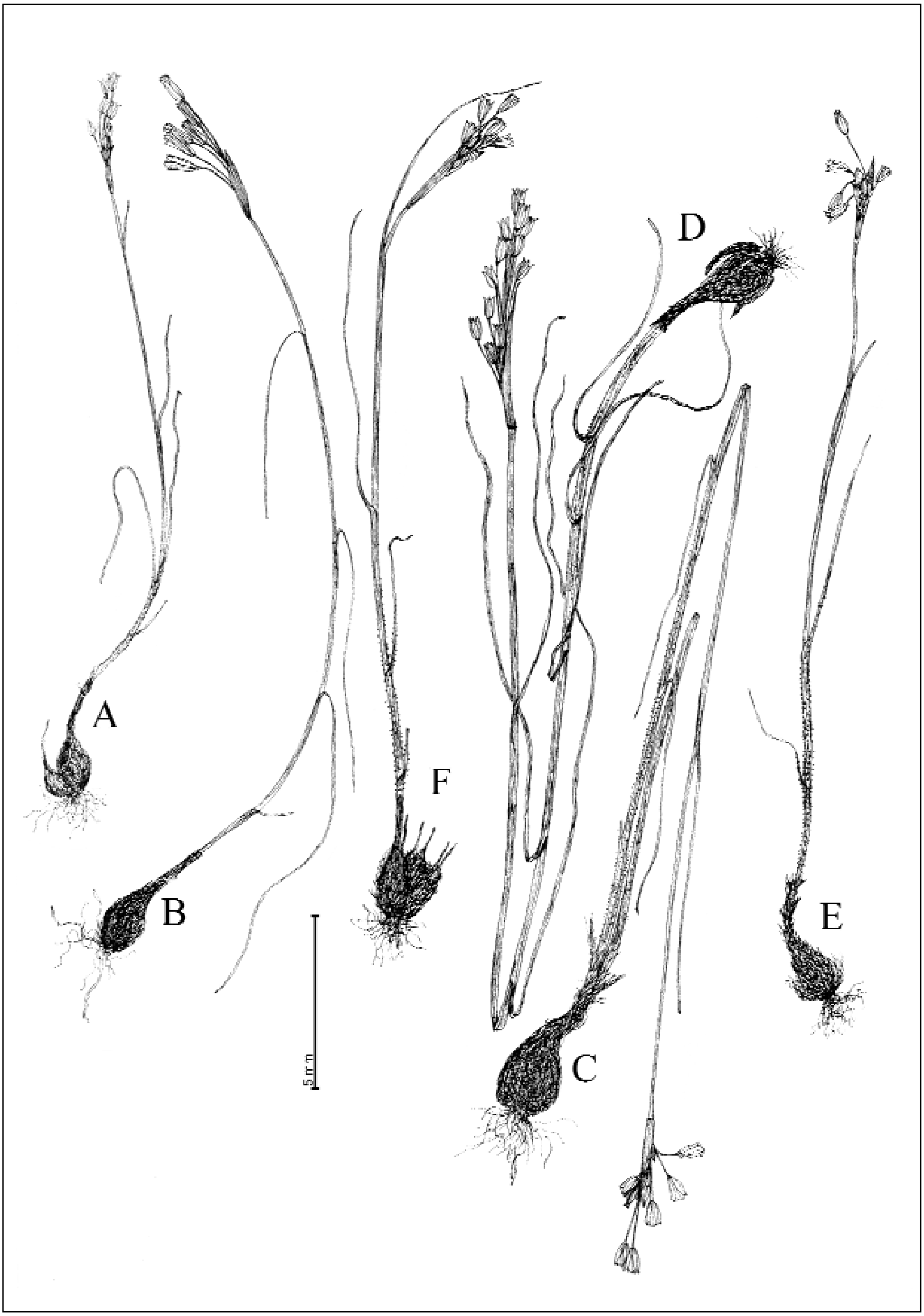

Fig. 1. Habit: **A.** *A. cupani*; **B.** *A. panormitanum*; **C.** *A. samniticum*; **D.** *A. mauritanicum*; **E.** *A. balcanicum*; **F.** *A. tzanoudakisanum* (Drawing by S. Brullo from living plants of type locality).

Ovary, ovoid or ovoid-pyriform, smooth, green, 1.8-2 × 1.5 mm; style white, 1-1.3 mm long. *Capsule* trivalved, ovoid to ellipsoid, uniformly coloured, 4.5-5 × 3.2-3.8 mm.

Distribution and habitat: Limited to some NW Sicilian mountains, such as Madonie, Mt. Pizzuta, Mt. Kumeta and Rocca Busambra. The species grows within orophilous meadows and dwarf shrub communities, which develop in rocky and semirupestrian places up to about 2000 m of elevation, on calcareous, dolomitic or quarzarenitic substrata.

Karyology: All investigated populations of *A. cupani* s. str. (Tab. 1) revealed a tetraploid chromosome complement with $2n = 32$ (Fig. 9A), which confirms the count reported by Garbari & al. (1979). The karyotype appeared to be diploidized with homologues arranged in pairs instead of tetraplets, revealing a possible allopolyploid origin. It was mostly characterized by more or less metacentric (*m* to *msm*) chromosomes, two submetacentric (*sm*) pairs, one of which microsatellited on the short arm, and 4 subtelocentric (*st*) pairs. Two to eight of these latter chromosomes, depending on the different analysed populations, showed microsatellites in the short arms. The karyotype formula can be summarized as follows: $2n = 4x = 32$: 12m + 8msm + 2sm + 2sm^{sat} + 8st. Plants from type locality (Madonie Mts.) revealed a haploid chromosome complement 131.68 µm in length, varying from 11.61 µm of the longest chromosome to 5.74 µm of the shortest one, while the relative length ranged from 8.82 to 4.36%.

Phenology: Flowering from mid July to late August.

Etymology: Francesco Cupani, pre-linnean Sicilian naturalist, is commemorated.

Taxonomic notes: In the protologue of *Allium cupani*, Rafinesque (1810) quoted as *locus classicus* "Nasce sopra il Monte Etna e le Madonie". Given the loss of the Sicilian herbarium of Rafinesque due to a shipwreck while he was returning to N America in 1815, we propose as lectotype the iconography published in Cupani (1713), that Rafinesque (1810) quoted in the protologue. Since this illustration is rather unclear and does not show the relevant diacritic features of this species, one specimen from Madonie Mts. is here designated as epitype. To this respect, it must be highlighted that the neotype previously designated by De Wilde-Duyfjes (1976: 109) "in montosis panormitanis a Monte Gallo, *Parlatore* (FI-W)" was not correctly chosen because it does not come from the *locus classicus*. Furthermore, this specimen differs from *A. cupani* in many relevant morphological features and corresponds to another species of the *A. cupani* group occurring at Monte Gallo, named *A. panormitanum*, which has an autumnal flowering period.

A. cupani s.str. belongs to a group of tetraploid taxa with $2n = 32$ only present in Sicily, CS Italy and NW Africa, which share some morphological characters, including bulb coats attached to the base of the bulb, glabrous to subglabrous or sparsely hairy leaves, 1-valved, 3-4-nerved spathe, shorter than the inflorescence and provided with a small appendage, smooth ovary, as well as a merely summer flowering time (July-August). Specifically circumscribed to some mountain localities of NW Sicily, *A. cupani* is characterized by relict populations, geographically isolated and confined to small surfaces with few individuals, which testify the very old origin and segregation of this taxon.

Additional specimens examined: Sicily, Nei Monti di Palermo e alle Madonie, 1822, *G. Gussone s.n.* (BOLO!); Madonie, Quacella, 30.7.1991, *S. Brullo s.n.* (CAT!); ibid., Pizzo Carbonara, 29.7.1991, *S. Brullo s.n.* (CAT!); ibid., Colma Grande, 24.7.1992, *S. Brullo s.n.* (CAT!); ibid., M. S. Salvatore, 21.7.1979, *S. Brullo s.n.* (CAT!); ibid., Piano

Fig. 2. Habit: **G.** *A. cephalonicum*; **H.** *A. maghrebinum*; **I.** *A. hirtovaginatum*; **J.** *A. meikleanum*; **K.** *A. pelagicum*; **L.** *A. tingitanum* (Drawing by S. Brullo from living plants of type locality).

Battaglia, 3.9.1972, *S. Brullo s.n.* (CAT!); ibid., inter Piano Battaglia et Pizzo Carbonara, 04.8.1965, *H. Merxmüller & H. Grau 20391* (M!); Pizzo dell'Antenna, 1850, no collector (PAL!); Madonie, con *Genista cupani*, nelle radure delle Faggete, Mercato di Cixè (Geraci Siculo), 1975, *F. M. Raimondo s.n.* (PI!); Monte Kumeta (Piana degli Albanesi), 25.7.1990, *S. Brullo s.n.* (CAT!); Monte Pizzuta (Piana degli Albanesi), 25.7.1990, *S. Brullo s.n.* (CAT!); Rocca Busambra, 12.7.1981, *S. Brullo s.n.*(CAT!); ibid., 26.7.1990, *S. Brullo s.n.* (CAT!)

2. *Allium panormitanum* Brullo, Pavone & Salmeri, spec. nova – Figs. 1B, 3B, 5B, 6B, 7B, 8B.

Allio cupano similis, sed scapo 20-30 cm longo, foliis glabris, spatha apiculata, 6-9-nervata, perigonio cylindrico-urceolato, 7,5-9 mm longo, tepalis exterioribus rotundatis, 2,3-2,7 mm latis, tepalis interioribus 1,8-2,2 mm latis, filamentibus staminum inferne cum tepalis per 1,7-2 mm in annulum connatis, antheris ellipticis, 1,4-1,5 mm longis, ovario papilloso-rugoso superne, capsula ellipsoidea, 4,2 mm longa.

Type: Sicily, Monte Pellegrino (PA), 10.9.1992, *S. Brullo s.n.* (Holo: CAT!).

Bulb ovoid, sometimes bulbiliferous, 12-20 × 7-12 mm, with brown outer tunics, reticulate-fibrous, attached to the base of the bulb, covering the stem up to 3 cm. *Stem* erect, flexuous, 20-30 cm high, covered by the leaf sheaths 1/2-3/4 of its length. *Leaves* 4-5, shorter than the inflorescence, filiform, subcylindrical, 5-15 cm long, glabrous or sometimes provided with hairs 0.2-0.3 mm long on the sheath gorge. *Inflorescence* fastigiate, unilateral, with 5-8 flowers on pedicels 10-40 mm long. *Spathe* 1-valved, shorter than the inflorescence, 6-9-nerved, 12-20 mm long, apiculate. *Bostryces* 2. Perigon cylindrical-urceolate, (7.5-)8-9 mm long; tepals subequal white-pink, tinged with purple, with a purplish mid-vein, the outers linear-elliptical, entire, rounded, 2.3-2.7 mm wide, the inners linear-oblong, rounded and gnawed-undulate at the apex, 1.8-2.2 mm wide. *Stamens* with white filaments, triangular, unequal, the outers 1-2 mm long and 0.7-0.8 mm wide at the base, the inners 1.8-3 mm long and 1.2-1.5 mm wide at the base, below connate with tepals into an annulus 1.7-2 mm high; anthers white-straw coloured, elliptical, rounded at the apex, 1.4-1.5 × 0.8 mm. *Ovary* green, ovoid, papillose-rugose in the upper part, 2 × 1.5-1.6 mm. Style white, 1 mm long. *Capsule* trivalved, ellipsoid, 4.2 × 3.5 mm.

Distribution and habitat: The species occurs in some mountains near Palermo (NW Sicily), such as Mt. Pellegrino, Mt. Gallo and Mt. Caputo. It preferably grows in crevices and rocky places at 100-500 m of elevation, where it is a member of thermo-xerophilous garigues or perennial grasslands, such as *Ampelodesmos mauritanicus* communities, linked to Mesozoic limestones.

Karyology: All analyzed populations of *Allium panormitanum* (Tab. 1) showed the same tetraploid chromosome number $2n = 32$ as *A. cupani* s.str. The karyotype structure (Fig. 9B) was also rather similar with chromosomes arranged in pairs instead of tetraplets and a majority of more or less median chromosomes (*m* or *msm* types) plus 4 subterminal (*st*) pairs. Notwithstanding, the karyotype of *A. panormitanum* differs in the occurrence of one additional submetacentric pair and in various karyomorphometric parameters, including greater chromosome length (THL), higher difference between long and short arms (D-value) and smaller difference in chromosome relative length (DRL). The karyotype formula can be summarized as: $2n = 4x = 32$: 12m + 8msm + 4sm + 8st. Satellites were clearly detected in specimens from Mt. Caputo, where one submetacentric pair

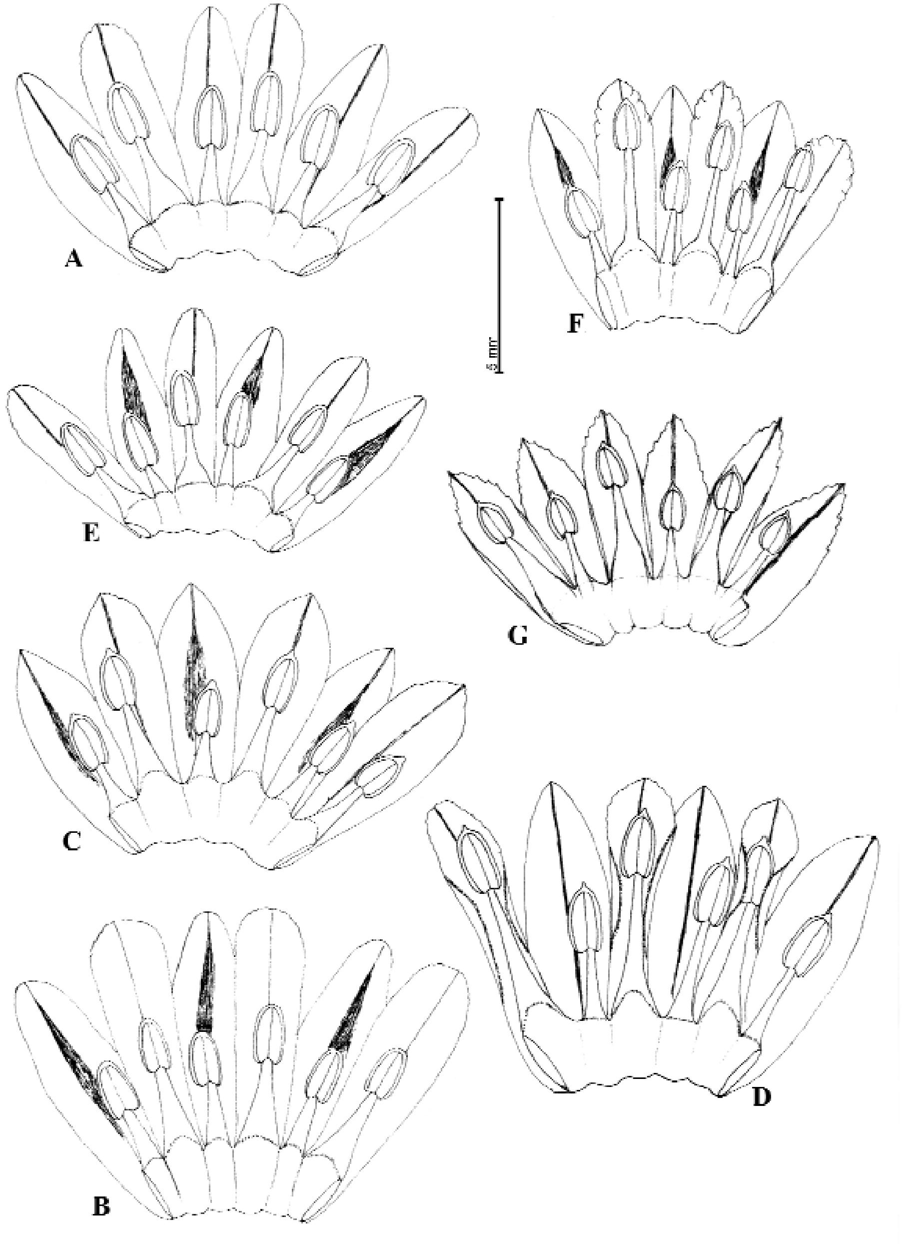

Fig. 3. Open perigon: **A.** *A. cupani*; **B.** *A. panormitanum*; **C.** *A. samniticum*; **D.** *A. mauritanicum*; **E.** *A. balcanicum*; **F.** *A. tzanoudakisanum*; **G.** *A. cephalonicum* (Drawing by S. Brullo from living plants of type locality).

showed macrosatellites on the short arms and 3 subtelocentric pairs were microsatellited. Specimens from type locality showed a haploid chromosome complement 154.35 ± 12.16 µm long, the total chromosome size varying from 12.65 ± 1.06 µm of the longest chromosome to 6.10 ± 1.7 µm of the shortest one, and the relative length ranging from 6.16 to 3.92%.

Phenology: Flowering from September to mid November.

Etymology: From Latin "*Panormus*", today's Palermo in NW Sicily.

Taxonomic notes: Based on bulb coats attached to the base of the bulb, 1-valved spathe shorter than the inflorescence, and tetraploid chromosome number ($2n = 32$), *Allium panormitanum* is quite related to *A. cupani*, although the two species significantly differ in several features. Firstly, *A. panormitanum* is a typical autumn-flowering (September-November) geophyte, whereas *A. cupani* flowers from late spring to summer (June-August). Then, *A. panormitanum* shows higher stem (20-30 cm), apiculate spathe with 5-9 complete nerves, bigger perigon (c. 8-9 mm) and papillose-rugose ovary, while *A. cupani* is characterized by a shorter stem (8-20 cm), appendiculate spathe with 3-5 complete plus 2 incomplete lateral nerves, smaller perigon (c. 6-7.5 mm) and entirely smooth ovary.

Paratypes: Sicily, Monte Pellegrino (PA), 10.9.1992, *S. Brullo s.n.* (CAT!); In montosis Siciliae, Monte Gallo, s.d., *F. Parlatore s.n.* (W!); Palermo, a Monte Gallo, 6.1854, *A. Todaro s.n.* (WU!); ibid., 9.1980, *C. Marcenò s.n.* (CAT!); ibid., 8.1880, *M. Lojacono 228* (WU!); ibid., 10. 1880, *M. Lojacono s.n.* (W!); ibid., 10.9.1992, *S. Brullo s.n.* (CAT!); ibid., 3.9.1993, *S. Brullo s.n.* (CAT!); ibid., 10.1868, *F. Parlatore* (FI!); ibid., s.d., *F. Parlatore* (FI-W!, PAL!); ibid., 1846, *A. Todaro s.n.* (PAL!); ibid., 10.1823, s.l. (PAL!); ibid., 10.1881, *M. Lojacono s.n.* (PI!); ibid., s.d., s.l. (PAL!); ibid., in aridis montosis, s.d., *A. Todaro 1454* (MPU!, PAL!); ibid., 9, *A. Todaro s.n.* (PAL!); ibid., s.d., *A. Todaro s.n.* (P!, W!); ibid., in saxosis calcareis, 10.1881, *M. Lojacono 110* (BC!); ibid., 10.1881, *M. Lojacono 20720* (FI!, G!, MA!); In collibus saxosis calcareis al Telegrafo, 10.1880, *M. Lojacono 228* (BM!, FI!, G!, MPU!, P!, WU!); Sopra Monte Gallo, 10.10.1824, s. l. (PAL!); Alla Scala del Guadagno, s.d., *F. Parlatore s.n.* (FI!); Alla Portella Spartivento, in sax. calc. c. 200 m, 30.10.1914, *C. Lacaita 328/11* (BM!); Monti presso Caputo (PA), 2510.1988, *S. Brullo s.n.* (CAT!); S. Maria di Gesù, s.d., s.l. (PAL!); Scala del Mezzagno, 10.1825, s.l. (PAL!); ibid., 1842, *F. Parlatore s.n.* (FI!); Palermo, 10.841, *F. Parlatore s.n.* (G!); ibid., 1847, *V. Tineo s.n.* (K!); ibid., 1859, *G. Gussone s.n.* (NAP-GUSS!); ibid., s.d., *F. Parlatore s.n.* (K!); ibid., s.d., s.l. (K!); ibid., s.d., *V. Tineo s.n.* (P!); Montagne de Palerme, s.d., *G. Gussone s.n.* (G!); In montosis panormitanis, s.d., *F. Parlatore* (FI-W!); ibid., s.d., *A. Todaro s.n.* (FI!); In montibus Panormi, s.d., *F. Parlatore s.n.* (BM!); In aridis montosis prope Panormum, s.d., s.l. (W!); In pascuis montanis Siciliae, s.d., *F. Parlatore s.n.* (K!).

3. *Allium samniticum* Brullo, Pavone & Salmeri, spec. nova – Figs. 1C, 3C, 5C, 6C, 7C, 8C.

Allio cupano similis, sed bulbo ellipsoideo-ovoideo, tunicis pallido-brunneis, scapo usque ad 28 cm alto, foliis pilosis, pilis 0,2-0,6 mm longis, spatha 5-7-nervata, appendice 2-7 mm longa, tepalis roseis vel roseo-purpureis, exterioribus acutis vel subobtusis, antheris apiculatis, capsula globoso-obovoidea, 4,8-5 × 4,2-4,5 mm.

Type: Italy, L'Aquila, Villavallelonga, 25.8.1990, *P. Minissale s.n.* (Holo: CAT!).

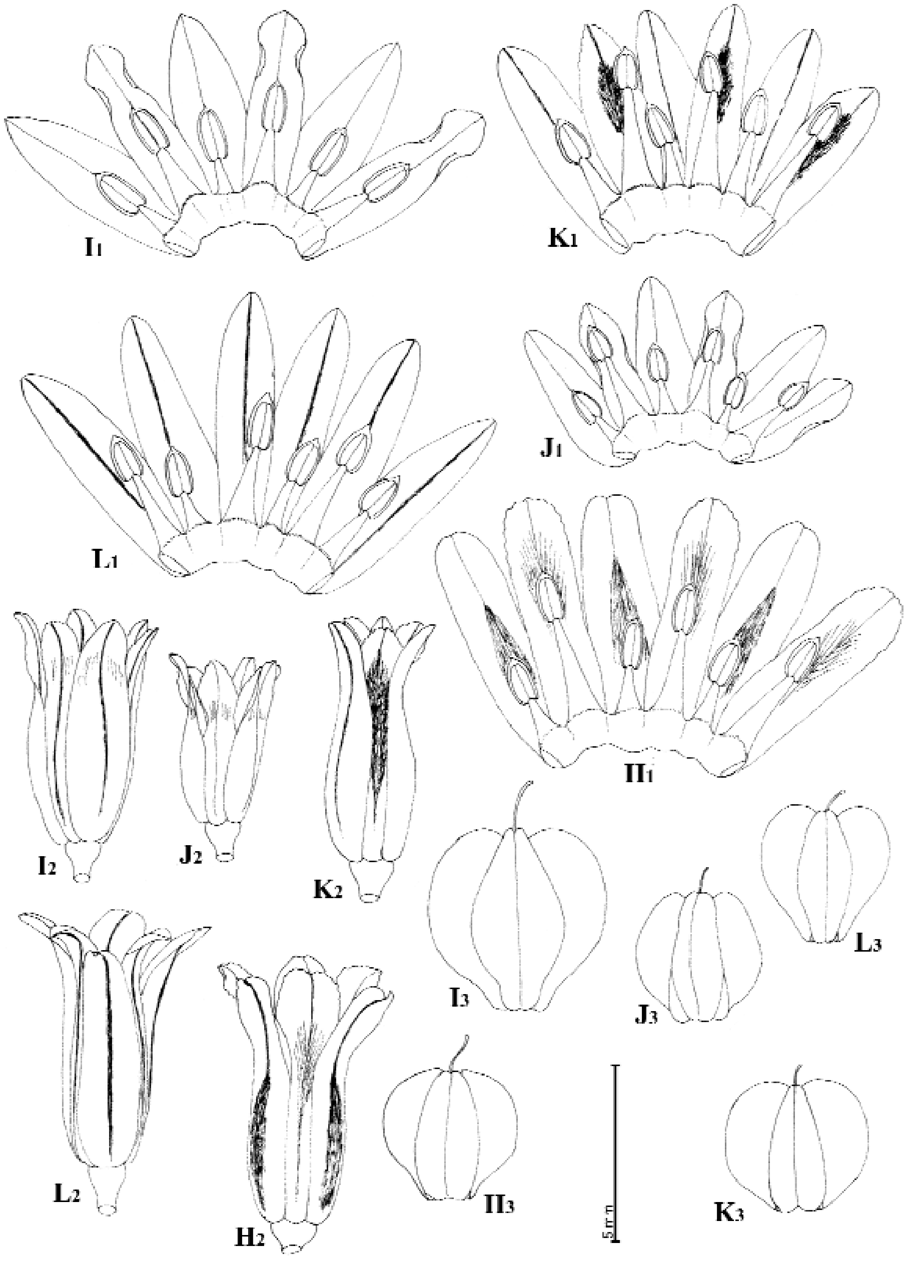

Fig. 4. Open perigon (1), perigon (2), capsule (3): **H.** *A. maghrebinum*; **I.** *A. hirtovaginatum*; **J.** *A. meikleanum*; **K.** *A. pelagicum*; **L.** *A. tingitanum* (Drawing by S. Brullo from living plants of type locality).

Bulb ellipsoid-ovoid, 12-20(-25) × 6-9 mm, with pale brown or golden-brown outer tunics, reticulate-fibrous, attached to the base of the bulb, covering the stem up to 4 cm. Stem erect, flexuous, 13-28 cm high, covered by the leaf sheaths 1/2-3/4 of its length. *Leaves* 4, shorter than the inflorescence, filiform, subcylindrical, 4-15 cm long, subglabrous or hairy with scattered subappressed hairs 0.2-0.6 mm long. *Inflorescence* fastigiate, unilateral, with 4-12(-20) flowers on pedicels 12-40 mm long. *Spathe* 1-valved, shorter than the inflorescence, 5-7-nerved, 13-27 mm long, with an appendage 2-7 mm long. *Bostryces* 2. *Perigon* cylindrical-subcampanulate, 6.5-7.5 mm long; tepals pink or pink-purplish with a marked brown-purplish mid-vein, the outers lanceolate-elliptical, entire, acute or subobtuse, 2-2.2 mm wide, the inners linear-oblong, rounded and gnawed-undulate at the apex, 1.5-2 mm wide. *Stamens* with white filaments, subulate-triangular, unequal, the outers 0.9-1.5 mm long and 0.6-0.8 mm wide at the base, the inners 2-2.6 mm long and 1.1-1.3 mm wide at the base, below connate with tepals into an annulus 1.5-1.7 mm high; anthers yellow-straw coloured, linear-elliptical, apiculate, 1.5-1.7 × 0.6-0.8 mm. *Ovary* ovoid, smooth, green, 1.5-2 × 1.5-1.7 mm. Style white, 1.3-1.5 mm long. *Capsule* trivalved, globose-obovoid, 4.8-5 × 4.2-4.5 mm.

Distribution and habitat: The species occurs in several mountains of C Italy, where it mainly grows in the rocky meadows on limestone, above 1000 m of elevation.

Karyology: The chromosome number of this species was turned out to be tetraploid with $2n = 32$ in all studied specimens (Tab. 1). The karyotype of *A. samniticum* (Fig. 9C) was similar to those ones of the two allied Sicilian taxa (*A. cupani* and *A. panormitanum*) in the prevalence of more or less metacentric chromosomes (*m* and *msm*), as well as in the occurrence of 4 subtelocentric pairs. Three of the latter pairs always carried microsatellites in the short arm. Main differences from the Sicilian species consisted in a major number of submetacentric (*sm*) pairs (which are 6, instead of 4 and 2 as in the Sicilian species) and in the occurrence of microsatellites in 3 *st* pairs, as well as various karyomorphometric parameters. Variation in the proportion of *m* and *msm* chromosomes (shifting to 10 and 8 respectively) has been recorded in samples from Latium. The karyotype formula of plants from type locality was: $2n = 4x = 32$: 14m + 4msm + 6sm + 2st + $6\mathrm{st}^{\mathrm{sat}}$. Size of haploid complement was 118. 55 µm, absolute length of chromosomes varied from 9.84 to 5.65 µm, while the relative one from 8.30 to 4.76 %.

Phenology: Flowering from mid July to late August.

Etymology: From Latin "*Samniticus*", i.e. coming from "*Samnium*", an old name of Abruzzo region (C Italy).

Taxonomic notes: *Allium samniticum* is a vicariant of *A. cupani* s. str. in central Apennines. Both species indeed share several features, including general habit, reticulate-fibrous bulb coats attached to the base of the bulb, 1-valved spathe shorter than the inflorescence and provided with an apical appendage, 2 bostryces, perigon 6.5-7.5 mm long, as well as summer flowering and tetraploid chromosome number ($2n = 32$). Nevertheless, *A. samniticum* differs from *A. cupani* in relevant diagnostic morphological characters, such as ellipsoid-ovoid bulbs, hairy leaves with 0.2-0.6 mm long hairs, spathe provided with 5-7 complete nerves and appendage 2-7 mm long, pink to pink-purplish tepals, the outer ones acute or subobtuse at the apex, apiculate anthers, globose-obovoid capsule, 4.8-5 × 4.2-4.5 mm.

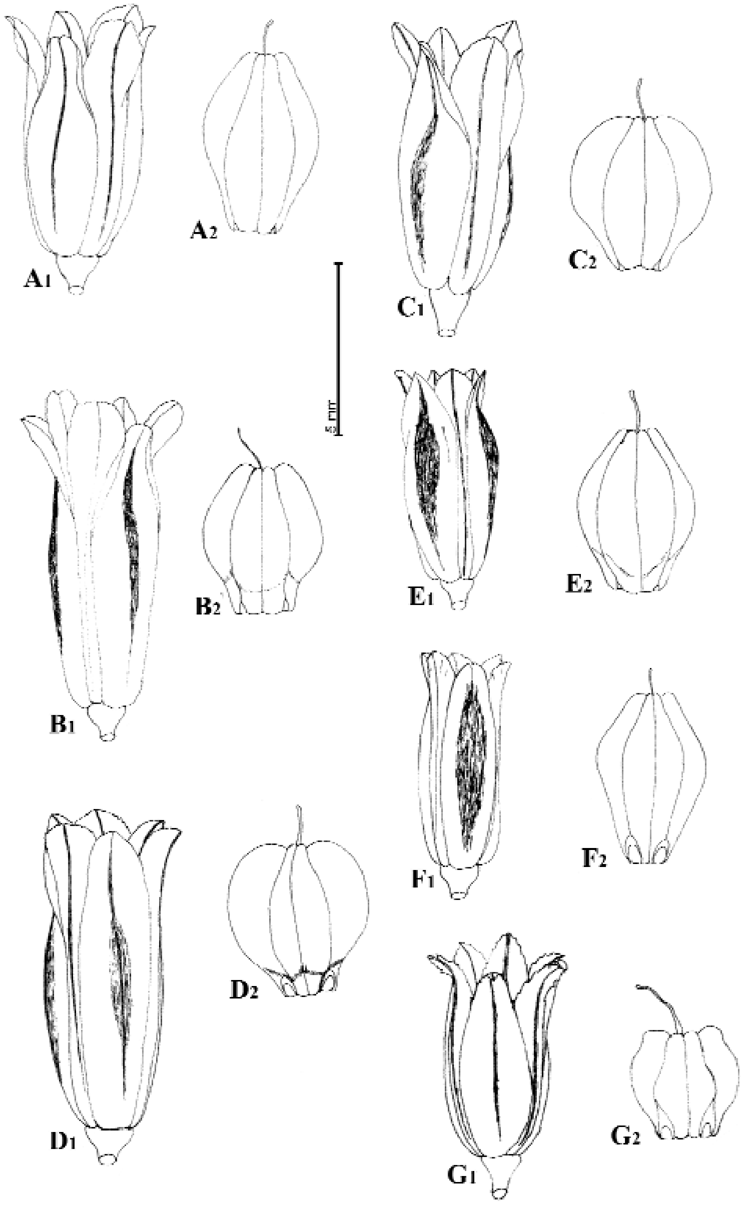

Fig. 5. Perigon (1), capsule (2): **A.** *A. cupani*; **B.** *A. panormitanum*; **C.** *A. samniticum*; **D.** *A. mauritanicum*; **E.** *A. balcanicum*; **F.** *A. tzanoudakisanum*; **G.** *A. cephalonicum* (Drawing by S. Brullo from living plants of type locality).

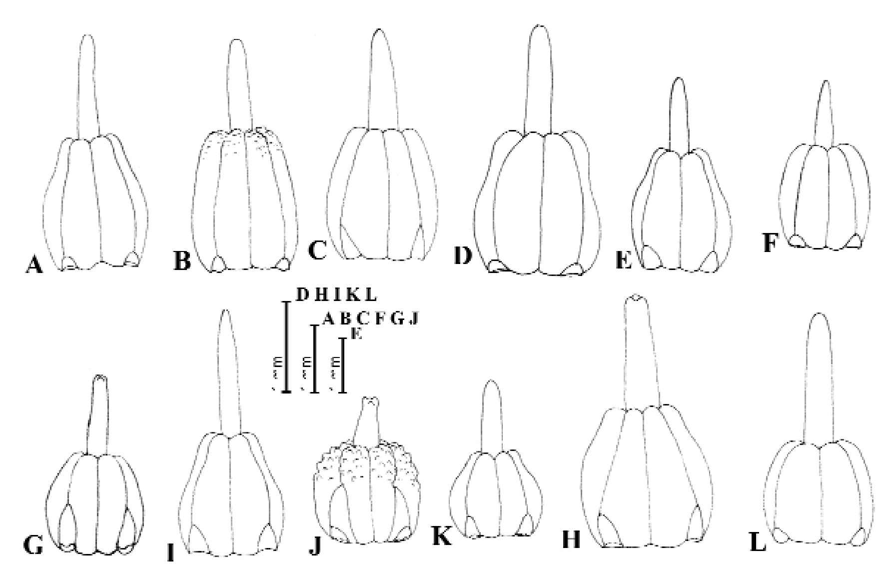

Fig. 6. Ovary: **A.** *A. cupani*; **B.** *A. panormitanum*; **C.** *A. samniticum*; **D.** *A. mauritanicum*; **E.** *A. balcanicum*; **F.** *A. tzanoudakisanum*; **G.** *A. cephalonicum*; **H.** *A. maghrebinum*; **I.** *A. hirtovaginatum*; **J.** *A. meikleanum*; **K.** *A. pelagicum*; **L.** *A. tingitanum* (Drawing by S. Brullo from living plants of type locality).

Paratypes: Italy, L'Aquila, Monte dei Cerri, 28.7.1903, *L. Grande s.n.* (FI!, RO!); ibid., in herbosis lapidosis alla Liscia, 1050 m circa, solo calcareo, 19.8.1905, *L. Grande 415* (BM!, FI!, K!, RO!); Subiaco, Piani di Arcinazzo, 20.7.1986, *S. Brullo s.n.* (CAT!); ibid., 20.8.1990, *P. Minissale s.n.* (CAT!); ibid., 17.8.1895, *C. Sommier s.n.* (FI!); Monti Simbruini sopra Filettino, 20.8.1990, *P. Minissale s.n.* (CAT!); ibid., Guercino, 8.1887, *Marcellino s.n.* (RO!); in Appenninis Filettino, presso la cerreta, 8.8.1860, *E. Rolli s.n.* (RO!); ibid., culta in Horto Botanico, 11.8.1862, *E. Rolli s.n.* (RO!); Campello, a Volta del Corno, luoghi sassosi, m. 850, 10.8.1986, *B. Moraldo s.n.* (RO!); ibid., *Minutillo & Dicroce s.n.* (FI!); San Nicola sopra Colle Amaro, Abruzzo, 16.9.1826, *G. Gussone s.n.* (NAP!); Collina sotto Varattizzi, Vaccariccia (Molise), 26.9.1994, *F. Lucchese s.n.* (CAT!).

4. ***Allium mauritanicum*** Brullo, Pavone & Salmeri, spec. nova – Figs. 1D, 3D, 5D, 6D, 7D, 8D.

Allio cupano similis, sed bulbo 18-25 × 10-13 mm, scapo usque ad 40 cm longo, pilis foliorum 0,1-0,15 mm longis, spatha apiculata, 12-45 mm longa, 3-5 nervis principalibus et 1-2 secondariis incompletis, perigonio cylindrico vel cylindrico-suburceolato, (7-)8-9 mm longo, tepalis exterioribus lineari-ellipticis, 2,4-2,6 mm latis, filamentibus staminum exterioribus 2-3 mm longis, interioribus 4-4,3 mm longis, inferne cum tepalis per 1,7-2 mm in annulum connatis, antheris apiculatis, 1,7-2 mm longis, capsula subgloboso-obovoidea, 4-4,2 × 4-4,2 mm.

Type: Morocco, Ifrane, 11.8.1995, *S. Brullo & P. Signorello M16* (Holo: CAT!).

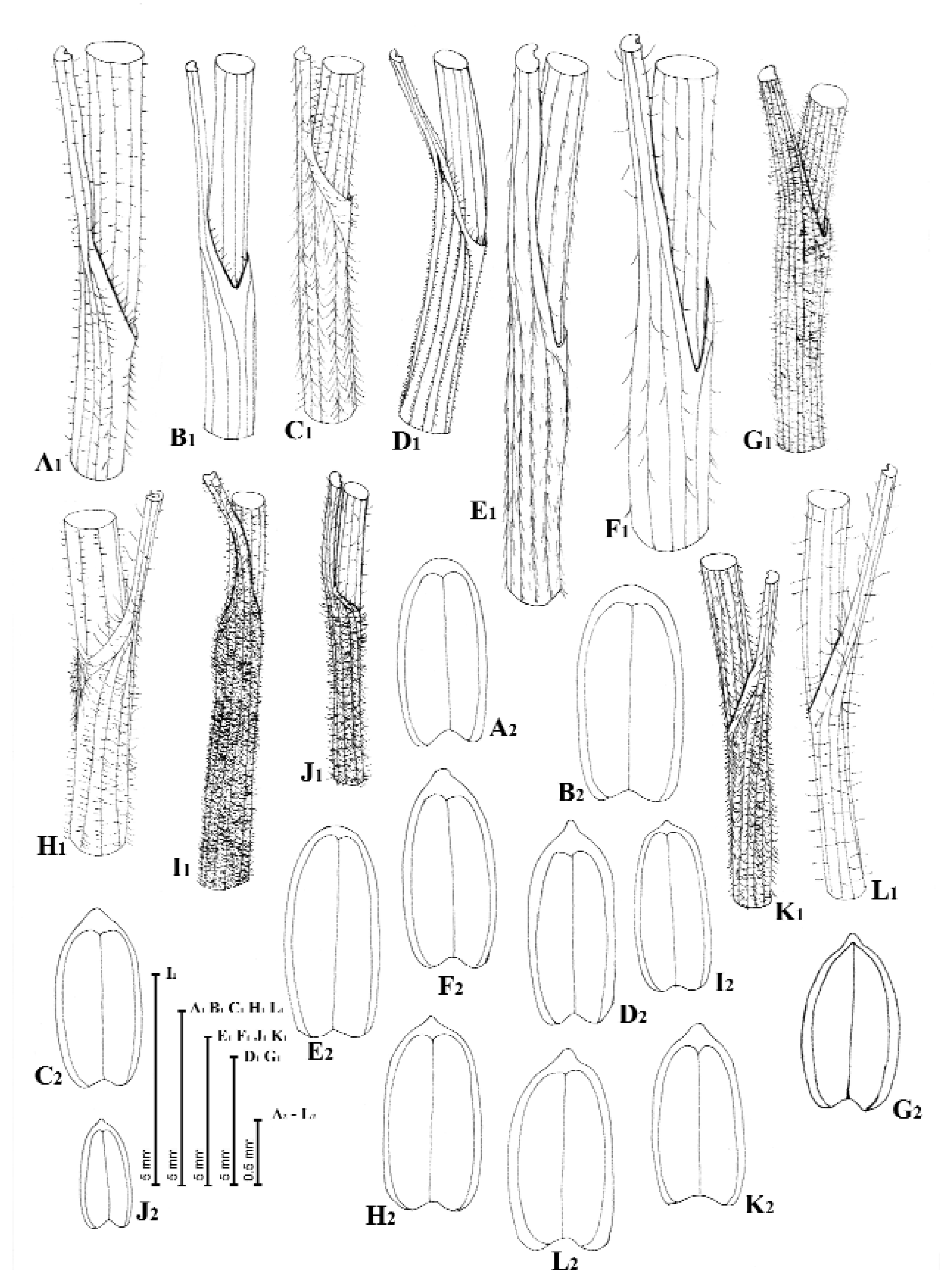

Fig. 7. Stem with leaf sheath (1), Anther (2): **A.** *A. cupani*; **B.** *A. panormitanum*; **C.** *A. samniticum*; **D.** *A. mauritanicum*; **E.** *A. balcanicum*; **F.** *A. tzanoudakisanum*; **G.** *A. cephalonicum*; **H.** *A. maghrebinum*; **I.** *A. hirtovaginatum*; **J.** *A. meikleanum*; **K.** *A. pelagicum*; **L.** *A. tingitanum* (Drawing by S. Brullo plants of type locality).

Bulbs ovoid, bulbiliferous, often clustered, 18-25 × 10-13 mm, with outer tunics brown, reticulate-fibrous, attached to the base of the bulb, covering the stem up to 1 cm. *Stem* erect, rigid, 10-40 cm high, covered by the leaf sheaths 1/2-2/3 of its length. *Leaves* 4-6, shorter than the inflorescence, filiform, subcylindrical, 10-20 cm long, subglabrous or hairy with scattered hairs 0.1-0.15 mm long. *Inflorescence* fastigiate, unilateral, with 3-14 flowers on pedicels 15-70 mm. *Spathe* 1-valved, shorter than the inflorescence, 3-5-nerved with additional 1-2 incomplete nerves, 12-45 mm long, apiculate. *Bostryces* 2. *Perigon* cylindrical or cylindrical-suburceolate, (7-)8-9 mm long; tepals white-pink, with a purplish-green mid-vein, the outers linear-elliptical, entire, obtuse, 2.4-2.6 mm wide, the inners linear-oblong, rounded and gnawed-undulate above, 1.6-1.8 mm wide. *Stamens* with white filaments, subulate-triangular, unequal, the outers 2-3 mm long and 0.6-0.7 mm wide at the base, the inners 4-4.3 mm long and 1-1.3 mm wide at the base, below connate with tepals into an annulus 1.7-2 mm high; anthers straw coloured, linear-elliptical, apiculate, 1.7-2 × 0.7-0.8 mm. *Ovary* yellowish-green, ovoid, smooth, 1.8-2.2 × 1.5-1.8 mm. *Style* white, 1.5 mm long. *Capsule* trivalved, subglobose-obovoid, slightly throttled towards the base, 4-4.2 × 4-4.2 mm.

Distribution and habitat: The species occurs in various coastal and mountain localities of N Morocco and NW Algeria. Usually, it is localized in rocky meadows and dwarf shrub communities, at 100-1600 m of elevation.

Karyology: All studied specimens from Morocco (Tab. 1) revealed a tetraploid chromosome complement $2n = 32$. The karyotype of *A. mauritanicum* (Fig. 9D) showed the same main structure as the other polyploid taxa from Sicily and C Italy, more resembling that one of *A. samniticum* in the number of submetacentric (*sm*) pairs. In particular, it was characterized by 12 metacentric (*m*) and 6 metasubmetacentric (*msm*) chromosomes, 3 submetacentric (*sm*) pairs, one provided with microsatellites in the short arm, and 4 subtelocentric (*st*) microsatellited pairs. The karyotype formula was as follows: $2n = 4x = 32$: $12\mathrm{m} + 6\mathrm{msm} + 4\mathrm{sm} + 2\mathrm{sm}^{\mathrm{sat}} + 8\mathrm{st}^{\mathrm{sat}}$. Particularly, in the mitotic plates from type locality total haploid chromosome length was 128.68 ± 14.27 µm, varying from 10.46 ± 0.59 µm of the longest chromosome to 66.13 ± 0.15 µm of the shortest one, while the relative length ranged from 8.09 ± 0.42% to 4.76 ± 0.12%.

Phenology: Flowering from late summer to early autumn (August-October).

Etymology: From "*Mauritania*", old name of NW Africa.

Taxonomic notes: Based on literature and our surveys, at present *Allium mauritanicum* is the only polyploid member of the *A. cupani* group occurring in N Africa, also characterized by bulb coats attached to the base of the bulb, 1-valved spathe shorter than inflorescence and 2 bostryces, likewise the other tetraploid endemics *A. samniticum*, *A. panormitanum* and *A. cupani*, from C Italy and Sicily respectively. In spite of this overall similarity, *A. mauritanicum* is well distinguished by its longer and rigid stem, leaves with shorter hairs and longer spathe. It shows more similarities with *A. panormitanum* due to the apiculate spathe, perigon 8-9 mm long, well developed annulus and late flowering period, but differs in many other relevant morphological characters, including leaf hairs 0.1-0.15 mm long, spathe up to 45 mm long, 3-5-nerved with 1-2 additional incomplete nerves, linear-elliptic and obtuse outer tepals, outer stamen filaments 2-3 mm long, inner ones 4-4.3 mm long, linear-elliptic and apiculate anthers up to 2 mm long, smooth ovary, and subglobose-obovoid capsule 4-4.2 × 4-4.2 mm. *A. mauritanicum* could have

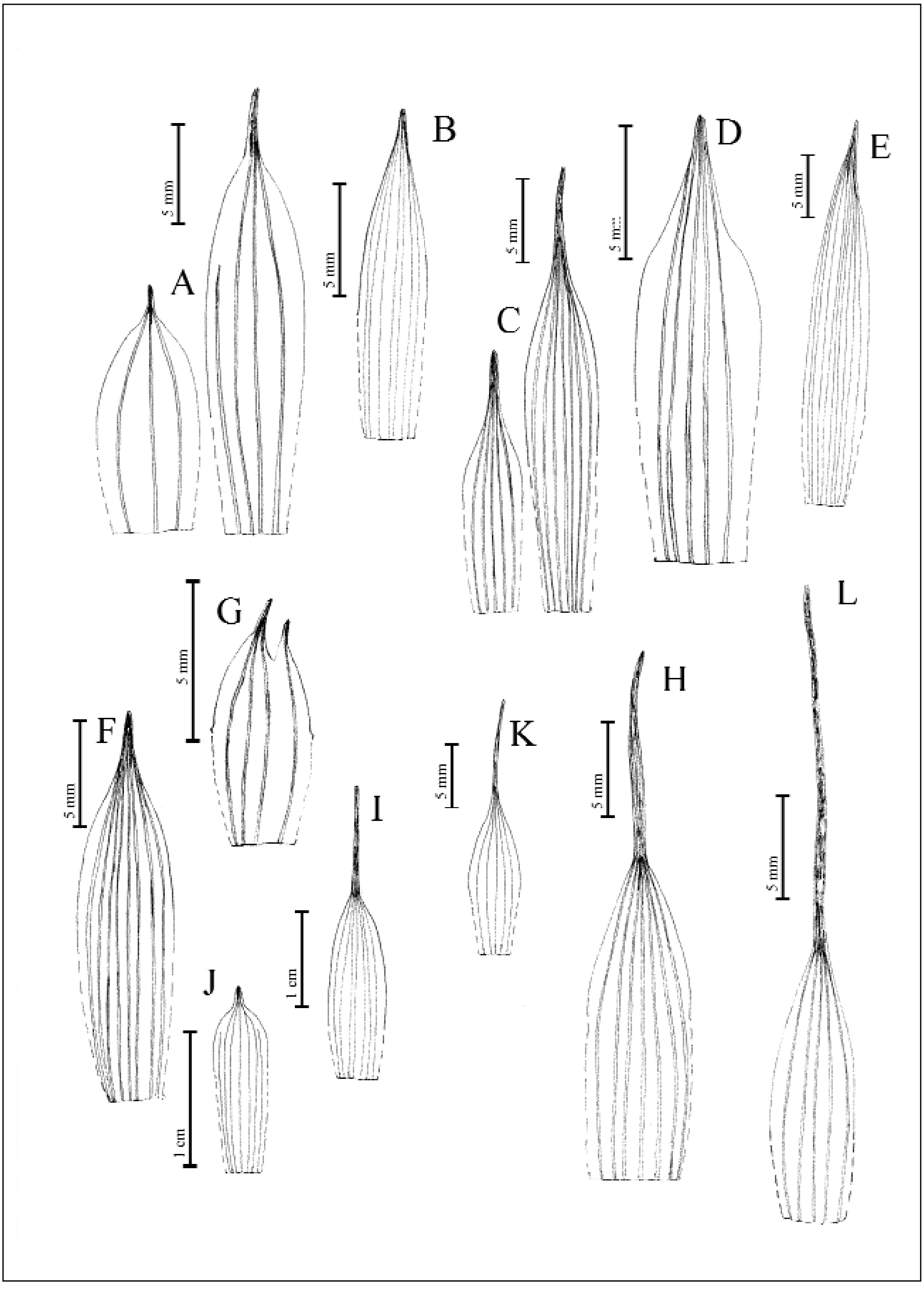

Fig. 8. Spathe: **A.** *A. cupani*; **B.** *A. panormitanum*; **C.** *A. samniticum*; **D.** *A. mauritanicum*; **E.** *A. balcanicum*; **F.** *A. tzanoudakisanum*; **G.** *A. cephalonicum*; **H.** *A. maghrebinum*; **I.** *A. hirtovaginatum*; **J.** *A. meikleanum*; **K.** *A. pelagicum*; **L.** *A. tingitanum* (Drawing by S. Brullo from plants of type locality).

originated from *A. panormitanum* as a consequence of speciation events likely arisen from old geographical isolation.

Paratypes: Morocco, Col Duzad, 22.7.1994, *S. Brullo & P. Signorello M7* (CAT!); Bir Bou Hidir, 22.7.1994, *S. Brullo & P. Signorello M15* (CAT!); Jebel el Alem, Bab Bou Hidir, 1600 m, between boulders in dry sandy soil, 17.8.1968, *W.L. Fry 2* (BM!); Melilla, s.d., *C. Vicioso s.n.* (BCF!); Marineur, Riff oriental (culta!), 23.9.1920, *C. Vicioso s.n.* (MA!); Riff oriental, s.d., *C. Vicioso s.n.* (BM!); Massif de Tichchoukt, above Boulemare, Middle Atlas, province de Meknes, very dry stony north facing hillside, 11.8.1966, *R.M. Harley 910* (BM!); Fez el Sefran, 10.1913, *Mourat 1384* (P!); **Algeria,** Oran, 3.9.1846, *M.C. Durieu* (K!); ibid., lieux secs, 8.1921, *A.C. d'Alleizette* s.n. (M!); Santa Cruz, lieux rocailleux, 16.9.1929, *A. Faure* (K!); Gorge de Santa Cruz, 19.9.1888, *Garrigues* (BM!, P!); Fort S. Gregoire, August, *G. Munby s.n.* (K!); ibid., 1847, s.l. (K!); M. Boù, au Planteur bord du chemin venant de l'Ardoisan pour le Belvedere, 8.1922, *A.C. d'Alleizette s.n.* (P!); Mostaganem, clairees des broussailles, 20.8.1848, *B. Balansa s.n.* (P!); ibid., rocheur nu, 9.1911, *A.C. d'Alleizette s.n.* (P!); Fedy et Ahmeur, a l'ouest du Kef Souma, Djebel Sgao, prov. De Costantine, 8.1888, *V.C. Reboud* (P!).

5. *Allium balcanicum* Brullo, Pavone & Salmeri, spec. nova – Figs. 1E, 3E, 5E, 6E, 7E, 8E.

Syn.: *A. balcanicum* Brullo, Pavone & Salmeri, Giorn. Bot. Ital. 129(1): 118, 1995, nom. nud.

Allio cupano similis, sed scapo rigido, foliis subglabris vel pilosis, pilis adpressis, 0,3-0,6 mm longis, spatha usque ad 28 mm longa, 7-10-nervata, apiculata, tepalis cylindrico-suburceolatis, roseis vel roseo-purpureis, exterioribus 1,7-2 mm latis, interioribus 1,4-1,5 mm latis, antheris albo-roseis vel purpureis, 1,5 mm longis, ovario subgloboso-ovoideo, 1,5-1,8 mm longo.

Type: Greece, M. Timfristòs, presso Karpenision, 12.9.1989, *G. Bartolo, S. Brullo & P. Minissale s.n.* (Holo: CAT!).

Bulb ovoid or ellipsoid-ovoid, sometimes bulbilliferous, 10-18 × 5-10 mm, with brown tunics, reticulate-fibrous, attached to the base of the bulb, covering the stem up to 2 cm. *Stem* erect, rigid, 8-20 cm high, covered by the leaf sheaths from 3/4 up to total length. *Leaves* 4, filiform, subcylindrical, shorter than the inflorescence, 4-10 cm long, the upper one often without blade, subglabrous or hairy with scattered, appressed hairs 0.3-0.6 mm long. *Inflorescence* fastigiate, unilateral, with 3-15 flowers on pedicels 5-28 mm long. *Spathe* 1-valved, shorter than the inflorescence, rarely subequal, 7-10-nerved, 15-28 mm long, apiculate. *Bostryces* 2. *Perigon* cylindrical-suburceolate, 6-7 mm long; tepals pink or purplish-pink, tinged with purple, with a purplish-brown mid-vein, the outers ovate-lanceolate, entire, subobtuse, 1.7-2 mm wide, the inners linear-oblong, rounded and gnawed-undulate at the apex, 1.4-1.5 mm wide. *Stamens* with white filaments, subulate-triangular, unequal, the outers 0.8-2 mm long and 0.5-0.7 mm wide at the base, the inners 1.8-2.3 mm long, markedly broadened at the base and 1-1.2 mm wide, below connate with tepals into an annulus 1-1.2 mm high; anthers pinkish-white to purplish, linear-elliptical, rounded, 1.5 × 0.7 mm. *Ovary* greenish, subglobose-ovoid, smooth, 1.5-1.8 × 1.2-1.5 mm. *Style* white, 1-1.2 mm long. *Capsule* trivalved, ellipsoid, 4.5-5 × 3.5-3.8 mm.

Distribution and habitat: This species occurs in several mountains of Balkan Peninsula, particularly in N Greece, W Bulgaria, Macedonia, Serbia and Albania. It grows sparsely in rocky places at elevation over 1000 m, mainly within orophilous pulvinate shrub communities.

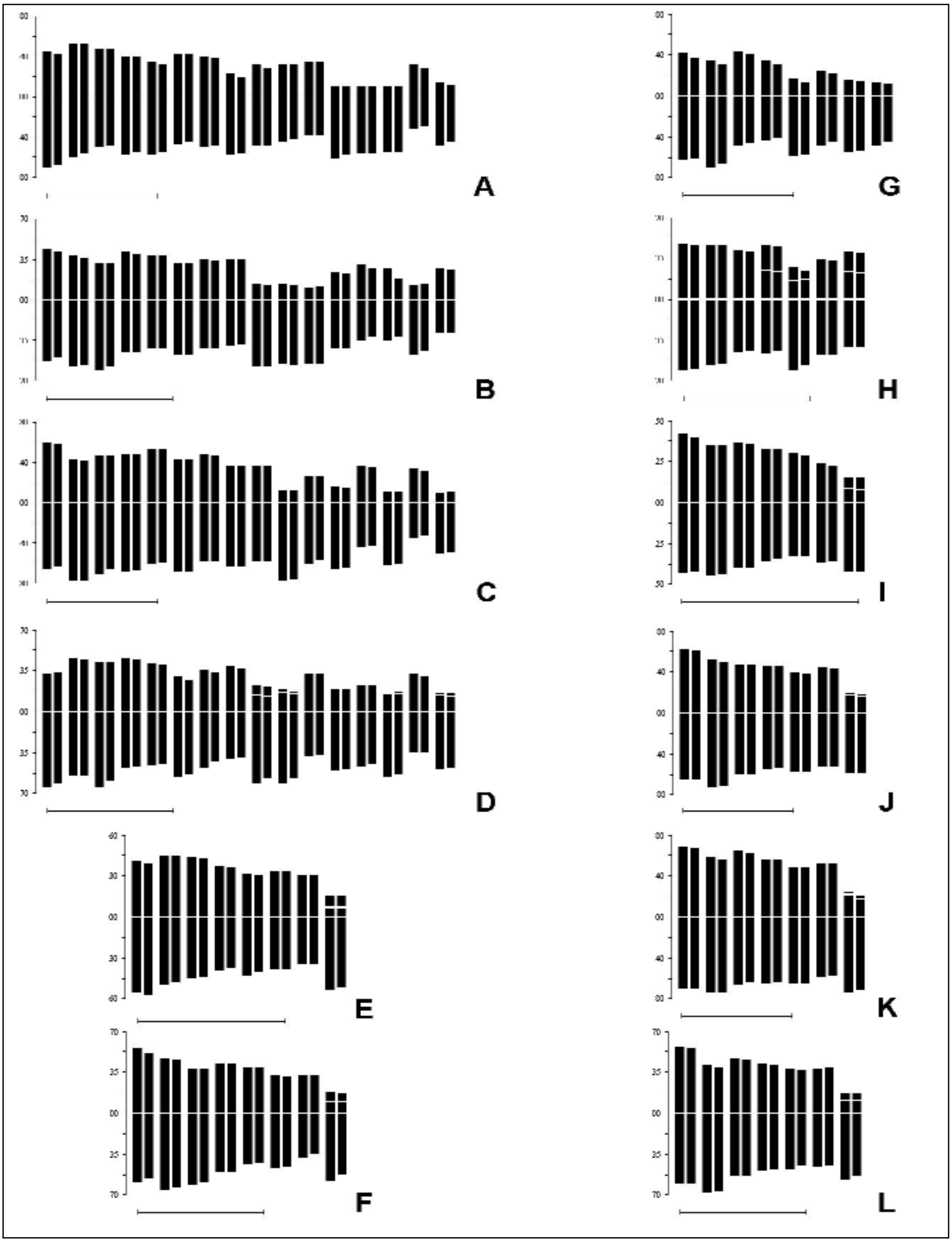

Fig. 9. Karyograms obtained from 10 well spread metaphase plates: **A.** *A. cupani* (Pizzo Carbonara); **B.** *A. panormitanum* (Mt. Pellegrino); **C.** *A. samniticum* (Villavallelonga); **D.** *A. mauritanicum* (Ifrane); **E.** *A. balcanicum* (Mt. Timfristos); **F.** *A. tzanoudakisanum* (Monopetra); **G.** *A. cephalonicum* (Mt. Enos); **H.** *A. hirtovaginatum* (Çeşme); **I.** *A. meikleanum* (Larnaca); **J.** *A. pelagicum* (Vallone Madonna); **K.** *A. maghrebinum* (Cape Bon); **L.** *A. tingitanum* (Taza). Bars = 10 µm. Localities in brachets correspond to the type localities (see Tab. 1).

Karyology: Studied populations from Greece and Bulgaria (Tab. 1) revealed a diploid chromosome complement with $2n = 16$, which confirmed previous reports from various Balkan populations referred to *A. cupani* or seldom to *A. cupani* var. *hirtovaginatum* (Sopova 1972; Cheschmejiyev 1973; Garbari & al. 1979; Strid & Franzen 1981; Tzanoudakis 1983). The karyotype (Fig. 9E) consisted of 5 pairs of metacentric chromosomes, 2 meta-submetacentric pairs, and one pair ranging from microsatellited subtelocentric type (Dancavo population) to macrosatellited telocentric type (type locality). The karyotype formula can be resumed as follows: $2n = 2x = 16$: 10m + 4msm + $2st^{sat}/2t^{Msat}$. Particularly, mitotic plates from type locality revealed a haploid chromosome complement 63.31 ± 4.57 µm in length, varying from 9.71 ± 0.96 µm of the longest chromosome to 6.58 ± 0.87 µm of the shortest one, while the relative length ranged from 7.66 ± 0, 2% to 5.19 ± 0.31%.

Phenology: Flowering from August to November.

Etymology: From latin "*Balcanicus*", meaning "from Balkans" (SE Europe), where the species can be found.

Taxonomic notes: Based on literature, populations of *Allium balcanicum* were usually ascribed to *A. cupani* or more rarely to *A. hirtovaginatum*. Nevertheless, as already highlighted by Brullo & al. (1995, 2008c), *A. balcanicum* clearly differs from *A. cupani* s.str. in the chromosome complement ($2n$=16), which is diploid instead of tetraploid ($2n$=32), and in the typically autumnal flowering, as well as in many significant morphological characters including rigid stem, subglabrous to hairy leaves with appressed hairs 0.3-0.6 mm long, apiculate 7-10-nerved spathe, up to 28 mm long, pink or purplish-pink cylindrical-suburceolate perigon, outer tepals 1.7-2 mm wide, inner tepals 1.4-1.5 mm wide, pinkish-white to purplish anthers up to 1.5 mm long, and subglobose-ovoid ovary, 1.5-1.8 mm long.

Paratypes: Greece, in latere meridionale montis, supra oppidum Karpenisi, ad 1550 m, In clivis dumetosis herbosis meridiem spectantibus, solo calcareo, 4.8.1977, *W. Greuter 15415* (B!, G!); M. Olympus, in declivis prope Hagios Dionisios, 14.9.1889, *P.E. Sintenis 1937* (B!, G!, K!, M!, P!, MPU!, W!, WU!); Mt. Vourinos (Saloniki), serpentine rocks 1000 m, 18.8.1981, *D. Babalonas B41* (MA!); Pellis, Mt. Pìnovon, S side 1400-1700 m, rocky limestone outcrops in *Fagus* woodland, 16.8.1979, *A. Strid & K. Papanicolaou 16554* (G!); ibid., M. Tzena, E side of the SE summit 1800-2000 m, alpine meadows and rocky outcrops limestone, 19.8.1979, *A. Strid & K. Papanicolaou 16715* (G). **Albania**, Gjergjevice, base stony ground in serpentine gorge, 21.8.1935, *A. Alston & C.I. Sandwith 2583* (BM!, K!); Hasi Pastrik Grajige Hange, in der subalpinen region, ca.1400 m, 2.9.1916, *I. Dörfler 355* (BM!, G!, K!, W!); Trockene steinige Weisen amsudwestabhang des Pashtrik, ca. 1400-1500 m, 9.8.1918, *Zerny s.n.* (W!). **Bulgaria**, Dancavo near Brestovitza, 24.11.1993, *I.V. Ceschmedziev s.n.* (CAT!); ibid., 20.10.1994, esemplare coltivato, *I.V. Ceschmedziev s.n.* (CAT!); In lapidosis calcareis M. Cepan, 28.8.1854, *V.I. Velcev & K. Kocev 379* (G!, MA!, MPU!, W!); Mt. Chepan, roches, 28.8.1854, *Georgioff s.n.* (K!); Prope stationem Dragoman, 28.8.1893, *Georgioff s.n.* (HUJ!, K!). **Macedonia**, Na Varovicen Kamenjar, 1320 m, 7.9.1974, *K. Micevski s.n.* (W!). **Serbia**, In fruticetis collium Mramor non procul ab urbs Nisch, 9.1888, *S. Petrović 2587* (BM!, G!, K!, M!, MPU!, P!, W!); Siccov, 8.1879, *S. Petrović s.n.* (G!); In saxosis calcareis ad Leskovak, s.d., *J. Panić s.n.* (WU!); In herbosis venosis in Leskovak,

Table 1. Populations karyologically investigated of the *Allium cupani* group.
Bold names indicate type localities

Taxon	Locality	Ploidy	N.chrom.
A. balcanicum	Bulgaria, Dancavo	$2x$	$2n=16$
	Greece, Mt. Timfristos	$2x$	$2n=16$
A. cephalonicum	**Aegean, Is. Kefalonia, Mt. Enos**	$2x$	$2n=16$
A. cupani s. str.	Sicily, Rocca Busambra		
	Sicily, Madonie Mts, Pizzo Carbonara	$4x$	$2n=32$
	Sicily, Piana degli Albanesi, Mt. Kumeta	$4x$	$2n=32$
A. hirtovaginatum	**Turkey, Çeşme**	$2x$	$2n=14$
A. maghrebinum	**Tunisia, Cape Bon**	$2x$	$2n=14$
	Tunisia, El Beja	$2x$	$2n=14$
	Tunisia, El Fas	$2x$	$2n=14$
	Tunisia, Korbous	$2x$	$2n=14$
	Tunisia, Sidi Daud	$2x$	$2n=14$
A. mauritanicum	Morocco, Bir Bou Hidir	$4x$	$2n=32$
	Morocco, Col Duzad	$4x$	$2n=32$
	Morocco, Ifrane	$4x$	$2n=32$
A. meikleanum	Aegean, Cyprus, Athalassia	$2x$	$2n=14$
	Aegean, Cyprus, Larnaca	$2x$	$2n=14$
A. panormitanum	Sicily, Palermo, Mt. Caputo	$4x$	$2n=32$
	Sicily, Palermo, Mt. Gallo	$4x$	$2n=32$
	Sicily, Palermo, Mt. Pellegrino	$4x$	$2n=32$
A. pelagicum	**Italy, Is. Lampedusa, Vallone Madonna**	$2x$	$2n=14$
A. samniticum	**Italy, Abruzzo, Villavallelonga**	$4x$	$2n=32$
	Italy, Latium, Piani d'Arcinazzo	$4x$	$2n=32$
A. tingitanum	**Morocco, Taza**	$2x$	$2n=14$
A. tzanoudakisanum	Aegean, Is. Evvia, Akro Kimi	$2x$	$2n=16$
	Aegean, Is. Lesbos, Vatoussa	$2x$	$2n=16$
	Aegean, Is. Naxos, Monopetra	$2x$	$2n=16$
	Aegean, Is Paros, Agion Theodoron	$2x$	$2n=16$

9.1879, *J. Panić s.n.* (W!); Staro Selo, unter dem Glicar Dagli, 780 m, 20.8.1938, *Houska s.n.* (K!); Just North of Titovales on road to Skopie in gneiss, 16.9.1974, *B.F. Mathew s.n.* (K!); Parmi le boissons sur le collines près de checonas non loin de Niv, 9.1888, *S. Petrovićc s.n.* (WU!); In subalpinis Pirot, 8.1892, *Favanović s.n.(*W!).

6. *Allium tzanoudakisanum* Brullo, Pavone & Salmeri, spec. nova. – Figs. 1F, 3F, 5F, 6F, 7F, 8F.

Allio balcanico similis, sed bulbis aggregatis, foliis subglabris pilis sparsis, usque ad 0,9 mm longis, folia superiori inflorescentia longiora, spatha usque ad 40 mm longa, appendice 1-3 mm longa, tepalis exterioribus lineari-lanceolatis, interioribus valde undulatis apice, filamentibus staminum subulatis, exterioribus 1,5-2 mm longis, interioribus ex abrupto dilatatis base, 2,8-3,3 mm longis, antheris lineari-ellipticis, luteis, apiculatis 1-1,5 mm longis, capsula 3,5-4,5 mm longa.

Type: Greece, Naxos, Monopetra, su calcare, 27.8.1994, *S. Brullo & F. Scelsi s.n.* (Holo: CAT!).

Bulbs ovoid-ellipsoid, bulbilliferous, clustered, 15-22 × 5-8 mm, with dark brown tunics, reticulate-fibrous, attached to the base of the bulb, covering the stem up to 8 cm. *Stem* erect, rigid, (6-)10-28 cm high, covered by the leaf sheaths from 1/2 up to total length. *Leaves* 4, filiform, subcylindrical, 4-12 cm long, subglabrous with scattered patent hairs 0.4-0.9 mm long, the upper one longer than the inflorescence and often without blade. *Inflorescence* fastigiate, unilateral, with 4-10(-12) flowers on pedicels 10-40 mm long. *Spathe* 1-valved, shorter than the inflorescence, (5-)7-10-nerved, 10-40 mm long, with an appendage 1-3 mm long. *Bostryces* 2. *Perigon* subcylindrical or cylindrical-suburceolate, 6-7 mm long; tepals white-pinkish, the outers tinged with purple, with a purplish-brown mid-vein, linear-lanceolate, entire, subobtuse, 1.6-1.8 mm wide, the inners linear-oblong, rounded and markedly undulate at the apex, 1.2-1.5 mm wide. *Stamens* with white filaments, subulate, unequal, the outers 1.5-2 mm long and 0.5-0.7 mm wide at the base, the inners 2.8-3.3 mm long, abruptly enlarged at the base and 1.2-1.5 mm wide, below connate with tepals into an annulus 1.6-1.8 mm high; anthers yellow, linear-elliptical, apiculate, 1-1.5 × 0.5-0.6 mm. Ovary greenish, ovoid or subglobose-ovoid, smooth, 1.3-2 × 1.1-1.5 mm. *Style* white, 1-2.5 mm long. *Capsule* trivalved, ellipsoid, 3.5-4.5 × 3-3.2 mm.

Distribution and habitat: *Allium tzanoudakisanum* is circumscribed to Greece, where it occurs in some Aegean islands (Evvia, Lesbos, Naxos, Dounussa, Syros, Sifnos, Amorgos, Paros and Serifos) and in E Peloponnesus too. The species is usually localized in the coastal or hill stands, growing in relatively shady and fresh rocky places on limestone and siliceous substrata.

Karyology: All investigated populations (Tab 1) showed a diploid chromosome number $2n = 16$. The karyotype of *A. tzanoudakisanum* (Fig. 9F) was rather similar to that one of *A. balcanicum*, especially differing in the terminal subtelocentric pair, which was often macrosatellited in the short arms, and in the proportion of *m* and *msm* chromosomes. Variation in numbers of *m* against *msm* pairs was also detected among examined populations, which differently showed from 6 to 4 metacentric pairs. The karyotype formula in plants from type locality was: $2n = 2x = 16$: 8m + 6msm + $2\mathrm{st}^{\mathrm{Msat}}$. The total haploid chromosome length was 71.75 ± 5.30 µm, varying from 11.51 ± 1.69 µm of the longest chromosome to 6.83 ± 0.52 µm of the shortest one, while the relative length ranged from 8 ± 0.8% to 4.76 ± 0.02%.

Phenology: Flowering from August to October.

Etymology: The species is named after Dimitris Tzanoudakis, Greek botanist in Patras and specialist of the genus *Allium*.

Taxonomic notes: *Allium tzanoudakisanum* is closely related to *A. balcanicum* sharing the same chromosome number ($2n = 16$), the autumnal flowering time and some morphological characteristics concerning habit, leaves and flower features. Notwithstanding, it differs from *A. balcanicum* due to bulbiliferous and clustered bulbs, leaves with patent longer hairs, the upper one longer than the inflorescence, longer spathe provided with a short appendage, linear-lanceolate outer tepals, the inner ones markedly undulate at the apex, longer stamen filaments and annulus, yellow, linear-elliptic, and apiculate anthers 1-1,5 mm long, capsule 3,5-4,5 mm long. Moreover the two species have very different ecological requirements, as *A. tzanoudakisanum* always grows at low elevation, whereas *A. balcanicum* is a typical orophyte.

Paratypes: Greece, Peloponnisos, Argos, esemplare coltivato, 27.8.1986, *S. Brullo s.n.* (CAT!); Evvia, Akros Kimi, esemplare coltivato, 9.9.1992, *S. Brullo s.n.* (CAT!); ibid., Pockets of soil in rocky ground limestone, 3500 ft., 8.1959, *K.W. Spicer 105* (K!); Lesbos, Vatoussa (Pineta), 28.8.1992, *S. Brullo & P. Minissale s.n.* (CAT!); Paros, Agion Theodoron (fessure della roccia), no flowered specimens, 9.8.1992, *S. Brullo & P. Minissale s.n.* (CAT!); Naxos, Zeus, esemplare coltivato, 11.8.1995, *S. Brullo s.n.* (CAT!); Amorgos, Profitis Elias, rupi calcaree, 28.8.1994, *S. Brullo & F. Scelsi s.n.* (CAT!); ibid., In garigue between Khore and Potamos, 6.10.1939, *P.H. Davis 943* (K!); Syros, Syringas, esemplare coltivato, 8.9.1994, *S. Brullo & P. Minissale E2* (CAT!); ibid., Mitakas, esemplare coltivato, 8.11.1994, *S. Brullo & P. Minissale E3* (CAT!); Sifnos, Profitis Elias, esemplare coltivato, 8.9.1994, *S. Brullo & P. Minissale E16* (CAT!); Serifos, on the hill called Troutos, 1500 ft., ground through *Poterium spinosum*, 24.9.1939, *P.H. Davis 872* (K!); Donoussa, Kavos Panagias, 29.8.1998, *G. Bartolo & S. Brullo s.n.* (CAT!).

7. *Allium cephalonicum* Brullo, Pavone & Salmeri, spec. nova. – Figs. 2G, 3G, 5G, 6G, 7G, 8G.

Allio karistano similis, sed bulbo 15-20 × 7-10 mm, tunicis leviter reticulato-fibrosis, foliis glabris, raro solitariis inconspicuis pilis, spathae appendicis gradatim acuminatis, valva majore 7,5-10 mm longa, valva minore 1-nervata, 6-9,5 mm longa, perigonio urceolato, 6-6,5 mm longo, tepalis eroso-incisis apice et acutis, exterioribus ovato-lanceolatis, interioribus lineari-ellipticis, filamentibus staminum interioribus 1,8-2,8 mm longis, non dilatatis basi, antheris luteis, ovario ovoideo, 1,3-1,5 × 1,2-1,4 mm, capsula obovoidea, 3-3,2 × 3,2 mm.

Type: Greece, Isola di Cefalonia, Monte Enos, a circa 1000 m, nelle formazioni pulvinari orofile, 18.7.2011, *S. Brullo & G. Giacalone s.n.* (Holo: CAT!).

Bulbs ovoid, densely clustered, 15-20 × 7-10 mm, with brown reticulate-fibrous outer tunics, attached to the base of the bulb. *Stem* solitary, rigid, erect, 8-10 cm high, covered by the leaf sheaths 4/5 of its length, sometimes totally. *Leaves* 4, filiform, cylindrical or subcylindrical, shorter than the inflorescence, 1.5-6 cm long, glabrous or rarely with inconspicuous and isolated hairs. *Inflorescence* fastigiate-ellipsoid, with 4-8 flowers on pedicels 1-2.5 mm long. *Spathe* 2-valved, shorter than the inflorescence, valves unequal, on one-side almost totally welded, gradually ending in an acuminate appendage 0.5-1.2 mm long, the bigger valve 3-nerved, 7.5-10 mm long, the smaller one 1-nerved, 6-9.5 mm long. *Bostryces* 4. *Perigon* urceolate, 6-6.5 mm long; tepals pinkish, erose-incised at apex, acute, with a purplish mid-vein, the outers ovate-lanceolate, 2.2-2.5 mm wide, the inners linear-elliptical, 1.5-1.8 mm wide. *Stamens* with white unequal filaments, the outers subulate or subulate-triangular, 1.5-1.8 mm long and 0.5-0.6 mm wide at the base, the inners subulate-triangular, 1.8-2.8 mm long and 0.8-1 mm wide at the base, not broadened below, connate with tepals into an annulus 1.2-1.6 mm high; anthers yellow, oblong, apiculate, 1.2-1.3 × 0.6-0.7 mm. *Ovary* greenish, ovoid, smooth, 1.3-1.5 × 1.2-1.4 mm. *Style* white, 1-1.2 mm long. *Capsule* trivalved, obovoid, 3-3.2 × 3.2 mm.

Distribution and habitat: This species only occurs on Mt. Enos in the Greek island of Kefalonia (Ionian archipelago). It grows on mountain rocky places, about at 1000 m of elevation, within the orophilous dwarf shrubby communities, dominated by *Astragalus cephalonicus* C. Presl.

Karyology: *Allium cephalonicum* is characterized by a diploid chromosome complement of $2n = 16$. The karyotype was rather asymmetrical (Fig. 9G) with a prevalence of aniso-brachial chromosomes (*sm* and *st*) and only one typical metacentric pair, as resumed by the following formula: $2n = 2x = 16$: 2m + 4msm + 4sm + 6st. No evident satellites were detected. The total haploid chromosome length was 63.75 ± 3 µm, varying from 10.5 ± 1.89 µm of the longest chromosome to 5.63 ± 1.3 µm of the shortest one, while the relative length ranged from 8.2 ± 1.1% to 4.41 ± 0.9%.

Phenology: Flowering from late July to August.

Etymology: From Latin "*Cephalonia*", nowadays Cephalonia or Kefalonia, island of the Ionian archipelago (NW Greece), where this plant grows.

Taxonomic notes: Due to bulb coats attached to the base of the bulb, 2-valved spathe, 4 bostryces and eu-diploid chromosome number ($2n = 16$), *Allium cephalonicum* belongs to the cycle of *A. callidictyon*, a species occurring in the Middle East and East Mediterranean (see Brullo & al. 1995). Within this cycle, it shows closest relationships with *A. karistanum*, endemic to Evvia island, in having clustered bulbs, upper leaf and spathe shorter than inflorescence, which is few-flowered, but *A. karistanum* clearly differs in many relevant morphological characters including bigger bulbs, hairy leaves with scattered hairs on the veins, longer spathe valves, which abruptly end in an apically rounded appendage, longer perigon, with tepals gnawed-undulate at apex, longer inner stamens, broadened at the base, anthers straw-coloured, ovary pyriform, bigger ellipsoid capsule. In addition, it has a late summer flowering time and very different karyotype structure (Brullo & al. 1997).

8. *Allium hirtovaginatum* Kunth, Enum. Pl. 4: 412, 1843. – Figs. 2I, 4I, 6I, 7I, 8I.

Syn.: *Allium cupani* var. *hirtovaginatum* (Kunth) Halácsy, Consp. Fl. Graec. 3(1): 253, 1904; *Allium cupani* f. *hirtovaginatum* (Kunth) Hayek, Feddes Repert. (Beih.) 30(3): 49, 1932; *Allium cupani* subsp. *hirtovaginatum* (Kunth) Stearn, Ann. Mus. Goulandris 4: 151, 1978.

Type: Turkey, Asia mineure, Tchesmé, no date, *G.A. Olivier & J.G. Bruguière s.n.* (lectotype P!, designated by Garbari & al. 1979).

Bulb ovoid, solitary, 9-15 × 7-12 mm, with pale brown outer tunics, fibrous, feebly reticulate, detached from the base of the bulb, covering the stem up to 3 cm. *Stem* erect or erect-ascending, flexuous, 12-20 cm high, covered by the leaf sheaths 2/3-3/4 of its length. *Leaves* 3-4, filiform, subcylindrical, shorter than the inflorescence, 5-15 cm long, hairy with dense patent hairs 0.1-0.25 mm long. *Inflorescence* fastigiate, unilateral, with 3-8(-12) flowers on pedicels 7-28 mm long. *Spathe* 1-valved, longer than the inflorescence or subequal, persistent, 7-9-nerved, 12-45 mm long, with an appendage 4-20 mm long. *Bostryces* 2. *Perigon* cylindrical-suburceolate, 6-6.5 mm long; tepals pink, with a purplish-brown mid-vein, the outers linear-ovate, entire and subacute at the apex, 1.8-2 mm wide, the inners linear-oblong, rounded and gnawed-undulate at the apex, 1.5-1.6 mm wide. *Stamens* with filaments white, triangular, unequal, the outers 1-1.2 mm long and 0.5-0.6 mm wide at the base, the inners 1.5-1.8 mm long and 0.9-1 mm wide at the base, below connate with tepals into an annulus 0.8-1 mm high; anthers yellow, linear-elliptical, apiculate, 1.2-1.3 × 0.5-0.6 mm. *Ovary* greenish, ovoid-subpyriform, smooth, 1.3-1.5 × 1.2-1.4 mm. *Style* white, 1.2-1.5 mm long. *Capsule* trivalved, subglobose, throttled below, 5 × 5 mm.

Distribution and habitat: This species s.str. is circumscribed to some localities of CW Anatolia, near Izmir. It occurs in the hilly and mountain rocky places, within the dwarf shrubby vegetation.

Karyology: Previous reports from many localities of Mediterranean area described *Allium hirtovaginatum* as a diploid species with an aneuploid complement $2n = 14$ (Garbari & al. 1979; Johnson 1982; Tzanoudakis 1983; Tzanoudakis & al. 1991). The population here investigated coming from the type locality (Çeşme, W Turkey) confirmed this count. The karyotype (Fig. 9H) was formed by more or less metacentric chromosomes (*m* and *msm* type), two submetacentric (*sm*) pairs, always provided with very long satellites in the short arms, and one subtelocentric (*st*) pair, also macrosatellited. The chromosome formula was summarized as follows: $2n = 2x = 14$: $6\mathrm{m} + 2\mathrm{msm} + 4\mathrm{sm}^{\mathrm{Lsat}} + 2\,\mathrm{st}^{\mathrm{Msat}}$. The total haploid complement was 63.10 ± 2.23 µm in length; absolute length of chromosomes ranged from 10.91 ± 0.6 µm of the longest one to 8.01 0.25 of the shortest one, while the relative length varied from 8.64 ± 0.2% to 6.36 ± 0.4%.

Phenology: Flowering from mid June to July.

Etymology: The specific epithet refers to the hairy leaf sheaths.

Taxonomic notes: Kunth (1843) in the protologue quoted *Allium hirtovaginatum* from “Persia (Tchesme, Olivier & Bruguiere leg.)”. As already pointed out by Gay (1847), Stearn (1978) and Garbari & al. (1979), Kunth provided a wrong indication, since Tchesme there is not in Persia but in W Anatolia, corrisponding to Çeşme, locality near Izmir. *Allium hirtovaginatum* has been often considered as synonym or a form, variety and subspecies of *A. cupani* simply differentiated by hairy leaves (Halácsy 1904; Hayek 1932; Maire 1958; Stearn 1978, 1980; Kollmann 1984). According to Garbari & al (1979) and Brullo & al. (1995, 2008c), *A. hirtovaginatum* markedly differs from *A. cupani* and allied species characterized by eudiploid ($2n = 16$) or tetraploid ($2n = 30$, 32) chromosome complements, mainly in having bulb coats detached from the base of the bulbs and aneuploid chromosome number ($2n = 14$). Based on our expanded investigations on living plants and herbarium specimens, these features are shared by many other populations of different localities of E Mediterranean area and N Africa, as also remarked by Garbari & al. (1979). In particular, *A. hirtovaginatum* s. str. is morphologically well distinct from the other aforesaid species in some remarkable diagnostic features, such as bulb coats with subparallel feebly reticulate fibres, densely hairy leaves with short hairs up to 0.25 mm long, spathe always longer than the inflorescence, with 7-11 nerves and appendage up to 2 cm long. The typical populations occur in a limited area of CW Anatolia, while in the remaining Mediterranean territories several populations, which were usually reported sub *A. cupani* subsp. *hirtovaginatum* or sub *A. hirtovaginatum*, indeed represent different geographical vicariants, often with a punctiform or very circumscribed distribution. The taxonomic position and relationships of these populations are currently being studied.

Additional specimens examined: Turkey, Colline presso Cesme, 25 Juin 1987, *S. Brullo, P. Pavone & P. Signorello s.n.* (CAT!); Manisa Dag, 8 July 1998, *S. Brullo & P. Pavone s.n.* (CAT!); Cima di Manisa Dag (Izmir), 25 Juin 1987, *S. Brullo, P. Pavone & P. Signorello s.n.* (CAT!); Cima di Manisa Dag, coltivato, 23 Juin 1999, *S. Brullo s.n.* (CAT); Manisadag (Sipylos), Steinige Gipfel Region, 12 August 1933, *O. Schwarz 1012* (B!); ibid., ca. 600 m, 24 August 1978, *Seçmen & Lesbebici 1714* (HUJ!).

9. *Allium meikleanum* Brullo, Pavone & Salmeri, spec. nova. – Figs. 2J, 4J, 6J, 7J, 8J

Syn.: *Allium cupani* Raf. subsp. *cyprium* Meikle, Ann. Mus. Goulandris 6: 94, 1983, non *A. cyprium* Brullo, Pavone & Salmeri, Candollea 48: 280, 1993.

Allio hirtovaginato aemulans, differt foliis subglabris vel pilosis cum pilis 0,3-0,5 mm longis, florum pedicellis usque ad 4 cm longis, spatha quam inflorescentia multo breviore, 10-18 mm longa, 5-nervata et cum aliis duobus incompletis nervis, appendice 1-5 mm longa, perigonio 4-5 mm longo, tepalis exterioribus 1,5-1,7 mm latis, interioribus 1,2-1,3 mm latis, filamentibus staminum subulato-triangularibus, exterioribus 0,6-1 mm longis, annulo 0.6-0.7 mm alto, ovario globoso, papilloso-tuberculato superne, 1-1,2 mm longo, capsula 3,5-3,6 mm longa.

Type: Cyprus, In montibus inter Potami et Evriku (Evrykhou), 14.6.1880, *P.E.E. Sintenis & G. Rigo 860* (holotype K!, isotypes G!, MPU!).

Bulb ovoid, solitary, 10-15 × 8-12 mm, with outer tunics brown, reticulate-fibrous, detached from the base of the bulb, covering the stem up to 4 cm. *Stem* flexuous, erect, 8-16 cm high, covered by the leaf sheaths 1/2-2/3 of its length. *Leaves* 3-4, filiform, subcylindrical, shorter than inflorescence or subequal, 5-15 cm long, subglabrous or hairy with patent hairs 0.3-0.5 mm long. *Inflorescence* fastigiate, unilateral, with 4-12 flowers on pedicels 1-4 cm long. *Spathe* 1-valved, shorter than the inflorescence, 5-nerved with 2 additional incomplete nerves, 10-18 mm long, provided with an appendage 1-5 mm long. *Bostryces* 2. *Perigon* campanulate-suburceolate, 4-5 mm long; tepals pinkish-white, with a purplish mid-vein, the outers linear-lanceolate, entire and subobtuse at the apex, 1.5-1.7 mm wide, the inners linear-oblong, rounded and gnawed-undulate above, 1.2-1.3 mm wide. *Stamens* with white filaments, subulate-triangular, unequal, the outers 0.6-1 mm long and 0.4-0.5 mm wide at the base, the inners 1.6-1.8 mm long and 0.6-0.8 mm wide at the base, below connate with tepals into an annulus 0.6-0.7 mm high; anthers white-straw coloured, linear-elliptical, apiculate, 1.2-1.3 × 0.5 mm. *Ovary* greenish, globose, papillose-tuberculate above, 1-1.2 × 1-1.3 mm. *Style* white, 0.5-0.7 mm long. *Capsule* trivalved, subglobose, 3.5-3.6 × 3.5-3.7 mm.

Distribution and habitat: *Allium meikleanum* is a very peculiar taxon limited to some localities of Cyprus, at 0-600 m of elevation. It grows in the ephemeral meadows amidst the phrygana and sub-halophilous shrubby communities alongside salt marshes.

Karyology: The investigated populations (Tab. 1) showed a diploid chromosome number $2n = 14$. This aneuploid complement agrees with that one reported by Tzanoudakis (1999) sub *A. hirtovaginatum*. The karyotype of *A. meikleanum* (Fig. 9I) was mostly characterized by metacentric chromosome pairs with only two subtelocentric chromosomes, which bear small macrosatellites in the short arms. Karyotype formula was as follows: $2n = 2x = 14$: $10\mathrm{m} + 2\mathrm{msm} + 2\mathrm{st}^{\mathrm{Msat}}$. Studied specimens from Larnaca showed a total haploid chromosome of 48.68 ± 5.17 µm; the absolute chromosome length ranged from 8.58 ± 0.59 µm of the longest chromosome to 5.58 ± 1.3 µm of the shortest one, while the relative length varied from 8.83 to 5.7%.

Phenology: Flowering from June to July.

Etymology: In honour of R. Desmond Meikle, English botanist and author of the "Flora of Cyprus".

Taxonomic notes: Meikle (1983) described the Cyprian plants of this group as *Allium cupani* subsp. *cyprium*. Due to the bulb tunics detached from the base of the bulb and the aneuploid chromosome complement (*2n* = 14), these plants are indeed well distinct from *A. cupani*, showing instead closest relationships with *A. hirtovaginatum.* However, the Cyprian populations differ from *A. hirtovaginatum* in having a little appendiculate spathe much shorter than the inflorescence, provided with 5 complete nerves plus 2 additional incomplete ones, very small perigon (4-5 mm long) and ovary markedly papillose-tuberculate in the upper part. As a result, the plants of *A. cupani* group from Cyprus have been treated as a distinct new species that could not bear the epithet "*cyprium*" used by Meikle (1983) because another valid species named *A. cyprium* already exists (see Brullo & al. 1993).

Paratypes: Cyprus, Athalassia, 6 October 1988, S. Brullo & P. Pavone s.n. (CAT!); ibid., esemplare coltivato, 15 July 1989, *S. Brullo s.n.* (CAT!); Larnaca, in prossimità dei pantani salmastri, 14.06.2001, *Brullo S., Giusso G., Guarino R. s.n.* (CAT!).

10. ***Allium pelagicum*** Brullo, Pavone & Salmeri, spec. nova. – Figs. 2K, 4K, 6K, 7K, 8K

Allio hirtovaginato aemulans, differt bulbis 15-22 × 8-20 mm, scapo erecto, rigido, usque ad 30 cm alto, vaginis foliorum per 3/4 longitudinis vel omnino tecto, folia superiore inflorescentia longiore, pilis 0,2-0,3 mm longis, pedicellis usque ad 4 cm longis, spatha inflorescentia breviore, 3-5-nervata, max. 3 cm longa, tepalis exterioribus lineari-ellipticis, obtusiusculis apice, filamentibus staminum exterioribus 1,5-2 mm longis, interioribus 2,5-3 mm longis, annulo 1-1,3 mm alto, antheris stramineis, ovario subgloboso, 1,1-1,2 × 1,2-1,3 mm, capsula 4 × 4 mm.

Type: Sicily, Lampedusa, Vallone Madonna, 20.8.1989, *S. Brullo s.n.* (Holo: CAT!).

Bulb ovoid, solitary or clustered, 15-22 × 8-20 mm, with outer tunics dark brown, fibrous, feebly reticulate, detached from the base of the bulb, covering the stem up to 4 cm. *Stem* rigid, erect, 10-30 cm high, covered by the leaf sheaths from 3/4 of its length up to totally. *Leaves* 4-5, filiform, subcylindrical, the upper one longer than the inflorescence, 6-16 cm long, hairy with patent hairs 0.2-0.3 mm long. *Inflorescence* fastigiate, unilateral, with 4-12 flowers on pedicels 0.5-4 cm long. *Spathe* 1-valved, shorter than the inflorescence or subequal, 3-5-nerved, 15-30 mm long, provided with an appendage 4-20 mm long. *Bostryces* 2. *Perigon* cylindrical-urceolate, 6-7 mm long; tepals white-pinkish or pink, with a brown-purplish mid-vein, the outers linear-elliptical, entire and subobtuse at the apex, 1.8-2 mm wide, the inners suffused with purple near the mid-vein, linear-oblong, rounded and slightly gnawed-undulate above, 1.5-1.6 mm wide. *Stamens* with white filaments, triangular, unequal, the outers 1.5-2 mm long and 0.6-0.8 mm wide at the base, the inners 2.5-3 mm long and 0.9-1.1 mm wide at the base, below connate with tepals into an annulus 1-1.3 mm high; anthers white-straw coloured, linear-elliptical, apiculate, 1.2-1.3 × 0.6-0.7 mm. *Ovary* greenish, subglobose, smooth, 1.1-1.2 × 1.2-1.3 mm. *Style* white, 1-1.5

mm long. *Capsule* trivalved, subglobose, 4 × 4 mm.

Distribution and habitat: This species is endemic to Lampedusa, island of the Pelagian Archipelago, in the Channel of Sicily. It occurs alongside the calcareous rocky coasts, where is member of ephemeral meadows.

Karyology: *Allium pelagicum* has a diploid chromosome number $2n = 14$, already reported by Brullo & al. (1990) sub *A. hirtovaginatum*. Its karyotype (Fig. 9J) mainly consisted in metacentric chromosomes and only one subtelocentric microsatellited pair, as summarized by the following formula: $2n = 2x = 14$: 8m + 4msm + $2\mathrm{st}^{\mathrm{sat}}$. The total haploid complement was 72.44 ± µm long; absolute chromosome length varied from 12.76 ± 1,95 µm of the longest chromosome to 7.45 ± 2.54 µm of the shortest one, while their relative length ranged from 8.82 to 5.07%.

Phenology: Flowering from late July to August.

Etymology: From Latin "*pelagicus*", i.e. "of Pelagian archipelago" in the Channel of Sicily.

Taxonomic notes: Populations from Lampedusa belonging to the *Allium cupani* group were previously referred to *A. hirtovaginatum* by Brullo & Pavone (1988) and Brullo & al. (1989). Further and more in-depth investigations indeed showed that these plants were well differentiated from the typical *A. hirtovaginatum* and had to be treated as a distinct species, here named *A. pelagicum*. It can be distinguished by *A. hirtovaginatum* due to its bigger bulbs, stem up to 30 cm long, covered by the leaf sheaths 3/4 of its length to totally, leaves with hairs 0.2-0.3 mm long, the upper one longer than the inflorescence, spathe shorter than the inflorescence or subequal, 3-5-nerved, subglobose shorter ovary, and smaller capsule. Moreover, *A. pelagicum* shows a later flowering time and a different karyotype structure without macrosatellited subtelocentric pairs as occurring in *A. hirtovaginatum*.

Paratypes: Sicily, Lampedusa, Vallone Madonna, 25.7.1985, *S. Brullo, P. Minissale & G. Spampinato s.n.* (CAT!); ibid., 25.3.1986, *S. Brullo, P. Minissale, P. Pavone & G. Spampinato s.n.* (CAT!); ibid., Vallone Imbriacole, 24.3.1986, *S. Brullo, P. Minissale, P. Pavone & G. Spampinato s.n.* (CAT!); ibid., Vallone della Forbice, 25.7.1985, *S. Brullo, P. Minissale & G. Spampinato s.n.* (CAT!).

11. *Allium maghrebinum* Brullo, Pavone & Salmeri, spec. nova – Figs. 2H, 4H, 6H, 7H, 8H.

Allio hirtovaginato similis, sed bulbis 12-25(-30) × 7-20(-22) mm, solitariis, geminatis vel fasciculatis, tunicis manifeste reticulato-fibrosis, scapo rigido et robusto, vaginis foliorum per 3/4 longitudinis vel omnino tecto, foliis subglabris vel sparsim pilosis, pilis 0,2-0,4(-0,7) mm longis, superiore inflorescentia longiore, pedicellis usque ad 4,5 cm longis, spatha inflorescentia breviore, interdum longiore, usque ad 7 cm longa, appendice usque ad 3,5 cm longa, perigonio cylindrico-campanulato, 7-8 mm longo, tepalis striis purpureis prope venam medianam, omnibus lineari-oblongis, exterioribus rotundatis apice, filamentibus staminum exterioribus 1-2 mm longis, interioribus 2,7-4 mm longis, annulo 0,7-0,8 mm alto, ovario subgloboso vel subgloboso-ovoideo, capsula globosa, 4 × 4 mm.

Type: Tunisia, Capo Bon, presso El Haouaria, 7.9.1990, *S. Brullo & P. Minissale s.n.* (Holo: CAT!).

Bulb ovoid or long ovoid, solitary, paired or clustered, 12-25(-30) × 7-20(-22) mm, with outer tunics brown or reddish-brown, reticulate-fibrous, detached from the base of the bulb, covering the stem up to 8 cm. *Stem* rigid, stout, erect or erect-ascending, 5-26 cm high, covered by the leaf sheaths 3/4 of its length up to totally. *Leaves* 3-5, filiform, subcylindrical, the upper one longer than the inflorescence, 6-25 cm long, subglabrous or sparsely hairy with patent hairs 0.2-0.4 mm long (0.7 mm long in the sheath gorge). *Inflorescence* fastigiate, unilateral, with 2-12(-18) flowers on pedicels 0.6-4.5 cm long. *Spathe* 1-valved, shorter or sometimes longer than the inflorescence, 1-7 cm long, 7-9(-11)-nerved, provided with an appendage 3-35 mm long. *Bostryces* 2. *Perigon* cylindrical-campanulate, 7-8 mm long; tepals pinkish-white to pink, with purple striae near the midvein, linear-oblong, the outers entire and rounded at the apex, 1.8-2 mm wide, the inners subobtuse or rounded and gnawed-undulate above, 1.5-1.7 mm wide. *Stamens* with white filaments, triangular, unequal, the outers 1-2 mm long and 0.7-0.8 mm wide at the base, the inners 2.5-4 mm long and 1.1-1.3 mm wide at the base, below connate with tepals into an annulus 0.7-0.8 mm high; anthers yellowish-white, linear-elliptical, apiculate, 1.2-1.5 × 0.7-0.8 mm. *Ovary* greenish, subglobose or subglobose-ovoid, smooth, 1.2-1.5 × 1-1.5 mm. *Style* white, 1-1.5 mm long. *Capsule* trivalved, globose, throttled below, 4 × 4 mm.

Distribution and habitat: The species is widespread from central and northern Tunisia to north-eastern Algeria. It usually occurs on compact soils of coastal and inland steppe territories, characterized by very dry climate, within thermo-xeric meadows and shrub vegetation.

Karyology: The chromosome arrangement was investigated on specimens from different localities of Tunisia (Tab. 1), all showing a diploid chromosome complement $2n = 14$. The karyotype was quite homogeneous, mostly characterized by chromosomes with a more o less median centromere, frequently with 3 *msm* pairs, and only one subtelocentric pair usually satellited in the short arm (Fig. 9K). Some variation in the satellite size was also found among the studied populations, where the subtelocentric chromosomes exhibited micro- (Cape Bon, El Beja) to macro-satellites (Korbous) or even a heteromorphic combination of both types (Sidi Daud, El Fas). The karyotype formula can be represented as: $2n = 2x = 14$: $6\mathrm{m} + 6\mathrm{msms} + 2\mathrm{st}^{\mathrm{sat}}$. Mitotic plates from the type specimens revealed a total haploid chromosome complement 83.84 μm in length, with chromosomes ranging from 13.97 to 8.97 μm in absolute length, and from 8.33 to 5.35% in relative length.

Phenology: Flowering from mid August to September.

Etymology: From Maghreb, geographical area corresponding to NW Africa.

Taxonomic notes: Due to the bulb coats detached from the base of the bulb, 7-11-nerved spathe sometimes longer than the inflorescence, and the aneuploid chromosome complement with $2n = 14$, this species is rather related to *A. hirtovaginatum*, which occurs in East Mediterranean territories. It also shows some resemblance to *A. pelagicum*, mainly in the rigid stem, covered by the leaf sheaths from 3/4 to total length, and upper leaf longer than the inflorescence. Notwithstanding, *A. maghrebinum* is well differentiated from these species in the late summer flowering time and many relevant morphological characters, including bulbs up to a 3 cm long, with markedly reticulate-fibrous outer coats, leaves with scattered hairs 0.2-0.4(-0.7) mm long, spathe up to 7 cm long, with an appendage up to 3.5 cm long, cylindrical-campanulate perigon 7-8 mm long, linear-oblong tepals, the outer ones rounded at the apex.

Paratypes: Tunisia, Capo Bon, presso El Haouaria, 21.11.1990, *S. Brullo & P. Minissale s.n.* (CAT!); Korbous, 1.9.1984, *S. Brullo s.n.* (CAT!); ibid., 6.9.1990, *S. Brullo & P. Minissale s.n.* (CAT!); Sidi Daud, 1.9.1984, *S. Brullo s.n.* (CAT!); ibid., 6.9.1990, *S. Brullo & P.*

Minissale s.n. (CAT!); El Beja, esemplare coltivato, 26.8.1992, *S. Brullo s.n.* (CAT!); El Fas, esemplare coltivato, 26.8.1992, *S. Brullo s.n.* (CAT!); In collibus dumetosis humilioribus circa Zaghouan, 9.7.1854, *J.-L. Kralik 380* (MPU!, G!, P!, PAL!); ibid., *J.-L. Kralik 385* (FI-W!, G!, PI!); Dj. Zaghouna, 6.8.1884, *J.-L. Kralik s.n.* (FI-W!); Ariana, 22.10.1901, *A. J. Cuenod s.n.* (G!); Nabel, in dumetosis, 16.10.1907, *M. Gandoger 151* (G!); **Algeria**, Batna, sur les collines incultes, 30.7. 1853, *B. Balansa 743* (MPU!, P!).

12. *Allium tingitanum* Brullo, Pavone & Salmeri, spec. nova – Figs. 2L, 4L, 6L, 7L, 8L.

Allio maghrebino aemulans, differt scapo flexuoso, vaginis foliorum ad dimidium tecto, pilis foliorum 0,5-0,8 mm longis, spatha 5-6-nervata, max. 4 cm longa, tepalis aequalibus vel subaequalibus, lineari-oblongis, integris et obtusiusculis apice, ovario 1-1,2 mm longo, capsula obovoidea.

Type: Morocco, Taza, esemplare coltivato, 20.7.1991, *S. Brullo s.n.* (Holo: CAT!).

Bulb ovoid, solitary, 15-20 × 10-12 mm, with outer tunics brown, reticulate-fibrous, detached from the base of the bulb, covering the stem up to 4 cm. *Stem* flexuous, erect, 12-25 cm high, covered by the leaf sheaths 1/2 of its length. *Leaves* 4, filiform, subcylindrical, shorter than the inflorescence, 6-15 cm long, subglabrous or hairy with scattered patent hairs (0.3-)0.5-0.8 mm long. *Inflorescence* fastigiate, unilateral, with 4-11 flowers on pedicels 1.5-4.5 cm long. *Spathe* 1-valved, shorter than the inflorescence or sometimes subequal, 5-6-nerved, 1.5-4.5 cm long, provided with an appendage 14-25 mm long. *Bostryces* 2. *Perigon* cylindrical-campanulate, 7-7.5 mm long; tepals equal or subequal, pinkish-white, with a purplish-brown mid-vein, linear-oblong, entire and subobtuse at the apex, 1.6-1.8 mm wide. *Stamens* with white filaments, unequal, the outers subulate-triangular, 1.1-1.6 mm long and 0.5-0.7 mm wide at the base, the inners triangular, 2.6-3 mm long and 0.8-1 mm wide at the base, below connate with tepals into an annulus 1-1.2 mm high; anthers yellow, oblong, apiculate, 1.4-1.5 × 0.8-0.9 mm. *Ovary* greenish, subglobose, smooth, 1-1.2 × 1-1.2 mm. *Style* white, 1.2-1.4 mm long. *Capsule* trivalved, obovoid, throttled below, 4 × 4 mm.

Distribution and habitat: This species occurs in N Morocco and NW Algeria. It is spread both in coastal and inland steppe territories, within the thermo-xeric meadows and shrub vegetation.

Karyology: Studied specimens from the type locality (Tab. 1) showed a diploid chromosome complement with $2n = 14$. Similarly to the previously investigated aneuploid taxa of this group, the karyotype of *A. tingitanum* (Fig. 9L) was characterized by relatively metacentric (*m*) chromosomes and one subtelocentric (*st*) pair, differing in the presence of one submetacentric (*sm*) pair, which sometimes revealed microsatellited in the short arm, and evident macrosatellites in the *st* pair. The karyotype formula was as follows: $2n = 2x = 14$: 8m + 2msm + 2sm + 2 $\mathrm{st}^{\mathrm{Msat}}$. The total haploid chromosome complement was 65.47 ± 6. 5 µm in length; chromosome absolute length ranged from 11.65 ± 1.8 µm of the longest chromosome to 7.02 ± 0.8 µm of the shortest one, while the relative length varied from 8.87 to 5.36%.

Phenology: Flowering from June to July.

Etymology: From Latin "*tingitanus*", i.e. "from *Tingitania*", historical region of N Africa corresponding to N Morocco.

Taxonomic notes: *Allium tingitanum* shows closest relationships with *A. maghrebinum* in having similar leaf indumentum, pedicel length, perigon shape and size, but many relevant morphological features involving both vegetative (stem, spathe) and reproductive (tepals, ovary, capsule) elements allow to distinguish very well the two species. Phenological differences also occur in their flowering and fruiting times, because *A. tingitanum* starts flowering much earlier than *A. maghrebinum* that fully blooms in late summer.

Paratypes: Morocco, Dar Druis, sol argileux très dur, 12.7.1930, *E.M. Sennen 7720* (G!, MPU!); ibid., 25.6.1931, *E.M. Sennen & H. Mauricio 8044* (G!, MA!, MPU!, P!); Berkane, lieux rocailleux près la Mouloya, 22.6.1932, *A. Faure s.n.* (G!, MA!, MPU!); Fez, a Sefrou, bord de route, 10.1913, *C.-J. M. Pitard 1384* (MPU!, P!); ibid., Dar Maharés, coteaux argilleux, 7.1913, *M. Mouret 2154* (MPU!); Melilla, Hidum, coteaux calcaires, 8.7.1933, *E.M. Sennen & H. Mauricio 8947* (G!, MA!, MPU!); Riff oriental, Monte Uixan, Benibuifruz, 17.9.1920, *B. Vicioso s.n.* (MA!); **Algeria**, Oran, 1851, *E.M. Durand s.n.* (G!, MPU!, P!); ibid., 10.9.1888, *Bouiquet s.n.* (MPU!); ibid., 8.1918, *A.C. d'Alleizette s.n.* (G!); ibid., lieux secs, 8.1921, *A.C. d'Alleizette s.n.* (MA!); ibid., sur les collines, 6.1850, *G.L. Durando 164* (FI-W!, G!, P!); ibid., in collibus siccis, 7.1851, *G. Munby s.n.* (G!, P!); ibid., a Santa Cruz, lieux rocailleux près du Belvedere, 26.8.1927, *A. Faure s.n.* (M!); ibid., maquis près Sidi-bel-Abbes, 20.8.1873, *E.A. von Regel 99* (P!); ibid., Zelouses, 20.7.1873, *Wariou s.n.* (G!, MPU!); Tlemcen, prov. d'Oran, 26.7.1894, *Vomnerguell s.n.* (P!); Mostaganem, 20.8.1848, *B. Balansa s.n.* (P!); ibid., rocher nu, 9.1911, *A.C. d'Alleizette s.n.* (P!).

Key to the investigated species of *Allium* sect. *Cupanioscordum*

1. Bulb tunics attached to the base of bulb....................................**2**

– Bulb tunics detached from the base of bulb....................................**8**

2. Stem 8-10 cm high; spathe with 2 valves partially fused; inflorescence arranged in 4 bostryces; capsule 3-3.2 mm long....................................***A. cephalonicum***

– Stem 10-40 cm high; spathe 1-valved; inflorescence arranged in 2 bostryces; capsule 3.5-5 mm long....................................**3**

3. Tepals usually 8-9 mm long....................................**4**

– Tepals usually 6-7.5 mm long....................................**5**

4. Leaves subglabrous to hairy; spathe 12-45 mm long, usually 3-5-nerved; anthers apiculate at the apex; ovary smooth; capsule subglobose-obovoid..............***A. mauritanicum***

– Leaves glabrous; spathe max. 20 mm long, 6-9-nerved; anthers rounded at the apex; ovary papillose-rugose on the top; capsule ellipsoid............................***A. panormitanum***

5. Stem flexuous; spathe 3-7-nerved; perigon cylindrical-campanulate............................**6**

– Stem rigid; spathe 7-10-nerved; perigon cylindrical-suburceolate................................**7**

6. Spathe 3-nerved, sometimes with 2 additional incomplete nerves, appendage 1-3 mm long; leaves with patent hairs, 0.15-0.2 mm long; anthers rounded at the apex; capsule ellipsoid....................................***A. cupani***

– Spathe 5-7-nerved, with an appendage 0.2-0.6 mm long; leaves with subappressed hairs, 0.2-0.6 mm long; anthers apiculate at the apex; capsule globose-obovoid........***A. samniticum***

7. Bulbs solitary (sometimes with few bulbills); leaves with appressed hairs; spathe apiculate; staminal annulus 1-1.2 mm high; anthers pinkish-white to purplish; capsule 4.5-5 × 3.5-3.8 mm....................................***A. balcanicum***

– Bulbs bulbilliferous; leaves with patent hairs; spathe with appendage1-3 mm long; staminal annulus 1.6-1.8 mm high; anthers yellow; capsule 3.5-4.5 × 3-3.2...***A. tzanoudakisanum***

8. Spathe with appendage 1-5 mm long; perigon 4-5 mm long; ovary papillose-tuberculate above; capsule 3.5-3.6 mm long..***A. meikleanum***

– Spathe with appendage 4-35 mm long; perigon 6-8 mm long; ovary smooth; capsule 4-5 mm long..**9**

9. Bulbs 9-15 mm long; spathe longer than inflorescence; capsule 5 × 5 mm..***A. hirtovaginatum***

– Bulbs (12-)15-25(-30) mm long; spathe shorter than inflorescence or subequal; capsule 4 × 4 mm..**10**

10. Stem flexuous, covered by the leaf sheaths 1/2 of its length; all leaves shorter than the inflorescence; capsule obovoid...***A. tingitanum***

– Stem rigid, covered by the leaf sheaths 3/4 of its length to totally; upper leaves longer than the inflorescence; capsule globose or subglobose...**11**

11. Leaves hairy; spathe 3-5-nerved; perigon cylindrical-urceolate, 6-7 mm long; staminal annulus 1-1.3 mm high; ovary 1.1-1.2 mm long....................................***A. pelagicum***

– Leaves glabrous or sparsely hairs; spathe 7-9(-11)-nerved; perigon cylindrical-campanulate, 7-8 mm long; staminal annulus 0.7-0.8 mm high; ovary 1.2-1.5 mm long..........***A. maghrebinum***

Conclusion

This study is a first contribution providing a morpho-karyological characterization and taxonomic revision of some relevant taxa belonging to the *Allium cupani* group. Most of exsiccata specimens in several Herbarium collections have been generally identified sub *A. cupani* Raf. or sub *A. hirtovaginatum* Kunth. Our investigations revealed that these are two complex species characterized by several highly variable and taxonomically controverse populations whose relationships and systematic position need further investigations. As a consequence, a full revision of the sect. *Cupanioscordum* is currently in progress to be published.

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Study of vertical and horizontal forest structure in Mt. Ainos National Park, Cephalonia Island, Greece

Abstract

Xanthakis, M., Panagiotis, M., Lysitsa, G. & Kamari, G.: Study of vertical and horizontal forest structure in Mt. Ainos National Park, Cephalonia Island, Greece. — Fl. Medit. 25 (Special Issue): 245-256. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

The analysis of the horizontal and internal/vertical structure (profile) of the forest and forested areas of Mt. Ainos National Park on Cephalonia Isl. is presented in this study. The horizontal structure of the forest and forested areas of Mt. Ainos National Park concerned the spatial distribution of the land-cover categories, which have been used in established forestry practices during approximately the last twenty years (1990-2009). The evaluation of the results shows a decrease of the *Abies cephalonica* forest and an increase of the pasture areas through time. A modern vegetation map of the National Park has been produced through this study from satellite data collected in 2009, with the assistance of remote sensing and GIS. The vertical structure of the *Abies cephalonica* forest stand of Mt. Roudi of the National Park was assessed, using data collected in sampling plots. The analysis provided data for important stand density indices that can help authorities in planning sustainable management interventions in the entire forest area.

Key words: forest structure monitoring, forest mensuration, Remote Sensing, Geographic Information Systems.

Introduction

Mt. Ainos National Park was founded in 1962, mainly in order to protect what was left of the once flourishing and magnificent forest, consisting almost entirely of *Abies cephalonica* Loudon (the Cephalonian Fir). The mountain constitutes, according to the International Code of Botanical Nomenclature, the *locus classicus* of the Cephalonian Fir, which is a Greek endemic species. The name *Abies cephalonica* was given by the English botanist J. W. Loudon in 1838, when he classified the Fir from Cephalonia as a new species. Moreover, the whole ecosystem of Mt. Ainos has a significant scientific and aesthetic value, being situated in the heart of Cephalonia Island, right at the center of the island's rich biodiversity.

On Mt. Ainos, *Abies cephalonica* reaches an altitude of 1600 m a.s.l., where it forms the treeline in contact with calcareous rocky slopes with orophilous petrophytic vegetation and it descends up to an altitude of approximately 600 m. The current upper limit of fir forests on Mt. Ainos are likely to be due to anthropogenic influence rather than to bioclimatic reasons, since the species at issues can be found well above the elevation of 1600 m, as it happens in continental Greece (Peloponnisos, Sterea Hellas).

According to the Dafis' (1973) classification of the forest vegetation in Greece, the fir forest of Mt. Ainos belongs to the beech-fir zone (Fagetalia) with the Abietion cephalonicae alliance, including mainly *Abies cephalonica* forests, and a *Pinus nigra* cluster as well. Recently, the occurrence of *Pinus nigra* subsp. *nigra* Arnold was recorded in the northwestern slopes of Mt. Ainos, at altitude of 1200 m by Efthymiatou-Katsouni & Phitos (2011) and confirmed by our observations.

The study of the structure of the forest allows, on one hand, to gather information on development stages and trends, and on the other, to analyze their potential interactions with wildlife in general (Gatzojiannis 1999a).

In the current study, we present the spatial distribution of the forest and forested areas for the core and buffer zone of Mt. Ainos National Park during the last twenty years (1990-2009). Moreover, a new vegetation map of the National Park was created, basing on a high resolution Geo-EYE orthophotomap of 2009. Finally, the vertical structure of the fir forest stand of Mt. Roudi, in the same National Park, was assessed, by using data collected in sampling plots.

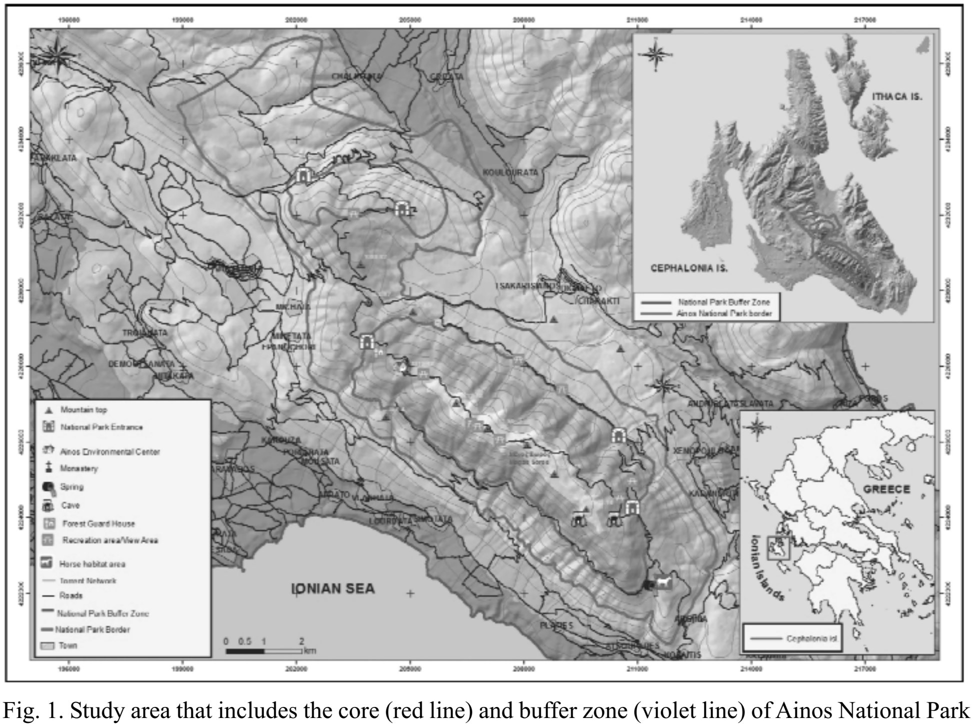


Fig. 1. Study area that includes the core (red line) and buffer zone (violet line) of Ainos National Park on Cephalonia island.

The Study Area

The National Park of Ainos extends to Mt. Ainos and the adjacent Mt. Roudi on Cephalonia Island, Greece (Fig. 1). Mt. Ainos with an altitude of 1628 m is the tallest mountain in the Ionian Islands, whereas Mt. Roudi reaches an altitude of 1125 m.

Besides of the Cephalonia island, *Abies cephalonica* also occurs on Evia Island and in continental Greece, from Peloponnesus to Mt. Olimbos and Mt. Athos. On Cephalonia isl., particularly after the 16th century, extensive woodcutting in the forest of Mt. Ainos-Mt. Roudi, as well as the inability to effectively control and exclude the fires affecting the area, threatened the survival of the Fir forest. As a result, its distribution has been restricted to ¼ the initial one (Y.PE.XO.D.E. 2002). It is possible that the temperature increase in the future, due to global climatic change, may threaten the survival of the Fir forests in the island. It is expected that the temperature increase, predicted in particular for the Mediterranean basin, will have important negative effects on the populations of most conifer species (Körner & al. 2005; Sarris & al. 2007), including *Abies cephalonica*.

In recognition of its significance at European level, the National Park has been designated as a European Biogenetic Reserve, belongs to the “Natura 2000” European Ecological Network of Protected Areas (EEA 2015) and is a Special Protected Zone for the protection of bird species. It has also been declared as a Wildlife Reserve (Michales & Gartsoni 1996). The responsible organizations for its management and administration are the Management Body of the National Park of Mountain Ainos and the Forest Service of Cephalonia.

More than 500 plant species and subspecies have been recorded in the National Park of Mt. Ainos (Phitos & Dambold 1985). Some of them are Cephalonian endemics, such as *Viola cephalonica* Bornm., restricted only to the higher altitudes of Mt. Ainos and *Saponaria aenesia* Heldr. with a wider distribution on the island. Moreover, some Greek endemic plant taxa, such as *Campanula garganica* subsp. *cephalonica* (Feer) Hayek, *Fritillaria mutabilis* Kamari, *Scaligeria moreana* Engstrand, *Scutellaria rupestris* Boiss. & Heldr. subsp. *cephalonica* (Bornm.) Greuter & Burdet, *Thymus holosericeus* Celak., or some rare taxa, such as *Paeonia mascula* subsp. *russoi* (Biv.) Cullen & Heywood etc. can be observed.

In the National Park, more than 100 bird species have been recorded (Handrinos & Akriotis 1997), among them, *Circaetus gallicus* Gmelin, *Buteo buteo* L., *Pernis apivorus* L., *Falco tinnunculus* L., *Athene noctua* Scop., *Alectoris chukar* Gray, *Caprimulgus europaeus* L., *Garullus glandarius* L., *Periparus ater* L., *Turdus viscivorus* L. etc.

The presence of some vertebrates, which can be detected in the area, are: *Podarcis tauricus* subsp. *ionicus* Pallas, *Algyroides moreoticus* Bibron & Bory, *Vipera ammodytes* L., *Erinaceus roumanicus* Barrett-Hamilton, *Talpa stankovici* V. Martino & E. Martino, *Myoxus glis* L., *Lepus europaeus* Pallas, several bat species etc. In the area of the Zoodohos Pigi Monastery, one can observe a herd of semi-wild horses (*Equus caballus* L.).

The climate of Cephalonia is generally of the Mediterranean type, characterized by mild winters with frequent rainfall, frequent sunny days and arid summer. From the existing reports and occasional research by the British Petroleum company (B.P.) of the years 1962-1968 it is known that Mt Ainos consists of: 1) Upper and 2) Lower Cretaceous rocks, aged 80-68 ma. The Upper Cretaceous is subdivided into 5 lithological units, consisting mostly of pelagic limestones with various fossils, the most characteristic being *Rudistacea*, *Hippuritidae* and *Radiolitidae* (I.G.M.E. 1985; Cestari & Sartorio 1995).

Material and Methods

The horizontal forest structure of Mt. Ainos National Park was studied in the vicinity of the core and buffer zone of the protected area with the use of Geographical Information Systems and Remote Sensing data. Initially, a digitization of land use classes from an orthophotomap derived from the Ministry of Agriculture and dated from 1990 was performed. The following land cover classes were recognized: forest land, shrub land, pasture land, agricultural land and bare land. Following that, a very high resolution satellite image of 2009 (GEOEYE, spatial resolution 0.05 m, four bands) was classified under the same categories as above, representing the current situation of land cover classes in the National Park. A comparison between the two maps revealed the land cover changes in the last 20 years. Using the satellite image of 2009, fieldwork and photointerpretation, a detailed vegetation map was produced. During the fieldwork, some interesting observations were made by the research team about the vegetation of the National Park, concerning the species of *Pinus nigra* subsp. *nigra* Arnold and *Ostrya carpinifolia* Scop.

The study of the vertical structure of *Abies cephalonica* forest was based on the selection of 30 ten-square sample plots 0.01 hectare size (10×10 m), based on a previous study of Politi & al. (2009). In every sample plot the position of each tree, kind of species, diameter at breast height (cm), height (m), crown height (m) and two diameters of crown were recorded, according to IUFRO forest measurement system (Leibundgut 1959; Dafis 1990; Gatzojannis 1999b, 2000; Thanasis 2004). Random sampling was used for the selection of the plots (Matis 1992). Every tree with diameter above 8 cm was measured. Data analysis was done by SPSS 21, SVS (Stand Visualization System), Microsoft Excel and Ecological Methodological software. In each plot the descriptive statistics, given below, were calculated:

- Mean average, standard deviation and standard error of diameter and height.
- Basal area, number of trees per hectare, Stand Deviation Index and Stand Volume.

Table 1. Area (ha) and land use percentage on Mt. Ainos National Park from a forestry point of view between the years 1990 and 2009.

Land use	**1990 (Area in ha)**	**2009 (Area in ha)**	**1990 Percentage (%)**	**2009 Percentage (%)**
Forest land	2907.5	2701.8	36.94	34.33
Shrub land	4299.2	4174.6	54.62	53.04
Pasture land	457.6	815.0	5.81	10.35
Agricultural land	36.5	15.5	0.46	0.20
Bare land	170.3	164.2	2.16	2.09
Total (ha)	**7871.1**	**7871.1**	**100**	**100**

Results and Discussion

Land use changes between the years of 1990 and 2009 in the core and buffer zone of Mt. Ainos National Park are presented in Table 1.

In Table 1 we can observe a reduction of the area of forest land, shrub land, agricultural land and bare land between the years 1990-2009 per 2.61, 1.58, 0.26 and 0.07% respectively, attributed to human impacts (fires, overgrazing, land abandonment) that the forest has faced in the previous years. On the contrary, pasture land has increased by 4.54%, following the increase in the number of animals in the areas around the National Park. In Fig. 2, land use maps that depicts the changes between the years 1990 and 2009 are presented.

The vegetation map of Mt. Ainos National Park is illustrated in Fig. 3, whereas in Table 2, the area and percentage of each vegetation class of the map is given for the core and buffer zone of Mt. Ainos National Park separately.

According to Table 2, *Abies cephalonica* forest, garrigue vegetation of East Mediterranean area and maquis vegetation occupy the majority of the area of the National park with 33.72, 18.31 and 40.84% respectively. In the core zone of the National Park, apart from *Abies cephalonica*, sixty eight trees of *Pinus nigra* subsp. *nigra* (black pine) were observed. From the measurement of morphometric characteristics of *Pinus nigra* trees, the mean breast height was 23 cm with the maximum of 36 cm and mean height was 17 m with maximum 23 m.

Additionally, in the location of "Melanitsa stream" and "Fagias" of the National Park, a small number, i.e. five individuals of *Ostrya carpinifolia* Scop. (hop hornbeam), a rare species of the Park, were observed.

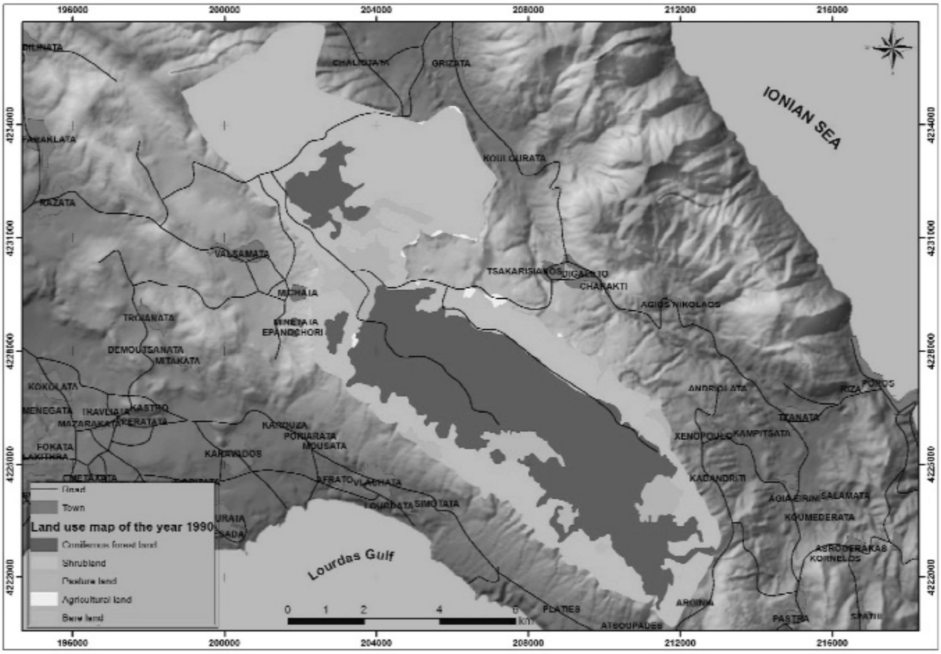
The *Abies cephalonica* stand of Mt. Roudi is pure by 96,82% and mixed with maquis vegetation by 3.18%. 15% of the diameter of trees ranges from 5-20 to 50-70 cm, 25.5% ranges from 20 to 30 cm and 44.4% from 30 to 50 cm.

In Table 3, typical descriptive statistics of the forest stand of Mt. Roudi of the National Park are presented. From the statistics and tree diameter distribution (Fig. 6) we conclude that the Mt. Roudi stand is of mid-aged condition. The measured stand density equals 1020 trees per ha. The mean height of the stand was determined as equal to 16.9 m, with 24.2 m being the maximum. The mean breast height of the stand was 33.9 cm.

The nonparametric test for the goodness of fit of tree diameters of all the plots with the Kolmogorov-Smirnov tests showed that the dbh distribution of *Abies cephalonica* trees in Mt. Roudi did not follow the normal distribution (p-value = 0.04). The distribution showed a single top curve of bell-shaped form with a slightly right asymmetry and uneven aged structure (Fig. 6).

Conclusions

This study is a contribution to the understanding of the horizontal and vertical structure of forest and forested areas of Mt. Ainos National Park. The creation of a new, detailed vegetation map of the core and buffer zone of the National Park was another accomplishment of this study. The discovery of sixty-eight new trees of black pine in the core zone of the National Park is an indication that the black pine is native in Ainos National Park. The



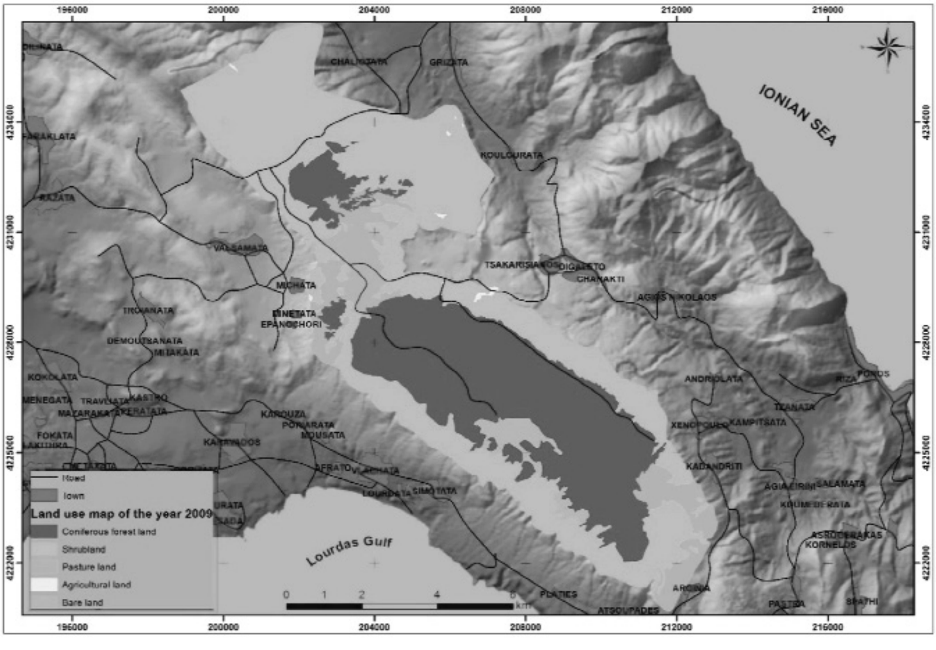


Fig. 2. Land use maps of the core and buffer zone of Ainos National Park in 1990 (above) and 2009 (below).

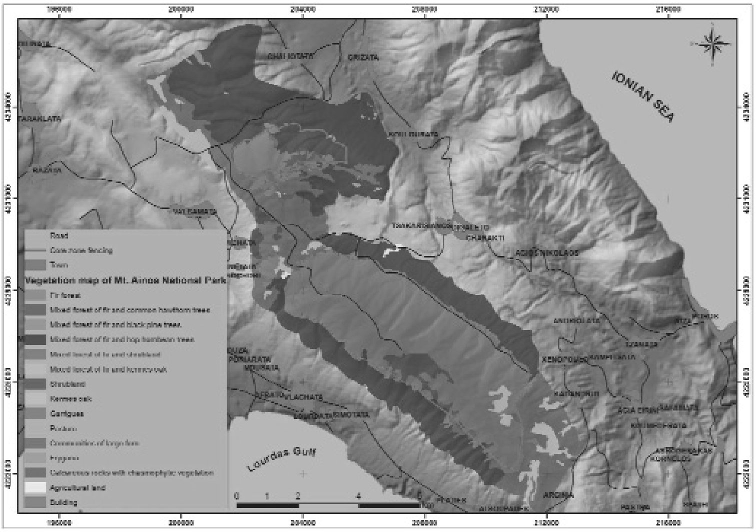


Fig. 3. Vegetation map of the core and buffer zone of Ainos National Park.

Table 2. Contribution of each land-cover type (ha) to the Ainos National Park area from a forestry point of view.

Vegetation class	*Core zone*	*Buffer zone*	*Total*	*Percentage (%)*
Abies cephalonica forest	2440.5	213.4	2653.9	33.72
Abies cephalonica forest mixed with maquis vegetation	6.6	0.0	6.6	0.08
Abies cephalonica forest mixed with *Crataegus monogyna* ssp. *monogyna*	23.7	0.0	23.7	0.30
Abies cephalonica forest mixed with *Ostrya carpinifolia*	0.012	0.2	0.2	0.002
Abies cephalonica forest mixed with *Quercus coccifera*	45.9	0.0	45.9	0.58
Abies cephalonica forest mixed with *Pinus nigra* ssp. *nigra*	1.7	0.096	1.8	0.02
Garrigue vegetation	54.3	1387.3	1441.6	18.31
Maquis vegetation	232.7	2981.6	3214.3	40.84
Quercus coccifera forest	0.0	274.4	274.4	3.49
Phrygana vegetation	0.0	13.3	13.3	0.17
Pteridium aquilinum communities	0.0	6.9	6.9	0.09
Pastureland	0.2	23.6	23.8	0.30
Buildings	1.1	3.7	4.8	0.06
Calcareous rocks with chasmophytic vegetation	146.7	0.0	146.7	1.86
Agricultural land	0.0	13.2	13.2	0.17
Total (ha)	**2953.4**	**4917.7**	**7871.1**	**100**

Fig. 4. *Pinus nigra* subsp. *nigra* tree in the core of Mt. Ainos National Park.

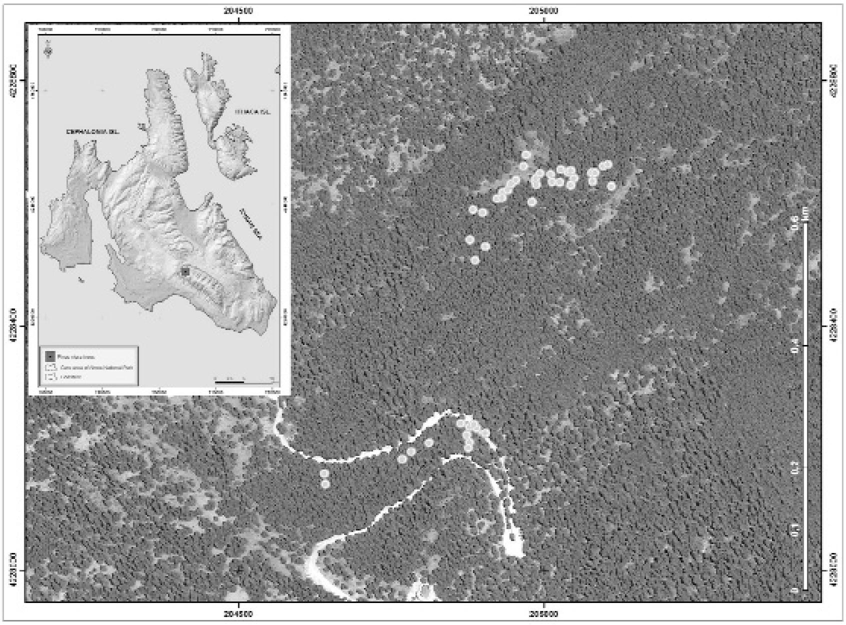


Fig. 5. Distribution of *Pinus nigra* subsp. *nigra* in the core area of the National Park of Mt. Ainos (yellow dots).

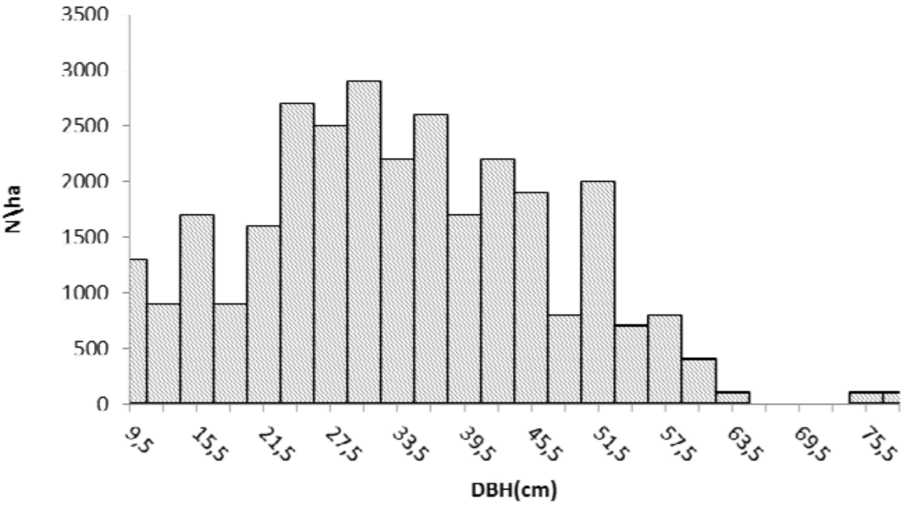


Fig. 6. Diameter distributions of the fir stand on Mt. Roudi.

Pinus nigra trees were found on poor, calcareous, sandy, pure limestone soils and steep slopes were the main topographic characteristic of its habitat. Moreover, the forest road (white outline in Fig. 5) near pine trees, was constructed recently, i.e. in 2009. All the above facts support our hypothesis that the black pine is native in Ainos National Park

The structure of the *Abies cephalonica* forest on the Mt. Roudi component of the National Park was examined too. The results of the study revealed a multi-aged structure that can be attributed to continuous anthropogenic influences (e.g. fire, grazing etc.). The forest had many attributes that were consistent with a fire-resistant evolutionary strategy. Forest structure was relatively open with large trees and high crown bases, reducing vulnerability to crown fire behavior. Shallow forest floors and low woody debris burden,

Table 3. Typical descriptive features of the forest formations on Mt. Roudi of the National Park, resulting from the survey of all sampling areas of forest stand (30 plots). SDI: Stand Density Index; N/ha (number of stems per ha); Basal area of the stand (m^2/ha); V: Stand volume (m^3/ha).

Indices	**Min**	**Max**	**Mean**	**Standard deviation**
SDI	592.25	3,033.67	1,906.47	685.10
N/ha	400.00	1,900.00	1,020.00	366.15
G	32.02	217.64	105.93	41.73
V	126.06	1,294.33	672.98	270.06

probably due to repeated fires, were also conducive to reduced fire severity. The Mt. Roudi forest stand had a wide range of large fir trees. The multi-aged stand structure indicated that regeneration had been dominated by fire events for at least 350 years, with mature over story trees surviving many surface fires.

More research and further scientific analyses are needed to study the dynamics of the forests of Ainos National Park and this is the purpose of the scientific team of its Management Body Mt. Ainos National Park, which monitors biodiversity and implements appropriate management practices.

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Franco Pedrotti

The genus *Cerastium* (*Caryophyllaceae*) in the Stelvio National Park (Central Alps)

Abstract

Pedrotti, F.: The genus *Cerastium* (*Caryophyllaceae*) in the Stelvio National Park (Central Alps). — Fl. Medit. 25 (Special Issue): 257-261. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

This work presents the list of species of *Cerastium* L. (*Caryophyllaceae*) collected in the Stelvio National Park (the Ortles-Cevedale group in the central Alps) in the years from 1961 to 1970 by F. Pedrotti, E. Orsomando and C. Cortini Pedrotti (Camerino). A total of 9 entities were found and identified by W. Moeschl (Graz) (†); in addition, Cerastium holeosteoides from the Val di Sole (Trentino) is reported. The material collected was deposited in the Herbarium of the former Department of Botany and Ecology of the University of Camerino (CAME).

Key words: *Cerastium*, altitudinal distribution, vegetation belts, phytosociology.

Introduction

This work lists the nine entities of *Cerastium* L. (*Caryophyllaceae*) collected in the years between 1961 and 1970 in the Stelvio National Park, defined by its 1935 boundaries, which is in the Ortles-Cevedale group in the central Alps (leg. F. Pedrotti, E. Orsomando & C. Cortini Pedrotti). The items collected were deposited in the Herbarium of the Department of Ecology and Botany of the University of Camerino (CAME).

All the *exsiccata* were determined by W. Moeschl (Graz) (†). A preliminary list of the species of the *Cerastium* L. genus in the Stelvio National Park was published by Pedrotti in 2005.

Material and methods

For each taxon the following information is presented: nomenclature (Conti & 2005), the chorological element (Aeschimann & 2004), the minimum and maximum altitude at which the item was found, the altitudinal level(s) of reference, the type of vegetation in which the *taxon* was observed at the moment of collection and during the execution of the phytosociological relevés (Pedrotti & al. 1974), and the name of the collection area.

In addition, *Cerastium holosteoides* was collected in the Val di Sole (Trentino), in an area close to the Stelvio National Park; the *exsiccatum* of this finding (*leg*. F. Pedrotti; *det*. W. Moeschl) was also deposited in the University of Camerino Herbarium (CAME).

The names of the collection localities are reported as they appear on the herbarium labels; followed by the toponym, the name of the valley where the plant was found from Pedrotti & al. (1974), in parenthesis to facilitate interpretation, with the lone exceptions of the cases in which the collecting locality in the label and the name of the valley in the I.G.M. maps coincide.

The locations are grouped with the following abbreviations: AA = Alto Adige (Sudtirol), TR = Trentino.

List of species

Cerastium alpinum L. subsp. ***alpinum***

Arctic-alpine; 2420-2580 m; alpine belt; various environments (moraines, soils rich in humus, etc.).

AA: morene Vedretta Saent (Val Martello), 2580 m, 26-VIII-1964.

TR: nei cirsieti (*Peucedano-Cirsietum spinosissimi*) presso il Rifugio Dorigoni (Rabbi), 2420 m, 3-VIII-1964.

Note*:* this finding confirms its presence in Trentino.

C. arvense subsp. ***molle*** (Vill.) Arcang.

South-eastern European; 1550-2500 m; from the montane to the alpine belt; various environments (grazed alpine meadows, “campivoli” **[grazing areas near mountain stalls]**, rocky environments, etc.).

AA: Solda di Fuori, 1550-1600 m, 25-VI-1965.

TR: sopra Malga Giumella (Peio), 1800 m, 21-VI-1965; parete rocciosa di Cima Vioz, 2500 m, 5-IX-1962; pendici occidentali Cima Vioz, nel *Festucetum variae*, 2400-2500 m, 5-IX-1962; Dente del Vioz, nel *Festucetum variae*, 2500 m, 5-IX-1962; sopra Peio, 1600-1650 m, 21-VI-1965; sopra Malga Stablazol (Rabbi), 1600 m, 20-VI-1965.

C. arvense subsp. ***strictum*** (W.D.J. Koch) Schinz **&** R. Keller

Montane southern European; 1800-2600 m; from the high hilly to the alpine belt; various environments (grazed alpine meadows, grassy slopes, calcareous gravel screes, moraines, pebbly riverbanks); indicated in the *Junipero-Arctostaphyletum* and *Homogyno-Piceetum* associations (Pedrotti 1966, 1980); *C. arvense* L. (*s.l.*, without indication of subspecies), it is reported in the phytosociological tables for Cirsium patches (*Peucedano-Cirsietum spinosissimi*) at the Cevedale Refuge and below Le Lame (Val di Peio) (Pedrotti 1983).

AA: Solda, greto Rio Solda, 1850-1870 m, 20-VIII-1965; Val del Pozzo (Val Martello), 2350 m, 29-VIII-1964; Dosso Tabaretta, 2539 m, 11-VIII-1965; Malga Campo Piccolo (Trafoi), 2050 m, 23-VIII-1965; morene Vedretta Fine del Mondo, ghiaioni calcarei, 2340 m, 28-VIII-1965; stazione di arrivo della seggiovia Monte delle Vacche (Solda), nel *Festucetum halleri*, 2350 m, 28-VIII-1965; Monte Muta (Solda), vegetazione nitrofila a *Poa alpina*, 2550-2570 m, 9-VIII-1965; imbocco Val Rosin (Val Martello), 1820 m, 2-IX-1964; ghiaioni calcarei fra Monte Marlet e Monte Muta, 2550 m, 9-VIII-1965; Solda, zone erbose vicino alla mugheta, 1900 m, 5-VIII-1965; Solda, scarpate erbose, 1900 m, 6-VIII-1965; Dosso Glorenza, 2000 m ca, 29-VI-1966; Val Martello, alla testata, 2200 m, 21-VIII-1964; lungo la strada dello Stelvio, 2000 m, 24-VI-1965; Val Peder (Val Martello), 2350-2400 m, 23-VIII-1964; sopra Rifugio Tabaretta (Solda), 2580 m, 8-VIII-1965; lungo strada dello Stelvio, 2000 m, 24-VI-1965.

TR: Pala della Donzella (Peio), 2600 m, 7-IX-1962; Saent (Rabbi), nello *Junipero-Arctostaphyletum*, lungo il sentiero dal Rifugio Dorigoni a Casotto Saent (versante sinistro), 2300 m, 20-VIII-1963; Passo Cercena (Peio), 2600 m, 12-VIII-1962; Monte Vedretta Lamare, 2500-2600 m, 23-VIII-1962; Saentin (Rabbi), 2150 m, 13-VIII-1964; nel *Peucedano-Cirsietum spinosissimi* alla base delle morene Vedretta di Lamare, 2400 m ca, 22-VIII-1962; coste sopra Malga Pontevecchio (Val Lamare), nel *Festucetum variae*, 2325 m, 12-VIII-1962; sopra Peio, 1600-1650 m, 21-VI-1965; sopra malga Stablasol (Rabbi), 1600-1650 m, 20-VI-1965.

C. cerastoides (L.) Britton

Arctic-alpine; 2436-2800 m; alpine belt; vegetation of the small nival valleys (*Salicetalia herbaceae*).

TR: Val Lamare, IX-1961; morene Vedretta Lamare, 2450-2500 m, 22-VIII-1962; Rifugio Dorigoni (Rabbi), 2436 m, 2-VIII-1962; costa sopra Lago Corvo (Rabbi), 2700-2800 m, 8-VIII-1964; Passo di Rabbi, 2480 m, 7-VIII-1964.

C. fontanum Baumg.

Arctic-alpine; 1880-2100 m; montane and subalpine belts; various environments (larch groves, peaty meadows, etc.).

AA: Paradiso del Cevedale (Val Martello), 2100 m, 26-VIII-1964; Solda, nel lariceto, 1880 m, 6-VIII-1965.

C. glutinosum Fr.

Mediterranean; up to 1600 m; montane belt; steppe meadows (*Festucetalia vallesiacae*).

TR: Peio, nella vegetazione steppica, 1600 m ca, 11-VIII-1962.

C. holosteoides Fr. [*C. holosteoides* subsp. *triviale* f. *glandulosum* (Boenn.) Möschl; *C. fontanum* subsp. *vulgare* (Hartm.) Greuter & Burdet]

Eurasiatic which became cosmopolitan; 1600-2600 m; from the montane to the alpine belt; in alpine meadows (*Arrhenatheretalia*) and in the megaforbs communities (*Adenostyletalia*); previously reported (sub *C. triviale*) for the following locations: Dorigoni Refuge (Val di Rabbi), Vallombrina, under the Cevedale Refuge, Lago Lungo, Casotto del Careser (Val di Peio), where it grows in the *Peucedano-Cirsietum spinosissimi* association (Pedrotti, 1983).

AA: Sottostelvio (Trafoi), nel *Rumicetum alpini*, 2188 m, 27-VIII-1965; Tre Fontane Sante (Trafoi), 1600 m ca, 29-VI-1966.

TR: presso Rifugio Cevedale, nel *Festucetum halleri*, 2550-2600 m, 26-VIII-1962; Peio nella vegetazione steppica, 1600 m ca, 11-VIII-1962; Val Maleda, 26-VIII-1963.

In the Val di Sole (Trentino) *C. holosteoides* grows from 800 to1650 m on mowable meadows throughout the valley where it is common in the meadow associations *Melandrio-Arrhenatheretum* and *Trisetetum flavescentis (Arrhenatheretalia), Scirpetum sylvatici (Molinietalia)* and *Rumicetum alpini* (*Adenostyletalia*); already reported (sub *C. caespitosum*) for the Val di Sole (Pedrotti 1963).

TR: Claiano, nei prati falciabili, 1000 m ca, 30-VI-1960; Menas, nei prati falciabili, 1650 m, VI-1960; Dimaro, 800-850 m, VI-1960; Carciato, prati falciabili, 850 m, 29-VI-1960.

C. pedunculatum Gaudin

Alpine; 2450-2900 m; alpine belt; pioneer vegetation of silicate substrata *(Androsacetalia alpinae*).

TR: morene Vedretta Lamare, 2450-2500 m, 22-VIII-1962; verso Passo Cavaion sopra bacino del Careser (Peio), 2800-2900 m, 11-IX-1962.

C. uniflorum Clairv.

Alpine-carpatic; 2100-3100 m; subalpine and alpine belts; pioneer vegetation of silicatic (*Androsacetalia alpinae*) and carbonatic (*Thaspietalia rotundifolii*) substrata.

AA: Val Martello, parete rocciosa sotto Rifugio Corsi, 2100-2220 m, 21-VIII-1964; verso Passo di Saent (Val Martello), 3000 m, 26-VIII-1964; Rifugio Tabaretta (Solda), 2555 m, 8-VIII-1965; Val Peder (Val Martello), 2780 m, 23-VIII-1964; ghiaioni calcarei fra Monte Muta e Monte Marlet, 2550 m, 9-VIII-1965; morene Vedretta Marlet (Solda), 2350 m, 8-VIII-1965; Passo Madriccio (Solda), 3124 m, 28-VIII-1964; Val Madriccio (Val Martello), 28-VIII-1964; morene Vedretta Saent (Val Martello), 2580 m, 26-VIII-1964; Dosso Tabaretta (Solda), 2539 m, 11-VIII-1965; sotto Rifugio Tabaretta (Solda), 8-VIII-1965; verso Passo del Coston (Solda), 2600 m ca, 26-VIII-1965; cresta sotto Rifugio Payer, 2900-3000 m, 10-VIII-1965.

TR: Vallombrina (Val del Monte, Peio), 2350-2400 m, 10-VIII-1962; La Valletta (Val del Monte, Peio), 2400-2500 m, 10-VIII-1962; Pala della Donzella (Peio), 2600 m, 7-IX-1962; ghiaioni sopra Lago Corvo (Rabbi), 2900 m ca, 8-VIII-1964; verso Passo Cavaion, sopra bacino del Careser, 2800-2900 m, 11-IX-1962; Saentin (Rabbi), 2150 m, 13-VIII-1964; Dente del Vioz (Peio), 2850-2900 m, 4-IX-1962; Val Lamare, IX-1961; Giogo Nero (Rabbi), 2833 m, 10-VIII-1964.

Discussion

The *taxa* of *Cerastium* were grouped according to the following altitudinal belts: from the high hilly to the montane (*C. glutinosum, C. holosteoides, C. arvense* subsp. *strictum*, *C. fontanum*), from the montane to the subalpine (*C. arvense* subsp. *molle*, *C. fontanum, C. holosteoides*) and from the subalpine to the alpine (*C. arvense* subsp. *strictum, C. arvense* subsp. *molle, C. uniflorum, C. alpinum* subsp. *alpinum, C. cerastoides, C. pedunculatum*).

The *taxa* of the high hilly and montane belts are elements that gravitate in mediterranean environments (subpontic) and in montane western Europe, reaching the continent of Asia, while those of the subalpine and alpine belts are arctic-alpine or alpine elements.

Concerning the environment and the vegetational types where they grow, the alpine and subalpine belts host a pioneer vegetation belonging to the *Androsacetalia alpinae* and *Thlaspietalia rotundifolii* (*C. uniflorum*, *C. pedunculatum*) orders, that of the small nival valleys (*Salicetalia herbaceae*) (*C. cerastoides*) and that of various environments (moraines, soils rich in humus, etc.) (*C. alpinum* subsp.*a.*). In the montane and subalpine belts, some species are of the mesophile meadows (*Arrhenatheretalia* and *Nardetalia*) and of the megaforbs communities (*Adenostyletalia*) such as *C. holosteoides,* others of steppe meadows (*Festucetalia vallesiacae*) like *C. glutinosum.* Finally, a group of *taxa* grows in diversified environments such as alpine meadows, megaforbs communities, grassy slopes, gravel screes, moraines, pebbly riverbanks, larch groves, open spruce woods and Swiss stone pine stands (*C. fontanum*, *C. arvense* subsp. *strictum*, *C. arvense* subsp. *molle*).

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Plants and grazing: an evaluation of the effects on Sardinian endemic plants conservation

Abstract

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We analysed the relationship between the 302 endemic entities of the Sardinian flora and the free-ranging domestic herbivores. This study highlights that the presence of spines, toxic compounds, resins, aromas and the adaptation to specific habitats are very effective defense traits that concur to the conservation of these species. The presence and abundance of 45.4 % endemic entities of the Sardinian flora is not affected by grazing and browsing, while domestic herbivores promote the presence and abundance of 38.4 % of endemic entities by reducing other competing species such as pabular herbs and woody species. However, grazing and browsing may threaten 16.2 % of the endemic species. This study remarks the importance of the management of free-ranging domestic herbivores for effective conservation politics aiming to protect the endemic entities of the Sardinian flora.

Key words: life forms, traits, defense, domestic herbivores, Sardinia.

Introduction

The endemic species characterise the biological history of a given region. A comprehensive understanding of the vegetation dynamic successions and of the relationships between animal and plant is the basis for an effective policy for nature conservation. That relationship could be positive and synergic, as in the case of plant-pollinators, or negative, or controversial, as in the case of herbivores and endemic plants.

The Mediterranean ecosystems, as most ecosystems at global level, have been disturbed for at least three millennia by the presence of free-ranging domestic animals (Naveh 1974; Tomaselli 1976; Di Castri 1981; Camarda 1984; Dell & al. 1986; Camarda 1991, 1992).

Domestic herbivores, in particular, have a specific impact on natural and semi-natural ecosystems in relation to the rangeland management system (Le Houérou 1981). Animal husbandry in Sardinia has affected most of the land in several ways (Le Lannou 1941) that have significantly shaped the vegetation. In Sardinia, the remains of domestic herbivores (sheep, mouflon, goat, cattle) are documented since the Neolithic period in several caves and are becoming more abundant in the Bronze Age until our time (Wilkens 2012). Their introduction could have caused the extinction of some botanic species, although this should be verified by data of paleobotanical research. In Sardinia, studies on relationship between plants and domestic animals has been only partially investigated (Aru & al.1982; Camarda 1984, 1987, 1989, 1990; Farris & Filigheddu 2008; Farris & al. 2009; Pisanu & al. 2009; Farris & al. 2010; Pisanu & al. 2012) despite its importance to different ecosystems. In the present study we focus on the endemic species of Sardinia. The availability of specific studies for this plant group (Arrigoni & al. 1977-91; Arrigoni 2006-15) gives the possibility to estimate the impact of domestic herbivores in relation to the different farming systems and rangeland management (Pulina & al. 2011; Pulina & Biddau 2015), aiming to assess the actual influence of domestic herbivores on the Sardinian landscape (Ronchi & al. 2013) and on the conservation of plant resources.

Material and Methods

In the last few decades, some areas formerly characterised by the free-ranging of domestic herbivores has been converted to more modern farming systems with sheds and other facilities that include the availability of extra-farm feeds. Nevertheless, the free-ranging of domestic herbivores is still a very common farming system, and grazing and browsing animals (cows, goats, sheep, pigs, horses, donkeys) use natural plant resources available in the rangelands or locally at the farm. In the present study, we did not take into account the presence and the effects of wild fauna, such as wild boars, mouflons (widespread in much of Sardinia), deers (a wild population is present in SW Sardinia), and roe deers (introduced in many areas of the island), foxes, pine marten and other small mammals such as oak rats.

Plant defensive traits are represented by functional adaptations to the local environment and by specific defensive traits against herbivores. In many cases, the same trait can be both an environmental adaptation and a defensive trait. The habitat type, such as rock outcrops and cliffs may be completely inaccessible to domestic herbivores, thus constituting a shelter that can protect the full plant life cycle. Geophytism is a life form that represents a natural adaptation to fire but also an effective defense against grazing and browsing. Geophytes with bulbs in the deep soil layers can survive for some time also in the absence of seed production. The presence of rhizomes, the prostrate or trailing habit, the presence of spines or hairiness, the production of toxic compounds (alkaloids, latex) or repellents (resins, aromas and flavours) are all very important defensive traits. The production of a high number of seeds is also an important indirect defense mechanism. Several defense traits can be shared by a single species to produce an effective defensive syndrome that could provide a competitive advantage in rangelands.

We took into account the entities that have a range restricted to Sardinia (endemic in the narrow sense) and also those species whose range includes Corsica, Balearic Islands, Tuscany Archipelago and Sicily. In a limited number of cases, we considered also those species which might be present also in the Italian southern regions facing the Tyrrhenian see. We did not consider those species with a range that includes Africa and continental Europe.

Mostly all plant species, whenever available forage resources are scarce, could be browsed by domestic herbivores. All the endemic entities of *Fabaceae*, *Brassicaceae* and *Poaceae* are edible and are often browsed, despite their specific differences. Different parts of the same species might be browsed differently. Plant species with toxic or irritant latex are usually avoided or browsed only occasionally. Other endemic species have alkaloids or glycosides that might be toxic (*Helleborus argutifolius*), irritant (*Urtica atrovirens*) or repellent, as in the case of *Lamiaceae* (despite having an agreeable smell to men). Many other species, belonging to different families, have a very small size and therefore are neglected by herbivores. As already mentioned, geophytism with the presence of bulbs or rhizomes buried in the soil is a defensive trait against grazing and browsing. Prostrate and sub-fruticose (sub-shrubs) growth forms are tolerant to browsing as well, especially when spines or thorns are present. Endemic and rare species, or species with a punctiform range, are of course the most threatened by grazing and browsing.

Results

Table 1 lists 302 entities (species, subspecies, varieties) and their main traits such as life forms and growth forms, their distribution in Sardinia, pabularity (yes/no), defensive traits against browsing. In addition, for each entity, we estimated whether their presence and abundance is promoted or reduced by browsing and grazing (see Tab. 1 and the respective graphics in Fig. 1 and Fig. 2).

Life forms and growth forms

The biological form of plant species expresses the conditions of adaptation to the environmental conditions as an effective response during the adverse season to its survival and development of the aerial parts of each species. This is also an effective defense to grazing (Camarda 1989). Hemicriptophytes (38.4 %), are the most common life form among the 302 endemic entities and present a high number of buds protected in different ways at the ground level. This mechanism favors the plant survival over time, and could be enhanced by the plant's shape, as in the case of caespitose (43.7 % over the total) whose basal part remains are a further protection for the basal overwintering buds. Chamaephytes (36.1 %) are the second most common life form. Pulviniform (cushion-shaped) chamaephytes have often thorny branches (*Genista morisii, Berberis aetnensis*) or thorny leaves (*Astragalus terraccianoi, Centaurea horrida*) acting as a defensive barrier protecting the full life cycle. Pulviniform chamaephytes can be a shelter for many other species (*Polygala sinisica, Saponaria alsinoides, Lamium corsicum, Viola limbarae*). Hemicrtyptophytes / Chamaephytes such as many species of *Limonium,* have often only a reduced leaf system and very small woody branches. The defense system may be further enhanced by specie leaf properties, branches or root system defensive traits. Endemic geophytes with bulbs of rhizomes buried and protected by the soils are the 13.2 % of the total endemic species (e.g. *Colchicum gonarei, Crocus minimus,* *Aristolochia tyrrhena*). Therophytes are in general more exposed to herbivores, but for many of them the very small plant size (*Herniaria litardierii, Euphrasia genargentea, Veronica brevistyla*) or the very early cycle (before the presence of free-ranging animals in the mountain rangelands) or short life span are traits that allow them to be neglected by herbivores.

Habitat

The habitat type is a very important element to consider in relation to the conservation of the endemic species of the Sardinian flora. Some species are strictly casmophilous (*Ptychotis sardoa*, *Campanula forsythii, Cymbalaria muelleri, Limonium morisianum, Saxifraga cervicornis*), while other (*Brassica insularis, Centaurea filiformis, Psoralea morisiana*, *Barbarea rupicola, Lactuca longidentata, Seseli praecox)* are usually casmophilous but, if not disturbed by grazers, can thrive also at the bottom of rocks and cliffs.

Thorns

The presence of spines can only partly reduce the browsing of the species in the genus *Genista, Anthyllis, Astragalus,* while the seeds in the legumes of these species are very rich in starch and proteins. On the contrary, the large amount of spines on leaves, stems and inflorescences of *Ptilostemon casabonae* and *Dipsacus valsecchiae* constitutes the ultimate defense against browsing.

Toxicity

Some endemic species have high contents of alkaloids and glycosides (*Aquilegia* sp.pl., *Paeonia morisii, Arum pictum*) and, despite their rich shoot system, are completely avoided by domestic herbivores during the summer season. *Helleborus argutifolius* is always unpalatable, even when dry, due to the presence of spines on the leaves, and for the high content of alkaloids and glycosides that are toxic. *Ruta corsica* produces furocumarins that are very irritating (Ena & Camarda 1990). Other species (*Nepeta foliosa, Santolina insularis, Santolina corsica, Stachys glutinosa*) produce aromas that may be agreeable to men but that are often repellent for domestic herbivores. *Thymus catharinae* is a species very rich in essential oils and as a result it is browsed only during the late summer period when there is less availability of other more palatable species. In spite of the very dense shoot systems, *Vinca sardoa* is always neglected by herbivores having a high content of toxic alkaloids.

Rarity

Browsing and grazing can seriously threaten rare and very rare endemic species, and those species with a punctiform range (*Ribes sardoum, Rubus limbarae*). This could increase extinction risk and surely reduce population size. Browsing and grazing should always be taken into account in the assessment of the conservation status of endangered species.

Conclusions

The free range of domestic herbivores reduces the presence and abundance of woody and herbaceous edible species. At the same time this phenomen promotes the abundance of those endemic species which have defensive traits against browsing and grazing. This mechanism explains the local abundance of species such as *Paeonia morisii*, *Astragalus genargenteus*, *Aquilegia* sp.pl., *Helleborus argutifolius,* and *Ruta corsica* in areas strongly degraded by grazing, while being considered as rare species at Island level. Species lacking of defensive traits against browsing and grazing are in total 92 (30.5 %), mostly *Poaceae* (*Festuca morisiana, Festuca sardoa, Sesleria insularis*) but also belonging to other families (*Scorzonera callosa, Hypochoeris robertia, Astragalus maritimus, Astragalus verrucosus, Borago pygmaea, Borago morisiana, Echium anchusoides*). We list 156 (51.7 %) endemic species that can be browsed by domestic herbivores and 146 (48.3 %) species that do not elicit pabular interest or are completely avoided because of their very limited plant size or inaccessibility of the habitat. The presence and abundance of 137 (45.4 %) species is not affected by browsing and grazing, 116 (38.4 %) species are promoted by grazing; and only 49 (16.2 %) decrease because of the presence of domestic herbivores. Nevertheless, these relationships are influenced by the species of domestic herbivores, the number of grazing animals, the presence of wild fauna, which could favor the spread of some seeds or propagules. Other driving forces are the anthropic activities, the road network, the movement of soil or other substrata that could promote the local presence of species such as *Tanacetum audiberti, Dipsacus valsecchiae, Hieracium templare*, *Ptilostemon casabonae*. *Urtica atrovirens* thrives very well close to sheep farms, specifically in sites where there is a high content of organic matter.

The present study highlights the complexity of the exciting relationships between free-ranging domestic herbivores and the endemic entities of the Sardinian flora. The knowledge of these relationships is a fundamental basis for conservation politics and action aiming to protect endemic species in rangelands both in Sardinia and in the Mediterranean region.

Table 1. The table shows endemic species with their life forms and growth forms and attributes regards relationships between pabularity, defense types, kind of presence (com.=common; freq. = frequent; spor.=sporadic; punct.=punctiform; rare/ab.= rare but locally abundant; v.r. = very rare) and favorite by grazing (fav = favorite; unfav = unfavorite; ind = indifferent).

No.	**Family**	**Taxon**	**Life forms**	**Growth forms**	**Pabularity**	**Defense-types**	**Presence**	**Favorite or not by herbivores**
1	*Lamiaceae*	*Acinos sardous* (Asch. & Levier) Arrigoni	H	scap	no	arom	rare	fav
2	*Liliaceae*	*Allium parciflorum* Viv.	G	bulb	no	arom	com.	fav
3	*Liliaceae*	*Allium roseum* var. *insulare* Gennari	G	bulb	no	arom	com.	fav
4	*Brassicaceae*	*Alyssum tavolarae* Briquet	Ch	caesp	no	hab	rare	ind
5	*Boraginaceae*	*Anchusa capellii* Moris	H	caesp	yes	no	rare	ind
6	*Boraginaceae*	*Anchusa crispa* Viv.	H	caesp	no	no	rare	ind
7	*Boraginaceae*	*Anchusa maritima* Valsecchi	T	caesp	no	no	rare	ind
8	*Boraginaceae*	*Anchusa formosa* Selvi, Bigazzi & Bacchetta	H	caesp	yes	no	punct.	unfav
9	*Boraginaceae*	*Anchusa littorea* Moris	H	caesp	no	no	rare	unfav
10	*Boraginaceae*	*Anchusa montelinasana* Angius, Pontecorvo & Selvi	H	caesp	yes	no	rare	unfav
11	*Boraginaceae*	*Anchusa sardoa* (Illario) Selvi & Bigazzi	H	prost	yes	no	v.r.	ind
12	*Fabaceae*	*Anthyllis hermanniae* subsp. *ichnusae* Brullo & Giusso	Ch	pulv	no	spin	rare	ind
13	*Ranunculaceae*	*Aquilegia barbaricina* Arrigoni & Nardi	H	scap	no	tox	punct.	ind
14	*Ranunculaceae*	*Aquilegia nugorensis* Arrigoni & Nardi	H	scap	no	tox	punct.	ind

Table 1. continued.

No.	Family	Taxon	Life forms	Growth forms	Pabularity	Defense-types	Presence	Favorite or not by herbivores
15	*Ranunculaceae*	*Aquilegia nuragica* Arrigoni & Nardi	H	scap	no	tox	punct.	ind
16	*Caryophyllaceae*	*Arenaria balearica* L	H	rept	no	hab	freq.	ind
17	*Aristolochiaceae*	*Aristolochia tyrrhena* Nardi & Arrigoni	G	rhiz	no	tox	rare	fav
18	*Plumbaginaceae*	*Armeria morisii* Boiss. in A. DC.	H	caesp	yes	hab	rare	fav
19	*Plumbaginaceae*	*Armeria sardoa* subsp. *genargentea* Arrigoni	H	caesp	yes	hab	v.r.	fav
20	*Plumbaginaceae*	*Armeria sardoa* Sprengel subsp. *sardoa*	H	caesp	yes	hab	rare	fav
21	*Plumbaginaceae*	*Armeria sulcitana* Arrigoni	H	caesp	yes	hab	v.r.	fav
22	*Asteraceae*	*Artemisia variabilis* Ten.	Ch	caesp	no	arom	rare	fav
23	*Asteraceae*	*Artemisia corensis* Vals. & Filigh.	Ch	caesp	no	arom	rare	fav
24	*Asteraceae*	*Artemisia densiflora* Viv.	Ch	caesp	no	arom	v.r.	fav
25	*Araceae*	*Arum pictum* L. fil.	G	rhiz	no	tox	com.	fav
26	*Rubiaceae*	*Asperula deficiens* Viv.	H	rept	no	hab	punct.	ind
27	*Rubiaceae*	*Asperula pumila* Moris	H	caesp	no	hab	v.r.	ind
28	*Fabaceae*	*Astragalus genargenteus* Moris subsp. *genargenteus*	Ch	pulv	yes	spin	rare/ab.	fav
29	*Fabaceae*	*Astragalus genargenteus* subsp. *gennarii* (Bacchetta & Brullo) Arrigoni	Ch	pulv	yes	spin	rare	fav
30	*Fabaceae*	*Astragalus rnaritimus* Moris	H	scap	yes	spin	punct.	fav
31	*Fabaceae*	*Astragalus terraccianoi* Valsecchi	Ch	pulv	yes	spin	rare	fav
32	*Fabaceae*	*Astragalus thermensis* Valsecchi	Ch	pulv	yes	spin	punct.	fav
33	*Fabaceae*	*Astragalus verrucosus* Moris	T	scap	yes	no	rare	unfav
34	*Brassicaceae*	*Barbarea rupicola* Moris	H	scap	yes	hab	spor.	unfav
35	*Asteraceae*	*Bellium bellidioides* L.	H	rept	yes	hab	com.	ind
36	*Asteraceae*	*Bellium crassifolium* Moris	H	ros	yes	hab	rare	unfav
37	*Berberidaceae*	*Berberis aetnensis* C. B. Presl	Ch	caesp	no	spin	rare	fav
38	*Brassiceae*	*Biscutella morisiana* Raffaelli	T	scap	yes	no	rare	unfav
39	*Boraginaceae*	*Borago morisiana* Bigazzi & Ricceri	H	scap	yes	no	spor.	unfav
40	*Boraginaceae*	*Borago pygmaea* (DC.) Chater & Greuter	H	scap	yes	no	spor.	unfav
41	*Brassicaceae*	*Brassica insularis* Moris	Ch	suff	yes	hab	rare	unfav
42	*Brassicaceae*	*Brassica thyrrhena* Giotta, Piccitto & Arrigoni	Ch	suff	yes	hab	com.	unfav
43	*Cucurbitacea*	*Bryonia marmorata* Petit	G	lian	no	hab	com.	unfav
44	*Boraginaceae*	*Buglossoides minima* (Moris) R. Fernandes	T	scap	yes	no	rare	fav
45	*Asteraceae*	*Buphthalmum inuloides* Moris	Ch	caesp	yes	arom	rare	fav
46	*Amiryllidaceae*	*Narcissus supramontanus* Arrigoni	G	bulb	no	tox	rare/ab.	fav
47	*Amiryllidaceae*	*Narcissus supramontanus* subsp. *cunicalarius*	G	bulb	no	tox	rare	fav
48	*Lamiaceae*	*Calamintha sandaliotica* Bacchetta & Brullo	H	scap	yes	arom	spor.	ind
49	*Campanulaceae*	*Campanula forsythii* (Arcangeli) Podlech	H	caesp	yes	hab	rare	ind
50	*Asteraceae*	*Carduus corymbosus* Ten.	H	scap	yes	spin	com.	fav
51	*Asteraceae*	*Carduus fasciculiflorus* Viv.	H	scap	yes	spin	rare	fav
52	*Asteraceae*	*Carduus sardous* DC.	T	scap	yes	spin	rare	fav
53	*Cyperaceae*	*Carex caryophyllea* subsp. *insularis* (Christ ex Barbey) Arrigoni	H	caesp	yes	no	rare	unfav
54	*Cyperaceae*	*Carex microcarpa* Bertol. ex Moris	H	caesp	yes	spin	rare	fav
55	*Cyperaceae*	*Carex panormitana* Guss.	H	scap	no	spin	v.r.	fav
56	*Asteraceae*	*Carlina macrocephala* Moris	Ch	scap	yes	spin	punct.	fav
57	*Asteraceae*	*Centaurea corensis* Filigheddu & Valsecchi	Ch	suff	yes	arom	rare	fav
58	*Asteraceae*	*Centaurea filiformis* subsp. *ferulacea* (Martelli) Arrigoni	Ch	suff	yes	hab	rare	ind
59	*Asteraceae*	*Centaurea filiformis* Viv. subsp. *filiformis*	Ch	caesp	yes	hab	rare	ind
60	*Asteraceae*	*Centaurea horrida* Bad.	Ch	pulv	yes	spin	rare/ab.	unfav
61	*Asteraceae*	*Centaurea magistrorum* Arrigoni & Camarda	Ch	pulv	no	arom	v.r.	fav
62	*Valerianaceae*	*Centranthus amazonum* Friedlender	H	scap	yes	hab	punct.	unfav
63	*Dipsacaceae*	*Cephalaria bigazzii* Bacchetta, Brullo & Giusso del Galdo	Ch	scap	yes	hab	rare	ind
64	*Dipsacaceae*	*Cephalaria mediterranea* (Viv.) Szabò	Ch	scap	no	hab	rare	ind
65	*Caryophyllaceae*	*Cerastium palustre* Moris	T	scap	yes	no	rare	fav
66	*Caryophyllaceae*	*Cerastium supramontanum* Arrigoni	H	caesp	yes	hab	rare	fav
67	*Colchicaceae*	*Colchicum actupii* Fridl.	G	bulb	yes	tox	rare	fav
68	*Colchicaceae*	*Colchicum gonarei* Camarda	G	bulb	yes	tox	rare	fav
69	*Colchicaceae*	*Colchicum verlaqueae* Fridl.	G	bulb	yes	tox	rare	fav
70	*Iridaceae*	*Crocus minimus* DC. in Rédouté	G	bulb	no	hab	com.	fav
71	*Scrophulariaceae*	*Cymbalaria aequitriloba* (Viv.) A. Chevalier	H	rept	yes	hab	rare	ind
72	*Scrophulariaceae*	*Cymbalaria muelleri* (Moris) A. Chevalier	H	caesp	no	hab	v.r.	ind
73	*Ranunculaceae*	*Delphinium longipes* Moris	H	scap	no	tox	rare	fav
74	*Ranunculaceae*	*Delphinium pictum* Willd.	H	scap	no	tox	rare	fav
75	*Caryophyllaceae*	*Dianthus siculus* subsp. *cyatophorus* (Moris) Arrigoni	Ch	caesp	yes	hab	rare	fav
76	*Caryophyllaceae*	*Dianthus siculus* subsp. *morisianus* (Valsecchi) Arrigoni	Ch	caesp	yes	no	rare	fav
77	*Caryophyllaceae*	*Dianthus siculus* subsp. *mossanus* (Bacchetta & Brullo) Arrigoni	Ch	caesp	yes	hab	rare	fav
78	*Caryophyllaceae*	*Dianthus siculus* subsp. *stellaris* (Camarda) Arrigoni	Ch	caesp	yes	hab	rare	fav
79	*Caryophyllaceae*	*Dianthus siculus* subsp. *tenuifolius* (Moris) Arrigoni	Ch	caesp	no	hab	rare	fav
80	*Dipsacaceae*	*Dipsacus ferox* Loisel.	H	scap	no	spin	rare	fav
81	*Dipsacaceae*	*Dipsacus valsecchiae* Camarda	H	scap	no	spin	rare	fav
82	*Araceae*	*Dracunculus muscivorus* (L. fil.) Parlatore	G	scap	no	tox	rare	fav
83	*Boraginaceae*	*Echium anchusoides* Bacchetta, Brullo & Selvi	H	rept	yes	no	rare	unfav
84	*Geraniaceae*	*Erodium corsicum* Léman in Lam. & DC.	H	rept	yes	hab	com.	fav
85	*Geraniaceae*	*Erodium nervulosum* L'Hér.	H	prost	yes	hab	rare	ind
86	*Euphorbiaceae*	*Euphorbia cupanii* Guss. ex Bertol.	T	caesp	no	tox	punct.	fav
87	*Euphorbiaceae*	*Euphorbia insularis* Boiss.	H	caesp	no	tox	rare	fav
88	*Euphorbiaceae*	*Euphorbia meuselii* Mazzola & Raimondo	H	caesp	no	tox	spor.	fav

Table 1. continued.

No.	Family	Taxon	Life forms	Growth forms	Pabularity	Defense-types	Presence	Favorite or not by herbivores
89	*Euphorbiaceae*	*Euphorbia semiperfoliata* Viv.	T	caesp	no	tox	rare	fav
90	*Scrophulariaceae*	*Euphrasia genargentea* (Feoli) Diana	T	scap	no	no	rare	fav
91	*Asteraceae*	*Evax rotundata* Moris	H	scap	no	no	spor.	ind
92	*Apiaceae*	*Ferula arrigonii* Bocchieri	H	scap	no	tox	rare	fav
93	*Poaceae*	*Festuca morisiana* Parl.	H	caesp	yes	no	rare	fav
94	*Poaceae*	*Festuca sardoa* (Hackel in Barbey) Richter	H	caesp	yes	no	rare/ab.	fav
95	*Rubiaceae*	*Galium corsicum* Sprengel	H	prost	yes	hab	rare	fav
96	*Rubiaceae*	*Galium glaucophyllum* E.Schmid	H	prost	yes	hab	rare	fav
97	*Rubiaceae*	*Galium schmidii* Arrigoni	T	prost	no	hab	rare	fav
98	*Fabaceae*	*Genista aetnensis* (Biv.) DC.	P	scap	yes	spin	com.	unfav
99	*Fabaceae*	*Genista arbusensis* Valsecchi	Ch	caesp	no	spin	com.	fav
100	*Fabaceae*	*Genista bocchierii* Bacchetta, Brullo & Feoli Chiapella	Ch	caesp	no	spin	rare	fav
101	*Fabaceae*	*Genista cadasonensis* Valsecchi	Ch	caesp	no	spin	com.	fav
102	*Fabaceae*	*Genista corsica* (Loisel.) DC. in Lam. & DC.	Ch	caesp	no	spin	com.	fav
103	*Fabaceae*	*Genista desoleana* Valsecchi	Ch	caesp	no	spin	com.	fav
104	*Fabaceae*	*Genista ephedroides* DC.	P	caesp	no	spin	rare	fav
105	*Fabaceae*	*Genista insularis* Bacchetta, Brullo & Feoli Chiapella	Ch	caesp	no	spin	rare	fav
106	*Fabaceae*	*Genista insularis* subsp. *fodinae* Bacchetta, Brullo & al.	Ch	caesp	no	spin	rare	fav
107	*Fabaceae*	*Genista ovina* Bacchetta, Brullo & Feoli Chiapella	Ch	caesp	no	spin	com.	fav
108	*Fabaceae*	*Genista morisii* Colla	Ch	caesp	no	spin	com.	fav
109	*Fabaceae*	*Genista pichi-sermolliana* Valsecchi	P	caesp	no	spin	com.	fav
110	*Fabaceae*	*Genista salzmannii* DC.	Ch	caesp	no	spin	rare	fav
111	*Fabaceae*	*Genista sardoa* Valsecchi	Ch	caesp	no	spin	rare	fav
112	*Fabaceae*	*Genista sulcitana* Valsecchi	Ch	caesp	no	spin	rare	fav
113	*Fabaceae*	*Genista toluensis* Valsecchi	Ch	caesp	no	spin	rare	fav
114	*Lamiaceae*	*Glechoma sardoa* (Bég.) Bég.	Ch	caesp	yes	hab	rare	ind
115	*Cistaceae*	*Helianthemum allionii* Tineo	Ch	caesp	yes	hab	rare	unfav
116	*Cistaceae*	*Helianthemum morisianum* Bertol.	Ch	caesp	yes	hab	rare	unfav
117	*Asteraceae*	*Castroviejoa montelinasana* E.Schmid	Ch	caesp	yes	hab	rare	ind
118	*Asteraceae*	*Helichrysum saxatile* Moris	Ch	caesp	yes	hab	rare	ind
119	*Asteraceae*	*Helichrysum saxatile* subsp. *morisianum* Bacchetta & al.	H	caesp	no	hab	spor.	fav
120	*Ranunculaceae*	*Helleborus argutifolius* Viv.	H	caesp	no	tox	rare	fav
121	*Caryophyllaceae*	*Herniaria litardierei* (Gamis.) Greuter & Burdet	H	scap	yes	no	rare	fav
122	*Asteraceae*	*Hieracium gallurense* Arrigoni	H	scap	yes	no	rare	unfav
123	*Asteraceae*	*Hieracium iolai* Arrigoni	H	scap	yes	no	rare	ind
124	*Asteraceae*	*Hieracium irginianum* Arrigoni	H	scap	yes	no	rare	ind
125	*Asteraceae*	*Hieracium limbarae* Arrigoni	H	scap	yes	no	rare	unfav
126	*Asteraceae*	*Hieracium martellianum* (Zahn) Arrigoni	H	scap	yes	no	rare	ind
127	*Asteraceae*	*Hieracium oliastrae* Arrigoni	H	scap	yes	no	rare	ind
128	*Asteraceae*	*Hieracium soleirolianum* Arv. Touv. & Briquet	H	scap	yes	no	rare	ind
129	*Asteraceae*	*Hieracium supramontanum* Arrigoni	H	scap	yes	hab	rare	ind
130	*Asteraceae*	*Hieracium templare* Arrigoni	H	scap	yes	no	com.	unfav
131	*Asteraceae*	*Hieracium zizianum* subsp. *sardonium* Zahn	H	scap	yes	no	com.	unfav
132	*Hypericaceae*	*Hypericum annulatum* Moris	Ch	caesp	no	tox	rare	fav
133	*Hypericaceae*	*Hypericum hircinum* L. subsp. *hircinum*	P	caesp	yes	tox	com.	ind
134	*Asteraceae*	*Hypochaeris linearifolia* Moris	H	caesp	yes	hab	rare	unfav
135	*Brassicaceae*	*Iberis integerrima* Moris	H	prost	yes	no	rare	unfav
136	*Asteraceae*	*Lactuca longidentata* Moris	H	scap	yes	hab	rare	unfav
137	*Lamiaceae*	*Lamium corsicum* Godr. & Gren.	H	caesp	yes	hab	rare	fav
138	*Asteraceae*	*Lamyropsis microcephala* (Moris) Dittrich & Greuter	H	caesp	yes	spin	v.r.	ind
139	*Malvaceae*	*Lavatera plazzae* Atzei	H	caesp	yes	no	rare	unfav
140	*Malvaceae*	Lavatera *triloba* subsp. *pallescens* (Moris) Nyman	P	scap	yes	no	rare	unfav
141	*Amaryllidaceae*	*Leucojum roseum* Martin	G	bulb	no	no	rare/ab.	fav
142	*Plumbaginaceae*	*Limonium acutifolium* subsp. *cornusianum* (Arrigoni & Diana) Arrigoni	Ch	caesp	no	hab	rare	ind
143	*Plumbaginaceae*	*Limonium acutifolium* subsp. *obtusifolium* (Rouy) Diana	Ch	caesp	no	hab	rare	ind
144	*Plumbaginaceae*	*Limonium acutifolium* subsp. *acutifolium*	Ch	caesp	no	hab	rare	ind
145	*Plumbaginaceae*	*Limonium acutifolium* subsp. *bosanum* (Arrigoni & Diana) Arrigoni	Ch	caesp	no	hab	rare	ind
146	*Plumbaginaceae*	*Limonium acutifolium* subsp. *nymphaeum* (Erben) Arrigoni	Ch	caesp	no	hab	rare	ind
147	*Plumbaginaceae*	*Limonium acutifolium* subsp. *tenuifolium* (Bertol.ex Moris) Arrigoni	Ch	caesp	no	hab	rare	ind
148	*Plumbaginaceae*	*Limonium acutifolium* subsp. *tharrosianum* (Arrigoni & Diana) Arrigoni	Ch	caesp	no	hab	rare	ind
149	*Plumbaginaceae*	*Limonium ampuriense* Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
150	*Plumbaginaceae*	*Limonium angustifolium* (Tausch) Degen	Ch	caesp	no	hab	rare	ind
151	*Plumbaginaceae*	*Limonium articulatum* (Loisel.) O.Kuntze	Ch	caesp	no	hab	punct.	ind
152	*Plumbaginaceae*	*Limonium capitis-eliae* Erben	Ch	caesp	no	hab	rare	ind
153	*Plumbaginaceae*	*Limonium capitis-marci* Arrigoni & Diana	Ch	caesp	no	hab	punct.	ind
154	*Plumbaginaceae*	*Limonium carisae* Erben	Ch	caesp	no	hab	rare	ind
155	*Plumbaginaceae*	*Limonium contortirameum* (Mabille) Erben	Ch	caesp	no	hab	freq.	ind
156	*Plumbaginaceae*	*Limonium coralliforme* Mayer	Ch	caesp	no	hab	rare	ind
157	*Plumbaginaceae*	*Limonium cornusianum* Arrigonl & Diana	Ch	caesp	no	hab	rare	ind
158	*Plumbaginaceae*	*Limonium cunicularium* Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
159	*Plumbaginaceae*	*Limonium dictyocladum* (Boiss. in A. DC.) O. Kuntze	Ch	caesp	no	hab	rare	ind
160	*Plumbaginaceae*	*Limonium dubium* (Andr. ex Guss.) R. Lit.	Ch	caesp	no	hab	rare	ind
161	*Plumbaginaceae*	*Limonium gallurense* Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
162	*Plumbaginaceae*	*Limonium glomeratum* (Tausch) Erben	Ch	caesp	no	hab	freq.	ind

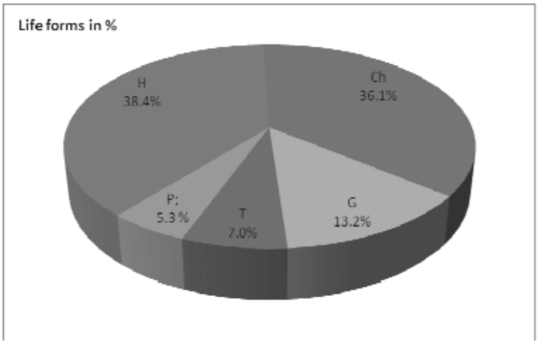
Table 1. continued.

No.	Family	Taxon	Life forms	Growth forms	Pabularity	Defense-types	Presence	Favorite or not by herbivores
163	*Plumbaginaceae*	*Limonium hermaeum* (Pignatti) Pignatti	Ch	caesp	no	hab	rare	ind
164	*Plumbaginaceae*	*Limonium insulare* (Bég. & Landi) Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
165	*Plumbaginaceae*	*Limonium laetum* (Nyman) Pignatti	Ch	caesp	no	hab	v.r.	ind
166	*Plumbaginaceae*	*Limonium lausianum* Pignatti	Ch	caesp	no	hab	punct.	ind
167	*Plumbaginaceae*	*Limonium malfatanicum* Erben	Ch	caesp	no	hab	rare	ind
168	*Plumbaginaceae*	*Limonium merxmuelleri* subsp. *oristanum* (Mayer) Arrigoni	Ch	caesp	no	hab	freq.	ind
169	*Plumbaginaceae*	*Limonium merxmuelleri* subsp. *sulcitanum* (Arrigoni) Arrigoni	Ch	caesp	no	hab	rare	ind
170	*Plumbaginaceae*	*Limonium merxmuelleri* subsp. *tigulianum* (Arrigoni & Diana) Arrigoni	Ch	caesp	no	hab	rare	ind
171	*Plumbaginaceae*	*Limonium merxmuelleri* Erben subsp. *merxmuelleri*	Ch	caesp	no	hab	spor.	ind
172	*Plumbaginaceae*	*Limonium morisianum* Arrigoni	Ch	caesp	no	hab	punct.	ind
173	*Plumbaginaceae*	*Limonium multifurcatum* Erben	Ch	caesp	no	hab	rare	ind
174	*Plumbaginaceae*	*Limonium protohermaeum* Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
175	*Plumbaginaceae*	*Limonium pseudolaetum* Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
176	*Plumbaginaceae*	*Limonium pulviniforme* Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
177	*Plumbaginaceae*	*Limonium racemosum* (Lojac.) Diana	Ch	caesp	no	hab	rare	ind
178	*Plumbaginaceae*	*Limonium retirameum* susp. *calaritanum* (Erben) Arrigoni	Ch	caesp	no	hab	rare	ind
179	*Plumbaginaceae*	*Limonium retirameum* Greuter & Burdet subsp. *retirameum*	Ch	caesp	no	hab	rare	ind
180	*Plumbaginaceae*	*Limonium strictissimum* (Salzmann) Arrigoni	Ch	caesp	no	hab	punct.	ind
181	*Plumbaginaceae*	*Limonium tibulatium* Pignatti	Ch	caesp	no	hab	punct.	ind
182	*Plumbaginaceae*	*Limonium tigulianum* Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
183	*Plumbaginaceae*	*Limonium tyrrhenicum* Arrigoni & Diana	Ch	caesp	no	hab	rare	ind
184	*Plumbaginaceae*	*Limonium ursanum* Erben	Ch	caesp	no	hab	rare	ind
185	*Scrophulariaceae*	*Limonium viniolae* Arrigoni & Diana	Ch	caesp	no	hab	v.r.	ind
186	*Scrophulariaceae*	*Linaria arcusangeli* Atzei & Camarda	Ch	caesp	yes	hab	rare	unfav
187	*Scrophulariaceae*	*Linaria flava* subsp. *sardoa* (Sommier) Arrigoni	T	scap	yes	hab	rare	ind
188	*Linaceae*	*Linum muelleri* Moris	T	scap	yes	no	rare	ind
189	*Caprifoliaceae*	*Lonicera cyrenaica* Viv.	P	lian	yes	hab	rare	unfav
190	*Cyperaceae*	*Luzula italica* Parl.	H	scand	yes	no	rare	unfav
191	*Lamiaceae*	*Mentha insularis* Requien	H	rept	no	arom	rare	ind
192	*Fabaceae*	*Mentha requienii* Benth.	H	caesp	no	arom	rare	ind
193	*Euphorbiaceae*	*Mercurialis corsica* Cosson	Ch	caesp	no	tox	v.r.	fav
194	*Lamiaceae*	*Micromeria cordata* (Moris ex Bertol.) Moris	H	caesp	no	hab	rare	ind
195	*Lamiaceae*	*Micromeria filiformis* (Aiton) Bentham	T	prost	yes	hab	rare	ind
196	*Brassicaceae*	*Morisia monantha* (Viv.) Ascherson ex Barbey	H	ros	yes	no	rare	unfav
197	*Boraginaceae*	*Myosotis soleirolii* Godr. in Gren. & Godr.	H	scap	no	hab	rare	ind
198	*Asteraceae*	*Nananthea perpusilla* (Loisel.) DC.	H	prost	no	hab	rare	fav
199	*Lamiaceae*	*Nepeta foliosa* Moris	Ch	caesp	no	arom	rare	fav
200	*Scrophulariaceae*	*Odontites corsicus* (Loisel.) G. Don	T	scap	yes	no	rare	fav
201	*Apiaceae*	*Oenanthe lisae* Moris	H	caesp	yes	no	rare	unfav
202	*Orchidaceae*	*Ophrys × domus-maria* Grasso	G	bulb	yes	no	rare	ind
203	*Orchidaceae*	*Ophrys × laconensis* Scrugli & Grasso nsubsp. *laconensis*	G	bulb	yes	no	rare	ind
204	*Orchidaceae*	*Ophrys × maremmae* nsubsp. *woodii* Corrias	G	bulb	yes	no	rare	ind
205	*Orchidaceae*	*Ophrys annae* Devillers-Tersch.	G	bulb	yes	no	rare	ind
206	*Orchidaceae*	*Ophrys chestermanii* (Wood) Golz & Reinhard	G	bulb	yes	no	rare	ind
207	*Orchidaceae*	*Ophrys scolopax* subsp. *conradiae* (Melki & Deschâtres) Baumann & al.	G	bulb	yes	no	rare	ind
208	*Orchidaceae*	*Ophrys eleonorae* Devillers-Tersch. & Devillers	G	bulb	yes	no	rare	ind
209	*Orchidaceae*	*Ophrys morisii* (Martelli) Soò in Keller & al.	G	bulb	yes	no	rare	ind
210	*Orchidaceae*	*Ophrys holoserica* subsp. *chestermanii* J.J. Wood	G	bulb	yes	no	rare	ind
211	*Orchidaceae*	*Ophrys morisii* (Martelli) Soo in Keller & al.	G	bulb	yes	no	rare	ind
212	*Orchidaceae*	*Ophrys panattensis* Scrugli, Cogoni & Pessei	G	bulb	yes	no	rare	ind
213	*Orchidaceae*	*Ophrys scolopax* ssp. *sardoa* Baumann & al.	G	bulb	yes	no	rare	ind
214	*Orchidaceae*	*Ophrys sphegodes* Miller subsp. *praecox* Corrias	G	bulb	yes	no	rare	ind
215	*Orchidaceae*	*Orchis × penzigiana* ssp. *sardoa* Scrugli & Grasso	G	bulb	yes	no	rare	ind
216	*Orchidaceae*	*Orchis brancifortii* Biv.-Bern.	G	bulb	yes	no	rare	ind
217	*Liliaceae*	*Orchis mascula* subsp. *ichnusae* Corrias	G	bulb	yes	no	rare	ind
218	*Liliaceae*	*Ornithogalum corsicum* Jordan	G	par	no	no	rare	fav
219	*Orobanchaceae*	*Orobanche denudata* Moris	G	par	no	no	com.	ind
220	*Orobanchaceae*	*Orobanche australis* Moris	G	par	no	no	v.r.	ind
221	*Orobanchaceae*	*Orobanche litorea* Guss.	G	par	no	no	rare	ind
222	*Orobanchaceae*	*Orobanche rigens* Loisel.	G	par	no	no	com.	fav
223	*Paeoniaceae*	*Paeonia morisii* Cesca, Bernardo & Passalacqua	G	scap	no	tox	com.	fav
224	*Amaryllidaceae*	*Pancratium illyricum* L.	G	bulb	yes	tox	com.	fav
225	*Poaceae*	*Phalaris rotgesii* (Husnot) Baldini	T	caesp	yes	no	v.r.	unfav
226	*Poaceae*	*Phleum sardoum* (Hackel) Hackel in Franchet	T	caesp	yes	hab	v.r.	ind
227	*Pinaceae*	*Pinus pinaster* ssp. *hamiltonii* (Ten.) H. Del Villar	P	scap	yes	res	rare	ind
228	*Asteraceae*	*Plagius flosculosus* (L.) Alavi & Heywood	H	caesp	yes	no	rare	unfav
229	*Plantaginaceae*	*Plantago sarda* C. Presl	Ch	caesp	yes	no	rare	fav
230	*Poaceae*	*Poa balbisi* Parl.	H	scap	yes	no	spor.	fav
231	*Polygalaceae*	*Polygala sardoa* Chodat	H	scap	yes	pulv	v.r.	ind
232	*Polygalaceae*	*Polygala sinisica* Arrigoni	Ch	scap	yes	pulv	freq.	ind
233	*Polygonaceae*	*Polygonum scoparium* Réq. ex Loisel.	Ch	caesp	yes	tox	rare	ind
234	*Rosaceae*	*Potentilla caulescens* subsp. *nebrodensis* (Strobl ex Zimm.) Arrigoni	H	rept	yes	hab	rare	unfav
235	*Rosaceae*	*Potentilla crassinervia* Viv.	H	rept	yes	no	rare	unfav
236	*Rosaceae*	*Potentilla corsica* Soleir. ex Lehman	Ch	rept	yes	no	spor.	unfav

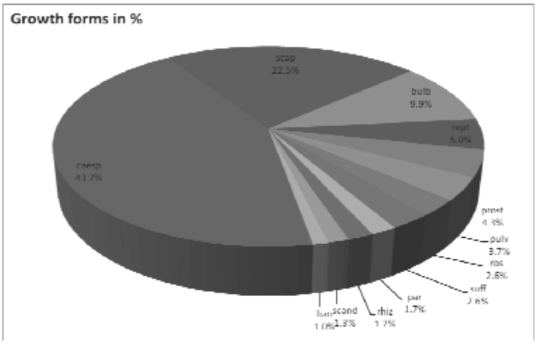
Table 1. continued.

No.	Family	Taxon	Life forms	Growth forms	Pabularity	Defense-types	Presence	Favorite or not by herbivores
236	*Rosaceae*	*Potentilla corsica* Soleir. ex Lehman	Ch	rept	yes	no	spor.	unfav
237	*Fabaceae*	*Psoralea morisiana* Pignatti & Metlesics	Ch	caesp	no	hab	spor.	unfav
238	*Asteraceae*	*Ptilostemon casabonae* (L.) Greuter	H	scap	no	spin	rare	ind
239	*Apiaceae*	*Ptychotis sardoa* Pignatti & Metlesics	H	scap	no	arom	rare	ind
240	*Ranunculaceae*	*Ranunculus cordiger* Viviani subsp. *cordiger*	H	ros	yes	no	rare	ind
241	*Ranunculaceae*	*Ranunculus cordiger* subsp. *diffusus* (Moris) Arrigoni	H	ros	yes	no	rare	ind
242	*Ranunculaceae*	*Ranunculus cymbalarifolius* Balbis ex Moris	H	ros	yes	no	rare	ind
243	*Rhamnaceae*	*Rhamnus persicifolia* Moris	P	caesp	yes	no	rare	unfav
244	*Saxifragaceae*	*Ribes sandalioticum* (Arrigoni) Arrigoni	P	caesp	yes	no	punct.	unfav
245	*Saxifragaceae*	*Ribes sardoum* Martelli	P	caesp	yes	no	v.r.	unfav
246	*Asteraceae*	*Hypochoeris robertia* Fiori	H	ros	no	hab	com.	unfav
247	*Iridaceae*	*Romulea requienii* Parl.	G	bulb	no	no	rare	fav
248	*Iridaceae*	*Romulea revelieri* Jord. & Fourr.	G	bulb	yes	no	rare	fav
249	*Rubiaceae*	*Rubia requienii* Duby	P	lian	yes	spin	punct.	fav
250	*Rosaceae*	*Rubus arrigonii* Camarda	P	suff	yes	spin	punct.	unfav
251	*Rosaceae*	*Rubus laconensis* Camarda	P	suff	yes	spin	punct.	unfav
252	*Rosaceae*	*Rubus pignatti* Camarda	P	suff	yes	spin	punct.	unfav
253	*Rosaceae*	*Rubus limbarae* Camarda	P	suff	yes	spin	punct.	unfav
254	*Polygonaceae*	*Rumex suffocatus* Moris ex Bertol.	H	ros	no	no	rare	fav
255	*Rutaceae*	*Ruta corsica* DC.	Ch	caesp	no	tox	rare	fav
256	*Caryophyllaceae*	*Sagina pilifera* (DC.) Fenzl	H	pulv	yes	no	rare	fav
257	*Salicaceae*	*Salix arrigonii* Brullo	P	scap	yes	no	com.	ind
258	*Lamiaceae*	*Salvia desoleana* Atzei & Picci	Ch	caesp	no	arom	v.r.	ind
259	*Asteraceae*	*Santolina corsica* Jord. & Fourr.	Ch	caesp	no	arom	com.	fav
260	*Asteraceae*	*Santolina insularis* (Gennari ex Fiori) Arrigoni	Ch	caesp	yes	arom	rare	fav
261	*Caryophyllaceae*	*Saponaria alsinoides* (Viv.) Viv.	H	*scand*	yes	*hab*	rare	*fav*
262	*Saxifragaceae*	*Saxifraga cervicornis* Viv.	H	caesp	no	hab	rare	ind
263	*Saxifragaceae*	*Saxifraga corsica* (Ser. ex Duby) Gren. & Godron	H	scap	yes	hab	rare	ind
264	*Hyacinthaceae*	*Scilla corsica* Boullu	G	bulb	no	no	rare	fav
265	*Caryophyllaceae*	*Scleranthus burnatii* Briquet	H	prost	yes	no	spor.	fav
266	*Asteraceae*	*Scorzonera callosa* Moris	H	ros	no	no	spor.	ind
267	*Scrophulariaceae*	*Scrophularia morisii* Valsecchi	H	scap	yes	tox	rare	fav
268	*Scrophulariaceae*	*Scrophularia oblongifolia* Loisel.	H	rhiz	no	tox	rare	fav
269	*Scrophulariaceae*	*Scrophularia trifoliata* L.	H	scap	no	tox	freq.	fav
270	*Crassulaceae*	*Sedum villosum* subsp. *glandulosum* (Moris) P. Fourn.	H	caesp	no	hab	spor.	ind
271	*Orchidaceae*	*Serapias nurrica* Corrias	G	bulb	yes	no	com.	ind
272	*Apiaceae*	*Seseli praecox* (Gamisans) Gamisans	Ch	caesp	yes	hab	rare	ind
273	*Poaceae*	*Sesleria insularis* subsp. *barbaricina* Arrigoni	H	caesp	yes	no	rare	fav
274	*Poaceae*	*Sesleria insularis* subsp. *morisiana* Arrigoni	H	scap	yes	no	rare	fav
275	*Poaceae*	*Sesleria insularis* Sommier subsp. *insularis*	H	scap	yes	no	rare	fav
276	*Caryophyllaceae*	*Silene beguinotii* Vals.	H	rhiz	yes	no	rare	ind
277	*Caryophyllaceae*	*Silene corsica* DC.	H	rhiz	yes	hab	rare	ind
278	*Caryophyllaceae*	*Silene martinolii* Bocchieri & Mulas	T	scap	yes	hab	rare	ind
279	*Caryophyllaceae*	*Silene morisiana* Bég. & Ravano	H	prost	yes	hab	rare	ind
280	*Caryophyllaceae*	*Silene nodulosa* Viv.	H	prost	yes	hab	rare	ind
281	*Caryophyllaceae*	*Silene nummica* Vals.	H	prost	yes	hab	rare	ind
282	*Caryophyllaceae*	*Silene sanctae-therasiae* Jeanmonod	Ch	scap	yes	no	punct.	unfav
283	*Caryophyllaceae*	*Silene valsecchiae* Bocchieri	Ch	scap	no	no	v.r.	ind
284	*Caryophyllaceae*	*Silene velutina* Pourret ex Loisel.	Ch	caesp	no	hab	v.r.	ind
285	*Urticaceae*	*Soleirolia soleirolii* (Réq.) Dandy	H	rept	no	hab	v.r.	ind
286	*Caryophyllaceae*	*Solenopsis minuta* ssp. *corsica* Meikle	H	rept	no	hab	rare	ind
287	*Caryophyllaceae*	*Spergularia macrorhiza* (Réq. ex Loisel.) Heynh.	Ch	rept	no	hab	com.	ind
288	*Lamiaceae*	*Stachys corsica* Pers.	H	rept	yes	hab	com.	ind
289	*Lamiaceae*	*Stachys glutinosa* L.	Ch	pulv	yes	arom	punct.	fav
290	*Lamiaceae*	*Stachys salisii* Jord. & Fourr.	H	rept	no	no	rare	ind
291	*Asteraceae*	*Tanacetum audiberti* (Requien) DC.	H	caesp	no	arom	rare	fav
292	*Lamiaceae*	*Teucrium subspinosum* Pourret ex Willd.	Ch	pulv	no	arom	rare	fav
293	*Santalaceae*	*Thesium italicum* DC.	T	prost	yes	no	rare	ind
294	*Brassicaceae*	*Thlaspi brevistylum* Jordan	T	scap	yes	no	com.	ind
295	*Lamiaceae*	*Thymus catharinae* Camarda	Ch	pulv	yes	arom	com.	fav
296	*Poaceae*	*Trisetaria gracilis* (Moris) Banfi & Arrigoni	H	caesp	no	no	spor.	unfav
297	*Urticaceae*	*Urtica atrovirens* Réq. ex Loisel.	H	scap	no	spin	spor.	fav
298	*Scrophulariaceae*	*Verbascum conocarpum* Moris	H	scap	no	tox	rare	fav
299	*Scrophulariaceae*	*Verbascum plantagineum* Moris	T	scap	yes	tox	rare	fav
300	*Scrophulariaceae*	*Veronica brevistyla* Moris in Moris & De Notaris	T	scap	no	no	spor.	fav
301	*Apocynaceae*	*Vinca sardoa* (Stearn) Pignatti	H	scand	no	tox	rare	fav
302	*Violaceae*	*Viola limbarae* (Merxm. & Lippert) Arrigoni	H	scand	yes	hab	rare	fav

Life forms	No.	%
H	116	38.4
Ch	109	36.1
G	40	13.2
T	21	7.0
P	16	5.3
total	302	100.0



Growth forms	No.	%
caesp	132	43.7
scap	68	22.5
bulb	30	9.9
rept	15	5.0
prost	13	4.3
pulv	11	3.7
ros	8	2.6
suff	8	2.6
par	5	1.7
rhiz	5	1.7
scand	4	1.3
lian	3	1.0
total	302	100.0



Presence	No.	%
rare	197	65.2
common	32	10.6
pointform	24	7.9
very rare	21	7.0
sporadic	17	5.6
frequent	6	2.0
rare but l. a.	5	1.7
total	302	100.0

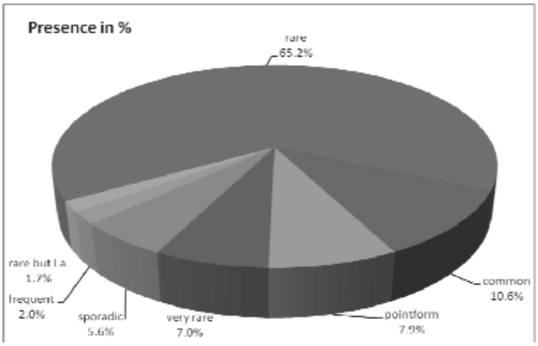
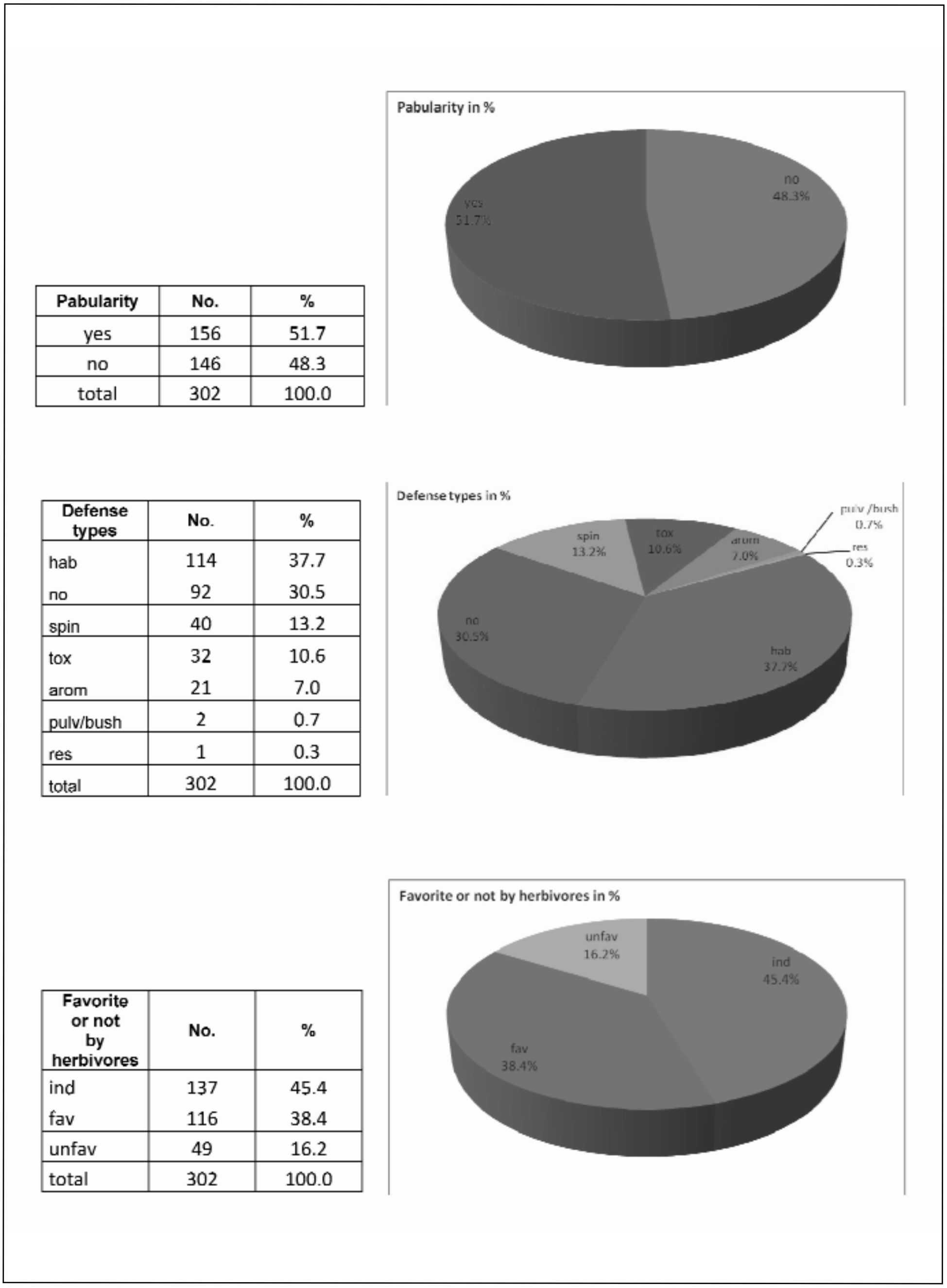


Fig. 1. Tables and related Pie charts expressed in % of the life forms, growth forms and their kind of presence. Abbreviations for Life forms: H = Hemicryptophyte, Ch = Chamaephyte, G = Geophyte, T = Therophyte, P = Phanerophyte.(rare but l. a. = rare but locally abundant). Abbreviations for Growth forms: caesp = cespitose, scap = scapose, bulb = bulbous, rept = reptant, prost = prostate, pulv = pulvinate, ros = rosulate, suff = suffruticose, par = parassite, rhiz = rhizomatous, scand = scandent, lian = lianas. Abbreviations for Presence: rare but l. a. = rare but locally abundant.



Pabularity	No.	%
yes	156	51.7
no	146	48.3
total	302	100.0

Defense types	No.	%
hab	114	37.7
no	92	30.5
spin	40	13.2
tox	32	10.6
arom	21	7.0
pulv/bush	2	0.7
res	1	0.3
total	302	100.0

Favorite or not by herbivores	No.	%
ind	137	45.4
fav	116	38.4
unfav	49	16.2
total	302	100.0

Fig. 2. Tables and relatives Pie charts expressed in % of the pabularity, defense-types and favorite by grazing. Abbreviations for Defense types: hab = habitus, spin = spinescent, tox = toxic, arom = aromatic, pulv/bush = pulvinate/bush, res = resinous. Abbreviations for Favorite or not by herbivores: ind = indifferent, fav = favorite, unfav = unfavorite.

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Mohamed Fennane & Mohamed Rejdali

The world largest cork oak Maamora forest: challenges and the way ahead

Abstract

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A potential area of around 300.000 hectares of cork oak trees, that turned nowadays to a low density tree cover of less than 50.000 hectares, with a very disturbed or even absent climax environment. This is the case of the world largest cork oak Maamora forest located at the Moroccan Atlantic plain between Rabat and Kenitra cities.
Research programs and scientific articles related to this magnificent forest are various and dealt with all its aspects: ecologic, floristic, faunistic, socio-economic, cultural, etc.
The future of the Maamora forest, however, causes much concern despite the many initiatives and lots of efforts made to protect, conserve and rehabilitate its ecosystems. Both decision makers and managers failed to refrain this rapid regression and decline of this forest caused mostly by heavy and anarchic human pressure. The authors of this paper try to present an outcome of the situation and presume that nature by itself and through fencing might be the appropriate way to meet the challenge.
The current paper is a synthetic review of some of the work done about Maamora forest and the initiatives made to safeguard this green heritage.

Key words: *Quercus suber*, conservation, ecological equilibrium, N Africa.

Introduction

The Maamora forest plain is known to be the world largest cork oak stand that played and is still playing great ecological, socio-economic and political roles in Morocco. It has been subject to much research works, and its biological and ecological aspects are quiet well known.

The Maamora is particular with its history, some of its ecological aspects and contradictory dynamics of which the effects are negatively very heavy.

Its permanence has always been since the beginning of the last century of great concern to many Scientists and managers as well as for decision makers.

In this paper we are dealing with the essential characteristics of this unique ecosystem with a critical review to the human behaviour approaches in relation with its exploitation, management and protection. A call for a greater attention on the risks of impoverishment of the biodiversity of this peculiar ecosistem has been presented by Rejdali & al. (2013) on the occasion of the XIV OPTIMA meeting held in Palermo in Semptember 2013.

Historical view

The occurrence of the cork oak on Moroccan Atlantic plain goes back to millions of years as shown by the pollen diagrams of three different sites: Oualidia, south west of El Jadida (Ballouche 1986), Mehdia, north east Rabat (Reille 1978), Krimda, north east Larache (Damblon 1991).

In Mehdia, the closer site to Maamora, *Quercus suber* L. pollen first appeared 6400 years b.p. (before present). This confirms Emberger's (1939) point of view who estimates that Maamora covers a potential area of around 300.000 hectares.

Concretely, the extent of the Maamora forest as delimited at the beginning of the last century was nearly 135.000 ha. Boudy (1958), author of this figure, talks about a stand of a fine growing and regularly rigorous enough forest without any alarming symptoms for the permanence. This status, generally satisfactory, is due to the insecure atmosphere that prevailed over centuries because of rivalries between tribes besides of its being a place of reference for rebels and looters. Even great sultans with their armed convey could not go through it. They always travel around the wood during their travels throughout the kingdom.

During the twentieth century to date, Maamora forest has played vital and great ecological, social and economic roles. Unfortunately, due to man abuse, the cork oak forest regressed quantitatively and qualitatively (status of population and individuals).

Nowadays, we witness a distressing landscape with large degraded areas (Fig.1). The forest, formerly uninhabited and dangerous for man, counts now around 300.000 residents

Fig. 1. General view of Maamora south est of Kenitra city (Google earth image 2015)

(Aafi 2007) and receives each week (except during rain periods) till 30.000 visitors and 5.000 cars: townsmen in search of relaxing and recreation spaces.

Main ecological and floristic aspects

Physical environment

The Maamora forest stretches over a vast low plateau (< 300 m of altitude) weakly rolling in its western part, and slightly furrowed in the eastern part. The soils are of varied thickness, almost everywhere sandy, laying on a more or less thick layer made up of stoneware clay or clayey sands locally rich in pisolites (reddish or blackish concretions of iron oxide and manganese). In depth, the geological substrate is shaped with Tortonian gray marl and clays of Miocene. It is worth mentioning, the presence of hydromorphic soils in dayas where cork oak is obviously absent as is the case of all other wood species.

From a climatic point of view, the Maamora receives an average of 300 to 500mm of rain fall per year spread over sixty days mainly of winter. Dry period covers at least five months (May to September) and meets high temperatures ; the average maximum in July and August is around 35° c.

Thus, we witness a semi-arid to sub-humid climate in west and north west. Occult precipitations (fog and dew) are common and important extra water for cork oak which takes benefit from the water table retained by the impermeable clay substrate.

Vegetation cover

We can simply say that the overall area of the Maamora plain is divided into four vegetation types of various importance: cork oak, scrub with wild olive and lentisc, coastal juniper forest and dayas vegetation.

Table 1. Areas covered by cork oak and other woody species (in hectares) in the Maamora.

	According to Naggar (2014), Figures of 2008	According to Aafi (2007)
Quercus suber	70 383	58 396
Eucalyptus sp. pl.	40 938	60 621
Acacia sp. pl.	2 523	
Pinus sp. pl.	9 442	5 686
others	8 472	
empty		7350
Total	131 758	132 053

In terms of surface, these natural areas are gradually and continuously losing space for the benefit of fully artificialised areas, wood plantation: eucalyptus, acacia, pin (Tab. 1); cereal , vegetable crops and fruit trees.

Cork Oak

It occupies nowadays the western part of the initial area. The more humid atmosphere and the sandy nature of the soil made here the ecosystem resilience more important than in the eastern part (drier and hard substrates) where the cork oak has completely disappeared.

The overall appearance is fairly homogeneous, dominated by two tree species: *Quercus suber* L. of highly varied density and a local endemic *Pyrus mamorensis* Trab. as isolated trees. The shrub element is typically rich in species *Teline linifolia* (L.) Webb & Berth*., Thymelaea lythroides* Barratte & Murb*., Phillyrea latifolia* L*., Halimium halimifolium* (L.) Willk*., Cistus salviifolius* L*., Lavandula stoechas* L*., Stauracanthus boivinii* (Webb) Samp*., Stauracanthus genistoides* (Brot.) Samp*., Daphne gnidium* L. and *Chamaerops humilis* L. which is becoming rarer and rarer. An important characteristic of the Cork oak of Maamora, that has negative influence on its natural renewal, is the palatabilty of its fruits, particularly sweet, that makes it demanded by animals and humans as food.

According to Aafi (2007), the dense cork oak forest (more than 200 trees/ha) covers only 4110 ha against 16 665 ha for the medium density (100-200 trees/ha) and 37 621 for open forest (less than 100 trees/ha).

Wild olive and Lentisc matorral

This vegetation type is spread in the oriental part, less humid on hard substrates. It has regressed a lot and anyway nowadays cork oak is completely absent. Matorral bunches of *Olea europaea* subsp. *oleaster* (Hoffm. & Link) Negodi*, Pistacia lensiscus* L*., Phillyrea latifolia* L., *Rhus pentaphylla* (Jacq.) Desf. etc. are current indicators.

Red coastal juniper wood land

This community occupies the coastal sand dunes where red juniper takes advantage and is more resistant to salt spray (salty sea water particles carried by the wind) and indifferent to the calcareous soil nature unlike cork oak. The Mehdia biological reserve gives a beautiful example of the juniper forest in good condition thanks to the protection provided by fencing for decades.

Dayas vegetation

Dayas are wet depressions more or less wide spread, with shallow temporary rainfall waters. These are asylvatic areas where grow low herbaceous species, floristically rich where flourish *Ranunculus aquatilis* L*., Panicum repens* L*., Illecebrum verticillatum* L*., Lemna gibba* L*., L. minor* L., *Eleocharis palustris* (L.) Roem. & Schult., *Isoetes* sp. pl., etc.

Flora

The Maamora counts many vascular species. More than the half are therophytes. According to Villemant & Titolet (1997), there are 750. Aafi (2007) noted that there are 408 specific and infra specific taxa, belonging to 261 genera and 62 families. We can still find 30 national endemic species and some peculiarities like *Maytenus senegalensis* (Lam.)

Exell and *Lotus benoistii* (Maire) Lassen (= *Benedictella benoistii* Maire), that are species with tropical affinities. Of peculiar interest for its relations with the cultivated species is *Cynara humilis* L.

The Maamora is rich with its cryptogamic flora which is not yet well studied and known regardless of some largely exploited species like truffle (*Terfezia* sp. pl.), lichen (*Parmelia* sp. pl. and *Cladonia* sp. pl.) and edible and poisonous mushrooms. Fungal biodiversity, by its own, counts 719 species according to Assfouri (2006) to whom this figure is too small below reality considering the many new data he could get in short time with little means.

Of interest, althought in severe regression, is also the bryophyte compound, in particular with some species of *Riccia*.

Alarming dynamic regression

The Maamora witnesses a very dramatic regression leading to the loss of hundreds of acres. An administration report (in Ghaioule & al. 2007) talks about an average loss of 1600 ha/year between 1955 and 2000. The causes of this disaster are divers and all in direct or indirect relation with man's behaviour.

Abusive exploitation of forest products

Timber and non-timber products extracted from the Maamora are numerous. However, apart from cork, the main regularly exploited product, the extraction of the other resources is done in anarchic and abusive ways as done to wood, charcoal, tannin, aromatic and medicinal plants, edible mushrooms thrashing and acorn harvesting (15000 tones per year according to Naggar 2014) etc.

Overgrazing *(Tab. 2)*

Overgrazing and the excessive acorns harvesting make it impossible for cork oak forest to regenerate naturally. Pastoral capacity is of 6,4 unit/year (UPB unites petit bétail) (Laaribya & al 2014). While the real optimum capacity balance is of 1.5 UPB. This means that capacity is four times higher than the ecosystem productivity.

Forest clearing and plantations

Forest clearing process is getting faster with human settlement. According to Aafi (2007) 300 settelments (douars) are set. Today, it is easy to see through Google Earth the extent of the cork oak surfaces that has been completely eliminated and replaced by houses, rangelands, cereal crops and vegetables and fruit trees.

Table 2. Evolution of the number of livestock in the Maamora.

	Boudy 1958 (figures 1955)	Laaribya & al. 2014
Ovins	104 800	173 000
Bovins	48 300	52 000
Total	153 100	225 000

Natural pests

The following fauna harmfull species are the most known: Gypsy Moth (*Limantria dispar*), lepidopteran defoliator; Great Capricorn (*Cerambix cerdo*), xylophagous beetle; Ant Cork (*Crematogaster scutellaris*), hymenoptera, burrows into cork; Cylindrical Platycarpe (*Platypus cylindrus*), xylophagous beetle; Gate-wood (*Cossus cossus*), lepidoptera, xylophagous.

There are also other species namely the xylophagous, but it should be noted that these devastating species are dangerous only for trees and stands in bad conditions as is well known in the world. Within the Maamora, many researchers and foresters have noted that in the royal reserve of Ain Johra, where the forest were in good condition, cork oak has never been devastated by the Gypsy moth.

Groundwater pumping

Water need for human use and agricultural activities is rapidly growing. The exploitation of the water table, being regular or not, becomes a current practice despite all its ecological dangers. This water table, the essential water supply to cork oak, is nowadays in danger. Fraval & Villemant (1997) noted "the water table of Maamora declines with an average of about 10 cm/year during the last 35 years."

Recreation area, peri-urban forest

The Maamora has been for decades a recreation and entertainment area for the inhabitants of the neighbouring cities (Rabat, Salé, Kenitra, Tiflet and Khemisset) even though the adequate accommodation for welcoming visitors without harm to the forest is not available (Fig. 2). The Maamora forest receives around 30 000 visitors and 5 000 cars per week.

Fig. 2. Wild pic-nic in the heart of Maamora forest.

Forest management and protection

The geographical situation and the socio-economical and political importance made the Maamora the first forest in Morocco to be managed by the Forest Department settled in the beginning of the last century. According to Piuyo (2012), the main efforts of French foresters, right from the beginning of the protectorate, were focused on the submission of the cork oak forest and its management to the state property since these woodlands were able to provide products highly needed by the French Metropolis.

Over the six last decades, Maamora was subject to three development plans (1951-71, 1972-92 and 1992-2012) of which the main aims are the exploitation, regeneration and protection of cork oak and artificial reforestation. The last project "Projet de rehabilitation de la Maamora" for the period 2005-2014 was with a global amount of 280 million dirhams (Naggar 2014) (about 25 million euros). A new management plan for the next decade (2015-2024) is being set.

Efforts of protection and conservation are shown by promoting natural regeneration by means of fencing which remains possible if the degradation is not too advanced.

The results of restocking by seeds or seedlings from nursery products are encouraging. Nevertheless, the appropriate areas concerned remain smaller than the one planted with exotic species namely *Eucalyptus* (formerly intended to supply Sidi Yahia plant pulp factory closed in 2012), *Pinus* and *Acacia* (Tab. 1)

Conclusion: What future for Maamora?

The status quo of the Maamora, of which we tried to present a precise and concise summary, is catastrophic. This forest is old, ecologically fragile and easy to reach. It has been victim of "its generosity" with the multiple services offered to man. Its disappearance seems to be ineluctable despite efforts and initiatives at its favour.

There is an infinite number of projects, programmes, meetings, credits, and expertise on it. The manager is helpless in front the dynamic process of regression. In spite of all this, there is yet a known solution. It consists of helping nature working by itself to repair damages. Everybody knows that natural regeneration is possible in the respected fences and that cork oak resists well to animal pests when the ecosystem is not fragile.

Why this solution has not been adopted ?

To our opinion, there are three answers :

1) The natural progressive dynamic needs time while the administration and the local want short time tangible results
2) The natural progressive dynamic needs decrease and halt of the anthropozone pressure. However, this complicated problem goes beyond providing vital needs for the Maamora inhabitants. It is used to satisfy the needs of citizens other than its inhabitants. For example half of the livestock belongs to citizens from the neighbouring cities.
3) Lack of courage and imagination. The issue is still dealt with traditional actions: projects, expertises, reports, seminars, and meetings. Tarrier & Delacre (2007) describe the situation in harsh terms "The Maamora lying near Rabat, its universities and administrations, the most amphigoric projects are wide emerging from either idealistic and respectable researchers in their wide naïvity, "we could be", or

> project makers and sustainable management lobbyist "doers" who find in their desperate cases subsidies in foreign and innocent funding donors because, nowadays there are, by the side of the sick ecosystems of the whole world project makers and fairground showmen. It is one, amongst others, of the contemporary tartufferies and it works! At least for them."

Finally, it is worth to be reminded that a few centuries ago, our ancestors of the city of Salé complained the elephant of Maamora that spoiled gardens and crops. Our hope today is to avoid to see, tomorrow, our descendants struggling with moving sands coming from the same Maamora.

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Barbara Manachini & Franco Palla

What does happen when an insect pest follows its host plant and viceversa?

Abstract

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Invasive species are usually well known but only make up a small percentage of the European's alien plants and insects. The ways these exotic species interact with our natural and cultural heritage are very complex and even some species considered invasive had and could have positive aspects on some European landscape and culture. A close look at the complicated relationship between non-native and native plants and insects in the Mediterranean areas reveals some unexpected twists in the story. Here are some cases of when aliens can threaten our cultural heritage or being part of it.

Key words: alien invasive species, cultural heritage, landscape, natural heritage, silkworms, rice.

The roots of the problem

Italian's cultural and natural heritages are under invasion. Since the earliest days of European trade and colonization, forest, woodland, artworks and ecosystems and more in general heritage have fallen victim to introductions of exotic insects, disease causing agents, plants and animals. The primary reasons for this invasion is human movements and trade. Different settlers in past and in more time brought with seeds and plants from different lands. New seeds, plants or transformed products were sometimes contaminated with seeds of other plants, pathogens, insects or nematodes. Some of these new organisms became established and spread over large areas, displacing the native flora and/or fauna (Andaloro & al. 2009). Some introduced organisms also escaped cultivation and displaced native species. Insects and disease causing organisms arrived on plants, imported logs, packing materials. They established themselves on native hosts that did not co-evolve with these agents. In the absence of natural enemies to regulate their numbers, they became widespread and damaging. Some invasive species have been with us for so many years that we have almost forgotten their origins. Today, the rate of introduction of invasive species is higher than ever, due to a global community with increased world trade and a highly mobile human population capable of traveling to the far corners of the world in high-speed aircraft in a matter of hours. The effects of human activities on the world ecosystems and on the landscape are pervasive. Historical approaches are increasingly used to better understand the structure and function of contemporary ecosystems and landscapes that have been affected by human activities for centuries or even millennia (Swetnam & al. 1999). The introduction of alien species was accidental, causing a lot of damages including loss of biodiversity (Elton 1958) but also was deliberated to growth species that could improve food, feed and fibber supplies (Hoyt 1992), as the case of the plant imported in Europe before the 1492 (approximately considered 1500) and named Archeophyta. Some of them became even the symbol of the landscape as the case of as the *Cupressus sempervirens* L. that is now the landmark of Tuscany (Fig. 1) (Guarrera 2006) or the case of palm trees, probably brought by Arabian, that is the symbol of the cultural heritage of Sicily (Italy) (Manachini & al. 2012, 2013). For the same region other exotic plants are Sicilian Flags like several species of Citrus (Calabrese 2004) and the prickly pears (Raimondo & al. 2005 a, 2005b). There are exotic species that draw the landscape also in the north of Italy as the case *Oryza sativa* (Cerina & al. 2007; Bao-Rong & al. 2007). Since its introduction rice has become more and more important not only as food but also in culinary, in poetry, music, fine arts and in the cultural heritage (Bao-Rong & al. 2007; Cerina & al. 2007).

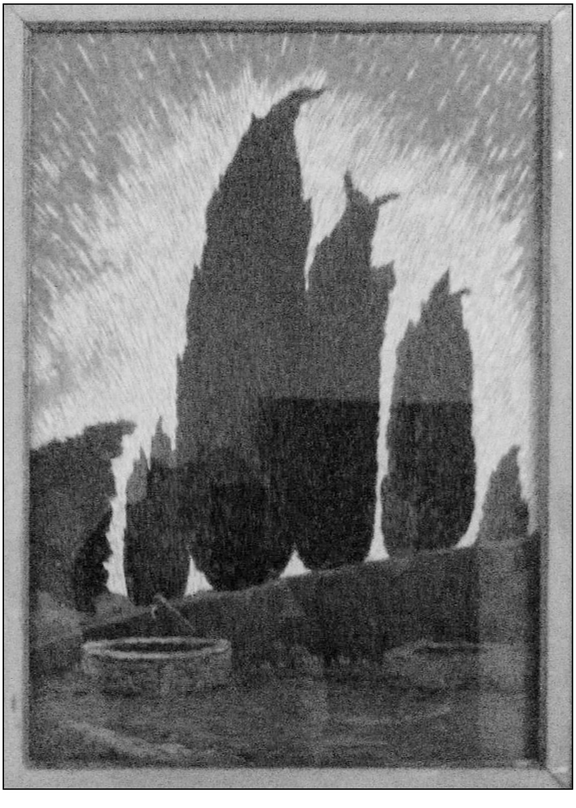

Fig. 1. Benvenuto Benvenuti in “ I cipressi” shows how *Cupressus sempervirens* L.is now a landmark of Tuscany.

Many of these exotic species were introduced to supply new production or for ornamental reasons and they were particularly welcome in the new environment as they did not have pests and pathogens that could affect them and decrease the yield or the quality (Manachini & al. 2013). However with the globalization the opportunity for the pests to meet again its host become more and more higher. There are many example of how the pests of the introduced archaeophyta were introduced in the new territory and meet again their native hosts. Some time they can even prefer the new host species that they have never met before. This is the case of the Red Palm Weevil (RPW, *Rhynchophorous ferrugineus*, *Coleoptera: Curculionidae*), which was not a host of the palm species *Phoenix canariensis;* however in the new introduced area (Mediterranean area) RPW prefers the new host rather than the Date palms (Fig. 2). The introduction of these insects has dramatically changed the landscape and the aesthetic of historical squares and boulevard (Longo & al. 2008; Giovino & al. 2009; Manachini & al. 2013). Although it is interesting to notice that in Australia and in New Zealand the *P. canariens* is considered an alien invasive species accidentally introduced in 2001.

Changes in the landscape could happen also in the rice landscape due to the Alien invasive insect Rice Water Weevil (RWW *Lissorhoptrus oryzophilus*). RWW is native of the United States, where the beetle reproduces sexually. In Italy the insect was first detected in 2004 in Ticino Park. Since then, only parthenogenetic female were found in our country (Lupi & al. 2007). As rice arrived in USA (South Carolina), in 1694 (Cerina & al. 2007; West 2007), its native hosts were different species than *O. sativa*, mainly monocots herbaceous plants as *Poaceae* and *Cyperaceae* weeds. However since this insect has been associated with rice from the time the crop had been introduced in the United States, where it is now the primary pest of the culture. To contrast this pest a part of chemical pesticides the other management control practices is to growth rice (e.g. some varieties) without water puddles. Consequently the famous "waterland" landscape will change in a normal grass-field (Lu Bao-Rong & Manachini 2007).

Well known is also the case of the phylloxera. This small, sap-eating, greenish insect, *Daktulosphaira vitifoliae,* closely related to the aphid, is a worldwide pest of commercial grapevines. It is originally native to eastern North America and was accidentally introduced in Europe in1860. In the late 19th century the phylloxera epidemy destroyed most of the vineyards for wine grapes in France, in Italy and in several countries of Europe. The first report of phylloxera in Italy was near the Lake of Como, but the regions struck hardest were Sicily and Calabria. In 1885 the *New York Times* reported that the Italian Consul estimated lost wages in Sicily over thirty million dollars ('Phylloxera Ravages Italy'). How the *Phylloxera* was introduced to Europe remains debated: American vines had been taken to Europe many times before, for reasons including experimentation and trials in grafting, without consideration of the possibility of the introduction of pestilence. Italy, along with many other European countries, enacted a temporary ban on plants that might carry the phylloxera into their vineyards. Vineyards found infected early on were burned at the expense of the state in order to slow the spread (Ordish 1972). Netherless there were many riots as the destruction of vineyards lead to loss employment.

Because phylloxera is native to North America, the native grape species are at least partially resistant. By contrast on *Vitis vinifera* L., it causes deformations on roots and secondary fungal infections can girdle roots, and gradually cut off the flow of nutrients and water to the vine. At significant amount of research was devoted in the late 19th century to finding a solution to the phylloxera problem, and two French wine growers, suggested the possibility that if *V. vinifera* vines could be combined, by means of grafting, with the aphid-resistant American vines, then the problem might be solved (Pastena 1990). Once grafting was accepted as a solution the ban on imported vines was lifted in order to supply Italian vineyards with resistant rootstocks subsidized by the Italian government (Cocco 1907). There is still no remedy, as such, for the *Phylloxera*, or the disease it brings with it, and it still poses a substantial threat to any vineyard not planted with grafted rootstock. In fact only few European varieties are resistant to *Phylloxera*.

When the insect meets a new host

The briefcase of RPW previously reported is just an example of the complexity of the phenomena (Manachini & al. 2012) and the possibility of a phytophagous to shift versus a new plant host species. RPW became pest of related species of palm trees of the *Arecaceae* but in other case the phytophagous can even attack plant that has not relative species in the new area or that are phylogenetically really far. *P. canariensis* is the most suitable host of Red Palm Weevil in the Mediterranean countries has never met this insect pest before the human trade of palm trees (Fig. 2).

The more emblematic example is the relationship among the maize and the lepidopteran pest *Ostrinia nubilalis* (*Lepidoptera*: *Crambidae*).

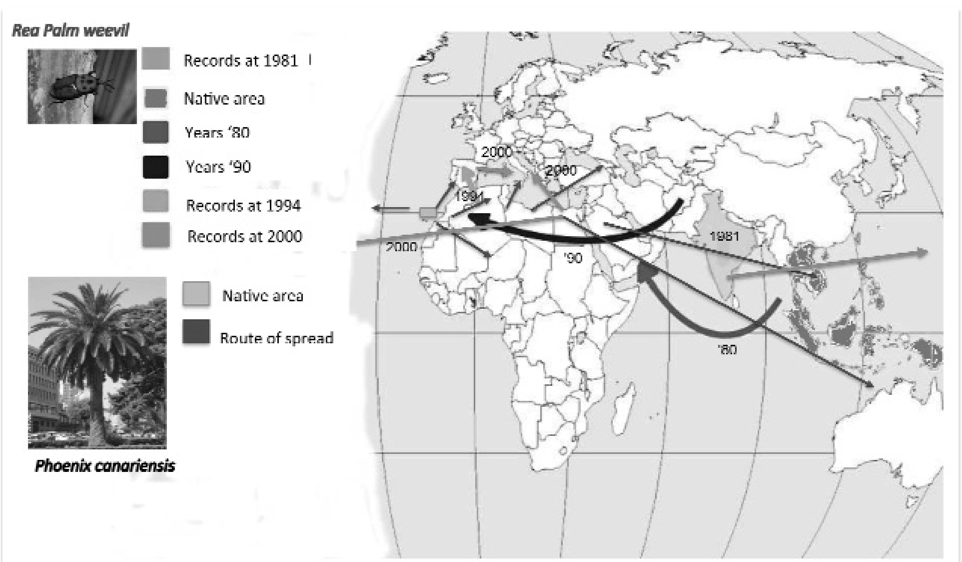

Fig. 2. Schematic view of the native areas and routes of spread of *Phoneix canariensis* and invasion routes of its new pest the coleopteran *Rhynchophorous ferrugineus*.

After European contact with the Americas in the late 15th and early 16th centuries, explorers and traders carried maize back to Europe and introduced it to other countries. Maize spread to the rest of the world because of its ability to grow in diverse climates. *Polenta*, made in the North of Italy is one of the typical recipes and was the major food available during the II World War.

O. nubilalis is the key pest of maize, being native to Europe is known as European corn borer (EBC). It is a pest of grain, but it shows a highly polyphagia. Before the introduction of *Zea mays* in Europe, ECB presumably ate on several herbaceous plants e.g, millet. The ECB was first reported in North America in 1917, but it was probably introduced from Europe several years earlier. Since its initial discovery in the Americas, the insect has spread even into Canada and many other regions becoming the major pest of corn. But ECB was found infesting also the *Oryza sativa*, *Artemisia* sp., *Humulus lupulus* L. and more than 200 plants can serve as hosts. The susceptibility of maize to the ECB and the resulting large crop losses, which are estimated at a billion dollars worldwide, led to the development of transgenic organisms, expressing the *Bacillus thuringiensis* subsp. *kurstaki* entomotoxin. "Bt maize" is widely grown in the United States and has been approved for release in other countries (Manachini 2006). Figure 3 gives a schematic view of the complex relationship among *Zea mays* - *Ostrinia nubilalis* and human trades. All these relationship have drastically changed not only the environment and the landscape, but also the our cultural heritage and culinary recipes!

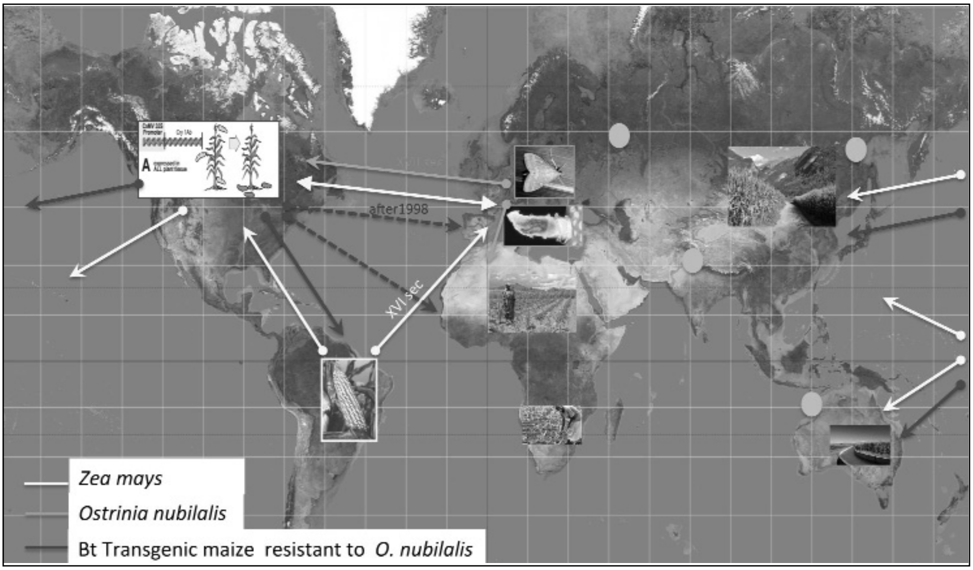

Fig. 3. Schematic view of the complex relationship among *Zea mays* - *Ostrinia nubilalis* and human trades.

When the plant follows the insect

Ailanthus altissima is an invasive species in Italy, where was imported in 1760 (Raimondo & al. 2014). It is a deciduous tree in the *Simaroubaceae* family. It is both native in northeast and central China, as well as Taiwan. The tree has been grown extensively both in China and abroad as a host plant for the ailanthus silkmoth, (*Phylosamia cynthia*) used for silk production. It is a saturniid moth, used to produce silk fabric but not as domesticated as the silkworm. The silk is extremely durable, but cannot be easily reeled off the cocoon and is thus spun like cotton or wool. However *P. cynthia* was unable to adapt at the new condition while *A. altissima* is what was left by this tentative in Europe (Raimondo & al. 2009). In addition the host plant was one of the first trees brought west during a time when *chinoiserie* was dominating European arts, and was initially hailed as a beautiful garden specimen. However, enthusiasm soon waned after gardeners became familiar with its suckering habits and its foul smelling odour. Despite this, it was used extensively as a street tree during much of the 19th century. Nowadays there is awareness of *A. altissima* invasiveness and its impact on forests, urban areas, rangelands and cultural heritage (Raimondo 2009), thus there are several laws addressed to eradicate and ban the use of *A. altissima* (e.g. Regione Toscana, Legge Reg. n.56 del 6/4/2000).

The most known imported insect is certainly the silkworm (*Bombyx mori*), originally existed in the wild throughout Asia, as we rely on their silk for our textile and clothing

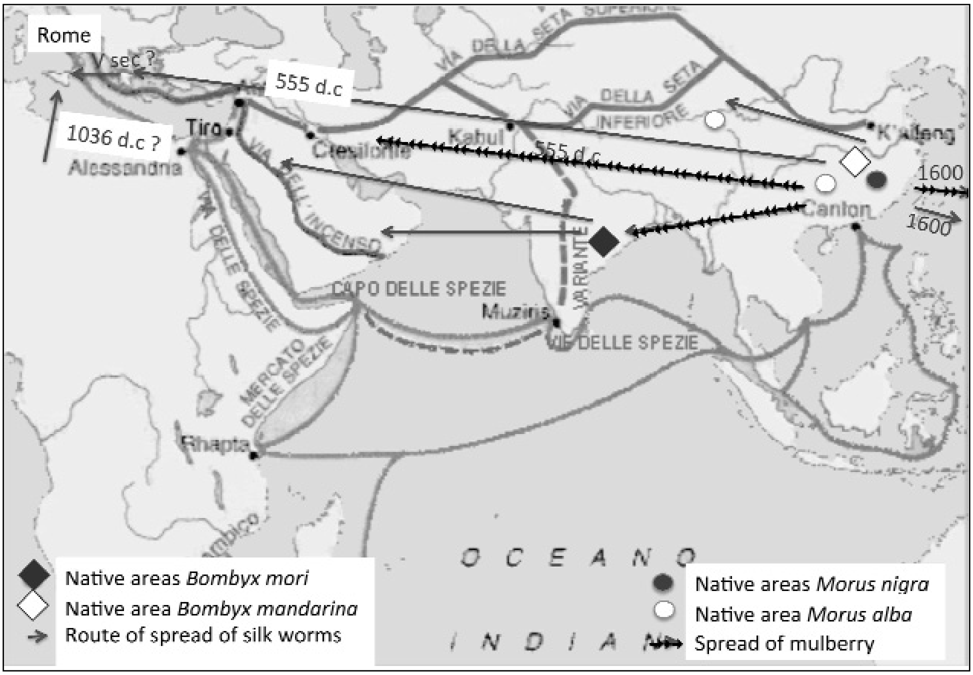

Fig. 4. Schematic view of the complex relationship among *Bombyx mori* – *Morus spp.* and human trades.

industries. Sericulture in Italy originated in an imprecise period of time between the 10th and 11th century. The silkworm rearing was probably introduced by Arabs to Sicily and by Byzantines to the other regions of the South (Cappellozza 2002).

Though they are believed to no longer exist in the wild, they are in the care of the silk industry world wild. This insect, the foundation of an industry that dates back over 4000 years to China, eats only one thing - the Mulberry and especially the White Mulberry. The silkworm's or Mulberry moth's scientific name, *Bombyx mori* reflects this close relationship with *mori* being derived from *Morus* (*M. rubra* and/or *M. nigra*). Also mulberry, is not native in Europe (Celesti-Grapow & al. 2010). Trees were brought here to support a silk industry, but at the moment silk production is restricted to few areas in Europe (Fig. 4). Thus the mulberry is considered a weed tree in many parts of Europe including urban areas. Nether less, mulberry trees are held in high regard in Sicily. The taste of the fruits is appreciated by most people, and they are used to made the famous "granita di gelsi", jams and jellies or fermented to make something a bit stronger. Wildlife ranging from birds to deer, however, find the fruit most attractive and they frequent the trees in the summer to consume the bountiful crop.

Domestic silk moths are closely dependent on humans for reproduction, as a result of millennia of selective breeding. Each Italian region, where sericulture represented an economic activity, had its own silkworm strains (or geographical races), which belonged to silkworm eggs producers; these races were adapted to live and produce in the particular environmental conditions where they had always been reared.

Conclusion

Increase awareness of invasive species and their impacts

There is a continuing need to increase the awareness of invasive species and their impacts on natural and cultural heritage. While specialists (e.g., entomologists, plant pathologists, weed scientists) at are often actively engaged in management or claim the risk of invasive species, program managers and other stackeholders may not fully appreciate the magnitude of the problem.

Others that must be made more aware of the problems associated with invasive species are the legislators (DAISIE 2015).

In 2008, the cost of controlling invasive species and repairing the damage they cause across the EU reached an estimated €9.6 - €12.7 billion (Anonymous [European Commission] 2009). But this range is certainly an underestimate, as often private costs, are not included and the estimation of damages on cultural heritage is far to be defined. Moreover, many European countries are only starting to count the costs (Anonymous [European Commission] 2009; DAISIE, 2015). However alien species have in several cases brought advantages in the new countries, but the globalisation speeds the potential spread of this phenomena and more precautions are needed than in the past (Manachini & al. 2012).

Differences in the composition of regional alien species are driven by a complex set of filters such as biogeography, socio-economic issues, cultural heritage, global trade dynamics, human populations, cultural acceptance and tradition. Furthermore, the increasing amount and efficiency, of global trade continues to provide the opportunity for new species to invade new areas.

In our analyses we examined example of patterns associated with different plants and insects species currently established in Italy and we reported how alien species in the past and now have changed culture and landscape, becoming even “symbol flag” of some regions. We recommend that further effort be made towards the formation, and analysis, of regional inventories of alien species that would impact natural and cultural heritage. This will allow a wider range of taxa and regions to be examined for generalisations, and help assess the risk posed by certain taxa to the economy or environment, and which habitats and cultural assets are at greater risk.

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E. Di Gristina, F. Scafidi & G. Domina

A new species of *Isatis* (*Brassicaceae*) from the Pollino National Park (Basilicata, S Italy)

Abstract

Di Gristina, E., Scafidi, F. & Domina, G.: A new species of *Isatis* (*Brassicaceae*) from the Pollino National Park (Basilicata, S Italy). — Fl. Medit. 25 (Special Issue): 297-303. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

A new species, *Isatis raimondoi* (*Brassicaceae*) is described from Mt Alpi in the Pollino National Park (Basilicata, Southern Italy). Its relationships with the other species of *Isatis* occurring in Italy are examined.

Key words: endemism, vascular flora, woad, phytodiversity, conservation.

Introduction

Isatis L. (*Brassicaceae*) is an Eurasian genus including 79 species (Al-Shehbaz & al. 2006). It is one of the most difficult cruciferous genera from the taxonomic point of view (Moazzeni & al. 2010). Some species are, in fact, highly polymorphic in fruit morphology, the structure that provide the most diagnostic character (Davis 1965). In addition, due to the extreme variability in all morphological characters, the limits of many species are uncertain (Ball & Akeroyd 1993; Moazzeni & al. 2008). Most, if not all, diagnostic characters used in earlier classifications are very variable and because of the unreliability of vegetative and floral characters it is difficult or impossible to identify many specimens when mature fruits are missing (Davis 1964). The patterns of variation suggest that hybridisation may be widespread (Moazzeni & al. 2008). Moreover, intermediate specimens are rather frequent, even between some taxa that are morphologically easily recognisable (Moazzeni & al. 2008). In Italy, according to Conti & al. (2005), *Isatis* includes three species: *I. apennina* Grande (= *I. allioni* P. W. Ball), endemic to Italy and France (south-west Alps and central Apennine), *I. praecox* Tratt., European taxon restricted to Lombardia, and *I. tinctoria* L., Asiatic species widespread in central and south Italy. Floristic investigations in the Pollino National Park (on the Lucanian side) led to the discovery of a little population consisting of individuals that show peculiar morphological characters. The study of this group resulted in the description and illustration of a species new to Science here described and discriminated from the related taxa.

Isatis raimondoi Di Grist., Scafidi & Domina, **sp. nov**. (Fig.1)

Holotype: Basilicata, Pollino National Park, Mt Alpi (Latronico, Potenza), 40° 7' 9.65" N, 15° 59' 16.95" E, carbonate stony slopes, 1750 m a.s.l.", 11 July 2014, *Scafidi & Di Gristina s. n.* (PAL102699). *Isotypes*: PAL-Gr, FI.

Etymology: Plant named after Prof. Francesco Maria Raimondo, Italian botanist and promoter of the *Herbarium Mediterraneum Panormitanum*, for his 70th birthday.

Biennial herb. Stems erect, (30)40–90(100) cm, simple or branched above, hirsute or sparsely hairy at the base. Basal leaves simple with slender petiole shorter or approximately equaling lamina, usually withered at anthesis; lamina glaucous or green, (2)2.5–5(5.5) × (7.5)8–13(14) cm, lanceolate-oblong to obovate-oblong, entire or repand-dentate, obtuse to subacute, attenuate into petiole, hirsute-pubescent, seldom sparsely hairy, on both surface. Cauline leaves sessile-amplexicaul, 0.5–1.5 × 3–8(9) cm, astate to oblanceolate, entire, obtuse to subacute, sparsely hairy, with rounded auricles. Inflorescence a large corymbose panicle. Pedicells slender, 0.7–1.0 cm long, patent in fruit. Sepals 2–2.5 (3) mm, erecto-patent, yellow-greenish, glabrous, with membranous margin. Petals 3–3.5(4) mm, obovate, yellow glaborus. Silicula patent, 4–6 × 11–13 mm, elliptical or elliptical-obovate, rounded or emarginate at apex, tapering or rounded at base, glabrous; central rib simple, slender to prominent.

Biological form: Biennial hemicryptophyte.

Phenology: Flowering June. Fruiting in July.

Distribution and ecology: *Isatis raimondoi*, occurs exclusively on Mt Alpi (Latronico, Potenza province), within the Pollino National Park (Fig. 2 & 3). Actually only a small population of about 150 individuals is known. It grows on north-exposed carbonate rocky slopes, at the upper border of *Fagus sylvatica* L. wood, between 1.700 and 1.850 m of elevation. Within this narrow mountain belt, it grows together with *Festuca circummediterranea* Patzke, *Cerastium tomentosum* L., *Sideritis taurica* Willd., *Centaurea deusta* Ten. subsp. *deusta*, *Vicia onobrychioides* L., *Edraianthus graminifolius* (L.) A. DC. subsp. *graminifolius*, *Clinopodium alpinum* subsp. *meridionale* (Nyman) Govaerts, *Pedicularis comosa* L. subsp. *comosa*, *Achillea rupestris* subsp. *lucana* (Pignatti) Greuter, *Narcissus poeticus* L., *Myosotis sylvatica* subsp. *elongata* (Strobl) Grau, etc.

Conservation Status: The new species, known only form the type locality in an area of about 2 ha. The population can be estimated in only 150 mature individuals. According to the IUCN Criteria (IUCN 2001) it can be classified ad Critically endangered (CR B2a) due to its punctual distribution and reduced population size.

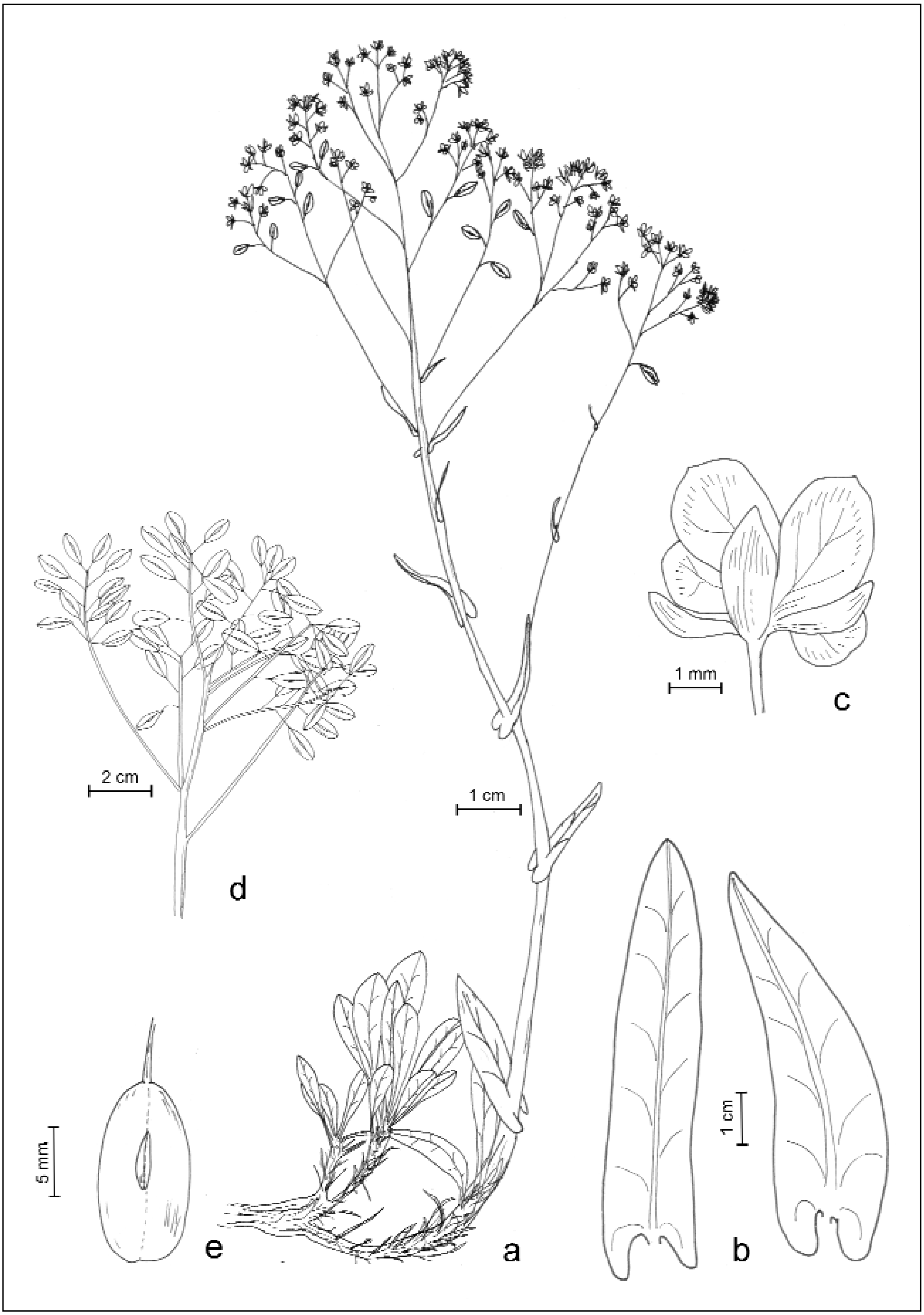

Fig. 1. *Isatis raimondoi*: a) habit, b) cauline leaves; c) flower; d) fruiting branch; silicula (Drawings by G. Domina).

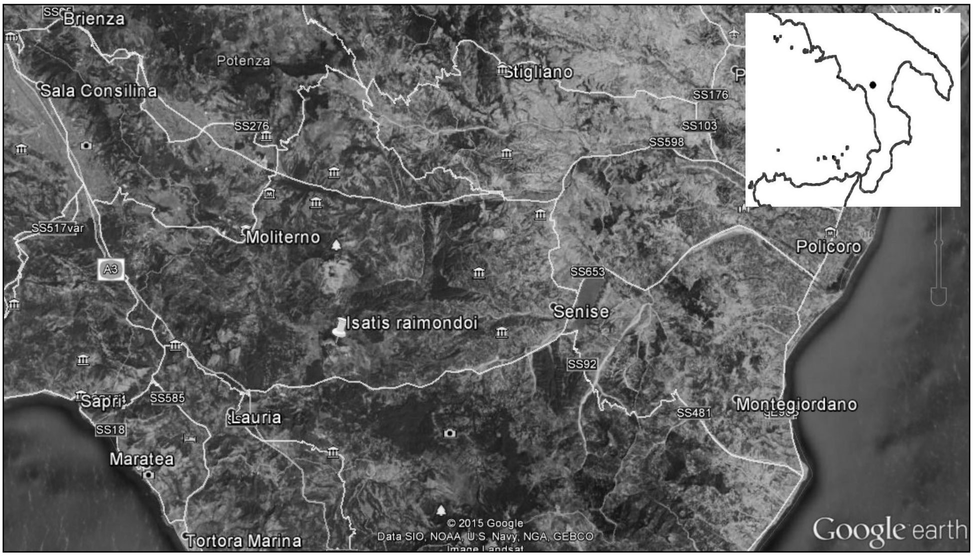

Fig. 2. Geolocation of the locus classicus of *Isatis raimondoi.*

Fig. 3. *Isatis raimondoi* in its natural habitat.

Taxonomic relationships: *Isatis raimondoi* strictly differs from the other Mediterranean species of *Isatis* by bearing the silicules patent rather than pendulous. The diagnostic characters with the other species of *Isatis* occurring in Italy are summarized in Table 1 and Fig. 4. *Isatis raimondoi* is taxonomically close to *I. tinctoria* but differs from it by the rounded (not acute) auricles of the cauline leaves and the short silicula with a ratio length/width of 2.1–2.75 instead than 4.8–5.3.

Table 1. Diagnopstic characters of the species of *Isatis* occurring in Italy.

Character / Taxon	***I. raimondoi***	***I. tinctoria***	***I. apennina***	***I. praecox***
lifecycle	biennial	biennial	perennial	biennial
Leaves auricles	rounded	acute	rounded	acute
Petal length (mm)	3–3.5(4)	(2.5)3–4	4–5	2.5–3
Silicula direction	patent	pendulous	pendulous	pendulous
Silicula size (mm)	4–6 × 11–13	3–6 × 16–29	8–10 × 16–29	3–6 × 7–14

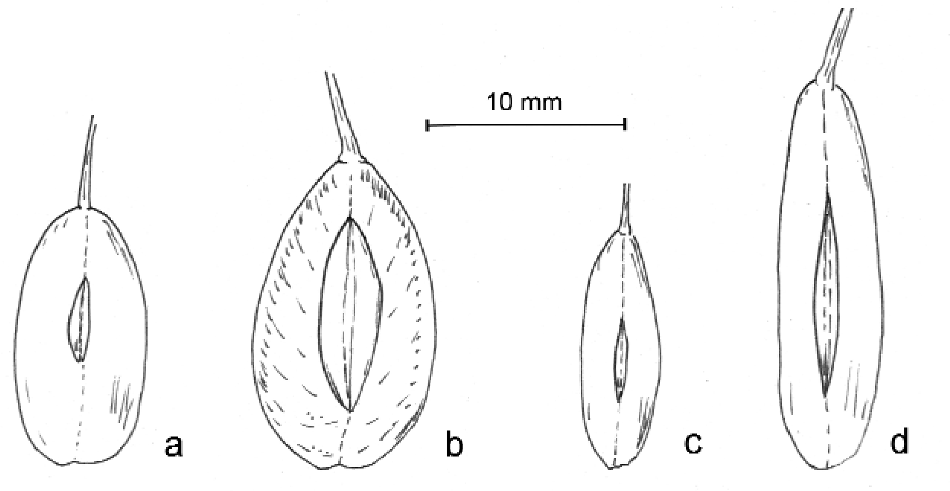

Fig. 4. Comparison of the siliculas of: a) *I. raimondoi*; b) *I. apennina*; c) *I. praecox*; d) *I. tinctoria* (drawings by G. Domina).

Other studied specimens

Isatis raimondoi

Italy, Basilicata: Pollino National Park, Mt Alpi (Latronico, Potenza), 40° 7' 9.65" N, 15° 59' 16.95" E, carbonate stony slopes, 1750 m a.s.l.", 10 June 2015, *Scafidi & Di Gristina s. n.* (PAL).

Isatis apennina

Italy, Piemonte: Mount Viso (Hautes Alpes), 1899, *A. Jordan s. n.* (PAL); Mt. Viso, s. d., *A. Jordan s. n.* [sub. *I. alpina*] (PAL); Mount Vizo, s. d., *Dauphiné Huguenin, s.n.* (PAL); Abruzzo: M.te Corno, s.d., *Orsini s. n.* (PAL); Abruzzo, P.so Portella, Gran Sasso, 2210 m, 6 Aug. 1996, *Ina Dinter 4728a.* (PAL-Gr38477).

Isatis praecox

Italy, Lombardia: Rupi del Lago Sebino, P. di Bergamo (PAL); Makedonja: in lat. Boreo-occ. Montis Galicia supra vicum Trpeja, alt. 1000 m, 9.7.1976, *W. Greuter 13853.* (PAL-Gr25247); Transylvania: Langenthal, in collibus apricis argillosis, 300 a s.m., 5.5.1893, *Bart s.n* (P5349021); in apricis collium junta Maros Solymos, solo argillacea, 200 m s. m., s. d., *Simkovics 578*, (P104177373); *sine loco*, *s. d.*, *Kitaibel P. s. n.* (W8668, original material).

Isatis tictoria

Italy, Sicily: Presso il Parco, Maggio, s. d., *Todaro* (PAL); Sicani, Monte Carcaci, 37°42'N-13°29'E, 900-1100 m a.s.l., calcareous soil, 01/06/1990, *Raimondo et al. 651* (PAL); Sciacca, Gole della Tardara, 37°33'N-13°00'E, 50-200 m a.s.l., calcareous soil, 02/06/1990, *Raimondo et al.* 875 (PAL); Greece: Lakonia, ep. Lakedhemona, between Mistras and Aj. Joannis Gorge naer Paroreou, alt 300 m, 37°03'50"N, 22°22'50"E,cliffs and scree, limestone, 2 April, Plants from Peloponnisos, Greece, *W. Greuter & B. Zimmer* 24260 (PAL-Gr46537); Spain: Sierra de Gador: Fondon, Cortijo de Bolichas, Pena Horadada, Prov. Alemria, Altim. 1450-1600, Hab. calcareous soils, 18/06/88, *B. Valdes et al. 790/88b* (PAL-Gr64352); Albania: Devoll-Tall, Gramshi, zwischen kokla und Bratila, 500-600 n, Serpentin, 7/5/1960, F.K. Meyer *5495* (PAL-Gr52703)

Acknowledgments

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Svetlana Bancheva & Zafer Kaya

Centaurea raimondoi, a new species from *Asteraceae*

Abstract

Bancheva, S. & Kaya, Z.: *Centaurea raimondoi*, a new species from *Asteraceae*. — Fl. Medit. 25 (Special Issue): 305-310. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

Centaurea raimondoi (*Asteraceae*) is described as a new species from surroundings of the cities of Mengen and Pazarköy, Turkey: A3 Bolu and is a steno-endemic species. The closest affinities are with *C. eflanensis* Kaya & Bancheva from Turkey, Karabük (A4): Eflani town, which occurs in an area of ca. 200 km distance. The new species is assessed as Critically Endangered (CR) according to IUCN criteria.

Key words: *Cardueae*, *Centaurea*, *Cyanus*, IUCN Red List, Bolu, Turkey.

Introduction

Centaurea L. is one of the largest genera in *Asteraceae*. Depending on the criteria for species delimitation used, it comprises between 200-700 species (Bremer 1994; Hellwig 2004; Bancheva & Greilhuber 2006). Turkey is one of the main centers of diversity for the genus *Centaurea* (Wagenitz 1986). In the Flora of Turkey, 172 plus six imperfectly known species of *Centaurea* were accepted (Wagenitz 1975). Since then, about 30 new species have been described.

Material and methods

Critical material of *Centaurea* was collected in June 2007 and again in June 2012: between the cities of Mengen and Pazarköy, on rocky places, Turkey: A3 Bolu, during field investigations related to a joint Research Project between TUBITAK and Bulgarian Academy of Sciences. Morphological characters of the critical population were studied from the original material in comparison with those of the related species observed in the following Herbaria: BGBM, ISTE, MA, P, PRM, SOM, W. The karyotype was studied from mitotic metaphase plates obtained from root tips of three plants collected in the wild from the type locality. Root tips were pretreated with 8-oxychinoline for 30 min, than fixed in acetic alcohol (1:3) for 24 h at 4°C, hydrolysed in 1 M HCl for 15 min at 60°C, stained with haematoxylin after Gomori (Melander & Wingstrand 1953) for 30 min at 60°C, then squashed in 45% acetic acid. The karyotype has been determined according to Levan & al. (1964) on the basis of eight metaphase plates.Herbarium specimens of the new species and allied taxa are deposited in ISTE and SOM.

On the basis of the obtained results the studied population has been recognized as a new species, endemic to Bolu province, here described and named *Centaurea raimondoi*.

Centaurea raimondoi Bancheva & Kaya, **sp. nov.** (Figs 1-4)

Holotype. Turkey: A3 Bolu: between the cities of Mengen and Pazarköy, on rocky places, N 40 55’ 25” N, E 32 8’ 12”, 13 June 2012, coll. *S. Bancheva & Z. Kaya*, SOM-171075! Isotype PAL!

Resembling *C. eflanensis* Kaya & Bancheva from Turkey, Karabük (A4): Eflani town, but plants densely lanate, with procumbent to decumbent stems; less thickened roots 0.7–0.9 mm, instead of 1–1.5 mm in *C. eflanensis*, violet florets and smaller achenes 2.8–3.5 mm long, instead of 4–4.5 in *C. eflanensis.*

Perennial. Rhizome short, truncate, without stolons, with single thickened root up to 10 cm long, about 0.7–0.9 cm wide, dauciform, at abruptly narrowing in short apex. Stems single to several (2–3), ascending, 9–21.5 cm high. Leaves densely lanate; lower entire to pinnatifid with 1–2 pairs of lanceolate segments, usually forming basal rosette at flowering time; median and upper leaves entire to pinnatipartite, sessile. Capitula single, 1.5–3 cm wide. Involucre 12–14 mm high and 6-10 mm wide. Phyllaries prolong-triangle, glabrate. Appendages with decurrent, light to black, 0.1–0.3 mm wide margin; cilia 0.7–1.5 mm long, silver to the top. Florets violet; marginal florets radiant, divided into 4–6 triangle lobes. Achenes 2.8–3.5 mm long, 2 mm wide, with lateral elaiosome; pappus about four times shorter than the achene (Figs 1-4).

Fig. 1. *Centaurea raimondoi* in its natural habitat.

HERBARIUM ACADEMIAE SCIENTIARUM BULGARIAE

HOLOTYPUS № 171075

Centaurea raimondoi Bancheva & Kaya, sp. nova

Turkey: A3 Bolu: between the cities of Mengen and Pazarköy, on rocky places, N 40 55' 25" N, E 32 8' 12".

13 June 2012 ***Leg. S. Bancheva & Z. Kaya***

Fig. 2. Holotype of *Centaurea raimondoi.*

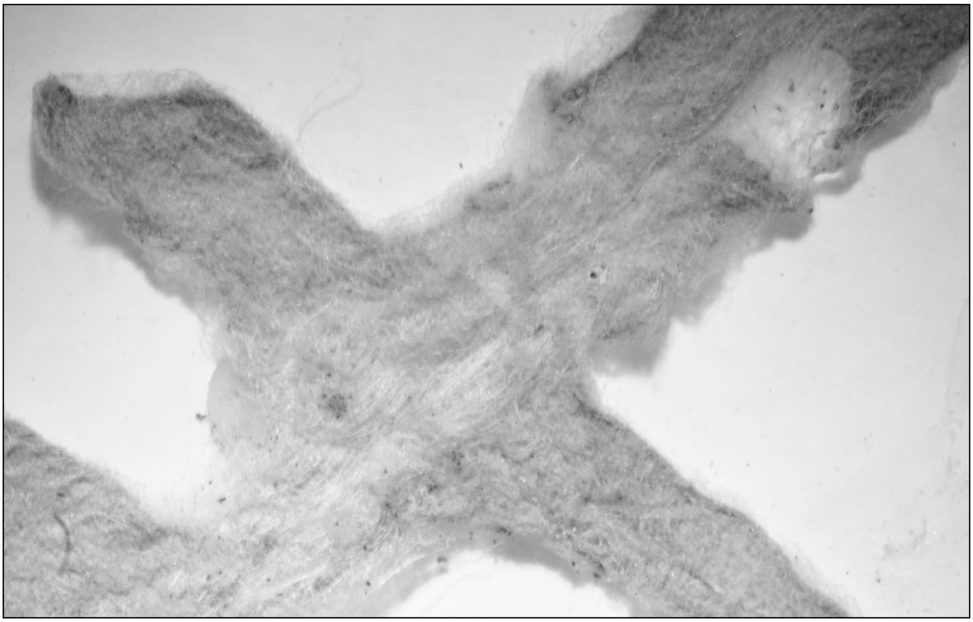

Fig. 3. Indumentum of leaf segment of *Centaurea raimondoi.*

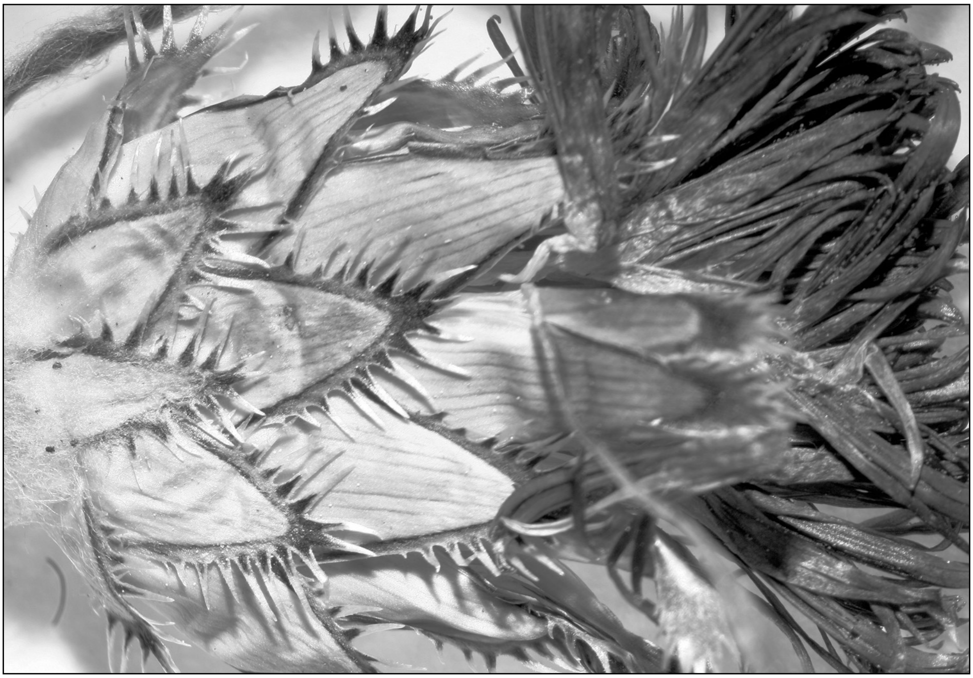

Fig. 4. Phyllaries of *Centaurea raimondoi.*

Karyology. *C. raimondoi* is a diploid species with karyotype comprising 20 small chromosomes (*ca*. 2–4 µm) with the submetacentric chromatid type prevalent. Four of the chromosomes have satellites (Fig. 5).

Distribution and ecology. *C. raimondoi* is currenty known only from one locality, in the Bolu province (A3), between the cities of Mengen and Pazarköy. It was growing on rocky places at an altitude of 1200 m alt., at the edge of forest dominated by *Pinus nigra* J. F. Arnold. The population comprises *c*. 350 individuals distributed in several small groups occupying an area of *c.* 5 000 m^2.

Phenology. Flowering in June. Fruiting in July.

Conseravtion status. The species is apparently very rare and local – it is known only from one population in the type locality and from an area of 5000 m^2. The population numbers approximately 300-350 plants. It should be regarded as belonging to Critically Endangered (CR) category (IUCN, 2001), because of its local distribution and rather small population size.

Etymology. The species is named in honour of Prof. Francesco M. Raimondo at the University of Palermo, Italy, the distinguished expert of Mediterranean flora and vegetation, to whom this paper is modestly dedicated on occasion of his 70 year anniversary.

Taxonomic relationships. Based on morphological carachters, the closest ally of *C. raimondoi* is *C. eflanensis*. The authors conducted herbarium and the literature comparison (Wagenitz 1975; Dostal 1976; Bancheva & Raimondo 2003; Kaya & Bancheva

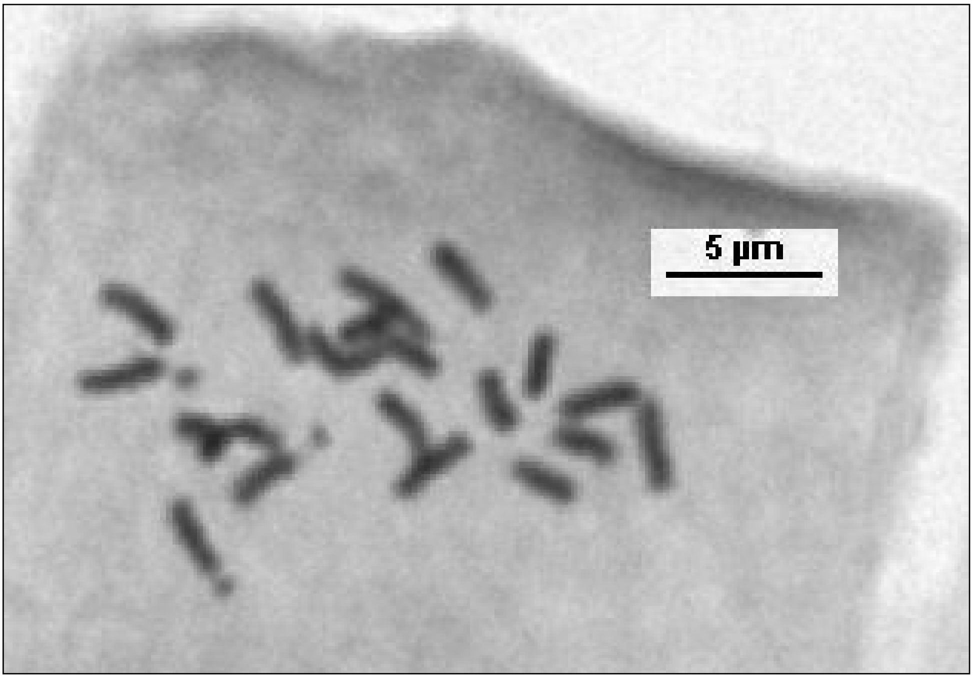

Fig. 5. Karyotype of *Centaurea raimondoi.* Scale bar 5 µm.

2009) and conclude that *C. raimondoi* differs morphologically from *C. eflanensis*. The diagnostic characters are contrasted in the following key couplet:

Glabrescent plant with thickened 1-1.5 cm wide dauciform root; florets violet-purple; achenes 4–4.5 mm long .... *C. eflanensis*

Densely lanate plant with thickened 0.7-0.9 cm wide dauciform root; florets violet, achenes 2.8-3.5 mm long .... *C. raimondoi*

Acknowledgments

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V. Spadaro, A. S. Faqi & P. Mazzola

Clinopodium raimondoi (*Lamiaceae*), a new species from Sicily

Abstract

Spadaro, V., Faqi, A. S. & Mazzola, P.: *Clinopodium raimondoi* (*Lamiaceae*), a new species from Sicily. — Fl. Medit. 25 (Special Issue): 311-315. 2015. — ISSN: 1120-4052 printed, 2240-4538 online.

On the basis of the taxonomic study of the collections made by F. M. Raimondo, kept in PAL, a new species of *Clinopodium* is described. The new taxon, named *Clinopodium raimondoi*, occurs in N-W coast of Sicily on limestone substrata, in steppe communities dominated by *Hyparrhenia hirta*. The main distinctive characteristics of *C. raimondoi*, with respect to other taxa known from Europe and other Mediterranean countries, are the large size, the opposite and decussate branches, and the clearly woody at base stems of mature plants as well. Relationships of the new taxon with the Mediterranean ones in the *C. nepeta* group are also discussed.

Key words: *Clinopodium*, vascular plants, Mediterranean flora.

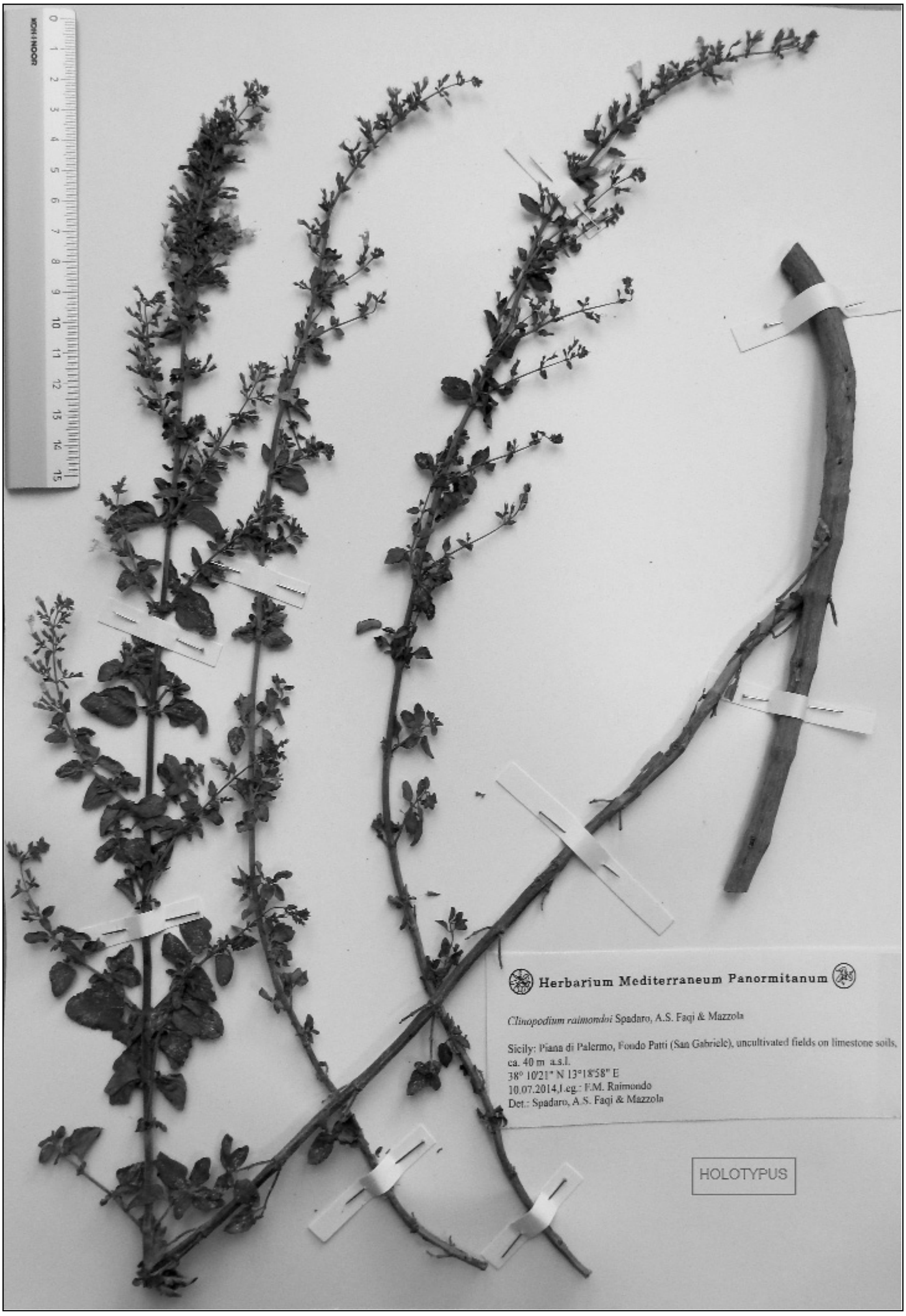
Introduction

In the last years, researches of pharmaceutical and phytochemical nature on wild Sicilian plant species of *Clinopodium* L. (*Lamiaceae*) have been carried out in the pharmaceutical biological Laboratory of the Palermo University. Firstly, in the research all the plant material, including that hard to be identified has been taxonomically characterized. From the taxonomical analysis, on the whole well known taxa belonging to the Sicilian flora, have been easily identified. Nevertheless, a population distinct from all taxa known in both Sicily and the whole Mediterranean area, spread along the north-western coast has been found. On the basis of the morphological characters observed, the population in question is referred to an unpublished taxon which is here described and named *Clinopodium raimondoi*.

Clinopodium raimondoi Spadaro, A.S. Faqi & Mazzola ***sp. nov.*** (Fig. 1)

Holotype: Palermo (Sicily): San Gabriele place, uncultivated fields on limestone soils, ca. 40 m s.l.m., 10.07.2014, *Raimondo* (PAL). *Isotypes*: PAL-Gr and FI.

Etymology: Name devoted to prof. Francesco Maria Raimondo, explorer of the Mediterranean flora, master, colleague and friend, in occasion of his 70° birthday.



Herbarium Mediterraneum Panormitanum

Clinopodium raimondoi Spadaro, A.S. Faqi & Mazzola

Sicily: Piana di Palermo, Fondo Patti (San Gabriele), uncultivated fields on limestone soils,
ca. 40 m a.s.l.
38° 10′21″ N 13°18′58″ E
10.07.2014, Leg.: F.M. Raimondo
Det.: Spadaro, A.S. Faqi & Mazzola

Fig. 1. The holotype of *Clinopodium raimondoi* in PAL.

Diagnosis: *Suffrutex caespitosus, 90–120 cm attingens. Caules validi prostrato-ascendentes, lignosi usque ad plus quam inferiorem dimidiam partem; superior dimidia pars pilosa. Rami secundi et tertii ordinis oppositi et decussati. Folia petiolata, plus minusve cordata; juvenia dense pilosa, senescentia sparsis pilis adpressis praedita. Calyx glandulosus, ciliolatus ad faucem; dentes inferiores trigoni, superiores longiores, lesiniformes. Corolla violacea vel plus minusve intense caerulea.*

Description: Bushy aromatic plant, 90–120 cm high. Mature stems 8–12 mm in diameter at the base, woody up to above the middle part, hairy in the upper half. Branches and branchlets opposite, decussate. Leaves glandulose, petioled, slightly tooted-crenate at margins; young leaves hairy, mature leaves green, covered with sparse, short, appressed hairs on both blades. Flowers 2–7, shortly pedicellate; in numerous verticillasters (5–20); calyx glandulose, (2.5) 3 (3.5) mm, opening ciliolate inside, 3 teeth short, triangular; the remaining 2 much longer, lesiniform; corolla more or less intense violet in colour, (9) 10 (11) mm.

Fenology: Flowering period March to December. Fruiting April to December.

Biological form: Camaephyte caespitose (**Ch** caesp).

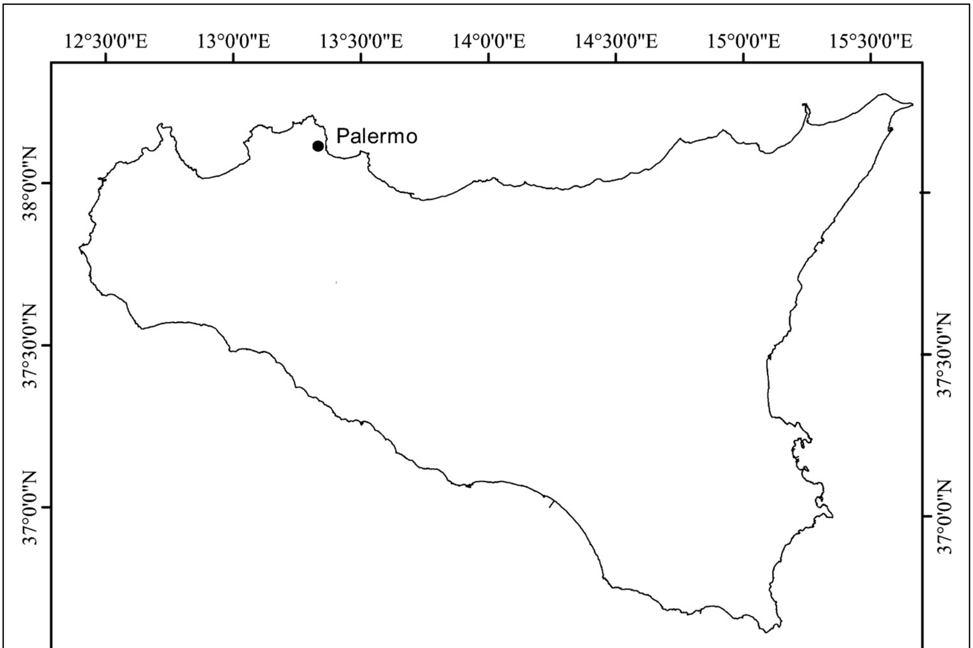


Fig. 2. Location of the locus classicus of *Clinopodium raimondoi.*

Ecology and distribution: Species termophilous belonging to steppe plant communities dominated by *Hyparrhenia hirta* (L.) Stapf on limestone substrata. It occurs along the central-northern and probably also the southern coasts of Sicily (Fig. 2).

IUCN Status: Vulnerable.

Taxonomic remarks

From a traditional taxonomic point of view the new species should be included in the genus *Calamintha* founded by Miller (1754). As it is shown by the relevant synonymy, not always this taxon is accepted. Indeed species assigned to *Calamintha* Miller were also placed in *Satureja* L. (Fiori 1926; Pottier-Alapetite 1981; Greuter & al. 1986).

Ball & Getliffe (1972), Davis & Lebeblici (1982), Siddiqi (1984), Ubera (1987), Morales Valverde (2011) and, as far as Italy, Sicily, Corsica and Sardinia are concerned, Pignatti (1982), Conti & al.(2005), Giardina & al. (2007), Jeanmonod & Gamisans (2007) and Arrigoni (2013) accepted *Calamintha* Miller and included there several species, differing in number, mostly occurring in the Mediterranean area. This number variation, besides the size of the relevant distribution areas, depends especially on the different systematic approach followed by each taxonomist in delimiting each species and assigning discriminant values to the characters taken into account. Nevertheles *Calamintha* Miller, has recently been critically reviewed (Harley & al. 2004), so that its specific and intraspecific taxa have been transferred to *Clinopodium* L. (Bräuchler & al. 2006; Peruzzi & Conti 2008; Bartolucci & Conti 2011). Following this new systematic and taxonomic approach, the species described here has been placed under *Clinopodium* L. Thus, according Harley & al. (2004) and Bräuchler & al. (2005, 2006), the genus *Calamintha* Miller is to be included in *Clinopodium* L. (cfr. Peruzzi & Conti 2008 and Bartolucci & Conti 2011).

Owing to be woody at base and its calyx with asymmetrical teeth, *Clinopodium raimondoi* is related to *C. nepeta* (L.) Kuntze (= *Calamintha nepeta* (L.) Savi = *Satureja calamintha* (L.) Scheele = *C. officinalis* Moench). Nevertheless, it is distinct by its larger size, stem hardy and more lignified, outside calyx and inner corolla lacking hairs. It is also similar to *C. incanum* L. [= *Calamintha incana* (Sm.) Boiss.] from Greece, Turkey, Cyprus, Syria and North-Africa, by its larger size and woody stems, besides the sparse hairiness and cordate leaves with crenulate-toothed margin, not ovate-rounded with margin entire and revolute.

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