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M. Meço, A. Mullaj & Z. Barina

The vascular flora of the Valamara mountain range (SE Albania), with three new records for the Albanian flora

Abstract

Meço, M., Mullaj, A. & Barina, Z.: The vascular flora of the Valamara mountain range (SE Albania), with three new records for the Albanian flora. — Fl. Medit. 28: 5-20. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

As a result of floristic investigations in the Valamara mountain range carried out between 2007 and 2016, 567 taxa belonging to 305 genera and 89 plant families were recorded, of which 307 taxa are reported as new for the area. A phytogeographical analysis showed that the Eurasian chorological type was the most dominant comprising 126 taxa (22.2% of the flora), the second was Balkan with 104 taxa (18.3%). There are 9 endemic and subendemic taxa. *Epilobium alsinifolium*, *Dichoropetalum stridii* and *Taraxacum pindicum* are new for the Albanian flora. Life-form analysis indicates that 56.8% of the species are hemicryptophytes; this high percentage points to the Mediterranean nature of the investigated area. A total of 119 species (20.9 %) are listed as deserving conservation status. Of these, 49 are in the Albanian Red List, 76 species in the IUCN Red List, two in the Habitats Directive, one included in Annex I of the Bern Convention and seven species in Appendix II of CITES.

Key words: floristic investigation, biodiversity, phenology, chorology, conservation.

Introduction

Valamara is a mountain range in south-eastern Albania, located between the districts of Korça, Pogradeci and Gramshi. It has a number of peaks, the highest of which is ‘Maja e Valamarës’, which reaches 2373 m elevation. The flora of the Valamara Mts is poorly explored and no detailed studies are available. The first floristic records from this region are by Markgraf (1927, 1931) and Demiri (1959). Sporadic floristic records were later published by Paparisto & Qosja (1976), Gölz & Reinhard (1984), Barina & Pifkó (2008, 2011), Shuka & Tan (2009) and Meyer (2011), and some notes on the vegetation of the area were published by Vangjeli (1983) and Buzo (1990). On the basis of these references and the collections deposited in the Tirana herbarium (TIR, 262 taxa are documented for the Valamara Mts).

The geographical location, complex topography, climate characteristics, different rock substrata and soil types and hydrological conditions, are factors contributing to a rich flora and vegetation and make the Valamara Mts unique. In this study we provide a list of the vascular flora together with an analysis of taxonomy, chorology, phenology, life form and conservation status for each species.

Study area: geology and climate

The three main summits of the Valamara Mts are 'Guri i Topit' (2122 m), 'Lenie' (2013 m) and 'Valamara ' (2373 m); at *ca*. 2100 m there are eight glacial lakes (Fig. 1).

The geology of the study area consists mainly of different sedimentary rocks spanning from early Cretaceous to Oligocene (140–30 million year old), together with some older magmatic Jurassic rocks (170 million years). The two main rock types encountered in the study area are flysch and ophiolite. Serpentine (ophiolithic) substrate covers large areas in the Valamara Mts, whereas limestone and various kinds of acidophilous metamorphic rocks are less prominent (Kabo 1990-1991; Norconsult 2010).

According to the categories of climatic regions in Albania, the Valamara Mts belong to the Southeast Mountain Mediterranean zone. The main characteristics of this climatic zone are dry summers and wet winters. The average annual temperatures vary from 7.5 °C to 14.7 °C and the coldest month of the year is January with an average temperature of -1.9 °C. July is the warmest month with an average temperature between 16.4 °C and 23.6 °C. Snowfall occurs annually and the number of days with snow cover varies from 30–35 days/year in the lower regions, to 80–90 days/year in the highest parts (Kabo 1990-1991; Norconsult 2010).

Vegetation

Due to the variation in altitude (from 700 to 2373 m), complex topography and the different rock substrates, a wide range of vegetation and habitat types are found within the study area. The vegetation of the Valamara Mts occurs in two different belts based on climatic and soil conditions:

1) montane forests are found at altitudes of *ca.* 700–1600 m, and are dominated by *Fagus sylvatica* and *Pinus nigra*; some smaller areas are covered by *Pinus heldreichii*. At lower elevations the vegetation is dominated by *P. nigra*.
2) alpine habitats: timberline is usually at an altitude of 1700 m asl.. The subalpine brushwood consists of low shrubs such as *Juniperus communis* subsp. *nana*, *Daphne oleoides*, *Rosa* spp. and *Chamaecytisus* spp. In many places the timberline has been artificially lowered by humans, and regeneration is prevented by grazing. Summer grazing by sheep and goats is often heavy. Above the timberline a variety of habitats occur, including snowbed meadows, mountain grasslands, screes and rocks; vegetation type and species composition are much influenced by the bedrock. Dry grassy moors cover vast areas above timberline and are dominated by *Carex* sp. pl., *Stipa* sp. pl., *Festuca* sp. pl., *Sesleria* sp. pl., *Nardus stricta*, etc.

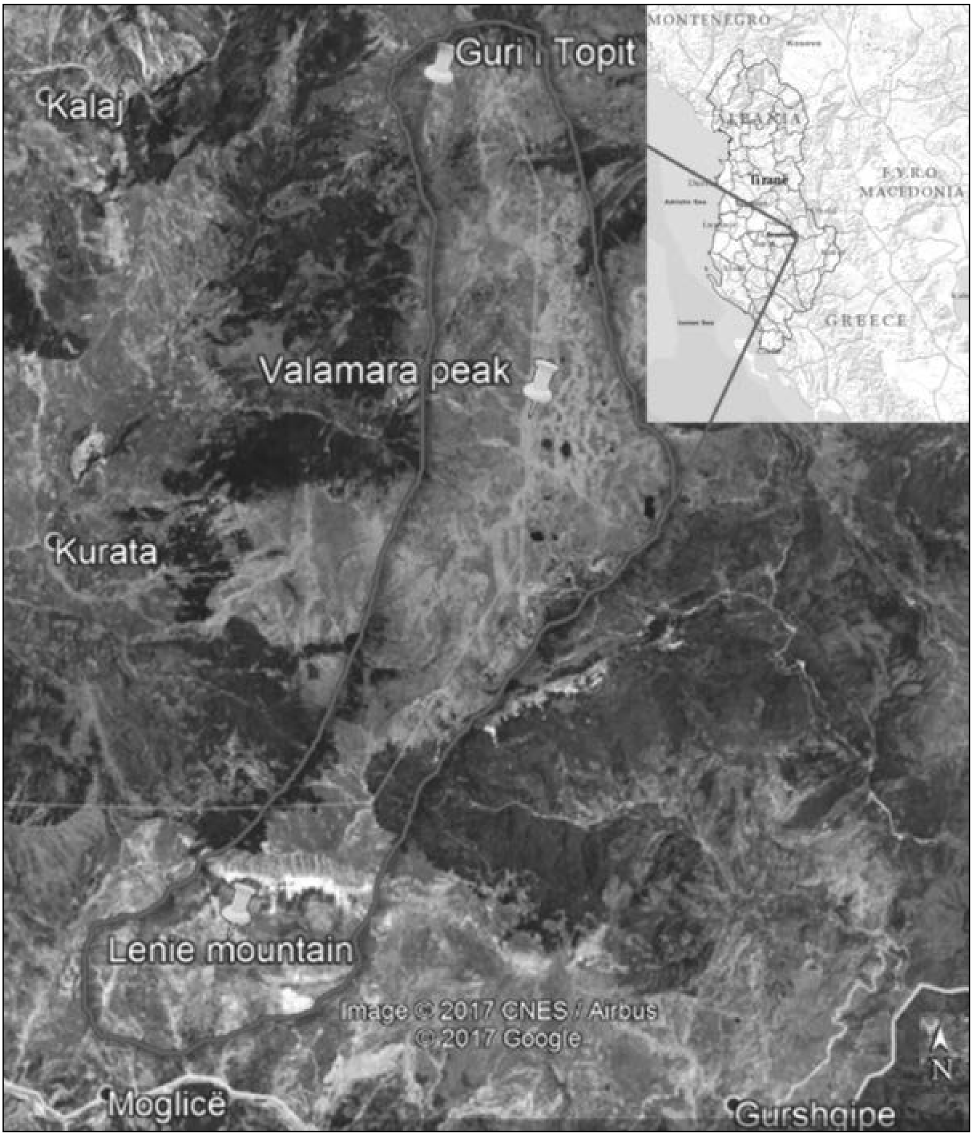

Fig. 1. The Albanian territory where is shown the study area (Valamara Mts).

Materials and Methods

The study is based on the results of field work carried out between 2007 and 2016. Collections of plant material (*ca* 1000 specimens) were made during different seasons of the year from all the representative habitats covered by different vegetation types. Herbarium specimens are deposited at University of Tirana (TIR) and Hungarian Natural

History Museum (HNHM). The species list is based on the authors' own collections, herbarium material at TIR, field observations and published information as provided by Markgraf (1927, 1931), Demiri (1959), Paparisto & Qosja (1976), Gölz & Reinhard (1984), Vangjeli (1983), Buzo (1990), Barina & Pifkó (2008, 2011), Shuka & Tan (2009) and Meyer (2011).

Plant identification follows Flora Europaea (Tutin & al. 1968-1980, 1993), Flora of Albania (Paparisto & al. 1988; Qosja & al. 1992, 1996; Vangjeli & al. 2000), nomenclature is mainly according to Euro+Med Plantbase (2006-). For conservation status we consulted the Albanian Red List of vascular plants (Council of Ministers' decision, 2013), the IUCN Red List of Threatened Species (IUCN 2016), Bern Convention (Council of Europe 1979), Annex II, IV and V of Habitat Directive (Council Directive 92/43/EEC) and Appendix II of CITES Convention (CITES 2011).

The chorology of the taxa is principally based on critical comparison of information provided by Strid & Tan (1997, 2002), Davis (1965-1988), Pignatti (1982), and Tutin & al. (1968-1980, 1993).

Life forms of the taxa are according to the systems of Raunkiaer (1934), Ellenberg (1956) and Ellenberg & Müller-Dombois (1967a, 1967b). The following abbreviations apply: Ph = phanerophyte, NPh = nano-phanerophyte, Ch = chamaephyte, H = hemicryptophyte, G = geophyte, T = therophyte, Hyd = hydrophyte, Lian = liana. The data concerning the flowering period or sporulation period for ferns were taken from Flora of Albania (Paparisto & al. 1988; Qosja & al. 1992, 1996; Vangjeli & al. 2000) and Mountain Flora of Greece (Strid 1986; Strid & Tan 1991). Number of species for each month was counted taking in consideration that for most of the species period of flowering lasts more than one month, and in this way each species was counted in all flowering months. The maps of the study area with indicated locations of species reported here for first time for Albania were prepared in ArcMap 10.1.

Results

567 taxa belonging to 305 genera and 89 families were identified within the study area. *Taraxacum pindicum, Dichoropetalum stridii* and *Epilobium alsinifolium* are new records for Albania and 306 taxa are new for the study area (Electronic Supplementary File 1). Hemicryptophytes are the most frequent followed by geophytes, therophytes, phanerophytes, chamaephytes, hydrophytes, and lianas. The taxa belong to 58 floristic elements (Table 2), of which the Eurasian and European with 127 and 104 taxa, respectively, are the largest. One Albanian endemic species, *Festucopsis serpentini*, and eight sub-endemic taxa were also identified. A total of 119 taxa have some conservation status (Table 3). Forty-nine are included in the Albanian Red List, 76 are part of the IUCN Red List, two species belong to annexes II, IV and V of the Habitats Directive (Council of Ministers' decision, 2013; IUCN 2016; Council Directive 92/43/EEC). *Centranthus longiflorus* is included in annex I of Bern Convention and seven species are listed in Appendix II of CITES.

Taxonomic analysis

Of the 567 vascular plant taxa observed in the Valamara Mts 95.9 % (544 taxa) of them are angiosperms and 4.1 % (23 taxa) pteridophytes. The flora comprises 15.6 % of the total Albanian flora, with 31.7 % of the genera and 50.8 % of the families (Meço & Mullaj 2015).

In table 1 families with the greatest number of the species are shown (ten or more species), that represent 64.1 % of all taxa and 62.9 % of the genera. In monocots, the *Poaceae* has the greatest number, 10 % of all taxa and 9.2 % of all genera. In Albanian flora, *Poaceae* is the third family with the highest number of taxa. In our study area, species of this family are dominant because the upper part of Valamara Mts is dominated by grasslands and rocky treeless terrains. Family with highest number of species is *Asteraceae*. It represent 10.2 % of total number or 58 taxa and 9.8 % or 30 genera. The high number of the species of Asteraceae comes by the fact that this is the biggest family of the flora of Albania (Meço & Mullaj 2015) and from a high presence of Circumboreal species, Orofil and Eurosiberic species, about 29.3 % of all *Asteraceae* grow in the upper part of Valamara Mts. Other families with greatest number of the taxa and genera are: *Caryophyllaceae* (5.8%), *Rosaceae* (5.6%), *Fabaceae* (5.4%), *Lamiaceae* (5.3%), *Brassicaceae* (4%), etc. (Table 1). Genera with five or more species are 24, such are *Carex* (11 species), *Campanula* (10 species), *Silene* (9 species), *Galium* (8 species), *Trifolium* (8 species), *Geranium* (7 species), *Hieracium* (6 species), *Plantago* (6 species), *Poa* (6 species), *Allium* (5 species), etc.

Table 1. Largest families in the flora of Valamara Mts.

Family	**Genera No. (%)**	**Species and subspecies No. (%)**
Apiaceae	14 (4.6)	15 (2.6)
Asteraceae	30 (9.8)	58 (10.2)
Boraginaceae	7 (2.3)	10 (1.8)
Brassicaceae	14 (4.6)	23 (4.0)
Campanulaceae	3 (1)	12 (2.1)
Caryophyllaceae	14 (4.6)	33(5.8)
Cyperaceae	5 (1.6)	21 (3.5)
Fabaceae	14 (4.6)	31 (5.4)
Lamiacea	18 (5.9)	30 (5.3)
Orchidaceae	8 (2.6)	10 (1.8)
Poaceae	28 (9.2)	57 (10)
Ranunculaceae	12 (3.9)	18 (3.2)
Plantaginaceae	2 (0.7)	10 (1.8)
Rosaceae	17 (5.6)	32 (5.6)
Scrophulariaceae	9 (3)	15 (2.6)

New records for the Albanian flora

1) *Taraxacum pindicum* Kirschner & Štěpánek [*Asteraceae*]

SE Albania. Valamara Mts, at the western foot of Guri i Topit' mountain, c. 900 m west-northwest of the peak and c. 5.9 km north-northeast of village Grabovë, 40.8425 N, 20.443889 E, in mountain pasture, 1862 m a.s.l., 18.08.2007, coll. Z. Barina & D. Pifkó (BP769285), det.: J. Štěpánek & J. Kirschner.

T. pindicum belongs to *Taraxacum* sect. *Piesis* (DC.) Kirschner & Štěpánek, which is unique in the genus and comprises only a few species. So far, it is known only from the N Pindos, Greece, described from the Katara Pass (Kirschner & Štěpánek 1998). In the Valamara Mts it is restricted to mountain pastures on serpentine substrate, between 1800–1900 m a.s.l. (Fig. 2). However, *Taraxacum* is a taxonomically difficult genus and the species might thus be overlooked and present also at other localities. *T. pindicola* belongs to *T.* sect. *Erythrocarpa*. We have observed that the species is rare in the rocky grasslands of Northeastern Albania from 2000 to 2700 m a.s.l.

2) *Dichoropetalum stridii* (Hartvig) Pimenov & Kljuykov [*Apiaceae*]

SE Albania. Northern slope of Mount of Valamarë, c. 2.4 km south of the summit, c. 3.7 km northwest of village Shalës and c. 5.8 km east of village Shënepremte, (district of Korçë), 40.77285 N, 20.46428 E; in open grassland, on serpentine, 2092 m a.s.l., 16.08.2007, coll. Z. Barina & D. Pifkó, Nr. 12647 (BP750303).

First described as *P. lavrentiadis* subsp. *multicaulis* Strid & Papanicolau (Strid & Papanicolau 1980), later considered a separate species differing in numerous characteristics from *P. lavrentiadis* (Hartvig 1986) and with different habitat preferences. So far known only from a fairly small area in Northern Pindos (N Greece) from the Katara Pass to the Gramos mountains at the Albanian border, It occurs on the following mountains: Aftia, Avgo, Gramos, Mavrovouni, Milea, and Smolikas (Hartvig 1986). Our new record extends the area of the species more to the North (Fig. 2). Our record confirms that *D. stridii* is a species of ophiolithic substrates. Further records for the border area with can be expected in the Gramos Mts.

3) *Epilobium alsinifolium* Vill. [*Onagraceae*]

SE Albania. Valamara Mts, Gramsh district: a small mountain lake below lake 'Guri i Topit', c. 750 m northwest of the peak of Mount "Guri i Topit" and c. 6.0 km north-northeast of village Grabovë, 40.842222 N, 20.447778 E, at the shore of a small mountain lake, 1838 m a.s.l., 18.08.2007, coll. Z. Barina (BP761674).

Other localities outside the study area:

District of Librazhd, Jablanica Mt. (Mali i Jablanices); on the western slope of Mt. "Varri i Marises" (2022 m), c. 6.7 km south-southeast of village Steblevë; 41.27968N, 20.50093E, in flysh, on gravel-conglomerate., 1887 m a.s.l.; 03.07.2008, coll. Z. Barina, D. Pifkó & A. Vojtkó, Nr. 13926 (BP).

Malësi e Madhe District (Rrethi i Malësisë së Madhe); above village Lëpushë, 42.50204 N, 19.74179 E, on limestone rocks, cliffs, 1861 m; 02.08.2011, coll. Z. Barina & G. Somogyi, Nr. 19683 (BP) (Fig. 2).

Not so rare in the mountains of Central Europe and also at lower altitudes northwards, but very scattered in the Balkan Peninsula. Rare in the mountains of Bulgaria between 1400–1800 m a.s.l. (Assyov & Petrova 2006) and in the Greek Mainland (Pindos Mts, Sterea Ellas and North Central; Dimopoulos & al. 2013), but absent from Montenegro (Pulević 2005) and without confirmed records from Croatia (Strgulc Krajšek & al. 2009).

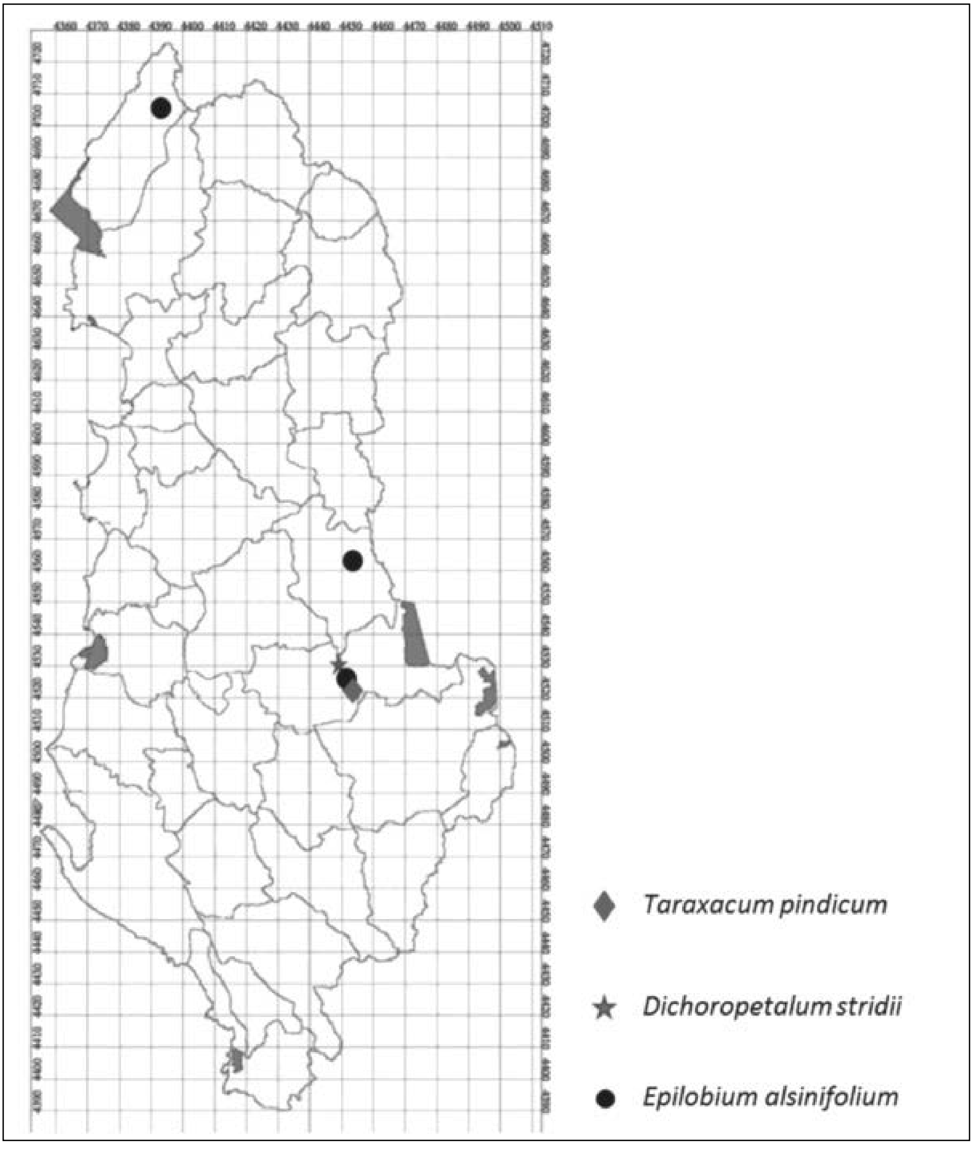

Fig. 2. Albanian map where is shown the location of new species reported for first time in territory of Albania.

Very rare in the mountains of Albania, so far known from altitudes between 1800 and 2000 m, where it occurs in wet places, along streams, at edge of mountain lakes, in flushes, exceptionally on shady, damp rocks on various substrates. Further localities can be expected in mountain habitats, especially in Northern and Eastern Albania.

Biological spectrum

Hemicryptophytes represent 57.0% of all species, followed by geophytes (13.8%), therophytes (11.8 %), phanerophytes (7.8%), chamaephytes (8.8 %) and hydrophytes (0.9%). In general, herbaceous species dominate (83.2%) as compared with trees and shrubs (16.8%). Hydrophytes were found in glacial lakes of Valamara and are represented mostly by *Potamogeton crispus, P. natans, P. pusillus, Nymphaea alba* and *Myriophyllum spicatum*, which, according to Pignatti (1982), belong to rooting hydrophytes. Lianas are represented only by *Clematis vitalba*. The high proportion of hemicryptophytes is determined by the fact that Balkan flora is dominated by hemicryptophytes (Stojanov 1924, 1950; Stojanoff 1941; Goranova & al. 2013) and their center of distribution is regarded Central Europe. The geographical position of Valamara mountain range and its high altitude, creates climatic conditions which favor these life forms (Cain 1950; Begon & al. 2006; Forseth 2012). The high influence of Mediterranean climate in the low altitude and the eroded areas with shallow soils have created favorable conditions even for a large number of therophytes (Stojanoff 1941; Stojanov 1950). High presence of geophytes is related to forest vegetation, which is dominant on the lower slopes of Valamara Mts as well as with the influence of human activity, especially with pastural activities (Tomović & al. 2005). More than 69% or 53 species of this life form were found in herbaceous layer of these forests. Due to the high altitude, where most of the surface is dominated by grassland vegetation, proportion of phanerophytes in the study area compared with the flora of Albania, is a bit lower, respectively 7.8% and 9.3%. A considerable area is destroyed and degraded and replaced by scrublands mainly dominated by *Juniperus communis, J. oxycedrus*, *Daphne oleoides,* etc.

Phytogeographical elements

The vascular plants belong to 57 chorological groups which are indicated in Table 2. After being grouped in ten larger centers, the analysis of chorological spectra showed that the highest number of the species originate from Eurasia (21.7%, 123 taxa), followed by Europe (18.3%, 104 taxa), Balkan (16.2%, 92 taxa), Mediterranean (11.5%, 65 taxa), boreal (10.6%, 60 taxa), Euro-Mediterranean (7.9%, 45 taxa), temperate (6.3%, 36 taxa), cosmopolitan / subcosmopolitan (5.1%, 29 taxa), endemic/sub-endemic (1.6%, 9 taxa); 0.7 % or 4 taxa originat from three other centers of distribution. The high number of species with southern centre of distribution like south Europe, Mediterranean, Euro-Mediterranean and Balkan species, are typical for xerothermic and xeromesophytic grassland communities (Pedashenko & Vassilev 2014), which are predominant in the Valamara Mts. The presence of a high number of boreal taxa (60 taxa, 10.6%), of which 9.1% belong to circumboreal taxa, 1.0% artic-alpine and 0.4% alpine, is quite high within the flora of

Albania (4.2%) and shows that the high altitude of Valamara Mts somewhat negates the effect of the Mediterranean climate and creates conditions which favor the growth of circumboreal species, mostly in its upper region.

The endemic and sub-endemic group comprise 9 species which represent 1.6% of the Valamara flora. *Festucopsis serpentini* is the only endemic species while sub-endemic species are represented by *Bornmuellera baldaccii, Campanula hawkinsiana, Cerastium smolikanum, Cistus albanicus, Onosma mattirolii, Taraxacum pindicum, Dichoropetalum stridii* and *Viola dukadjinica*. All these species occur in both Albania and Greece.

Table 2. Centre of distribution of vascular flora of Valamara Mts and number of species belonging to each chorological group.

	Phytogeographical elements	**Taxa No. (%)**
1	**Eurasian**	**123 (21.7)**
	1. Euro-caucasian	71 (12.5)
	2. Europ. - Siber (Euro-Siberian)	29 (5.1)
	3. Europ. - Asia (Eurasian)	10 (1.8)
	4. Orof. Europ. - Caucas. (Euro-caucasian orofil)	3 (0.5)
	5. S Europ-S Siber. (south European- south Siberian)	3 (0.5)
	6. S Europ - Subsiber (south European- sub Siberian)	2 (0.4)
	7. S Europ. - CaucAsia. (south European- asiatic Caucasian)	2 (0.4)
	8. Orof. Europ. - Asia (Eurasian orofil)	1 (0.2)
	9. Pontic	1 (0.2)
	10. Subpont. (sub Pontic)	1 (0.2)
2	**European**	**104 (18.3)**
	1. S Europ. (south European)	40 (7.0)
	2. Orof. - S Europ. (south European orofil)	22 (3.9)
	3. C Europ. (central European)	19 (3.3)
	4. Europ. (European)	11 (1.9)
	5. SE Europ. (southeast European)	6 (1.0)
	6. S Europ. - Pont. (south European- Pontic)	3 (0.5)
	7. Pontic-Europ. (Pontic-European)	1 (0.2)
	8. E Europ. (east European)	1 (0.2)
	9. Europ. - Balk (European-Balkan)	1 (0.2)
3	**Balkan**	**92 (16.2)**
	1. Balk. (Balkan)	53 (9.3)
	2. SubBalk (sub Balkan)	30 (5.4)
	3. Amphiadriatic	4 (0.7)
	4. StenoBalk. (steno Balkan)	3 (0.5)
	5. S Balk (south Balkan)	1 (0.2)
	6. Illir. (Anfiadriat.) (Anfiadriatic- Illiric)	1 (0.2)
4	**Mediterranean**	**65 (11.5)**
	1. Medit. (Mediterranean)	12 (2.1)
	2. Stenomedit. (steno Mediterranean)	10 (1.8)
	3. Orof-Medit. (Mediterranean orofil)	10 (1.8)
	4. NE Medit. (north east mediterranean)	6 (1.0)
	5. Medit.-Atlant. (Mediterranean atlantic)	5 (0.9)
	6. Orof. NE Medit. (north east Mediterranean orofil)	4 (0.7)

Table 2. continued.

	7. SubMedit. (Submediterranean)	3 (0.5)
	8. E Medit. (East Mediterranean)	2 (0.4)
	9. Medit.- Mont. (Mediterranean mountains)	2 (0.4)
	10. Medit.-Turan. (Mediterranean-Turanian)	2 (0.4)
	11. N Medit. (north Mediterranean)	2 (0.4)
	12. S Medit. (south Mediterranean)	2 (0.4)
	13. Stenomedit-N Orient. (steno Mediterranean- north Oriental)	2 (0.4)
	14. Orof. W Medit. (west Mediterranean orofil)	1 (0.2)
	15. NE Medit.-Pontic (north Mediterranean-Pontic)	1 (0.2)
	16. Stenomedit.-Turan. (steno Mediterranean- Turanian)	1 (0.2)
5	**Boreal**	**60 (10.6)**
	1. Circum.-Boreal (Circumboreal)	52 (9.1)
	2. Artico-Alpine (Artico-Alpine)	6 (1.0)
	3. Alpine	2 (0.4)
6	**Euro-Mediterranean**	**45 (7.9)**
	1. Europ. - Medit. (Euro-Mediterranean)	44 (7.7)
	2. Europ. - Medit.Occid. (Euro-Mediterranean occidental)	1 (0.2)
7	**Temperate**	**36 (6.3)**
	1. Pan-temperate	30 (5.3)
	2. Pan.subtrop. (pan-subtropical)	5 (0.9)
	3. Pantrop. (Pantropical)	1 (0.2)
8	**Cosmopolitan / sub cosmopolitan**	**29 (5.1)**
	1. Cosmop. (Cosmopolitian)	9 (1.6)
	2. Subcosmop. (sub Cosmopolitian)	20 (3.5)
9	**Endemic/Subendem. (Sub-Endemic)**	**9 (1.6)**
	1. Endem. (Endemic)	1 (0.2)
	2. Subendem. (Sub-Endemic)	8 (1.4)
10	**other**	**4 (0.8)**
	1. S Am (south Americ)	1 (0.2)
	2. C Asia (center Asia)	1 (0.2)
	3. Asia	1 (0.2)
	4. E Asia (east Asia)	1 (0.2)

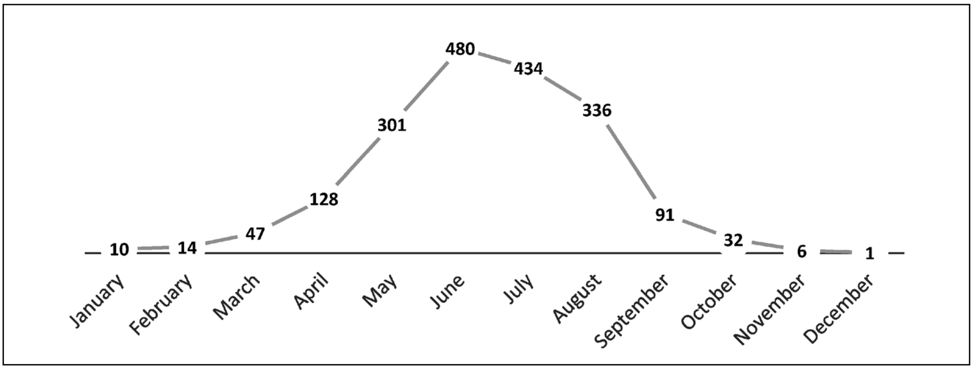

Fig. 3. Number of species in flowering by month.

Species with conservation values

Of the 567 taxa identified in the Valamara Mts, about 20.9% (119 taxa) have a conservation status as classified in the Albanian Red list or the IUCN Red list (Table 3). Forty-nine of them (41.2 % of the taxa with conservation status) are included in Albanian Red List, approved by the Decision of Council of Ministers in 2013. These species represent 12.2 % of the Albanian Red List of vascular plants. According to this national

Table 3. Species with a conservation status according IUCN red list (IUCN 2016) and Albanian red list (ARL) (Council of Ministers' decision 2013)

no.	**Taxa**	**IUCN**	**ARL**	**no.**	**Taxa**	**IUCN**	**ARL**
1.	*Abies alba*	LC		61.	*Festucopsis serpentini*		NE
2.	*Achillea millefolium*	LC		62.	*Gentiana lutea*		EN
3.	*Aconitum lamarckii*		VU	63.	*Gladiolus palustris*	DD	LR
4.	*Adiantum capillus-veneris*	LC	VU	64.	*Halacsya sendtneri*		EN
5.	*Agrimonia eupatoria*	LR		65.	*Herniaria parnassica*		EN
6.	*Agrostis canina*	LC		66.	*Hippocrepis comosa*	LC	
7.	*Alchemilla xanthochlora*	LC		67.	*Hordeum bulbosum*	LC	
8.	*Alkanna scardica*		LR	68.	*Hypericum perforatum*		EN
9.	*Allium schoenoprasum*	LC		69.	*Isatis tinctoria*	DD	
10.	*Alyssoides utriculata*		LR	70.	*Juncus conglomeratus*	LC	
11.	*Alyssum bertolonii*		LR	71.	*Juniperus communis*	LC	VU
12.	*Anthyllis vulneraria*	DD		72.	*Juniperus oxycedrus*	LC	VU
13.	*Aquilegia vulgaris*	DD		73.	*Lilium albanicum*		EN
14.	*Arabis hirsuta*	DD		74.	*Luzula forsteri*	DD	
15.	*Aster albanicus*		EN	75.	*Lythrum portula*	LC	
16.	*Athamanta turbith*		EN	76.	*Mentha longifolia*	LC	
17.	*Atropa bella-donna*		CR	77.	*Myriophyllum spicatum*	LC	
18.	*Berula erecta*	LC		78.	*Narthecium scardicum*		VU
19.	*Betula pendula*	LC	CR	79.	*Nasturtium officinale*	LC	
20.	*Blysmus compressus*	LC	CR	80.	*Neottia nidus-avis*	LC	
21.	*Bornmuellera baldaccii*		EN	81.	*Nymphaea alba*	LC	VU
22.	*Botrychium lunaria*		EN	82.	*Onosma mattirolii*		VU
23.	*Brachypodium retusum*	LC		83.	*Origanium vulgare*		EN
24.	*Calamagrostis pseudophragmites*	LC		84.	*Ostrya carpinifolia*	LC	
25.	*Caltha palustris*	LC	VU	85.	*Parnassia palustris*	LC	
26.	*Campanula hawkinsiana*		LR	86.	*Platanthera chlorantha*		
27.	*Campanula tymphaea*		LR	87.	*Phleum alpinum*	LC	
28.	*Carex digitata*	LC		88.	*Pinus heldreichii*	LC	
29.	*Carex distans*	LC		89.	*Pinus nigra*	LC	
30.	*Carex flava*	LC		90.	*Pinus peuce*	NT	EN
31.	*Carex nigra*	LC		91.	*Poa pratensis*	LC	
32.	*Carex paniculata*	LC		92.	*Polygonum amphibium*	LC	
33.	*Centaurea pindicola*		EN	93.	*Polygonum hydropiper*	LC	
34.	*Cerastium smolikanum*		CR	94.	*Populus nigra*	LC	
35.	*Chamaecytisus tommasinii*		EN	95.	*Potamogeton crispus*	LC	
36.	*Chamaespartium sagittale*	LC		96.	*Potamogeton natans*	LC	
37.	*Cephalanthera longifolia*			97.	*Rhus coriaria*	VU	
38.	*Cephalanthera rubra*			98.	*Salvia officinalis*	LC	VU

Table 3. continued.

39.	*Cistus albanicus*		EN	99.	*Sanguisorba officinalis*	LC	
40.	*Corylus avellana*	LC		100.	*Satureja montana* subsp. *montana*		VU
41.	*Crepis geracioides*		VU	101.	*Sedum serpentini*		LR
42.	*Crocus dalmaticus*		LR	102.	*Sesleria coerulans*	LC	
43.	*Cyperus difformis*	LC		103.	*Sideritis raeseri*	NT	
44.	*Cyperus flavescens*	LC		104.	*Silene vulgaris*	LC	
45.	*Cyperus fuscus*	LC		105.	*Silene caesia*		DD
46.	*Cyperus glaber*	LC		106.	*Silene tommasini*		EN
47.	*Cyperus longus*	LC		107.	*Sorbus aucuparia*	CR	
48.	*Dactylorhiza saccifera*			108.	*Stipa pulcherrima*	VU	
49.	*Dactylorhiza cordigera*	LC		109.	*Taxus baccata*	LC	VU
50.	*Dictamnus albus*		VU	110.	*Thymus teucroides*		DD
51.	*Centranthus longiflorus*		LR	111.	*Trifolium pratense*	LC	
52.	*Dryopteris filix-mas*			112.	*Trifolium pilczii*		LR
53.	*Eleocharis palustris*	LC		113.	*Trollius europaeus*		VU
54.	*Epilobium angustifolium*	LC		114.	*Urtica dioica*	LC	
55.	*Epilobium parviflorum*	LC		115.	*Vaccinium myrtillus*		VU
56.	*Epipactis palustris*	LC		116.	*Veronica beccabunga*	LC	
57.	*Equisetum palustre*	LC		117.	*Veronica serpyllifolia*	LC	
58.	*Equisetum telmateia*	LC		118.	*Viola dukadjinica*		LR
59.	*Eriophorum angustifolium*	LC		119.	*Viscum album*		VU
60.	*Euphrasia minima*	EX					

conservation status, 15 species (30.6%) are extinct (EX), 15 species (30.6%) vulnerable (VU), 11 species (22.4 %) of least concern (LC), five species (10.2 %) critically endangered (CR), four species (4.2 %) DD (deficient data), and one species (2.1 %) NE (not evaluated). According to the IUCN Red List 76 species were evaluated, which represent 13.4 % of all vascular flora of the study area. Conservation status for about 84 % is categorized as least concern (LC), 8 % deficient data (DD), 3 % vulnerable (VU), 3 % near threatened (NT), 1 % extinct category (EX), 1 % critically endangered (CR). *Gentiana lutea* and *Gladiolus palustris* are two species which are part of the Habitats Directive, respectively in Annexes V and II, IV. *Centranthus longiflorus* is listed in Annex I of Bern Convention and seven species of orchids are listed in Appendix II of CITES viz., *Cephalanthera longifolia*, *Cephalanthera rubra*, *Dactylorhiza saccifera*, *D. cordigera*, *Epipactis palustris*, *Neottia nidus-avis*, *Platanthera chlorantha*.

Analysis of flowering period

The flowering period and flowering state are important for plant identification and choice of time for the field trips. June is the month with the greatest number of species in flower (481 species), while the month with the fewest species in flower is December, only *Taraxacum haussknechtii* (September to December).

About 52.7% (299 species) of taxa flower from January to July. Of these 221 species or 73.6% belong to hemicryptophytes, geophytes and therophytes, which finish flowering before the environmental conditions which characterize serpentine substrate (high temperature and low humidity) reach the extreme values.

During the warmest months of July and August, only 41 species begin flowering., and of these 10 species arecircumboreal and, Euro-Siberian. In Valamara Mts these species occur at high altitudes. Fig. 3 shows the number of species in flower every month.

Discussion and conclusions

The predominance of *Asteraceae* is clear; other families (e.g., *Brassicaceae*, *Caryophyllaceae*, *Cyperaceae*, *Fabaceae*, *Lamiaceae*, and *Rosaceae*) have only half the number of species.

In Valamara Mts hemicryptophytes are the dominant life form, however, geophytes, therophytes, phanerophytes and chamaephytes, all are represented by a high number of species. The high dominance of hemicryptophytes even in Valamara Mts, as other Balkans territory such as Bulgaria, Sokolovica Mt in Serbia and Montenegro (Uzunov & Gussev 2003; Tomović & al. 2005; Vuksanović & al. 2016), support the fact that flora of Balkan is dominated by this life form (Goranova & al. 2013). Though Bulgaria is more continental and less mediterranean as compared with Albanian, the high altitude of Valamara reduce the influence of the Mediterranean climate and make its climate more continental so that both these areas have similarities in their percentage of life forms. The high number of geophytes in the upper regions of Valamara Mts is related to the extreme conditions of cold winters and summer drought, and as influenced by pastural activities, such is overgrazing (Tomović & al. 2005). In the flora of Montenegro where the average altitude is lower and climatic conditions not so extreme and pastural activities less abundant, the number of geophytes is lower and after hemicryptophytes, the second life form with the greatest number of the species is represented by chamaephytes. In general, herbaceous species dominate (83.2%).

The high percentages of Euro-Caucasian, circumboreal, Euro-Siberian, south European and central European species are related to the high elevation of the Valamara Mts. A considerable number of species which are Mediterranean, Balkan, Euro-Mediterranean, south European and sub-Mediterranean, reflect a modified-Mediterranean to moderate climateas characteristic oft the lower parts of the range.

Taking into consideration the study area as compared to other Albanian territorities, the presence of 119 plant taxa with a conservation status, representing 20.9% of the vascular flora, makes this mountain range of some importancefor nature conservation. Eight subendemics occur in the Valamara Mts. In the Balkans, Greece possibly the country with the highest number of endemic taxa, ca. less than 900 (Kit Tan, pers. comm. 2017). The discoveries of *Taraxacum pindicum, Dichoropetalum stridii* and *Cerastium smolikanum*, the latter reported by Shuka & Tan (2009), in the Valamara Mts reduced them as endemics to Greece, and the Valamara Mts are now the northernmost localities for these species.

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Khellaf Rebbas

Première observation de *Physalis acutifolia* (*Solanaceae*) dans la région de M'Sila (Algérie), nouvelle pour l'Afrique du nord

Abstract

Rebbas, K.: Première observation de *Physalis acutifolia* (*Solanaceae*) dans la région de M'Sila (Algérie), nouvelle pour l'Afrique du nord. — Fl. Medit. 28: 21-25. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Physalis acutifolia (*Solanaceae*), native to the southwestern United States, California Texas, and northern Mexico, has been observed in many localities in the M'Sila region, central north Algeria. Distribution and ecological notes are also provided. This is the first report of this species in N Africa.

Key words: xenophytes, weeds, North Africa, medicinal plants.

Introduction

Le genre *Physalis* comprend un certain nombre d'espèces comestibles et ornementales d'importance commerciale. Sa haute valeur nutritionnelle et ses propriétés médicinales potentielles entraînent un intérêt commercial accru pour les produits de ce genre dans le monde entier (Wei & al. 2012).

Ce genre contient plus de 90 espèces dont 35 dans la région de Mexique (Cuevas-Arias & al. 2008). *Physalis acutifolia* (Miers) Sandw. (= *Saracha acutifolia* Miers, *Physalis wrightii* Gray) est originaire des États-Unis, de la Californie au Texas, et au nord du Mexique, où il peut être trouvé dans de nombreux types d'habitats, y compris les zones perturbées. C'est parfois une mauvaise herbe quand elle se développe dans les champs agricoles, mais elle n'est généralement pas envahissante dans l'habitat sauvage.

En Afrique du nord, la plante n'est pas citée dans l'index de Dobignard & Chatelain (2010-2013). De même aucune flore ou catalogue d'Algérie (Battandier 1888-1890; Battandier & Trabut 1905; Maire 1952-1987; Quézel & Santa 1962-1963; Ozenda 1983) ni même de Tunisie (Bonnet & Barrate 1896; Pottier-Alapetite 1979-1981; Le Floc'h & al. 2010; Guittonneau 2011), ni aussi au Maroc (Fennane & Ibn Tattou 1998, 2005; Fennane & al. 2007) ne signale ce taxon. Cette plante n'est pas signalée dans l'Euro+Med PlantBase (Euro+Med 2006-) et pas même dans les plus récents contributions sur les espèces étrangères dans les territoires voisins (Celesti Grapow & al. 2016).

L'index de Dobignard & Chatelain (2010-2013) a cité 5 espèces de *Physalis*: *P. alkekengi* L. et *P. viscosa* L. au Maroc, *P. angulata* L. en Mauritanie, Maroc, Egypte, *P. ixocarpa* Hornem. en Egypte, *P. peruviana* L. en Madère, Mauritanie, Maroc.

En Algérie, Munby (1847) a signalé *Physalis somnifera* L., sur les décombres autour d'Alger, au cimetière des Juifs à Bab-el-Oued.

Description botanique et répartition géographique

Physalis acutifolia (Miers) Sandw. est une plante annuelle, avectiges et branches étalées et ascendantes, pubescentes et légèrement pubescentes sur les bords et les nervures des feuilles, plus denses sur les nouvelles pousses, les tiges atteignant 50 cm de long; poils atteignant 1 mm de long, non glanduleux. Feuilles elliptiques, souvent étroites, parfois lancéolées ou ovales, de 4-12,5 cm de long, de 1-5 cm de large, 1,8-6 fois plus longues que larges; base aiguë à acuminée souvent obliquement ainsi; apex aigu à acuminé; bords dentés à incisés ou dentés. Fleurs de 0,7-1,2 cm de long; pédoncule de 1,2-3 cm de long, habituellement environ 2-3 fois plus long que la fleur; calice de 0,3-0,5 cm de long, les lobes étant aussi longs que le tube; corolle blanc jaunâtre, parfois avec centre obscurci orange jaunâtre, 1-2,2 cm de large; anthères jaunes, 3-4 mm de long, environ 3-4 fois plus longues que larges. Le calice ovoïde, 1,2-2,3 cm de long, 1-2 cm de large, baie de 0,6-1,3 cm de diamètre; graines lenticulaires, 2-2.2 mm de large. Floraison et fructification, Juillet-Septembre (Landrum & al. 2013)

Dans la région de M'Sila, cette solanacée a été observée dans 5 stations localisées dans des champs de culture du piment (Tableau 1, Fig. 1 et 2).

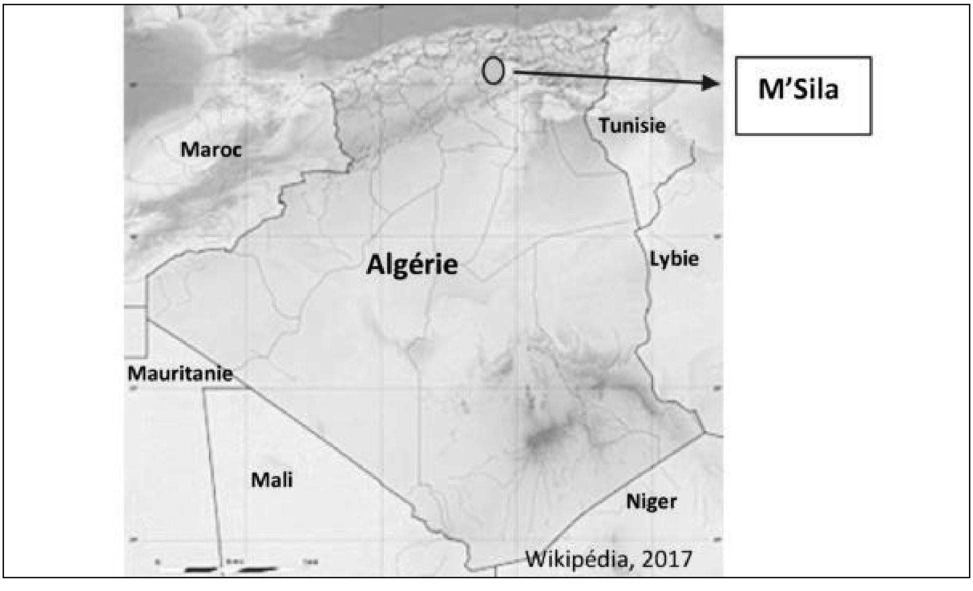

Fig. 1. Localisation géographique de la région de M'Sila.

Tab. 1. Localisation des stations d'observation de *P. acutifolia* dans la région de M'Sila.

Station	Nbre de plantes	N	E	Altitude (m)	Date
Lamarate	3	35°32′58′′	04°29′21′′	380	18/8/2017
Saïda	7	35°35′12′′	04°29′45′′	376	18/8/2017
OuledMadi	4	35°36′25′′	04°30′16′′	361	18/8/2017
El Beida	3	35°37′17′′	04°29′39′′	424	18/8/2017
Maaza	2	35°52′16′′	04°23′45′′	696	15/9/2017

Fig. 2. *Physalis acutifolia* (1. Habitat: champ de culture du piment; 2. Port; 3. Fleur; 4. Fruit, photos: K. Rebbas, 18.8.2017).

Intérêts et Activités pharmacologiques

Physalis L. est un genre américain qui a une utilisation alimentaire enracinée dans l'alimentation quotidienne de nombreuses régions géographiques du Mexique, où les espèces *P. philadelphica* et *P. angulata*s ont cultivées, ainsi que la récolte des fruits d'au moins une douzaine d'espèces sauvages. Les preuves de la valeur nutritive et fonctionnelle des fruits sont passées en revue, citant le contenu de certaines espèces en fibres, minéraux, protéines, lipides solubles et sucres, ainsi que les vitamines A et C, certains principes phytochimiques bioactifs aux propriétés antioxydantes, anti-cancer, anti-inflammatoire et antibiotique, entre autres. Ces propriétés font des tomates à coque des modèles biologiques de grand intérêt pour les industries agricoles et pharmaceutiques (Vargas-Ponce 2015).

Les plantes de *Physalis* sont aussi largement répandues dans toute l'Inde, la Chine et d'autres pays subtropicaux. Les alcaloïdes, les flavonoïdes et les withanolides sont les constituants primaires des espèces de *Physalis* principalement considérées pour être responsables de ses actions thérapeutiques larges. En dehors de l'activité analgésique, ces plantes sont utilisées pour traiter le cancer, la leucémie, l'hépatite, ayant des propriétés comme hépatoprotecteur, diurétique, anti-ulcère, anti-microbienne, anti-oxydante, anti-inflammatoire, une activité protectrice rénale (Jyothibasu &Venkata 2015). D'autres espèces de même genre comme *Physalis somnifera* L. (*Withania somnifera* (L.) Dunal) a été utilisée pendant des siècles dans la médecine traditionnelle indienne (Mirjalili & al. 2009; Pandit & al. 2013). Au Yémen, où il est connu sous le nom d'ubab, les feuilles séchées sont broyées en une poudre à partir de laquelle une pâte est fabriquée et utilisée pour les brûlures et les plaies (Hehmeyer & Schönig 2012).

Conclusion

Physalis acutifolia, ainsi que pour la flore d'Afrique du Nord, est une nouveauté pour toute la région méditerranéenne. Cette découverte enrichit davantage la flore vasculaire algérienne et elle constitue un ajout important pour la flore médicinale du pays.

Elle est fort probable que la population de *P. acutifolia* provient de graines introduites au niveau des champs de culture du piment.

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Je tiens à remercier vivement Marcus Joseph A.(Lady Bird Johnson Wildflower Center, Texas) qui m'a aidé à identifier cette solanacée et le (s) relecteur(s) anonyme(s) pour les diverses améliorations apportées pour ce travail.

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A revision of *Allium* subsect. *Allium* (*Amaryllidaceae*) for the Maltese Islands

Abstract

Mifsud, S. & Mifsud, O.: A revision of *Allium* subsect. *Allium* (*Amaryllidaceae*) for the Maltese Islands. — Fl. Medit. 28: 27-51. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

A revision of species in *Allium* subsect. *Allium* occurring on the Maltese Islands was done on field and herbarium data. *A. ampeloprasum* L., the presumed endemic *A. melitense* (Borg.) Ciferri & Giacomini and *A. commutatum* Guss. are the three species mentioned in the Maltese floras within this group. The results clearly encompassed four different taxonomic units, corresponding to *A. polyanthum* Schult. & Schult. f. which has never been recorded for the Maltese Islands, two populations of *A. commutatum* and two forms (one sterile, one fertile) of their putative hybrid *A. commutatum* × *A. polyanthum* growing on few coastal areas. *A. ampeloprasum* is excluded from the Maltese islands while *A. melitense* is synonymised with *A. polyanthum*. All past records of *A. commutatum* (apart from a giant form) are referred to *A. polyanthum*. Moreover, *A.* . *commutatum* × *A. polyanthum* is reported from Sicily for the first time.

Key words: *Allium polyanthum*, *A. commutatum*, Malta, Central Mediterranean region.

Introduction

The classification of the genus *Allium* (*Amaryllidaceae*) has been intricate since the pioneer work of Don (1827) and subsequent treatments (Regel 1875; Vvedensky 1935; Feinbrun 1943; Omelczuk 1962), but recent classifications (Friesen & al. 2006; Nguyen & al. 2008; Li & al. 2010) divided the genus into three unnamed clades which are referred to as *lineages*, and which together form 15 different subgenera. These clades were raised to generic level (*Allium*, *Caloscordum* and *Nectaroscordum*) by Banfi & al. (2011) although this treatment is still questionable. Subgenus *Allium* is further divided into fifteen sections, of which section *Allium* is represented by some 115 species. This is further subdivided into two subsections (Hermann 1939): subsect. *Oenoprason* F. Herm. which is characterised with leaves having a semicircular or oblong cross-section and subsect. *Scordoprason* F. Herm. with flat, channelled or V-shaped leaves (Mathew 1996). According to the article 22.1 of the ICN (McNeill & al. 2012) subsect. *Scordoprason* is superfluous and should be corrected to subsect. *Allium*.

The following native species of *Allium* sect. *Allium* have been recorded for the Maltese Islands (Weber & Kendzior 2006; Mifsud 2002-2014; Casha 2013): *A. amethystinum* Tausch. (*Allium* subsect. Oenoprason), *A. ampeloprasum* L., *A. melitense* (Sommier & Caruana Gatto) Ciferri & Giacomini (a putatively Maltese endemic) and *A. commutatum* Guss. The latter three species within subsect. *Allium* are dealt in this study.

The first *Allium* species recorded on the Maltese Islands was *A. ampeloprasum*, with the Maltese name "*Korrat selvaġġ*" (wild leek), flowering in June and growing in fields together with the cultivated *Allium porrum* "Korrat" (Zerapha 1827). Grech Delicata (1853) also listed *A. ampeloprasum* as the single species of wild leek in Malta, where he reports it from cultivated and uncultivated places as at Corradino.

Sommier & Caruana Gatto (1915) catalogue *A. ampeloprasum* in their flora which they reported it to grow in various locations on rocky ground, especially near the sea. Additionally, they described a new variety from Boschetto – *A. ampeloprasum* var. *melitense,* which they distinguished because of its smaller hemispherical inflorescences up to 3 cm accross and for being plants with a more delicate habit reaching only up to 25 cm in height. They state that this local variety is similar to *A. ampeloprasum* var. *hemisphericum* Sommier (= *A. hemisphericum* (Sommier) Brullo) from Lampedusa and to *A. preslianum* Schult. & Schult. f. (=*A. rotundum* L.), adding that it should be studied in a more taxonomic depth while retaining *A. ampeloprasum* var. *melitense* as a provisional name.

Borg (1927) classifies *A. ampeloprasum* into three varieties: *A. ampeloprasum* var. *ampeloprasum* (Maltese: Kurrat selvagg) which flowers in April-May and is very common in rocky places near the sea and near fields; *A. ampeloprasum* var. *porrum* (Maltese: Kurrat) which is widely cultivated and *A. ampeloprasum* var. *melitense* considered endemic to Malta. This variety was then elevated to a species level in the catalogue of Italian Flora by Ciferri & Giacomini (1950).

Subsequent floristic accounts and publications maintained Borg's treatment (Lanfranco G. 1960, 1969; Haslam & al. 1977), until Lanfranco (1989) put forward for the first time the species *A. commutatum* in the Red Data Book. He also quesioned the systematic status of *A. melitense*. Additionally, reference was also made to giant forms of '*A. commutatum*' occurring on the islets of Filfla and General's Rock (found by Michael Briffa). It was concluded that *A. ampeloprasum* complex required further critical investigations (Lanfranco 1989; Lanfranco & Bonnett 2015). Our preliminary field observations also confirmed that the species within *Allium* sect. *Allium* are not represented correctly in the Maltese florae and local floristic accounts and hence a taxonomic revision was carried out.

Materials and methods

The study on *Allium* subsect. *Allium* was carried out between 2014 and 2016 both in Malta and Gozo, mostly from wild samples but cultivated escapees were also included. In addition, material from Cava d'Aliga and Marina di Modica, Ragusa, Sicily; and a three specimens from Nantes, France (submited from cultivation by Errol Vela) were also studied for comparison purposes. A total of 165 specimens were examined in this study. Relevant Herbarium specimens are deposited in the author's personal herbarium and in the National Museum of Natural History in Mdina, Malta. Electronic Supplementary File

(ESF) 1 provides information about the material studied including the date of examination, location, (locality and toponym) and the habitat. According to keys and species descriptions by Stearn (1980), Mathew (1996), Aedo Pérez (2014), Tison & al. (2015) and Pignatti (2017), the following set of morphological characters were chosen *a priori* for this study: plant height; width of longest leaf; colour and size of leaf sheath; inflorescence size; proportion of the leaf-sheathing along the stem; presence and morphology of papillae on margin and keel of leaves; colour of tepals and their midvein; size and shape of tepals including the apex; presence and distribution of papillae on tepals; shape and size of tepal's papillae; shape of stamens (filaments and cusps); ratio of the length of the cusps with that of the lamina of inner stamens whorl; the protrusion of anthers from corolla and finally the shape, colour and size of the bulblets. The length of the beak of the spathe was found to be important and measured for a smaller sample of specimens. The most important diagnostic characters used to circumscribe taxa were the foliar and floral papillae, morphology of the stamens (protrusion, shape of stamens and length of cusps) and the shape and size of the bulblets. The flowering time, width of leaves, colour of tepals and length of spate were of additional support to carry out taxon circumscription.

Results

The character states recorded from 165 specimens are given in the ESF 2. On studying critically the diagnostic characters, four distinct groups (taxonomic units) from wild populations were circumscribed and referred to as P, C, G and Z. The fifth group consisted of cultivated specimens (or escapees) and was labelled as taxon K. A summary of the relationship of these characters and how they were employed to delimit these five taxa is summarised in Table 1, while a detailed account is given below.

Foliar papillae on leaf margins and keel

Seven types of leaf margins labelled A to G have been defined according to the presence, weathering, persistence, continuity, gruoping, regularity, size and shape of minute papillae lining the margins and keel of young leaves. Leaf papillae can be classified in two groups: i) types A to C with small, hemispherical or tuberculate papillae not longer than 75 µm and at various levels of weathering - completely weathered or absent in type A to partially preserved in Type C, not detected by the unaided eye (observed under ×40 magnification); and ii) types D to G composed of larger papillae, 100–400(–500) µm and usually visible by the naked eye or a lens; persistent even in old leaves during inflorescence, with various shapes including subspherical and rounded (Type D) to digitiform (Type E) or teat-shaped, hence with a broad base and slightly swollen tips (Type E and F). Leaf margins were found to have either simple and homogenous papillae (Types A to D and Type G) or complex, irregular and grossly heterogenous as in Type F and sometimes in Type E.

The seven types of leaf margins (type A to type G) are illustrated in Fig. 1 and described below:

A: Smooth; margin a narrow hyaline lining without any papillae (Fig. 1a).

B: Subcrenulate; margin almost smooth but with flattened, weathered papillae (≤ 25 µm long) not visible to the unaided eye (Fig. 1b).

Table 1. Main distinctive characters of the five groups recognized.

Diagnostic character	**Group P**	**Group Z**	**Group G**	**Group C**	**Group K**
Length of plants (cm)	(15–)50(–100)	(80–)120(–180)	(80–)120(–180)	(60–)100(–150)	70–120
Length of foliar papillae (µm)	25–75	150-250	150-250	100-200	300-450
Weathering of foliar papillae	Yes, leaf margin becomes smooth	No	No	No	No
Shape of foliar papillae	Homogenous, simple, subcylindrical	Heterogenous, various shapes simple and complex forms	Heterogenous, various shapes simple and complex forms	Homogenous, simple, hemispherical, or broadly conical	Homogenous, digitiform
Length of spathe beak (cm)	2–5	6–11	7–13	15–30	Not recorded
Flower colour	Lilac to pale purple	Dark purple	Dark purple	White or pale green	Light purple
Stamen protrusion	Included or partially exserted	Fully exserted	Fully exserted	Fully exserted	Fully exserted
No. of cusps on the internal stamens (Fig. 4)	1 Type A	1(–2) Type A & B	(1–)2–3 Type C & D	(2-)3 Type D (& C)	1 Type A
Papillae on internal tepals (Fig. 9)	Absent or very few	Numerous small papillae throughout entire tepal	Numerous small papillae throughout entire tepal	Numerous small papillae throughout entire tepal	Numerous small papillae throughout entire tepal
Distribution of papillae on tepals (Fig. 9)	Type A	Type C	Type C	Type B	Type D
Bulblet shape and size (mm). (Figs. 10 & 11)	Type A, 4–9, homogenous	Type C, 8–18, heterogenous	Type C, 8–18, heterogenous	Type B, 15–35, homogenous	Type B, but less compressed 18–25, homogenous
Seeds	Fertile	Fertile	In majority sterile	Fertile	Not recorded
Flowering period	Beg May to end of May	End May to mid June	Beg/mid June to end of June	End of June to mid July	End May to end June

C: Irregularly subcrenulate-scabridulous; margin with short, narrow conical or subdigitiform papillae, 25–75 µm long, visible with a a magnyfing glass, often in an irregular or patchy distribution present towards the terminal part of leaf (Fig. 1c).

D: Regularly scabrid by subspherical or widely conical papillae,100–200 µm long simple, widely spaced, homogenous present along entire margin (Fig. 1d).

E: Regularly denticulate-scabrid by short digitiform to tuberculate papillae, 200–300 µm long, mostly simple, densely packed, homogenous or heterogenous, present along entire margin (Fig. 1e).

F: Irregularly denticulate-scabrid due to a mixture of large, cylindrical, digitiform or tuberculate papillae 200–300 µm long and small, hemispherical or subdigitiform papillae 50–75µm long, often with irregular and complex papillae, densely packed, heterogenous, present along entire margin (Fig. 1f).

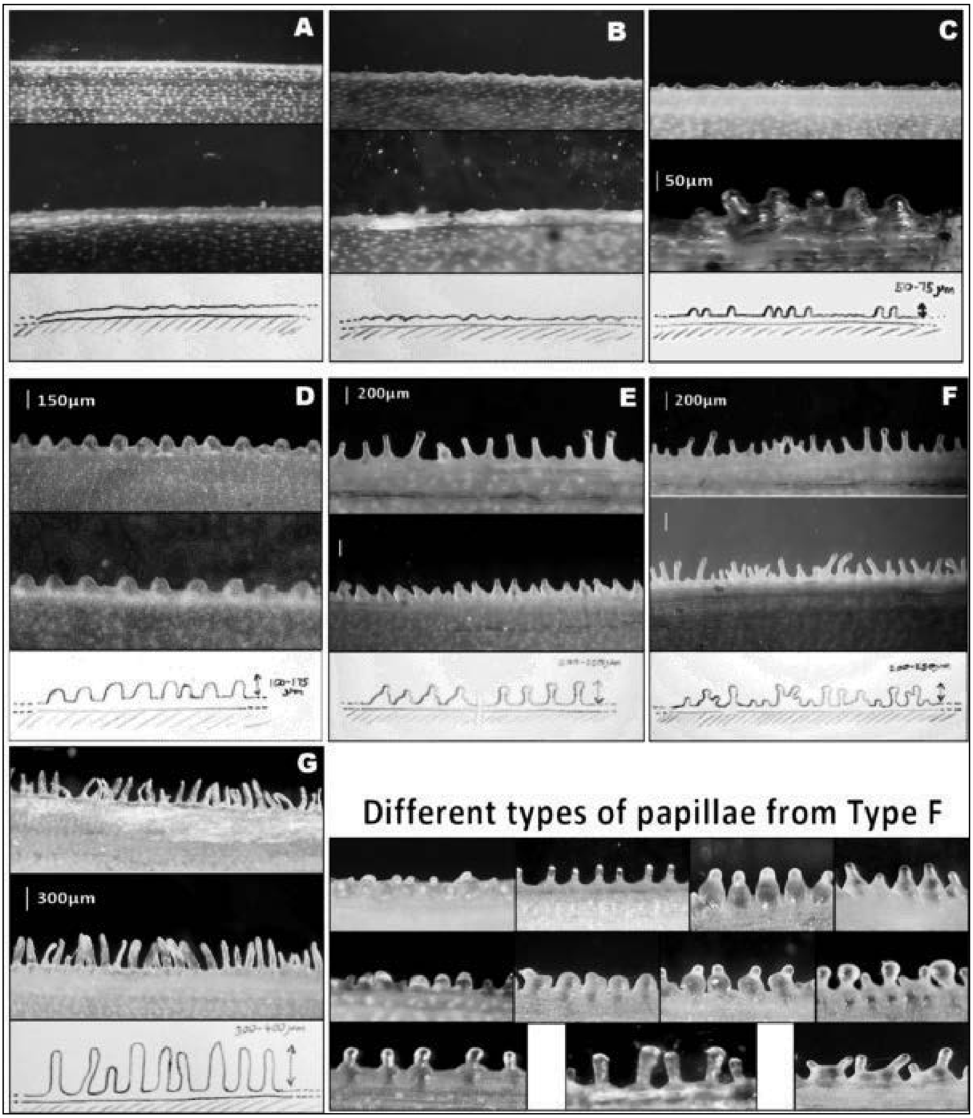

Fig. 1. Different types of leaf margins based on the presence and type of papillae. Type A: smooth (*A. polyanthum*: specimens AS523c, AS524a); Type B: subcrenulate with weathered flat papillae (*A. polyanthum*: specimens BS502b, AS601a); Type C: subcrenulate-scabridulous with small cylindrical papillae, 25–75 µm long (*A. polyanthum*: specimens AS513a, AS513b); Type D: scabrid with spherical papillae, 100–200 µm long (*A. commutatum*: specimen BS627a, CS625a); Type E: regularly denticulate-scabrid with short digitiform to tuberculate papillae, 200–300 µm long, homogenous morphology (*A. commutatum* × *A. polyanthum*: specimen AS601f & BS612a); Type F: irregularly denticulate-scabrid with variously-shaped papillae, 200–300 µm long, heterogenous morphology (*A. commutatum* × *A. polyanthum*: specimen AS601e & BS606a), where the various shapes of papillae observed are illustrated in the bottom right inset; Type G: dentate-subpilose with digitiform papillae, 300–400 µm long (*A. porrum* var. *kurrat*: specimen BS603b & BS606e).

G: Dentate-subpilose with relatively long, slender, digitiform papillae without swollen tips, 300–500 µm long, usually simple, densely packed, homogenous, present along entire margin (Fig. 1g).

Different shapes of papillae have been observed within the examined specimens, but plants in Taxon Z and G and had very heterogenous papillae (Type F) with variable shapes; either observed from different specimens of the same population or along leaf margins of the same specimen. Eight papillae forms have been in fact classified as shown in Fig. 1f: minute-pustulate; slender digitiform; swollen digitiform; hemispherical-doliform; hemispherical with eccentric narrow bulging ends; hemispherical with central wide bulging ends (russian dolls); subcapitate; capitate with swollen heads (teat-shaped); and complex forms with wide bases and 2 or 3 bulging or projecting ends. It is likely that these morphological combinations are the result of the merging of narrow digitiform or pustulate papillae (e.g. Type C) with broad, hemispherical-doliform papillae (e.g. Type D).

Based on foliar papillae, four unit were segregated as follows: taxon group P with type A, B, or C papillae (smooth or weathered); taxon group C with type D papillae (homogenous and persistent); taxon group Z and G with type E or type F papillae (persistent, heterogenous, simple or complex) and the cultivated taxon group K with type G papillae (very long and subpilose margin).

Plant, leaf and umbel sizes

The examined specimens can be divided into two groups based on the plant plant height, leaf width and inflorescence sizes. Taxon P made most of one group while taxon C, G, Z and K represented the other group.

Group 1 (taxon P): smaller plants with height of (16–)25–80(–105) cm (=55 cm), (2–)4–12(–20) mm wide(=8.5 mm), and smaller flower-heads measuring (11–)22–48(–66) mm wide (=35 mm);

Group 2 (taxon C, G, Z, and K): larger plants (65–)90–158(–181) cm long (=125 cm), leaves with a pale yellowish-green hue, (12–)16–28(–34) mm wide (=22 mm), and larger flower heads measuring (30–)42–72(–90) mm wide (=57 mm).

Group C from Sicily were at the lower range of group 2 and upper range of group 1. Groups G and Z had the largest plants in terms of plant size, leaf width and flower head diameter.

Stamens: cuspidate filaments and anther protrusion

All examined material was found to have tricuspidate inner stamens with the median cusp being firm and bearing a fertile anther, whereas the lateral cusps were much longer, thread–like, spindly, often found coiled, initially attached with a sterile anther which usually falls prematurely. The lateral cusps were longer than the median by (1.8)–2–4(–4.5) times and could not be used to segregate specimens in any distinct group. However, the ratio of the length of the filament's lamina to the median cusp was more useful, and specimens could be divided into two groups: one group had the lamina subequal or only slightly longer from the median cusp by (0.9–)1.5(–2.0) times; while lamina of the other group was in comparison longer by a ratio of (2.2–)3.0–4.0(4.5). The former group had a more distinct and longer median cusp resulting in the exertion of its anthers well out from the corolla mouth by 2 mm or more. Taxon group C, Z, G and K had this latter type of stamens while taxon group P had shorter median cusps with their anthers at the level of the corolla mouth or just exserted by 1 mm. (Fig. 2).

The amount of protrusion of the anthers out of the urn-shaped or bell-shaped perigone is reported to be a very important character. In this study, it was found that this character is not very easy to assess or reliable because for instance, some flowers had their anthers protruding half-way through the orifice of the corolla mouth, whereas others had stamens protruding marginally by about 1 mm within the same specimen. For consistency this observation is carried out only at pollination. As described in the methodology, stamens had to be exserted by 2 mm or more from the corolla mouth to be classified as exserted anthers, otherwise they were classified as included anthers. Only taxon group P was found to have included anthers.

More important and much easier to evaluate was the variation in the number of cusps observed in the outer whorl of stamens. The studied material could be reliably divided into four groups based on four types of outer stamens labeled Type A, B, C and D as shown in Fig. 3. Type A consisted of specimens with an outer whorl of three simple, completely non-cuspidate, stamens bearing a fertile stamen. Some individuals had monocuspidate stamens but with a small and partial secondary tiny cusp, often detected by a hand lens or magnified images. This is indicated by an arrow in Fig. 3-B3 and 3-B4. Stamens with this morphology were grouped as Type B stamens. Type C stamens had a mixture of two or three cusps (rarely just one) and often with one of the cusps of half or partial length. Leeks with an

Fig. 2. Protrusion of stamens from corolla mouth. A: Included, partially exserted, or shortly exserted by 1 mm (*A. polyanthum*: left BS505a; centre AS524c; right BS512a); B: conspicuously exserted at least by 2 mm (left: *A. commutatum* (CS625a); centre: *A. commutatum* × *A. polyanthum* (BS609a); right: *A. commutatum* (BS627f)).

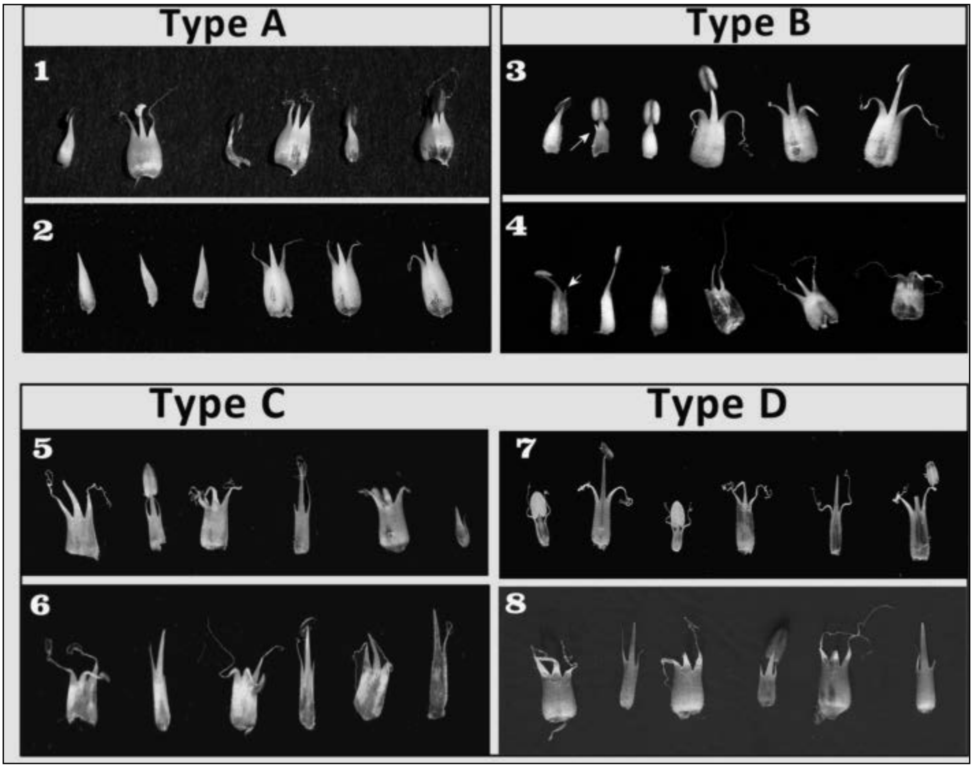

Fig. 3. Stamen morphology. Type A: inner and outer whorls simple and monocuspidate (*A. polyanthum*, top:AS509a; bottom:AS523c); Type B: inner whorl tricuspidate, outer whorl simple and monocuspidate sometimes with a partial lateral cusp (*A. commutatum* × *A. polyanthum*, top:AS601e; bottom:BS606c); Type C: inner whorl tricuspidate, outer whorl with two or three cusps, sometimes with a partial lateral cusp, rarely simple (*A. commutatum* × *A. polyanthum*, top:BS612b; bottom: BS609a); Type D: inner and outer whorls tricuspidate, rarely the outer whorl with a reduced lateral cusp (*A. commutatum*, top:BS627c; bottom:CS625a).

outer whorl of tricuspidate stamens, more or less consistently found so within different flowers were categorized as type D stamens. It is here hypothesized that individuals having Type B stamens with 1-2 cusps or Type C stamens with 2-3 cusps represent an intermediate morphological state between simple monocuspidate stamens (Type A) and tricuspid stamens (Type D).

All specimens within groups P and K had type A stamens, whereas group C and the cultivated specimens had type D stamens. Group Z mostly had type A and type B stamens while group G predominantly had type C stamens (occassionally type D).

Floral papillae

Two types of papillae have been detected: (i) small pustulate papillae 25–40 µm wide, not visible by the naked eye, subcylindrical, slightly longer or subequal to their diameter and (ii) large papillae (80–)100–150(–170) μm wide, hemispherical, fusiform or compressed conical papillae, shorter than their length. The presence and distribution patterns of these two types of papillae on the external and internal petals are classified in four types as follows (Figs 4 to 8):

Type A: Internal tepals without papillae. External tepals with large papillae, 100–170 μm mostly present on the keel sometimes merging forming 'walls', with their frequency decreasing abruptly towards the margin, hence becoming absent at the lateral borders of the tepals. Papillae not numerous and visible to the naked eye mostly compressed spherical-fusiform in shape - Fig. 4 and Fig. 8.

Type B: Internal tepals with small, subcylindrical papillae 25–40um wide. External tepals also with similar small papillae, uniformly distributed throughout the entire surface of the tepal. Large papillae absent or few broad, large hemispherical papillae 80–110um wide restricted only at a small part of the keel - Fig. 5 and Fig. 8.

Type C: Internal tepals with small, subcylindrical papillae, 25–40 μm wide. External tepals with two types of papillae; small (25–40 μm wide) pustulate papillae uniformly dis-

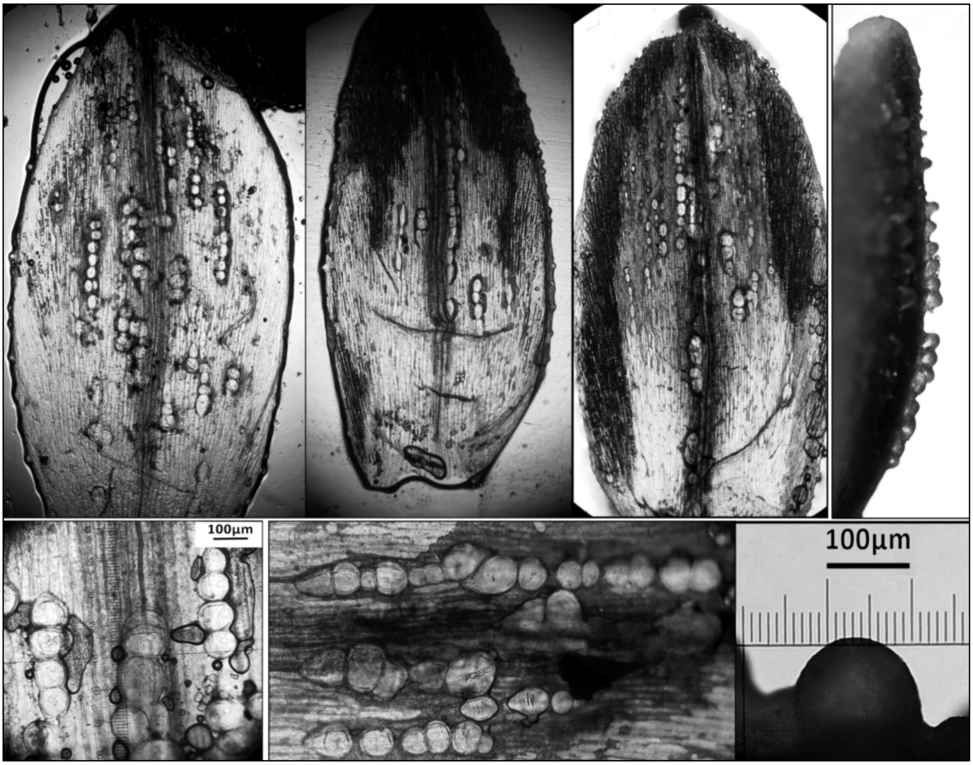

Fig. 4. Type A floral papillae on external tepals of Group P (*Allium polyanthum*), characterised by large hemispherical papillae distributed on and close to the keel, often subfused forming rows or walls, (100–)120–170 μm wide.

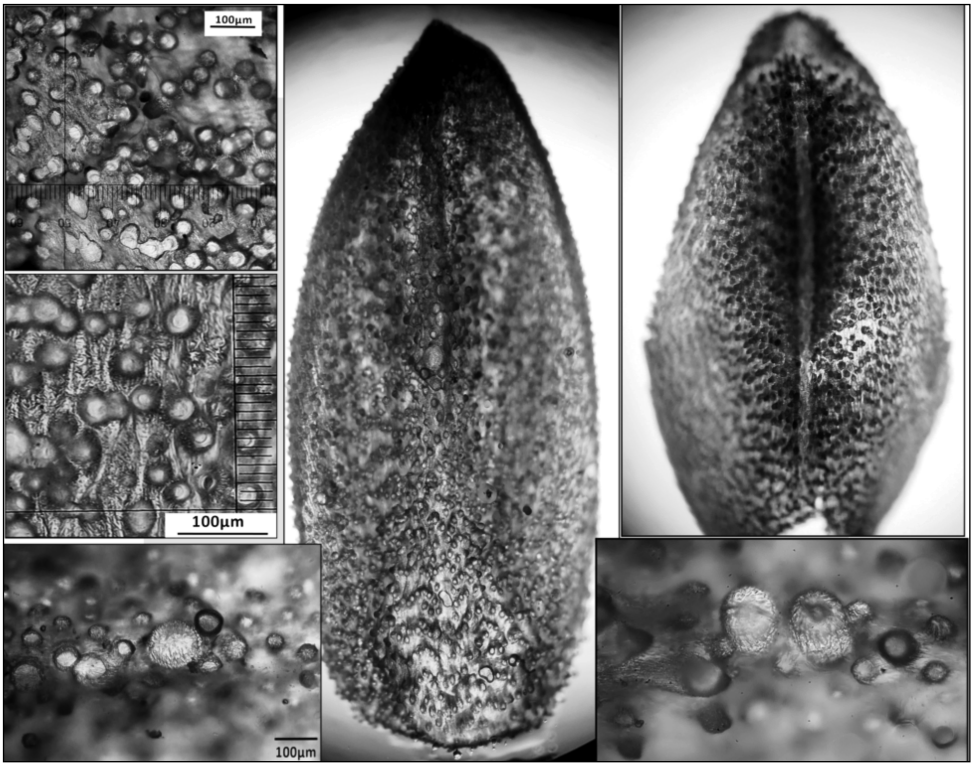

Fig. 5. Type B floral papillae on external tepals of Group C (*Allium commutatum*) characterised by small, 30–40 µm wide papillae evenly distributed throughout the entire surface and occasionally few larger hemispherical to conical papillae on the keel 80-110 µm wide.

tributed throughout the entire tepal and numerous large papillae mostly present on the keel, sometimes merging forming short walls and occupying one third or more of the length of the keel - Fig. 6 and Fig. 8.

Type D: Internal tepals with small, subcylindrical papillae, 25–40 µm wide. External tepals with two types of papillae: small, (25–40 µm wide), pustulate, papillae uniformly distributed throughout the entire surface and large papillae (80–140 µm wide) scattered throughout most of the central part of the tepal hence not restricted only on the keel, sometimes extending up to near the margin of the tepal but then decreasing in size. Papillae numerous and in various sizes with the larger ones present on or close to the keel - Fig. 7 and Fig. 8.

Type B and type C can generally be considered to be similar, but type C have more numerous and larger papillae on the keel, running along at least one third of its length.

The distribution of the papillae on the tepals corresponded with the four groups circumscribed above. All specimens in taxon P had type A floral papillae. Group C primarily had type B papillar distribution on its tepals while that of the cultivated group K was distinctly type D. Plants within taxon group Z and G had type C papillae but some specimens in

Fig. 6. Type C floral papillae on external tepals of groups G and Z (*Allium commutatum* × *A. polyanthum*) characterised by small, 30–40 µm wide papillae evenly distributed throughout the entire surface and several larger hemispherical to conical papillae on the keel, about 80-150 µm wide, sometimes fused at the base forming papillary walls.

group G occasionally possessed type B papillae but with a tendancy of being smaller.

On comparing the four types, here aided by a representative illustration (Fig. 8), it can be preassumed that type C and perhaps Type D are a result of a combination or superimposition of type A and type B papillae.

Bulblet shape

Two main bulblet shapes here referred to as helmet-shape and hemispherical or navicular have been met during this study and labelled as Type A and Type B. Type A bulblets are char-

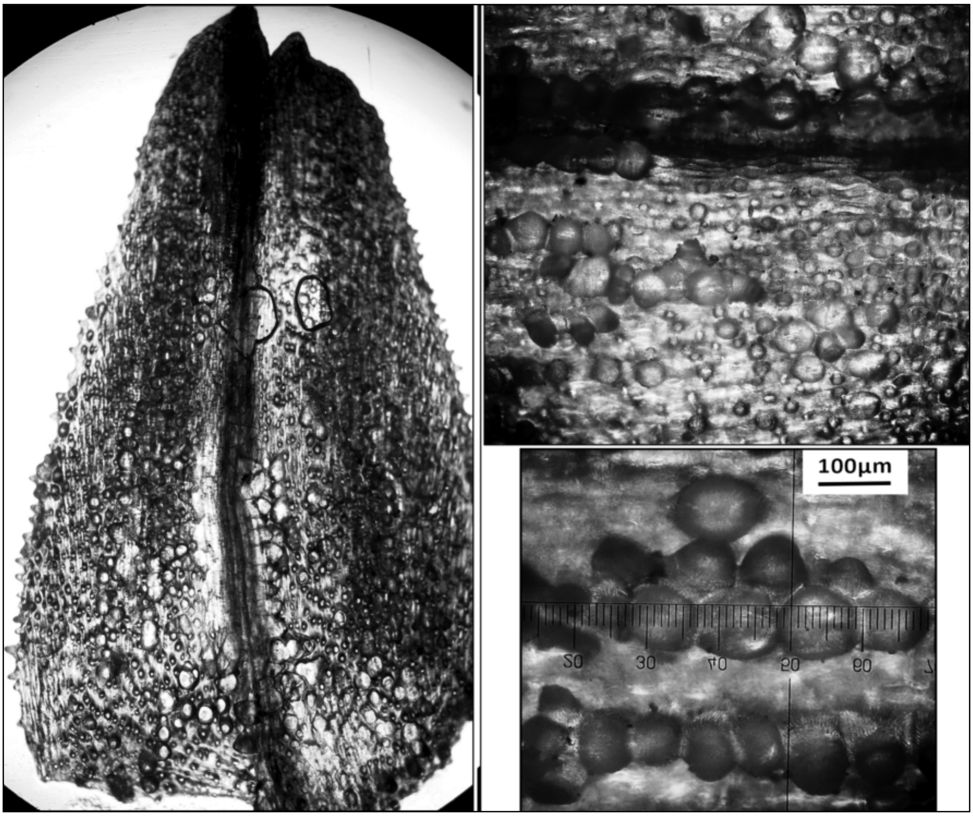

Fig. 7. Type D floral papillae on external tepals of group K (*Allium kurrat* and *A. ampeloprasum*) characterised by small (30–40 µm) and large (80–150 µm) papillae evenly distributed throughout the entire surface but with the large papillae more frequent on and close to the keel and gradually decreasing in size towards the margin.

acterized by sub-globular structures, 4–9 mm in diameter, with a short flattened side at the base hence forming a shape similar to a helmet. The flattened side is only 3–5 mm long and is always shorter from the height or longest diameter of the bulblet body. Type B bulblets have an elongated hemispherical or hemi-ellipsoid structure with acuminate or tapering ends, usually one end more acuminate than the other. The flattened side is longer than the height or width of the bulblet, and can be termed as navicular or compressed fusiform. They vary in size, usually between 10–30(–40 mm) long and 6–12 mm high. Both type A and type B bulblets are homogenous in shape and are illustrated in Fig. 9.

Moreover, a third bulbet morphology has been categorized as Type C which collectively are heterogenous and composed of a mixture of Type A and B bulblets and other bulblets which are considered as a range of intermediates between the two forms, usually hemispherical with a short acuminate end, sometimes compressed and measuring about 12 mm ± 5 mm (Fig. 10).

Specimens within group P produced helmet-shaped (Type A) bulblets whereas those forming group C produced navicular or compressed (Type B) bulbets. Group G and taxon

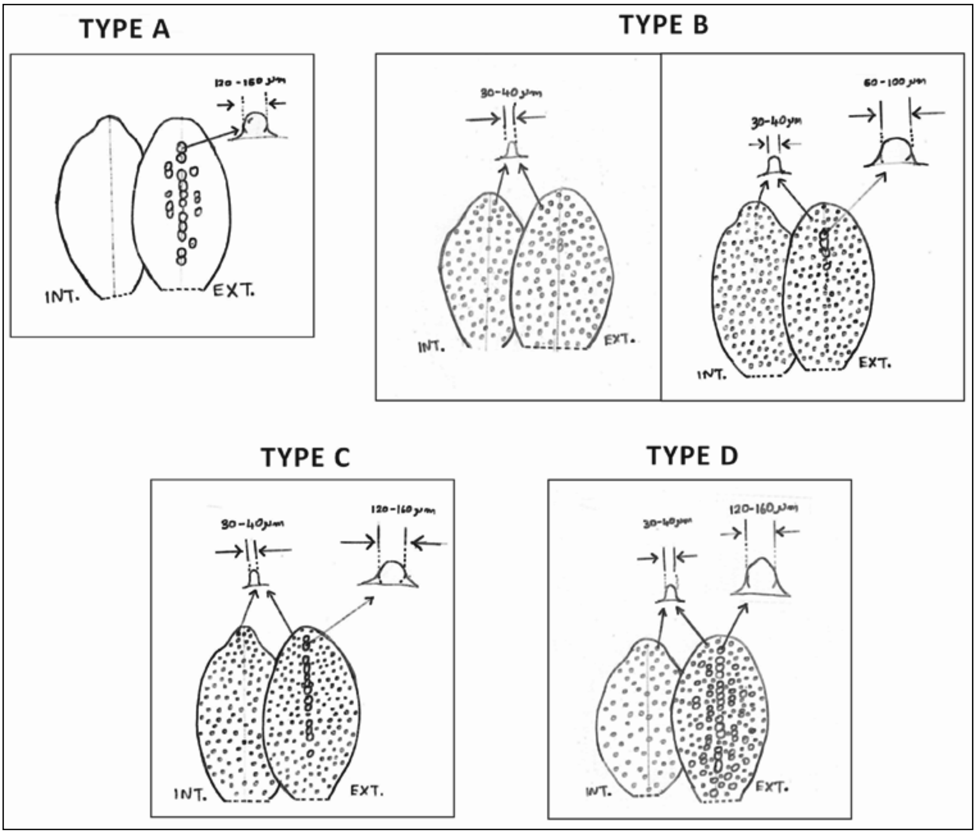

Fig. 8. Representative line diagrams of the four types (Types A to D) of flora papillae on the internal and external tepals.

group Z had heterogenous bulblets (Type C). It was further observed that the Sicilian specimens produced smaller bulblets thna the Maltese plants, and that group Z had an elevated number of helmet-shaped bulblets than group G.

Length of beak of the spathe.

Group P had the shortest beaks, typically 2–5 cm long; group C had the longest beaks, 15 cm up to 29 cm in some individuals and groups Z and G had intermediate lengths, normally between 7 cm and 13 cm. In all cases, the spathe splits open from one side and falls down soon after anthesis.

Summary of the circumscribed groups.

Combining the results above, five taxon groups have been circumscribed, four from the wild (groups P, G, Z, C) and one cultivated (group K). Their discriminating characters are summarised in the Table 1.

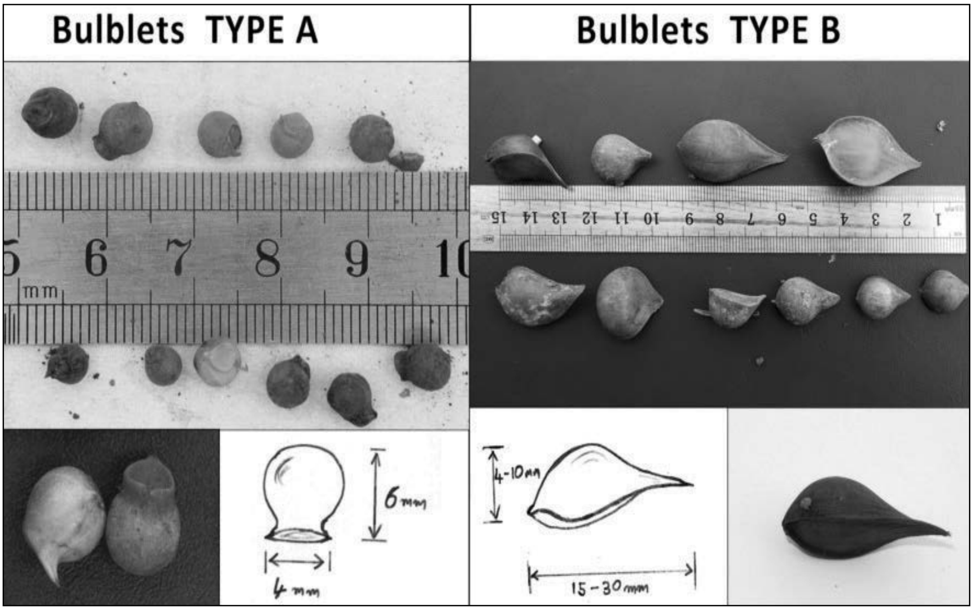

Fig. 9. Two of the three types of bulblet morphology found in the studied specimens. Type A subglobose with a short flat base forming the what so called "helmet" shaped bulblets, 4–9 mm wide (*Allium polyanthum*: specimen AS601a); and Type B with hemispherical to hemi elliptical-fusiform shapes with one end distinctly acuminate, the other shortly acuminate, caudate or obtuse, always longer than high, 15–30(–40) mm long (*Allium commutatum*: specimen CS625b).

Discussion

Identity of group P

Found in exposed rocky patches in garigue, degrded garigue, steppe, abandoned fields, less often in vegetated coastal areas and wasteground, 5–250 m asl. The characters of group P corresponds with *A. polyanthum*. This species is related to *A. ampeloprasum*, but it is a smaller plant, with smooth margins in mature plants due to the quick weathering (or absence) of papillae, have less papillae on the external tepals, and more importantly possess very few or usually complete absence of papillae on the internal tepals.

The classification of *A. polyanthum* is a rather debatable and subjective. Aedo Pérez (2014) followed the classification of De Wilde-Duyfjes (1976); observing plants with intermediate character-states between *A. polyanthum* and *A. ampeloprasum* to co-occur in Spain, their taxonomic treatment was a single, broad *A. ampeloprasum*. Jauzein & Tison (2005) and Tison & al. (2015), consider such intermediates as a hybrid swarm of two distinct subspecies. Jeanmonod & Gamisans (2007), Dobignard & Chatelain (2010) and Floc'H & al. (2010) also followed this classification. Mathew (1996) considered the distinction wide enough to treat *A. polyanthum, A. ampeloprasum* and *A. porrum* L. as distinct species and later they were clearly separated on moleculer bases by Hirschbegger & al.

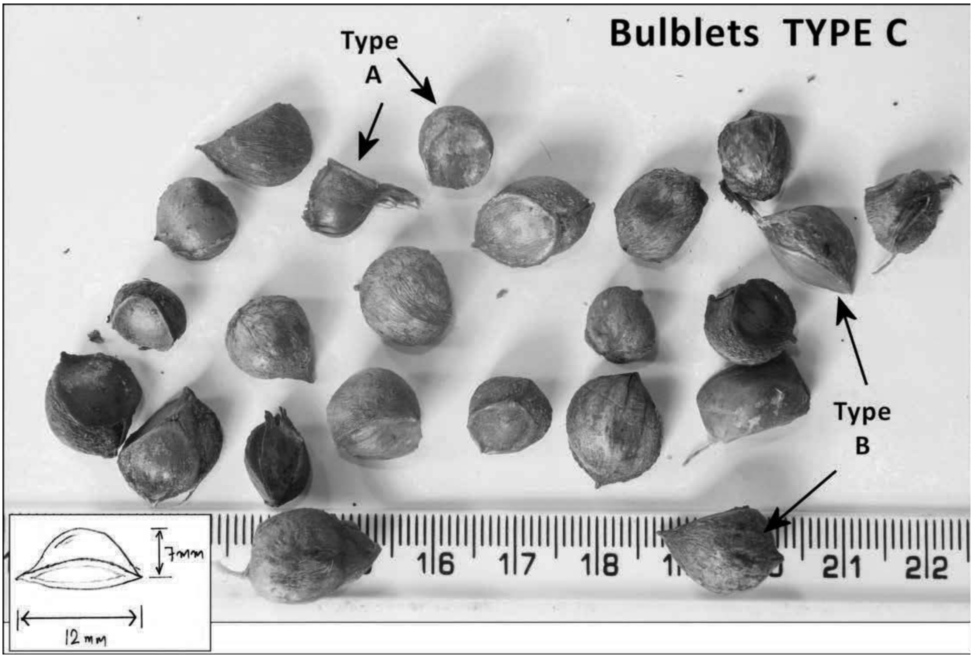

Fig. 10. Type C bulblets composed of mixed Type A and Type B bulblets, and numerous irregular or somewhat intermediate shapes measuring between 7–20 mm long (*A. commutatum* × *A. polyanthum*: specimen AS601e).

(2009). Since our plants are well distinct from the cultivated *A. porrum* s. str. and since specimens showing the characters of *A. ampeloprasum* have not been found, the species rank for *A. polyanthum* is preferred in this work.

The presence of *A. polyanthum* in Malta extends the western distribution of the species, currently occurring in Algeria, Balearic islands, Corsica, France, Italy, Morocco, Sardinia, Spain and Tunisia (GBIF 2017, Euro+Med 2006-2017). However unpublished records from Greece and Crete have been confirmed (pers. comm J-M. Tison).

Identity of group C

Found in littoral habitats, 5-20m asl up to 300m inland. According to the keys and descriptions of Stearn (1980), Mathew (1996), Aedo Pérez (2014), Tison & al. (2015) and Pignatti (2017), group C corresponds perfectly with *A. commutatum*. This species has been confirmed only from Xgħajra at the south east coast of mainland Malta and is to a new record for the Maltese islands. All records of *A. commutatum* for the Maltese Islands in past literature (Lanfranco 1995, Lanfranco & Lanfranco 2003, Mifsud 2002-2014, Bonett & Attard 2005, Weber & Kendzior 2006, Lanfranco 2007, Casha 2013 and Lanfranco & Bonett, 2015) refer to *A. polyanthum* or to groups Z and G for the reported ‘giant forms’ at Filfla and Fungus Rock and nearby mainland shores. The large population at Cava D’Aliga and the few individuals at Arizzo in Ragusa, Sicily are also *A. commutatum* and were used to compare their characters with the Maltese material. The Maltese population comprises of plants that are distinctly larger from those in Cava D'Aliga but within the variation range of the species and they might be a result of ecotypism or more likely polyploidy. Moreover, all specimens have white tepals instead of pink or purple as it was found at Ragusa, however it is well known that the flower colour of *A. commutatum* vary, and is found either white or deep purple in France and Corsica (sometimes intermixed within the same population) or pink in Greece. The Maltese population exhibit a homogenous morphology.

Identity of groups Z and G and their relationship with A. commutatum

Groups Z and G are found in littoral habitats or abandoned fields near the coast, 5-80 m a.s.l. and are clearly related to *A. commutatum*, but they do not match in a number of characters, the most important being that the internal stamens are never tricuspidate: simple and monocuspidate in group Z, bicuspidate sometimes tricuspidate but with the third cusp partial in group G. Other important differences from *A. commutatum* were observed in the morphology of the papillae of the leaf margin and tepals, the spathe has a shorter beak, the corolla is deep purple, flowering earlier by 3-4 weeks and the bulblets are heterogenous including helmet-shaped and irregular forms as described in detail below and summarised in Table 1.

On evaluating these diagnostic characters, group Z appears to have an array of intermediate characters between *A. polyanthum* (group P) and *A. commutatum* (group C). The type C floral papillae (Fig. 6) of group Z superficially seems to be a direct superimposition of Type A papillae (of *A. polyanthum*) and Type B papillae (of *A. commutatum*). The foliar papillae also seems to be a combined morphology or patter of mixed *A. commutatum* and *A. polyanthum* either in their simple form, hence both papillar forms are found separately on the leaf margin or in a compound or complex form as if having shapes of both papillar types merged together, typically forming broad-based papillae abruptly narrowing to a teat-shaped tip or into capitate heads (Fig. 1f). Bulblets shapes typical of the two species mentioned above were found together in specimens of groups G and Z together with irregularly shaped bulblets judged as intermediate forms. The flowering period (end May to beginning of June) occurs after that of *A. polyanthum* (May) and before *A. commutatum* (end June). The monocuspidate shape of the internal stamens in group Z is a strong character of *A. polyanthum*, while some tricuspidate internal stamens found in group G are typical in *A. commutatum*. The number of bicuspidate internal stamens found in group G (Type C stamens, Fig. 3c) or tiny secondary lateral cusps (tiny appandage) ocassionally found in group Z (Type B stamens, Fig. 3b) are considered as an intermediate form between monocuspidate and tricuspidate stamens of *A. polyanthum* and *A. commutatum* respectively. The length of the beak of group G and Z of 6-13 cm is also perfectly intermediate between 2-4 cm in *A. polyanthum* and 12-30 cm in *A. commutatum.*

This morphological study strongly suggest that group Z and group G represent a hybridogeneous population between *A. commutatum* and *A. polyanthum.* As discussed above, both groups either share character states of both parents resulting in an overall heterogenous picture of both states, or have intermediate morphological states between the putative parents or have characters which superficially appears to be a superimposition of character states of the parents. As a result, it is concluded that groups Z and G are likely hybrids: *A. commutatum* × *A. polyanthum.*

Group Z (Żurrieq, southern coast of Malta) show a more balanced character set between the putative parents, while group G (Gozo populations) approaches more to the parent *A. commutatum,* with a later flowering period, smaller papillae on the tepals and 2–3 cusps on the internal stamens. Interestingly, group Z produces fully fertile seeds, but plants of group G in majority are sterile, where the seeds are shrivelled, empty and crumble easily when pressed.

Some individuals within these taxon groups reach up to 180 cm in height, form an umbel the size of a tennis ball, with huge leaves up 4 cm wide and generally very robust plants. These large leeks have also been observed from the islets of Filfla and Fungus rock (Lanfranco 1989; M. Briffa & J. Sultana pers. comm. 2014) and referred to giant forms of *A. commutatum*. Likely, they also represent a well-established hybridogeneous community of *A. commutatum* × *A. polyanthum* as found in the closest shores in mainland Malta and Gozo respectively. Photos of these large leeks growing in Filfla taken by Edwin lanfranco and Joe Sultana are in general identical to groups Z or C, although their details could not be assessed.

Nevertheless, it is safely assumed that Filfla and Fungus Rock harbour an *Allium* population showing features of group Z and group G respectively. Further karyological studies are currently being carried out to confirm the *A. commutatum ′ polyanthum* hybrid, also detected in south France and North Africa (pers. comm. Errol Vela).

Identity of group K

The cultivated leeks collected from fields in Żurrieq, Xewkija and Mġarr ix-Xini shared the same morphology and were identified as *A. porrum* L. s.l. According to two interviewed farmers their crops correspond to *A. porrum var. kurrat* (K. Krause) Seregin. This taxon, forms vigorous plants with thick stems and wide leaves (up to 35 mm broad) with characteristic elongated papillae between 300 and 400 µm long at the margin and keel forming a subpilose fringe (Fig. 1g). The tepals have a particular distribution of small and large papillae throughout the external tepals, where the large papillae are not restricted on the keel but occupying most of the face except at the border (Figs 7 & 8: type D). On examing material of *A. ampeloprasum* submitted to us from France, the same type of distribution was observed concluding that these cultivars maintained these diagnostic characters from *A. ampeloprasum* from which they originate. *A. porrum* and *A. porrum var. kurrat* have not been found naturalising rocky habitats away from their source of cultivation or known to form any populations except some casual escapees close to field margins. As a result they should be treated as agricultural crops and not to be included in flora of the Maltese Islands.

What is *Allium melitense*?

A. melitense (Sommier & Caruana) Cif. & Giacom. was described as a small variety of *A. ampeloprasum*. According to this revision they correspond to the lower small-sized individuals within group P with all diagnostic characters identical to the larger plants of this group. Therefore, no taxonomic distinction could be found plausible as has already been suspected by Mifsud (2011).

In the early 20th century, *A. ampeloprason* was thought to occur in steppic and garigue communities in Malta. Being by description a rather large species (80-180 cm high), the small-sized *Allium* individuals may have contrasted with *A. ampeloprason* and merited to be described as a distinct small variety (*A. ampeloprasum* var. *melitense)*. But since now it is established that the Maltese plants are *A. polyanthum* - a species with a height of 15–100 cm, these small plants fall within the lower range of *A. polyanthum,* hence resulting that *A. melitense* has no particular distinction. Individuals with a very small habit, flowerheads (2 cm across), bulblets (4-5 mm) and bulbs (8-12 mm) are considered to be small ecotypes of *A. polyanthum* occurring in very degrarded areas or in restricted volume of soil in pockets of karst rock.

The fact that the size of the plant and flower head have no taxonomic importance was demonstrated in situ in several occassions. A clump of twelve plants found at Wied Diegu, Żurrieq (Fig. 11) were composed both of normal sized plants (‘*A. ampeloprasum*’) and small-sized plants (‘*A. melitense’*). The May-flowering Maltese population contributes to a continuous range of sizes within the species concept of *A. polyanthum*. Such small plants have also been observed in France intermixed with *A. polyanthum* (pers. comm. Errol Vela, 2014). As a result, *A. melitense* and *A. ampeloprasum* subsp. *melitense* should be treated as synonyms of *A. polyanthum*.

***Allium ampeloprasum* and its status in Malta**

A. ampeloprasum had been recorded from the Maltese islands in historical literature, until it was gradually substituted by *A. commutatum* (Lanfranco 1989). To verify that none of our studied material correspond to *A. ampeloprasum* and since the distinction in literture (eg. Stearn 1980; Mathew 1996, etc) is based on an unclear character of stamen exsertness, a voucher specimen of *A. ampeloprasum* kindly submitted by Errol Vela was studied and compared with the collected material. The diagnostic characters differed from those found in all Maltese collections but related to specimens from or close to cultivated areas which in this study corresponded to *A. porrum* var. *kurrat*. This taxon is often found in synonym with *A. ampeloprasum* or as its infraspecific rank (ThePlantList 2013), although it is considered distinct by some authors for being a cultivated leek with wider leaves and larger bulbets (Mathew 1996). The shape, distriburion and morphology of the floral papillae of *A. ampeloprasum* was for example similar to *A. porrum* var. *kurrat*, but slightly smaller and longer than it is wide, hence more conical in shape. Therefore, since *A. ampeloprasum* was not collected from natural habitats it is suggested to be removed from the current flora of the Maltese Islands and historical records likely refered to *A. polyanthum* or its hybrid with *A. commutatum.*

Specimens from the southeast coast of Sicily

On June 2015, a sizeable population of *A. commutatum* was found east of Cava’ d’Aliga beach on vegetated coastal rock, a few metres away from the sea. This population was composed of several hundreds of individuals in three seperate clumps very close to each other. On comparing with the Maltese population (Fig. 12), the Sicilian plants were in general smaller and had pinkish tepals. A higher frequency of slightly larger papillae on the

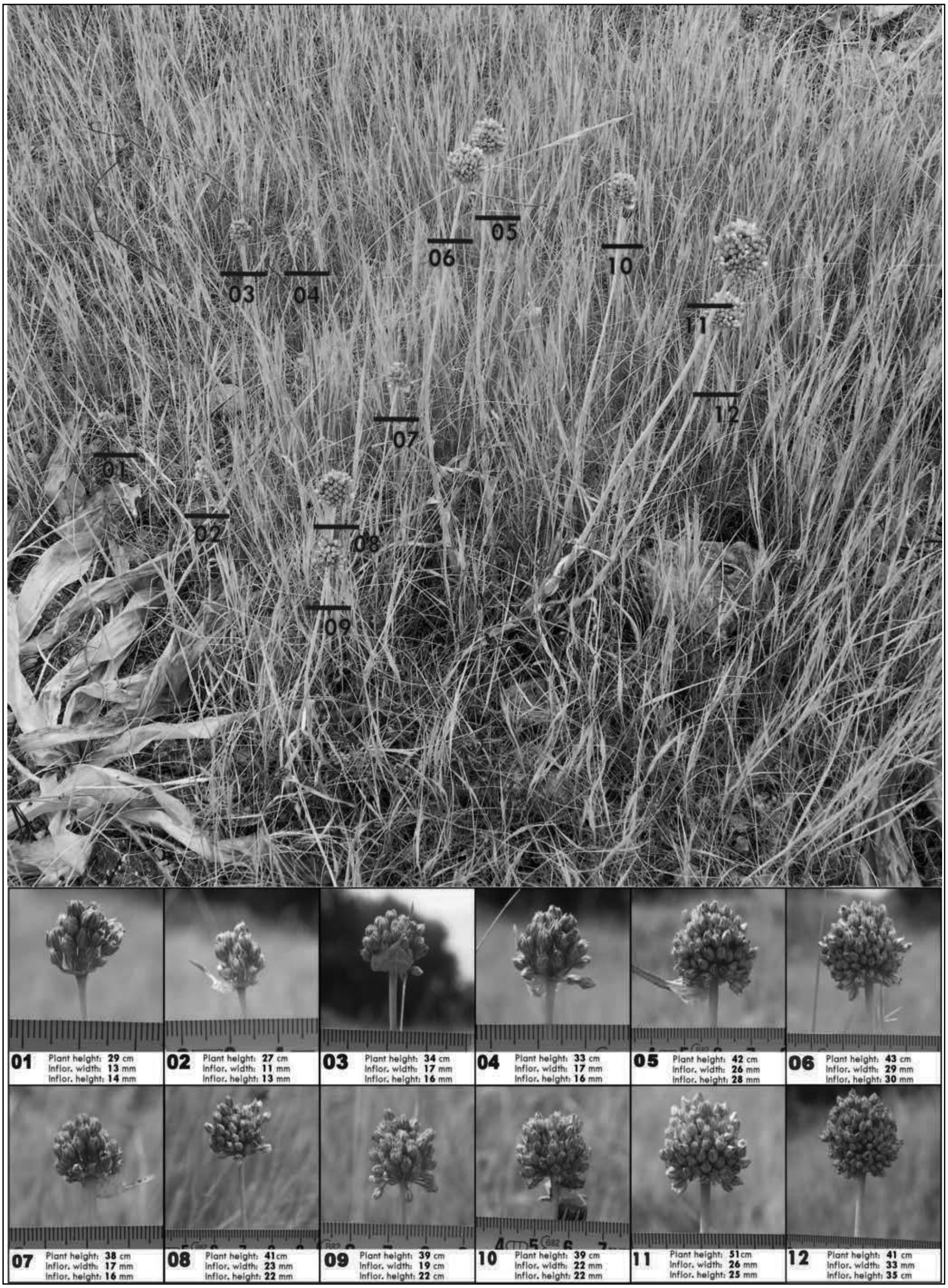

Fig. 11. Clump of twelve individuals of *Allium polyanthum* at Wied Diegu, Żurrieq (1 June 2014) and their plant height and inflorescence size clearly showing that some measurements are within the species concept of the presumed endemic *A. melitense*, distinct and described for its small stature and hemispherical inflorescences less than 3 cm wide.

keel of the external tepals was observed, but then not as numerous or large as in the hybrid taxa (groups G and Z).

Five individuals of *A. polyanthum* were found at Spiaggia Bruca, close to Arizza beach, in their developed but still closed fruit. It is assumed that their flowering period was several weeks prior to this observation, hence in mid May. Despite the fact that these examples were quite dry, they had leaves with a smooth leaf margin, Type A floral papillae and small helmet-shaped bulblets. Previous notes to the name *A. polyanthum* in Sicily, as synonym of *A. ampeloprasum,* can be found in Giardina & al. (2007). The record of this species for Sicily is included in the recent checklist of the Flora of Italy (Bartolucci & al. 2018).

Three individuals *Allium* sp. were found close to Marina di Modica, in a degraded vegetated littoral ground. They had very young pale green fruits and few old, shrivelled flowers indicating that the flowering period occurred a few weeks before, more or less in mid June. The leaf margin had half-weathered but distinct papillae; the outer stamens tricuspidate, inner stamens simple and monocuspidate; floral papillae Type C but with some large papillae spread away from the keel in few tepals and numerous heterogeneous bulblets with helmet-like, hemispherical and irregular (angular) shapes as in Type C bulblets (Fig. 10) This character set approaches that of *A. commutatum ´ polyanthum*. This is the first record for Sicily and Italy according to Giardina & al. (2007) and Brullo & Guarino (2017). Bartolucci & al. (2018) does not includes hybrids. Further investigations are needed to clarify its distribution in Sicily.

Allium **section** ***Allium*** **subsect.** ***Scoroprasum*** **on the Maltese Islands**

A. polyanthum Schult. & Schult. f. Syst. Veg. 7: 1016 (1830)

= *A. ampeloprasum* var. *melitense* Sommier & Caruana Gatto; = *A. melitense.* (Sommier & Caruana Gatto) Ciferri & Giacomini

Common in Malta, Gozo, Comino and other islets (Mifsud 2011; Mifsud & al. 2016), probably also present in the islets of Filfla and General's rock (Fungus rock). Habitat: steppe and degraded garigue, but sometimes also in wasteground, abandoned clayey fields (usually forming larger plants), and rarely in littoral areas. Native.

A. commutatum Guss. Enum. Pl. Inarim. 339 (1855)

Very rare and confirmed from the location at Xgħajra, Malta, and very recenlty found at Saint Paul's Bay. Habitat: disturbed coastal rocky ground. Native, threatened by human disturbance, future or illegal development, alien species, massive collection of waste dumping and recreational activities close to the sea. It is suggested to include this species in the future edition or the Red List for the Maltese Islands.

A. commutatum* × *A. polyanthum

Rare but locally frequent in established populations at the coast of Wied iż-Żurrieq, Wied Babu and Blue Grotto, Żurrieq in mainland Malta and at Dwejra, Xlendi and San Dimitri in Gozo. Large individuals recorded from the islets of Filfla and General's rock (Fungus rock), (Lanfranco 1989; pers. comm. Michael Briffa and Joe Sultana) are likely other established hybridigenous populations. Habitat: coastal rocky ground and steppe. Native.

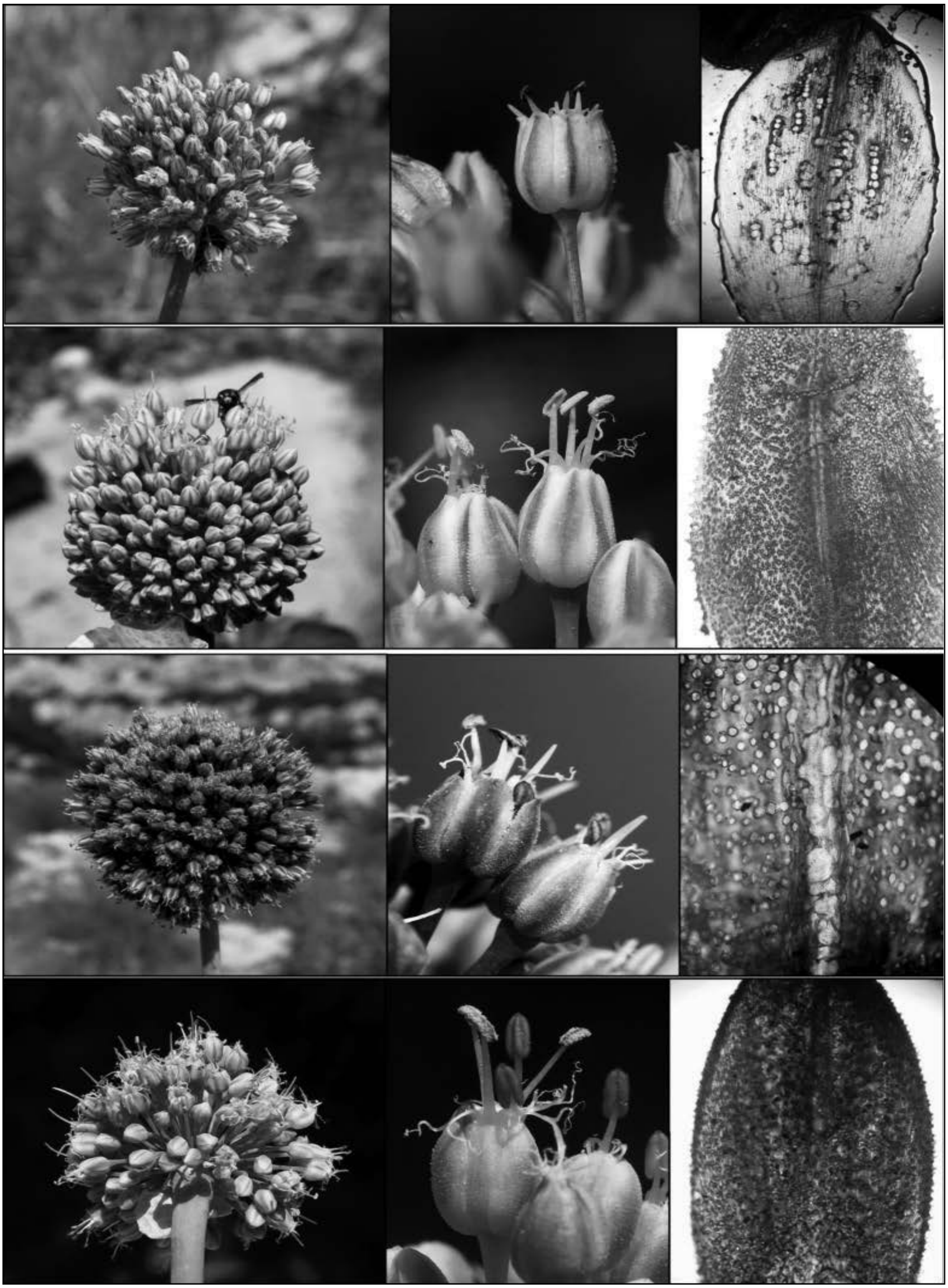

Fig. 12. Photos comparing the umbel, corolla and floral papillae of the external tepals of: 1. *A. polyanthum* (Mġarr ix-Xini, Ta' Sannat, Gozo, 23 May 2014); 2. *A. commuatum* (Xgħajra, 25 June 2016); 3. *A. commutatum* × *A. polyanthum* (Wied iż-Żurrieq, 6 June 2015) from the Maltese Islands and 4. *A. commutatum* (Cava d'Aliga, 27 June 2015) from the southeast coast of Sicily.

Identification key to species of Allium *subsect.* Allium *in Malta*

1. Leaf margin subpillose with long digitate papillae more than 400 µm long. Only cultivated .... ***A. porrum* var. *kurrat***

1. Leaf margin smooth or with shorter conical papillae reaching up to 300 µm long. Wild, native or naturalised. **2**

2. Stamens included, same level of corolla mouth or slightly exserted by 1 mm; leaf margins smooth (papillae absent) or rarely crenulate with weathered flattened papillae <100 µm long; inner tepals without or with very few papillae................ ***A. polyanthum***

2. Stamens fully exserted by 2 mm or more above the corolla mouth; leaf margins scabrid by persistent papillae, usually visible by naked eye (>150 µm long) even in mature individuals; inner tepals densely papillose and punctate. **3**

3. Outer tepals with numerous large papillae (>80 µm) distributed throughout most of the tepal except at the border and small papillae (20–40 µm) spread throughout the entire surface. Inner stamens always simple and monocuspidate. .... ***A. ampeloprasum***

3. Outer tepals without of with few large papillae (>80 µm) present only on the keel and small papillae (20–40 µm) spread throughout the entire surface. Inner stamens tricuspidate or bicuspidate (very rarely monocuspidate.) **4**

4. Inner stamens mostly tricuspidate; outer tepals without large (>80 µm) papillae, or if present occupying less then third of the keel; bulblets homogenous all fusiform-elleipsoid, with a long tapering end; spathe beak >15 cm long..................... ***A. commutatum***

4. Inner stamens either simple, or mixed biscuspidate and tricuspidate but never all tricuspidate; tepals with large distinct papillae (>80um) on at least one third of the length of the keel; bulblets heterogenous; spathe beak usually < 15 cm long. .... ***A. commutatum* × *A. polyanthum***

Conclusion

This study on *Allium* subsection *Allium* has brought important changes for the flora of Malta, which so far relied on historical flora (e.g. Sommier & Caruana Gatto 1915; Borg 1927; Haslam & al. 1977). The study on 165 specimens from 59 populations resulted in the occurrence of three reckognised taxa in the Maltese Islands: *A. polyanthum* (very common), *A. commutatum* (very rare) and their hybrid *A. commutatum* x *A. polyanthum* (rare). *A. melitense* is now treated as synonym of *A. polyanthum* while *A. ampeloprasum* was not found in the examined material and most probably is not present in natural habitats in Malta.

Despite these novelities, more karyological work is required to establish the chromosome numbers of these population especially for the two hybrid populations in the Maltese islands, where the Gozitan population was found to be sterile while that from Żurrieq in mainland Malta produced many sterile seeds.

Acknowledegments

Our special thanks must go to Errol Vela, and Daniel Pavon for the comments pertaining to the taxonomy and treatment of *Allium* Sect. *Allium* in France and to Edwin Lanfranco, Michael Briffa and

Joe Sultana for supplying their knowledge, expeience and photos of *Allium* from Filfla and Fungus rock. Finally we are in debt to Brian Farrugia who informed us about the population of leeks at Xgħajra and to Toni Saliba (Zebbug, Gozo) and George Formosa (Qormi, Malta) for providing us some samples of cultivated leeks from their fields and comments related to their cultivation.

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Ellenberg Indicator Values for the vascular flora alien to Italy

Abstract

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Studies to date about plants alien to Italy have had limited focus on the ecology of this component of the flora. Ellenberg's indicator values are a useful tool to delineate the relationship between plants and environment, recognizing for each species a functional role as biological indicator; these values have been proposed for estimating the influence of the main environmental factors in determining flora and vegetation changes on a specific surface area. This contribution includes a list of 1206 taxa of plants naturalized in at least one administrative region or casual in at least three regions of Italy. In addition, some methodological considerations on the attribution and use of Ellenberg's indicator values and a comparison with the average indices for the native Italian flora are reported.

Key words: non-native flora, EIVs, bioindicator, plant ecology.

Introduction

Plant invasions have become one of the main drivers of global environmental changes and the second major cause of the loss of global biodiversity after habitat loss (Sala & al. 2000). The Mediterranean region, and Italy in particular, host a large number of plants and plant communities, and are among the areas most threatened with homogenization and endemic extinction (Hulme & al. 2008). To date, studies in Italy about non-native flora have focused mostly on the number of taxa, their alien status, and a rough estimation of the biogeographic regions at regional scale (Celesti-Grapow & al. 2009, 2010, 2016). This kind of approach offers clues on the habitat quality of a given region, but the study of the ecological traits of the non-native taxa occurring in a given area could provide more information not only about the naturalness of this area but also about its ecological conditions and its potential for being prone to new alien invasions (Lodge 1993; Lloret & al. 2005).

The aim of this contribution, whose preliminary results were presented during the 112th Congress of the Botanical Society of Italy, held in Parma from 20 to 23 September 2017 (Domina & al. 2017), is to provide an overview of the ecological preferences of the alien flora of Italy through the use of Ellenberg's indicator values (from now on: EIVs).

The ecological requirements (Bazan & al. 2015), along with dispersal strategies (Vincente & al. 2014), seed traits (Vittoz & Engler 2007; Moravcová & al. 2015), and their adaptive responses to granivory (Guarino & al. 2005), are key factors in the establishment and success of neophytes.

EIVs have been proposed to estimate the influence of the main environmental factors in determining flora and vegetation changes on a specific surface area (Ellenberg 1974, 1996; Ellenberg & al. 1992). Ellenberg outlined the synecological preferences of all Central European vascular plants by means of numerical indices referring to seven main environmental factors. Three indices refer to climatic variables: light conditions (L), temperatures (T), and climatic continentality (K); and four refer to edaphic conditions: moisture (F), reaction (R), nutrient availability (N), and salinity (S).

In the original scales (Ellenberg & al. 1992), all indices ranged between 1 and 9, with the exceptions of F, ranging between 1 and 12, and S, ranging between 0 and 9. Subsequent to the original formulation, the range for S has been limited to 0 and 3 (Ellenberg 1996).

Pignatti & al. (2005) assigned EIVs to the taxa of the flora of Italy and modified Ellenberg's scales to adapt them to the Italian territory. In fact the same species can be an indicator of different habitats at different latitudes. For this reason, a recalibration at the regional scale is needed to allow an ecological comparison of the floras of different climates. An enlargement of the scales L and T to 12 values, to respect the statistical homogeneity with Ellenberg's original assumption, has been adopted (Pignatti & al. 2005).

The EIVs for the Italian flora published by Pignatti & al. (2005) were based on the species list of the first edition of the "Flora d'Italia" (Pignatti 1982). Recently we have seen the publishing of updates: the updated checklists of the native and alien flora to Italy (Bartolucci & al. 2018; Galasso & al. 2018) and the first two volumes of the second edition of the "Flora d'Italia" (Pignatti & al. 2017); the last two volumes and the digital supplements will be issued soon. Thus the new complete data set for the updated flora of Italy is under preparation. A recent update to the EIVs for the flora of Italy has been published for ferns, fern allies, gymnosperms, and monocots (Guarino & al. 2012).

The aim of this paper is to provide the integration of the EIVs for the non-native flora of Italy and, at the same time, to present some ecological considerations on the investigated flora based on EIVs.

Material and methods

The floristic list used as a basis for this study was the updated checklist of the vascular flora alien to Italy (Galasso & al. 2018). This list includes 1597 taxa (including hybrids), with their family, main synonyms, and indication of their ecological behaviour (invasive, naturalized, casual) in each administrative region. From this list, we extracted the taxa invasive or naturalized in at least one region or casual in at least three regions of Italy, and we added their EIVs. Besides the values already published in Pignatti & al. (2005) and Guarino & al. (2012), more than 570 still lacking indices are newly proposed here. To assign these new values, we considered the environmental conditions of the Italian localities in which they were recorded. All the criteria and recommendations adopted by Ellenberg & al. (1992)

have been followed, even if the criterion “per analogy” was leading our choices in most of the cases (see Guarino & al. 2012 for details). The main problems in the assignment of EIVs concerned taxa with a wide ecological niche, such as *Ailanthus altissima* (Mill.) Swingle and *Senecio inaequidens* DC. or casual rare ones such as *Gomphrena globosa* L. and *Russelia equisetiformis* Schltdl. & Cham. occurring in a few localities, often close to cultivated plants. The same for species cultivated for human consumption since long time, on a large scale, such as *Avena sativa* L., *Brassica oleracea* L., *Triticum turgidum* L., etc.

The significance of the differences observed in the EIVs of native vs. non-native flora was checked by means of a two-tailed T-test, assuming that the two data sets had unequal variance (heteroscedastic). All graphics and basic statistical analysis were produced by means of MS Excel.

Results

On the whole, 1206 taxa recorded as naturalized at least in one administrative region or casual in at least three administrative regions of Italy, were considered in this contribution.

Average EIVs for the non-native flora of Italy are: L= 7.81, T= 7.64, K= 4.96, F= 4.54, R= 5.45, N= 4.49.

There are 16 taxa (mainly *Acacia* sp. pl. and *Sporobolus* sp. pl.), tolerant to salinity (S >1) and 31 (*Tamarix* sp. pl. and *Aizoaceae*) with some tolerance (S = 1). For these, the average value of S is 1.63, denoting an overall relatively low tolerance to soil salinity.

Several ornamental species as *Aeonium* sp. pl., that in nature grow on semi-natural habitats, in Italy have synecological preferences toward anthropized environments.

Others as *Amaranthus* sp. pl. show the same behaviour in countries where are native and in those where are alien as well. A direct comparison with the average indices of the native flora of Italy given in Pignatti & al. (2005) (Table 1 and Fig. 1) suggests that the alien flora have similar light requirements (L= 7.85 vs. 7.84), higher temperature requirements (T= 7.67 vs. 6.36), slightly higher continentality (K= 4.96 vs. 4.60), slightly higher edaphic humidity (F= 4.50 vs. 4.17), similar soil reaction (R= 5.43 vs. 5.45), and a preference for higher nutrient availability (N= 4.34 vs. 3.26).

In general (Table 1 and Fig. 2), the distribution of EIVs for the non-native species has a lower variance and higher kurtosis, resulting in infrequent outliers as opposed to frequent modestly sized deviations. This is particularly true for the T value, confirming that the non-native component of the flora of Italy is significantly more thermophilous than the native one.

The list of considered EIVs for the flora alien to Italy is available as Electronic supplementary file to be readily used for data processing. As already suggested by Pignatti & al. (2005) and Guarino & al. (2012), the current list of EIVs has to be considered a first approximation, which may require a long period of adjustments and revisions. Ellenberg (1974) himself, when proposing the first edition of his indicator values, stated that it was a work in progress. This is particularly true for the exotic species that are found in one or very few regions, often under dissimilar environmental conditions.

Table 1. Arithmetic mean, variance, kurtosis, skewness, and T-test of the EIVs of the native flora and of the alien flora to Italy considered in this study.

	native flora **mean**	alien flora **mean**	native flora **var.**	alien flora **var.**	native flora **kurt.**	alien flora **kurt.**	native flora **skew.**	alien flora **skew.**	**T-test**
L	7.84	7.85	3.78	2.42	0.07	0.30	-0.09	-0.10	n.s.
T	6.36	7.67	6.07	2.36	-0.49	0.91	-0.12	0.16	p<0.001
K	4.60	4.93	1.21	1.11	2.07	2.83	0.14	-0.28	p<0.001
F	4.17	4.50	5.22	5.52	1.48	1.37	1.27	1.25	p<0.001
R	5.45	5.43	4.08	1.81	-0.49	1.39	-0.48	-0.20	n.s.
N	3.26	4.34	4.37	4.47	-0.16	-0.89	0.85	0.25	p<0.001

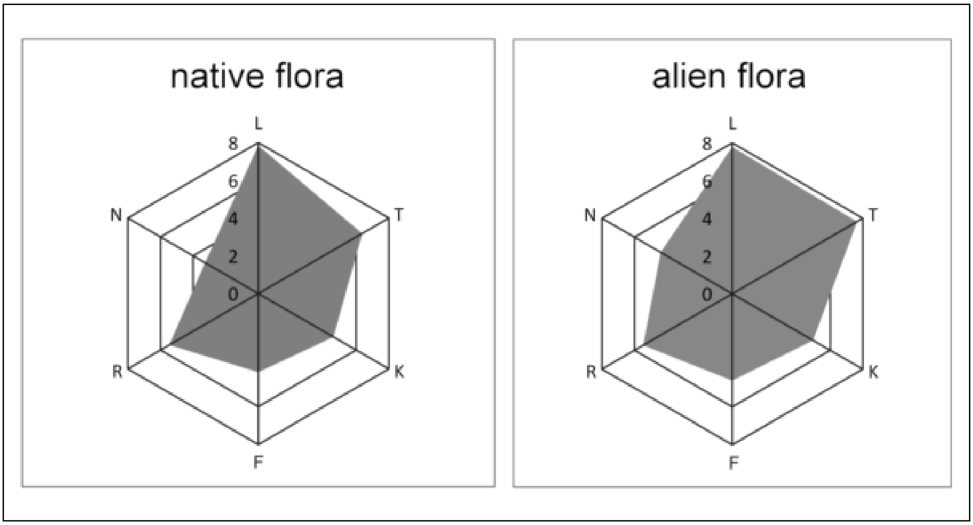

Fig. 1. Ecograms for the native flora of Italy (left) and the alien flora (right) from the means of the six ecological values: L – light; T – temperature; K – continentality; F – soil moisture; R – soil reaction; N – soil nutrients. Only the numeric values have been considered (X values have been ignored).

Discussion and conclusions

Ellenberg's indices should be seen as practical tools to draft quick estimates for ecological interpretations of plant-species lists. This can be particularly useful in anthropogenic and disturbed habitats, often hosting a high number of alien species, to make comparisons with the ecological preferences of the surviving elements of the native plant cover. To date, the application of EIVs to "fingerprint" the ecological context of plant communities including a high percentage of non-native species has been quite limited. The reason could

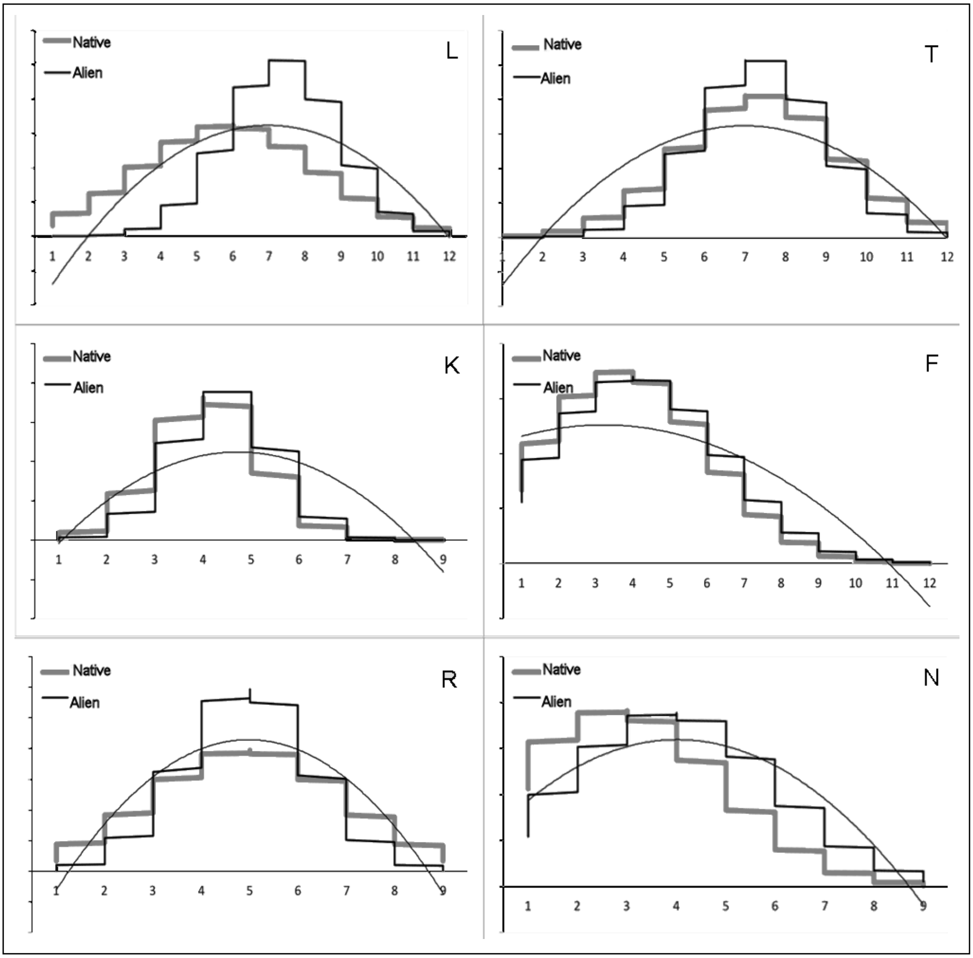

Fig. 2: Comparative distribution and polynomial regression curve of EIVs for the native vs. the alien flora to Italy.

be the lack of such indices for many exotic species. In the present paper, EIVs are proposed for most of the non-native flora of Italy, and their statistical properties have been compared to the EIVs previously assigned to the nativeo flora of Italy.

We are aware that assigning EIVs to non-native species includes some critical points, particularly because their ecological behaviour can shift from one region to another and in many cases their distribution patterns are rather discontinuous, thus making difficult the "averaging" of their ecological preferences at the national level.

Working on taxa coming from different areas, with a wide variability, the corrections suggested by Berg & al. (2017) to assign the value of continentality proved to be very useful for homogenizing data reducing subjectivity.

However, it should be recognized that the Italian territory hosts many more narrow-ranging species than broad-ranging ones, and their coexistence or close proximity with broad-ranging and non-native species offers many useful indications for assigning the most appropriate EIV to them.

Until now, for the Italian territory, the following papers corroborate the EIVs and their utility: Pignatti & al. (1996, 2001a, 2001b); Pignatti (1998, 1999); Guarino & Bernardini (2002); Fanelli & al. (2007); Schwabe & al. (2007); Gristina & Marcenò (2008); Mossa & al. (2008); Burrascano & al. (2009); Brunialti & al. (2010); Pretto & al. (2010); Blasi & al. (2012); Pignatti E. & Pignatti (2014); Del Vecchio & al. (2015); Filibeck & al. (2015); Guarino & al. (2015); and Marcenò & Guarino (2015). We hope that this contribution will encourage new applications.

Some authors (Durwen 1982; Böcker & al. 1983; Kowarik & Seidling 1989; Möller 1992), even if sometimes recognising a practical utility in calculating average EIVs of a species list, state that this is not mathematically correct, because EIVs are ordinal scales, without dimensional correlation with chemical/physical parameters. This is certainly true, but on the other hand it is demonstrated by vegetation data (see, for instance, Pignatti & al. 2001a) that, when the number of samples is high enough, EIVs fit the normal distribution, whose essential parameters are average and variance. So, in addition to non-parametric statistics, all kinds of statistical tests based on average and variance can be used. If only a small number of samples is available, a parametric statistical approach can be essayed anyway, because in the case of Ellenberg's scales it is always possible to transform data into their respective ranks, to better approximate the normal distribution and to create the conditions to use a parametric approach. This widens the potential applications of EIVs as a practical tool to sketch biodiversity traits.

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P. P. Ferrer-Gallego, J. B. Peris, R. Roselló & E. Laguna

Typification of the Iberian endemic *Salvia valentina* Vahl (*Labiatae*)*

Abstract

Ferrer-Gallego, P. P., Peris, J. B., Roselló, R. & Laguna, E.: Typification of the Iberian endemic *Salvia valentina* Vahl (*Labiatae*). — Fl. Medit. 28: 63-66. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

The typification of the name *Salvia valentina* Vahl (*Labiatae*) is discussed. A lectotype collected in Sierra de la Murta (Valencia province, Spain) by Antoine Laurent de Jussieu in 1716 and preserved in the herbarium of the Muséum national d'Histoire naturelle de Paris at P is designated as the lectotype.

Key words: Salvia, lectotype, nomenclature, Spain.

Introduction

The genus *Salvia* L. (*Labiatae*) represents a cosmopolitan assemblage of nearly 900-1000 species displaying a remarkable diversity in growth forms, secondary compounds, floral morphology and pollination biology (Hedge 1992; Walker & Elisens 2001; Walker & Sytsma 2007). The demonstration of the non-monophyly of the genus (Walker & al. 2004) has led to a reinvestigation of the defining character of the genus, the elongation of the connective tissue of the stamen (Walker & Sytsma 2007).

In the Iberian peninsula the genus comprises 18 species and several infraspecific taxa and hybrids (Hedge 1972; Sáez 2010). *Salvia valentina* was described by Vahl (1804: 268) from material collected by Antoine Laurent de Jussieu in 1716 in La Murta (Valencia province, Spain). It is a narrow endemic plant distributed only in the Valencian Community and Catalonia (Spain). This species was treated as infraspecific taxon of *S. sylvestris* L. [lectotype designated by Hedge (1961: 564), Herb. Burser XIII: 117 in UPS-Burser] as f. *valentina* (Vahl) Pau, or subsp. *valentina* (Vahl) O. Bolòs & Vigo, or as subspecies of *S. nemorosa* L. (*S. nemorosa* subsp. *valentina* (Vahl) O. Bolòs & al.) (see Bolòs & al., 1993). Furthermore a variety was described: var. *barcinonensis* (O. Bolòs & Vigo) O. Bolòs & Vigo (≡ *S. nemorosa* var. *barcinonensis* O. Bolòs & Vigo) with holotype at BC 596928. However, these names are currently considered as synonymous of the *S. valentina* s. str. (Sáez 2010). On the other hand, a hybrid of *S. valentina* and *S. verbenaca* subsp. *controversa* (Ten.) Briq. has been described from

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*To Prof. Dr. Ramón Figuerola Lamata (1953-2017), *in memoriam.*

material collected in Valencian province (Rótova, pr. Gandia), as *S.* ×*rosuae* Figuerola & al. (1990) (with holotype at VAL ex VF 15150).

The purpose of this paper is to contribute to the nomenclatural stability of the Vahl's name *Salvia valentina* by lectotypification. The lectotype is based on the protologue and consultation of Vahl's original material in the Jussieu herbarium at P (Muséum national d'Histoire Naturelle, Paris). Jussieu's handwriting was identified by comparison with published samples (Burdet 1976).

Background and typification of the name *Salvia valentina*

The Vahl's protologue (1804: 268) of *Salvia valentina* consists of a diagnosis "*SALVIA foliis cordato-lanceolatis inaequaliter crenatis, bracteis cordatis attenuatis basi coloratis calyce longioribus*", with a complete and extensive morphological description of this plant in Latin. The protologue also contains a synonyms cited from Barrelier (1714: ic. 1317) "*Horminum hispanicum, foliis herbae venti, flore coeruleo*", the geographical locality "*Habitat in regno* Valentino *locis aridis et desertis*", and material from the Jussieu herbarium "*Ex herbario Jussiaei*". The synonym is accompanied by an excellent illustration (see Barrelier 1714: page 25, n. 237, ic. 1317), and therefore it is original material and candidate for the lectotype of this name.

In accordance with the transcription of Folch (Salvador 1972), Joan Salvador and Antoine and Bernard de Jussieu were in Valencian area (incl. Sierra de la Murta) between 24 October 1716 and 8 November 1716. The herbarium of this travel is preserved in the Jussieu herbarium at P, and several duplicate sheets are at BC (BC-Salvador) (see Bolòs 1946; Layssus & Layssus 1970; Ibáñez 2006).

In the Antoine Laurent de Jussieu herbarium at P there is only a herbarium sheet of this plant, P-JU-5239 (code according to *Catalogue de l'Herbier d'Antoine–Laurent de Jussieu* 1868, conserved in the *Laboratoire de Phanérogamie* of the *Muséum national d'Histoire naturelle de Paris*, MNHN) (see Stafleu 1964). This sheet, also with code P00657955, bears a fragment well preserved and developed, with leaves and flowers, and a label handwritten by Antoine Laurent de Jussieu "Salvia valentina / Sclarea folio lanceolato hispanica Barr. obs. / N. 233 [237] p. 25. / horminum hispanicum foliis herba venti - / flore coeruleo Barr. ic. 1317. / in deserto La Murta dicto Regni valentini" (image available at http://mediaphoto.mnhn.fr/media/14594288337061omA6Xl67zCEPhR8).

We have been unable to trace any further original material, e.g., in the Salvador herbarium at BC (see Ibáñez 2006) or in the Vahl's personal herbarium at C. In conclusion, although the Barrelier's illustration match with the traditional concept and current use of Vahl's *Salvia valentina*, according to Art. 9.5 of the *ICN* (see also Art. 40 Note 2) (see McNeill & al. 2012) the specimen at P (with code P00657955) can be considered as a syntype, and therefore it has priority in the lectotype designation (see Art. 9.12 of the *ICN*). Fortunately, the specimen match with the traditional concept and current use of the name (e.g., Sáez 2010; Mateo & Crespo 2014) and it is designated as the lectotype of *Salvia valentina*.

Salvia valentina Vahl, Enum. Pl.: 268. 1804
≡ *S. sylvestris* f. *valentina* (Vahl) Pau (1896: 86)

≡ *S. nemorosa* subsp. *valentina* (Vahl) O. Bolòs & al. (1993: 1215)

≡ *S. sylvestris* subsp. *valentina* (Vahl) O. Bolòs & Vigo (1996: 347)

Lectotype (designated here):—[SPAIN]. “La Murta dicto Regni valentini” [La Murta, Valencia] (P-JU-5239 [code P00657955!]) (image available at http://mediaphoto.mnhn.fr/media/1459428833706l omA6Xl67zCEPhR8).

Note: The material of this species indicated by Vahl (1804) in the protologue as “Ex herbario Jussiaei” perhaps is represented by a single specimen (i.e., P-JU-5239 [code P00657955!]). However, it is not the holotype of the name since the author indicated in the protologue other element, i.e., the Barrelier’s illustration (1714: ic. 1317) (see McNeill 2014).

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B. Medjahdi, A. Letreuch-Belarouci, S. Maazouz & K. Taïbi

Diversité floristique des subéraies des monts de Tlemcen (Nord Ouest Algérien)

Abstract

Medjahdi, B., Letreuch-Belarouci, A., Maazouz, S. & Taïbi, K.: Diversité floristique des subéraies des monts de Tlemcen (Nord Ouest Algérien). — Fl. Medit. 28: 67-77. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

The floral diversity's analysis of cork oak forests in Tlemcen mounts has revealed the existence of 429 taxa belonging to 65 families and 265 genera. The comparaison of the flora in three cork oak forests allowed us to highlight the occurrence of an important original flora, where 85 taxa are present only in the forest of Hafir-Zarrifette, 87 in the forest of Sidi Hamza-Ain Souk-Zerdeb and 65 belong to for the forest of Ifry, 84 taxa are common to all the three forests. The number of endemic and/or rarely inventoried taxa contains 14 endemic algero-moroccan and 17 ibero-algero-moroccan ; 9 are endemic to North Africa (Algeria, Morocco, Tunisia) ; and 11 are endemic to the Iberian peninsula and North Africa. So, despite the degradation of the endemic and rare flora, what remains, is often accompanied by stable species in all the three forests. These species can be used for the reconstruction of cork oak forests in the Tlemcen mounts.

Key words: inventory, endemism, cork oak, biodiversity.

Introduction

Si la richesse floristique des monts de Tlemcen est importante, celle des subéraies occupe une place assez particulière (Letreuch-Belarouci 2009). En effet, il est bien connu que les subéraies ne se développent que sur des sols acides, ces habitats sont ainsi très localisés en Oranie (Boudy 1948). Des espèces particulièrement rares et endémiques sont souvent inféodées à ces milieux qui constituent un important patrimoine naturel du pays (Letreuch-Belrouci & al. 2009).

Dans ce contexte, l'inventaire et l'étude phytoécologique des subéraies des monts de Tlemcen ont été entamés depuis quelques années. Nous avons réalisé un premier inventaire de la forêt de Hafir-Zarifette (Letreuch-belarouci & al. 2009). Pour une meilleure connaissance des subéraies des monts de Tlemcen, nous avons entrepris deux autres inventaires, un dans la forêt de Sidi Hamaza-Ain Souk-Zerdeb (Taibi 2010) et un autre dans la forêt d'Ifry (Maazouz 2013).

Dans le présent travail nous allons réaliser une synthèse des différents inventaires pour connaitre les espèces présentent dans l'ensemble des subéraies de cette région. La mise en évidence des espèces communes et abondantes dans les zones étudiées va permettre de proposer grace à la méthode de Benabedli (1996) de réstaurer les formations de chêne-liège. Cette méthode se base sur l'identification des espèces ligneuses les plus présentent dite constantes dans un premier temps. Ces espèces doivent être multipliées (par graines pré-germés ou par plantules élevées en pépinière), dans un deuxième temps, pour préparer le milieu au chêne-liège. L'étude des listes floristiques permet aussi d'identifier les espèces rares et/ou endémiques. Ces dernières exigent le développement de stratégies pour les protéger.

Site et Méthodologie

Les monts de Tlemcen, région montagneuse de l'Algérie occidentale, constituent le massif montagneux le plus étendu du nord-ouest algérien. Ils correspondent à un vaste horst de direction NE-SW et sont composés essentiellement de formations d'âge jurassique supérieur souvent calcaire ou dolomitiques et crétacé inférieur principalement gréseuses (Despois & Raynal 1972). C'est sur ces derniers types de formations que se développent les principales subéraies. En effet, les monts de Tlemcen sont principalement dominés par les matorrals de chêne vert (*Quercus ilex* subsp *ballota* (Desf.) Samp.) où apparaissent çà et là des subéraies. Au sud-Ouest de la ville de Tlemcen apparaissent les subéraies de Zarifette (962 ha) et d'Hafir (9872 ha) qui constituent la zone intégrale du parc national de Tlemcen. Elles sont de loin les subéraies les plus importantes, suivies par celles d'Ain Souk (1307 ha), Zerdeb (2381 ha) et Sidi Hamaza (1245 ha) qui constitue un autre ensemble plus à l'Est sur le même niveau altitudinal et les mêmes expositions (Letreuch-Belarouci 2009). La forêt d'Yfri située plus bas, au nord-est de la ville de Tlemcen est d'une contenance de 1080 ha (Fig. 1).

D'une manière générale, le climat des monts de Tlemcen est marqué par une sécheresse estivale qui se manifeste dès le mois de juin. Seulement 7,2% de précipitations estivales, sur une tranche annuelle de 483 mm, d'après les données de la station de la ville de Tlemcen situé à 805 mètre d'altitude. La moyenne des températures maximales du mois le plus chaud (M) est de 32,35 °c, celle des minima du mois le plus froid (m) est de 3,2 °c. L'indice pluviométrique d'Emberger est de 51,1, ce qui confirme un climat semi-aride supérieur à variante tempérée pour la station de Tlemcen. Ce bioclimat est le même pour la forêt d'Ifry, alors que les deux autres subéraies le bioclimat sub-humide domine à cause de leurs situations plus en altitude et leurs expositions favorables (Nord-Ouest). Pour l'orographie la plupart des subéraies de cette zone s'installent sur des terrains en pente le plus souvent sur des expositions Nord-Ouest.

Pour la réalisation de cette étude trois catalogues ont été réalisés. Le premier a fait l'objet d'une publication en 2009 (Letreuch-belarouci & al. 2009). Le deuxième et le troisième ont été réalisés dans le cadre de mémoires de fin d'études (Taibi 2010 ; Maazouz 2013). Ainsi 150 relèves phytosociologiques ont été réalisés dont 60 à Haffir-Zarrifet, 50 dans les subéraies de Ain souk sidi Hamza et 40 à Ifry. En plus de ces données des récoltes ont été effectées entre les points de relevés (à chaque fois quand on recontre une nouvelle espèce). Les relèves des trois catalogues ont été effectuées en période printanière durant le mois de

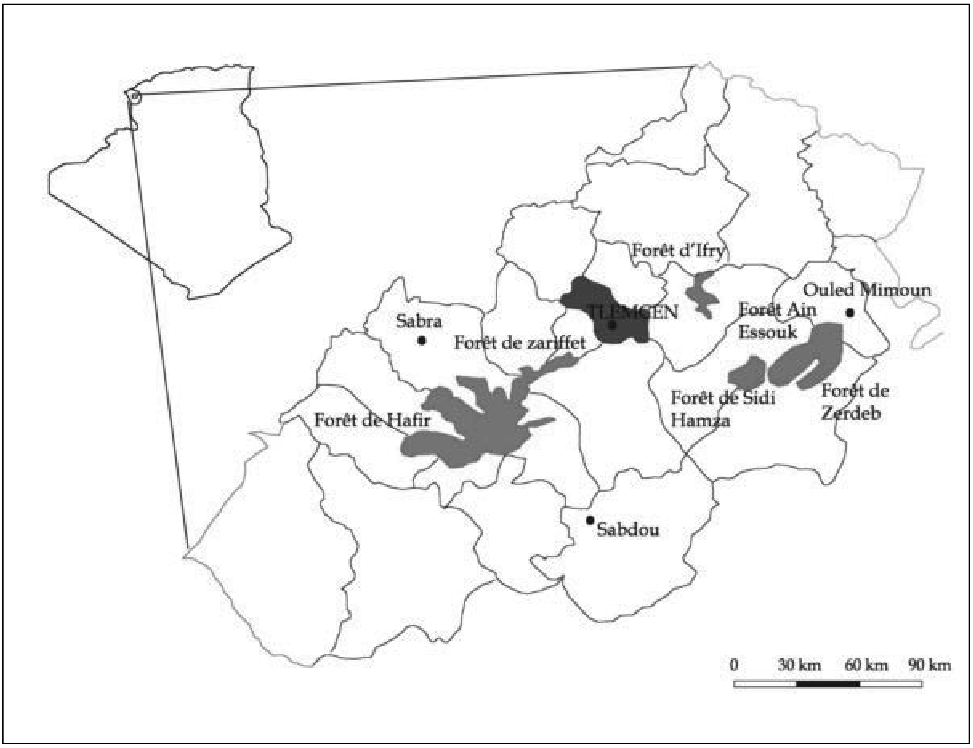

Fig. 1. Situation géographique des trois subéraies dans les monts de Tlemcen.

mars, avril et mai (c'est la meilleure saison pour inventorier le maximum d'espèces). Des passages ont été effectués durant les saisons estivales, automnales et hivernales.

Pour l'identification des espèces nous avons utilisé principalement la flore d'Algérie de Quèzel & Santa (1962-1963) (http://www.ville-ge.ch/cjb/flore/html/index.html) qui reste la référence de base pour ce genre d'étude. Mais il est nécessaire d'utiliser d'autres flores : Flore d'Afrique du Nord (Maire 1952-1987), Flore pratique du Maroc (Fenanne & al. 1999-2014), Catalogue des plantes vasculaires du Maroc du Nord (Valdes & al. 2002)

La systématique a été complètement revue et corrigée grâce à la base de données Afrique et l'index synonymique et bibliographique de la flore d'Afrique du Nord (Dobignard & Chatelain 2010-2013). Les espèces ont été rattachées aux familles suivant l'APGIII (2009).

Le catalogue floristique (Fichier Électronique Supplémentaire 1) présenté en plus de la liste des espèces ou taxons présents dans les subéraies, les informations suivantes: Nom scientifique (les taxons sont organisés suivant l'ordre alphabétique dans chaque familles. Ces dernières sont organisées aussi par ordre alphabitiques dans le groupe en question; Type biologique Thérophytes (Th) ; Espèces endémiques (on distingue les endémiques de l'Algérie et du Maroc (AM); de l'Algérie, du Maroc et de la Péninsule Ibérique (AMI); de l'Algérie, du Maroc et de la Tunisie (Afn) et enfin de l'Afrique du Nord et de la Péninsule Ibérique (AfnI). Le statut des espèces exotiques cultivées est aussi précisé (Cul.).

Le degré d'abondance, RR: l'espèce est considérée comme très rare si elle n'est présente que dans 1 à 2 relevés; **R:** rare si elle est retrouvée de 3 à 5 fois; **C:** Commune si elle se rencontre de 6 à 10 fois; **AC:** Assez commune si elle se recontre de 11 à 20 fois; **CC:** Très commun si on la rencontre plus de 20 fois. Pour chaque taxon nous avons noté la subéraie, ou les subéraies, où il a été observé.

Pour l'étude de la biodiversité nous avons utilisé les indices de Vanpeen-Bruhier (1998), qui a proposé d'analyser la richesse spécifique en quatre niveaux : la richesse ponctuelle par relevé, la richesse locale, la richesse globale et la richesse originale.

La richesse ponctuelle est le nombre d'espèces trouvées dans un relevé. Cette richesse est calculée de manière instantanée, relevé par relevé.

La richesse locale est la moyenne du nombre d'espèces par relevés de la même catégorie selon l'une des agglomérations choisies (paysage, type physionomique, type d'habitat…). Elle traduit pour une catégorie de relevés donnée, la moyenne de la richesse ponctuelle par relevé et permet donc de prendre en compte l'hétérogénéité des relevés.

Dans le présent travail, on a calculé la richesse globale (richesse spécifique Alpha), la richesse originale (richesse spécifique Beta) et le fond commun (richesse spécifique gamma).

La richesse globale est définie comme étant la somme des espèces présentes dans une catégorie. Elle peut être calculée à tous les niveaux d'agrégation spatiale : les types d'habitats, paysages, les types physionomiques de la végétation et pour les autres catégories pertinentes. La comparaison des différentes listes par catégories similaires permet de rendre compte de l'hétérogénéité et du degré de distinction des catégories.

Résultats

En se référant aux trois catalogues floristiques, celui de Hafir et Zarifette (Letreuch-Belarouci & al. 2009) et celui de Sidi Hamaza, Ain Souk, Zerdeb (Taïbi 2010) et le catalogue d'Ifry (Maazouz 2013). On a pu inventorier 429 taxons de rang spécifique ou sous spécifique, répartis entre 65 familles, les angiospermes dicotylédones forment le groupe systématique le plus important avec 43 familles et 196 genres, les monocotylédones contiennent 14 familles et 53 genres, les ptéridophytes comptent 7 familles et 9 genres et les gymnospermes comptent seulement 2 familles et 4 genres.

Les catalogues floristiques insérés à la fin de ce manuscrit, regroupe tous les taxons présents dans les trois subéraies.

L'inventaire a permis de mettre en évidence les résultats résumés dans le tableau 1.

Ce tableau met en évidence la richesse de la forêt de Sidi Hamza-Zerdeb-Ain Souk par rapport aux deux autres. Celle-ci présente une richesse floristique plus importante de 3 taxons par rapport à Hafir-Zarifette et 17 taxons supplémentaires vis-à-vis à celle de la forêt d'Ifry.

Dans les subéraies de Hafir-Zarifette, les familles les plus riches sont les *Asteraceae*, *Fabaceae*, *Poaceae*, *Lamiaceae*, *Cistaceae* et *Asparagaceae* avec respectivement 25, 22, 18, 12 et 10 taxons chacune. Ces 5 familles détiennent presque 50**%** de la richesse totale du site. Au niveau de la subéraie d'Ifry les familles les plus riches sont les *Asteraceae*, *Poaceae*, *Fabaceae*, *Lamiaceae* et *Orchidaceae* avec respectivement 32, 20, 18, 12 et 10 taxons chacune. Alors que dans la subéraie de Sidi-Zerdeb-Ain Souk les familles les plus

Tableau 1. Nombre de espèces et sous-espèces, familles et genres au niveau de chaque subéraie.

	Subéraies de Hafir-Zarieffet		***Subéraie de Sidi Hamza-Ain souk-Zerdeb***		***Subéraie d'Ifry***	
Richesse globale	239 sp. et subsp.	61 familles	242 sp. et subsp.	48 familles	225 sp. et subsp.	59 familles
		174 genres		169 genres		178 genres
Angiospermes dicotylédones	175 sp. et subsp.	41 familles	202 sp. et subsp.	33 familles	159 sp. et subsp.	38 Familles
		124 genres		136 genres		124 genres
Monocotylédones	52 sp. et subsp.	12 familles	35 sp. et subsp.	12 familles	56 sp. et subsp.	13 familles
		40 genres		30 genres		46 genres
Ptéridophytes et Gymnospermes	12 sp. et subsp.	8 familles	05 sp. et subsp.	3 familles	10 sp. et subsp.	6 familles
		10 genres		3 genres		8 genres

riches sont les *Asteraceae*, *Fabaceae*, avec respectivement 39, 29 taxons chacune. Suivies de loin par les *Brassicaceae*, *Caryophyllaceae*, *Cistaceae*, *Lamiaceae*, *Apiaceae* avec 14, 14, 12, 12, et 12 taxons respectivement. La famille des Poaceae n'est représentée que par 9 taxons seulement, alors qu'elle est la deuxième famille de point de vue importance taxonomique dans la flore algérienne.

Les richesses originales traduisent l'hétérogénéité des milieux ou des secteurs, ainsi que leur part dans le patrimoine floristique. Alors que le fond commun d'espèces représente le nombre d'espèces que l'on trouve partout. Il traduit l'homogénéité de la végétation, les espèces les plus communément répandues ou n'ayant pas d'exigence écologique particulière.

On remarque que la richesse originale de la subéraie de Sidi hamza-Zerdeb-Ain souk est nettement plus élevée que celle du massif forestier Hafir-Zarifette et la forêt d'Ifry. De ce fait, cette forêt englobe probablement un très grand potentiel floristique. Le fond commun rassemblant des espèces que l'on peut trouver dans les trois subéraies est en nombre élevé, elles sont dans leur globalité communes selon des degrés d'abondance variés, et parfois même endémiques.

Tous ses différents niveaux de richesse spécifique permettent d'avoir un regard différent sur la notion de richesse floristique d'un secteur et de relativiser les résultats obtenus pour apporter une aide à la gestion de l'espace.

Flore endémique et rare dans les subéraies des monts de Tlemcen

Avec l'intérêt de plus en plus important pour la biodiversité et la conservation de la nature, l'étude de l'endémisme végétal attire l'attention des scientifiques. En effet, pour déterminer les 25 hotspots mondiaux Myers & al. (2000), se sont particulièrement basés sur le nombre de taxons endémiques par unités de surfaces. De même Quézel & Médail (1995) ont fait pour déterminer les dix points chauds ou points névralgiques (*Hotspots*) dans le bassin méditerranéen. De ce fait, on est amené à sélectionner les espèces rares, ou endémiques présentes dans nos subéraies.

A travers tableau 2 on remarque que le nombre total des taxons endémiques est important, avec une remarquable abondance des endémiques ibéro-algéro-marocains (17) ce qui confirme l'appartenance des monts de Tlemcen à l'hotspot Bético-rifain (partagé entre la péninsule Ibérique, le Maroc et l'Algérie). Sur les 17 taxons endémiques ibéro-algéro-marocaines un seul est bético-rifaines les restes sont des Ibéro-mauritaniennes (Quézel & Santa 1962-1963). Les endémiques algéro-marocains (14) et ibéro-Nord africains (11) représentent les taux les plus importants après la catégorie précitée, laissant la place en dernier lieu aux endémiques de l'Afrique du Nord (09).

Dans le massif forestier Hafir-Zarifette, Il n'y a qu'un taxon endémique algérien. Il s'agit de Coleostephus multicaulis. Les endémiques algéro-marocains comptent 7 taxons. Les taxons endémiques ibéroalgéro-marocains sont au nombre de 11 dont 4 rares à l'échelle nationale (Quèzel & Santa 1962-1963). Les endémiques d'Afrique du Nord et les endémiques communes à la Péninsule ibérique et l'Afrique du nord sont représentées par 4 et 7 taxons respectivement.

Les taxons rares à l'échelle du pays selon l'échelle de Quèzel & Santa (1962-1963) et non endémiques comptent 17 taxons. 9 taxons sont endémiques et menacés (Letreuch-Belarouci *&* al. 2009).

Dans la subéraie de Sidi Hamza-Zerdeb-Ain Souk, il existe une trentaine d'espèces endémiques. Les endémiques algéro-marocains comptent aussi 7 taxons. Les taxons endémiques ibéro-algéro-marocains sont nombreux, on en compte 12. Les taxons endémiques de l'Algérie, du Maroc et de la Tunisie sont peu nombreux (4). On compte 7 endémiques de l'Afrique du Nord et de la péninsule Ibérique. Il existe une flore rare remarquable au niveau de cette forêt. En effet, 38 espèces comprises dans un intervalle allant de l'assez rares au très rares à l'échelle du pays.

Tableau 2. Richesse originale et flore endémique et rares des trois subéraies.

	Hafir-zarieffet	**Sidi Hamza-Zerdeb-Ain Souk**	**Ifry**	**Total**
Richesse originale	85	87	65	
Endémiques Algériennes	1	0	0	1
Endémiques algéro-marocains (AM)	8	7	4	14
Endémiques ibéro-algéro-marocains (AMI)	8	11	9	17
Endémiques d'Afrique du Nord (Afn)	5	4	4	09
Endémiques de l'Afrique du Nord et de la Péninsule Ibérique (AfnI)	6	4	6	11

La forêt d'Ifry compte 23 taxons endémiques dont 9 endémiques Ibéro-algéro-marocains, 4 endémiques algéro-marocains, 4 endémiques d'Afrique du Nord et 6 endémiques ibéro-Nord Africains. Les taxons rares sont peu nombreux, Seuls un taxon est très rare, 12 taxons sont rares et 1 est assez rare. La plupart des espèces inventoriées dans cette étude sont communes ou assez communes pour l'ensemble du territoire national.

L'analyse des spectres biologiques vient compléter l'étude taxonomique de la flore des trois subaries. Les représentations graphiques des pourcentages du nombre d'espèces exprimées en fonction de leur type biologique (Fig. 2) donnent une idée de la structure de la végétation dans la région d'étude. Les thérophytes occupent la part la plus importante, suivie de loin par les géophytes, les hémicryptophytes, les chaméphytes, les nanophanérophytes et les phanérophytes. Cette tendance générale change d'une subéraie à une autre. En effet, les géophytes occupent la deuxième place après les thérophytes à Hafi-Zarifette et Ifry, dans le massif forestier de Sidi Hamaza-Ain Souk-Zerdeb les hémicryptophytes occupent la deuxième place après les thérophytes. Ces dernières présentent un taux beaucoup plus élevé dans ce massif par rapport aux deux autres.

Discussions et Conclusions

Nous avons inventorié 429 taxons en réalisant 150 relevés, alors qu'au Maroc, Aafi (2007), pour un effort d'échantillonnage 2,5 fois plus important que le nôtre (400 relevés), a recensé une richesse similaire (408 taxons, réparties sur 62 familles et 261 genres). Pour un effort beaucoup moins important (80 relevés) Meddour, (2010) a inventorié 217 taxons. Ce résultat correspond parfaitement aux richesses obtenues pour les trois forêts séparément avec une intensité d'échantillonnage plus ou moins égale. Plus à l'Est dans les subéraies

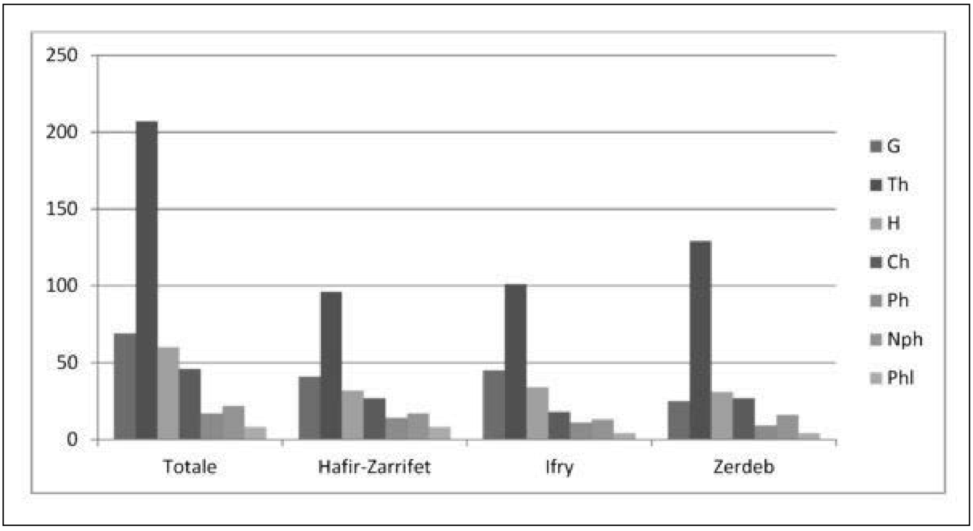

Fig. 2. Spectre biologique de la flore des subéraies des monts de Tlemcen.

de la Numidie orientale pour 150 relevés Bennadja et al. (2013) ont recensé 292 taxons. Les subéraies des monts de Tlemcen présentent une richesse globale similaire à celles de la Kabylie et plus élevée que les subéraies du Maroc et de la Numidie, qui présentent des conditions écologiques plus favorables (des climats plus humides).

Cette importance est sans doute due à la dégradation du milieu. Letreuch & al. (2009) et Meddour (2010) déplorent l'état des peuplements du chêne-liège. L'examen du spectre biologique confirme cette situation. En effet, même si le taux des thérophytes est habituellement élevé dans les formations méditerranéennes. Il se situe entre 25 et 50 pourcents pour les formations forestières (Barbéro 1989). Il devient beaucoup plus important par ouverture du milieu sous l'effet de la sécheresse et des perturbations (Daget 1980 & Grime 1977). La richesse de la subéraie de Sidi Hamza-Ain souk-zerdabe par rapport aux deux autres le confirme. Elle présente le taux le plus élevé de thérophytes, qui sont pour la plupart des taxons très communs (CC), assez commun (AC) ou commun (C) ou c'est-à-dire observées dans plus de 10 relevés. Il faut signaler aussi que ces taxons sont communs à l'échelle nationale (Fig. 3).

Malgré la dégradation de ces écosystèmes nos subéraies gardent tout de même une certaine richesse floristique. Les taxons endémiques constituent 10% du total, parmi ces endémiques une bonne partie présentent un degré de rareté plus ou moins important allant de l'assez rare au rarissime. Cela nous a permis d'établir la liste suivante :

Allium massaessylum Batt. & Trab.: endémique algéro-ibéro-marocaine très rare;
Fritillaria oranensis Pomel: endémique d'Afrique du Nord et péninsule Ibérique rare;
Gagea algeriensis Chaber: endémique ibéro-algéro-marocaine rare;
Ophrys atlantica Munby subsp. ***atlantica****:* espèce très rare, signalée dans la région redécouverte récemment dans la forêt de Haffir-Zarifette;
Centaurea eriophora L.: endémique ibéro-algéro-marocaine assez rare;
Coleostephus multicaulis (Desf.) Durieu: endémique algérienne***;***

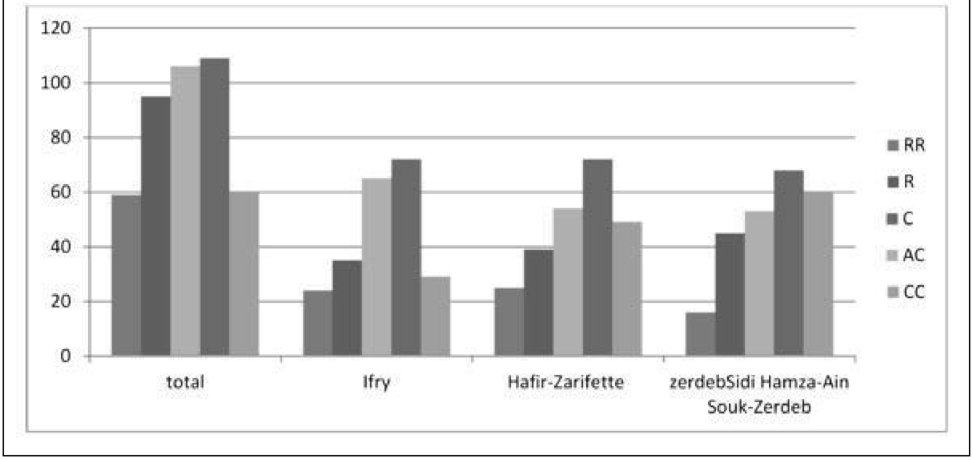

Fig. 3. Degrés d'abondances des taxons dans les trois subéraies.

Diplotaxis siifolia Kunze*:* endémique ibéro-algéro-marocaine rare;

Guenthera setulosa (Boiss. & Reut.) Gómez-Campo: endémique algéro-marocaine rarissime. Espèce protégée par la loi de 1993;

Cistus umbellatus subsp. ***viscosus*** (Willk.) Demoly: Endémique algéro-ibéro-marocaine; en Algérie, elle est présente uniquement dans la région de Hafir-Zarifette;

Helianthemum origanifolium subsp. ***molle*** (Cav.) Font Quer & Rothm.: Endémique algéro-ibéro-marocaine rare;

Helianthemum papillare Boiss.: endémique algéro-ibéro-marocaine rare;

Convolvulus valentinus Cav.: endémique algéro-ibéro-marocaine rare;

Silene pomeli Batt.: endémique algéro-marocain rare trouver par Doumergue (herbier du musée d'oran in Taieb 2012) dans la même région de Ouled Mimoune;

Sedum mucizonia (Ortega) Raym.-Hamet: endémique algéro-ibéro-marocaine rare;

Ononis antennata subsp. ***natricoides*** Sirj.: endémique algéro-marocaine assez-rare;

Stauracanthus boivinii (Webb) Samp.: endémique algéro-ibéro-marocaine rare présente seulement au niveau des monts Tlemcen;

Linum numidicum Murb.: endémique d'Afrique du Nord, rare;

Linaria multicaulis subsp. ***heterophylla*** (Desf.) D.A. Sutton: endémique d'Afrique du Nord, rarissime;

Linaria tristis subsp. ***marginata*** (Desf.) Maire: endémique algéro-marocaine localisée au niveau des monts de Tlemcen dans la région de Ghar Rouban;

Hieracium amplexicaule L.: espèce rarissime protégée par la loi de 1993.

La protection des espèces passe nécessairement par le maintien de la subéraie. Cette formation végétale est actuellement très menacée par le surpâturage et les incendies. Ces deux perturbations dégradent les subéraies en ouvrant le milieu favorisant ainsi l'installation des thérophytes. Pour pallier ce phénomène il faut fermer le milieu par l'installation des espèces buissonnantes ou arbustives, car il est difficile de mettre en place directement le chêne-liège (Benabdelli 1996). Pour la reconstitution de la subéraie, il faut ainsi prendre en considération les espèces les plus présentes ou les plus stables. Il faut choisir parmi les phanérophytes, les nanophanérophytes et certaines chaméphytes les taxons qui couvrent bien le sol (Medjahdi 2001). Nous proposons les espèces suivantes : *Pinus halepensis*, *Pistacia lentiscus*, *P. terebinthus*, *Arbutus unedo*, *Erica arborea*, *Quercus coccifera*, *Calicotome intermedia*, *Cytisus villosus*, *Genista tricuspidata*, *Stauracanthus boivinii*, *Olea europea*, *Rhamnus lycioides* subsp. *oleoides.*

Il faut signaler à la fin que certaines espèces ont été observées pour la première fois dans ces subéraies et dans la région Tlemcen voir dans la région oranaise. Il s'agit de *Cystopteris fragilis* subsp. *fragilis* observée pour la première fois dans la subéraie de Hafir-Zarifette. *Linum numidicum* endémique d'Afrique du nord observée en Numidie, Kabylie et dans les montagnes marocaines. Il s'agit sans doute de la variété signalée au Maroc (var. *fontqueri* Maire). Les subéraies des monts de Tlemcen gardent ainsi, certainement des trésors floristiques à découvrir dans le futur.

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Filippo Scafidi & Francesco M. Raimondo

First record of *Pilea microphylla* (*Urticaceae*) in Sicily

Abstract

Scafidi, F. & Raimondo, F. M.: First record of *Pilea microphylla* (*Urticaceae*) in Sicily. — Fl. Medit. 28: 79-84. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Pilea microphylla (*Urticaceae*) is a species native to Mexico and tropical South America that has been collected for the first time in Sicily in the surroundings of the city of Palermo. According to our observations, this species is to be considered as a casual alien.

Key words: alien flora, vascular flora, xenophytes, urban area, Palermo.

Introduction

Pilea is the largest genus of the *Urticaceae* and one of the largest genera in the *Urticales* (Monro 2006). It includes over 600 species (Adams 1970; Burger 1977; Monro 2004), that are mostly distributed throughout the tropics, subtropics, and warm temperate regions (Monro & al. 2012). The majority of species are succulent herbs, epiphytes or small shrubs growing in heavy shade (Monro 2009).

In June 2017, during the study of the alien urban flora of Palermo (Ciccarello & al. 2016) a remarkable population, identified as *Pilea microphylla* (L.) Liebm., was discovered. This new alien species had not previously been reported in any Italian and Sicilian floristic literature (Fiori 1926; Pignatti 1982; Giardina & al. 2007; Raimondo & al. 2010; Celesti-Grapow & al. 2016; Domina & al. 2018; Galasso & al. 2018). Recently, it had been founded as weed in the greenhouses in Lombardy (Northern Italy) (Acta Plantarum 2017: http://www.floraitaliae.actaplantarum.org/viewtopic.php?t=98852_).

Therefore, the new finding represents the first record for Sicily and the second for Italy as well.

Material and Methods

Plant material was collected in the field. Herbarium specimens were deposited in FI, PAL and PAL-Gr (acronyms according to Thiers 2011).

The taxonomical identification was made on the basis of the descriptions by Standley (1937), Wagner & al. (1999), Monro (2001) and Bhellum & Hamid (2016). The protologue by Linnaeus (1759) was also examined.

Data about the habitat and the population size of *P. microphylla* are based on personal observations in the field. The evaluation of the invasive status was defined according to Pyšek & al. (2004).

Results and Discussion

Pilea microphylla (L.) Liebm. in Kongel. Danske Vidensk. Selsk. Skr., Naturvidensk. Math. Afd. ser. 5, 2: 296 (1851).

Typus: Jamaica? (LINN 1220.8! – lectotype) designated by De Rooij (1975).

≡ *Parietaria microphylla* L., Syst. Nat., ed. 10, 2: 1308 (1759).
=*Urtica serpyllacea* Kunth in Humb., Bonpl. & Kunth, Nov. gen. sp. 2: 37 (1817).
=*Pilea muscosa* Lindl., Coll. hot.: t. 4 (1821), nom. superfl.
=*P. serpyllacea* (Kunth) Liebm. in Kongel Danske Vidensk. Selsk. Skr., Naturvidensk. Math. Afd. ser. 5, 2: 296 (1851).
=*P. portula* Liebm. in Kongel. Danske Vidensk. Selsk. Skr., Naturvidensk. Math. Afd. ser. 5, 2: 297 (1851).

Pilea microphylla, commonly known as artillery weed, rockweed or gunpowder plant, is native to Mexico and tropical South America (Monro 2001). It is mainly utilized in gardens and landscapes as foliage or groundcover ornamental plant (Saha & al. 2017), but also for many ethnobotanical uses (Bhellum & Hamid 2016).

At present, it is considered as a problematic weed affecting tropical and subtropical environments worldwide (Pacific Island Ecosystems at Risk 2010).

In Europe, *P. microphylla* is known as casual alien in Belgium, introduced as weed via plant nurseries (Verloove 2006); naturalized in the Balkan Peninsula (Ball 1976), Archipelago of Madeira (Vieira 2002), or doubtfully naturalized in the Canary Islands (Otto & Verloove 2016).

During our field surveys, *P. microphylla* has been ascertained occurring in the Favorita Park of Palermo (Sicily, Southern Italy), that is placed on the southwestern foothills of Mt. Pellegrino, at 36 a.s.l. (38° 08' 58.98" N 13° 20' 50.80" E).

Climate can be referred to thermo mediterranean type, with an average annual temperature of 18°C and rainfall of 642 mm (Buffa & al. 1986).

P. microphylla was found on shady surrounding wall. Overall there are many hundreds individuals covering an area of approximately 20 m^2 (Fig. 1).

The vector of introduction is uncertain. Probably, *P. microphylla*, escaped from nearby gardens, where, probably, originally was introduced as weed in several pots of ornamental exotic plants.

In the growing site considered here, flowering has been observed only in the year 2017, from June up to September (Fig. 2); fruits, however, were not produced. It seems likely that at present the spread of this species entirely depends on vegetative reproduction.

Fig. 1. Habitat of *Pilea microphylla* in the Favorita Park in Palermo (Sicily, southern Italy), Photo by F. Scafidi (18.07.2017).

Fig. 2. Individuals of *P. microphylla* in blooming. Photo by F. Scafidi (18.07.2017).

Because the observation period is very short, further field research are necessary to fully assess the proper behaviour of this plant. Therefore, at this state of knowledge, according to Pyšek & al. (2004), it must be considered a casual alien.

For this reason, *P. microphylla* in Sicily should be permanently monitored, taking into account that it could represent a future threat to natural and semi-natural habitats.

The discovery of this new taxon is added to other records in the last years for the urban area of Palermo (Scafidi & al. 2016a, Scafidi & al. 2016b, Scafidi & al. 2016c, Raimondo & Spadaro 2017, Scafidi & Raimondo 2017, Spadaro & Raimondo 2017).

Specimina visa

ITALY: Sicily, Favorita Park (Palermo), shady surrounding wall, 38° 08' 58.98" N 13° 20' 50.80" E, 36 m a.s.l., 12 Jun 2017, *F. Scafidi s. n.* (FI, PAL, PAL-Gr).

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P. Bareka, E. Katopodi, G. Kamari & D. Phitos

Karyosystematic study of some taxa from the Ionian floristic region (Greece). I

Abstract

Bareka, P., Katopodi, E., Kamari, G. & Phitos, D.: Karyosystematic study of some taxa from the Ionian floristic region (Greece). I. — Fl. Medit. 28: 85-97. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

A karyosystematic study of five characteristic taxa from the Ionian Islands (Greece) is presented. The cytogeography of *Centaurea subciliaris* is commented. The chromosome number of a newly studied *Teucrium halacsyanum* population from Lefkada island is given. The taxonomic position of *Viola alba* s. l. is also discussed and a microphotograph (for the first time) of its karyotype from Lefkada island is provided. The chromosome number and karyotype morphology of *Moraea mediterranea* and *Crocus speciosus* subsp. *speciosus* are confirmed on material from Lefkada island and the presence of the latter in the island is referred for the first time.

Key words: *Centaurea subciliaris*, *Crocus speciosus*, *Moraea mediterranea*, *Teucrium halacsyanum*, *Viola alba*, cytology, distribution, taxonomy.

Introduction

The latter two authors of this publication already since 1966, among other research interests, initiated the study of the flora of the Ionian Islands in close collaboration with their good friend and collaborator Jürgen Damboldt (1937-1978), Professor in Systematic Botany of the Freie University of Berlin.

In recent years, W. Gutermann (Wien) and his colleagues have also extensively studied the flora of the Ionian Islands. In 2016, the results of this study, titled “Flora Ionica”, were published as a comprehensive list of floristic findings from all the Ionian islands (Flora Ionica Working Group 2016-onwards). However, as is usually the case with the rich native flora of Greece, new floristic elements are constantly being added to the existing ones, and surprises are never missing (Phitos & al. 2016).

The present publication is one more contribution to the flora of the Ionian floristic region. The given information concerns five taxa found on the island of Lefkada. Four of them also appear in other Ionian islands and belong to the corresponding floristic region. However, *Crocus speciosus* M. Bieb. subsp. *speciosus*, known to be distributed in locations of mainland Greece, is found for the first time in the Ionian region and specifically on the island of Lefkada.

These new floristic findings confirm the need for a further study of the flora and vegetation of the Ionian Islands, which the last two authors of this publication have steadily pursued over several decades. We estimate that this is particularly true for the island of Lefkada with its mountainous geomorphology and a coastline with many sandy places, creating a diversity of important habitats.

The above data for the five studied taxa are supplemented for the first time by cytogeographical information. It should be mentioned that previous karyological investigations on plants from the Ionian Islands and especially from Lefkada have also been made by Artelari & Kamari (1986), Kriemadi & al. (2002), Bareka & al. (2006) and Samaropoulou & al. (2013).

Material and methods

Living plants of the studied taxa were collected from several locations of the Ionian area (Table 1) and cultivated at the University of Patras and the Agricultural University of Athens. Vouchers are deposited in Herb. Phitos & Kamari (UPA).

Chromosome counts were obtained from root tip metaphases, using the squash technique (Östergren & Heneen 1962) with some small modifications. Chromosome plates were observed with Zeiss Axiophot photomicroscope.

Chromosome terminology follows Levan & al. (1964), Stebbins (1971) and Kamari (1976), taking into consideration comments and suggestions by Sybenga (1959), Bentzer & al. (1971) and Favarger (1978).

Results and discussion

Centaurea subciliaris Boiss. & Heldr. s. l. (***Asteraceae***)

Centaurea subciliaris, an endemic species of the Ionian flora, grows on the islands of Cephalonia and Lefkada (Fig. 1A), as well as on the opposite Akarnanika Ori (Mt. Boumistos and Mt. Perganti) of mainland Greece (Prefecture Aetolia-Akarnania).

Centaurea subciliaris has been described by Boissier & Heldreich (in Boissier 1875) from the island of Cephalonia. According to Matthäs (1976), the plants of Mt. Boumistos form a separate subspecies, i.e. subsp. *acarnanica* Matthäs. Greuter (2003) upgraded subsp. *acarnanica* to species level as *Centaurea acarnanica* (Matthäs) Greuter. We think that the morphological differences of the plants of Cephalonia from those of Mt. Boumistos are not significant enough to distinguish them into two species, however, we expect that the final conclusions of the ongoing, comprehensive study of the populations of *C. subciliaris* s. l. in the whole Ionian region, will shed more light.

With regard to the nomenclature, it should be noted that even though *Centaurea subciliaris* is reported by Dimopoulos & al. (2013) as *Centaurea alba* subsp. *subciliaris* Boiss. & Heldr. (Dostál), it is known that *C. alba* grows only in the western Mediterranean area (Iberian Peninsula and southern France), while the Italian and Balkan populations, which are referred to as *C. alba* (Dostál 1976), belong, in fact, to *C. deusta* Ten. (López & Devesa 2011, López-Vinyallonga & al. 2015).

Table 1. Chromosome number, locality and collectors of studied taxa.

Taxon	**Chromosome number**	**Locality**	**Collectors**
Centaurea subciliaris subsp. *subciliaris*	2*n* = 2x = 18	Ins. Kephalonia, Mt. Aenos, at summit Chionistra, alt. 1600 m	*G. Kamari, G. Lisitsa, S. Moschopoulou & K. Volteras, no 29013*
”	2*n* = 4x = 36	Ins. Kephalonia, at the lowlands of Mt. Aenos, above the village Michata, alt. ca. 450 m	*D. Phitos, G. Kamari & G. Ismailos, no 29000*
”	2*n* = 2x = 18	Ins. Lefkada, Mt. Mega Oros, close to the village Eglouvi and Agios Donatos, alt. 600-650 m	*D. Phitos, G. Kamari & E. Katopodi, no 29138*
”	2*n* = 4x = 36	Ins. Lefkada, close to the villlage Chortata, at the place named Paraspori, alt. 668 m	*D. Phitos, G. Kamari & E. Katopodi, no 29134*
Centaurea subciliaris subsp. *acarnanica*	2*n* = 4x = 36	Sterea Ellas, Akarnanika Ori, Mt. Perganti, alt. ca. 1090 m	*D. Phitos & G. Kamari, no 28075*
Crocus speciosus subsp. *speciosus*	2*n* = 2x = 18	Ins. Lefkada, Mt. Elati, alt. ca. 1000 m	*E. Katopodi s.n.*
Moraea mediterranea	2*n* = 4x = 24	Ins. Lefkada, at the northern sandy place named Gyrapetra	*D. Phitos, G. Kamari & E. Katopodi, no 29209*
”	2*n* = 4x = 24	Ins. Kephalonia, supra sinu Lagadakia, alt. ca. 20 m	*D. Phitos & P. Minetos, no 29255*
Teucrium halascyanum	2*n* = 2x = 32	Ins. Lefkada, from the suburban area of the city Lefkada	*D. Phitos, G. Kamari & E. Katopodi, no 29292*
”	2*n* = 2x = 32	Sterea Ellas, Prov. Aetolia-Akarnania, Mt. Varasova, alt. ca. 5 m	*G. Kamari & E. Liveri, no 29326*
Viola alba subsp. *thessala*	2*n* = 2x = 20	Ins. Lefkada, gorge of Melissa, alt. 200-250 m	*D. Phitos, G. Kamari, E. Katopodi & B. Lazaris, no 29262*

Additionally, our doubts, regarding the presence of *Centaurea subciliaris* in Bulgaria (Greuter & Raab-Straube 2008) were proven to be justified, based on the examination of the photographs of three herbarium specimens from Mt. Stavryanka of Bulgaria (leg. D. Delipavlov, I. Cheshmedziev & M. Popova 1980) from the Herbarium Instituti Agriculturae “V. Kolerov” – Plovdiv, which had been identified as *Centaurea subciliaris*. All three specimens, certainly, belong to the subsect. Phalolepis (Cass.) N. Garcia, Hilpold, Susanna & Vilaters. However, the branching of the Bulgarian plants, the shape of the basal leaves and the stem, as well as the bracts of the involucres, are distinctly different from the corresponding features of *C. subciliaris* plants from the Ionian floristic region.

Fig. 1. Studied taxa from Lefkada island: **A**, Capitula of *Centaurea subciliaris* s. l. from the place named Paraspori, close to the village of Chortata; **B**, individual of *Crocus speciosus* subsp. *speciosus* from Mt. Elati; **C**, *Moraea mediterranea* from the northern sandy area, at the place Gyrapetra.

Karyology

The chromosome number of *Centaurea subciliaris* from Cephalonia island was initially given by Phitos & Damboldt (1971 & 1985) and later by Samaropoulou & al. (2013). In these studies, the diploid $2n = 18 + 0–2B$, as well as the tetraploid number $2n = 4x = 36 + 0–4B$, was found in plants from Mt. Aenos at 1300–1596 m a.s.l. In individuals from the foot of the mountain (350–450 m a.s.l.), only the diploid number $2n = 18 + 0–2B$ was counted.

Matthäs (1976) reports the same results as those by Phitos & Damboldt (1971) for the typical *Centaurea subciliaris* from Cephalonia and, additionally, gives the tetraploid number $2n = 4x = 36 + 4B$ for *C. subciliaris* subsp. *acarnanica* from Mt. Boumistos (Akarnanika Ori). For the typical subspecies, originating from the island of Lefkada, she mentioned only the diploid number $2n = 18$.

The somatic number $2n = 4x = 36$ for the plants of *C. subciliaris* subsp. *acarnanica* from Akarnanika Ori (Mt. Perganti), is confirmed here. However, for the typical subspecies from Lefkada island we found $2n = 2x = 18$ (Fig. 3A), also reported by Matthäs (1976), as well as $2n = 4x = 36$ chromosomes (Fig. 3B) (see Table 1).

The karyotype of *Centaurea subciliaris* from Lefkada island is symmetrical with mostly submetacentric (sm) to metacentric (m) chromosomes, and one acrocentric pair (two in tetraploids) bearing small satellites (st-SAT) (Figs 3A & 3B). The size of the chromosomes varies from 2.5 to 4.5 μm.

Crocus speciosus **M. Bieb. subsp.** ***speciosus*** **(*Iridaceae*)**

Crocus speciosus subsp. *speciosus* has a wide distribution from Caucasus and Crimea to N Iran and N & C Turkey, extending westwards to the Balkan peninsula.

In Greece, the typical subspecies of *Crocus speciosus* was initially found by Phitos & Kamari (1983) in the Prefecture of Ioannina, near the village Monodendri. Recently, it was also found on the island of Lefkada (Fig. 1B) by the second author. It should be noted that the presence of *Crocus speciosus* subsp. *speciosus* in Lefkada is, to date, unique for the Ionian Islands and constitutes the westernmost finding, regarding its distribution. In particular, two subpopulations of the taxon, located on the mountain range Stavrotas of Lefkada island, were studied here. One subpopulation exists at the top of Mt. Elati, at ca. 980 m a.s.l. and the other at the place Ammocampos close to the summit area of Mt. Profitis Ilias, ca. 950 m a.s.l.

Significant information on the presence of *Crocus speciosus* in Greece is also provided by Karamblianis & Constantinidis (2009). According to them, subsp. *speciosus* has been found on Akarnanika Ori (Karamblianis 2007), as well as near the Monastery of Varnakovis of Prefecture Fokida (Karamplianis & Constantinidis 2009).

So far, *Crocus speciosus* subsp. *speciosus* appears in Greece only in few (four) small populations. A typical example is the island of Lefkada, where each of the two subpopulations found there does not exceed 20 individuals. According to Karamblianis & Constantinidis (2009), subpopulations on Akarnanika Ori, close to Romvou Monastery, amount to no more than 100 individuals, while only one individual was found at Varnakovis Monastery (Prefecture of Fokida)! Based on the up-to-date data on the state of the known subpopulations of subsp. *speciosus* and agreeing with Karamplianis & Constantinidis

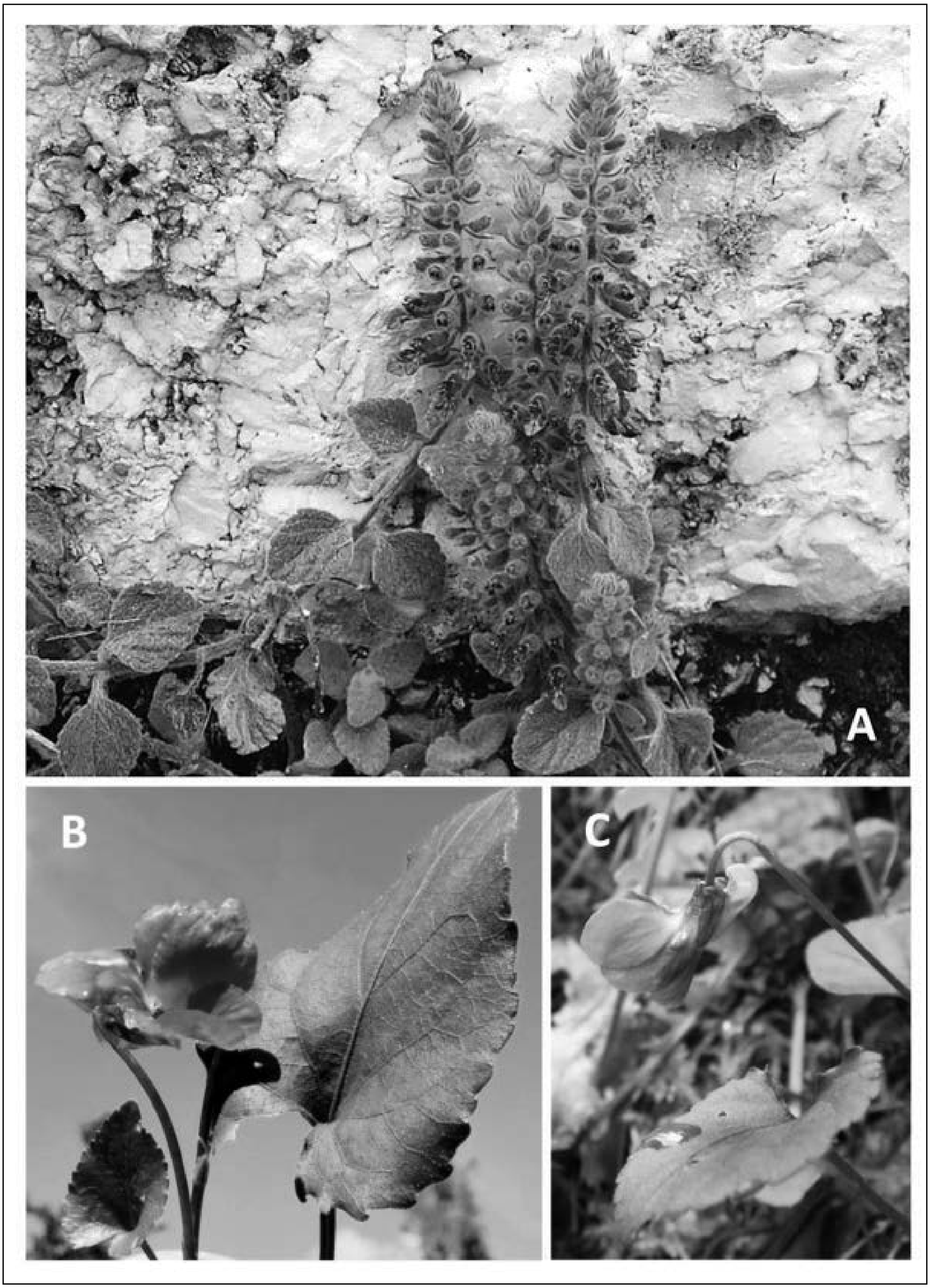

Fig. 2. Studied taxa from Lefkada island: **A**, flowering stems of *Teucrium halacyanum* from the cliffs close to the village Apolpaena; **B**, & **C**, flowers and leaves of *Viola alba* subsp. *thessala* from the gorge of Melissa.

(2009) the taxon should be classified at least as Vulnerable (VU), according to the IUCN (2016) criteria [C2a(i); D1+2], even though the recorded sporadic appearance of the subspecies does not exclude its existence in other regions of Greece, possibly in the form of small populations. In any case, we think that this taxon needs immediate protection.

Karyology

The chromosome number of *Crocus speciosus* subsp. *speciosus*, in plants from Lefkada island was found to be 2*n* = 18 (Fig. 3C).

The same chromosome number 2*n* = 18 has also been reported by Phitos & Kamari (1983) for plants from the Prefecture of Ioannina, close to the village Monodendri. This number corresponds to one of the various chromosome numbers 2*n* = 8, 10, 12, 14, 18 given for *C. speciosus* by Brighton & al. (1973), as well as by Mathew (1982).

The karyotype of *Crocus speciosus* subsp. *speciosus* is asymmetrical concerning the morphology of the chromosomes, with most chromosomes being submetacentric (sm) to acrocentric (st), varying in size between 8.5 to 19.6 μm long.

Moraea mediterranea Goldblatt (***Iridaceae***)
Syn. *Gynandriris monophylla* Klatt

Moraea Mill., is mainly a South African genus, comprising ca. 130 species, including the 9 species of the well-known, small genus *Gynandriris* Parl. (Goldblatt 1998).

Moraea mediterranea is distributed in the Mediterranean area including the coastal areas of Libya and Egypt up to Sinai, as well as of Greece (Crete, some Cyclades islands, Rodos, Peloponnisos, Attiki etc.). As for the Ionian Islands, which are of particular interest here, *M. mediterranea* is not rare, especially in the coasts areas of Zakynthos, Cephalonia Lefkada and Kerkyra, where it sporadically forms small populations. Specifically on the island of Lefkada, its presence is known only from two small localities (Gyrapetra and Myloi) at the northern, sandy places of the island (Fig. 1C).

Moraea mediterranea usually grows on sandy or gravelly places or in open phrygana, at sea level, with the exception of Kriti, where it occasionally grows at up to 700 m a.s.l.

Karyology

Polyploidy is a common phenomenon in the genus *Moraea*, according to Goldblatt & Manning (2013), leading to disploidy and subsequently to recent speciation events. Goldblatt (1980), also referring to the cytology of the two *Moraea* species found in Greece under their old names *Gynandriris sisyrinchium* Parl. and *G. monophylla* Klatt (the present names of these species are respectively *Moraea sisyrinchium* Ker Gawl. and *M. mediterranea*), notes that the karyotypes of the Greek populations from Attiki, were tetraploids (2*n* = 4x = 24), since the basic chromosomal number of the genus, is x = 6.

Indeed, the karyotype formula of the examined material here from Lefkada island appears also to be tetraploid, included 2*n* = 4x = 4m + 16sm + 4st = 24 chromosomes, medium in size, ranging in size between 6.8 and 15 μm (Fig. 3E). It is noteworthy that in one or two pairs of submetacentric (sm) chromosomes, secondary constrictions close to the centromere were visible, which, due to the applied squash technique during chromosome preparation, very often, got separated and look like B-chromosomes or very large satellites.

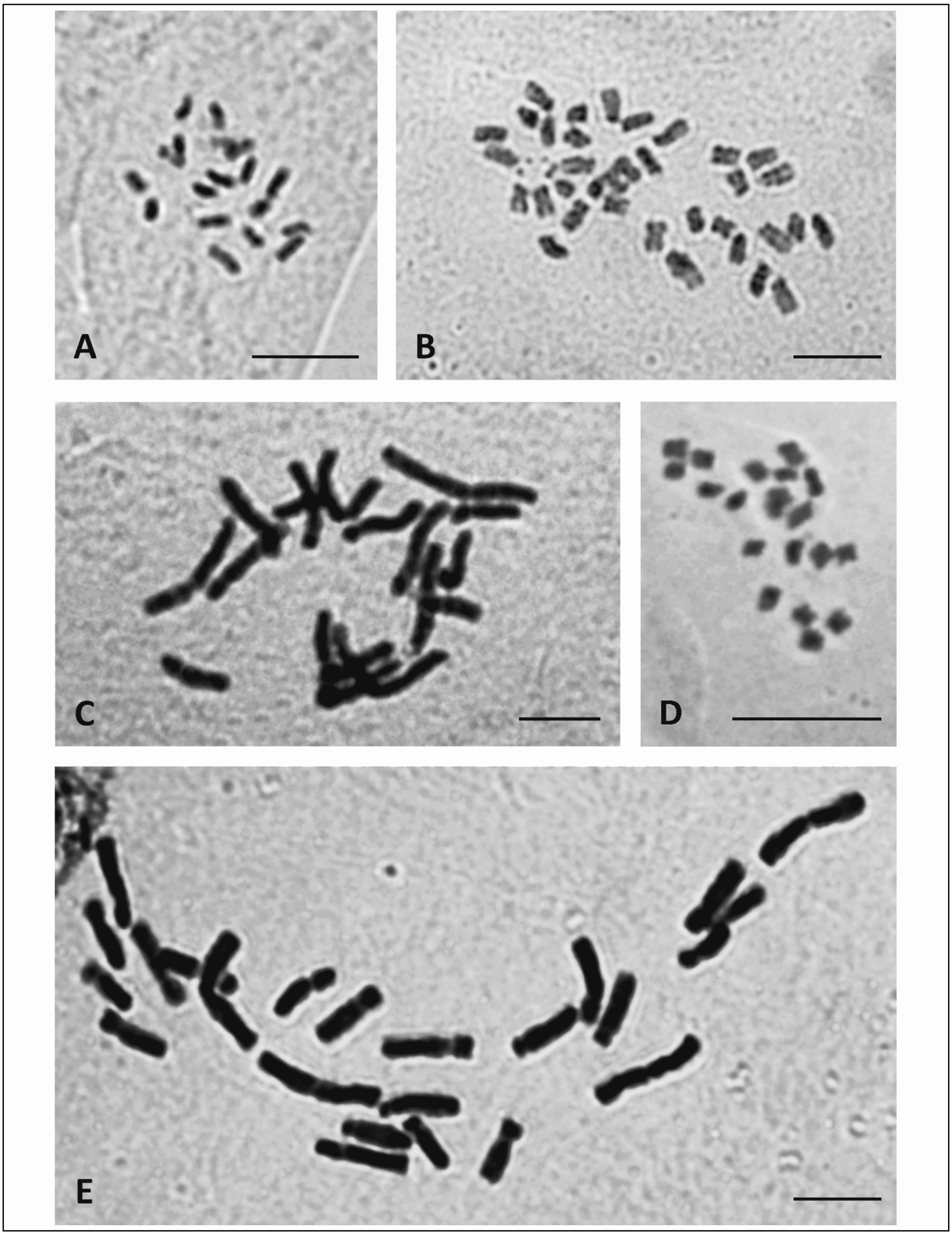

Fig. 3. Microphotographs of mitotic metaphase plates of the taxa studied from Lefkada island: **A**, *Centaurea subciliaris* subsp. *subciliaris* from Mt. Mega Oros, close to the vill. Eglouvi, 2*n* = 18 and **B,** close to the village Chortata, at the place named Paraspori, 2*n* = 4x = 36; **C**, *Crocus speciosus* subsp. *speciosus* from Mt. Elati, 2*n* = 18; **D**, *Viola alba* subsp. *thessala* from the gorge of Melissa, 2*n* = 20; **E**, *Moraea mediterranea* from the northern sandy place named Gyrapetra, 2*n* = 4x = 24. – Scale bars = 10 µm.

Teucrium halacsyanum Heldr. (**Lamiaceae**)

Teucrium halacsyanum (Fig. 2A), an endemic species of Flora Hellenica, can be considered as an important element of the Ionian floristic region, since its main distribution area includes all major Ionian Islands (Zakynthos, Cephalonia, Lefkada, Kerkyra) and some of the western and southern coasts of Sterea Hellas (Prefecture of Aetolia-Akarnania). The only locality of the species which is a bit distant from the Ionian Sea, is located in Vouraikos gorge (NW Peloponnisos), over Diakopto town (Heldreich, collection year 1899).

Teucrium halacsyanum has been described by Heldreich (1879) from the two neighbouring, relatively short mountains (*locus classicus*), i.e. Mt. Varasova and Mt. Klokova (Prefecture of Aetolia-Akarnania), the southern edges of which fall into the Patraikos Gulf, just across the city of Patras. The highest of these is Mt. Klokova or Paliovouna (known also Tafiassos in ancient times) with an altitude of 1037 m a.s.l., while Mt. Varasova is 914 m tall. Evinos River flows next to Varasova, merging with Patraikos Gulf, at the area where the ancient city of Chalkis was located. The name Chalkis is sometimes also used for Mt. Varasova.

Teucrium halacsyanum is a characteristic obligate chasmophyte found mostly on limestone cliffs. On Mt. Varasova it grows together with another endemic chasmophyte, *Centaurea heldreichii* Halácsy. An interesting and attractive divergence of *Teucrium halacsyanum* from its usual ecological habitat is its appearance (close to the city of Lefkada) on the walls of an abandoned old olive press about 100 m in length, on which more than 120 robust individuals of the species were counted.

Karyology

The somatic number of $2n = 32$ has already been given for *Teucrium halacsyanum* material from Kerkyra island (Quezel & Contandriopoulos 1966) and from Cephalonia island (Damboldt 1976). In the present study, plants from the *locus classicus*, as well as from Lefkada island (close to the village Apolpaena and the suburban area of the city of Lefkada) were examined, showing the same chromosome number ($2n = 32$) with very small (less than 0.5 μm) chromosomes with indistinct centromeres. For this reason, the karyotype morphology was not possible to be determined.

Viola alba Besser s. l. (**Violaceae**)

Viola alba is a very variable, widespread and common species distributed in southern Europe and the adjacent parts of North Africa and West Asia.

The material of *Viola alba* s. l. studied here comes from the island of Lefkada, specifically from Melissa gorge, at 330 m a.s.l. Due to the period of their collection (June 9, 2017), the collected plants from Lefkada, were in fruit. However, the morphology of the leaves and their hair, some mature capsules, as well as flower photos (kindly provided by Mr. B. Lazaris), constituted morphological features, capable to identify beyond doubt the plants in question (Figs. 2B & 2C).

Marcussen (2003), after a thorough study of the *Viola alba* complex, using allozymes and morphometry, distinguished this species into three subspecies: *V. alba* subsp. *alba*, *V. alba* subsp. *dehnhardtii* (Ten.) W. Becker and *V. alba* subsp. *cretica* (Boiss. & Heldr.) Marcussen, including the species *V. scotophylla* Jord. and *V. thessala* Boiss. & Spruner as synonymes under the typical subspecies.

We adopt in this work the classification of *V. alba* s. l., reported by Livaniou-Tiniakou (1991), in her comprehensive PhD Thesis, based on a large number of specimens from the entire distribution area of those taxa in Greece. Livaniou-Tiniakou (1991) classifies *Viola dehnhardtii* and *V. thessala* as subspecies of *V. alba*, both very widespread in Greece, whereas the typical form of *V. alba* itself does not grow in Greece. In addition, the author preserves *V. cretica*, endemic to Crete, at species level due to its clear distinctive features from *V. alba*, but also by its isolated geographical distribution.

The taxonomic distinction of the two subspecies of *V. alba* occurring in Greece according to Livaniou-Tiniakou (1991) is as follows:

V. alba **subsp.** ***dehnhardtii***

Leaves ovate-cordate, ±obtuse with convex margins, usually light green to green. *Flowers* lilac with long, slender, acuminate, usually lilac spur. *Capsule* purplish, pubescent to glabrous.

V. alba **subsp.** ***thessala***

Leaves long triangular-cordate, ±acute with straight margins, usually deep green to green. *Flowers* lilac with short, stout, not acuminate, usually bluish-white spur. *Capsule* usually green, hairy.

We give a short description of the ***Viola alba*** s. l. material from Lefkada (Figs 2B & 2C): *Leaves* long triangular-cordate, ±acute, (2.5–)4 × 5–7 cm, with straight margins, deep green; *trichome* very sparce; *leaf blade* glabrate with sparce hair mostly at the veins of the bottom surface of the leaves, 0.2–0.5 mm long. *Flowers* light blue to lilac with short spur antrose, bluish-white, rotund and not acuminate. *Capsule* light green, sparcely lanulose to hairy.

Therefore, the plants from Lefkada island, according to their morphological features, certainly belong to *V. alba* subsp. *thessala*, which is reported here for the first time from the island of Lefkada. Livaniou-Tiniakou (1991) mentioned that the widely distributed subsp. *thessala* in Greece, is also present on some other Ionian Islands (Cephalonia, Paxoi, Kerkyra), as well as on Akarnanika Ori (Mt. Boumistos).

Karyology

The karyotype of the studied population consists of $2n = 20$ chromosomes. The same chromosome number, as well as a respective karyotype drawing, was previously given by several authors for all the subspecies of *Viola alba* s. l. from Greece (but not from Lefkada island) and other countries (Schöfer 1954; Schmidt 1961; Uhríková & Májovsky 1978; Váchová & Májovský 1978; Fernández Casado 1984; González Zapatero & al. 1986; Montmollin 1986; Livaniou-Tiniakou 1991; Tiniakou 1991 & 1992).

A microphotograph of the karyotype of *Viola alba* subsp. *thessala* is given here for the first time (Fig. 3D). Its karyotype is symmetrical, consisting of very small, mostly metacentric chromosomes, ± 1.5 µm in size.

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The flora of Mt Imittos (Sterea Ellas, Greece): checklist, new records, analysis and phytogeographical aspects

Abstract

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The floristic investigation of the area of Mt Imittos in Sterea Ellas, Greece, resulted in the addition of 95 specific and infraspecific vascular plant taxa. As a result the flora of the mountain now comprises 869 taxa. For each newly recorded taxon local distribution and habitat types are presented. A significant part of the new records concern adventive taxa a fact that reflects the present day dynamics of the flora of human influenced and heavily urbanized areas of Greece. Old records of the Greek endemics *Anthemis tomentosa* subsp. *heracleotica* and *Centaurea orphanidea* are also confirmed. A detailed checklist of the total vascular flora is also presented. The results of floristic analysis and phytogeographical aspects demonstrate the pronounced Mediterranean character of the mountain's flora. Floristic similarities to other mountains of Sterea Ellas and Peloponnisos are discussed.

Key words: biodiversity, phytogeography, adventive taxa, Attiki, Mediterranean.

Introduction

Mt Imittos occupies a significant part of Attiki, a historical region of Greece directly associated with the creation of the Greek civilization. It belongs to the phytogeographical region of Sterea Ellas as defined in the *Flora Hellenica* project (Strid & Tan 1997). More specifically it lies E of the basin of Athens demarcating the eastern boundaries of the Athens urban area.

The mountain has a longitudinal shape. It can be subdivided in two geographical units, which are separated by a pass called Stavros at 454 m. Northern Imittos is bigger and higher with a NNE-SSW orientation. It encompasses the main ridge of the mountain and its higher peak Evzonas (1026 m a.s.l.). The inclination of the ground is often high and a considerable number of impressive cliffs are formed especially in its eastern slopes. These formations host a significant number of interesting plant taxa. Southern Imittos has a N-S orientation, is drier and has in general a lower and gentler relief which ends progressively to the Saronic gulf. Thus the southern part of the mountain is much influenced by the sea. Its main peak is Mavrovouni (774 m a.s.l.).

The main substrates of the mountain are marbles and dolomites followed by schists and limestones. Its peripheral zone is covered mainly by old and new talus cones and scree and terrestrial and fluvial-terrestrial deposits (IGME 2003). The maximum boundaries of the investigated area are defined by the coordinates 37°48’00” to 38°00’40”N and 23°45’18” to 23°51’44”E. However, as a major portion of its lower parts are heavily urbanized, these boundaries are nowadays obscured and often difficult to be distinguished in the field.

Climatic data are available from the nearby meteorological stations of Spata, Elliniko, Tatoi and Anavrita all situated in an altitudinal range of 43-310 m. According to the climatic diagram by Emberger (1955, 1959) and Sauvage (1963), the bioclimate of the area is semi-arid with mild winter. The dry period, according to the ombrothermic diagram by Bagnouls & Gaussen (1957), lasts five (Anavrita) to six and a half (Spata) months. Internal variation also exists, depending on altitude and topography, i.e. the upper altitudinal zone, north-facing slopes and northern Imittos receive considerable higher amounts of precipitation.

Human interferences have been acting since antiquity in the investigated area owing to its proximity to the city of Athens one of the predominant centers of the ancient world. The physiognomy of the western margins has dramatically altered in 1920s with the foundation of settlements for the Greek refugees of Minor Asia and mainly after the 1950s when waves of migrants from rural Greece concentrated in the basin of Athens following changes that occurred in social and economic structure of the country. Its eastern margins remained rural until 1990s when a rapid expansion of the local towns (Glika Nera, Peania, Koropi, Vari) took place in the last decades owing to their proximity to the city of Athens. These towns and villages are now transformed to satellite cities that are economically connected to the Athens urban area. As a result the mountain is nowadays enclosed by urban areas all over its peripheral zone. A significant part of its natural and agricultural ecosystems have been taken over by concrete. A serious human impact was the construction of a huge telecommunication facilities center and military camp that cover a significant part of the extensive ridge of northern Imittos. That caused severe visual pollution and aesthetic degradation of its upper parts visible from a long distance from the inhabitants of the city of Athens. Abandoned marble quarries have a smaller impact in the physiognomy of the mountain especially when compared to the profound impact that this activity has had in the nearby Mt Pendelikon. The quality of the marbles of Imittos is inferior when compared to the ones of Mt Pendelikon. Thus, their exploitation was restricted. Other worth mentioned human interferences comprise deforestation caused by extensive logging that took place mainly in the difficult period of Second World War, wildfires and grazing. The latter is on decline nowadays.

The investigated area has a rich history of botanical exploration due to its proximity to the city of Athens. John Sibthorp visited Mt Imittos in June 1787, and collected several species, some of which were subsequently illustrated in Flora Graeca (Sibthorp & Smith 1806, 1813, 1824, 1825a, 1825b, 1825c, 1835) among them *Cerastium tomentosum* (now *C. candidissimum*), *Delphinium tenuissimum* (now *Consolida tenuissima*), *Dianthus serratifolius*, *Gypsophila ochroleuca* (now *Petrorhagia ochroleuca*), *Salvia calycina* (now *S. pomifera* subsp. *calycina*), *Silene rigidula* (now *S. corinthiaca*), *Trigonella foenum-graecum* (now *T. cariensis*), *Valantia muralis* and *Veronica glauca*. Collectors in the period 1830-1860 include Zuccarini, Friedrichsthal, Sartori, Aucher-Éloy, Spruner, Boissier, Mill, Clementi, Guicciardi and, most importantly, Heldreich and Orphanides, the two leading botanists in Athens in the mid-19th century. In the late 19th century botanical collections were made by Halácsy, Haussknecht, Leonis, Barbey, Pichler, Tuntas and others. Among the most important contributions were the extensive collections made by Haussknecht in the spring and summer of 1885, partly together with Heldreich (Strid, pers. comm.). The first published records concerning its flora are to be found in Heldreich (1877) and Haussknecht (1893-1900). All these old reliable records were summarized in the great work of Halácsy (1900-04, 1908, 1912). Important contributions to the flora of the mountain in the 20th century include Maire & Petitmengin (1908), Rikli & Rübel (1923), Rechinger (1929, 1936), Zerlentis (1965), Strid (1986), Strid & Tan (1991), Sarlis (1994). New records are to be found in the phytosociological tables of doctoral thesis concerning the vegetation of the mountain (Gouvas 2001) and the vegetation of Attiki (Hermjakob 1977). Regel (1938) discussed also the forest vegetation of Mt Imittos. Fragmentary floristic information can be found in other publications irrelevant with the flora of the mountain mostly taxonomic revisions of a genus (Dahlstedt 1926; Lowe 1953; Snogerup 1962; Stork 1972; Scholz 1985; Frey 1997; Brullo & al. 1998; Pedersen & Faurholdt 2007; Karamplianis & al. 2013) or dealing with a specific family (Hermjakob 1969; Krämer & Krämer 1983) or with various parts of Greece (Sfikas 2001). Recent florist reports of one or few taxa include Pearce (2006), Jordan (2007), Bazos (2007), Polymenakos & Tan (2012a, 2012b, 2013, 2014a, 2014b, 2015), Alexiou (2014) and Sfikas (2015) while a new taxon has been described recently from the mountain (Zografidis & al. 2014). The present study aims to reveal the floristic diversity of a mountain of a historical region of Greece which has suffered greatly from human interferences and to assess present day dynamics.

Material and methods

The study is based on collections and field observations made mainly from 2015 to 2017. Collections were conducted in various localities and habitats of the mountain in all the seasons of the year in order to obtain a precise idea of the character of its flora. All specimens are temporarily kept in my personal herbarium and will be deposited in the Herbarium of the Agricultural University of Athens (ACA). Species identification and/or nomenclature were based mostly on Davis (1965-1985), Tutin & al. (1968, 1972, 1976, 1980, 1993), Greuter & al. (1984, 1986, 1989), Strid & Tan (1997, 2002), Greuter & Raab-Straube (2008) and Dimopoulos & al. (2013). The life-form and chorological categories used in the relevant classifications follow Dimopoulos & al. (2013). The complete plant list including spontaneous and subspontaneous taxa reports the new findings and literature records, most of which have been confirmed by the author and is included in the Electronic Supplementary File 1. Families, genera, species and subspecies are listed within the major taxonomic groups in alphabetical order. Transliteration of localities is in accordance with "*Flora Hellenica*" (Strid & Tan 1997, 2002).

Localities (Fig. 1)

1. Summit Evzonas, 1026 m a.s.l. 37°56’47”N 23°48’51”E
2. N of the summit Evzonas, 850-980 m a.s.l., 27.2.2016, 13.4.2015. 37°57’18”N 23°49’15”E
3. c. 0.5 Km N of Peanias cave, 400-700 m a.s.l., 13.4.2015, 22.4.2015. 37°57’27”N 23°49’39”E
4. Southeastern slopes of Korakovouni summit, 500-550 m a.s.l., 30.4.2015. 37°58’19”N 23°49’26”E
5. Municipality of Glika Nera, 200-270 m a.s.l., 22.9.2015, 27.10.2015, 1.9.2017. 37°59’19”N 23°50’44”E
6. Between Glika Nera and Peania, 200-300 m a.s.l., 1.9.2017. 37°58’23”N 23°50’33”E
7. Prosilio, 280-400 m a.s.l., 30.4.2015. 37°58’14”N 23°49’50”E
8. Municipality of Peania, 160-210 m a.s.l., 13.4.2015, 22.4.2015, 2.6.2015, 1.9.2017. 37°57’13”N 23°51’02”E
9. Between Peania and Peanias cave, 210-300 m a.s.l., 13.4.2015, 22.4.2015, 12.5.2015, 2.6.2015. 37°56’56”N 23°50’10”E
10. Peanias cave, 520 m a.s.l., 22.4.2015. 37°56’46”N 23°49’43”E
11. Agios Nikolaos and Chalidou, 160-240 m a.s.l., 12.5.2015, 1.9.2017. 37°56’11”N 23°50’06”E
12. Doukas stream, 320 m a.s.l., 8.4.2016. 37°54’28”N 23°48’30”E
13. Locality Kalivia, 170-200 m a.s.l., 8.4.2016. 37°52’17”N 23°49’29”E
14. Galini settlement, 100-130 m a.s.l., 8.4.2016. 37°51’18”N 23°49’05”E
15. c. 1.5 Km W of Galini settlement, 160-180 m a.s.l., 11.3.2016. 37°51’18”N 23°47’58”E
16. Municipality of Vari, between the locality Cheroma and the military training camp, 40-50 m a.s.l., 11.3.2016, 24.3.2017. 37°50’27”N 23°48’08”E
17. Terpsithea athletic facilities, 170-190 m a.s.l., 16.5.2015. 37°54’01”N 23°46’34”E
18. Stavros pass, 454 m a.s.l., 16.5.2015. 37°54’42”N 23°48’10”E
19. Between Terpsithea athletic facilities and Stavros pass, 200-450 m a.s.l., 16.5.2015. 37°54’44”N 23°47’26”E
20. Profitis Ilias chapel, 500-520 m a.s.l., 16.5.2015. 37°54’58”N 23°48’52”E
21. Between Stavros pass and Profitis Ilias chapel, 450-500 m a.s.l., 16.5.2015. 37°54’42”N 23°48’37”E
22. Monastery of Kesarianis, 350-370 m a.s.l., 27.2.2016. 37°57’38”N 23°47’52”E

Habitats

a. *Quercus coccifera* scrub, marbles.
b. Open *Pinus halepensis* wood, marbles.
c. Open scrub with *Olea europaea* subsp. *europaea* and *Juniperus phoenicea*, schists.
d. Disturbed places (street margins, crevices and edges of pavements, disturbed ground).
f. Fallow and abandoned fields.
g. *Genista acanthoclada* subsp. *acanthoclada-Thymbra capitata* dominated phrygana, dolomites.

h. Stony slopes with *Olea europaea* subsp. *europaea, Pistacia lentiscus* and phrygana, dolomites.
o. Olive groves.
r. Road margins.
s. Forest roadsides.
v. Vineyards.

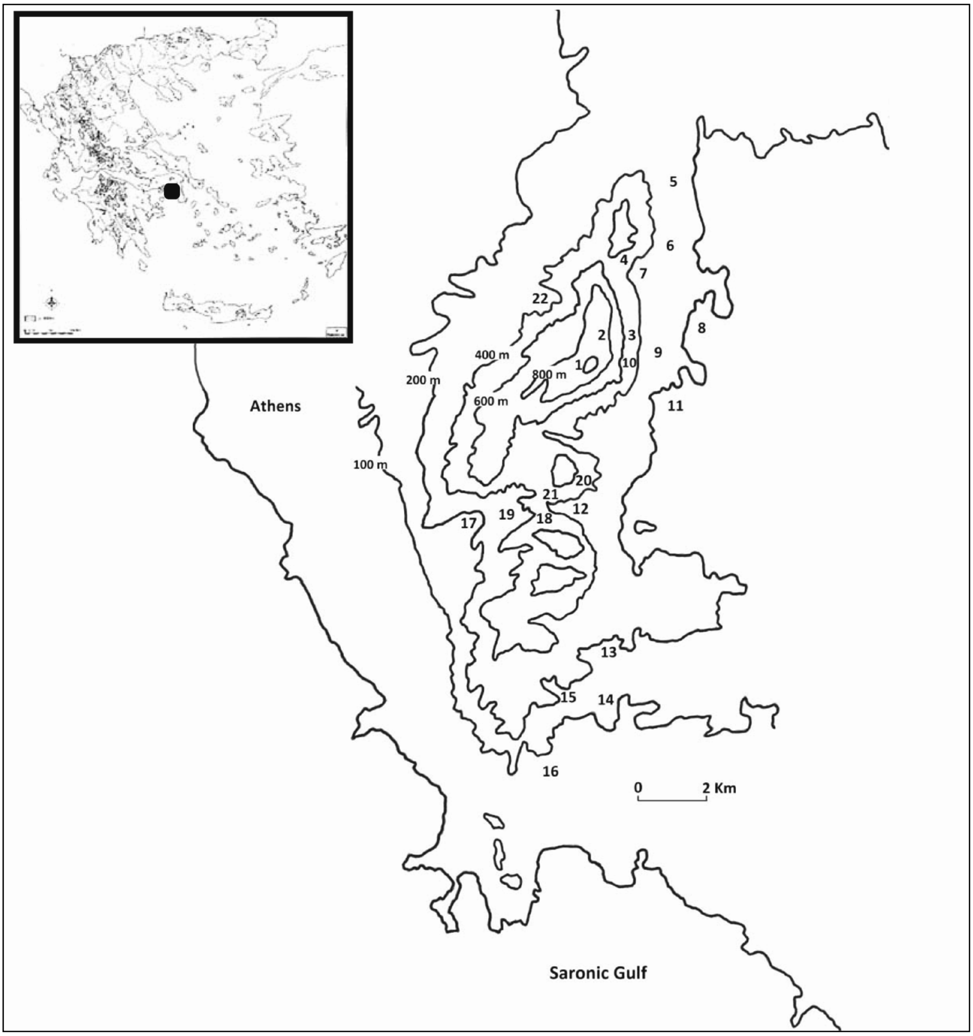

Fig. 1. Geographical position of Mt Imittos in Greece and a map of the investigated area.

Floristic analysis - Discussion

The present study raises the total number of vascular plant taxa that have been reported from Mt Imittos to 869. This number does not include dubious records, mainly for phytogeographical reasons, not substantiated by herbarium specimens. The 869 taxa belong to 97 families and 414 genera (Table 1). The 5 richest in number of taxa families are *Fabaceae* (100), *Asteraceae* (95), *Poaceae* (74), *Brassicaceae* (47), *Orchidaceae* (47).

The diversity of the flora of Imittos can be attributed to the diversity the mountain exhibits in geology, topography and climate and to the range of the human impacts. Consequently to the diversity of its habitats many of which are of anthropogenic origin. Many of the new records presented in this paper concern taxa characteristic of the latter habitat category. This fact reflects the contemporary dynamics of the flora of heavily urbanized areas of Greece and particularly in Attiki (Baliousis & Yannitsaros 2011).

The life-form spectrum shows that therophytes dominate (48.9 %) followed by hemicryptophytes (21.3 %) while the other life forms are represented by smaller percentages (Table 2). The high proportion of therophytes can be attributed to the xerothermic bioclimatic conditions that prevail in this part of Attiki, to the intensity of human influences and to the low altitude of Mt Imittos.

The analysis of the chorological spectrum (Table 3) shows that Mediterranean floristic elements are dominant (62.2 %). Greek endemics comprise 60 taxa (6.9 % of the total flora) a proportion that is expected for a mountain of Attiki (Constantinidis 1997; Baliousis 2011). Balkan endemics (19 taxa, 2.2 %) are weakly represented in the flora of Mt Imittos. Its phytogeographical position (eastern Sterea Ellas) and its lower altitude compare to higher massifs of the Pindhos mountain range explains the relatively small number of this chorological group which is more prominent in the Greek mountain flora (19.9 %). The latter includes mainly taxa found above an altitude of 1500-1800 m (Strid 1993). The flora of Mt Imittos has been enriched significantly with adventive taxa (38) mainly of American origin. The same phenomenon has been observed in the nearby Mt Pendelikon (Baliousis

Table 1. Distribution of vascular plant taxa (species and subspecies) of the flora of Mt Imittos in the major systematic units.

Systematic unit	**Families**	**Genera**	**Taxa**	**%**
Pteridophyta	4	5	5	0.6
Gymnospermae	3	3	5	0.6
Angiospermae Dicotyledones	71	321	666	76.6
Angiospermae Monocotyledones	19	85	193	22.2
Total	97	414	869	100

Table 2. Life-form spectrum of the vascular flora of Mt Imittos.

Life-forms	**Number of taxa**	**%**	**Vascular flora of Greece (%) (Dimopoulos & al. 2013)**
Therophytes (T)	425	48.9	25
Hemicryptophytes (H)	185	21.3	44
Geophytes (G)	130	15	13
Chamaephytes (C)	67	7.7	10
Phanerophytes (P)	61	7	6
Aquatics (A)	1	0.1	2
Total	869	100	100

& Yannitsaros 2011; Baliousis 2011). Many of them are reported here for the first time. Newly recorded alien species such as *Euphorbia prostrata*, *Euphorbia maculata, Chenopodium giganteum*, *Symphyotrichum squamatum* and *Solanum elaeagnifolium* expand rapidly their distribution range in the investigated area and generally in Attiki, especially in anthropogenic habitats.

Floristic affinities were examined with mountains of the closely related phytogeographical regions of Sterea Ellas and Peloponnisos. Comparisons were made with other medium sized mountains with altitude below 1500 m and more specifically with the well studied mountains of Attiki such as Gerania, Pateras, Kitheron (Constantinidis 1997), Pendelikon (Baliousis 2011) and the mountains of Peloponnisos, Likeo (Baliousis 2013) and Aphrodisio (Baliousis 2016) (Table 4). The floristic affinities to these mountains were estimated using the Sørensen similarity coefficient or index (Sørensen 1948). As it was expected Imittos has the strongest floristic similarity with the nearby Mt Pendelikon followed by the mountains of western Attiki Pateras and Gerania. The floristic similarity index is lower with the mountains Aphrodisio and Likeo. These two mountains of Peloponnisos comprise habitats such as *Quercus frainetto* Ten. forests which have been shaped by a combination of ecological factors that does not exist in Mt Imittos, i.e. more humid bioclimatic conditions and flysch as geological substrate. On the contrary floristic affinities are enhanced by floristic elements found in man-made habitats. It seems that human interference tends to homogenize the flora of the examined mountains although this factor does not affect these areas to the same degree. The examined mountains of Peoponnisos are sparsely populated nowadays. On the contrary the physiognomy of Mt Imittos has changed dramatically in recent decades and especially its lower parts have been transformed to an urban environment. As a result its flora has a more dynamic character, e.g. it comprises more adventive taxa. It is

Table 3. Chorological spectrum of the flora of Mt Imittos.

Chorological group	**Number of taxa**	**%**	**% of all taxa in Greece (Dimopoulos & al. 2013)**
1. Widespread taxa	***185***	***21.3***	***24.5***
European (Eu)	3	0.3	4.3
European-SW Asian (EA)	95	11	9.9
Euro-Siberian (ES)	8	0.9	3.5
Paleotemperate (Pt)	34	3.9	2.0
Circumtemperate (Ct)	7	0.8	1.0
Irano-Turanian (IT)	1	0.1	0.2
Saharo-Sindian (SS)	0	0	0.2
Subtropical-Tropical (ST)	7	0.8	0.6
(Circum-)Boreal (Bo)	0	0	0.8
Arctic-Alpine (AA)	0	0	0.4
Cosmopolitan (Co)	30	3.5	1.5
2. Mediterranean taxa	***541***	***62.2***	***33.1***
E Mediterranean (EM)	87	10.0	9.2
Mediterranean (Me)	310	35.7	14.3
Mediterranean-Atlantic (MA)	9	1.0	1.0
Mediterranean-European (ME)	60	6.9	5.1
Mediterranean-SW Asian (MS)	75	8.6	3.5
3. Balkan taxa	***45***	***5.2***	***16.4***
Balkan (Bk)	19	2.2	9.8
Balkan-Italian (BI)	6	0.7	1.8
Balkan-C European (BC)	0	0	1.3
Balkan-Anatolian (BA)	20	2.3	3.5
4. Endemic taxa	***60***	***6.9***	***22.2***
5. Alien taxa	***38***	***4.4***	***3.8***

Table 4. Floristic affinities of Mt Imittos to other mountains.

Mountain	**Total taxa**	**Shared taxa**	**Sørensen index**
Pendelikon	1090	757	77.3
Pateras	791	555	66.9
Gerania	945	590	65.0
Kitheron	835	391	45.9
Aphrodisio	650	361	47.5
Likeo	701	375	47.8

evident that the factors shaping the floristic similarity index with these two mountains of Peloponnisos are related to phytogeography and ecology.

An important issue studying the flora of Mt Imittos is to assess the status of the indigenous taxa. It seems from the results of this investigation, that though the mountain has suffered from numerous human interferences, its main mass still acts as a refugee for the diverse and spectacular flora of Attiki which includes many rare and/or endangered taxa. Monitoring of their populations in the years to come will continue thus enabling us to make definite conclusions.

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Apparition de *Senecio angulatus* (*Asteraceae*) en Algérie

Abstract

Miara, M. D., Boutabia, L., Telaïlia, S. & Vela, E.: Apparition de *Senecio angulatus* (*Asteraceae*) en Algérie. — Fl. Medit. 28: 111-118. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Arrival of *Senecio angulatus* (*Asteraceae*) in Algeria. — In this contribution, the authors report for the first time the presence of *Senecio angulatus* L. (*Asteraceae*) in Algeria. Field observations have shown the presence of this taxon in five localities in the center of the country. The identification was checked with particular regard to closely related taxa (e.g. *Senecio mikanioides* Harv.). This report indicates a recent arrival of this taxon in Algeria. The ecological and economic consequences of this finding are mentioned while a careful oversight of the spread of this invasive plant in the country is needed.

Key words: *Delairea odorata*, invasive species, *Senecio mikanioides*, North Africa.

Introduction

L'Algérie de par sa position géographique présente une grande diversité de biotopes occupée par une importante richesse floristique (Médail & Quézel 1997; Véla & Benhouhou 2007).

Cette flore comportant 3139 espèces totalisant 3744 taxons d'après Quézel & Santa (1962-63) in Véla & Benhouhou (2007), est désormais évaluée à 4449 taxons dont 3951 natifs de l'Afrique du Nord (Dobignard & Chatelain 2010-13).

D'après Sekkal & al (2018), cet accroissement taxinomique est la conséquence de plusieurs facteurs à savoir: la découverte chorologique d'espèces nouvelles, la prise en considération des taxons autrefois négligés (synonymes) ou cryptiques (non décrits) suite aux révisions taxinomiques et l'apparition de xénophytes nouvelles sur le territoire.

Ce dernier facteur avait constitué l'une des principales sources d'enrichissement de cette flore avec un apport considérable en espèces souvent à caractères invasif ayant une large valence écologique, leur permettant de s'installer au niveau de diverses situations écologiques. Aussi, avec l'embellissement des villes et le développement du tourisme dans la deuxième moitié du XXe siècle, le nombre des espèces exotiques introduites dans les pays d'Afrique du Nord a été considérablement augmenté (Véla & al. 2013).

Ces plantes envahissantes se définissent comme étant des espèces exotiques naturalisées dans un territoire qui modifient la composition, la structure et le fonctionnement des écosystèmes naturels ou semi-naturels dans lequel elles se propagent (Cronk & Fuller 1995). D'après Lisan (2014), ces plantes représentent souvent un réel danger pour la biodiversité et d'autres problèmes notamment: la disparition des plantes locales, la diminution de la biodiversité, perturbation des activités humaines : pêche, chasse, navigation, problèmes d'allergie, brûlures et coupures, etc. Par contre, certaines espèces invasives naturalisées présentent parfois des intérêts pour les populations des pays colonisés notamment dans les domaines thérapeutiques et médicinaux (El Mokni & El Aouni 2011).

Parmi ces taxons connus mondialement par leurs caractères invasif, *Senecio angulatus* L. f., est une *Asteraceae* qui a été d'abord signalée en Lybie et aux iles canaries par Dobignard & Chatelain (2010-13). Son existence en Algérie n'a jamais été indiquée alors qu'une éventuelle confusion avec l'espèce *Delairea odorata* Lem. (= *Senecio mikanioides* Walp.) est fortement suspectée, car ce fut parfois le cas ailleurs au cours du 20^{e} siècle (Delucchi & al. 2016).

Dans cette étude nous abordons dans un premier temps l'existence du taxon *S. angulatus* proprement dit en Algérie. Par la suite nous discutons quelques problèmes taxonomiques et chorologiques que présente ce taxon notamment la confusion avec certains taxons proches et semblables à savoir *S. mikanoides*. Nous essayerons a l'occasion de tester l'hypothèse d'une éventuelle confusion entre ces deux taxons d'origine et d'apparence semblables. Enfin, nous essayerons d'évaluer les éventuelles conséquences écologiques et économiques liées à l'apparition de cette plante invasive en Algérie.

Ecologie et reproduction

S. angulatus habite les matorrals, particulièrement près de la mer comprenant des dunes de sable (Blanca & al. 2009). Elle peut se retrouver également à proximité des habitations, dans les friches mais aussi en lisière de maquis et sur les rochers du littoral (Fried 2012).

C'est une plante qui ne présente pas d'exigences particulières en terme de substrat et pouvant occuper un terrain quelconque. Elle présente une croissance très rapide, pouvant être cultivée en pot profond, mais ne se développera correctement qu'en pleine terre. Elle résiste au froid jusqu'à -6°C. Elle gèle à des températures plus basses, mais repart par ses racines très vite, alors que sa résistance à la chaleur est excellente. En Corse, cette plante ne se développe que très rarement à des altitudes supérieures à 200 m (Andreani 2014).

Elle pousse généralement dans des sites secs et ouverts. C'est une plante qui se propage rapidement, grimpant sur les arbustes et le sol, formant souvent de grands fourrés denses qui empêchent les autres espèces de s'établir. Elle peut se propager rapidement en produisant de nombreux drageons. De petits fragments peuvent germer et pousser facilement (Bergin 2006).

Chorologie et biogéographie

Senecio angulatus est une plante native d'Afrique du Sud (NGRP 2013), qui a été introduite dans de nombreuses régions du monde comme ornementale (Csurhes & Edwards

1998; Rossini-Oliva & al. 2003; Groves & al. 2005). Elle a été repérée en plusieurs pays aux quatre points du monde notamment en Albanie et en Chilie (Barina & al. 2011; Ugarte & al. 2011) et a été considérée comme naturalisée en Albanie, Italie, France, Espagne et au Portugal (Jeanmonod & Schlüssel 2006; Romero Buján 2007; Pyke 2008; Barina & al. 2011; NGRP 2013; Celesti & al. 2016; Galasso & al. 2018). Elle existe également en Nouvelle Zélande et Australie (Bergin 2006; Muyt 2001 ; Murray & Phillips 2012), Argentine et Chili (Ugarte & al. 2011; Dellucchi & al. 2016), et aux Etats-Unis d'Amérique (USDA 2013).

En Afrique du Nord, cette plante est signalée en Lybie (Alavi 1983; Dobignard & Chatelain 2010-2013). Elle n'avait encore jamais été citée pour le Maroc, l'Algérie ou la Tunisie.

Premières observations de *S. angulatus* en Algérie

A la suite de nos recherches, plusieurs observations de terrain de *S. angulatus* ont été effectuées dans plusieurs régions dans le centre et l'est du Nord algérien. Les premières observations ont été réalisées en Kabylie (Sidi Aich) dans la wilaya de Bejaia à l'est d'Alger ainsi qu'a Nador (Chenoua) dans la wilaya de Tipaza. Ensuite, cette plante a été repérée près d'Ouled Fayet aux environs d'Alger. Plus récemment, elle a été également observée dans la région d'Annaba ainsi que dans la région de Tarf (commune de Berrihane sur cordon dunaire, vers El Kala) (Fig.1). En plus des photographie de la plante qui ont été prises sur terrain à ces occasions (Fig. 2-3), un spécimen de cette plante a été déposé au niveau de l'herbier de l'école nationale supérieure agronomique (ENSA). La plante se présente souvent en population relativement importante dans des biotopes plus ou moins anthropisés notamment au bord de la route, en limite de propriétés privées ou en lisière des exploitations agricoles (Fig. 3).

Confusions taxonomiques autour de *S. angulatus*

Le genre *Senecio* dans son sens large historique est représenté dans la flore d'Algérie (Quézel & Santa 1962-63) par 18 espèces dont 5 endémiques. Toutefois, Dobignard & Chatelain (2010-13) ont restreint le genre et réduit ce nombre à 13 espèces dont 2 taxons qui sont endémiques.

Parmi ces espèces signalées pour l'Algérie, *Delairea odorata* Lem. (=*Senecio mikanioides* Walp.) qui est une espèce qui ressemble à *S. angulatus* mais bien différente.

En effet, *Delairea odorata* a de petits capitules jaunes brillants sans "pétales" évidents (i.e. fleurons ligulés). Or, *Senecio angulatus* possède une inflorescence jaune vif modérément grande avec plusieurs "pétales" (i.e. fleurons) de 6-9 mm de long.

En Argentine, Dellucchi & al. (2016) ont observés une certaine confusion entre *S. angulatus* et quelques taxons d'apparence similaires et d'origine sud-africaine notamment *Delairea odorata* Lem., *Senecio macroglossus* DC. et *S. tamoides* DC.

Afin de tester une éventuelle confusion pareille dans notre pays, nous avons consulté plusieurs planches de spécimens d'herbier anciens provenant de l'herbier du Musée de Paris, herbier de Montpellier. Le travail a consisté à vérifier les spécimens de *S. mikanoi-*

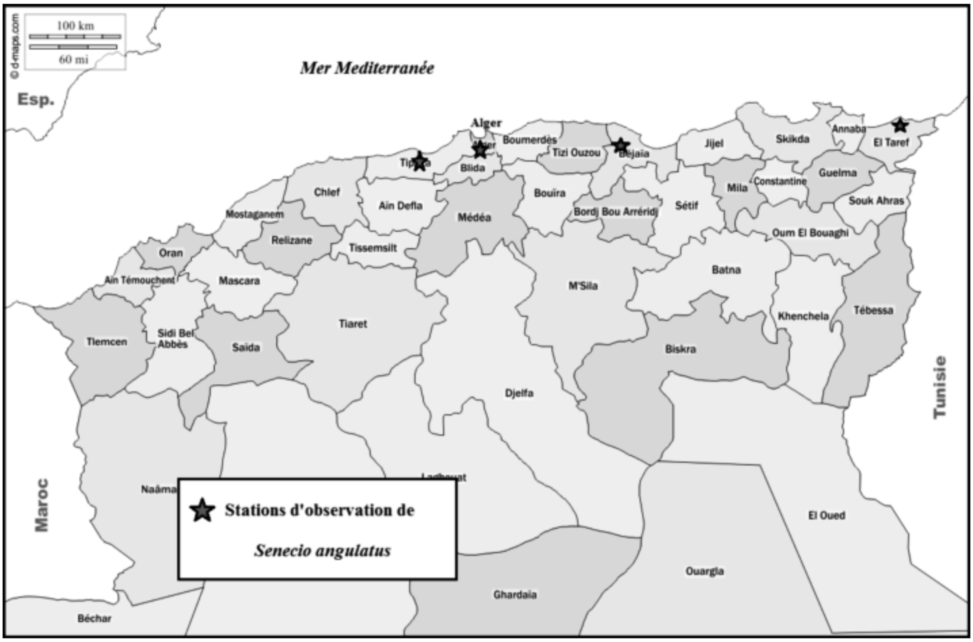

Fig. 1. Les stations d'observation de *Senecio angulatus* en Algérie du Nord (carte de base extraite de map.com, modifiée).

des récoltés en Algérie pendant l'époque coloniale. Les planches d'herbier suivantes ont été examinés à cette fin: P04116555: Alger, broussailles sur les falaises calcaires au-dessous d'El Biar, 100-200m (1923); P02685470: Alger, broussailles (1924); MPU350996: Alger, naturalisé dans les broussailles de nos ravins, complètement naturalisé (1923); P02817859: Alger, jardin d'essai, très cultivé à Alger pour couvrir les tonnelles (1855); P02685471: Alger, El Biar, naturalisé (1934).

L'examen attentif de ces planches permet d'avancer que la présence de *S. angulatus* en Algérie est plutôt récente car les spécimens anciens de *S. mikanoides* sont corrects. Par ailleurs, d'autres spécimens observés pour la France et l'Espagne montrent parfois des erreurs d'identification issue de la confusion entre ces deux taxons (*S. mikanoides* et *S. angulatus*).

Au niveau des pays voisins (Maroc, Tunisie), *S. angulatus* qui n'a pas été encore signalée semble toutefois exister dans en Tunisie (R. El Mokni, comm. pers.). Pour le Maroc, cette plante qui a été signalée à Gibraltar près du littoral Marocain est fortement susceptible d'exister dans ce pays.

Conséquences de la découverte de *S. angulatus* en Algérie

La découverte de ce taxon en Algérie pourra avoir de multiples conséquences qui sont essentiellement d'ordre économique et écologique.

Fig. 2. Capitules de *Senecio angulatus* (Annaba-Algérie).

Sur le plan économique notamment celui pastoral, cette plante ne présente pas de valeur nutritive ou fourragère pouvant lui attribuer un intérêt agro-pastoral. En effet, les espèces de *Senecio* sont en général connues pour être toxiques pour le bétail (Burrows & Tyrl 2001; Riet-Correa & al. 2017. Néanmoins, l'étude d'Andreani (2014) montre que cette plante est riche en huiles essentielles et possédant des propriétés antioxydantes ce qui indique un éventuel intérêt économique et médicinal.

D'autre part, et malgré que certaines études avancent que cette espèce ne semble pas menacer les zones agricoles (Burrows & Tyrl 2001), son caractère invasif pourra constituer une éventuelle menace pour les systèmes agropastoraux locaux qui sont déjà fortement fragilisé par les contraintes écologiques et anthropiques (MATE 2014).

Sur le plan écologique, cette plante qui est généralement reconnu comme mauvaise herbe des systèmes naturels et perturbés par l'homme (Groves & al. 2005; Randall 2007), possède un caractère invasif qui impose une grande méfiance vis avis de sa propagation en Algérie.

En effet, cette plante est considérée comme envahissante et dangereuse dans plusieurs pays et particulièrement en Australie et en Nouvelle Zélande (Muyt 2001) et en France métropolitaine (Jeanmonod & Schlüssel 2006). Elle envahit et constitue une menace pour les zones côtières, rocheuses, les falaises, les lisières de brousse, les forêts sclérophylles sèches et régénération des forêts de plaine (Healy 1959; Csurhes & Edwards 1998; WMC 2013).

Parmi les conséquences de l'établissement de cette plante dans les milieux naturelles: la modification de la structure des communautés et de la composition des espèces, la réduction de la régénération des espèces indigènes ainsi qu'un réel risque de menace pour les espèces rares (Newton 1996; Weber 2003; Williams & Hayes 2007; WMC 2013).

Fig. 3. Biotope de *Senecio angulatus* (Nador, Tipaza – Algérie).

Conclusion

Cette étude rapporte les premières observations de *S. angulatus* en Algérie. Cette plante qui fait partie désormais de la flore du pays semble d'une apparition récente malgré la confusion fréquente avec des taxons proche comme *S. mikanoides* qui en revanche ne semble pas y avoir été revu.

Il semble également que cette plante est apparue suite à des plantation ornementales, mais qu'elle est en train de s'échapper des haies et des propriétés privés pour coloniser les espaces natureles.

Par ailleurs, cette première signalisation n'exclut pas son existence dans d'autres régions du pays alors que sa présence dans les pays voisins est soupçonnée (Maroc) voire indiquée.

Cette découverte qui enrichit d'une part la liste floristique du pays, pourrait d'autre part avoir plusieurs conséquences écologiques et économiques parfois préoccupantes.

C'est ainsi que nous insistons sur la nécessité de la surveillance de la propagation au niveau national de cette plante envahissante, car elle est susceptible de constituer une réelle menace sur les écosystèmes naturels dans le pays.

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New records of alien plants for the flora of Gran Canaria (Canary Islands, Spain)

Abstract

Verloove, F., Salas-Pascual, M. & Marrero Rodríguez, Á.: New records of alien plants for the flora of Gran Canaria (Canary Islands, Spain). — Fl. Medit. 28: 119-135. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Recent field work by the authors in Gran Canaria (Canary Islands, Spain) yielded records of non-native vascular plants that were not previously reported in the wild. *Acokanthera oblongifolia, Alstroemeria ligtu, Capsicum annuum, Chasmanthe bicolor, Cotyledon orbiculata* var. *spuria, Digitaria setigera, Phlomis purpurea, Setaria pumila* subsp. *pallide-fusca, Solanum betaceum, S. seaforthianum, Syzygium cumini, Tecoma ×smithii,* and *Tradescantia spathacea* are newly recorded for the Canary Islands whereas *Bauhinia variegata, Chasmanthe floribunda, Crassula multicava, Cupressus sempervirens, Ficus rubiginosa, Galinsoga quadriradiata, Jacaranda mimosifolia, Kalanchoe ×houghtonii, Merremia tuberosa, Nerium oleander, Passiflora morifolia, Phytolacca dioica* and *Salvia hispanic*a are new records for the flora of Gran Canaria. Although several of these taxa are considered mere ephemerals at present, nearly all of them have the potential to naturalize and/or become invasive.

Key words: chorology, new records, vascular plants, xenophytes.

Introduction

Despite the long tradition of studies on the flora of the Canary Islands (native as well as introduced) there is a constant and almost uninterrupted amount of new taxonomic and distributional data. Particularly the non-native flora is still imperfectly known and the number of new introductions (deliberate as well as accidental) still seems to increase, also in Gran Canaria (see for instance Verloove 2013; Verloove 2017; Verloove & al. 2017). In this paper new records are presented for species and hybrids that are either new to the Canary Islands (and even Macaronesia as a whole) or new to the island of Gran Canaria.

The estimated degree of naturalization of the taxa here presented varies from mere casuals, over locally naturalized to highly invasive aliens. Even those taxa that are reported here as ephemerals have – in most cases – the potential to naturalize or become invasive in the near future since such behavior has been observed in climatologically similar areas elsewhere in their secondary distribution range.

Several of the taxa treated occur spontaneously in the Botanical Garden 'Viera y Clavijo' in Tafira, Las Palmas de Gran Canaria where they had not been planted in the past. This applies to species such as *Chasmanthe floribunda* (Salisb.) N.E. Br.*, Crassula multicava* Lem.*, Kalanchoe ×houghtonii* D.B. Ward*, Passiflora morifolia* Mast., *Phytolacca dioica* L. or *Solanum seaforthianum* L. (all treated in this paper), but also to others that were already previously reported from Gran Canaria, e.g. *Caesalpinia spinosa* (Molina) Kuntze (syn.: *Tara spinosa* (Molina) Britton & Rose), *Eucalyptus camaldulensis* Dehnh., *Lablab purpureus* Sweet, *Ligustrum lucidum* W.T. Aiton, *Pelargonium inquinans* (L.) L'Hér., etc. In other cases, such as *Ficus rubiginosa* Vent., *Grevillea robusta* R. Br., *Jacaranda mimosifolia* or *Pittosporum undulatum* Vent., regeneration has been observed lately from individuals cultivated in the Botanical Garden, as well as in many gardens in peri-urban or rural areas of the island. Environmental conditions as created in the Botanical Garden (arboretum, ponds, waterfalls) are ideal for many frugivorous birds as pigeons, blackbirds, etc. The Botanical Garden doubtlessly perfectly illustrates what is happening in similar habitats elsewhere in Gran Canaria. While within the limits of the Botanical Garden control is permanent and relatively easy, in other areas (e.g. protected natural areas, or private gardens), the situation can be very different, even if the arrival of particular species can be a welcome surprise, for instance the spontaneous occurrence of *Syzygium cumini*, in a private garden.

Material and methods

The new distributional records presented in this paper are mainly the result of field work by the first author in March, April and December 2017. Additional records were provided by the other two authors.

For each record either herbarium specimens or photos were made. Vouchers were deposited either in the herbarium of the Botanic Garden of Meise, Belgium (BR) or the herbarium of the Botanical Garden 'Viera y Clavijo' in Las Palmas de Gran Canaria, Spain (LPA). Relevant herbarium specimens from the latter herbarium were critically revised by the third author.

Each entry includes the name of the taxon (if useful with one or more synonyms), the place and date of the new record and additional information about the geographic distribution (native and introduced area), the behavior in its secondary area, etc. For most taxa photos are also presented.

Taxa are arranged in two parts. The first part includes taxa that were either found in the wild or as weeds in gardens, whereas in the second part taxa are treated that were exclusively observed (as escapes) within the limits of public or private gardens where they are also grown as ornamentals.

Results

Part one: taxa observed either in the wild or as weeds in gardens.

Acokanthera oblongifolia (Hochts.) Codd. (*Apocynaceae*) (Fig. 1a)

Syn.: *A. spectabilis* (Sond.) Hook. f.

GRAN CANARIA: Telde, Las Piletillas, Lomo Los Mudos, small barranco in residential area, 04.04.2017, *F. Verloove* 12857 (BR). – casual.

A species native to southern Africa, *Acokanthera oblongifolia* is widely cultivated as an evergreen ornamental shrub in many warm-temperate and subtropical regions of the world, also in the Canary Islands and elsewhere in Spain (e.g. Sánchez de Lorenzo Cáceres 2010). A single young shrub was found in a shallow barranco in a residential area in Telde (Las Piletillas). Interestingly, this species is already known to escape from cultivation in the Canary Islands since many decades. Kunkel (1972) reported about sexual reproduction in Arucas and La Calzada, also in Gran Canaria. It is still considered an ephemeral alien although a future naturalization is not unlikely, the species probably being dispersed by birds.

Acokanthera oblongifolia is considered a naturalized weed or escape in climatologically suitable areas, for instance in Australia (Randall 2007). In New South Wales it is naturalizing in subtropical rainforest undergoing regeneration and in coastal dunes (Hosking & al. 2011).

Alstroemeria ligtu L. (incl. hybrids) (*Liliaceae*) (Fig. 1b)

GRAN CANARIA: Santa María de Guía, Cruce Sta. Cristina, road GC-70 at km 13, roadside, among *Pteridium*, 07.04.2017, *F. Verloove* 12824 (BR). – naturalized.

Alstroemeria ligtu is a taxon native to Chile but widely grown as an ornamental elsewhere in the world. In the Canary Islands a single species of this genus has been reported as an escape from cultivation, *A. pulchella* L. f. (Hansen 1975, Acebes Ginovés & al. 2010). The latter is distinguished from *A. ligtu* in having all perianth segments spotted (vs. only inner perianth segments spotted). Both species are often confused in the horticultural trade and many claims of *A. pulchella* turn out to be *A. ligtu* (Matthews 1986). These days cultivated (and escaped) plants rarely represent wild species but rather complex hybrids.

In Guía a small, apparently established population was seen in a roadside, on the verge of woodland. Identical plants have also been recorded recently in La Palma (Otto & Verloove, in press).

Species of *Alstroemeria* grow often very vigorously, as a result of strong rootstocks with clusters of tubers or rhizomes. They are sometimes classified as invasive environmental weeds, e.g. *A. aurea* Graham (Weber 2017).

Capsicum annuum L. (*Solanaceae*)

GRAN CANARIA: San Bartolomé de Tirajana, Maspalomas (San Fernando), Av. Alejandro del Castillo, street side in urban area, a single individual, 31.03.2017, *F. Verloove* 12798 (BR). – casual.

A taxon native to southern North America, this species is commonly grown as a vegetable (pepper, paprika). It easily germinates from seed and can be seen wherever its seeds are deposited, e.g. near sewage works. A single individual was seen in an urban area in Maspalomas, doubtlessly as a mere casual alien.

This genus and species had not yet been recorded in the wild from the Canary Islands.

Chasmanthe bicolor (Gasp.) N.E. Br. (*Iridaceae*) (Fig. 1c)

GRAN CANARIA: Valleseco, road GC-21, p.k 20.45, La Laguna – Valleseco, 950-1000 m s.m., roadside and slopes, 28R DS 437 030, 17.03.2018, *Á. Marrero*, LPA: 35205-35206; *Ibidem*, road GC-21, p.k 20, La Laguna - Valleseco 930-945 m s.m., 28R DS 440 032, 18.03.2018, *Á. Marrero*, LPA: 35207-35208; Teror, Mayorazgo, Finca de Osorio, 670 m s.m., 28R DS 462 053, anthropized hillsides along the road and lower edge of the cork oak woodland, scarce, in fruiting stage, *M. Salas, F. Verloove* & *Á. Marrero*, 24.04.2018, LPA: 35529-35530; *Ibidem*, in fruiting and flowering stage, *Á. Marrero* & *C. Santiago*, 29.04.2018, LPA: 35531-35533. – naturalized.

Chasmanthe bicolor is endemic to the Western Cape Province of South Africa where it occurs in sheltered ravines and in open woodland near streams. It is highly vulnerable and faces a risk of extinction in the wild. It is, however, widely cultivated as an ornamental beyond its native range. In Gran Canaria it is locally naturalized forming dense hillside stands below Valleseco. This species had not yet been recorded in the wild from the Canary Islands, nor are there records for it from the Euro+Med area (http://www.emplantbase.org/home.html). Its presence was recently reported from Italy (Grandis 2016).

Compared with *Chasmanthe floribunda* flower are smaller but more striking. The upper tepals are orange-scarlet, whereas the lower tepals are dark green with a yellow tube. The latter are short and triangular.

Chasmanthe bicolor is considered an environmental weed in Australia (Randall 2007).

Chasmanthe floribunda (Salisb.) N.E. Br. (*Iridaceae*) (Fig. 1d)

GRAN CANARIA: Gáldar, Juncalillo, road GC-223, roadside ditch, 07.04.2017, *F. Verloove* 12810 (BR); Las Palmas de Gran Canaria, Botanical Garden, 15.05.1971, *E.R. Sventenius*, LPA: 15665; *Ibidem*, Barranquillo de Siete Puertas, below Llanos de María Rivera, 360 m s.m., 28R DS 527 037, fonolitic rocky outcrops, 02.02.2012, *Á. Marrero*, LPA: 30585-30586; Firgas, Lomo San Pedro, La Caldera, 450 m s.m., 28R DS 464 090, 07.01.2018, *Á. Marrero*, s.c.; Teror, Cruz de los Caideros, 640 m s.m. 28R DS 496 028, 10.03.2018, *Á. Marrero*, LPA: 35189; *Ibidem,* Caldera de Pino Santo, 835 m s.m., 28R

DS 475 018, 10.03.2018, *Á. Marrero*, LPA: 35190; *Ibidem,* Osorio, 640 m s.m., 28R DS 467 051, 10.03.2018, *Á. Marrero*, s.c.; Las Tres Acequias, 610 m s.m., 28R DS 470 056, 10.03.2018, *Á. Marrero*, s.c.; Valleseco, Carpinteras, Puerta de La Montaña, 18.03.2018, *Á. Marrero*, LPA: 35209; *Ibidem*, Barranco de La Virgen, 700 m s.m., 28R DS 422 042, 28.10.2017, *Á. Marrero*, s.c. – naturalized.

This member of the southern African genus *Chasmanthe* is commonly grown as an ornamental in climatologically suitable areas in the world. It has long been confused with the similar-looking *C. aethiopica* (L.) N.E. Brown, not only in the Canary Islands (see Otto & Verloove 2016 for details about their separation) but also elsewhere in Europe, for instance in Italy (Grandis 2016). It was shown that most Canarian populations are in fact referable to *C. floribunda*, not to *C. aethiopica*. The latter is a much less attractive species with shorter stems (it barely reaches half the size of the other two species: up to about 60 cm in *C. aethiopica*, compared to 120 -150 cm in *C. floribunda* and *C. bicolor*) and smaller flowers. At least in Gran Canaria claims of it need confirmation. The presence of *C. floribunda* in Gran Canaria as a naturalized species is here confirmed. It is in fact commonly naturalized in the entire North and Northeast of the island, ranging in altitude between 300-1000 m s.m.

Cotyledon orbiculata var. ***spuria*** (L.) Toelken (*Crassulaceae*)
Syn.: *Cotyledon spuria* L.

GRAN CANARIA: Teror, road of Tamaraceite, La Molineta, 365 m s.m., 28RDS 490 060, 24.03.2018, *Á. Marrero* s.c. – naturalized.

This taxon is native of the southern Little Karoo and south of this region from the vicinity of Albertinia to Worcester. Occasionally, it also occurs on the west coast near Cape Town, as well as along the eastern slopes of the western Cape mountains as far north as the Hantams Mountains (Toelken 1979). Elsewhere in the world it is widely cultivated as an ornamental.

It was recently discovered in an anthropized area in La Molineta (Teror), where it has escaped from gardens and occurs on slopes. It reproduces both sexually and vegetatively. This taxon had not yet been recorded in the wild from the Canary Islands.

Cotyledon macrantha A. Berger is a related species that has been reported from Tenerife (Acebes Ginovés & al. 2010). Its leaves are shiny green, not farinose-glaucous as in *C. orbiculata*.

Cotyledon orbiculata is a significant environmental weed in parts of Australia (Randall 2007).

Crassula multicava Lem. (*Crassulaceae*) (Fig. 1e)

GRAN CANARIA: Valleseco, El Molinete, 21.03.2013, *M. Salas Pascual* s.c.; Las Palmas de Gran Canaria, Solana de la Angostura, alongside track, near houses, 09.04.2017, *F. Verloove & M. Salas Pascual* 12826 (BR); *Ibidem*, Botanical Garden 'Viera y Clavijo', 255 m s.m., 28R DS 546 044, in small groups, 19.03.2018, *Á. Marrero* s.c.; Firgas, La Caldera, 480-490 m s.m., 28R DS 462 090, on rocky slopes along with *Crassula argentea* L. f., very abundant, *Á. Marrero* s.c.; Teror, Cruz de los Caideros, 640 m s.m., 28R DS 496 028, growing over ridges, *Á. Marrero* s.c. – naturalized.*Crassula multicava* – a taxon native to South Africa but commonly cultivated as a garden ornamental worldwide – is known as a naturalized invasive species in Tenerife and La Gomera (Acebes Ginovés & al. 2010), as well as in El Hierro and La Palma (Santos-Guerra et. al. 2014). It had not been recorded before in the wild in Gran Canaria where it can also be classified as locally invasive. It is in fact relatively common in the Middle windward side of the island where it grows over ridges and slopes, forming very dense groups.

Cupressus sempervirens L. (*Cupressaceae*)

GRAN CANARIA: Las Palmas de Gran Canaria, Tafira, slope N of Calle Lomo de Enmedio, a single individual, 07.12.2017, *F. Verloove* s.c. – casual.

This conifer from the Mediterranean area and adjacent parts of Asia and southwestern Europe is commonly planted as an ornamental tree, also in the Canary Islands. As an escape it has been observed before in El Hierro and La Gomera (Acebes Ginovés & al. 2010). It is here reported for the first time from Gran Canaria.

Digitaria setigera Roth (*Poaceae*)

GRAN CANARIA: Agaete, at Noni Sports Pádel, plantation weed, 13.12.2017, *F. Verloove* 13106 (BR). – casual.

Digitaria setigera, native to southeastern Asia, is now widely naturalized in the New World tropics and subtropics. It is very similar to *D. ciliaris* but easily distinguished: a lower glume is absent and the upper glume is very short, much less than ½ spikelet length. These species and others related to *D. sanguinalis* are all much alike and some seem to intergrade in some areas. Molecular phylogenetic studies may shed new light on species boundaries in this group.

Digitaria setigera is here reported for the first time from the Canary Islands, although it may have been overlooked so far. Interestingly, in Agaete it grows close to another *Digitaria* species from southeastern Asia, *D. radicosa* (J. Presl) Miq. (Verloove 2017). The latter is still present as a weed in the Huerto de las Flores.

Ficus rubiginosa Vent. (*Moraceae*) (Fig. 1f)

GRAN CANARIA: Las Palmas de Gran Canaria, Avenida de Escaleritas - Plaza Plácido Álvarez Buylla, 105 m s.m., 28R DS 569 102 and 570 103, spontaneous regeneration in cracks and fissures along walls of gardens or as epiphyte on *Phoenix* spp., 11.11.2012, *Á. Marrero,* LPA: 35222; *Ibidem*, Botanical Garden 'Viera y

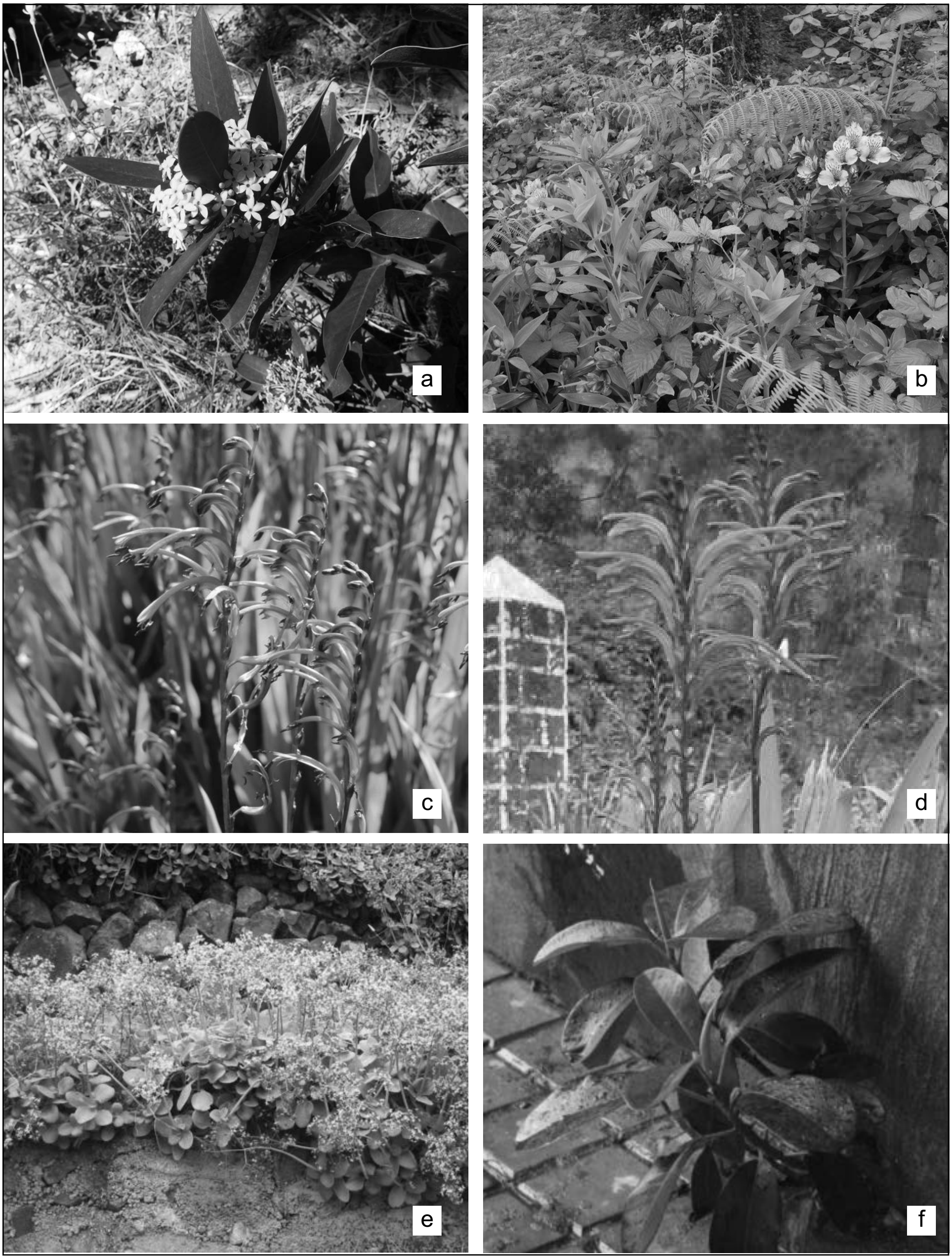

Fig. 1. **a.** *Acokanthera oblongifolia*, Telde, dry riverbed, April 2017, F. Verloove; **b.** *Alstroemeria ligtu*, Guía, roadside, April 2017, F. Verloove; **c.** *Chasmanthe bicolor*. Flower details, Valleseco, March 2018, Á. Marrero; **d.** *Chasmanthe floribunda*, Valleseco, February 2006, M. Salas Pascual; **e.** *Crassula multicava*, Valleseco, March 2013, M. Salas Pascual; **f.** *Ficus rubiginosa*. Las Palmas de Gran Canaria (Escaleritas), foot of wall, November 2012, Á. Marrero.

Clavijo', 250 m s.m., 28R DS 545 046, spontaneous in cracks in rock garden, *Á. Marrero*, LPA: 35215-35216. – casual.

This ornamental tree from Australia is commonly planted as an ornamental in the Canary Islands. It produces numerous figs that birds feed on. As a result the species increasingly escapes from cultivation, although mostly in the vicinity of planted individuals. In the Canary Islands escaped plants had been reported before from Tenerife (Verloove & Reyes-Betancort 2011) and La Palma (Otto & Verloove, in press). In similar circumstances (i.e., epiphytic on palm trees, cracks in concrete, walls, etc.) it is here reported for the first time from Gran Canaria as well.

Galinsoga quadriradiata Ruiz & Pav. (*Asteraceae*) (Fig. 2a)

GRAN CANARIA: Las Palmas de Gran Canaria, Tafira, side of the road El Dragonal-La Calzada, 02.02.2013, *M. Salas Pascual* s.c.; Firgas, El Cortijo, cruce a Los Rosales, 295 m s.m., 28R DS 457 106, roadside and adjacent degraded thermophilous shrubland, 05.05.2013, *Á. Marrero* LPA: 30944-30946. – naturalized.

A taxon native to Central Mexico, *Galinsoga quadriradiata* has become a nearly cosmopolitan weed. In the Canary Islands it was previously recorded from La Gomera and Tenerife (Acebes Ginovés & al. 2010), as well as from La Palma (Brandes 2005). Since 2013 it has been observed as a plantation weed in and near the Botanical Garden 'Viera y Clavijo' in Tafira Baja and in Firgas, apparently for the first time in Gran Canaria.

Jacaranda mimosifolia D. Don (*Bignoniaceae*)

GRAN CANARIA: Las Palmas de Gran Canaria, Tafira, Calle de Rafael Rafaeli, cracks in pavement, ca. 5 young individuals (self-sown), 03.12.2017, *F. Verloove* s.c. (photo); Las Palmas de Gran Canaria, Tafira, Carretera General del Centro (Villa Leonor), gravel, numerous saplings under planted tree, 03.12.2017, *F. Verloove* s.c. – casual.

This is a widely planted ornamental tree from south-central South America. It produces large capsules which eventually split open and release numerous flat, winged seeds. In recent years it increasingly reproduces from seed in areas where it was formerly introduced, also in the Canary Islands. In the wild it was observed before, for instance, in Tenerife (Verloove & Reyes-Betancort 2011) and La Palma (Santos-Guerra & al. 2014). It is here reported for the first time from Gran Canaria. In addition to the records cited above, this species is also known to reproduce from seed in the Botanical Garden 'Viera y Clavijo' in Tafira Baja. A future naturalization, especially in the northern parts of the island, in places with sufficient water supply such as *barrancos*, is not unlikely.

J. mimosifolia invades savanna, wooded kloofs, rocky ridges and river banks in South Africa where it competes with and replaces indigenous species (Invasive Species South Africa 2018). It is also considered an invasive species in Florida and eastern Australia (Weber 2017).

Kalanchoe ×houghtonii D.B. Ward (*Crassulaceae*)
K. daigremontiana Raym.-Hamet & H. Perrier × *K. delagoensis* Eckl. & Zeyh.

GRAN CANARIA: Mogán, Arguineguín, close to Avenida Mencey, dry riverbed, two individuals, 10.11.2011, *F. Verloove* s.c.; Ingenio, barranco de Ingenio at Calle Antonio Rodríguez Medina, dry riverbed, 21.12.2017, *F. Verloove* s.c.; Las Palmas de Gran Canaria, road from Siete Puertas to El Zardo, 395 m s.m., 28R DS 532 044, 10.03-2018, *Á. Marrero* s.c.; *Ibidem*, Botanical Garden 'Viera y Clavijo', 275 m s.m., 28R DS 547 046, 22.03.2018, *Á. Marrero* s.c.; Artenara, La Portada, Tirma, 675 m s.m., 28R DS 266 012, 17.03.2018, *Á. Marrero* s.c. – naturalized.

This species is morphologically similar to *K. daigremontiana* but distinguishable by the leaf base that is neither auriculate nor cordate (Ward 2006; Wang & al. 2016; Mesquida & al. 2017). Both have been widely confused and *K. ×houghtonii* is in fact much more frequent than the latter these days, in gardens as well as in the wild (as an escape). It is considered a troublesome invasive weed in many warm-temperate regions worldwide (Wang & al. 2016; Mesquida & al. 2017).

In the Canary Islands its presence was noted so far in La Palma (Otto & Verloove 2016) and Tenerife (Verloove, unpublished records). It is here reported for the first time from Gran Canaria where it doubtlessly is relatively frequent but confused with *K. daigremontiana*. The presence of genuine *K. daigremontiana* in the wild in Gran Canaria requires confirmation.

Merremia tuberosa (L.) Rendle (*Convolvulaceae*) (Fig. 2b)

GRAN CANARIA: Las Palmas de Gran Canaria, Almatriche, Lugar Lomo el Diviso, rough ground, large patch, probably from discarded garden waste, 06.04.2017, *F. Verloove* 12803 (BR, LPA: 34254). – naturalized (?)

This very vigorous vine, native to Mexico and parts of Central America, is frequently grown as an ornamental in Spain (Sánchez de Lorenzo Cáceres 2010). In the Canary Islands it has been recorded as an escape in various parts of Tenerife (Verloove & Reyes-Betancort 2011; pers. obs. F.V. 01.2017). It is here reported for the first time from Gran Canaria as well. It is obviously distributed by humans from discarded cuttings.

Merremia tuberosa is an invasive species in a number of islands in the Pacific and Indian Ocean.

Nerium oleander L. (*Apocynaceae*)

GRAN CANARIA: San Bartolomé de Tirajana, Cercados de Espinos, barranco de Arguineguin, dry riverbed, 03.04.2017, *F. Verloove* 12853 (BR). – casual.

Nerium oleander, a species native to the Mediterranean region, Iran, the Indian subcontinent and southern China, is widely cultivated as an ornamental, also in the Canary Islands. It rarely reproduces from seed which may explain why it has rarely been reported as an escape of cultivation there. It has been known from La Palma since 2013 and since 2014 from Tenerife (Otto & Verloove 2016; Verloove 2017).

It is here reported for the first time from Gran Canaria. In Cercados de Espinos it grows in a dry river bed, probably from washed-up rhizomes.

Passiflora morifolia Mast. (*Passifloraceae*) (Fig. 2c)

GRAN CANARIA: Las Palmas de Gran Canaria, Tafira Baja, Botanical Garden 'Viera y Clavijo', garden weed, frequent, 09.04.2017, *M. Salas Pascual & F. Verloove* 12795 (BR). – naturalized.

A species native to parts of Central and South America, *Passiflora morifolia* is sometimes grown as an ornamental and subsequently naturalizes from seed. It is, however, rarely reported as troublesome. In the Mediterranean area it is known as a naturalized weed from Israel (Joel & Liston, 1986) and it is a rather frequent and undesirable weed in the Botanic Garden and its surroundings in Puerto de la Cruz in Tenerife (Verloove & Reyes-Betancort 2011).

At least since 2014 *Passiflora morifolia* grows in identical circumstances in the Botanical Garden 'Viera y Clavijo' in Tafira in Gran Canaria, along with *P. suberosa* L. Both are probably dispersed by birds.

Phlomis purpurea L. (*Lamiaceae*)

GRAN CANARIA : Las Palmas de Gran Canaria, Llanos de Maria Rivera, rocky slope, 09.04.2017, *M. Salas Pascual & F. Verloove* 12854 (BR, LPA: 34258). – naturalized.

Phlomis purpurea is native to Spain, Portugal and Morocco but widely grown as an ornamental elsewhere. A small population of this species was discovered in 2013 on a rocky, sun-exposed slope in Llanos de Maria Rivera. It was doubtlessly introduced on purpose, along with other exotics like *Cistus ladanifer* L. and *Crassula argentea* (Mill.) Druce. It has now established itself in a habitat that closely matches that in its area of origin.

Phytolacca dioica L. (*Phytolaccaceae*)

GRAN CANARIA: Las Palmas de Gran Canaria, Tafira Baja, barranco de Guiniguada close to Palmeral, dry riverbed, two individuals (self-sown), 09.04.2017, *M. Salas*

Pascual & F. Verloove 12808 (BR); Las Palmas de Gran Canaria, Tafira Baja road, access to the Botanical Garden 'Viera y Clavijo', 325-330 m s.m., 28R DS 549 045, 12.04.2018, *Á. Marrero* s.c. – casual.

This ornamental tree is native to the Pampa of South America and is much grown in the Canary Islands and other climatologically suitable areas. It has been known as an escape in the Canary Islands since about 2010 when it was recorded as abundantly escaping in Barranco Martiánez in Puerto de la Cruz in Tenerife (Verloove & Reyes-Betancort 2011).

In similar circumstances self-sown trees were discovered recently in Tafira Baja in Gran Canaria, for instance in the dry riverbed of Guiniguada river and other places near to the Botanical Garden 'Viera y Clavijo'. To our knowledge this species was never planted in the Botanical Garden in the past. The young subspontaneous trees most likely originate from planted individuals in nearby private gardens from where they were dispersed by berry-eating birds.

In order to prevent a future naturalization of *Phytolacca dioica* in this area, attempts to control or eradicate the plants are developed, just as for *Passiflora* sp. pl.

Salvia hispanica L. (*Lamiaceae*)

GRAN CANARIA: Telde, La Mareta, near road GC-116, drain, from sewage water, three individuals with *Cucurbita* sp., *Solanum lycopersicum*, etc., 09.04.2017, *M. Salas Pascual & F. Verloove* 12796 (BR, LPA: 34261). – casual.

A species native to central and southern Mexico and Guatemala, *Salvia hispanica* is now widely grown for its edible seeds ('chia'). As a result, these days it is regularly seen on sewage sludge, on exposed river banks, etc., also in the Canary Islands. It has been reported on various occasions from Tenerife (Verloove 2017). In 2017 it was also seen in Gran Canaria, apparently for the first time. It often grows along with typical sewage plants such as *Cucurbita* spec. and *Solanum lycopersicum* L.

Salvia hispanica will probably be recorded again in the Canary Islands but at least at present there are no signs of an incipient naturalization process.

Setaria pumila subsp. ***pallide-fusca*** (Schumach.) B.K. Simon (*Poaceae*)
Syn.: *Setaria pallide-fusca* (Schumach.) Stapf & C.E. Hubb.

GRAN CANARIA: Arucas, Santidad, Camino La Guitarrilla, by track, close to houses, small population, 10.04.2017, *F. Verloove* 12811 (BR). – casual.

This taxon, a (sub-) tropical variant of the more temperate nominal species, has a debated taxonomic value. It is sometimes accepted as a distinct species (e.g. Meredith 1955, Gibbs Russell & al. 1991) while other authors merely subsume it under *S. pumila* (e.g. Morrone & al. 2014).

The small population discovered in 2017 in Gran Canaria is characterized by having very narrow inflorescences (resembling those of *S. parviflora* (Poir.) Kerguélen but plants are clearly annuals) with small spikelets ca. 2 mm long. These features are characteristic of subsp. *pallide-fusca* (see, for instance, Rominger 2003), a taxon that apparently had not been recorded before in the Canary Islands.

Setaria pumila subsp. *pallide-fusca* is a common weed throughout the subtropics. It is particularly noxious in Africa, in Senegal, Sudan, Uganda and Zambia (Holm & al. 1979).

Solanum betaceum Cav. (*Solanaceae*) (Fig. 2d)
Syn.: *Cyphomandra betacea* (Cav.) Sendtn.

GRAN CANARIA: Firgas, Casa Blanca, barranco near sewage work, dry riverbed, four small spontaneous trees, 10.04.2017*, F. Verloove* 12814 (BR, LPA: 34262). – casual.

Solanum betaceum, the tree tomato or tamarillo, is native to Andean South America. It is widely grown as a minor fruit crop in the subtropical and warm-temperate regions of the world. Like other fruits and vegetables, it sometimes can be observed near sewage works.

Four young trees were found spontaneously growing in the depth of a barranco near Firgas, along with other sewage plants like *Cucurbita* sp. and *Solanum lycopersicum* L. This record probably represents the first record of this species in the wild in the Canary Islands.

This species is naturalizing in areas where it has been introduced, for instance in Australia, New Zealand and parts of Asia and Africa (e.g. Symon 1981). It is probably nowhere considered an invasive species yet although it is increasingly observed in (near-) natural areas.

Tree tomato was segregated from the genus *Solanum* L. for quite a long time and then accommodated in the genus *Cyphomandra* Mart. ex Sendtn. Based on chloroplast DNA sequence data, however, it has been shown to be a well-supported major group in *Solanum* (Bohs 2007).

Solanum seaforthianum L. (*Solanaceae*)

GRAN CANARIA: Las Palmas de Gran Canaria, Tafira Baja, Botanical Garden 'Viera y Clavijo', near the Research Center, 315 m s.m., 28R DS 548 045, 01.07.2011, *Á. Marrero*, LPA: 27356. – casual.

Of somewhat uncertain origin, *Solanum seaforthianum* is probably native to the islands of the West Indies and coastal northern South America in Colombia and Venezuela, perhaps also on the Caribbean slope of Central America and Mexico (Knapp 2013). It is cultivated as an ornamental vine and naturalized in many tropical and subtropical areas, often as an aggressive environmental weed, for instance in South Africa and Australia (e.g. Foxcroft & al. 2003; Randall 2007). It is a very vigorous liana and plants are known to produce large numbers of seeds which can be easily dispersed by birds.

It has been recorded in the Botanical Garden 'Viera y Clavijo' as a subspontaneous weed of unknown provenance. It had not been recorded before in the Canary Islands and apparently is a very exceptional alien in the entire E+M Plantbase area where it is only known to be naturalized in Sicily (Galasso & al. 2018).

Solanum seaforthianum is a liana with showy violet corollas and pinnatifid to deeply pinnatifid leaves with up to four pairs of leaflets (Knapp 2013). It cannot be confused with other members of the genus in the Canary Islands, native as well as introduced.

Tecoma ×smithii W. Watson (*Bignoniaceae*) (Fig. 2e)
Putative parentage: *Tecoma capensis* (Thunb.) Lindl. × *T. stans* (L.) Kunth

GRAN CANARIA: Agüimes, Llano Blanco, Av. de la Banda, roadside and adjacent fallow field, ca. 25 self-sown individuals (planted nearby), 21.12.2017, *F. Verloove* 13121 (BR). – naturalized (?).

A small population with about 25 individuals of *T. ×smithii* was discovered by a roadside and in the adjacent fallow field in Agüimes (Llano Blanco) in December 2017. It evidently escaped from a nearby plantation.

This shrub is thought to be a hybrid between the central Mexican *Tecoma stans* (var. *velutina* DC.) and the South African *Tecoma* [*Tecomaria*] *capensis* (Watson 1893). It indeed combines features of what was formerly called *Tecomaria* and *Tecoma* s.str.: the leaf rachis is distinctly winged, leaflets are numerous (up to 15) and leathery and the corolla is orange, not yellow (*Tecomaria*); anther thecae, however, are divaricate (*Tecoma*). Some authors suggest an alternative parentage for *T. ×smithii*, *T. arequipensis* (Sprague) Sandwith × *T. stans* (Sánchez de Lorenzo Cáceres 2018), which seems – on morphological grounds – less likely.

T. ×smithii freely reproduces from seed (its hybrid nature therefore has been questioned) (Watson 1893). This is quite obvious in the locality where it was discovered in Gran Canaria.

Tradescantia spathacea Sw. (*Commelinaceae*)
Syn. *Rhoeo spathacea* (Sw.) Stearn

GRAN CANARIA: Teror, road of Tamaraceite, La Molineta, 360 m s.m., 28RDS 489 059, 24.03.2018, *Á. Marrero* s.c. – naturalized (?).

Tradescantia spathacea is native to Mexico and Central America (Hunt 1994). It is grown as an ornamental and naturalized in Florida, Texas, Hawaii, Cuba and other oceanic islands (Govaerts 2004). It invades and disrupts native plant communities creating a dense groundcover on the forest floor which prevents native plants from germinating. As a result, it locally is declared a noxious environmental weed (e.g. Randall 2007).

It was recently discovered in an anthropized area in La Molineta (Teror), where it has escaped from gardens and occurs on slopes. It reproduces solely vegetatively. This taxon had not yet been recorded in the wild from the Canary Islands.

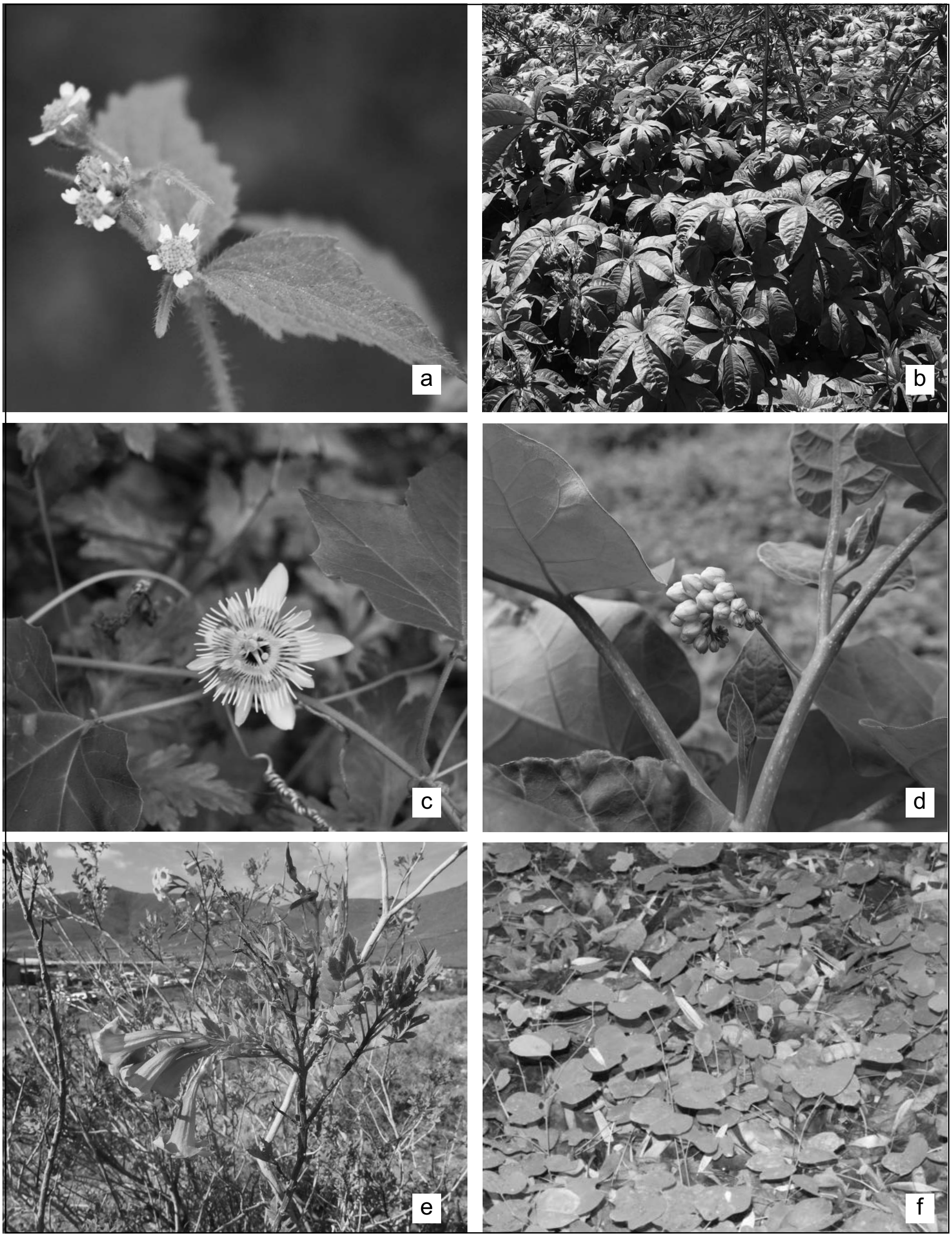

Fig. 2. **a.** *Galinsoga quadriradiata*, Tafira, roadside close to the Botanic Garden, February 2013, M. Salas Pascual.; **b.** *Merremia tuberosa*, Las Palmas de Gran Canaria, rough ground, April 2017, F. Verloove; **c.** *Passiflora morifolia*, Las Palmas de Gran Canaria, Botanic Garden, September 2014, M. Salas Pascual; **d.** *Solanum betaceum*, Firgas, dry riverbed, April 2017, F. Verloove; **e.** *Tecoma ×smithii*, Agüimes, fallow field, December 2017, F. Verloove; **f.** *Bauhinia variegata*, Agaete, understory of Huerto de las Flores, December 2017, F. Verloove.

Part two: taxa exclusively observed within the limits of public or private gardens where they are grown for ornament.

Bauhinia variegata L. (*Caesalpiniaceae*) (Fig. 2f)

GRAN CANARIA: Agaete, Huerto de las Flores, numerous saplings under planted tree, 12.12.2017, *F. Verloove* s.c. (photo) – casual.

Bauhinia variegata – a species native to southeastern Asia (China, India, Nepal, Thailand and Vietnam) – is widely cultivated as an ornamental tree in the tropics and subtropics, also in the Canary Islands. It is increasingly reproducing from seed in areas where it was formerly introduced. It now has become a troublesome invasive weed in, for instance, the southern United States, South Africa and eastern Australia (Weber 2017).

In the Canary Islands its escape was recently noticed in La Palma (Otto & Verloove, in press) and it is here reported for the first time from Gran Canaria. Numerous saplings were recorded in the Huerto de las Flores in Agaete. A future naturalization in the Canary Islands is likely, especially in areas with sufficient water supply.

Syzygium cumini (L.) Skeels (*Myrtaceae*)

GRAN CANARIA: Las Palmas de Gran Canaria, Tafira Alta, 370 m s.m., 28R DS 546 037, spontaneous in gardens at the foot of the parental tree, 11.03.2018, Á. Marrero s.c.; Firgas, La Caldera, 445 m s.m., 28R DS 463 092 and 464 092, next to the parental plant in anthropic environments, 07.01.2018, *Á. Marrero*, LPA: 35210-35211. – casual.

Native to southeastern Asia, this species is widely grown as an ornamental tree (less frequently for its edible fruit or timber), also in the Canary Islands. It has the ability to form a dense cover, excluding all other species which allowed *Syzygium cumini* to become invasive in Hawaii, the Cook Islands and French Polynesia (Global Invasive Species Database 2018). In Gran Canaria it was only found so far in the vicinity of planted individuals. In micro-habitats or under the canopy of the adult plants it reproduces normally, sometimes even explosively.

The congeneric *Syzygium jambos* (L.) Alston is known to reproduce from seed in La Palma (Otto & Verloove, in press) and Gran Canaria, but on this island no naturalization process has been observed so far.

Acknowledgements

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The genus *Tamarix* (*Tamaricaceae*) in Apulia (southern Italy)

Abstract

Gargano M. L.: The genus *Tamarix* (*Tamaricaceae*) in Apulia (southern Italy). — Fl. Medit. 28: 137-143. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

This survey is part of the floristic exploration activities on the Italian territory related to the identification of spontaneous and cultivated plants of the genus *Tamarix* L. A list of tamarisks from Apulia (southern Italy) is here reported together with ecological and distributive data. On the whole, 7 species and 1 variety were recorded in the Apulian region. *T. arborea* var. *arborea* is the species with the widest distribution in the Apulian territory. The presence of *T. canariensis*, *T. dalmatica* and *T. gallica*, previously indicated for Apulia by other authors, is currently not confirmed.

Key words: Tamarisks, Ecology, Distribution, Mediterranean Area.

Introduction

An intensive floristic exploration has been carried out in Italy aimed at the characterization of the genus *Tamarix* L., notoriously a critical genus of the Italian vascular flora (Venturella & al. 2007; Alaimo & al. 2013; Tuttolomondo & al. 2014; Grisafi & al. 2016).

Until a few years ago, knowledge of this genus for the region was very limited. In fact, “An annotated checklist of the Italian vascular flora” (Conti & al. 2005) reports only 3 taxa for Apulia: *Tamarix africana* Poir., *T. canariensis* Willd., and *T. gallica* L.

T. africana Poir. and *T. gallica* L. were also cited by Mele & al. (2006) in the annotated checklist of the flora of Salento Peninsula.

The recent exploration of the territory aimed at knowledge of this genus brought to the report of new species: *T. macrocarpa* (Ehrenb.) Bunge, collected in the Gargano National Park, has been reported as a new species for Europe (Mandracchia & al. 2017).

In 2017, the author of this paper, together with Prof. G. Venturella, provided (*in verbis*) some data on the distribution, nomenclature and taxonomy about *Tamarix* species in Apulia for the updated checklist of the Flora of Italy. These data have been included in Bartolucci & al. (2018) that reports for Apulia six native species: *T. africana*, *T. arborea* (Ehrenb.) Bunge, *T. canariensis*, *T. dalmatica* Baum, *T. gallica*, *T. hampeana* Boiss. & Heldr. and in Galasso & al. (2018) that adds two more naturalized species: *T. macrocarpa* and *T. meyeri* Boiss.

The aim of this paper is to characterize the tamarisk flora of Apulia providing new and/or additional notes on the ecology and distribution of each taxa and to contribute to the knowledge of this still under investigated genus of vascular plants.

Materials and Methods

On the basis of the methodology proposed by Venturella & al. (2007), a several number of branches and racemes taken from wild, naturalized, and cultivated tamarisks growing on the Apulian territory were analyzed.

The exsiccata are kept in the Herbarium of the Department of Agricultural, Food and Forest Sciences (SAF). The geographic coordinates of the localities of collection have been obtained from Google Maps finder.

List of collected species, distribution and ecological notes

Tamarix africana* Poir. var. *africana

San Pietro in Bevagna, Manduria, province of Taranto, wild plant, on the beach, 3 m, 15 Apr 2011, 40°18′25.329″N, 17°40′20.89″E, *M.L. Gargano & G. Venturella*; SAF 01ap.

Lido La Baia, Marina di Pulsano, province of Taranto, wild plant, on the beach, 0 m, 15 Apr 2011, 40°21′11.149″N, 17°21′49.878″E, *M.L. Gargano & G. Venturella*; SAF 02ap.

***Tamarix africana* Poir. var. *fluminensis* (Maire) Baum**

Saturo, Marina di Leporano, province of Taranto, cultivated, seafront, 8 m, 15 Apr 2011, 40°22′26.004N, 17°18′22.599E, *M.L. Gargano & G. Venturella*; SAF 03ap.

Tamarix arborea (Ehrenb.) Bunge **var. *arborea***

Castrignano del Capo, Santa Maria di Leuca, province of Lecce, wild plant, on the cliff, 123 m, 15 Apr 2011, 39°49′53.72N, 18°21′7.242E, *M.L. Gargano & G. Venturella*; SAF 04ap.

Torre Colimella, Manduria, province of Taranto, at the entrance of the Natural Reserve “Salina dei Monaci e dune di Torre Colimena”, wild plant, on dune, 1 m, 15 Apr 2011, 40°17′44.864N, 17°45′6.144E, *M.L. Gargano & G. Venturella*; SAF 05ap.

Punta Prosciutto, Porto Cesareo, province of Lecce, wild plant, on the beach, 1 m, 15 Apr 2011, 40°17′42.063″N, 17°46′16.445″E, *M.L. Gargano & G. Venturella*; SAF 06ap.

Porto Cesareo, province of Lecce, Oriented Regional Natural Reserve “Palude del Conte e Duna Costiera” cultivated, 4 m, 15 Apr 2011, 40°18’02.126″N 17°45’30.902″E, *M.L. Gargano & G. Venturella*; SAF 07ap.

Torre Lapillo, province of Lecce, naturalized, on sand, 2 m, 15 Apr 2011, 40°17’19.222″N, 17°51’8.061″E, *M.L. Gargano & G. Venturella*; SAF 08ap.

Porto Cesasero, province of Lecce, naturalized, seafront, on sand, 4 m, 15 Apr 2011, 40°15′37.346N, 17°53′35.128E, *M.L. Gargano & G. Venturella*; SAF 09ap.

Sant’Isidoro, Nardò, province of Lecce, cultivated, seafront, 0 m, 15 Apr 2011, 40°13′4.431N, 17°55′38.338E, *M.L. Gargano & G. Venturella*; SAF 10ap.

Marina di Leporano, Baia d'Argento-Porto Saguerra, province of Taranto, cultivated, close to the dock, 3 m, 15 Apr 2011, 40°21′22.209N, 17°21′10.794E, *M.L. Gargano & G. Venturella*; SAF 11ap.

Marina di Leporano, crossroads Lungovivo road, Km. 3,800, road 122, province of Taranto, wild plant, 7 m, 15 Apr 2011, 40°18′0.026N, 17°32′42.097E, *M.L. Gargano & G. Venturella*; SAF 12ap.

Lido Onda Blu, Torretta, province of Taranto, wild plant, on dunes, 0 m, 15 Apr 2011, 40°19′58.894N, 17°25′5.615E, *M.L. Gargano & G. Venturella*; SAF 13ap.

Le Conche, Lizzano, province of Taranto, naturalized, 1 m, 15 Apr 2011, 40°19′10.011N, 17°27′23.695E, *M.L. Gargano & G. Venturella*; SAF 14ap.

Campomarino di Maruggio, province of Taranto, naturalized, 1 m, 15 Apr 2011, 40°18′14.462N, 17°41′54.191E, *M.L. Gargano & G. Venturella*; SAF 15ap.

Torre Ovo, province of Taranto, cultivated in a seaside villa, 13 m, 15 Apr 2011, 40°18′10.913N, 17°30′19.438E, *M.L. Gargano & G. Venturella*; SAF 16ap.

San Pietro in Bevagna, Manduria, province of Taranto, naturalized, on the beach, 3 m, 15 Apr 2011, 40°18′25.329″N, 17°40′20.89″E, *M.L. Gargano & G. Venturella*; SAF 17ap.

Gallipoli, province of Lecce, cultivated, 14 m, 15 Apr 2011, 40°03′21.063N, 17°591′33.409E, *M.L. Gargano & G. Venturella*; SAF 18ap.

Santa Cesarea Terme, province of Lecce, cultivated, 23 m, 15 Apr 2011, 40°02′6.786N, 18°27′21.217E, *M.L. Gargano & G. Venturella*; SAF 19ap.

La Fraula, Santa Cesarea Terme, province of Lecce, cultivated, 40 m, 15 Apr 2011, 40°04′28.867N, 18°28′46.27E, *M.L. Gargano & G. Venturella*; SAF 20ap.

Polignano a Mare, province of Bari, naturalized, on the cliff, 23 m, 16 Apr 2011, 40°59′41.639N, 17°13′21.14E, *M.L. Gargano & G. Venturella*; SAF 21ap.

Cozze, province of Bari, naturalized, on the cliff, 4 m, 16 Apr 2011, 41°02′18.803N, 17°08′20.157E, *M.L. Gargano & G. Venturella*; SAF 22ap.

Torre a Mare, Bari, cultivated, 4 m, 16 Apr 2011, 41°05′6.824N, 16°59′56.228E, *M.L. Gargano & G. Venturella*; SAF 23ap.

San Giorgio, Bari, cultivated, 7 m, 16 Apr 2011, 41°05′36.556N, 16°58′18.445E, *M.L. Gargano & G. Venturella*; SAF 24ap.

Bari, cultivated, seafront, 9 m, 16 Apr 2011, 41°07′1.716N, 16°52′18.737E, *M.L. Gargano & G. Venturella*; SAF 25ap.

Molfetta, province of Bari, naturalized, on the beach, 0 m, 16 Apr 2011, 41°12′9.996N, 16°35′55.387E, *M.L. Gargano & G. Venturella*; SAF 26ap.

Bisceglie, province of Barletta, cultivated, along the road, 9 m, 16 Apr 2011, 41°14′33.814N, 16°30′7.434E, *M.L. Gargano & G. Venturella*; SAF 27ap.

Barletta, cultivated, along the road, 15 m, 16 Apr 2011, 41°19′10.789N, 16°17′1.754E, *M.L. Gargano & G. Venturella*; SAF 28ap.

Gattarella Resort, Lama le Canne, Vieste, province of Foggia, cultivated, 14 m, 16 Apr 2011, 41°50′18.564N, 16°11′6.64E, *M.L. Gargano & G. Venturella*; SAF 29ap.

Lido Cristalda Beach, Vieste, province of Foggia, cultivated, 0 m, 16 Apr 2011, 41°53′9.395N, 16°10′16.435E, *M.L. Gargano & G. Venturella*; SAF 30ap.

Mattinata, province of Foggia, along the road, cultivated, 85 m, 16 Apr 2011, 41°42′38.229N, 16°02′56.717E, *M.L. Gargano & G. Venturella*; SAF 31ap.

Tamarix hampeana **Boiss. & Heldr.**

Gallipoli, province of Lecce, cultivated, 14 m, 15 Apr 2011, 40°03′21.063N, 17°591′33.409E, *M.L. Gargano & G. Venturella*; SAF 32ap.

Tamarix macrocarpa **Bunge**

Manacore, Peschici (province of Foggia), county road n° 52, km 13, along the road, group of small trees, 8 m, 41°56′14,19″, 16°04′14, 913″, 16 April 2016, *M.L. Gargano & G. Venturella*, SAF 075 (Mandracchia et al. 2017).

Tamarix meyeri **Boiss.**

Porto Tricase, Tricase, province of Lecce, wild plant, close to the beach, 0 m, 15 Apr 2011, 39°56′2.829N, 18°23′46.227E, *M.L. Gargano & G. Venturella*; SAF 33ap.

Porto Cesasero, province of Lecce, naturalized, seafront, on sand, 4 m, 15 Apr 2011, 40°15′37.346N, 17°53′35.128E, *M.L. Gargano & G. Venturella*; SAF 34ap.

Santa Cesarea Terme, province of Lecce, cultivated, 23 m, 15 Apr 2011, 40°02′6.786N, 18°27′21.217E, *M.L. Gargano & G. Venturella*; SAF 35ap.

Polignano a Mare, province of Bari, cultivated, close to Arco Marchesale, 23 m, 16 Apr 2011, 40°59′41.639N, 17°13′21.14E, *M.L. Gargano & G. Venturella*; SAF 36ap.

Cozze, province of Bari, naturalized, on the cliff, 4 m, 16 Apr 2011, 41°02′18.803N, 17°08′20.157E, *M.L. Gargano & G. Venturella*; SAF 37ap.

Tamarix parviflora **DC.**

Lido La Baia, Marina di Pulsano, province of Taranto, cultivated, seafront, 0 m, 15 Apr 2011, 40°21′11.149″N, 17°21′49.878″E, *M.L. Gargano & G. Venturella*; SAF 38ap.

Gallipoli, province of Lecce, cultivated, 14 m, 15 Apr 2011, 40°03′21.063N, 17°591′33.409E, *M.L. Gargano & G. Venturella*; SAF 39ap.

Castrignano del Capo, Santa Maria di Leuca, province of Lecce, naturalized, along the road, 23 m, 15 Apr 2011, 39°49′53.72N, 18°21′7.242E, *M.L. Gargano & G. Venturella*; SAF 40ap.

Marina Serra, Tricase, province of Lecce, naturalized, along the road, 66 m, 15 Apr 2011, 39°54′51.868N, 18°23′26.214E, *M.L. Gargano & G. Venturella*; SAF 41ap.

Polignano a Mare, province of Bari, cultivated, close to Arco Marchesale, 23 m, 16 Apr 2011, 40°59′41.639N, 17°13′21.14E, *M.L. Gargano & G. Venturella*; SAF 42ap.

Polignano a Mare, province of Bari, naturalized, on the cliff, 23 m, 16 Apr 2011, 40°59′41.639N, 17°13′21.14E, *M.L. Gargano & G. Venturella*; SAF 43ap.

Cozze, province of Bari, naturalized, on the cliff, 4 m, 16 Apr 2011, 41°02′18.803N, 17°08′20.157E, *M.L. Gargano & G. Venturella*; SAF 44ap.

Bisceglie, province of Barletta, cultivated, along the road, 9 m, 16 Apr 2011, 41°14′33.814N, 16°30′7.434E, *M.L. Gargano & G. Venturella*; SAF 45ap.

Tamarix rosea **Bunge**

Campomarino di Maruggio, province of Taranto, cultivated along the road, 1 m, 15 Apr 2011, 40°18′14.462N, 17°41′54.191E, *M.L. Gargano & G. Venturella*; SAF 46ap.

San Pietro in Bevagna, Manduria, province of Taranto, naturalized, on the beach, 3 m, 15 Apr 2011, 40°18′25.329″N, 17°40′20.89″E, *M.L. Gargano & G. Venturella*; SAF 47ap.

Bisceglie, province of Barletta, cultivated, along the road, 9 m, 16 Apr 2011, 41°14′33.814N, 16°30′7.434E, *M.L. Gargano* & *G. Venturella*; SAF 48ap.

Conclusions

Currently, 7 species and 1 variety characterize the tamarisk flora of Apulia. As shown in Figs. 1-2, the population of *Tamarix africana* var. *africana* and *T. africana* var. *fluminensis*, the latter is a cultivated plant in the seafront, are concentrated in the province of Taranto. *T. arborea* var. *arborea* is the species with the widest distribution in the Apulian territory. The plant is used as an ornamental mainly in coastal cities, along the promenades, the roads, and the public and private gardens. As wild plant, *T. arborea* var. *arborea*, colonize cliffs, dunes, beaches and, road margins. Some plants, growing on sand, observed in different localities of the provinces of Taranto and Bari are naturalized. Also *T. parviflora* has a wide distribution in Apulia as cultivated plant along the roads and the seafronts. As naturalized plant, *T. parviflora* can be observed along the roads in the province of Lecce and on the cliffs of Polignano a Mare (Fig. 1) and Cozze. *T. hampeana* is an uncommon

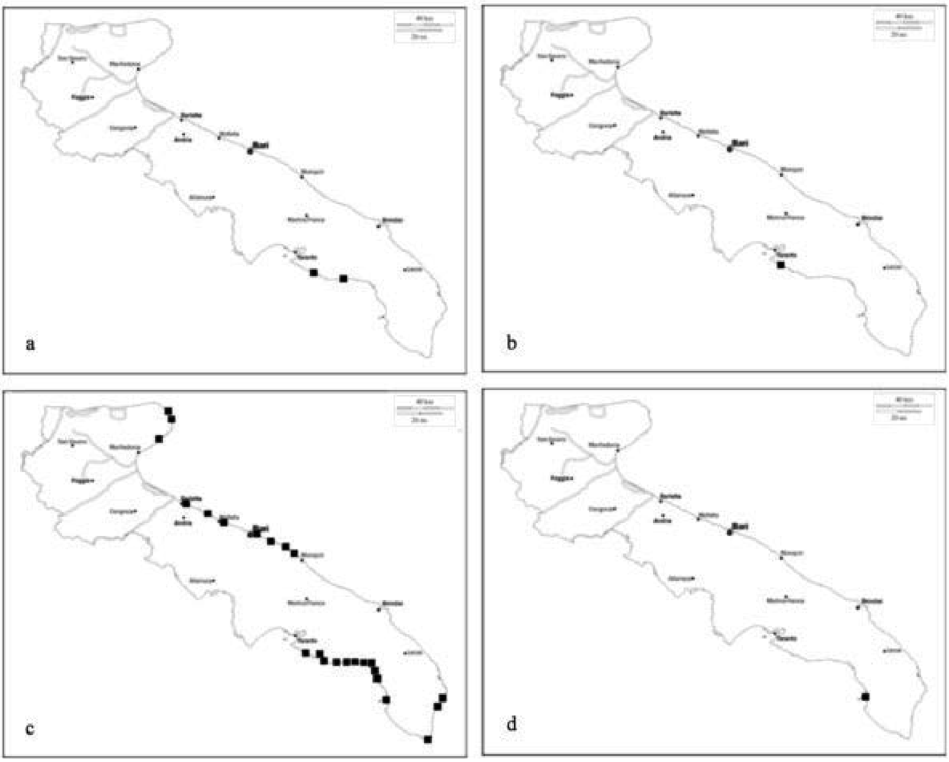

Fig. 1. Distribution of: **a)** *Tamarix africana* var. *africana*; **b)** *T. africana* var. *fluminensis*; **c)** *T. arborea* var. *arborea* and, **d)** *T. hampeana*.

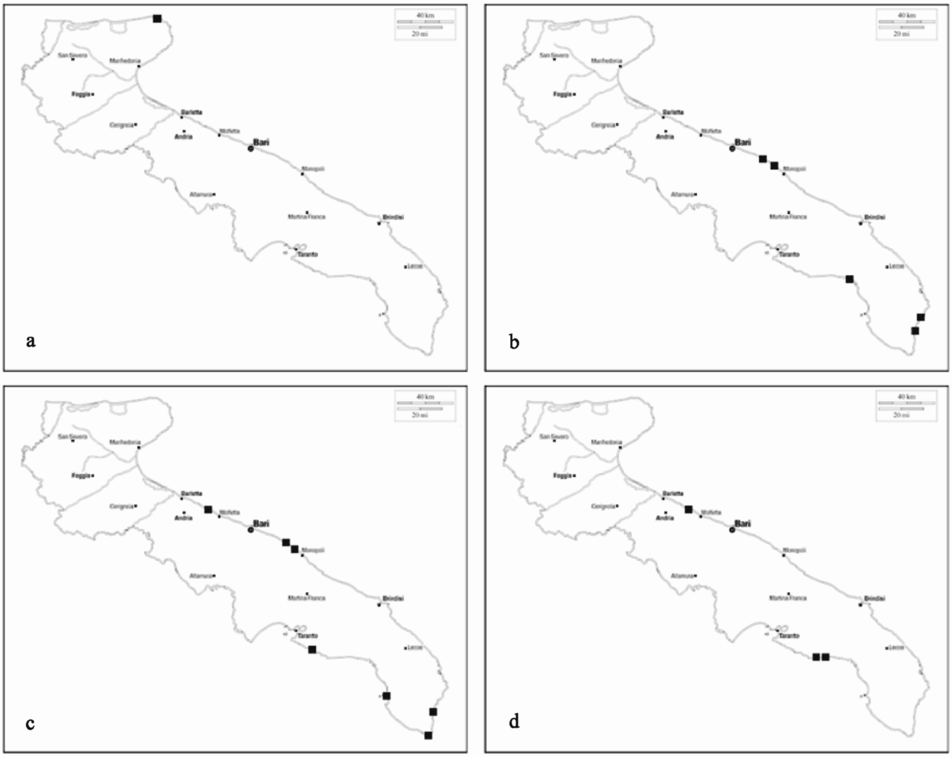

Fig. 2. Distribution of: **a)** *Tamarix macrocarpa*; **b)** *T. meyeri*; **c)** *T. parviflora* and, **d)** *T. rosea*.

species currently observed in the Apulian territory only as cultivated, while in Calabria (Venturella & al. 2008) and Sicily (Venturella & al. 2007) it was also found as a wild species. *T. rosea*, a species cultivated in some Italian regions, is reported for the first time as a wild plant on the beach of San Pietro in Bevagna in the province of Taranto. *T. meyeri*, previously recorded from Sicily, Calabria, Marche, Abruzzo, Veneto and Piemonte (Venturella & al. 2012) has been collected as wild, naturalized and cultivated plant in different localities in the provinces of Lecce and Bari.

The presence in the region of *T. canariensis*, *T. dalmatica* and *T. gallica* included in Bartolucci & al. (2018), is currently not confirmed.

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A new record for the non-native flora of Tunisia, *Eclipta prostrata* (*Asteraceae*), and a note on the national status of *Erigeron bonariensis*, *Symphyotrichum squamatum* (*Asteraceae*), and *Lepidium didymum* (*Brassicaceae*)

Abstract

El Mokni, R. & Iamonico, D.: A new record for the non-native flora of Tunisia, *Eclipta prostrata* (*Asteraceae*), and a note on the national status of *Erigeron bonariensis*, *Symphyotrichum squamatum* (*Asteraceae*), and *Lepidium didymum* (*Brassicaceae*). — Fl. Medit. 28: 145-153. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Floristic and phytosociological surveys in NE-Tunisia allowed to discover *Eclipta prostrata* (*Asteraceae*) which represents the first record at national level. A description of the species, notes on its ecology and phytosociological remarks are provided. We also stated, for the first time in Tunisia, the status of naturalization of three species (*Erigeron bonariensis*, *Symphyotrichum squamatum*, and *Lepidium didymum*) which does not appear still published until now.

Key words: Alien species, Naturalization, North Africa.

Introduction

Invasions by non-indigenous plant species has become an important component of global environmental change (e.g., Mack & al. 2000). Ruderal environments as well as coastal and riverine habitats have often been reported to harbor many neophytes (Sobrino & al. 2002; Bruno & al. 2004; Dark 2004; Von Holle & Motzkin 2007; Chytrý & al. 2007). Several studies of the coastal region of the Mediterranean Basin have shown a high degree of naturalization of introduced species (see e.g., Badano & Pugnaire 2004; Campos & al. 2004). Tunisia is no exception and several aliens have been recorded in the last decade along the coasts (El Mokni & al. 2013, 2016; Iamonico & El Mokni 2017).

Eclipta L. is a small genus of 4–5 species native to North America (Chen & Hind 2011). Some *Eclipta* species occur outside of their natural range (Greuter 2006+; Chen & Hind 2011; SANBI 2012; Atlas Living of Australia 2016) and, in some cases, they have spread causing ecological and economic impacts (e.g., Holm & al. 1977; Moody 1989; Das & Duarah 2013).

During botanical field surveys carried out along coastal territories of North-eastern Tunisia (Bizerta city), aimed at improving knowledge on the vascular flora of Tunisia, we found a population which can be ascribed to *Eclipta prostrata* (L.) L., a species that was not previously recorded in the country. At the same time, we observed the populations of other three species [*Erigeron bonariensis* L., *Lepidium didymum* L., and *Symphyotrichum squamatum* (Spreng.) G. L. Nesom] that participate to the vegetation communities in which *E. prostata* occurs. We here clarify their status at national level for the first time.

Materials and methods

The present work is based on field surveys (since 2011 to today), analysis of relevant literature (e.g. Pottier-Alapetite 1981; Greuter 2006+; Le Floc'h & al. 2010; Dobignard & Chatelain 2011; SANBI 2012) and examination of specimens preserved at K, P, PAL, RO, and WU (acronyms according to Thiers 2018+) and the personal collection of R. El Mokni deposited in the herbarium of the Faculty of Pharmacy of Monastir (University of Monastir), herbarium of the Faculty of Sciences of Bizerta (University of Carthage).

The description of the species is based on Tunisian specimens, while the status of naturalization and/or degree of invasion of plants was assessed according to the criteria proposed by Richardson & al. (2000) and Pyšek & al. (2002, 2004).

Results and discussion

Eclipta prostrata (L.) L., Mant. Pl. Alt.: 286. 1771 ≡ *Verbesina prostata* L., Sp. Pl. 2: 902. 1753 ≡ *Cotula prostrata* (L.) L., Syst. Nat., Ed. 12, 2: 564. 1767 ≡ *Eclipta alba* var. *prostrata* (L.) Miq., Fl. Ned. Ind. 2: 66. 1856.

Lectotype (designated by Wijnands 1983: 74): [Icon] *Chrysanthemum maderaspatanum*, *Menthae arvensis* folio & facie, *floribus bigemellis*, ad foliorum alas, pediculis curtis in Plukenet (1691: t. 118, f. 5); image of the lectotype available http://bibdigital.rjb.csic.es/ing/Libro.php?Libro=4826&Pagina=73.

– *Eclipta alba* var. *prostrata* (L.) Kuntze, Revis. Gen. Pl. 1: 334. 1891, isonym (Art. 6.3 Note 2).

Description (Fig. 1)

Annual, biannual or perennial herb; stem 10–30 cm tall, erect or prostrate, weak, scabrous, ribbed, branched; adventitious roots develop when plants are prostrate or submerged. Leaves opposite, sessile, oblong to lanceolate (4–13 × 0.8–2.0 cm), margins entire to shortly and irregularly dentate, apex acute-acuminate, cuneate at base, pubescent on both surfaces (hairs adpressed). Flowers arranged in terminal and axillary capitula, each one hemispherical, up to 1 cm in diameter, heterogamous; peduncles up to 7 cm long. Involucral bracts 8–10, herbaceous, ovate (6 mm long), acute, pubescent; receptacular scales setaceous, ciliate at apex; ray-florets 30–50, the pistillate one with corolla 4–5-fida; ligules 2–6 mm long, white, entire or bifid, disc-florets perfect; anthers apically blunt, basally slightly sagittate. Fruits of ray-florets (achenes)

Fig. 1. *Eclipta prostrata*. A) habitus, B) leaves, C) capitulum, D) different stages of flowers with black and glabrous mature achenes in the older flower (photos by R. El Mokni). Tunisia, Bizerta city, 22 December 2015.

3-angled in transversal section with two short cartilaginous margins, those of disc-florets 4-angled; all fruits strongly tuberculate, black, glabrous, except for a few apical hairs, depressed-truncal; seeds with neiloid to conic shape (2.0–2.2 × 0.8–1.0 mm), scarce hairs at apex; pappus is represented by some scattered hairs or a minute cup of 2 or 3 short tooth-like awns.

Habitat and ecological notes

Eclipta prostrata grows in Tunisia along roadsides at altitudes of about 10 m a.s.l. In 2011, the Tunisian population of *E. prostrata* found in Bizerta consisted of approximately 20 individuals forming small scattered sub-populations distributed over an area of 60×100 m (approximately 6.000 m^2), whereas since 2015 to present, the population comprised approximately 30 individuals mostly in small scattered tufts distributed over an area of 100×100 m (approximately 10.000 m^2). We suspect that this species was accidently introduced with ornamental plants or by commercial seeds used as food for domestic birds. According to Pyšek & al. (2002) criteria and categorisation, *E. prostrata* can be considered as a naturalized alien species in Tunisia (not invasive).

Phenology

Flowering and fruiting times in Tunisia, June–January.

Native and introduced range

Eclipta prostrata is native to the Americas (Chen & Hind 2011) but some authors (e.g., Stone 1970) suggest an Asiatic origin, while it is considered as an alien species (sometimes naturalized or invasive) in the other continents [see e.g., Greuter (2006+), Domina & al. (2018), Galasso & al. (2018) for Europe, Chen & Hind (2011) for China, Atlas Living of Australia (2016) for Australia]. In Africa, this species has been reported from Egypt, and Morocco as naturalized alien (Fennane & Ibn Tattou 1998; Boulos 2002; Greuter 2006+; APD 2017), it was also recorded from Angola, Côte d'Ivoire, Ghana, Nigeria, South Africa, and Sudan (see http://www.cabi.org/isc/datasheet/20395). In Tunisia, our first observation of *E. prostrata* was in October 2011 along the coast in Bizerta city (north-east of Tunisia). *E. prostrata* was recorded again at the same site some years later (December 2015, November 2016, June 2017, July 2018), and its population appeared to be increased.

Notes on vegetation

Eclipta prostrata was found in open and herbaceous communities which are characterized mainly by medium-sized therophytes, both native and aliens (see Table 1).

These plant communities develop from autumn to spring in ruderalized soils, mainly on road margins (typically between the pavement slabs of streets) and in irrigated gardens with fertile soils. From the phytosociological point of view, the communities belong to the alliance of the *Sclerochloo durae-Coronopodion squamati* Rivas-Martínez 1975 and the association *Poo annuae-Coronopodetum didymi* Carretero & Aguilella 1995 (see Ninot & al. (2010-2011) where *Poa annua* subsp. *annua*, and *Lepidium didymum* are the characteristic species.

Table 1. Floristic composition of the Tunisian communities in which *Eclipta prostrata* was found. The alien status (3rd column) follow the Greuter (2006+) and Le Floc'h & al. (2010).
Abbreviations. 2nd column: G = geophyte, H = hemicryptophyte, T = therophyte; 3rd column: NAT = naturalized, INV = invasive. Asterisks (*, 1st column) indicate the species for which the status of naturalization is defined for the first time in the present paper.

Plants name	**Life-form**	**Status**
Amaranthus deflexus L.	T	Alien (NAT)
Amaranthus viridis L.	T	Alien (NAT)
Brassica nigra (L.) Koch	T	Native ?
Catapodium rigidum (L.) C.E. Hubb. s. str.	T	Native
Chenopodiastrum murale (L.) S. Fuentes et al.	T	Native
Chenopodium album L. *s. lat.*	T	Native
Convolvulus arvensis L.	G	Native
Cymbalaria muralis P. Gaertn., B. Mey. & Scherb.	C	Native
Cynodon dactylon (L.) Pers.	G	Native
Cyperus longus L.	G	Native
Cyperus rotundus L. subsp. *rotundus*	G	Native
Dittrichia graveolens (L.) Greuter	T	Native
Echinochloa colonum (L.) Link.	T	Native (Le Floc'h & al 2010)
**Erigeron bonariensis* L.	T	Alien (NAT)
Lepidium coronopus (L.) Al-Shehbaz	T	Native
**Lepidium didymum* L.	T	Alien (INV)
Malva parviflora L.	T	Native
Oxalis corniculata L.	H	Native
Parietaria judaica L.	H	Native
Poa annua L. subsp. *annua*	T	Native
Polygonum aviculare L. s. str.	T	Native (Le Floc'h & al 2010)
Polygonum rurivagum Boreau	T	Native (Le Floc'h & al 2010)
Portulaca oleracea L. *s.lat.*	T	Native
Senecio leucanthemifolius Poir. s. str.	T	Native
Setaria adhaerens (Forssk.) Chiov.	T	Native
Sonchus oleraceus L.	T	Native
Sonchus tenerrimus L.	T	Native
Stellaria pallida (Dumort.) Piré	T	Native
**Symphyotrichum squamatum* (Spreng.) G.L. Nesom	T	Alien (NAT)
Urtica urens L.	T	Native

Note on status of naturalization of *Erigeron bonariensis*, *Symphyotrichum squamatum*, and *Lepidium didymum*

The status of naturalization of these three species has not previously been defined in Tunisia. *Erigeron bonariensis* and *Symphyotrichum squamatum* were indicated by Greuter (2006+) as "Alien (status unknown)", while Le Floc'h & al. (2010) did not indicate any status for these two taxa. The populations of *E. bonariensis* and *S. squamatum* found by us appear to be well established, since we observed them during the last six years. However, these populations do not seem to increase their areas, so we here consider both species as naturalized for Tunisia. As regards *Lepidium didymum*, Marhold (2011) reports "Cultivated, doubtfully escaping", while Le Floc'h & al. (2010: 141) indicated this species as both casual and naturalized based on previous published works and avoided a conclusion about its status in Tunisia. The population of this species at Bizerta is not only well established, but it also tends to expand itself, and, as a consequence, we here assess the status of alien invasive for *L. didymum*.

Notes on nomenclature

D'Arcy (1975: 1102) indicated the specimens nos. 1020.4 or 1020.5 (at LINN) as the type of *Verbesina prostrata* L., presumably in error as both are associated with the name "*Eclipta latifolia*". Neither these two Linnaean specimens, nor the LINN-1020.7, which is a post-1753 Browne's collection treated as the lectotype by Kupicha (1975: 46), are original material for the name. Grierson (1980: 212) treated the material preserved in the Herb. Plukenet (BM-SL) as "type" but this would not have been seen by Linnaeus and is not original material either. Wijnands' (1983) choice of Plukenet's illustration as lectotype is correct.

Taxonomic notes

Some achenes of disc-florets appear to be similar to those characterizing *Eclipta platyglossa* F. Muell s. str. especially concerning the fruit shape and seed surface. However, *E. platyglossa* can be easily distinguished from *E. prostrata* by the color of the ligules (yellow vs. white or whitish in *E. prostrata*), and the number of ray flowers (10 vs. 50 in *E. prostrata*) (see Orchard & Cross 2013).

Selected specimens examined

TUNISIA, Bizerta, South-Bizerta, Bridge, 37°16′15.12″ N, 09°52′33.97″ E, ruderalized soils, mainly in path and road margins, and typically between the pavement slabs of streets, in irrigated gardens, 7 m a.s.l., 03/10/2011, *R. El Mokni s.n.* (Herb. El Mokni!); *ibidem* 18/09/2012, *R. El Mokni s.n.* (Herb. El Mokni!); *ibidem*, 11/10/2013, *R. El Mokni s.n.* (Herb. El Mokni!); *ibidem*, 06/11/2014, *R. El Mokni s.n.* (Herb. El Mokni!); *ibidem* 07/01/2016, *R. El Mokni s.n.* (Herb. El Mokni, PAL, and RO); *ibidem* 27/09/2016, *R. El Mokni s.n.* (Herb. El Mokni!).

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Découverte de *Gamochaeta antillana* (*Asteraceae*) en Numidie orientale (El Tarf-Algérie)

Abstract

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Discovery of *Gamochaeta antillana* (*Asteraceae*) in eastern Numidia (El Tarf-Algeria) — The new presence of *Gamochaeta antillana* (Urb.) Anderb. in Algeria is discussed. Its presence in Garâat Dakhla pond in eastern Numidia (North-East Algeria) is considered in perspective with the diversity and wetlands conservation.

Key words: xenophytes, conservation, *Compositae*, North Africa.

Introduction

Les zones humides du pourtour méditerranéen, qui abritent un patrimoine naturel remarquable, représentent un élément majeur des ‘points chauds’ de biodiversité de la région (Myers 1988, 1990; Mittermeier & al. 2004; Véla & Benhouhou 2007). Elles sont classées parmi les écosystèmes les plus riches de la planète (Quézel 1998; Médail & Quézel 1999).

L’Algérie, et plus particulièrement la Numidie (K3 au sens des divisions biogéographiques proposées par Quézel & Santa 1962-1963), est riche en zones humides répondant aux critères Ramsar (Stevenson & al. 1988; Samraoui & al. 1998; De Bélair & Samraoui 2000; De Bélair 2005; Haou & al. 2011; Bouldjedri & al. 2011; Belouahem & al. 2011). Aussi, leur protection représente un enjeu majeur pour la préservation de la diversité végétale terrestre et aquatique. La conservation de ces zones humides remarquables de Numidie nécessite avant tout une valorisation effective par la réalisation d'inventaires et la localisation précise de ces milieux afin de décrire leurs caractéristiques écologiques et biogéographiques et leur valeur patrimoniale et les enjeux associés.

C’est au niveau de l’une de ces zones humides qu’en mai 2018, nous avons fortuitement récolté *Gamochaeta antillana* (Urb.) Anderb., espèce inconnue jusqu’alors dans les contrées algériennes. Cette nouvelle observation est l’objectif de ce travail.

Description de la station d'observation

Coordonnées: 036°50'40.03"N; 007°59'15.02"E. Altitude 7m. Surface approximative: 12h. Profondeur : 3,5m. Sol : sable (Fig. 1).

Description botanique et distribution géographique

Le genre *Gamochaeta* (*Gnaphalieae*, *Asteraceae*) se compose de 60 espèces principalement distribuées en Amérique tropicale et subtropicale. Au sein de la tribu *Gnaphalieae*, le genre se caractérise par des épis ou des amas en forme de tête, quelques fleurons centraux hermaphrodites et des soies pappées à la base dans un anneau (Urtubey & al. 2016).

Un effectif total de 120 individus de *Gamochaeta antillana* (Urb.) Anderb (= *Gnaphalium antillanum* Urb.) a été dénombré sur la rive de la mare Garâat Dakhla et cela sur une surface de 350m^2. La plante observée est une annuelle à couleur grise-blanche ou tomenteuse-blanche (Fig. 2). Tiges érigées ou ascendantes, généralement simple. Feuilles alternes, sessiles, les basales sont oblongues-spatulées et généralement dépérissantes avant la floraison; les supérieures sont oblongues-linéaires. Les fleurs flosculeuses, ferrugineu-

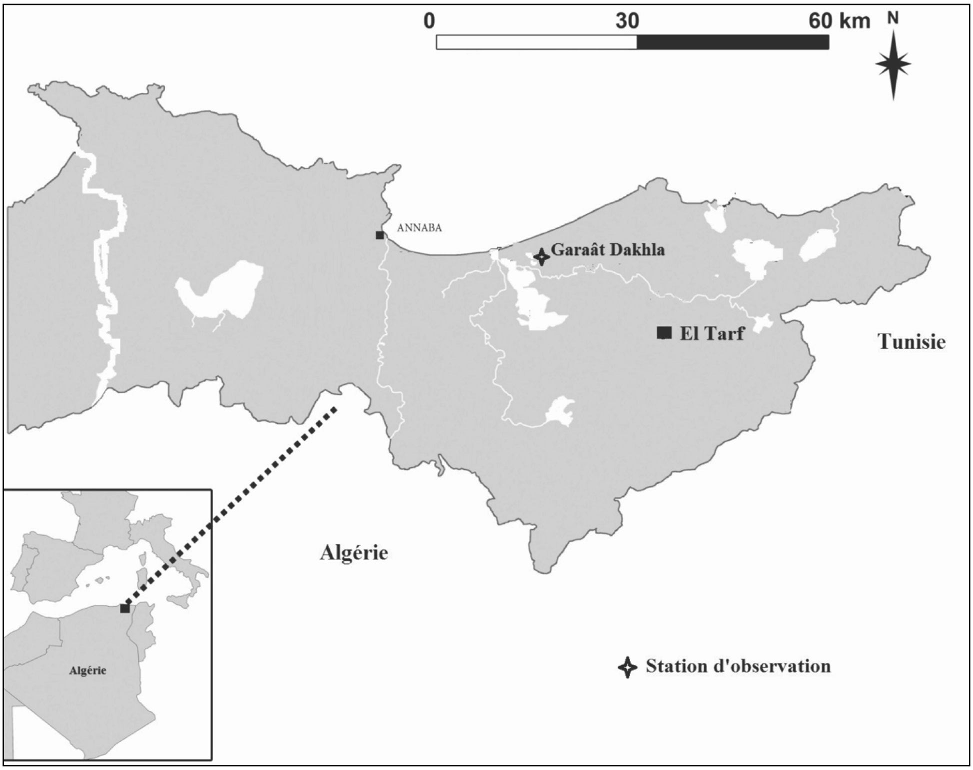

Fig. 1. Cartes de localisation de la station d'observation.

ses principalement à l'apex. Akènes mûrs de moins de 0,7 mm de long; floraison entre mars-mai, mais parfois jusqu'au juin en présence d'assez d'humidité (Blanca & al. 2009). Ce taxon est étroitement similaire à *Gamochaeta stagnalis* (I.M. Johnst.) Anderb. avec une taille de 6-40 cm et de 2,5-20 cm pour *G. stagnalis*. Bien qu'aussi, les feuilles basales et caulinaires chez cette dernière sont oblancéolées, ainsi *G. antillana* se rencontre dans les climats et les habitats humides, tandis que *G. stagnalis* est une espèce de climat et d'habitat arides. Une étude plus approfondie de la distinction entre ces deux taxons est nécessaire (Nesom 2004).

La gnaphale américaine (*Gamochaeta antillana*) est une herbe originaire de l'Amérique, décrite par Urbainb aux États-Unis en 1905, sur des champs agricoles dans les vallées de Sacramento et de San Joaquin en Californie (Hickman 1993). L'espèce est naturalisée jusqu'en Amérique du Sud (notamment à Cuba et en Argentine) et également naturalisée à Nouvelle-Zélande et l'Australie (Otto & Verloove 2016). Elle est en même temps introduite en Europe avec des status différents: France, Porutgal, Espagne et sur les îles de Corse, Sicile et les Canaries (Greuter 2006+; Domina & al. 2018; Galasso & al. 2018).

En Algérie, la plante n'est pas citée dans l'index de Dobignard & Chatelain (2010-2013). De même, aucune flore ou catalogue d'Algérie (Battandier 1888-1890; Battandier & Trabut 1905; Maire 1952-1987; Quézel & Santa 1962-1963), ni même en Tunisie (Pottier-Alapetite 1979-1981; Le Floc'h & al. 2010) ont signalé ce taxon. Au Maroc, la plante est considérée comme une adventice des cultures (Ibn Tattou & Fennane 2008). Par ailleurs, l'index de Dobignard & Chatelain (2011) attribue le statut naturalisé pour la plante. Cependant, la flore xénophyte en Algérie est dominée par la famille des Amaranthaceae et Asteraceae (Meddour & El Mokni 2016).

Selon la flore de l'Algérie (Quézel & Santa 1963), le genre *Gnaphalium* (Hilliard & B. L. Burtt) Tzvelev comprenait deux espèces *G. luteo-album* L. et *G. uliginosum* L. Plus récemment, Dobignard & Chatelain (2011), limitent la présence en Algérie d'un seul taxon (*G. uliginosum* L.), le premier taxon est enregistré sous *Laphangium luteoalbum* (L.) Tzvelez.

Discussion

La découverte de cette plante à Garâat Dakhla enrichit davantage la flore vasculaire algérienne d'origine naturalisée. En se basant sur la littérature et nos prospections périodiques des zones humides de la Numidie orientale, il est fort probable que cette espèce commence à s'installer dans ce site à partir de l'année 2018 et qu'elle provient éventuellement de graines introduites accidentellement au niveau des champs de cultures avec les semences (tomate, pastèque et haricot). Ces activités socioéconomiques sont généralement les moteurs de l'invasion au-delà des frontières nationales et internationales (Pyšek & al. 2012).

Cependant, la biologie de l'espèce laisse présager dans un avenir plus ou moins proche une possibilité d'installation au niveau des champs de culture et des zones humides. A cette nouvelle plante, nous ajoutons deux autres taxons d'origine américaine sont notés dans la station d'observation (*Erigeron bonariensis* L. et *E. canadensis* L.). En effet, les champs de culture et les zones humides demeurent des milieux très favorables à de nombreuses espèces xénophytes (Meddour & El Mokni 2016).

Fig. 2. a. Aspect et port de la plante dans son milieu; b. Spécimen prélevé; c. Habitat de la plante (Garâat Dakhla); d. la végétation accompagnatrice du taxon trouvé.

Bien entendu, la naturalisation des espèces xénophytes sur le territoire algérien est un processus continu, car de nombreuses espèces sont déjà notées (Véla & al. 2013).

En revanche, cette découverte confirme également le fait que l'extrême Nord-Est algérien (El Tarf) est un carrefour biogéographique pour sa flore comme pour sa faune (De Bélair 2005). Cette zone était historiquement mal prospectée (Quézel & Bounaga 1975). Cela nous encourage à une recherche encore plus méticuleuse des taxons qui pourraient avoir échappé aux investigations, comme ce fut le cas de *Sixalix farinosa* (Coss.) Greuter et Burdet et de *Galium verrucosum* subsp. *halophilum* (Ponzo) Lambinon découverts en 2004 sur les falaises maritimes de Cap Sigleb (Véla & al. 2012; Véla & De Bélair 2013) et d'*Allium commutatum* Guss. en 2008, sur le littoral de Medjez Echaïr (De Bélair & al. 2012). Ainsi le cas de redécouverte de *Limonium narbonense* Mill. en 2016 dans une mare distante de 1,5 Km de notre station d'observation (Boulemtafes & al. 2017).

Néanmoins, étant donné la grande étendue des zones humides numidiennes dans nombreux points d'investigation (El Tarf, Annaba et Skikda) (Allem & al. 2017), il est fort probable que d'autres stations de Gnaphale américaine puissent être découvertes, sur les rives des lacs comme sur les terrains agricoles, et dans toutes les plaines numidiennes, où *Oenothera rosea* Aiton a été récemment découverte sur les champs de culture de Annaba (Hamel 2016).

Observations complémentaires

Une végétation des dunes littorales à base de *Juniperus oxycedrus* subsp. *macrocarpa* (Sm.) Neilr. et *Retama raetam* subsp. *bovei* (Spach) Talavera & Gibbs a été enregistrée sur la rive de la mare Garâat Dakhla conjointement avec la végétation hydro-hygrophile à base de *Salix pedicellata* Desf. et *Iris pseudacorus* L.

Une vingtaine de plantes, en fleurs et/ou en fruits, ont été observées avec la gnaphale américaine (Tab. 1). Les espèces ont été identifiées selon la flore de Quézel & Santa (1962-1963) et Maire (1952-1987). La nomenclature a été actualisée selon l'index de Dobignard & Chatelain (2010-2013), et le site web de la base de données des plantes d'Afrique [http://www.ville ge.ch/musinfo/bd/cjb/africa/recherche.php?langue=fr.]. Les types biologiques sont donnés selon Blanca & al. (2009), Pignatti (1982) et Raunkiaer (1934).

Ce cortège floristique montre que l'espèce observée est très associée à deux communautés: une première association avec la communauté terrestre thérophytique (*Bellis annua*, *Erigeron canadensis*, *E. bonariensis*, *Raphanus raphanistrum* subsp. *raphanistrum*, *Trifolium campestre* et *Xanthium strumarium*), une deuxième association est moins répondue sur le terrain avec la communauté amphibie (*Isoetes histrix*, *Hypericum afrum*, *Juncus bufonius* subsp. *bufonius*, *Mentha pulegium* et *Poa trivialis*). Ces groupements végétaux ont une distribution spatiale variable, d'une année à l'autre (Rhazi & al. 2006).

Néanmoins, les zones humides abritent des communautés biologiques remarquables, qui leur sont en grande partie inféodées et sont caractérisées par de nombreuses espèces rares, menacées et à forte valeur patrimoniale (Médail & al. 1998; Quézel 1998).

Bien que, l'endémisme soit limité en Algérie (11,6%) (Véla & Benhouhou 2007), les endémiques se développant dans la mare Garâat Dakhla sont relativement peu nombreux

Tab. 1. Liste des espèces accompagnatrices du taxon observé.

Taxon	Type de végétation			Type biologique	Association avec le taxon trouvé
	Hydrophytique	Amphibie	Terrestre		
Arundo donax L.	X	X		G.rh	/
Bellis annua L.			X	Th	Haut
Bellis prostrata Pomel		X		Th	/
Callitriche obtusangula Le Gall	X			Hyd	/
Calystegia sepium (L.) R. Br.		X		G.rh	/
Cladium mariscus (L.) Pohl	X			G.rh	/
Cotula coronopifolia L.		X		Th	/
Cyclamen africanum Boiss. & Reut.			X	G.tu	/
Cynodon dactylon (L.) Pers.			X	G.rh	Moyenne
Ecballium elaterium (L.) A. Rich.			X	Th	/
Echium sabulicolum Pomel			X	Th	/
Erigeron bonariensis L.			X	Th	Haut
Erigeron canadensis L.			X	Th	Haut
Euphorbia biumbellata Poir.			X	Ch	/
Galactites mutabilis Durieu			X	Hém	Moyenne
Galium elongatum C. Presl		X		Hém	/
Geranium dissectum L.		X		Th	/
Isoetes histrix Bory		X		Hém	Haut
Juncus bufonius L. subsp. *bufonius*		X		Th	Haut
Hypericum afrum Lam.		X		Ch	Haut
Lemna minor L.	X			Hyd	/
Linaria pinifolia (Poir.) Thell.			X	Th	/
Ludwigia palustris (L.) Elliott	X			Hyd	/
Lysimachia tyrrhenia U. Manns & Anderb.		X		Hém	/
Lythrum junceum Banks & Sol.		X		G.rh	Moyenne
Lythrum salicaria L.		X		G.rh	/
Mentha pulegium L.		X		Hém	Haut
Myriophyllum alterniflorum DC.	X			Hyd	/
Nymphaea alba L.	X			Hyd	/
Oenanthe virgata Poir.		X		Hyd	/
Osmunda regalis L.		X		Hém	/
Oxalis pes-caprae L.			X	G.bu	Moyenne
Panicum repens L.	X	X		Hém	/
Persicaria senegalensis (Meisn.) Soják		X		Hém	/
Phragmites australis (Cav.) Steud.	X	X		G.rh	/
Poa trivialis L.		X		Hém	Haut
Pteridium aquilinum (L.) Kuhn.			X	G.rh	Moyenne
Raphanus raphanistrum L. subsp. *raphanistrum*			X	Th	Haut
Ranunculus aquatilis L.	X			Hyd	/
Ranunculus sardous Crantz		X		Th	/
Rubus ulmifolius Schott			X	Ph	/
Salvinia natans (L.) All.	X			Hyd	/
Schoenoplectus lacustris (L.) Palla	X			G.rh	/
Sonchus oleraceus L.			X	Th	Moyenne
Tamarix gallica L.	X			Ph	/
Trifolium campestre Schreb.				Th	Haut
Trifolium repens L.			X	Hém	Moyenne
Verbena officinalis L.			X	Hém	/
Xanthium strumarium L.			X	Th	Haut

G.rh: Géophyte à rhizome, G.tu: Géophyte à tubercule, G.bu: Géophyte à bulbe, Th: Thérophyte, Hyd: Hydrophyte, Hém: Hémicryptophyte, Ph: Phanérophyte.

Tab. 2. Liste des espèces patrimoniales observées au Garâat Dakhla [Type biogéographique selon Blanca & al. 2009 et pour les endémiques Dobignard & Chatelain (2010-2013); rareté selon Quézel & Santa 1962-1963].

Taxon	Type biogéographique	Rareté	JORA 2012	UICN 2017
Bellis prostrata	Tropical	RR		NT
Cladium mariscus	Subcosmopolite	RR		LC
Cyclamen africanum	Endémique du Maghreb	C	P	
Euphorbia biumbellata	Méditerranéen	R		
Galactites mutabilis	Endémique algéro-tunisien	AC		
Geranium dissectum	Eurasien	R		
Hypericum afrum	Endémique algéro-tunisien	R		NT
Linaria pinifolia	Endémique algéro-tunisien	R		
Ludwigia palustris	Holartique	RR	P	LC
Lysimachia tyrrhenia	Endémique tyrrhénien	R		
Myriophyllum alterniflorum	Méditerranéen atlantique	R		
Nymphaea alba	Eurasien	RR		LC
Oenanthe virgata	Endémique du Maghreb	C		
Persicaria senegalensis	Tropical	RR		LC
Salvinia natans	Paléotempéré	RR	P	LC

AR: assez rare; R: rare; RR: très rare; C: commun; LC: préoccupation mineure; NT: Quasi menacé; P: Protégé

par rapport à ce qui a été observé dans les mares d'Annaba, 18 taxons (Tab. 2) (Allem & al. 2017). Sept taxons sont évalués sur la liste rouge de l'UICN (2017) et trois sont protégés par le décret exécutif de 2012 de la République Algérienne.

Si, pour des raisons orographiques, les taxons endémiques sont très peu représentés dans le peuplement végétal numidien (Quézel 1964), les taxons d'origine septentrionale semblent constituer par contre une de ses composantes principales (Quézel 1956; Véla & Benhouhou 2007; Hamel & al. 2013).

Avec un cortège floristique assez riche, cette mare et le maquis qui les accompagne sont en grand péril en raison des diverses pressions exercées sur ce secteur de la Numidie: décapage du maquis sur les dunes pour l'agriculture, envahissement de *Xanthium strumarium* et d'*Oxalis pes-caprae* dans les parties défrichées pour la culture puis abandonnées, surexploitation de la nappe hydrique dunaire (Stevenson & al. 1988; Belouahem & al. 2011; Zouaidia & al. 2015).

Conclusion

La découverte de *Gamochaeta antillana* dans la zone humide « Garâat Dakhla » en Numidie orientale ajoute une nouvelle espèce naturalisée pour la flore algérienne. Taxon qui a été fort probablement introduit involontairement à partir des semences importées des États-Unis, depuis cette année.

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M. Aleffi, L. Miserere & R. Tacchi

Bryophytes from the wet areas of the Maritime Alps and their use as indicators of anthropic impact

Abstract

Aleffi, M., Miserere, L. & Tacchi, R.: Bryophytes from the wet areas of the Maritime Alps and their use as indicators of anthropic impact. — Fl. Medit. 28: 165-177. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

The research was conducted in six areas of the Maritime Alps Natural Park to examine the bryophyte flora of this territory and to identify priority areas for conservation, with particular reference to those where livestock graze and that are marked by evident disturbance. The data on the ecological factors of humidity, light, nitrogen/fertility, and pH were elaborated to address ecological state of the studied sites. Detrended Correspondence Analysis (DCA) was used in order to highlight the role of these factors on the impact of anthropic activity and of grazing. Analysis of the sensitivity of the species to anthropic impact reveals that, on one side, there is a prevalence of species preferring moderate anthropic impact, but on the other hand, many are the species adapted to living in conditions strong anthropic impact.

Key words: Bryophyta, DCA, Conservation, Peat-bogs, Italy.

Introduction

In the course of recent years, several studies have been carried out in the frame of the Cross-border Project between the Maritime Alps Natural Park (Italy) and the Mercantour National Park (France). The objective of these studies was to gain knowledge on the natural patrimony and the biodiversity of the Maritime Alps territory (SIC IT1160056 Alpi Marittime). To this end, between the summer of 2013 and autumn of 2015, a series of explorations was conducted in some areas of the Maritime Alps Natural Park, in particular those characterized by lakes, wet environments and peat-bogs. Based on a large species list, it was possible to develop a series of elaborations and statistical, chorological and ecological considerations; in addition, the bryophytes of these environments can be used as bioindicators of impacts caused by anthropic activities such as grazing of domestic livestock and tourists flow (Diekmann 2003; Kollmann & Fischer 2003; Wamelink & van Dobben 2003; Holt & Miller 2011).

The ecological factors analyzed have a crucial influence on the biological forms of growth of the colonizing species (ephemeral or pioneer) and stress tolerant perennials, that indicate the influence that altitude and the impact of grazing by wild and domestic animals can have on the forms of growth and thus on the selection of species that develop in the six areas studied.

Study Area

The Site of Community Interest (IT1160056 Alpi Marittime) covers a vast portion of the Alpi Marittime Park. It ranges between 700 m a.s.l,. at the valley bottom, to 3297 m a.s.l. at the South Peak of Argentera, the highest peak in the Maritime Alps. The rocky substrata influence the scenery noticeably. Most of the territory outstands by the presence of crystalline rocks that create a harsh, rugged, high-mountain environment, with deep, steep-sided valleys, vast areas with little vegetation and deep avalanche gullies. Elsewhere sedimentary rocks predominate on limestone cliffs and vast scree slopes, open grassland and karst features dominate the scenery. Lower down on the south-facing slopes, we find areas of "sub-Mediterranean" vegetation. The perennial snowfields and remaining relict glaciers are of particular interest. The alpine lakes and the high-altitude hygrophilous marshland environments around them are also of glacial origin. Among the numerous wet environments in the Park, the explorations have focused on some areas in which problems linked to grazing and anthropic impact are more evident. A study of the bryophyte flora was conducted (Fig. 1) in the following six areas:

1. Piano del Valasco (1764 m a.s.l.; Exp. NE; 44°11'55" N – 7°13'58" E)
2. Piano della Casa (1850 m a.s.l.; Exp. N; 44°09'3" N – 7°16'34" E)
3. Lagarot di Laroussa (1971 m a.s.l.; Exp. N; 44°11'59" N – 7°17'36" E)
4. Lago del Vei del Bouc (2049 m a.s.l.; Exp. NE; 44°08'28" N – 7°25'37" E)
5. Lago della Vacca (2266 m a.s.l.; Exp. NW; 44°07'52" N – 7°27'57" E)
6. Lago Villazzo (1838 m a.s.l.; Exp. N; 44°10'04" N – 7°29'52" E)

Materials and methods

In order to characterize the sampling areas, ecological variables were estimated for each species. Humidity (F), light (L), reaction (R) and nitrogen/fertility (N), were successively attributed and elaborated, according to Hill & al. (2007).

The values attributed to each species are based on Ellenberg & al. (1991) adapted by Düll (1991) for the bryophytes, and are elaborated with the INDEXT program (Hill & al. 2000), starting with the ecological values of vascular plants, grouped in quadrants, calculating the average values of each quadrant and using the regressions in order to elaborate new values for the bryophytes. The observations on the ecology of each species were derived from Dierβen (2001).

The data on the ecological parameters were elaborated according to the species reported in the six areas and according to the environmental characteristics of the territories studied using Detrended Correspondence Analysis, in which the scatters of the relevés were separate from those of the species, concentrating in particular on the parameters of humidity, light, nitrogen/fertility, and reaction, in order to highlight the role that these factors have on the impact of anthropic activity and of grazing.

Nomenclature follows Ros & al. (2007) for liverworts and Ros & al. (2013) for mosses. The species distribution refers to Aleffi & al. (2008). The samples are kept at the

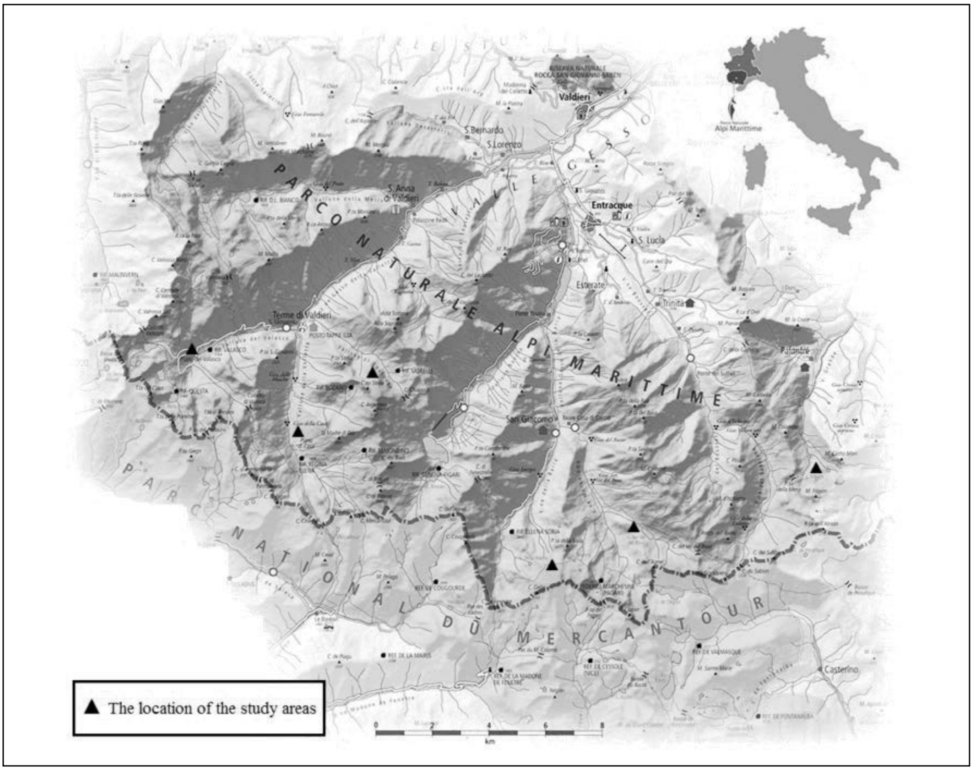

Fig. 1. The map of the Maritime Alps Natural Park with the location of the six study areas.

Herbarium of the Maritime Alps Natural Park and at the Herbarium of the University of Camerino (CAME).

Results and discussion

A total of 199 bryophyte taxa were identified (31 liverworts and 168 mosses). Of these, 8 taxa (1 liverwort and 7 mosses) were new for the Piedmont Region: *Blepharostoma trichophyllum* subsp. *brevirete*, *Brachythecium tommasinii*, *Bryum intermedium*, *Bryum moravicum*, *Bryum sauteri*, *Cratoneuron curvicaule*, *Schistidium crassipilum*, and *Schistidium platyphyllum*. Also, 12 taxa (3 liverworts and 9 mosses) were reported before 1950: this is a group of species whose first and only report was in the late 1800s to early 1900s, and were found on the occasion of that research. Finally, 43 species (8 liverworts and 35 mosses) can be considered rare and chorologically interesting.

Table 1 summarizes the results of the explorations conducted in the six research sites. In particular are listed the species that develop in wet environments and in peat bogs and which have been used for the study. Next to each species (preceded by the abbreviation used in the phase of elaboration of the ecological data), values for the ecological parameters are attributed.

Table 1. List of *taxa* found in the wet environments of the six study areas, indicating for each of them the ecological parameters of humidity (F), light (L), reaction (R) and nitrogen/fertility (N).

Code	*Taxa*	F	L	R	N
Aneu_ping	*Aneura pinguis* (L.) Dumort.	9	8	6	2
Anoe_aest	*Anoectangium aestivum* (Hedw.) Mitt.	7	6	7	2
Atri_undu	*Atrichum undulatum* (Hedw.) P. Beauv.	6	4	5	5
Aula_andr	*Aulacomnium androgynum* (Hedw.) Schwägr.	6	5	3	4
Aula_palu	*Aulacomnium palustre* (Hedw.) Schwägr.	8	7	3	2
Barb_hatc	*Barbilophozia hatcheri* (A. Evans) Loeske	5	6	3	2
Barb_lyco	*Barbilophozia lycopodioides* (Wallr.) Loeske	6	6	4	2
Barbu_bi	*Barbula bicolor* (Bruch & Schimp.) Lindb.	6	5	9	4
Bart_ithy	*Bartramia ithyphylla* Brid.	6	4	4	2
Bart_pomi	*Bartramia pomiformis* Hedw.	6	4	4	2
Blep_tric	*Blepharostoma trichophyllum* subsp. *brevirete* (Bryhn & Kaal.) R.M.Schust.	8	4	5	2
Blin_acut	*Blindia acuta* (Hedw.) Bruch & Schimp.	9	7	5	1
Brac_rivu	*Brachythecium rivulare* Bruch & Schimp.	8	6	6	5
Brac_ruta	*Brachythecium rutabulum* (Hedw.) Bruch & Schimp.	6	6	6	6
Brac_sale	*Brachythecium salebrosum* (Hoffm. ex F. Weber & D. Mohr) Schimp.	6	5	6	5
Brac_tomm	*Brachythecium tommasinii* (Sendtn. ex Boulay) Ignatov & Huttunen	5	4	8	5
Bryo_ferr	*Bryoerytrophyllum ferruginascens* (Stirt.) Giacom.	6	7	7	2
Bryu_blin	*Bryum blindii* Bruch & Schimp.	6	9	5	4
Bryu_dich	*Bryum dichotomum* Hedw.	5	7	7	7
Bryu_eleg	*Bryum elegans* Nees	3	7	8	3
Bryu_inte	*Bryum intermedium* (Brid.) Blandow	6	8	7	4
Bryu_mora	*Bryum moravicum* Podp.	5	5	6	5
Bryu_mueh	*Bryum muehlenbeckii* Bruch & Schimp.	8	7	5	2
Bryu_saut	*Bryum sauteri* Bruch & Schimp.	5	6	5	5
Bryu_schl	*Bryum schleicheri* DC.	9	7	6	4
Bryu_torq	*Bryum torquescens* Bruch & Schimp.	3	8	7	3
Bryu_weig	*Bryum weigelii* Spreng.	9	7	5	3
Call_cord	*Calliergon cordifolium* (Hedw.) Kindb.	10	5	4	5
Call_cusp	*Calliergonella cuspidata* (Hedw.) Loeske	7	7	7	3
Call_rich	*Calliergon richardsonii* (Mitt.) Kindb.	8	6	4	4
Caly_fiss	*Calypogeia fissa* (L.) Raddi	7	3	3	3
Camp_chry	*Campyliadelphus chrysophyllus* (Brid.) R.S. Chopra	2	8	8	2
Camp_stell	*Campylium stellatum* (Hedw.) Lange & C.E.O.Jensen	8	8	6	2
Ceph_grim	*Cephaloziella grimsulana* (J.B. Jack ex Gottsche & Rabenh.) Lacout.	5	6	5	2
Ceph_leuc	*Cephalozia leucantha* Spruce	7	3	1	1
Cera_purp	*Ceratodon purpureus* (Hedw.) Brid.	4	7	5	3
Chil_poly	*Chiloscyphus polyanthos* (L.) Corda	9	6	5	4
Cinc_font	*Cinclidotus fontinaloides* (Hedw.) P. Beauv.	8	7	7	4
Clim_dend	*Climacium dendroides* (Hedw.) F.Weber & D.Mohr	7	7	5	3
Crat_curv	*Cratoneuron curvicaule* (Jur.) G. Roth	7	6	7	3
Crat_fili	*Cratoneuron filicinum* (Hedw.) Spruce	8	6	7	5
Cten_moll	*Ctenidium molluscum* (Hedw.) Mitt.	6	7	7	2
Cyno_grac	*Cynodontium gracilescens* (F. Weber & D. Mohr) Schimp.	6	4	2	2
Dich_palu	*Dichodontium palustre* (Dicks.) M. Stech	9	7	4	2
Dich_pell	*Dichodontium pellucidum* (Hedw.) Schimp.	8	6	6	2
Dicr_cris	*Dicranoweisia crispula* (Hedw.) Milde	4	7	3	1
Dicr_denu	*Dicranodontium denudatum* (Brid.) E. Britton	6	4	3	2
Dicr_maju	*Dicranum majus* Sm.	6	4	3	2
Dicr_scop	*Dicranum scoparium* Hedw.	5	6	3	2
Dicr_spad	*Dicranum spadiceum* J.E. Zetterst.	6	8	5	2
Dicr_subu	*Dicranella subulata* (Hedw.) Schimp.	5	7	3	2
Dicr_taur	*Dicranum tauricum* Sapjegin	4	4	3	3
Dicr_var	*Dicranella varia* (Hedw.) Schimp.	5	7	7	4
Didy_fall	*Didymodon fallax* (Hedw.) R.H. Zander	4	7	7	3
Didy_insu	*Didymodon insulanus* (De Not.) M.O. Hill	5	6	6	4
Didy_sinu	*Didymodon sinuosus* (Mitt.) Delogne	6	4	7	5
Dist_capi	*Distichium capillaceum* (Hedw.) Bruch & Schimp.	6	6	7	2
Drep_adun	*Drepanocladus aduncus* (Hedw.) Warnst.	10	7	7	6
Enca_cili	*Encalypta ciliata* Hedw.	5	4	7	3

Table 1. continued.

Fiss_adia	*Fissidens adianthoides* Hedw.	7	7	6	2
Fiss_bryo	*Fissidens bryoides* Hedw.	5	4	5	5
Fiss_osmu	*Fissidens osmundoides* Hedw.	7	7	5	2
Fiss_rivu	*Fissidens rivularis* (Spruce) Bruch & al.	9	2	5	4
Font_anti	*Fontinalis antipyretica* (Hedw.) subsp. *antipyretica*	12	6	6	5
Font_grac	*Fontinalis antipyretica* subsp. *gracilis* (Lindb.) Schimp.	12	7	6	4
Grim_alpe	*Grimmia alpestris* (F. Weber & D. Mohr) Schleich.	1	8	5	1
Grim_anom	*Grimmia anomala* Schimp.	6	5	2	2
Grim_caes	*Grimmia caespiticia* (Brid.) Jur.	6	7	1	2
Grim_funa	*Grimmia funalis* (Schwägr.) Bruch & Schimp.	3	7	5	2
Grim_hart	*Grimmia hartmanii* Schimp.	5	3	3	2
Grim_incu	*Grimmia incurva* Schwägr.	1	8	2	2
Grim_mont	*Grimmia montana* Bruch & Schimp.	1	8	4	1
Grim_ramo	*Grimmia ramondii* (Lam. & DC.) Margad.	5	6	3	2
Grim_tric	*Grimmia trichophylla* Grev.	1	7	2	2
Gymn_aeru	*Gymnostomum aeruginosum* Sm.	8	5	6	2
Hedw_cili	*Hedwigia ciliata* (Hedw.) P. Beauv.	1	8	3	1
Hedw_leuc	*Hedwigia ciliata* var. *leucophaea* Bruch & Schimp.	1	8	3	1
Hete_dimo	*Heterocladium dimorphum* (Brid.) Schimp.	5	6	6	2
Hygr_coch	*Hygrohypnum cochlearifolium* (Venturi) Broth.	8	9	4	4
Hygr_duri	*Hygrohypnum duriusculum* (De Not.) D. W. Jamieson	10	5	5	4
Hygr_luri	*Hygrohypnum luridum* (Hedw.) Jenn.	9	6	7	4
Hygr_smit	*Hygrohypnum smithii* (Sw.) Broth.	10	6	6	3
Hylo_pyre	*Hylocomiastrum pyrenaicum* (Spruce) M. Fleisch.	5	6	4	2
Hylo_sple	*Hylocomium splendens* (Hedw.) Bruch et al.	5	6	4	2
Hyme_recu	*Hymenostylium recurvirostrum* (Hedw.) Dixon	8	6	7	2
Hypn_cupr	*Hypnum cupressiforme* var. *subjulaceum* Molendo	4	6	4	4
Isot_alop	*Isothecium alopecuroides* (Dubois) Isov.	6	4	6	5
Isot_myos	*Isothecium myosuroides* Brid.	6	4	4	3
Jung_atro	*Jungermannia atrovirens* Dumort.	8	5	6	3
Jung_hyal	*Jungermannia hyalina* Lyell	8	5	5	3
Jung_obov	*Jungermannia obovata* Nees	9	5	5	3
Jung_pum	*Jungermannia pumila* With.	8	4	5	2
Lesc_saxi	*Lescuraea saxicola* (Schimp.) Molendo	5	6	7	2
Lesk_poly	*Leskea polycarpa* Hedw.	5	6	7	6
Loph_bide	*Lophocolea bidentata* (L.) Dumort.	6	5	4	3
Loph_hete	*Lophocolea heterophylla* (Schrad.) Dumort.	5	4	4	5
Loph_vent	*Lophozia ventricosa* (Dicks.) Dumort.	6	5	2	2
Marc_poly	*Marchantia polymorpha* subsp. *montivagans* Bischl. et Boisselier	8	7	6	4
Mees_triq	*Meesia triquetra* (L. ex Jolich.) Ångstr.	9	7	6	2
Metz_furc	*Metzgeria furcata* (L.) Dumort.	4	5	5	3
Mniu_spin	*Mnium spinosum* (Voit) Schwägr.	6	4	7	3
Mniu_thom	*Mnium thomsonii* Schimp.	6	4	7	3
Nard_geos	*Nardia geoscyphus* (De Not.) Lindb.	7	6	3	2
Orth_cupu	*Orthotrichum cupulatum* Hoffm. ex Brid.	4	7	8	4
Orth_pall	*Orthotrichum pallens* Bruch ex Brid.	4	6	6	4
Oxys_tenu	*Oxystegus tenuirostris* (Hook. & Taylor) A.J.E. Sm.	7	4	3	2
Palu_comm	*Palustriella commutata* (Hedw.) Ochyra	9	6	8	2
Palu_deci	*Palustriella decipiens* (De Not.) Ochyra	9	7	6	2
Palu_falc	*Palustriella falcata* (Brid.) Hedenäs	9	8	6	2
Pell_endi	*Pellia endiviifolia* (Dicks.) Dumort.	8	4	7	4
Pell_epip	*Pellia epiphylla* (L.) Corda	8	4	4	4
Pell_nees	*Pellia neesiana* (Gottsche) Limpr.	8	6	5	3
Phil_arne	*Philonotis arnellii* Husn.	6	6	5	4
Phil_calc	*Philonotis calcarea* (Bruch & Schimp.) Schimp.	9	8	8	2
Phil_font	*Philonotis fontana* (Hedw.) Brid.	9	7	4	3
Phil_marc	*Philonotis marchica* (Hedw.) Brid.	7	6	6	5
Phil_seri	*Philonotis seriata* Mitt.	9	7	4	2
Phil_tome	*Philonotis tomentella* Molendo	9	7	6	2
Plag_cavi	*Plagiothecium cavifolium* (Brid.) Z. Iwats	6	5	6	2

Table 1. continued.

Plag_dent	*Plagiothecium denticulatum* (Hedw.) Schimp. var. *denticulatum*	6	4	4	5
Plag_elli	*Plagiomnium ellipticum* (Brid.) T.J. Kop.	8	7	5	3
Plag_oede	*Plagiopus oederianus* (Sw.) Crum & Anderson var. *oederianus*	5	6	7	2
Plag_pore	*Plagiochila porelloides* (Torrey ex Nees) Lindenb.	6	4	6	4
Plag_succ	*Plagiothecium succulentum* (Wilson) Lindb.	6	3	5	5
Plat_ripa	*Platyhypnidium riparioides* (Hedw.) Dixon	10	4	6	6
Pogo_urni	*Pogonatum urnigerum* P. Beauv.	5	7	3	1
Pohl_crud	*Pohlia cruda* (Hedw.) Lindb.	6	5	5	2
Pohl_drum	*Pohlia drummondii* (Müll. Hal.) A.L.Andrews	6	7	3	2
Pohl_nuta	*Pohlia nutans* (Hedw.) Lindb.	5	5	2	2
Pohl_wahl	*Pohlia wahlenbergii* (F. Weber & D. Mohr) A.I. Andrews var. *wahlenbergii*	8	6	6	4
Poly_alpi	*Polytrichastrum alpinum* (Hedw.) G.L. Sm.	5	6	2	2
Poly_comm	*Polytrichum commune* Hedw.	7	6	2	2
Poly_juni	*Polytrichum juniperinum* Hedw.	5	8	3	2
Poly_pili	*Polytrichum piliferum* Hedw.	3	9	3	1
Pore_plat	*Porella platyphylla* (L.) Pfeiff.	4	6	8	3
Pseu_incu	*Pseudoleskea incurvata* (Hedw.) Loeske	5	6	7	2
Pseu_nerv	*Pseudoleskeella nervosa* (Brid.) Nyholm	5	7	7	2
Pseu_pate	*Pseudoleskea patens* (Lindb.) Kindb.	5	6	7	3
Pseu_tect	*Pseudoleskeella tectorum* (Funck ex Brid.) Kindb. ex Broth.	2	8	7	4
Pter_fili	*Pterigynandrum filiforme* Hedw.	5	6	6	2
Pter_grac	*Pterogonium gracile* (Hedw.) Sm.	4	7	5	2
Ptyc_bimu	*Ptychostomum pseudotriquetrum* var. *bimum* (Schreb.) Dm.T.Holyoak & N.Pedersen	9	8	6	3
Ptyc_comp	*Ptychostomum compactum* Hornsch.	6	9	7	4
Ptyc_imbr	*Ptychostomum imbricatulum* (Müll. Hal.) Holyoak & Pedersen	4	7	6	5
Ptyc_pall	*Ptychostomum pallens* (Sw.) J.R. Spence	7	7	6	4
Ptyc_palsc	*Ptychostomum pallescens* (Schleich. ex Schwägr.) J.R. Spence	5	7	6	4
Ptyc_plic	*Ptychodium plicatum* (Schleich. ex F.Weber & D.Mohr) Schimp.	5	6	7	2
Ptyc_pseu	*Ptychostomum pseudotriquetrum* (Hedw.) J.R.Spence & H.P.Ramsay var. *pseudotriquetrum*	9	8	6	3
Raco_cane	*Racomitrium canescens* (Hedw.) Brid.	3	8	6	2
Raco_elon	*Racomitrium elongatum* Ehrh. ex Friswoll	4	8	4	2
Raco_eric	*Racomitrium ericoides* (Weber ex Brid.) Brid.	5	7	4	2
Raco_micr	*Racomitrium microcarpon* (Hedw.) Brid.	5	7	6	1
Raco_sude	*Racomitrium sudeticum* (Funck) Bruch & Schimp.	3	7	2	1
Raco-obtu	*Racomitrium obtusum* (Brid.) Brid.	2	7	2	1
Radu_lind	*Radula lindenbergiana* Gottsche ex C. Hartm.	5	6	6	3
Rhiz_magn	*Rhizomnium magnifolium* (Horik.) T.J.Kop.	9	6	5	3
Rhiz_punc	*Rhizomnium punctatum* (Hedw.) T.J.Kop.	8	5	5	4
Rhyt_squar	*Rhytidiadelphus squarrosus* (Hedw.) Warnst.	5	7	5	4
Rhyt_triq	*Rhytidiadelphus triquetrus* (Hedw.) Warnst.	6	6	6	3
Sani_unci	*Sanionia uncinata* (Hedw.) Loeske	6	6	4	2
Scap_aequ	*Scapania aequiloba* (Schwaegr.) Dumort.	7	5	7	2
Scap_curt	*Scapania curta* (Mart.) Dumort.	6	6	3	2
Scap_helv	*Scapania helvetica* Gottsche	6	7	6	2
Scap_irri	*Scapania irrigua* (Nees) Nees	8	7	4	2
Scap_nemo	*Scapania nemorea* (L.) Grolle	7	5	4	2
Scap_suba	*Scapania subalpina* (Nees ex Lindenb.) Dumort.	8	7	4	2
Scap_uligi	*Scapania uliginosa* (Sw. ex Lindenb.) Dumort.	9	7	4	2
Scap_undu	*Scapania undulata* (L.) Dumort.	10	6	4	2
Schi_apoc	*Schistidium apocarpum* (Hedw.) Bruch & Schimp.	2	7	7	4
Schi_cras	*Schistidium crassipilum* Blom	1	7	8	4
Schi_platy	*Schistidium platyphyllum* (Mitt.) H.Perss. subsp. *platyphyllum*	8	7	5	3
Schi_rivu	*Schistidium rivulare* (Brid.) Podp. subsp. *rivulare*	8	7	5	3
Sc-hy_plum	*Sciuro-hypnum plumosum* (Hedw.) Ignatov & Huttunen	8	5	4	3
Sc-hy_star	*Sciuro-hypnum starkei* (Brid.) Ignatov & Huttunen	7	6	5	2
Scor_coss	*Scorpidium cossonii* (Schimp.) Hedenäs	8	8	7	2
Scor_scor	*Scorpidium scorpioides* (Hedw.) Limpr.	10	8	6	2
Spha_capi	*Sphagnum capillifolium* (Ehrh.) Hedw.	7	7	2	2
Spha_cent	*Sphagnum centrale* C.E.O. Jensen ex Arn. & C.E.O. Jensen	8	7	3	2
Spha_cont	*Sphagnum contortum* Schultz	9	8	5	2

Table 1. continued.

Spha_fall	*Sphagnum fallax* (H.Klinggr.) H.Klinggr.	9	7	2	3
Spha_mage	*Sphagnum magellanicum* Brid.	8	8	1	1
Spha_palu	*Sphagnum palustre* L.	8	7	3	2
Spha_plat	*Sphagnum platyphyllum* (Lindb. ex Braithw.) Warnst.	9	8	5	2
Spha_russ	*Sphagnum russowii* Warnst.	7	6	2	2
Spha_squa	*Sphagnum squarrosum* Crome	9	6	4	3
Spha_subs	*Sphagnum subsecundum* Nees ex Sturm	9	8	4	2
Spha_tene	*Sphagnum capillifolium* var. *tenerum* (Sull. & Lesq. ex Sull.) H. A. Crum	7	7	2	2
Spha_tenel	*Sphagnum tenellum* (Brid.) Bory	8	8	1	1
Spha_tere	*Sphagnum teres* (Schimp.) Ångstr.	9	7	4	2
Stra_stram	*Straminergon stramineum* (Dicks. ex Brid.) Hedenäs	9	7	3	2
Synt_calc	*Syntrichia calcicola* J.J. Amann	3	8	7	4
Synt_norv	*Syntrichia norvegica* F. Weber	4	8	7	2
Synt_rura	*Syntrichia ruralis* (Hedw.) F. Weber & D. Mohr var. *ruralis*	3	8	7	4
Tetr_pell	*Tetraphis pellucida* Hedw.	6	3	3	3
Tort_hopp	*Tortula hoppeana* (Hedw.) Limpr.	2	9	7	2
Tort_mura	*Tortula muralis* Hedw.	2	6	8	5
Tort_tort	*Tortella tortuosa* (Hedw.) Limpr. var. *tortuosa*	4	7	7	2
Warn_exan	*Warnstorfia exannulata* (Schimp.) Loeske	9	8	4	2
Warn_sarm	*Warnstorfia sarmentosa* (Wahlenb.) Hedenäs	9	8	5	2

Humidity

The hygrophytes (30.89%) and the mesophytes (36.62%) represent the dominant group. Conversely, the xerophytes (11.52%) represent a smaller group that grow prevalently on the rocky substratum directly exposed to sunlight.

The first axis of the DCA graph (Fig. 2) distinguishes various degrees of humidity of the individual relevés. There is a distinction between the various points of relevés of the Lago del Vej del Bouc (white circles) and Valasco (white squares), and the points that are dryer (GPS 68, grey squares of the dry, rocky grazing lands near the Lago della Vacca and GPS 54, dry grazing lands of the Lago del Vej del Bouc).

Some relevés of the Lago Villazzo (grey rhombuses), of the Piano del Valasco and the Lago del Vej del Bouc, which are grazed humid areas or near-grazing areas, tend to be in intermediate positions on the graph. This is probably due to the presence of species more adapted to situations of dehydration, and whose growth can be favored by these conditions of disturbance. These species (e.g. *Brachythecium tommasinii*, *Climacium dendroides*, *Phylonotis tomentella*, *Pseudoleskea patens*) are well remarked by the grey square in the DCA species ordination (Fig. 3).

Light

The bryophytes that predominate in the environments studied are species adapted to living in environments that are moderately to strongly illuminated, conditions linked to the strong exposition to sunlight of these habitats, above all during the summer. Also in this case, these are species typical of peat-bogs that adapt to conditions of extreme climatic and environmental variability.

The DCA for the parameter of light (Fig. 4) does not seem to show any particular differences. Rather, it seems to reflect the divisions of the parameter of humidity. However, it should be noted that about half of the species identified are very adaptable

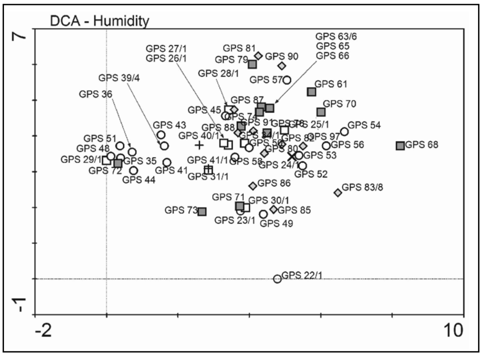

Fig. 2. The DCA humidity graph of the relevés.

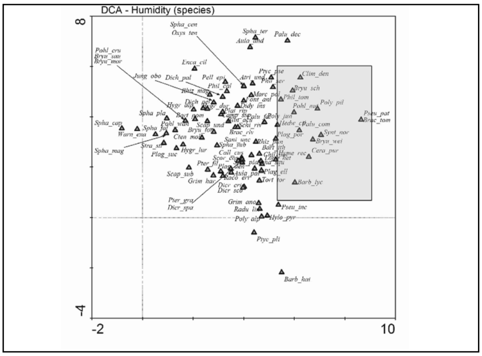

Fig. 3. The DCA humidity ordination of the species.

regarding this ecological parameter, inasmuch as they can live in conditions of shade and those of full sunlight.

However, we can note a certain division along the second axis, above all if it is compared with the axis of the species (Fig. 5) where at the base there are species that are distinguished from the others because they traditionally live in conditions more typical of underbrush.

Nitrogen/fertility

Analyzing the graph for the values of nitrogen/fertility of the substratum (Fig. 6), the most nitrophilous species are located on the right (white rectangle) while the least nitrophilous ones are on the left (grey rectangle).

According to Hill & Preston (1998) and Dierβen (2001), the species that are more eutrophic/nitrophilic are *Tortula hoppeana, Ceratodon purpureus, Leskea polycarpa* and *Brachythecium rutabulum*. All of them are found on the right in Fig. 6.

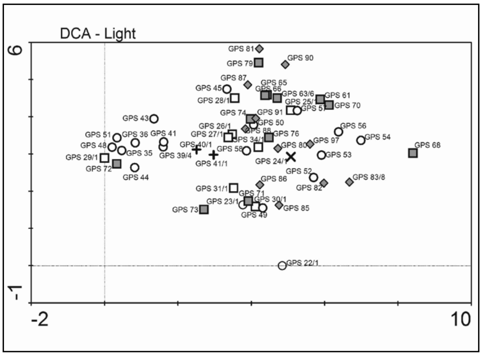

Fig. 4. The DCA for the parameter of light of the relevés.

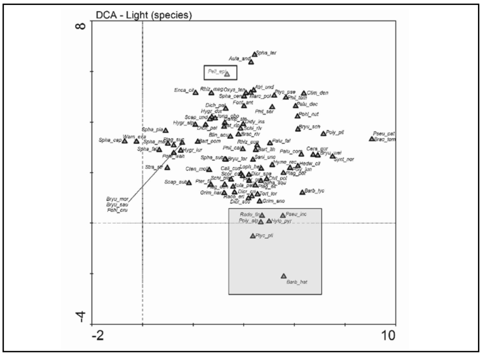

Fig. 5. The DCA light graph of the species.

The species classified by Dierβen (2001) as typical of a substratum with an average content of nutrients (m nitrophyt) are *Aulacomnium androgynum, Bryum dichotomum, Calliergon cordifolium, Calliergonella cuspidata, Lophocolea heterophylla, Marchantia polymorpha subsp. montivagans, Orthotrichum pallens, Ptychostomum imbricatulum, Ptychostomum pallescens, Rhytidiadelphus squarrosus, Rhytidiadelphus triquetrus, Scapania irrigua, Sciuro-hypnum starkei* and *Sphagnum squarrosum*. These species are distributed prevalently in the right part of Fig. 6. Instead, the indicator species of a low nutrients content (oligotrophic) are *Hygrohypnum cochlearifolium, Hygrohypnum smithii, Jungermannia obovata, Scapania undulata,* and *Blindia acuta*. These species, as shown by the grey rectangle, are located in the left part of Fig. 6.

Along the second axis, the species in a higher position seem to be those that grow where there is water, while in a lower position are those that grow in drier sites.

Observing the same graph regarding the relevés (Fig. 7), most of the grazed sites, such as those of the Lago del Vej del Bouc, are located on the right, while those of mires and humid zones, notoriously poorer in nutrients, are on the left. Some of these, even though they are in humid zones such as GPS52, GPS53 together with some of Lago Villazzo (grey rhombuses: GPS82 and 83) and of the Lago della Vacca (grey squares: GPS 70), are found on the right, near those of grazing sites. This is the same as in Valasco (white squares) which, except for one, are found prevalently in the central part.

pH

Regarding acidity, a distribution similar to that of the previous graphs is seen along the first axis also in the two graphs for soil pH (Figs. 8, 9). The presence of species of the *Sphagnum* genus (grey square), as shown by the grey rectangle, which are indicators of the maximum values of acidity, distinguish some survey observations from the others in Fig. 8. It appears clear that the relevés (in wet zones as well) in the area of the Valasco (Fig. 9, white squares) are almost all located in the central part of the graph, indicating intermediate values of acidity. In this area, *Calliergonella cuspidata* was found with greater frequency (3 relevés). This species typical of basic environments can thus be considered an indicator element for an anomalous increase in pH.

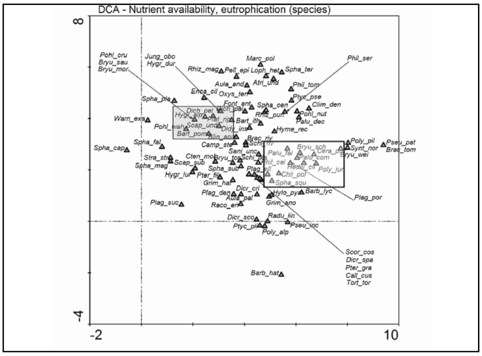

Fig. 6. The DCA graph for the nutrient availability of the species.

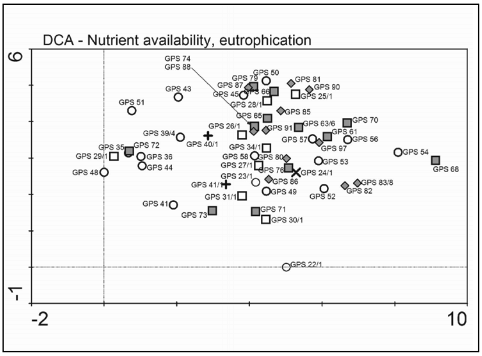

Fig. 7. The DCA graph of the relevés for the values of nitrogen/fertility of the substratum.

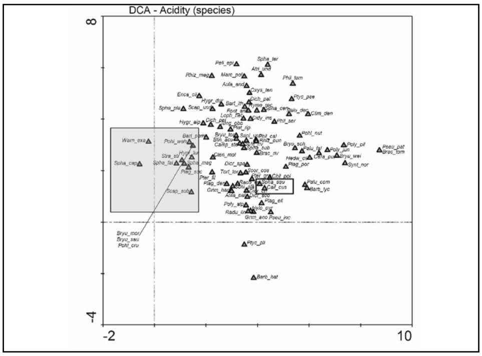

Fig. 8. The DCA graph for soil pH of the species.

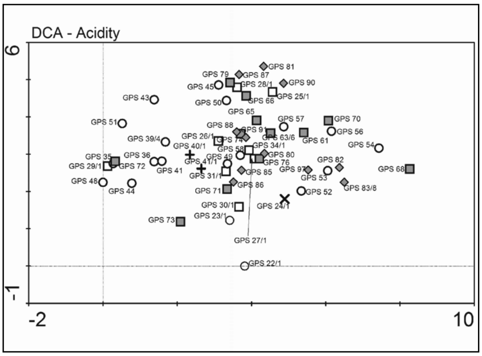

Fig. 9. The DCA graph for soil pH of the relevés.

Sensitivity of the species to anthropic impact

Analysis of the sensitivity of the species to anthropic impact reveals that on the one hand, there is a prevalence of species that prefer moderate anthropic impact, but on the other hand, on the whole, there are many species adapted to living in conditions of moderate or strong anthropic impact, an observation that should be related, especially in some sites, to the high degree of trampling by livestock, which inevitably conditions the species component.

Dierβen (2001) identifies a series of indicator species for the presence of different levels of anthropic impact. On this basis, it was possible to identify target species that are indicators of natural conditions and/or of moderate anthropization and of deterioration of the studied areas, and in this way proceed to characterize the study areas, through analysis of the ecological parameters considered up to this point, and applied to the species identified. In this way, it was possible to obtain criteria and indications for planning actions of direct and indirect guardianship, protection and restoration of the habitats.

We list here, on the basis of the degree of anthropic impact, the species that were noted during the course of this study that better than others are able to represent the various degrees of anthropization and that can be used in the future as indicator species for these phenomena.

Indicator species of high/strong anthropic impact (Eu-polyhem)
- *Bryum dichotomum* Hedw. (Lago del Vej del Bouc, bare soil)

Indicator species of high anthropic impact (Euhem)
- *Bryum sauteri* Bruch & Schimp. (Lagarot di Laroussa, dripping wall; Lago del Vej del Bouc, peat-bog)
- *Dicranella varia* (Hedw.) Schimp. (Lago del Vej del Bouc)

Indicator species of moderate/strong anthropic impact (Meso-polyhem)
- *Ceratodon purpureus* (Hedw.) Brid. (Piano della Casa, bare soil; Lago del Vej del Bouc, bare soil; Lago Villazzo, banks of the river)
- *Didymodon fallax* (Hedw.) R.H. Zander (Lagarot di Laroussa, wet meadow)

- *Pohlia nutans* (Hedw.) Lindb. (Piano della Casa; Lago del Vej del Bouc, bare soil; Gias Prato, wet meadow; Lago Vacca, banks of the river)
- *Tortula muralis* Hedw. (Piano della Casa, on soil)

Indicator species of moderate/high anthropic impact (Meso-Euhem)
- *Brachythecium rutabulum* (Hedw.) Bruch & Schimp. (Lago Villazzo, banks of the river)
- *Chiloscyphus polyanthos* (L.) Corda (Lago del Vej del Bouc, peat-bog)
- *Cinclidotus fontinaloides* (Hedw.) P. Beauv. (Lagarot di Laroussa, wet meadow)
- *Dicranella subulata* (Hedw.) Schimp. (Piano del Valasco, bare soil)
- *Didymodon insulanus* (De Not.) M.O. Hill (Piano del Valasco, banks of the river)
- *Lophocolea heterophylla* (Schrad.) Dumort. (Lago del Vej del Bouc, bare soil)
- *Plagiomnium ellipticum* (Brid.) T.J. Kop. (Lago del Vej del Bouc, peat-bog; Piano della Casa, bare soil)
- *Platyhypnidium riparioides* (Hedw.) Dixon (Piano del Valasco, banks of the river; Lagarot di Laroussa, wet meadow)
- *Ptychostomum imbricatulum* (Müll. Hal.) Holyoak & Pedersen (Piano della Casa, on soil)
- *Ptychostomum pallescens* (Schleich. ex Schwägr.) J.R. Spence (Lagarot di Laroussa, wet meadow)

Conclusions

The explorations conducted in the six areas have allowed us to achieve an in depth study of the bryophyte flora in a territory of the Alps whose bryophytes have received little attention so far. We offer below a summary of the concluding considerations that can serve as the foundations for future research to monitor the areas studied and identify opportune actions to safeguard these environments.

Some areas (Piano del Valasco, Piano della Casa), are more subject to the effects of both grazing and the influx of tourists, which in some periods of the year, reaches unsustainable levels for an environment of such extremely fragile equilibrium as that of a mire. The floating marshy peat mats often appear to have been crushed underfoot by tourists. In these areas, one can observe that alongside the typical flora of peat-bogs represented by *Sphagnum*, there is the development of a more banal and ubiquitous ruderal and anthropic flora; in the part uphill, where the valley closes near the waterfall, the pressure from cattle grazing appears greater, and the bryophyte flora concentrates in proximity of boulders and strips of larch groves on the edges of the Piano.

Lago del Vej del Buc, Lago Villazzo and Lago della Vacca appears to be strongly conditioned by the notable impact of livestock grazing. The pet-bog appears to be particularly damaged by the trampling of animals, while in the places where there is the greatest trampling, the vegetation appears to be characterized by ruderal and ubiquitous species typical of grazing environments. On the lake shore where there has been no trampling or a lesser degree of trampling, there are traces of a *Sphagnum* bog, even though observation of the state of conservation of the *Sphagnum* indicates that it suffers from the aridity and the state of drying of the summer, in all likelihood related to the karstic nature of the subsurface. In fact, in places where the water reappears, species typical of wet environments are seen. It should be noted that the peat-bog is subject to trampling by animals with consequent damage and impoverishment of its species component.

The Lagarot di Laroussa is the only site with the greatest characteristics of naturalness. In fact, no livestock were seen there. The shores of the small lake, which appear to be in an excellent state of conservation, attract afternoon visits of chamois who go there to drink. The influx of tourists seems to be quite orderly and respectful of the environment. In Lagarot, as in the other sites, *Sphagnum* were not observed, but unlike the others, the aquatic and wet environment flora is rich, making this site an environment that is surely interesting and to be used as a model of conservation, also for the other sites.

The indicator species of anthropic impact identified during this research, could be used for future monitoring efforts, at least in areas with elevated anthropic impact. Precisely because of the ecological and natural characteristics described in this work (colonizing species or those linked to a certain chemism of the waters or substrata), they adapt to living well in situations where there is a high degree of anthropization.

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Ernst Vitek

Gundelia (*Compositae*), from one to many species – an ignored diversity*

Abstract

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For long time in scientific botany the genus *Gundelia* (*Compositae*) was treated with only one polymorphic species *Gundelia tournefortii* L. When finding new populations in Armenia it was realized, that several species are hidden in the variety. At the moment 15 species are accepted as distinct taxa. The genus can be found from Turkey eastwards to Afghanistan, southwards to Israel and Iraq. The centre of diversity is in Eastern Turkey.

Key Words: Mediterranean Flora, systematics.

Introduction

Linnaeus (1753) described *Gundelia tournefortii*, all later described species and varieties have been put back into synonymy by later authors (e.g. Kupicha 1975; Rechinger 1989). Therefore during the OPTIMA excursion in Armenia in 2002 plants of this genus have been presented to the participants as *"Gundelia tournefortii"*. In 2005 two new localities of *Gundelia* have been found in Armenia, and comparing these populations it became clear that there is more than one species in the genus. After finding the important characters to distinguish the species, step by step all published names of whatever rank have been checked, typified and – as far as possible – the type localities visited. The plants of the genus *Gundelia* are called „Kenger" in Turkish, „Akub" in Arabic and „Kuub" in Farsi language, with some local dialectic variations. Young shoots are used as vegetables or as food for animals. The latex of the cut shoots can be dried and used as chewing gum. The roasted fruits can be used to replace coffee beans.

Results

At the moment 15 species are accepted (Vitek & Jarvis 2007; Vitek & al. 2010; Vitek & al. 2014; Nersesyan 2014; Armağan 2016; Fırat 2016, 2017a; Vitek & al. 2017a, 2017b; Vitek & Noroozi 2017a, 2017b; Fırat 2017b; Çakılcıoğlu & al. 2018; Vitek 2018). They can be distinguished by size of the plant, colour of flowers (Fig. 1), number of flowers in one partial synflorescence, indumentum, shape and size of fruits, climatic and ecological requirements (Table 1).

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*Extended and enriched version of the oral presentation given at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

Table 1. Gundelia species and their characters.

Taxon	**Plant size (cm)**	**Synflorescences per plant**	**Flower colour (inside)**	**Number of flowers**	**Indumentum (in synflorescence)**	**Distribution (countries)**
G. anatolica	30–60	10–15	yellowish green to green	6	young shoots with dense arachnoid hairs	Turkey
G. aragatsii subsp. *aragatsii*	50–80	5–15	brown	3 (–5)	arachnoid hairs when young	Armenia, Azerbaidjan
G. aragatsii subsp. *steineri*	50–80	5–15	brown	3	arachnoid hairs when young	Armenia
G. armeniaca	50–80	5–15	violet	6	glabrous	Armenia, (Turkey?)
G. asperrima	20–50	5–10	blackish brown	3 (–5)	very dense arachnoid hairs	Turkey
G. cilicica	30–70	5–10	golden yellow	(5–) 6	arachnoid hairs when young	Turkey
G. colemerikensis	50–80	15–30	reddish maroon to pinkish–maroon	5–6	glabrous or arachnoid hairs when young	Turkey
G. dersim	60–100	5–15	brown to reddish–brown	6–7	densely covered with tomentose (and arachnoid) hairs	Turkey
G. glabra	30–60	5–10	brown	3–4	glabrous	Turkey
G. komagenensis	30–60	1–5	golden yellow	3 (–5)	glabrous or sparsely arachnoid hairs	Turkey
G. mesopotamica	50–80	5–20	whitish to pale yellowish	6–7	glabrous to tomentosely hairy	Turkey
G. microcephala	20–60	3–10	yellow	6–7	young state covered with hairs	Iran, Iraq
G. munzuriensis	30–80	5–10	bright pink to pink	3–6	sparsely hairy with arachnoid hairs	Turkey
G. rosea	40–120	10–60	pale violet	(7–) 8 (–10)	arachnoid hairs when young	Iran, Iraq, Turkey
G. tehranica	40–120	10–60	yellow	(7–) 8	glabrous, rarely few arachnoid hairs on young shoots	Iran
G. tournefortii	40–100	5–10	bright yellowish to yellow	5–7	hairy to densely hairy	Cyprus, Israel, Syria, Lebanon, Turkey, (Iran?, Iraq?)
G. vitekii	40–60	1–5	dark pink to red	3 (–5)	arachnoid hairs when young	Turkey

Accepted taxa:

Gundelia L., Sp. Pl. 2: 814 (1753), type species: *G. tournefortii.*

G. anatolica Fırat, *Gundelia* Spec. Anatolia: 23–24 (2016). – Fig. 1c.

Type: Turkey, B4, Kırıkkale, Delice province, Tuzkayası region, 700 m, 39°58'20" N, 34°04'12" E, 2. 5. 2015, M. Fırat 32645 [holotype VANF, isotypes ANK, Herb. Yıldırımlı, Herb. Fırat].

G. armeniaca Nersesyan, Ann. Naturhist. Mus. Wien, B 116: 192 (2014). – Fig. 1f.

Type: Абовянский район, окр. с. Гехадир, 10. 06. 1988, А. Нерсесян, [Abovian region, surroundings of Geghadir village, 10. 06. 1988, A. Nersesyan] [holotype ERE 137773, isotypes ERE 137772, ERE 149115, ERE 149116, ERE 149117, W 2006-0005938, W 2006-0005939].

G. aragatsi Vitek, Fayvush, Tamanyan & Gemeinholzer subsp. *aragatsi*, Ann. Naturhist. Mus. Wien, B 111: 92 (2010).

Type: Armenia, Aragatsotn province, Mt. Aragats SW-slope, track between Avtona water reservoir and Kakavadzor, 1880 m s. m., 40°22'5"N/44°2'49"E, 23. 6. 2007 G. Fayvush, K. Tamanyan, H. Ter-Voskanyan, E. Vitek 07-1373 [holotype ERE, isotypes W (four sheets) 2009-18514–2009-18517, B, BC, BM, BRNU, E,MO, MSB, NY, WU].

G. aragatsi subsp. *steineri* Vitek, Fayvush, Tamanyan & Gemeinholzer, Ann. Naturhist. Mus. Wien, B 111: 96 (2010).

Type: Armenia, Vayots Dzor province, mainroad to south Armenia,Wof Yeghegnadzor, SE of crossroad to Erechgnadzor, slope S of river, 1050 m. s. m, dry rocky slope, 39°44'21"N/45°15'3"E, 2009-06-01 G. Fayvush, K. Tamanyan, E. Vitek 09-0700 [holotype ERE, isotypes W2009-18513, B, BC, E, MO, MSB, NY, WU].

G. asperrima (Trautv.) Fırat, Ot Sist. Bot. Dergisi 24(2): 62 (2017) [31 Dec 2017?]

≡ *G. asperrima* (Trautv.) Çakılcıoğlu, Yüce & Vitek, Ann. Naturhist. Mus. Wien, B, 120: 240 (2018). [Jan 2018, isonym]

Type: “In Turciae districtu Erzerum, in montibus Palänteken, altit. 6300' [1920 m], Radde” [TB n. v.].

G. colemerikensis Fırat, Gundelia Spec. Anatolia: 15–16 (2016). – Fig. 1b.

Type: Turkey, C9, Hakkâri Province (Colemerîk) from Karadağ hill to Berçelan plateau, 2284 m, 37°36'39" N, 43°44'44" E, 11. 6. 2015, M. Fırat 32465 [holotype VANF, isotypes ANK, Herb. Yıldırımlı, Herb. Fırat].

G. dersim Vitek, Yüce & Ergin, Phytotaxa 161: 131 (2014).

Type: Turkey, Province Tunceli (Dersim), Ovacık, c. 11. 7 km WWSW Ovacık, 1. 9 km ENE Ziyaret (fountains of river Munzur), 1300 m s. m., 39°20'16" N / 39°4'57" E, 12. 06. 2013, E. Vitek, E. Yüce, C. Ergin & H. H. Makal 13-0030 [holotype W 2013-0006146, isotypes Tunceli University, HUB, ISTE, E, G, US].

G. glabra Mill., Gard. Dict., ed. 8. n. 2 (1768). – Fig. 1a.

Type: Turkey, province Bayburt, c. 4.4 km SSE Bayburt, road to Gümüşsu, c. 100 m from main road, 1595 m s.m., 40°13'37"N 40°15'43"E, 14.6.2013 E. Vitek, E. Yüce, C. Ergin & H. H. Makal 13-0173 [neotype W 2013-0006162, iso-neotypes Tunceli University, B, E, G, HUB, INU, ISTE, NY, US].

G. komagenensis Fırat, Gundelia Spec. Anatolia: 6–7 (2016). – Fig. 1g.

Type: Turkey, C7, Adlyaman: Kahta Province, Nemrut mountain, 1445 m, 31'57'01" N, 38°45'38" E, 26. 5. 2015, M. Fırat 32494 [holotype VANF, isotypes ANK, E, Herb. Yıldırımlı, Herb. Fırat].

G. mesopotamica Fırat, Acta Biol. Turc. 30: 65 (2017).
Type: Turkey. C8 Mardin: 2–3 km from Mardin to Nusaybin (Nisêbîn), eroded slopes, aride steppe, 807 m, 37°17'36"N, 40°46'20"E, 8. 5. 2017, M. Fırat 33725 [holotype VANF, isotypes ANK, Herb. M. Fırat].

G. microcephala (Bornm.) Vitek, Ann. Naturhist. Mus. Wien, B, 120: 235 (2018).
Type: Inter Kermandschahan et Bagdad, prope Khanegyn [Chanekin, Chanaqin] ad fines Persiae, Grenzstation, 3. 4. 1894, Strauss s. n. [JE 00015288].

G. munzuriensis Vitek, Yüce & Ergin, Phytotaxa 161: 135 (2014).
Type: Turkey, Province Tunceli (Dersim), Ovacık, c. 2 km WWSW Ovacık, 1275 m s. m., 39°21'19" N / 39°11'29" E′, 12. 6. 2013, E. Vitek, E. Yüce, C. Ergin & H. H. Makal 13-0025 [holotype W 2013-0006270 (inflorescence) and 2013-0006269 (additional leaf), isotypes Tunceli University, HUB, INU, ISTE, B, E, G, L, US].

G. rosea M. Hossain & Al-Taey, Notes Roy. Bot. Gard. Edinburgh 42 (1): 41 (1984). – Fig. 1d–e.
Type: Iraq, c. 60 km. N. E. of Mosul, 10. 5. 1978, Hossain s. n. [holotype MSUH, isotypes BAG, E00385310, K000797235]

G. tehranica Vitek & Noroozi, Ann. Naturhist. Mus. Wien, B, 119: 246 (2017).
Type: Iran, Tehran, Tuchal Mt., above Velenjak, 2200-2300 m, 35°49'26"N, 51°23'30"E, 6. 5. 2016, J. Noroozi [holotype W 2016-0011195, isotypes E, G, IRAN, NY, TARI, W 2016-0011196].

G. tournefortii L., Sp. Pl. 2: 814 (1753).
Lectotype: [Aleppo,] Rauwolf 1583, t. 74. Epitype: [Aleppo,] Rauwolf, hort. sicc. 81 [L].
= *G. cilicica* Fırat, *Gundelia* Spec. Anatolia: 19–20 (2016).
Type: Turkey, C5, Mersin, Erdemli province, Tozlu village, 1460 m, 36°48'12" N, 34°07‘09" E, 5. 5. 2016, M. Fırat 32705 [holotype VANF, isotypes ANK, Herb. Yıldırımlı, Herb. Fırat].

G. vitekii Armağan, Ann. Naturhist. Mus. Wien, B, 118: 130 (2016).
Type: Turkey, province Tunceli (Dersim), Tunceli Merkez, c. 8 km N of Tunceli, mountain slope NW of Tüllük Bucaği, 39°10'32"N 39°32'04"E, 1745 m s. m., 31. 5. 2015, E. Vitek, M. Armağan & M. Özel 15-0042 [holotype VANF, isotype W 2015-11168].

Names still needing clarification:
Gundelia tenuisecta Freyn & Sint., Oesterr. Bot. Z. 42: 168 (1892).
G. tournefortii var. [β] *araneosa* DC., Prodr. Syst. Nat., 5: 88 (1836).
G. tournefortii var. *armata* Freyn & Sint, Österr. Bot. Z. 42: 168 (1892).
G. tournefortii var *tenuisecta* Boiss., Fl. Orient. 3: 421 (1875).

Discussion

It is a surprising fact, that the diversity in the genus has been ignored for long time. Probably this is partly due to the difficulties in collecting these often rather big, spiny and badly drying plants. In the herbarium specimens some characters as the flower colour can-

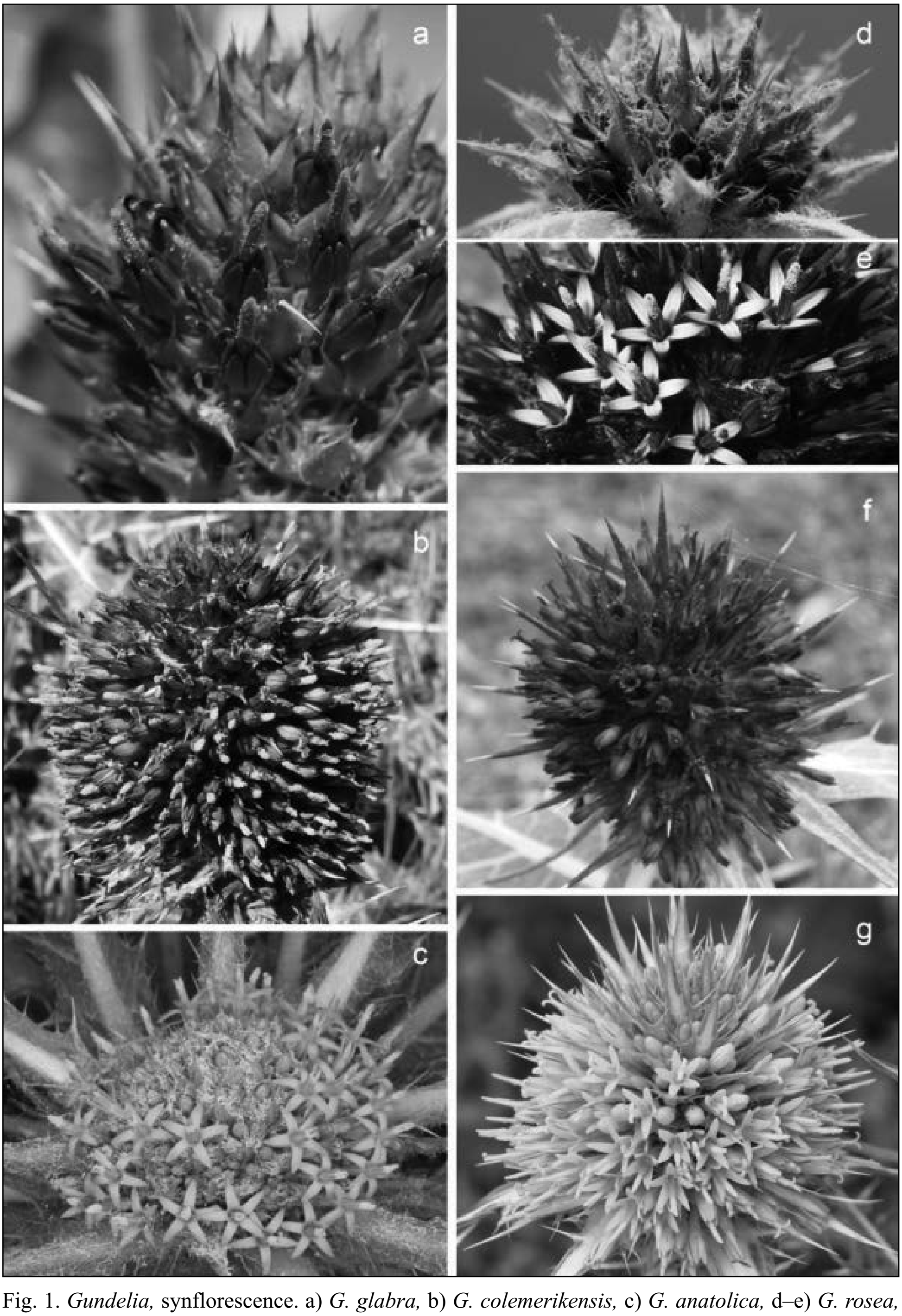

Fig. 1. *Gundelia,* synflorescence. a) *G. glabra,* b) *G. colemerikensis,* c) *G. anatolica,* d–e) *G. rosea,* f) *G. armeniaca,* g) *G. komagenensis.* – a, d, e, g © Vitek, b, c, f © Armağan.

not be seen and in most cases there is no information on the habitat. Some authors (e.g. Bornmüller 1906; Trautvetter 1876) found the important differencing characters, but described the taxa as varieties.

All species are clearly differentiated in their characters (Table 1), but also well defined in their ecological needs. E.g. *G. glabra* has been found in the province Elaziğ, near Sivrice growing on a dry slope (Vitek & al. 14-0189 [W 2014-0014879]; Vitek & al. 2017: Fig. 4c), and *G. dersim* in about 30 m distance in a grassy humid ditch (Vitek & al. 14-188 [W 2014-0014881], new record for the province Elaziğ). No plants could be found in between showing the strict limitation to the required habitat. In Armenia *G. aragatsi* subsp. *aragatsi* is found in mountain (steppe) meadows (1700-1900 m), *G. aragatsi* subsp. *steineri* on a stony slope with Shibljak vegetation (1000-1100 m) and *G. armeniaca* in semi-humid to dry meadows in lower altitude (1300-1600 m).

Gundelia has its centre of diversity in Turkey with 12 (-13) species, reaching Afghanistan in the East, Israel in the South and Cyprus. Based on photos and information found in the internet there are still some species to describe. There is insufficient information on the variability in Iran and Iraq with 3 (-4) species at the moment. For other countries from which *Gundelia "tournefortii"* is reported, e.g. Azerbaijan or Turkmenistan, there is no reliable information to assign a species, but with high certainty this is not *G. tournefortii.* The same is valid for Afghanistan - the photo in Breckle & Rafiqpoor (2010: 271) shows some similarity to *G. tehranica*, but does not allow a clear assignment. Anyway the total number of species could go up to 20-25 species in future.

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Autecology and *ex situ* growth of *Leontopodium nivale* subsp. *nivale* (*Asteraceae*) from North Pirin marbles (SW Bulgaria)

Abstract

Kozuharova, E., Panayotov, M. & Spadaro, V.: Autecology and *ex situ* growth of *Leontopodium nivale* subsp. *nivale* (*Asteraceae*) from North Pirin marbles (SW Bulgaria). — Fl. Medit. 28: 187-206. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Leontopodium nivale subsp. *nivale* is a local and disjunct endemic of the central Apennines in Italy and the Pirin Mountains in Bulgaria. The aim of this study is to investigate *in situ* microhabitat specifics and *ex situ* ontogenesis regarding the possible future cultivation and to evaluate hazards for wild populations in conditions of human impact and climate change.
Leontopodium nivale subsp. *nivale* is stenobiont which is difficult to grow *ex situ* and therefore particularly vulnerable. Its wild habitats and populations in Pirin Mts. should be efficiently protected. The results of our study indicate that the stenobiontic plants such as *Leontopodium nivale* subsp. *nivale* are particularly subject to hazard.

Key words: endemic plant, microhabitat specifics, *ex situ* ontogenesis, conservation strategy.

Introduction

Leontopodium (Pers.) R. Br. is a genus of approximately 30 species with an Asian–European disjunct distribution (Blöch & al. 2010). Several molecular clades of *Leontopodium*, each with morphological integrity have been identified. A distinct one contains the European taxa (*Leontopodium alpinum* Cass., *L. nivale* (Ten.) Hand.-Mazz.). These taxa belong to the type section *Leontopodium* [*Alpina* Hand.-Mazz.]. They are genetically distinct from all Asian species in the ITS analysis, although perhaps not as distinctly separated as might be expected from the geographic distance (Blöch & al. 2010). *Leontopodium nivale* is the accepted name Euro+Med PlantBase (2011). *Leontopodium nivale* subsp. *nivale* is a local and disjunct endemic of the central Apennines in Italy and the Pirin Mountains in Bulgaria whereas *Leontopodium nivale* subsp. *alpinum* (Cass.) Greuter or known by the basionym *L. alpinum* Cass. grows in the Pyrenees, throughout the Alps, the Carpathians and the Balkan Peninsula, (Meusel & Jaeger 1992; Euro+Med PlantBase 2011). It is recommend recognising *Leontopodium* *alpinum* and *L. nivale* at species rank until more sophisticated population-level analyses may clarify their status (Blöch & al. 2010). At this stage of AFLP analysis, the populations of Edelweiss from Bulgarian mountains still remain an unsolved taxonomic and phylogenetic issue and no conclusion is possible yet on the relationship between them. AFLP analysis showed that a group containing both European taxa *L. nivale* subsp. *alpinum* and *L. nivale* subsp. *nivale* is indeed well separated from all other 14 taxa in the other groups with a BS of 99%. (Safer & al. 2011, see Fig. 3 Neighbor-net network, highlighting groups and subgroups among species of *Leontopodium*: ACH, *L. alpinum* [Switzerland]; ABG, *L. alpinum* and *L. nivale* [Bulgaria]).

Species delimitation in *Leontopodium* seems to be complicated by the possible occurrence of apomixis. However this phenomenon is poorly investigated in *Leontopodium*. The only species where apomixes, namely diplosporia, has been studied and found is in *Leontopodium nivale* subsp. *alpinum/L. alpinum* (Erhardt 1993; Noyes 2007; Blöch & al. 2010). *L. alpinum* do have apomictic biotypes but more often it is facultative apomixs and sexual reproduction dominates (Hörandl & al. 2011). Additionally along with hermaphrodite plants occur ginomonoecious or andromonoecious ones and in different parts of the range the ratio varies. The population in the Alps is almost entirely andromonoecious (Erhardt 1993). *L. alpinum* in the Tatry mountains is polyploid with $2n= 4x= 52$ (Murín & Paclová 1979; Hörandl & al. 2011) but no data are available for the chromosome numbers of other populations of this taxon as well as for *L. nivale* subsp. *nivale* from Pirin Mts or from the Apennines.

Edelweiss grows in Bulgaria on the marbles of North Pirin Mts. and on the limestone of the Central Stara Planina Mts. (Fig. 1). *Leontopodium nivale* subsp. *nivale* is a perennial herbaceous plant. Stems (1)5–20(30) cm high, erect, simple. Leaves alternate, entire, spathulate, 1.5–4 cm long, densely white lanate; the upper subtending the capitula and equal in length. Capitula subglobose. Involucre 4–6 mm; outer involucral bracts lanceolate, lanate, acute, margin brownish at apex. Florets yellowish white. Achenes 0.5 mm long. *L. nivale* subsp. *nivale* is the taxon that occurs on the marbles of Nort Pirin (Fig. 1). These are plants with patent hairs, stems 1-5 (10) cm and both sides of the leaves lanate. The leaves beneath anthodia, slightly longer then them, spathulate. *Leontopodium nivale* subsp. *alpinum* grows in Stara Planina Mts. (Fig. 1). These are plants with accumbent hairs, stems longer than 5 cm and the upper side of the leaves greenish. The leaves beneath anthodia, much longer then them, oblong-linear (Kuzmanov 2012).

The two species native to Europe, *L. alpinum* (*L. nivale* subsp. *alpinum* known as the common 'Edelweiss') and *L. nivale* (*L. nivale* subsp. *nivale*), are part of the cultural heritage of the people living there (Safer & al. 2011). The Alpine Edelweiss (*L. nivale* subsp. *alpinum*) has a long tradition in folk medicine (Safer & al. 2011). References from the year 1582 mentioned the use of Edelweiss for the treatment of diarrhoea and dysentery (Tabernaemontanus 1582). Several other applications for extracts and plant parts of Edelweiss have been described throughout the years, and recent phytochemical research has resulted in the detection of unknown and uncommon secondary metabolites, some with strong anti-tumour and anti-inflammatory biological activities, and they promote cholesterol efflux etc. (Comey & al. 1997; Hook & Sheridan 2001; Stuppner & al. 2002; Dobner & al. 2003a, 2003b, 2004, Dweck 2004; Schwaiger & al. 2004, 2005; Speroni & al. 2006; Hornick & al. 2008; Reisinger & al. 2009; Tauchen & Kokoska 2016; Wang & al. 2016).

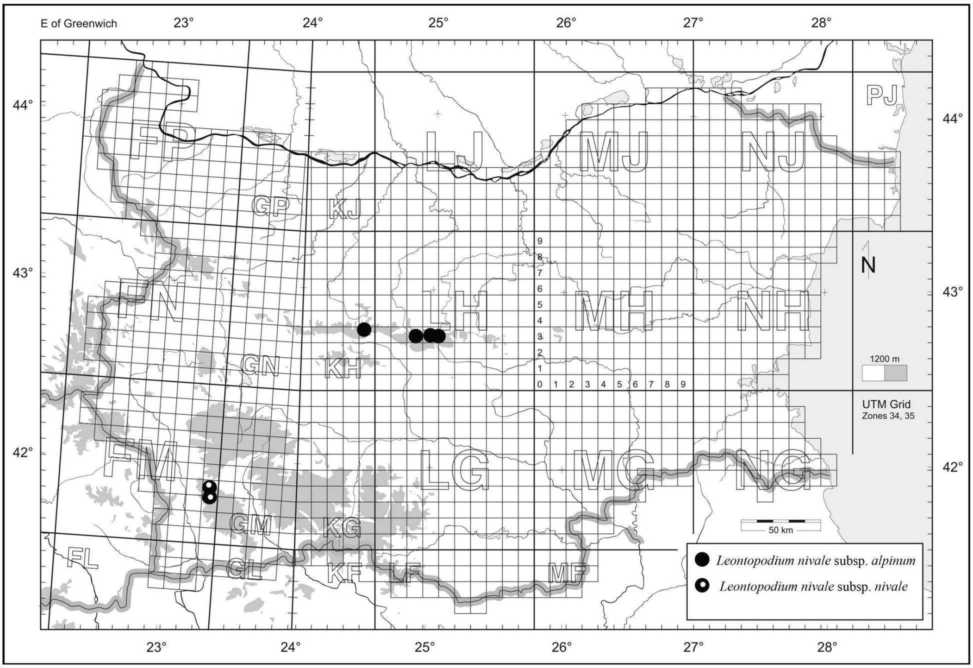

Fig. 1. Distribution of *Leontopodium nivale* subsp. *nivale* in Bulgaria.

The anti-inflammatory activity of the Edelweiss is related to the biosynthesis of leukotrienes, which are potent inflammatory mediators which may have a role in inflammatory diseases such as allergic rhinitis, inflammatory bowel disease and asthma (O'Donnell 1999; Ganzera & al. 2012). These promising results have increased the interest in Edelweiss for pharmaceutical research. There is some in vitro cultivation (Hook 1993, 1994; Zapartan 1996; Butiuc-Keul & Deliu 2000; Trejgell & al. 2010; Daniela & al. 2012).

The Alpine Edelweiss (*Leontopodium nivale* subsp. *alpinum/L. alpinum*) is an important and widely known plant which is now established in cultivation. Edelweiss flowers are highly prized and were collected from the wild in the past, but collection is now regulated or banned in many European countries. This plant is threatened in several European countries and populations declined due to collection in the past; however, it has a large distribution and without information on the extent of population declines, it does not qualify for a threatened category in Europe or the EU 27. It is therefore listed as Least Concern (Khela 2013). Bulgaria is one of those European countries where populations have declined. The IUCN status of *L. alpinum* is Endangered (Bancheva 2011) and the plant is protected by the Biological Diversity Act. Therefore it is important to maintain an appropriate conservation strategy and develop a cultivation establishment.

The aim of this study is to investigate *in sit*u microhabitat specifics and *ex situ* ontogenesis of the endemic *Leontopodium nivale* subsp. *nivale* regarding the possible future cultivation and to evaluate hazards for wild populations in conditions of human impact and climate change.

Materials and methods

Study sites and habitat investigations

The *in situ* field investigations were conducted in the marbleized karst regions of North Pirin Mts., namely the main watershed of North Pirin Mts. with its highest peaks and their slopes build of marble. The study sites are summarized in Table 1 and Fig. 2. They are all located in marble areas of the mountain since *Leontopodium nivale* is calciphilous. The period of investigations of wild populations was during the summers of 1995, 1996, 2001, 2002, 2005, 2014 and 2015. The *ex situ* experiments and observations were conducted during the period 2006-2010. The exact geographic location of all sites was determined in 1995, using a global positioning receiver Garmin GPS 12, Datum WGS 1984, UTM projection (Fig. 2, numbers marking the study sites correspond to the way points recorded with GPS receiver for this plant species in the field). Elevation was double checked with an altimeter (Table 1). Slope and exposure were recorded and described both in the field and using the global positioning system (GPS) methods. Soil samples (two samples at each study site) were taken from the rooting zone of study plants. Each sample was taken from area of 20-30 cm^2 and 4 cm depth. The soil characters were measured after a standard methodology at the Newcastle University in January 2002. The volume of 10 cm^3 of air dry soil (scoop filled and struck of level without tapping) was weighted on digital scales. The soil was ground to pass 2 mm mesh sieve. We transferred 5 cm^3 sieved soil into a bottle and added 100 cm^3 sodium bicarbonate reagent of pH 8,50 at 20°C to extract the phosphorus (Table 2). The concentration of the blue complex produced by the reduction, with ascorbic acid, of the phosphomolibdate formed when acid ammonium molybdate reacts with phosphate was measured spectrophotometrically at 880 nm. The number of µg of phosphorus equivalent to the absorbances of the sample and the blank determinations were calculated from the standard graph. The difference was multiplied by 100 to obtain the quantity of extractable phosphorus in the soil [mg P/kg soil]. Soil pH characters were measured using a pH electrode and meter at about 20°C (between 20,2°C and 20,8°C for each sample). Phytocenosis was recorded after Braun-Blanquet system. The plants were identified and named after Jordanov (1963-2011).

Table 1. Study sites and altitude.

Local Topographic name	Study sites Way point	Altitude
Above Kasan Shelter	7	2605 m a.s.l
Above Kasan Shelter	8	2605 m a.s.l
Below Kasan Shelter	21	2251 m a.s.l
Zhultite skali, Okadenski cirque	16	2170 m a.s.l
Zhultite skali, Okadenski cirque	37	2210 m a.s.l

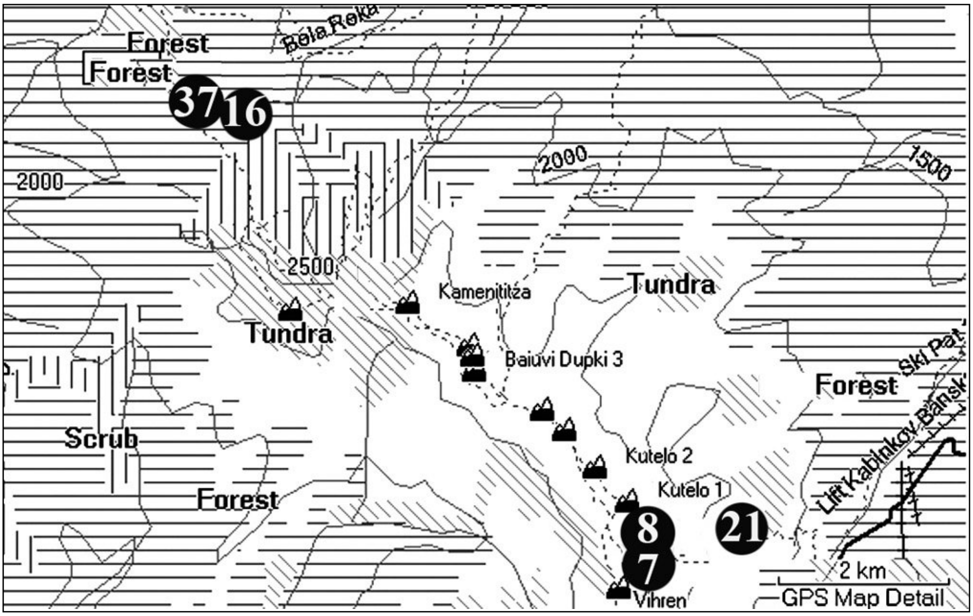

Fig. 2. Localization of the study sites.

Table 2. Features of the soil samples. Legend (-) absent in the sample, (+) sporadic or small, (++) plenty of material, (+++) dominates.

Locality	Sample number	Slope	Exposure	Weight volume [g/10cm^3]	Roots & straw	Sand	Pebbles	Water absorbtion	pH	pH measured at temp°C	mg P/kg soil
Above Kasan Shelter	8	20°	NW	6,3	+	-	+++	medium	7.69	20.5	21.35
Above Kasan Shelter	8	20°	NW	6,3	+	-	+++	medium	7.26	20.5	23.02
Below Kasan Shelter	21	35°	E	7,8	+	++	+	delayed	7.70	20.6	20.65
Below Kasan Shelter	21	35°	E	8,4	+	++	+	delayed	7.42	20.7	23.89
Zhultite skali	16	33°	SE	10,8	++	++	+	medium	7.29	20.5	20.95
Zhultite skali	16	33°	SE	10,8	++	++	+	medium	7.55	20.7	20.72
average									7.49	20.58	21.76
stdev									0.193	0.098	1.361
min									7.26	20.50	20.65
max									7.70	20.70	23.89

Fig. 3. *Ex situ* experimental plot in the vicinity of Dobrinishte in the foothill of Pirin Mts. – drainage layer and stonework with marble peaces.

Ex situ *experiments and observations*

Some local people in the settlements in the northern foothills of Pirin Mts (Bansko and Dobrinishte) are interested in growing Edelweiss in their gardens. They tend to transplant adult plants from the native populations mostly. Therefore our *ex situ* experiment was in two steps – transplantation of adult plants and growing seedlings. Firstly we obtained permissions from MOEW - Bulgarian Ministry of Environment and Water No: RD – 744/15.07.1/2005 and No: 67/20.06.2006.

The experimental plot for adult transplants was established in 2005 in the yard of a house in Dobrinishte village, in the foothill of Pirin Mts. The experimental rock garden for seedlings was established in 2006 near the village, in a hay meadow of approximately 500 m^2 near the river, situated at 865 m above sea level, at N 41°48'80,9" and E 23°33"67,4" (WGS84). We chose the steepest part of a hay meadow with an exposure to the north-east. The place was chosen with consideration for several factors: i) close enough to the river for watering; ii) away from potential floods; iii) moderately shaded; iv) the snow lies relatively long here, protecting the plants from the spring frosts, and providing a cool microclimate in summer (Fig. 3).

Three adult plants were carefully excavated from their native habitats and immediately transplanted in the experimental plot. We used marble peaces with holes drilled in them to resemble as much as possible the natural environment. The soil was predominantly from the native habitat.

Seed was collected in September 2005 and kept cool (4°C, in the fridge, but not frozen). Several sets of seeds were processed for germination on moisture filter paper at natural light – dark photoperiod and average temperature 19°C. Once the seeds had germinated, the seedlings were transferred individually to plastic pots filled with a mix of 30% rough marble sand, 30% sieved humus, 30% sieved good soil, 10% perlite or with a mix of 60% silty brown soil and 40% rough marble sand. When seedlings were at the 2-6 true leaf stage, they were transported to the experimental rock garden. They were planted singly into the flower beds with fine marble gravel top-dressing. We followed the concept of discrete description of plant ontogenesis (Komarov & al. 2003)

Data analysis

Descriptive statistics was used to analyze the data obtained.

The comparative analysis of the vegetation at the sites was done calculating the Jaccard coefficient (Muller-Domboa & Ellenberg 1974). The Jaccard coefficient measures the similarity of two sample sets (Table 3). It uses the ratio of the intersecting set to the union set as the measure of similarity. Thus it equals zero if there are no intersecting elements and equals one if all elements intersect.

$$T = \frac{N_c}{N_a + N_b - N_c}$$

Where: *Na* - number of elements in set A, *Nb* - number of elements in set B, *Nc* - number of elements in intersecting set.

A comparative analysis of the climate parameters both in native habitats and in the *ex situ* experimental plot was performed based on data officially available from national institutions and local meteo-stations (Table 4). The measurements in Vihren hut (1954-1974) and Bansko (1933-2014) were conducted by the National Institute of Hydrology and Meteorology of Bulgaria. The measurements at Vihren hut (2010-2015) were carried out by Grunewald & al., while those at Treeline location close to the *in situ* study sites (native habitats) by Panayotov & al. (Grunewald & al. 2016).

Table 3. Jaccard coefficient of similarity between the plant communities of the investigated subpopulations of *Leontopodium nivale* subsp. *nivale* (N=5)

Study sites	Way point 8	Way point 7	Way point 21	Way point 16
Way point 8				
Way point 7	0,32			
Way point 21	0,69	0,37		
Way point 16	0,26	0,64	0,58	
Way point 37	0,47	0,31	0,73	0,78

Results

Autecology of Leontopodium nivale *subsp.* nivale

Leontopodium nivale subsp. *nivale* grows in North Pirin Mts in the belt of the subalpine meadows (study sites 16, 21, 37) and in the alpine belt (7, 8). The altitude of the microhabitats ranges in wide diapason 2170-2605 m a. s. l. (Table 1). The exposure of the microhabitats is diverse so the plant is tolerant to this factor.

The granulometric composition of the soils, determined by sieving them (2 mm mesh sieve) revealed that the soils consisted of rough particles-sand and pebbles (Table 2). Soil pH in our samples was neutral to slightly alkaline (Table 2) and this confirmed the calciphilous nature of the Edelweiss. Extractable phosphorus (P) in the soil was between 20.65 g/kg soil (site 21, Table 2) and 23.89 (site 8, Table 2).

In most of our study sites *Leontopodium nivale* subsp. *nivale* grows as a calciphilous chasmophyte together with *Potentilla apennina* subsp. *stojanovii* Urum. & Jáv. and *Dryas octopetala* L. It occupies habitats where the vegetation cover varies between 50% and 80%. In our study sites *L. nivale* is an element of plant communities dominated by *Sesleria korabensis* (Kumm. et Javorka) Deryl, and *Carex kitaibeliana* Degen ex Bech. Highly abundant are *Potentilla apennina* subsp. *stojanovii* Urum. & Jáv., *Dryas octopetala* L., *Saxifraga ferdinandii-coburgii* Kellerer et Sund, *Saxifraga oppositifolia* L., *Campanula cochleariifolia* Lam., *Veronica kellererii* Degen & Urum., *Linum capitatum* Schultes, *Acinos alpinus* (L.) Moench, *Centaurea achtarovii* Urum., *Papaver degenii* (Urum. & Jáv.) Kuzmanov, *Alyssum cuneifolium* Ten., *Thymus perinicus* (Velen.) Jalas, *T. thracicus* Velen., *Helianthemum nummularium* (L.) Miller, *Rhodax canus* (L.) Fuss., *Cerastium alpinum* L., *Aster alpinus* L., *Achillea ageratifolia* (Sibth. et Sm.) Boiss., *Daphne velenovskyi* Halda, *Oxytropis urumovii* Jav. and *O. kozurahovii* Pavolova, Dimitrov & Nikolova. The floristic compostion of the plant communities in our study sites demonstrated more or less high similarity (Table 3). Interestingly, similarity was higher between sites that were not in the near vicinity (e. g. way points 7 and 16) and lower between closely situated sites (e. g. way points 7 and 8).

Ex situ *ontogenesis of* Leontopodium nivale *subsp.* nivale

Transplantation of adult plants - All three plants that we transplanted in September 2005 survived the winter and leaf rosettes were developed in April 2006. One of the plants

Table 4. Climate parameters measured close to the *in-situ* locations and the *ex situ* experimental site.

Location & altitude, m a.s.l.	Period	Para-meter	Month												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Vihren hut	2010-2015	T mean, °C	-3.5	-3.2	-1.5	2.7	7.7	11.3	14.0	14.4	8.6	5.5	4.3	-2.1	4.9
1950 m a.s.l.		T min, °C	-19.8	-17.3	-13.3	-11.3	-1.4	0.3	3.8	3.9	-1.4	-8.9	-10.8	-18.2	-19.8
		T max, °C	10.1	11.8	10.1	17.6	23.9	31.6	33.6	31.6	21.3	19.4	26.0	10.9	33.6
		H, %	64.3	63.1	68.5	67.5	74.3	68.3	66.3	64.3	75.0	65.6	64.2	63.7	67.1
Vihren hut,	1954-1974	T mean, °C	-4.7	-4.2	-2.5	0.8	5.8	9.8	11.9	11.7	8.3	4.5	1.2	-2.7	3.3
1950 m a.s.l.		Precip., mm	146	144	121	107	123	112	81	58	86	109	173	175	1435
		T min, °C	-23.2	-23.5	-19.7	-14.5	-8.1	-5.5	-1.2	-0.5	-6.5	-8.7	-16.3	-22.5	-23.5
		T max, C	9.3	11.4	11.4	14.1	19.5	24.0	25.2	25.8	24.4	18.5	15.1	14.6	25.8
Treeline,	2013-2016	T mean, °C	-3.0	-1.7	-1.5	2.5	5.8	9.8	13.0	12.8	9.1	5.8	2.7	-0.6	4.6
2250 m a.s.l.		T min, C	-18.4	-18.3	-12.3	-11.0	-3.1	1.0	4.5	3.3	-1.5	-7.8	-10.2	-19.4	-19.4
		T max, °C	4.2	6.5	3.8	10.0	10.4	17.7	15.6	14.4	14.2	8.9	7.0	4.2	17.7
Bansko,	1933-2014	T mean, °C	-1.6	0.1	3.7	8.7	13.4	17.0	19.1	18.8	14.9	9.7	4.6	0.1	9.0
936 m a.s.l.		Precip., mm	60	58	50	56	60	53	40	32	37	59	73	77	656

bloomed in July 2006 (Fig. 4A). The plant developed one flowering stem and the anthodia were only three and small but they produced seeds (achenae, Fig. 4B and 4C). The second winter period was survived by only two individuals and in June 2007 the full bloom was recorded. One of the plants developed three flowering stems and the other – nine flowering stems (Fig. 4D). The flowering stems were big with 6-9 large anthodia. Both plants overwintered successfully and developed leaf rosettes. The plant that previous year bloomed lavishly formed a flowering stem (Fig. 4E). By August 2008 both plants dried and vanished despite the regular moderate watering. In summary, during the first season after transplantation the flowering was depressed. Lavish flowering was achieved the second season but the plants did not live long enough for a third flowering. The breaking point was the summer. Our experiments revealed that Pirin Edelweiss adult plants have weaker ability of adaptation to *ex situ* conditions compared to other rare and endemic species which we transplanted in the same experimental plot such as: *Aubrieta gracilis* Boiss., *Veronica kellereri* Degen & Urum., *Hypericum linarioides* Bosse, *Cerastium decalvans* Schloss. & Vuk., *Achillea chrysocoma* Friv., *Thymus thracicus* Velen. All these plants demonstrated

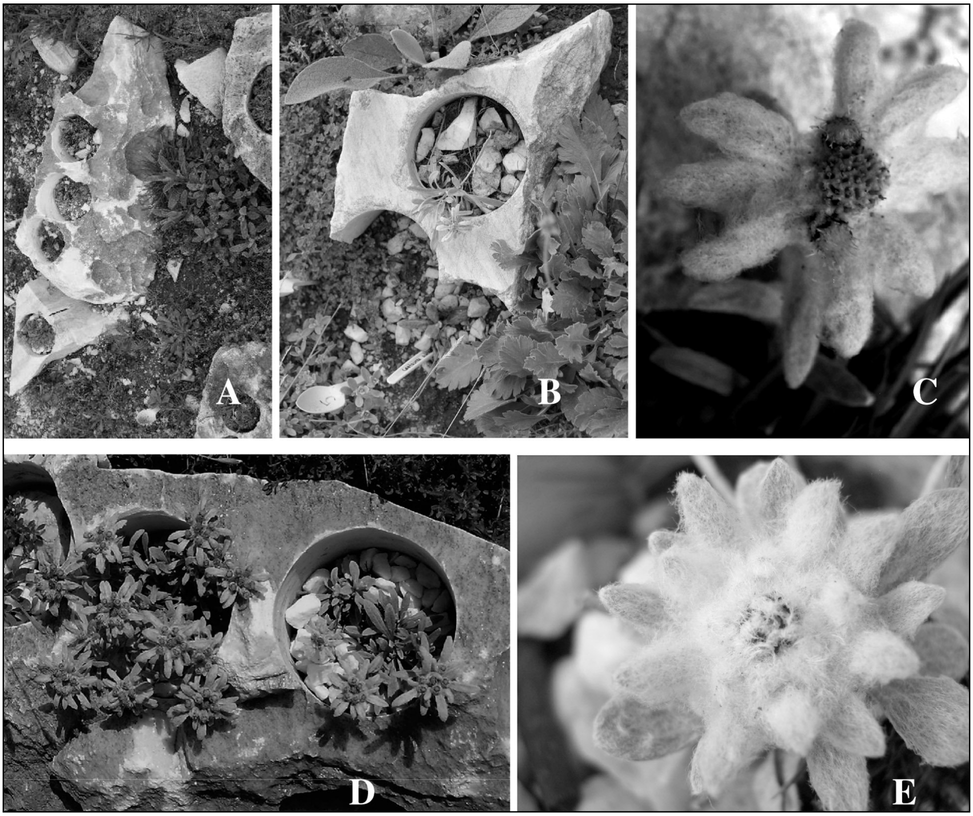

Fig. 4. Adult plants - transplantation and ontogenesis. A: 2006 April, beginning of vegetation; B: and C: 2006 July full bloom; D: 2007 June full bloom; E: 2008 June beginning of blooming.

ability for vegetative propagation, enlargement of the biomass and lavish flowering.

Among the possible reasons for the mortality of the transplanted plants were unfavorable climate conditions during the experimental years. 2007 especially was characterized by unusual climate conditions – the winter was generally dry with twice as low a precipitation sum compared to the long-term (1933-2014) average for Bansko station (Table 4), combined with the third highest winter temperature. Especially warm were January and February, for which the warmest average temperature was recorded. Additionally the summer was also unusually warm with the fourth highest June-August temperature for the record. Despite the fact that the plants were watered during the summer, the combination of winter draught and high temperatures plus summer high temperatures might have created stress conditions that made the plants vulnerable to pathogens.

Seed propagation - *Leontopodium nivale* subsp. *nivale* from Pirin Mts. reached a germination percentage of 85.4 ± 7.6% (average ± SE) during the first two years after the seed collection under variable conditions (5-28°C; 13/11 and 14/10 photoperiod; no GA3 addition, Table 5). Survival of the seedlings in the pots until the moment to be planted in the rock garden was better when seeds germinated at higher temperature and with a longer light photoperiod (in May). Germination percentage with GA3 addition was 80% (Table 5). The untreated processed for germination on moisture filter paper at natural light – dark photoperiod and average temperature 19°C seed of Edelweiss - germinated well (71%-89%). The seedling developed well at the early stages (1-4 real leaves and size 3-5 mm). Later on many of the seedlings planted in the experimental rock garden did not survive (Tables 5 and 6). None of the plants grown by seedling survived for five years i. e. during the whole experimental period. During the first year after seed collection, 80 % of the experimental set of seeds germinated (Table 5). For a period of four months (February to July) seeds kept germinating gradually. Interestingly there was no moulding of the moisture paper around the seeds. All seedlings survived to be planted in the experimental rock garden, but only half of the seedlings planted *ex situ* survived till the end of the summer (Tables 5 and 6). Only one plant grown by seed survived for four years (Table 6). During the second year after the seed collection germination remained very high. Germination was similar both for those stimulated with giberellic acid (GA3) and for non-treated seeds (Table 5). Also survival of the seedling resulting by both regimes of germination was similar. However seeds processed for germination later in spring at higher temperature germinated better (Table 5). These seedlings survived better as well (Table 5).

During the forth year after the seed collection germination remained very high as in the previous years (Table 5). Survival of the seedlings to the stage for planting in the rock garden however was poor (Table 5). The germination experiment set in December revealed that seeds dormancy is breakable in the autumn-winter period if the temperature regime is favorable (Table 5). The seedlings did not survive. Consequently four years period reduces the seeds viability. Percent of germination decreased twice for period of seven years (Table 5). Almost half of the seedlings (42%) grown in the first year after seed collection survived in the rock garden during the whole summer (Table 6). The survival of seedlings grown during the second year after the seed collection was less successful (20%). During their first summer seedlings passed through the stage of juvenile plants, and reached the stages of immature and virginal plants. The reproductive stage was reached by some plants during

Table 5. Germination of Edelweiss seeds and survival of the seedlings at their early stages.

Year after seed collection	Processed for germination	Period for germination	Experimental set of seeds	Temperature during germination period	Percent of germination	Survived to be planted in the rock garden
I	2006 February	Four months	30	5-28°C	80%	24
II	2007 March non-treated	Three months	22	12-22°C	82%	2
	March treated with	One month	45	12-22°C	80%	6
	GA3 May non-treated	One month	85	19-28°C	98%	66
	Total		152	12-28°C	Average 87%	74
IV	2009 Second half of April to Second half of May	One month	45	16-28°C	82%	1
IV	2009 December	One month	45	22,5°C	71%	71%
VII	2013 Second half of January to Second half of February	One month	31	22,5°C	35%	35%

the second or third summer (Table 6). They developed 1-4 flowering stems. After that, many of them died (Table 6). Most vulnerable are plants in their juvenile-immature stages. Most critical for adult plants (virginal and reproductive) is the winter period.

Both adult transplants and plants grown from seed *in situ* had different habitus compared to wild plants. They were obviously bigger (stems 5-9 cm, leaves of the rosettes 5-6 cm and the rosette of bracts 3-4.5 cm) and this was valid particularly for the plants grown from seed *in situ*. However they preserved all other diagnostic features for the taxon (patent hairs, both sides of the leaves lanate, bract rosette leaves spathulate), except the size. *Ex situ* grown plants had patent hairs, and both sides of the leaves had silvery whitish hairs. The leaves beneath anthodia remained slightly longer compared to the anthodia, spathulate.

The temperatures at the experimental plot were higher (Table 4) because of its position at a lower altitude compared to the wild populations. This had an impact on the flowering phenology, which was about a month earlier compared to the natural habitats no matter whether these were transplanted adults or plants grown by seed. For the young seedlings the juvenile and immature stages were critical and 50% to 68% mortality was recorded during the summer after their planting in the experimental plot. The winter was Rubicon for all mature seedlings and regardless of whether they were at the virginal or reproductive stage 50% to 60% did not sur-

Table 6. Seedlings planted in the experimental rock garden - ontogenesis and survival.

		Reading of ontogenesis and survival of plants grown form seed		
		2006 planting in May	2007 planting in April	2009 plating in May
2006		First year		
	May	24 juvenile		
	August	12 immature		
	October	10 virginal		
2007		Second year	First year	
	April	6 virginal	74 juvenile	
	May	6 virginal	24 immature	
	August	5 virginal	14 virginal	
2008		Third year	Second year	
	May	1 reproductive	14 virginal and reproductive	
	June	1 (1 reproductive blooming)	14 (4 reproductive blooming)	
	August	1 (1 reproductive fruiting)	14 (4 reproductive fruiting)	
	September	1 (1 reproductive fruiting)	14 (4 reproductive fruiting)	
2009		Forth year	Third year	First year
	May	1	7 (3 reproductive blooming)	1 juvenile
	June	1 (1 reproductive blooming)	7 (3 reproductive fruiting)	1 immature
	July	1 (1 reproductive fruiting)	7 (3 reproductive fruiting)	1 virginal
2010		Fifth year	Third year	Second year
	July	0	4 (reproductive, no blooming)	1 virginal

vive (Table 6). An explanation could be found in the combination of winter warm periods which cause thinner snow cover that is not permanent the whole winter. The plants unprotected by snow are exposed to sporadic frosts. Also the summer high temperatures might have created stress conditions that made the plants vulnerable to pathogens.

Discussion

Leontopodium nivale subsp. *nivale* population in Pirin Mts. grows as a calciphilous chasmophyte on neutral to slightly alkaline soil with poor morphology and quality. The studied populations are localized in the criolithogenic belt. Ninov (1982) has described well this extremely poor soil-forming process and scanty soil hidden between the marble boulders, rock cracks, grooves, and fissures as a result of the high elevation with harsh climate and marble terrain. The periglacial relief is a result of crionivalic processes with periodical freezing and unfreezing of the soil and the weathering crust. Due to the karst terrain no ponds are formed because water is drained. Regeneration processes are slow, so that the average vegetation cover is about 50%. In result the soil is primitive, poorly developed and its cover is rather loose. The nature of the marble weathering is the reason for the fragmented soil cover, poor development and functioning as well as poor interaction with the vegetation. The index of the potential bio-production is 0,1 – the same as in the tundra or in the desert. Thus most of the soils here have poor morphology and quality. They have a ”cryo” temperature regime and are defined as Cryrendolls. Such soils are rare for Bulgaria. They occur only here in Pirin and rarely in Slavyanka Mts. (Ninov 1982). Being formed on hard rock they are defined in details, at a lower taxonomic level as Lithic Cryrendolls (ST) or Lithic Leptosols – Rendzic Leptosols (F.A.O.).

The calciphilous chasmophyte *Leontopodium nivale* subsp. *nivale* in Pirin Mts. grows together with *Potentilla apennina* subsp. *stojanovii, Dryas octopetala,* as well as with *Carex kitaibeliana, Saxifraga ferdinandii-coburgii* and *Campanula cochleariifolia. Leontopodio - Potentilletum stojanovii* in a plant community described for Pirin Mts (Mucina & al. 1990) and it is noted as a specific one. The native populations of *Leontopodium nivale* subsp. *nivale* occupy habitats which belong to montane tall-herb, grassland, fell-field and snow-bed vegetation. These are alpine and subalpine open calcicolous herbaceous and alpine calcicolous herbaceous communities near melting snowpatches. Here psychrophytous and cryophytous hecistothermal vegetation is found in the alpine woodless belt; calciphilous cryophytous grass formations *Kobresieta myosuroides, Cariceta kitaibelianae, Seslerieta korabensis* and small shrub formations *Dryeta octopetalae, Saliceta reticulatae,* etc. (Bondev 1991). Lately *Leontopodio nivalis-Elynion myosuroidis* (Blasi & al. 2003) Di Pietro & Mucina (Crytrý & al. 2015) is described as a new alliance of Southern Europaean alpine tundra. This is an important syntaxonomic description, because if an Apennine-Balkan delimitation of the *Leontopodio-Elynion* was accepted, the mountain ranges of Korab, Prokletije, Rila and Pirin would represent the southernmost limit of the *Carici-Kobresietea* in south-eastern Europe (Chytrý & al. 2015). Adaptations to habitat specifics might be related to endemism. For example, the main environmental variable discriminating sites occupied by two butterworts in the Alps is the elevation. Growth and reproductive performances of the wide spread *Pinguicula vulgaris* and the endemic *P. arvetii* are influenced by the site conditions. The endemic is typically confined to the metamorphic rocks of the Pennidic domain where the “Calcescisti e Pietre Verdi” complex is largely predominant. From the phytogeographical viewpoint, it belongs to a floristic contingent centred in the south-western Alps (Zaccara Bertolini & al. 2016).

Leontopodium nivale subsp. *nivale* occurs in two NATURA 2000 habitats: 6170 Alpine and subalpine calcareous grasslands and 8120 Calcareuos and calcshist screes of the montane to alpine levels (Tzonev & al. 2009; Roussakova 2009, 2011).

Our experiments revealed that adult individuals *L. nivale* subsp. *nivale* have weak vegetative propagation ability and low potential for transplantation *ex situ*. Consequently the result after transplantation is gradual extinction. Therefore transplantation of adult individuals for further *ex situ* propagation is not a prospective approach for cultivation. The local people in Bansko and Dobrinishte in the foothill of Pirin Mts. who tend to transplant adult Edelweiss individuals in their gardens should be discouraged from doing that.

The optimal germination of *Leontopodium nivale* subsp. *nivale* from Pirin Mts. was two years after the seed collection, 85.4 ± 7.6% (average ± SE) under variable conditions in spring (5-28°C; 13/11 and 14/10 photoperiod; no GA3 addition). The Edelweiss achenae germinate well if they are exposed to the sun light and on the surface of the soil. They need a high air temperature (18-20°C) and longer light photoperiod. Such conditions are favourable for many members of family *Asteraceae* (Schlorhaufer, pers. comm.). *L. nivale* from the Apennines (Italy) reached a germination percentage of 98.0 ± 2.0% (average ± SE) under control conditions such as 20°C,12/12 photoperiod and without GA3 treatment (Di Martino & al. 2014). The two disjunct populations from Pirin Mts. and the Apennines demonstrated similar germination behaviour. The optimal temperature for germination of *L. nivale* subsp. *alpinum* seeds is 25°C (RBG Kew, Wakehurst Place, http://data.kew.org/sid/SidServlet?ID=13572&Num=B6i).

Seed viability of *L. nivale* from Pirin Mts. decreased for 4-7 years period. Seeds of *Leontopodium nivale* subsp. *alpinum* (*L. alpinum*) can be maintained for 3 years in commercial storage conditions (Priestley 1986). During their first summer seedlings reached the stages of immature and virginal plants. Some plants reached reproductive stage during the second or third summer. Seedling survival was poor in all experimental regimes. Most critical was the winter period. Most vulnerable were plants in their juvenile-immature stages.

Morphological characters – patent hairs, both sides of the leaves lanate, bract rosette leaves spathulate – by which *Leontopodium nivale* subsp. *nivale* is distinguished (Kuzmanov 2012), proved to be genetically determined and preserved when plants were grown *ex situ*.

The Pirin Edelweiss is stenobiont which is difficult to grow *ex situ*. Similar results are obtained in Romania (Lidia 2012). *Leontopodium nivale* subsp. *alpinum* is one of the taxa from spontaneous flora which does not resist in the conditions of rockeries, “Anastasie Fătu” Botanical Garden together with *Campanula carpatica* Jack, *Dryas octopetala* L., *Minuartia laricifolia* (L.) Schinz ex Thell (Lidia 2012). Our preliminary data for *ex situ* growth of *D. octopetala* demonstrate similar discouraging results (unpubl.). At the same time, Alpine Edelweiss (*L. nivale* subsp. *alpinum*/*L. alpinum*) is now established in cultivation (Khela 2013) which may indicate better tolerance of the populations from Central Europe.

Serious threats for the wild populations of Edelweiss (*Leontopodium nivale* subsp. *nivale* and *L. nivale* subsp. *alpinum*) are adaptation to specific habitat conditions, low numerical strength of most populations, fragmentation of the distribution area, low reproductive potential destruction of individuals for commercial purposes and by tourists (Bancheva 2011). Our *ex situ* experiments revealed that *L. nivale* subsp. *nivale* is particularly stenobiontic and therefore especially vulnerable. Its wild habitats and populations in Pirin Mts. should be efficiently protected. It is crucial to consider the difficulties for *ex situ* growth in the future Management Plans for National Park Pirin Mts. with respect to the concept of sustainable development.

The climate in the natural habitats is characterized by average yearly temperatures close to 5ºC with negative monthly temperatures in the December-March period. The warmest period is July-August (Table 4). The absolute maximum measured temperature was 33.6 ºC, but this is in a location of about 200 vertical meters below the natural locations of the studied species. The absolute minimum temperature was -23.5 ºC. We note that temperatures recorded during measurements in the last decade were higher than temperatures recorded in the period 1954-1974, which follows a general trend of increase of temperatures in the high Bulgarian mountains (Grunewald & al. 2009; Nojarov & al. 2012). The data from Mussala peak station (2925 m a.s.l.), which is the only long-term reliable high-mountain record in the region, shows a trend of temperature increases with continuously positive temperature anomalies relative to the 1961-1990 period after the mid 1990s. This trend is well expressed in the summer period, but also in late autumn (Fig. 5). The rainfall is significant (about 1400 mm), 1/3 of which falls in the winter period primarily as snow, forming persistent thick snow cover, which remains about 150-180 days. Although in winter much of the locations of the plants are covered by snow, on rock ridges and steep rocky slopes the snow cover may be very thin and temporary disappearing in winters with less precipitation. Such cases were observed in the last decade when Edelweiss locations were without snow for short periods in some winters.

The climate close to the *ex situ* experimental site is characterized by higher temperatures (average annual temperature is 9ºC) and precipitation (656 mm), which is twice as low (Table 4, Bansko location). In some winters long precipitation-free periods and drought conditions were observed both at the foot of the Mountain Range and the Mountain locations (Panayotov & al. 2010).

The low survivorship in the *ex situ* experimental site, which is characterized by drier and warmer conditions might be a sign of potential future problems for the original populations in case of drier and warmer years. Such are expected under the regional climate change scenarios (IPCC 2013). Climate changes may alter conditions seriously affecting the growth niches of alpine species, thus limiting the distribution of some of them (Grabherr & al. 2010). In such cases especially species found in micro-habitats with already very limited distribution may be those which will be the most threatened. In most cases they are unable to outcompete species with better adaptability and find new habitats when the original ones become unfavorable.

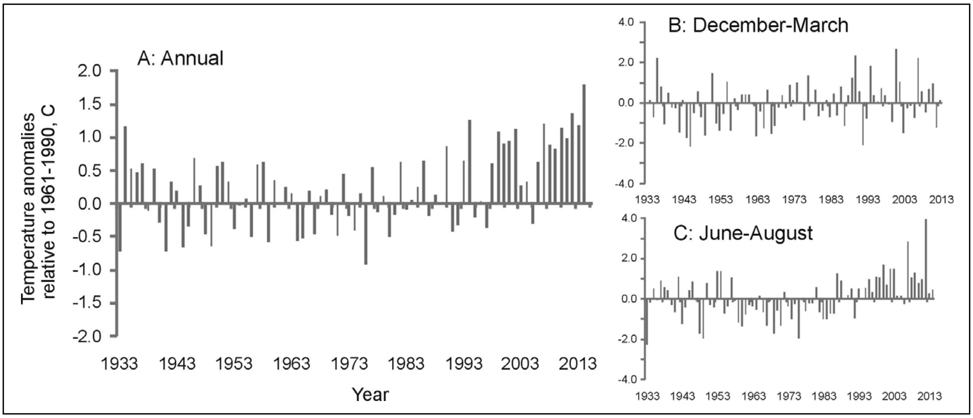

Fig. 5. Temperature anomalies relative to the 1961-1990 period in the record of Mussala peak meteorological station: A) annual average temperatures; B) winter temperatures; C) summer temperatures.

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The cultural heritage of Mediterranean botanic gardens*

Abstract

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Mediterranean botanic gardens represent a rich and diverse cultural heritage, both tangible and intangible. They include spectacular landscapes and the plantings include many important introductions of both ornamental and economically important species. The gardens also contain many buildings of great architectural merit, some historic, some modern. Also important are the historic glasshouses and shade houses. Many of these gardens contain important herbarium collections that have served a key role in the preparation of Floras and major botanical libraries containing historical works of great value as well as works of art, sculptures paintings, drawings, and other illustrations and invaluable historic archives. The intangible cultural heritage of these gardens is represented by the impact that they have had the inhabitants of the cities and towns in which they are located and on generations of visitors – students, professionals and the public. With the decline of teaching and research in botany as a university discipline, some of these collections are at risk of dispersal or an even worse fate. In the face of these uncertainties a series of proposals to help safeguard this invaluable heritage is given, including the compilation of an inventory of these historically important buildings, libraries, works of art and archives and the use of the latest scanning and imaging techniques so that a visual record is prepared.

Key words: landscapes; herbaria; museums; libraries; inventory.

Introduction

For nearly 700 years, Mediterranean botanic gardens in their various manifestations have not only been important centres of botanical knowledge and research but have also had a major influence on social and cultural life though the gardens themselves, their buildings, museums, libraries herbaria and collections, all of which represent a rich and important heritage (Heywood 2015).

Landscapes, trees and plantings

Although many of the older Mediterranean botanic gardens are small and located in towns and cities where space is at a premium, some of them are noted for their spectacular

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landscapes and vistas. This is especially true of gardens located on the coast offering views down to the sea, such as the Giardino botanico Hanbury, La Mortola, Italy (Fig. 1) with its spectacular views from the upper terraces and the New Vista walk interrupted at intervals by steps and fountains, leading all the way down to a short stretch of the Via Aurelia at the bottom of the Garden. Another example is the Jardin Exotique de Monaco (Fig. 2) where the views, are so outstanding that I once heard Prince Rainier remark that he envied the Director because the views from his office were the finest in the Principality.

As well as such vistas, some spectacular plantings can be fund, include the avenue of *Ceiba speciosa*, in the Orto Botanico, Palermo, the *Wisteria sinensis* covering the great iron gazebo in the Jardín Botánico-Histórico La Concepción, Malaga, Spain, the choreographed plantings and topiary in the Jardim Botánico da Madeira, the avenue of plane trees (*Platanus*) in the Jardín Botánico-Histórico La Concepción, Málaga, Spain, the vividly colourful Passeig [staircase] de Font y Quer in the Jardí Botànic Marimurtra, Blanes, Spain.

Mediterranean botanic gardens contain hundreds of examples of monumental trees both native and exotic such as the specimens of *Taxus baccata* planted in 1720 and of *Quercus suber* dating from 1805 in the Giardino dei Semplice, Firenze, the Sweet Gum (*Liquidambar styraciflua*, a swamp cypress (*Taxodium distichum*) and *Pistacia atlantica* in the Orto Botanico, Bologna, the Cedar of Lebanon (*Cedrus libani*) planted in 1734 in the Jardin des Plantes, Paris by the botanist Bernard de Jussieu, *Celtis australis* in the Jardin Botanique, Montpellier, to name but a few. Publications documenting such trees have been prepared by some of the Gardens as in the case of the Jardí botànic, Valencia, Spain (Costa & Plumed 2016).

Fig. 1. Giardino botanico Hanbury, La Mortola, Italy.

Fig. 2. Jardin Exotique, Monaco.

Buildings and architecture

Many of the buildings in historic botanic gardens are of considerable architectural merit, such as:

- The emblematic Pabellón de Villanueva in the Real Jardín Botánico de Madrid, which was originally constructed in the 18th century as an ‘invernáculo’ or glasshouse to shelter tender plants in the winter (in effect an orangery) and also housing the cátedra (professorial chair) where Antonio José Cavanilles taught his classes. A second floor was built in in the 1930s which later housed the herbarium and then removed in 1981. Today it is an exhibition centre.
- The Orangerie La Gardette, Jardin des Plantes, Montpellier built by the celebrated architect Claude Mathieu de la Gardette in 1801–06 to replace and in effect complete an earlier hothouse in 1759 (Verdier 1997);
- The iconic building of the Orto Botanico di Pisa is the shell-covered façade of the Palazzo delle Conchiglie, the old Fonderia (Foundry), a laboratory for the preparation of medicaments derived from the medicinal plants grown in the Garden, set up at the end of the 16th century. Current plans are to restore the Fonderia, and house in it an exhibition on the history of the garden;
- The trio of neo-classical buildings dating from 1789 of the Orto Botanico di Palermo, Sicily, designed by the French architect Léon Dufourny – the Gymnasium, which originally housed the Schola Regia Botanices (school of botany), the Herbarium, the library and the director’s office, and the Calidarium and Tepidarium which grew plants from warm and temperate zones respectively (Raimondo & Mazzola 1992);

- Il Castello, Real Orto Botanico di Napoli built between the sixteenth and seventeenth centuries. It has been restored and now houses administrative offices and the museum of Palaeobotany and Ethnobotany.

Glasshouses and shade houses

Although not usually comparable with the great palaces of glass that are a common feature in more northern countries, a wide diversity of glasshouses and shade houses are to be found in Mediterranean botanic gardens, including some architecturally important examples. In fact, the origin of the glasshouse is to be found in the *orangeries*, *stanzoni degli agrumi, arancieri* and *limonaie* that were introduced in the 16th century to protect citrus trees from the winter cold. Some of these original structures may still be found and some have been restored and adapted for new uses, while others have fallen into disrepair or have been demolished.

Notable examples are the Estufa de Graells, Real Jardín Botánico, Madrid (1856), the Serra Carolina (1823, rebuilt 1857), Orto Botanico di Palermo, Les Grandes serres (1877–82), Jardin botanique de Lyon, France, the Serra Merola, Real Orto Botanico di Napoli (1809/1820), L'Umbracle [shade house] (1897–1900), Jardí botànic, Valencia (Fig. 3), the Serre Scopoliane, Orto Botanico di Pavia, Italy, and more recent examples such as the

Fig. 3. L'Umbracle, Jardí botànic, Valencia, Spain.

Invernadero de Bordeaux Bastide, France, the Nuova Serra Biosfera dell'orto Botanico di Padova, Italy. Although not in a botanic garden as such but in a public park, mention should be made of what Santiago Castroviejo Bolivar in the Real Jardín Botánico, Madrid, les serres, Jardin botanique hat is probably the largest shade house known, the Estufa fria, located in the Parque Eduardo VII, Lisbon, Portugal. It was originally a temporary shelter in an old basalt quarry for delicate plants that were to be introduced into municipal gardens but the project was put on hold and the plants started taking root. In 1933 the architect Raul Carapinha, designed the space as the Estufa fria, later complemented in 1975 with the addition of the Estufa Quente (Hot Greenhouse) and the Estufa Doce (Sweet Greenhouse).

Herbaria and Museums

Since the first recorded herbaria (*hortus siccus* as opposed to the *hortus vivus*, the botanic garden) were created in the 16th century, over 200 herbaria have been established in the Mediterranean region (Heywood 2003a), many of them in botanic gardens, with the bulk of herbaria and specimens (some c.34 million) found in only three countries, France, Italy and Spain. Although the Italian botanist Luca Ghini reputedly created the first herbarium in Pisa in 1544, an English merchant and botanist John Falconer (fl. 1547) who lived for some time in Italy and an apprentice surgeon Jean Girault in Lyon, France, each formed one in the same period of time as Ghini and it is likely that other botanists did so as well. Probably the key factor was the availability of paper as a mounting material for plants following the development of simpler and cheaper methods for the manufacture of continuous sheets of paper after the invention of printing in the in the mid-15th century: it has been suggested that the appearance of herbaria coincides with the technological improvements which allowed the manufacture paper at a low price (Saint-Lager 1886)[1]. The herbarium of Girault is dated 1558 in his own hand and is reportedly preserved in the Musém nationale d'histoire naturelle in Paris. The oldest known extant herbaria are those of Gherardo Cibo (alias Ulisse da Cingoli) (1512-1600) which he began in 1532 and is preserved in Rome in the Biblioteca Angelica and those of Ulisse Aldrovandi (1552–1605) conserved in the University of Bologna and Andrea Caesalpino (1525–1603) in the Museo Botanico dell'Università di Firenze (Moggi 1986).

It should be noted that an earlier use of the term herbarium referred to botanical treatises with engravings facing the text and many examples are conserved in Mediterranean botanic gardens along with other examples of botanical iconography (Montaccchini 1986), especially those concerning medicinal plants known as Herbals.

Although botanists from outside the region have played a major role in writing Floras of some Mediterranean countries and many of their important herbarium collections (incIuding types) of Mediterranean plant specimens are located in countries such as Switzerland (Geneva), Austria (Vienna), Czech Republic (Prague),Hungary (Budapest), Germany (Berlin), Sweden (Lund), the UK (Edinburgh, Kew, Natural History Museum) and even in

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[1] This extensive if somewhat wordy review of the origin of herbaria by St-Lager is an important source of information. See also Anon. Bull. Torrey Bot. Club, 12(12): 129-131 (Dec. 1885) for a brief English summary.

the United States (Heywood 2003), the herbaria of Mediterranean botanic gardens, notably those of Bologna, Firenze, Madrid, Montpellier, Paris and Palermo, contain substantial collections and type material of vital importance for Mediterranean plant taxonomy.

Botanical museums, on the other hand, are usually no longer held in great esteem, and many have suffered a lack of funding and a loss of confidence in the value of the collections (Clifford & al. 1990). Nonetheless, many botanic garden museums still contain many important collections of artefacts of both historical significance and importance for research in ethnobotany which is currently undergoing a marked revival of interest and development of techniques.

Much of the material in these museums is documentary or artistic rather than museological although with new sampling and analytical techniques biocultural collections can now be used more effectively as source material for research in various disciplines (Salick & al. 2014). However, with changing fashions, many important objects and even whole collections have been disposed of or destroyed and many of the collections are at risk as many of the artefacts are, incorrectly, no longer considered relevant. As regards displaying the materials, the emphasis today is on thematic exhibitions and on the use of interactive media, both indoors in exhibits and in the garden itself. Some new museums have been created, for example the ethnobotanical museum in Córdoba and the Pabellón del Bioma Boreal Europeo Carlos Linneo in the Jardín Botánico Atlántico, Gijon.

Plant introductions

For over 500 years Mediterranean botanic gardens played an important role in role as introduction centres for both ornamental and economically useful plants, although they were created too late to play a role in the initial post-1492 introductions from the Americas. As Raimondo & Garbari (1986) comment one can say that all the botanic gardens, whether university or not, both public and private, ancient foundations or newer creations, have contributed effectively to the introductions acclimation and spread of exotic medicinal, food, forestry and ornamental plants which in many cases have given a boost to the economy as well as having a significant impact on the landscape. An enormous diversity of species has been brought into cultivation and introduced into the economy outside the gardens. Because of the benign climate of the Mediterranean region, the introductions included many tropical and subtropical species. In particular, there were many introductions of *Citrus* species and cultivars to botanic gardens such as Palermo, Florence, La Mortola as well as in many villa and palace gardens. Although much of the emphasis in the past has been on the introduction of exotic species, there is now an increasing focus on the potential of the native flora as a source of new energy crops and ornamentals (Heywood 2003b).

The records of these gardens are an important but neglected archive of information about plant introductions and may be of relevance today to research into the adaptation of plants to climate change. Many gardens published catalogues of the plants they cultivated which are an invaluable source of data on the time and pattern of introductions as are the seed lists (*Indices Seminum*) (Heywood 1976) which many Mediterranean botanic gardens have published, often annually. Seed Lists not only catalogued the species for which seed was available but often contained valuable information about the Garden concerned and in some cases articles on taxonomy, cultivation requirements, floristics and other topic (Heywood 1964). Many new species have been described in Seed Lists and an online searchable ‘Guide to the plant species descriptions published in seed lists from Botanic Gardens for the period 1800 – 1900’ has been produced by Lut (2017). Seed Lists were published in limited editions and were often not kept so that their availability in botanic garden and other libraries is poor – in fact many of them were retained by the curatorial staff and never reached the library. Because of their historical importance efforts should be made by botanic gardens to seek out and collate any seed lists that can be traced.

Acclimatization (acclimation) and trial gardens

The introduction and successful cultivation of exotic species to botanic gardens was often a difficult process, especially in the case of tropical plants, because of their particular climatic requirements. To face this challenge, many acclimatization gardens which aimed at attempting to adapt the species to the local conditions were developed in the 17th and 18th centuries in the Mediterranean region, especially in France, Italy and Spain and were aimed largely at plants of agricultural or other economic importance. Some of these were within, or associated with, botanic gardens while others were private, in gardens belonging to the nobility. Such acclimatization gardens and acclimatization societies were quite common in some regions such as Tuscany in Italy (Moggi 2013). Many acclimatization gardens were established in Spain to cater for the plants brought from various parts of the then Spanish colonial territories. Examples are those that existed in Cartagena, Cordoba (although short-lived), Barcelona, Aranjuez, Madrid, Malaga, Burgos, Sevilla, Carmona, Cádiz, and La Orotava (Tenerife), Valencia (Puerto Sarmiento 2002). In France, acclimatization of plants was widely practised in Provence and various gardens for this purpose were established (Potron 1995) and the Jardin botanique de la villa Thuret, France has been engaged in the introduction and acclimation of plants for over 150 years (Ducatillion & Blanc-Chabaud 2010).

A number of trial gardens were established in the Mediterranean region, especially in France, Italy, Portugal and North Africa to assess and introduce plants of economic interest from mainly tropical countries. When linked to colonial development, they were termed Colonial Gardens as in the case of the Giardino Coloniale di Palermo and Jardim Colonial in Lisbon (now the Jardim Botânico Tropical). 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. The gardens were created between 1914 and 1919, under a joint initiative of the sultan Moulay Hafid and the French Protectorate and were designed by Jean-Claude Nicolas Forestier. They fell into disrepair and have recently been restored and with a broader remit, including the conservation of Moroccan endemic species. The Jardin d’Essais was classified a national heritage site in 1992 and in 2012, it was recognized by UNESCO as a World Heritage Site. In Egypt, the experimental garden of El Saff about 50 km south of Cairo was of major importance for plant introductions as 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.

Today as we are facing the impacts that global and in particular climate change is having on all aspects of our life, the need for research into plant acclimation and adaptation has a new resonance. This will be essential if we are to be able to develop and grow crops adapted to the new climatic regimes and thereby safeguard our food supply. Mediterranean botanic gardens have played an important role in the past in introducing and disseminating new agricultural and horticultural crops, trees and ornamental plants and are well placed to resume such vital work to meet today's challenges.

Art and sculpture

Mediterranean botanic gardens contain a great wealth of paintings and drawings, some of which are displayed although the majority are in kept in storage or in the archives. When they are used in exhibitions, they attract considerable public interest. Also, a great diversity of sculptures, many of them hidden in the undergrowth, is found in the Mediterranean's botanic gardens (Fig. 4). A number of tombs are found in the gardens, usually of the founder of the garden as in the case of the Orto Botanico Hanbury in Las Mortola where Sir Thomas Hanbury is buried.

Libraries – books, journals, archives

The libraries and archives of Mediterranean botanic gardens are a treasure house of material about the history of botany, plant exploration and introduction, economic botany and taxonomy, which is not only of regional but of global importance. The libraries and

Fig. 4. Example of sculptures found in the Mediterranean's botanic gardens.

archives of the early Italian *Orti botanici* such as Pisa, Padova, Firenze and Bologna contain materials are essential resources for understanding the early development of botany and botanic gardens. The Library of the Real Jardín Botánico, Madrid contains 32,000 books, 2,084 journals, 2,545 maps, 30,000 pamphlets and reprints. Its general Archive contains 4,865 historic documents from 1762 to 1900 and 169 boxes of contemporary documents. It includes 4000 drawings and engravings (Papiol 2005). In addition, the Archive contains documents and graphic material from important expeditions such as those of Loefling to South America, José Celestino Mutis to New Granada, Sessé & Mociño to Mexico and Central America, and Ruíz & Pavón to Peru.

A serious problem is that with the decline in the teaching of botany and the closure of botany departments or their merger with other departments, the libraries of university botanic gardens are being transferred to the universities' main library or even dispersed and then lose the necessary dedicated curatorial attention.

History and historical figures

Many celebrated botanists were directors or worked in Mediterranean botanic gardens, such as Antonio José Cavanilles, Augustin Pyramus de Candolle, Andrea Cesalpino, Mariano Lagasca, Luca Ghini, Michele Tenore, Pierre Magnol, Joseph Pitton de Tournefort, Antoine Laurent de Jussieu, Agostino Todaro, Filippo Parlatore, Pietro Andrea Mattioli, Pier Andrea Saccardo, Gustave Thuret to name just a few. One of the most celebrated was Luca Ghini who instituted the first botanic gardens in Pisa and Florence between 1543 and 1545 at the behest of Cosimo I de' Medici. He also created the plant press and one of the first herbaria and instituted the formal teaching of medicinal botany and laid the foundations for modern pharmacognosy.

Social impacts

The intangible heritage of the Mediterranean's botanic gardens is of enormous and incalculable social and cultural importance and influence. The relationship between the gardens and their patrons, students and the general public is an important dimension of their social impact. This interaction has changed over the centuries as the gardens themselves have occupied different roles. The impact on the life of the citizens of the towns and cities where they are located has been major factors in the evolution of their civic, social, economic and cultural development. Although many botanic gardens today tend to emphasise their role in the conservation of plant diversity, most visitors are motivated more by the aesthetic and recreational opportunities they afford. This is especially true of the large number of Mediterranean botanic gardens that are located in an urban setting. Public attitudes and expectations of the services that botanic gardens should offer, have changed and have in many cases affected policy. As Rakow & Lee (2015) note '… many are finding that the plants themselves are not enough to attract the size or diversity of audiences that they need to survive. More and more, gardens are embracing entertainment options to attract young professionals, families, and members of specific ethnic groups'. Although the general public visiting the botanic garden can appreciate the plants collections, the landscapes and vistas, the displays in the greenhouses and shade houses, and the statues, fountains and other features they are unaware of the riches to be found in the museums, libraries and archives as they are not normally accessible. Many botanic gardens put some of this material on display in occasional exhibitions and perhaps more effort should be invested in such events if they are to obtain public support for their work: one cannot expect such much-needed support if the rich heritage material is kept hidden. Regular open days and guided tours allowing the pubic to visit the herbaria, museums, libraries and the scientific, technical and conservation activities should be considered.

Two botanic gardens in the region have been recognized by UNESCO as World Heritage Sites – the Orto Botanico di Padova and the Jardin d'Essais, Rabat. It is perhaps surprising that so few have achieved such a status.

Safeguarding the heritage

The Mediterranean botanic garden estate is one of the most important in the world. It has seen the origin and development of the dominant western model of the botanic garden as we know it today and collectively the gardens contain an invaluable store of irreplaceable materials both in the living collections and their records, in their rich libraries and archives and in their herbaria and museums. Yet, much of the material is not fully documented, catalogued or recorded, and a considerable part of it is still poorly studied if at all.

As we have noted above, as a consequence of changes in the perception of the value of botany by university administrators and even by other biological scientists, and with falling numbers of students, departments of botany or plant biology are being closed or merged and university botanic gardens also face reduction in funding or even closure. As a result, some of the important collections in Mediterranean botanic garden are at risk of neglect or dispersal. The tragic destruction by fire of the Brazilian National Museum in Rio de Janeiro which housed one of the richest collections of natural history artefacts in the world, most of which were lost[2] should serve as a wake-up call to all natural history museums and botanic gardens to review the security of their collections in terms of fire and water damage risk, sprinklers, insurance (or as in the case of the Brazilian museum, lack insurance), documentation, duplicates, etc. As Zamudio & al. (2018) comment, 'Museum collections are timeless national treasures that represent our histories, cultures, and scientific achievements. Every institution and government should reflect and take heed at this sad moment. We must invest in and safeguard our museums and collections for the benefit of science and society worldwide'. Indeed, it would be tragic, if the public were to learn of the treasures that a botanic garden contained only after they had been lost by fire, flood, neglect or ignorance. The time for action to avoid such tragedies is now.

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[2] Fortunately not the herbarium which had been removed to a separate building.

Conclusions

This brief overview of the diversity of the living, preserved and artistic collections contained in the botanic gardens of the Mediterranean region has highlighted the major contribution that they have made to our understanding not only of the origin and development of botanical science and related disciplines such as herbal medicine, ethnobotany and ethnopharmacology, but of many of the crops we grow, the food we eat and the trees, shrubs and herbs that adorn our streets, parks and gardens. There are few areas of human life and wellbeing that have not been impacted by botanic gardens: from medicine and pharmacology to health and nutrition, from gardening and horticulture to exhibitions, recreation and enjoyment and social gatherings. Yet, the rich diversity of resources in the Mediterranean's botanic gardens is generally poorly known and little studied. Unless prompt action is taken, many of these unique resources risk falling into neglect, dispersal or even loss as is already happening in some gardens.

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The genus *Tamarix* (*Tamaricaceae*) from archaeological to contemporary landscape*

Abstract

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This review includes the data concerning the presence of *Tamarix* species in old and contemporary landscapes, and their presence in archaeological areas. Their role as wild and ornamental plants, their use in sacred places, and their depiction in old relief sculpture, old and more recent paintings is also reported. Notes on the presence of *Tamarix* species in current landscapes and their invasiveness are discussed.

Key words: *Tamarix,* archaeology, landscape, biological invasion, distribution.

Introduction

Since ancient times tamarisks (*Tamarix* sp. pl.), were used in different Babylonian rituals, to ward away evil influence, in celebrations, as act of gratitude, to commemorate the birth of children, to accompany the procuring of water rights, as ornamental, medicinal plant, windbreak, etc. (Calvin 1847). In addition, tamarisks were a component of oaths and they were utilized in purification and divination. As folk use, the tamarisks were also used to produce a resinous, sugar exudation and for making cakes when mixed with wheaten flour (Forster 1942).

As reported by Umbarger (2012), the Genesis 21:33 states that “Abraham planted a tamarisk tree in Be'er Sheva”. On the basis of subsequent interpretations, it seems likely that Abraham planted a tamarisk to delimit the area around his altar in Be'er Sheva wanting to depict a sanctuary in the open or as symbol of his hospitality.

The remains of Saul, the first king of the Kingdom of Israel, and Judah (1047-1007 B.C.), was buried under a tamarisk tree (Holman Bible Publishers 2010).

Tamarix species were sacred to Osiris, the God of Afterlife (Barguet 1967), and it is said that next to his tomb the branches of a tamarisk support his soul with the appearance of a bird (McIntosh 2005).

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*Extended and enriched version of the oral presentation given at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

The above examples highlight the knowledge and several uses of tamarisks by ancient populations. The documents consulted show how tamarisks have long been a constant component of the landscape of various territories and in particular of the Middle East.

In this work, an analysis of the role of tamarisks in the evolution of the plant landscape is reported through their representation in old and more recent paintings, in wooden sculptures, etc. In addition, the current problems related to their invasiveness and the effects on ecosystems are also analyzed.

***Tamarix* as a component of plant landscape in sacred places**

Tamarix nilotica (Ehrenb.) Bunge is a floristic element characterizing the plant landscape in sacred places. This tree still characterizes the flora of Israel, currently consisting of 13 *Tamarix* taxa according to reports by Danin & Fragman (2016) in Flora of Israel Online. This is a well adapted species to saline soils, it is free of thorns, and not succulent. The twigs are slender and the leaves are lanceolate. The racemes bring pentamerous, white or pink, flowers. In Israel, *T. nilotica* grows on soil “islands” at the main channel of Nahal Zin and in sites where soil stays wet even many days after the flood (Danin & Fragman 2016), and on alluvium on Mount Sinai.

Tamarix aphylla (L.) Karsten is a rare species in Israel, common only in the Arava Valley, usually planted near wells in the northern Negev, northern Sinai, west and northwest of Mishmar HaNegev, Shuval, and Bet Kama, including the well of Abraham in Be'er Sheva (south Israel), the remnants of the village Masmiya and Tel Nizzana. This species can be recognized by its purplish brown and smooth branches. The twigs are drooping, wiry or needle-like and the leaves are bluish-green, alternate, reduced to tiny scales. The flowers are numerous, tiny, whitish-pink. Old trees of *T. aphylla* from the Hamriyah area of the Emirate of Sharjah (United Arab Emirates) are considered by local population of cultural importance and a link beteween present, past, and future generations (Mahmoud & al. 2015).

In the Zarka River Valley (biblical Jabbok) along the Jordan river, there is a wide population of *Tamarix jordanis* Boiss. It is a small tree with slender stems, red when young, leaves alternate, scale-like. The racemes bring white or pink flowers, clustered on terminal spikes.

***Tamarix* in relief sculpture, old and more recent paintings**

Looking at some most important and prized old paintings in which *Tamarix* species are depicted, it is possible to recognize the habitat and morphological characters of each species.

In Guy Rose (1867–1925), “Tamarisk Trees”, Southern France it is possible to observe the twisted shape of the slender trunks and the scattered foliage as well as the sandy habitat of *T. aphylla.*

In “Pharonic Fantasies of a Foolish Old Man” by Stanza Widen, Canada, it can be recognized the habitus of *T. usneoides* E.Mey. ex Bunge with slender branches and an upright form.

The “Tamarisk Tree of Lake Como” by Sigismund Christian Hubert Goetze, hosted in The Fitzwilliam Museum (Cambridge, United Kingdom), is clearly referred to *T. gallica* L., and in particular to a still living plant occurring along the shores of the lake.

Finally, the Private Painting Holiday by Angela Corben (Majorca, June 2017), entitled “Plein Air under the tamarisk”, refers to a tree of *Tamarix africana* Poir., that grows on sand near the sea.

Most Egyptian timber consists of tamarisk, acacia and Sycamore figs (Liphschitz 1998). Tamarisk wood, most probably from *T. nilotica,* was used in combination with wood of *Ficus sycomorus* L. The timber of tamarisks is dense, hard, durable, and used to prepare throwing sticks, bows, pegs, walking sticks and, boxes. The wooden nail of wooden masks, dating back to the 18th, 19th and 20th dynasties and some nail of coffins (320–330 BC) from Museums in Israel are made with tamarisks. A stamp seal with a small ring on the back dating to the Egyptian Middle Kingdom, the Head of Osiris (26th Dinasty), the statuettes of Shabti (New Kingdom), Isis and the head of the statuette of Osiris Ptah-Sokar (Ptolemaic Period, 3rd-2nd century B.C) are made with tamarisk wood.

Current distribution of *Tamarix* species

The genus *Tamarix* L. is naturally and widely distributed from Mediterranean Area (including North Africa) to western Europe, northeastern China, Mongolia, India, and Japan (Baum 1978). Tamarisks are adapted to arid climates and grow into the wild in a wide range of habitats. Some species are cultivated as ornamental plants or marine windbreaks and for the sandy dune stabilisation (Mandracchia & al. 2017). Some other species are cultivated for their recognized ethnobotanical uses (Tuttolomondo & al. 2014). The halophytic character of *Tamarix* leaves and the presence of salt glands are also a common feature (Alaimo & al. 2013; Grisafi & al. 2016).

In Europe, thanks to the recent increase in floristic exploration, the number of known tamarisk species is gradually increasing. New tamarisks growing spontaneously and others, introduced for cultivation in Italy through nurseries or random events, have recently been described as casual alien plants (Venturella & al. 2012).

The fluctuation in the number of tamarisks species occurring in Italy is mainly due to difficulties in the correct identification. The analysis of some features (habitus, size of racemes, etc.) adopted in the past are not exhaustive since the type of flower disk is an important discriminant character.

Notes on invasiveness

Tamarisks are considered worst invasives across different countries and included among the top twelve America’s “least wanted” by Nature Conservancy (Stein & Flack 1996; Zavaleta 2000). *Tamarix* sp. pl. are reproductive, competitive, and tolerant (Brotherson & Field 1987). In fact, these species are characterized by continuous seed production during the growing season, a seed output of more than 500,000 per individual per year, a high seed viability, an adaptation for long distance dispersal by means of wind and water. In addition, tamarisks show a high vegetative reproductive capability. The deep and extensive root system makes it easy to compete with other plants and to tolerate a wide range of environmental conditions. *Tamarix* sp. pl. are also facilitated in their invasiveness for the ease with which it is possible to root out after a fire, flooding, cutting, and herbicide treatment.

Among the various examples reported in the literature, highlighting the role of tamarisks in the alteration of some habitats and in the composition of flora and fauna, we can mention that of *Tamarix ramosissima* Ledeb. which has been related to several environmental changes in North America, and it negatively affected avian communities and bird nests (MacGregor-Fors & al. 2013).

In recent times, *T. usneoides* has undergone biological control in the United States and South Africa (Marlin & al. 2017).

T. ramosissima and *T. chinensis,* introduced from Asia in the United States of America, have become common and invasive in many western riparian habitats (Gaskin & Kazmer 2009).

One of the most effective biological agents tested in arid and semi-arid ecosystems against the invasiveness of *Tamarix* is *Diorhabda carinulata* Desbrochers, 1870, also known as northern tamarisk beetle (Pattison & al. 2011).

In Italy, although there is some evidence that tamarisks introduced and escaped from cultivation are spreading in nature, there are still no specific studies on the invasiveness of this genus.

Conclusions

Tamarix species show interaction with four ecological factors, such as regional climate and local weather climate, hydrologic variables, fire dynamics, and the salinity of the soil and groundwater. Over the years, these interactions have contributed to create a different plant landscape than in the past.

The tamarisks have long characterized the plant landscape of the coastal dunes and hinterland and have been elected as symbolic plants in some rituals and sacred places. The tamarisks, moreover, are widely cultivated as ornamentals and as such have been depicted in many paintings and sculptures.

The correct identification of these species is still a problem, as well as the absence in the catalogues of nurseries of the exact origin of the cultivated species. The problems linked to the invasiveness of tamarisks that escape cultivation are known above all in the United States, while they are becoming increasingly evident in Europe, especially because tamarisks are ofteb introduced as ornamentals, but also used in some environmental restoration works.

It is therefore necessary to intensify taxonomic studies on this still critical genus and to monitor actions on species that are gradually becoming spontaneous in different territories.

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Filippo Scafidi & Francesco M. Raimondo

Contribution to the vascular flora of the archaeological park of Selinunte and Cave of Cusa (South-Western Sicily, Italy): preliminary results*

Abstract

Scafidi, F. & Raimondo, F. M.: Contribution to the vascular flora of the archaeological park of Selinunte and Cave of Cusa (South-Western Sicily, Italy): preliminary results. — Fl. Medit. 28: 225-232. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

This study aims to present a complete inventory of the vascular flora of the Archaeological Park of Selinunte. A total of 443 specific and infraspecific taxa are here reported. *Fabaceae* was the most collected family with 47 species. *Asteraceae* and *Poaceae* were the next largest families with 45 and 35 species, respectively. *Euphorbia* was the largest genus, represented by 9 species. The analysis of the biological spectrum of the vascular flora indicate the predominance of therophytes (42%) and hemicryptophytes (22%) while, from a chorological point of view, most of the species show a Mediterranean distribution. The presence of *Cynara cardunculus* subsp. *zingaroensis* (taxon endemic to W-Sicily) is reported for the first time for the investigated area.

Key words: archaeological areas, vascular flora, endemics, alien species, Sicily, Italy.

Introduction

Archaeological sites in the Mediterranean Basin are often of great artistic and historical value and play an important role in the tourist industry (Celesti-Grapow & Blasi 2004).

Among these, the Archaeological Park of Selinunte and Cave of Cusa (Trapani Province) is, certainly, one of the largest and most extraordinary archaeological sites in the Western Mediterranean.

This contribution is limited only to the part of the park around the ancient city of Selinunte. This area and its temples represented the western part of the Greek advance in Sicily. It was founded in 651-650 B.C. and built with calcarenites extracted from the quarries of the near locality Cusa, in Campobello di Mazzara territory (Trapani Province) (Brai & al. 2004).

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*Extended and enriched version of the poster presented at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

The toponym “Selinunte” probably, is due to savage parsley, ‘selinon’ in ancient Greek, which in tern refers to *Apium* spp. growing wild in such moist habitats (Guarino & Pasta 2017) and was also present on the local coins (Fabbrocino & al. 2001).

The Archaeological Park, with almost 270 hectares of extension, houses also elements of flora and vegetation of great natural value.

The site is also characterized by the presence of wide sandy dunes included in “The Natural Reserve Foce of Belice and Dune Limitrofe" and in the SIC (Sites of Community Interest) ITA010011 named “Dunal system of Capo Granitola, Porto Palo and Foce of Belice”.

Nevertheless, very poor are studies carried out on the flora and vegetation on this area (Frei 1937; Brullo & al. 1974; Speranza & al. 1993; Troia & Spallino 2009).

Furthermore, in the past, plant cover and Mediterranean maquis of the Selinunte archaeological site have been attentioned by various landscape ecologists, mainly with regard to its restoration (Raimondo & al. 1991; Raimondo & al. 2018), however at today, a floristic inventory of the whole area is still missing.

In 2018, the project “Census of the vascular plants of the Archaeological Park of Selinunte and Cave of Cusa” started, with the aim of improving the botanical knowledge of this area and to produce a complete check-list of this flora.

The studied area

The Archaeological area of Selinunte is located on the southwest coast of Sicily in the central part of the coastline, between Capo Granitola and Capo San Marco (south-western Sicily).

It is stretched over three hills that from east to west are: Marinella or Eastern Hill, Manuzza and Gaggera Hills (Piro & Vesinon 1995), and it is part of a territory that is represented by Modione basin and partially by the Belice basin (Fig. 1). The area is characterized by clay or clayey-marl with sand breakthroughs covered by calcarenites (Liguori & Porcaro 2010) it falls in the floristic subunit “2.3.1 Southern and Western coast” (Domina & al. 2018a). Phytogeographically, the site falls in the Drepano-Panormitano district. (Brullo & al. 1995).

According to Bazan & al. (2015), the bioclimate of the area can be defined lower thermomediterranean and lower dry, with annual average temperature around 18 ° C and upper dry ombrotype (average annual rainfall of 500 mm) (La Rosa & al. 2012).

Material and Methods

Inventory of the flora was carried in the year 2018, from February to August, several samplings were performed in order to cover the whole area investigated.

Herbarium specimens have been collected and stored in the Herbarium Mediterraneum Panormitanum (PAL-Gr), acronym according to Thiers (2018).

For the taxa identification, we mainly referred mainly to the Italian floras (Fiori 1923-29; Pignatti 1982) and systematic revisions and monographs (Delforge 2005; Giardina & al. 2007; Venturella & al. 2007; Domina & al. 2011).

In the floristic list, the systematic order and taxonomic circumscription of the families

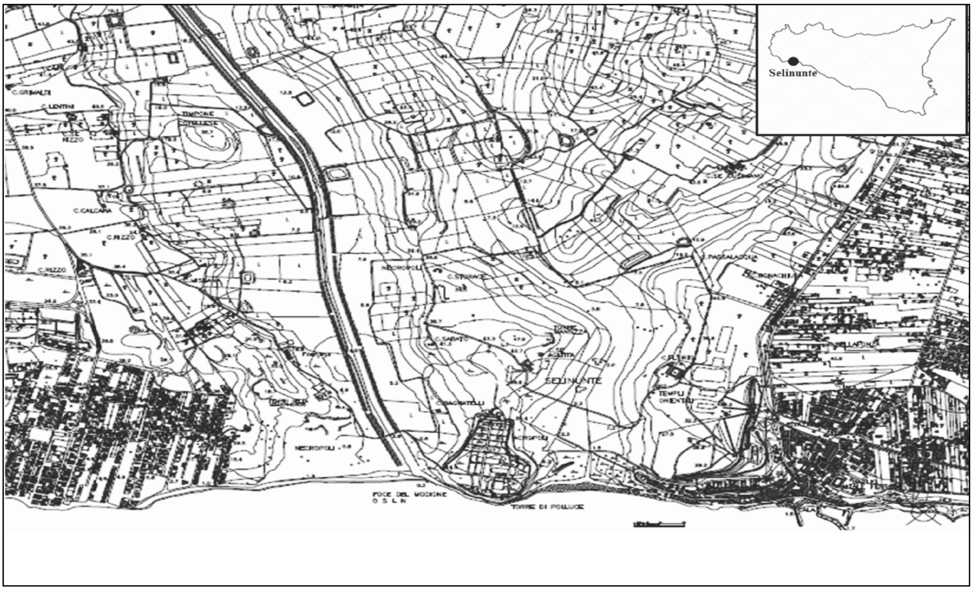

Fig. 1. Study area: the Archaeological Park of Selinunte (Sicily, Italy).

follow Bartolucci & al. (2018) and Galasso & al. (2018). Taxa are ordered alphabetically within each family. Life forms and chorological types of natural and alien taxa are according respectively to Raimondo & al. (2010) and Raimondo & al. (2005), while cultivated plant follow Bazan & al. (2005).

Results and Discussion

A total of 443 specific and infraspecific taxa currently occur on the Archaeological Park of Selinunte, belonging to 302 genera and 85 families. *Fabaceae* was the largest family with 47 species. *Asteraceae* and *Poaceae* were the next largest families with 45 and 35 species. *Euphorbia* was the largest genus, represented by 9 species.

The life form spectrum (Fig. 2A) shows a dominance of Therophytes (42%), followed by Hemicryptophytes (22%), Phanerophytes (15%) and Geophytes (11%). From a chorological viewpoint, most species show a Mediterranean distribution (Stenomedit. and Eurimedit.) (Fig. 2B).

Italian endemics are seven (Raimondo & al. 2010; Bartolucci & al. 2018) which amounted to 2% of the taxa observed. In particular, only two taxa are endemic to Sicily:

- *Cynara cardunculus* subsp. *zingaroensis* (Raimondo & Domina) Raimondo & Domina (Fig. 3A), is endemic to W-Sicily (Raimondo & al. 2004). The population founded in the Eastern Hill has never been reported at today and therefore it is the first record for this area.
- *Limonium selinuntinum* Brullo (Fig. 3B), is a narrow endemic that occur only on the sea cliffs in in the Archaeological Park of Selinunte. (Brullo 1980). At today, the total pop-

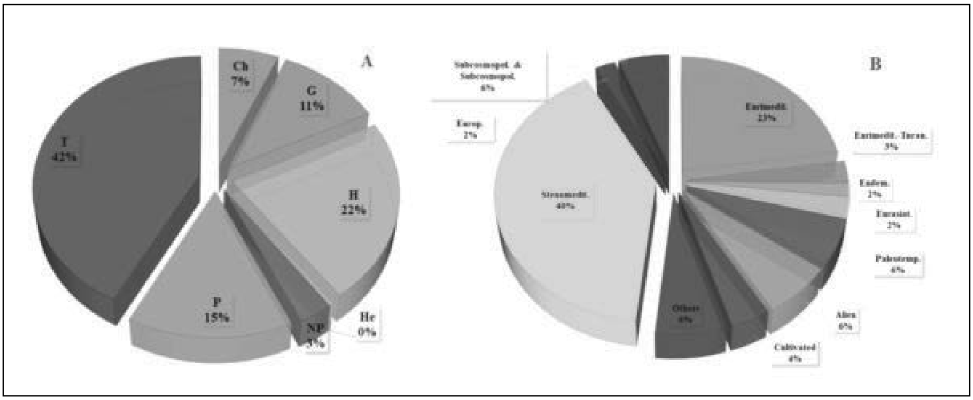

Fig. 2. A) Biological spectrum of the vascular flora of Archaeological Park of Selinunte. Ch - chamaephytes; G - geophytes; H - hemicryptophytes; He - helophytes; NP - nanophanerophytes; P - phanerophytes; T - therophytes; and B) The Chorological spectrum.

ulation is estimated to be fewer than 200 individuals. Its range is seriously threatened due to strong anthropogenic pressure present in the investigated area.

Antirrhinum siculum Mill. shows wide Italian distribution, three taxa are endemic to Southern Italy (*Euphorbia ceratocarpa* Ten; Gypsophila arrostii Guss. subsp. *arrostii; Retama raetam* (Forssk.) Webb & Berthel. subsp. *gussonei* (Webb) Greuter), and *Seseli tortuosum* subsp. *maritimum* (Guss.) C.Brullo, Brullo, Giusso & Sciandr. is endemic to Southern Italy and Sardinia.

Others taxa with particular phytogeographical interest are: *Ajuga iva* subsp. *pseudoiva* (DC.) Briq., *Crucianella marittima* L. *Echium sabulicola* Pomel subsp. *sabulicola, Launaea fragilis* (Asso) Pau, *Lomelosia rutifolia* (Vahl) Avino & P. Caputo, and *Pancratium maritimum* L.

Fig. 3. A) *C. cardunculus* L. subsp. *zingaroensis* (Raimondo & Domina) Raimondo & Domina; B) *L. selinuntinum* Brullo.

Fig. 4. Some alien taxa in the Archaeological Park of Selinunte: A) *Ailanthus altissima*; B) *Agave americana* subsp. *americana;* C) *Carpobrotus edulis*.

Our results confirm that this area is among the richest in biodiversity of the southern coast of Sicily as reported in Domina & al. (2018b). The present contribution has also highlighted the presence of the high number of alien species (29 taxa), mostly naturalized and sometimes more or less invasive (Fig. 4) such as: *Ailanthus altissima* (Mill.) Swingle, *Carpobrotus edulis* (L.) N. E. Br., *Eucalyptus camaldulensis* Dehnh. subsp. *camaldulensis, Phoenix canariensis* H. Wildpret. and *Vachellia karroo* (Hayne) Banfi & Galasso. Other alien species (13 taxa) are cultivated in the Archaeological Park for ornamental purposes.

Moreover, on the basis of our observations in the field the exclusion of *Scrophularia frutescens* L., is confirmed. In the past, its presence in the dune system was reported by Brullo & al. (1974) and misidentified with *S. canina* L.

At the end, due to its specific climatological position and habitat diversity, we can expect that the investigated area hosts more species than currently recorded.

The complete list of taxa is reported in online Appendix to this volume (ESF1).

Conclusion

This study not only highlighted the great naturalistic value of the studied area, but also allowed to verify some critical issues such as the presence and sometimes large spread of some invasive alien species which threaten not only local biodiversity but also the monuments themselves. In fact, the damage inflicted by alien plants on the country’s historical heritage is a particularly relevant issue in Italy (Celesti-Grapow & al. 2009).

It would be desirable in the future, that alien species present in this archaeological site to be constantly monitored and to prevent their diffusion through a landscape management plan that involving regular containment and eradication interventions.

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V. Rotolo, M. L. De Caro, A. Giordano & F. Palla

Solunto archaeological park in Sicily: life under mosaic tesserae*

Abstract

Rotolo, V., De Caro, M. L., Giordano, A. & Palla, F.: Solunto archaeological park in Sicily: life under mosaic tesserae. — Fl. Medit. 28: 233-245. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Biodeterioration is a complex process induced by the growing and metabolic activity of a wide range of macro and microorganisms, becoming a revelling problem also for the mosaic tesserae of “Casa di Leda” in the Greco - Roman site of Solunto in Sicily.
In this case-study, a thick biofilm inducing a deep alteration of mortar and consequently the mosaic tesserae detachment has been highlighted during the restoration plan.
The biofilm microbial consortium has been investigated by an integrate approach based on Microscopy analysis (O.M., C.L.S.M.), in vitro culture (Nutrien and Saboraud media) and molecular biology investigation (DNA target sequence amplification, sequencing, sequence analysis).
A microbial diversity has been revealed belonging to bacteria (*Bacillus*) and fungi (*Alternaria*, *Aspergillus*), besides cyanobacteria (*Chroococcus*) and green algae (*Chlorella*).
In order to control the biofilm colonization two essential oils (EO), *Thymus vulgaris* and *Origanum vulgare*, have been utilized and their antimicrobial activity, preliminarily in vitro (agar disc diffusion methods) and after ex situ and in situ evaluated. This experimentation is aimed at identifying and implementing green biocides for the control of microbial colonization, a promising technology with a reduced impact on human health and environment, able to replace traditional biocide action.

Key words: biodeterioration, microsopy analysis, in vitro colture, molecular biology.

Introduction

Stone artworks biodeterioration is related to the combination of biological colonization and environmental factors, as happen in archaeological areas, where complex *biofilm* have been frequently revealed (Thomas & Demas 2013; Marzano & Métraux 2018).

Concerning inorganic specimens, the first colonizers are represented by pioneered photoautotrophic organisms, such as cyanobacteria, algae and lichens, but also oligotrophic or poichilotrophic microbial groups, such as some fungi and chemo-lithotrophic bacteria (i.e. using as oxidation inorganic compounds) have been identified; converting the substrate

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*Extended and enriched version of the oral presentation for the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

and helping the colonization of other heterotrophic organisms (Tiano & al. 1995; Warscheid & Braams 2000; Caneva & al. 2007).

Moreover, the association as *biofilm* confers a character of resistance to the biocenoses involved (Flemming 1993), becoming problematic to remove (Chorianopoulos 2008).

In this case-study, biofilm was not straightaway seen, since it was spread under several tesserae of the *impluvium*, located in the centre of the “Casa di Leda” *peristylo*, in Solunto (Palermo, Italy) one of the archaeological-park in Mediterranean basin (Marzano & Métraux 2018). Combining biological and biotechnological approaches (Palla & al. 2010, 2013; Di Carlo & al. 2016; Palla & Barresi 2017) microbial taxa such as bacteria, fungi, cyanobacteria and green algae have been identified.

Since the extensive microbial spreading affects both the constitutive materials and the legibility of the artworks (Barranguet & al. 2005), the control of biodeterioration phenomena represents a significant phase in conservation project. In routine practice, microbial colonization is addressed by chemical biocides, which toxicity and persistence in the environment is well known (De La Paz & al. 2006; Guiamet & al. 2006).

In the last decade, in order to develop green conservation strategies, plant products have been applied in prevention and treatment of microbial contaminants (Guiamet & al. 2008; Afifi 2012; Sasso & al. 2013; Fierascu & al. 2014; Stupar & al. 2014; Borrego & al. 2016; Rotolo & al. 2016).

In this study, the antimicrobial activity of two commercial essential oils, *Origanum vulgare* and *Thymus vulgari*s, have been evaluated against microbial species isolated from *biofilms* of floor mosaic tesserae of “Casa di Leda” in the *Greco - Roman site of Solunto* in Sicily (Fig. 1), to control the biodeterioration phenomena, applying novel protocols safe for humans and environment (Rotolo & al. 2017).

Materials and methods

Essential oils (EO)– The *Origanum vulgare* and *Thymus vulgaris* essential oils have been used as pure essence (100%) or diluted solutions (50, 25, 12.5, 6.5 %) in 70% Ethanol.

Fig. 1. Mosaic floor around the *impluvium* in the *peristyle* of Leda’s house, in archaeological park - Solunto, Sicily.

Origanum vulgare, is an aromatic hemicryptophyte, belonging to *Lamiaceae*, native to Europe and in particular in the Mediterranean basin, but today cultivated all over the world. The plant is rich in carvacrol, a phenolic monoterpene with recognized anti-inflammatory and antitumor properties (Burts & al. 2007; McCann & al. 2014).

Thymus vulgaris, is a chamaephyte belonging to *Lamiaceae*, including 250-350 evergreen taxa, native to southern Europe, North Africa and Asia.

The aromatic active molecules have a strong antiseptic and antibacterial properties, they also have digestive, warming, spasmolytic, carminative, diuretic and disinfectant action of the urinary tract. In addition they contain phenolic monoterpenes such as thymol (30-70%) and carvacrol (3-15%), oxides such as cineol and thymol methilesters, alcohols such as borneol, geraniol, linalool, esters such as acetate and linalyl, hydrocarbons such as cymene and terpinen (Mitsch & al. 2004; Bolukbasi & al. 2007).

Sampling.– Biofilm aliquots were collected by sterile scalpel or swab, and directly observed by optical microscopy or utilized for *in vitro* culture and molecular investigations.

Microscopy observation.– Cyanobacteria and microalgae, as well as the morphological profile of bacterial and fungal isolated colonies were analysed by Stereo (Wild-M1B, 14X) or Fluorescent (DMR-Leica, 40X) microscopes. Conidiophores and conidia fungal structures were observed by Optical Microscope (Leica, 40X), after Lugol's iodine staining (Di Carlo & al. 2016).

In vitro culture.– Sabouraud Dextrose Agar + Chloramphenicol (CAF) and Nutrient Agar plates, seeded by biofilm aliquots, were incubated at 30°C (Palla & al. 2006; Pasquarella & al. 2015); after 24/48 h fungi and bacteria colonies

Microbial DNA extraction.– Each isolated bacterial and fungal colony was lysed at 94°C per 2 min in 20 µl of 1X T.E. (10 mM TRIS-HCl pH 7,5 / 1 mM EDTA), extracting the genomic DNA by the *Genomic DNA purification* and *Gene JET Genomic DNA purification* kits (Fermentas).

Polymerase Chain Reaction (PCR) – Genomic DNA molecules were utilized as template for *in vitro* amplification (Polymerase Chain Reaction) of target ribosomal-DNA sequences: 16S-rDNA gene or Internal Transcribed Sequence (ITS – rDNA), specific for bacteria or fungi.

ITS-PCR reactions were carried out by the following oligonucleotides as primers, bacteria: ITS1= 5'-GTCGTAACAAGGTAGCCGTA-3' and ITS2= 5'-GCCAAGGCATCCACC-3'; fungi: ITS4 = 5' - TCCTCCGCTTATTGATATGC-3' e ITS1 = 5' –CTTGGTCATTTAGAGGAAGTAA - 3' (Cardinale & al. 2004).

PCR products were analysed by 2% Agarose gel electrophoresis, nucleotide composition determined by MWG Operon Sequencing Service and sequences comparison performed by BLAST platform (Altschul & al. 1997; Palla & al. 2010, 2013; Palla 2012; Palla & Barresi 2017).

Evaluation of antimicrobial activity.– In vitro assay: *agar disc diffusion* method was performed utilizing paper disc (6 mm in diameter), wetted with 10µl of each EO at different concentrations (100%, 50%, 25%, 12.5%, 6,25%) and placed onto the surface of Nutrient or Sabouraud agar (90 mm Petri dish), previously seeded by 1x10^6 CFU/mL - bacterial cells or 1x10^4 conidia/mL - conidia suspension (Borrego & al. 2012).

Control assays were performed wetting the paper disc with 70% Ethanol or 0.2% (vol/vol) Benzalkonium chloride + chlorhexidine (BC, one of the frequently used commercial biocides).

After incubation at 30°C for 24/48 h, confluent microbial growth was observed and the diameter (mm) of growth inhibition areas was measured (Balouiri & al. 2016; Rotolo & al. 2016); each test was performed in triplicate.

Ex situ assay: the antimicrobial activity of the two essential oils was also evaluated exposing the biofilm to the volatile compounds. Particularly, eleven colonized tesserae, gathered from specific areas of *impluvium* were placed on paper discs (60 mm, Whatman) into equal in diameter sterile Petri dishes, soaked with: *i*) *Oregano* (100, 50, 15%) EO; *ii*) *Thyme* (100, 50, 15%) EO; *iii*) Biotin-R (100, 50, 15%); *iv*) Ethanol (70%); Petri dishes were sealed by Parafilm membrane (Heathrow Scientific) to prevent evaporation phenomena. The effect of EOs was evaluated after 72h and up to 7 days, analysing both biofilm green pigmentation and auto-fluorescence (MD Fluorescent Microscope, Leica).

In situ assay: biocide activity was also directly evaluated on selected (eleven) *peristyle mosaic* areas. As performed in laboratory assays, differently concentrated Essential Oils (100, 50, 15%) and Controls (100, 50, 15% Biotin-R or 70% Ethanol) solutions were injected (by sterile needle/syringe) through interstitial mortar tesserae.

Results

In order to characterize the microbial species constituting the pigmented *biofilm* revealed below the mosaic tesserae (Fig. 2), an integrated approach was applied (Palla & Barresi 2017). Particularly, a complex microbial community with prevalence of cyanobacteria, belonging to the genus *Chroococcus* and green algae such as *Chlorella* (Fig. 3), was observed by Optical Microscopy. Through *in vitro* culture and molecular investigations, the presence of bacteria, *Bacillus* sp. pl. (Fig. 4) and fungi, *Alternaria* (Fig. 5) sp. and *Aspergillus* sp. (Fig. 6) have been also identified.

The characterization of microbial consortium components is strictly related to the control of microbial spreading, accordingly to the biocide product that will be applied. The aim of this study was also the set-up of alternative biocides, as plant essential oils, less invasive/dangerous than commercial chemical compounds (Guiamet & al. 2008; Afifi 2012; Sasso & al. 2013; Fierascu & al. 2014; Stupar & al. 2014; Borrego & al. 2016; Rotolo & al. 2016).

Performing *in vitro* agar diffusion disc method, different antimicrobial effects of EOs and Controls solutions were defined against *Bacillus* sp. p.l, *Alternaria* sp. and *Aspergillus* sp. colonies, basing on inhibition-halo diameter (Tab.1)

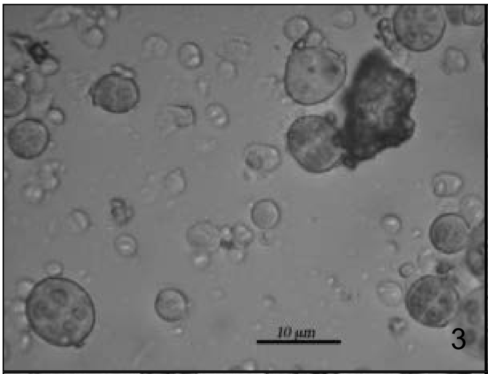
Particularly, *in vitro* assays highlight a stronger antimicrobial activity EOs, as showed in Fig.7a, per *Oregano* solutions (50, 25. 12,5%) *versus Bacillus* sp., compared to the activity of commercial biocide Benzalkonium Chloride solutions (100, 6.25%), showed in fig. 7b.

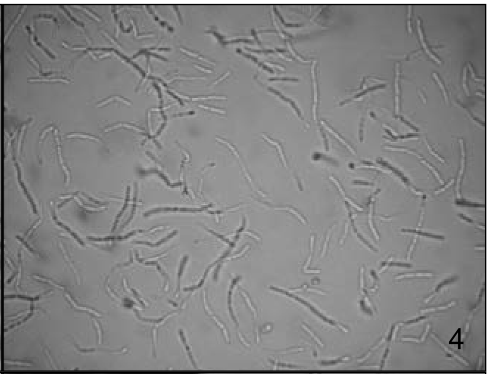
Fig. 2. Pigmented *biofilm* revealed below the mosaic tesserae in some area of the Leda’s house *peristyle*.

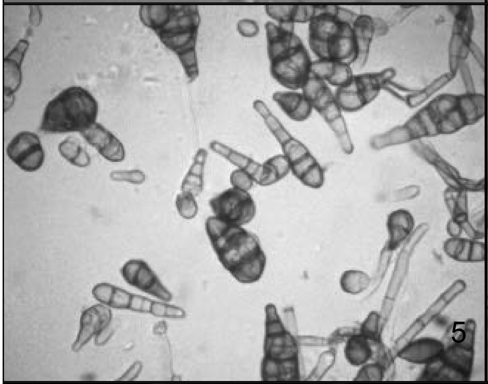
Similar strength is showed by *Oregano* solutions (100, 12.5%) vs *Aspergillus* sp. (Fig. 8a) and *Alternaria* sp. (Fig. 8b) colonies, significantly greater comparing the inhibition halo produced by 12.5% Benzalkonium Chloride solution against *Aspergillus* sp. (Fig. 9a) and *Alternaria* sp. (Fig. 9b).

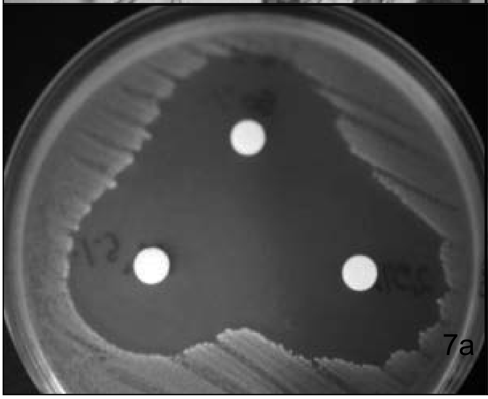
The *ex situ* assays were performed exposing the mosaic-colonized tesserae to the volatile compounds of *Oregano* or *Thyme* EOs, analysing the biofilm after 7 days (will be assessed up one year). As showed in Fig. 10, a different pigmentation can be distinguished between control (D = no-biocidal compound) and treated samples (A= Biotin-R; B= Thyme-EO=; C= Oregano-EO), allowing us to hypothesize that the lack of green pigmentation is related to the reducing in biofilm photosynthetic activity; related Fluorescent Microscope observations performed by Zeiss-Axioskop 2-Plus, are showed in Fig. 11. It is evident only a background of fluorescence in treated samples A, B, C, while defined biological structures are evident in no-treated sample D.

Finally, *in situ* tests were performed injecting below the tesserae, *Oregano* or *Thyme* EOs solutions (100, 50, 15%), through the interstitial space. As showed in Fig. 12, a clear effect on biofilm was revealed for the 15% *Thyme* EO solution, concentrically diffused









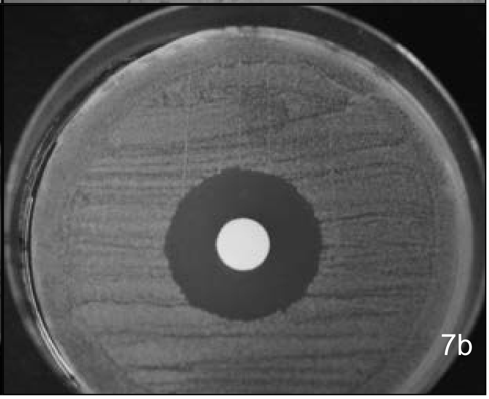


Fig. 3. *Chlorella* sp. colonies observed by Optical Microscope (Leica, 40× magnification).

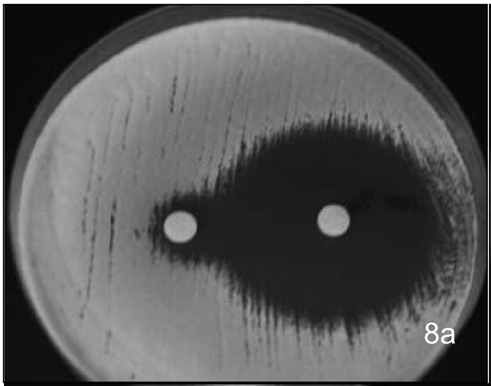
Fig. 4. *Bacillus* sp. bacterial cells observed by Optical Microscope (Leica, 40× magnification).

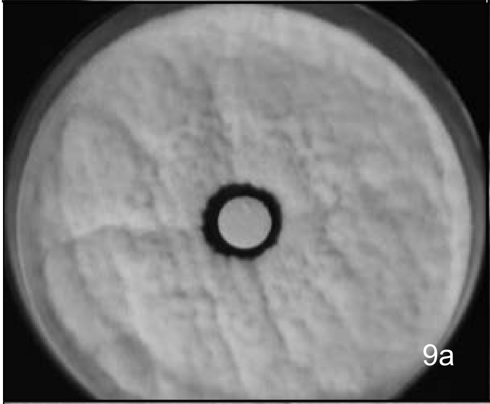
Fig. 5. *Alternaria* sp. spore structure, observed by Optical Microscope (Leica, 40× magnification), after Lugol's staining.

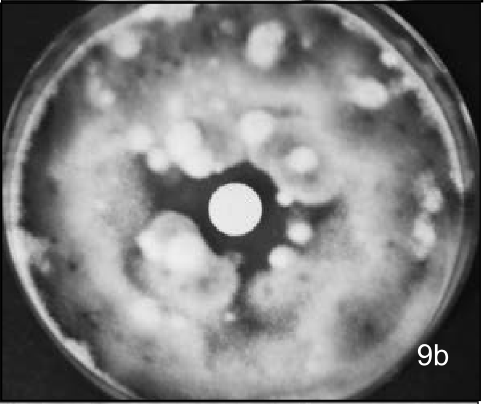
Fig. 6. *Aspergillus* sp. conidiophores and spore structures, observed by OM (Leica, 40× magnification), after Lugol's staining.

Fig. 7a. Antimicrobial activity of *Oregano* solutions (50.0, 25.0, 12.5%) *versus Bacillus* sp., the confluent inhibition halos prove a strong activity of EO.

Fig.7b. Antimicrobial activity of the commercial biocide, Benzalkonium Chloride (6.25%) solution, a confluent inhibition halo is show.







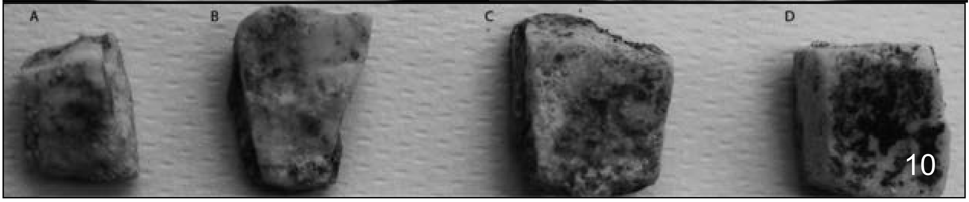


Fig. 8a. Inhibition halo produced by *Oregano* solutions (100, 6.25%) vs *Aspergillus* sp.
Fig. 8b. Inhibition halo produced by *Oregano* solutions (100, 6.25%) vs *Alternaria* sp.
Fig. 9a. Inhibition halo produced by 6.25% Benzalkonium Chloride solution against *Aspergillus* sp.
Fig. 9b. Inhibition halo produced by 6.25% Benzalkonium Chloride solution against *Alternaria* sp.
Fig. 10. *Ex situ* assays. Effect of volatile compounds of Oregano or Thyme EOs, after 7 days of exposure, on the biofilm of mosaic-colonized tesserae: A= Biotin-R (commercial biocide); B= Thyme-EO; C= Oregano-EO; D= no-biocidal compound.

with respect to the injection point (highlighted as red line). Particularly, the biofilm came in contact with the EO solution showed a loss in pigmentation, while a vital green colour is still present in the portion not reached by the oil solution (pointed by a red asterisk). Instead, the 15% *Oregano* OE treatment does not show similar effect, may be related to the presence of inhibitory substances in the completely degraded bedding mortar.

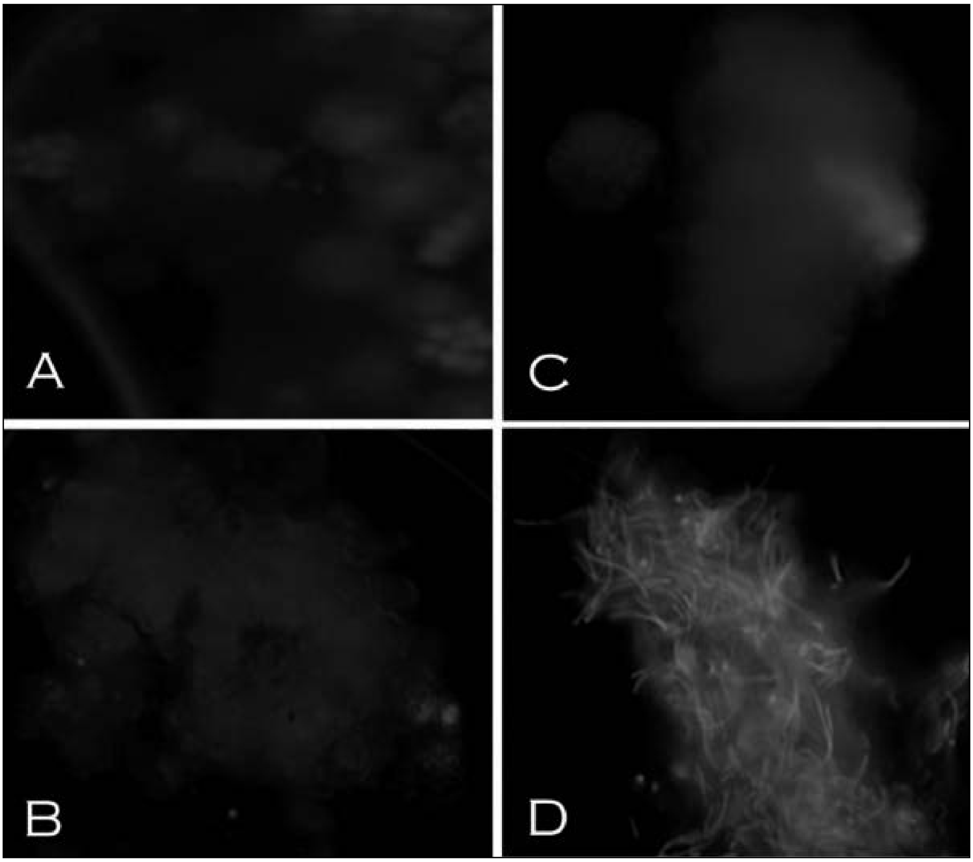


Fig. 11. *Ex situ* assays. The lack of biofilm photosynthetic activity, observed by Zeiss-Axioskop 2-Plus Fluorescent Microscope observations. Corresponding to Fig.10 samples: A= Biotin-R (commercial biocide); B= Thyme-EO; C= Oregano-EO; D= no-biocidal compound (40× magnification).

Discussions and Conclusions

The rich distribution of archaeological assets in the Mediterranean basin, their cultural, artistic, religious significance and high social impact, highlight the requirement of dedicated conservation strategies. The identification of the different factors (biological, chemical, physical) able to induce structural and compositional changes (Warscheid 2000) is of fundamental importance in defining suitable fruition, maintenance and conservation policies.

The role played by micro-organisms in the processes of cultural heritage deterioration (biodeterioration) has been widely demonstrated: growth, development and metabolic activities can bring physical-chemical and aesthetic damage to works of art, inducing negative consequences for their conservation (Fort & al. 2006).

Many species of microorganisms (bacteria, fungi, unicellular algae) can find favourable conditions for their development both on statues and monumental works and on archaeo-

Fig. 12. *In situ* assays. Mosaic tesserae after treatment with 15% *Thyme* solution, concentrically diffused with respect to the injection point (highlighted as red line), a lost in pigmentation is clearly recognizable. A vital green colour is still present in the portion not reached (pointed by an asterisk).

logical remains (Kovacik 2000), as the mosaic tesserae of "Casa di Leda" - Greco - Roman Solunto archaeological site park, Sicily.

Particularly, a thick *biofilm* inducing a deep alteration of mortar and consequently the mosaic tesserae detachment has been identified during the restoration activities.

The *biofilm* has been characterized through optical microscopy, *in vitro* culture and molecular biology techniques, allowing the identification of microbial *taxa* as *Bacillus* sp., *Alternaria* sp., *Aspergillus* sp., as well as cyanobacteria, *Chroococcus* sp. and green algae, *Chlorella* sp. These microorganisms are considered biodeteriogens, able to induce precipitation of mineral crystals or promoting pH changes, causing damage on stonework surface (Sanchez-Moral & al. 2003; Albertano & al. 2003).

In this study new biocompatible products to control *biofilm* growth have been also assessed, evaluating the antimicrobial activity of two commercial essential oils, *Origanum vulgare* and *Thymus vulgaris*.

Table 1. *Agar disc diffusion* method. Average inhibition halo diameter (mm) of EOs (*O. vulgare*, *T. vulgaris*) Antimicrobial activity: Positive ≥ 9 mm; Moderate: 6 - 9 mm; Negative ≤ 6mm; *total growth inhibition. Benzalkonium chloride + chlorhexidine and Ethanol solutions were the controls.

Essential olis	Conc. (%)	*Bacillus* sp. pl.	*Alternaria* sp.	*Aspergillus* sp.
Origanum vulgare	100	*	60	50
	50.0	42	49	45
	25.0	40	48	46
	12.5	39	38	35
	6.25	28	16	16
Thymus vulgaris	100	*	*	*
	50.0	*	*	*
	25.0	*	*	*
	12.5	48	*	*
	6.25	30	36	32
Benzalkonium chloride + chloroexidine	0.2% (vol/vol)	12	6	8
Ethanol	70%	3	1	1

The results of *agar disc diffusion* assays are summarized in Table 1, showing a strong antimicrobial activity of both essential oils against bacterial and fungal colonies, consistent with the dedicated literature (Reichling & al. 2009; Stupar & al. 2014; Casiglia & al. 2015), although little is known about the permanence and application methods of EOs (Salem & al. 2014; Noshyutta & al. 2016).

In this case study *Origanum vulgare* and *Thymus vulgari*s EOs solution (100, 50, 15 %) have been tested *in situ*, on mosaic tesserae of "Casa di Leda", after seven days of application.

Particularly, *Thymus vulgari*s 15% EO solution has proven to be the best diffused, strongly influencing the *biofilm* liveliness (Fig. 12).

Although further studies are needed to set up a standard protocol, according to these and previously result (Rotolo & al. 2016, 2017), we hypothesize the use of OEs to contrast microbial colonization, representing valid alternatives to traditional biocides, without negative environmental impacts and respecting the human health, in accordance with modern restoration strategies.

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From ethnobotany to experimental research: the therapeutic properties of Sicilian hellebore

Abstract

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The Sicilian hellebore (*Helleborus bocconei* subsp. *intermedius*) is an endemic plant of the family *Ranunculaceae* from southern Italy and Sicily. This plant is known for the traditional use of dried rhizomes for treating pneumonia in domestic animals, cattle and horses in particular. In recent years, this plant was subject to various ethnobotanical, phytochemical, morpho-anatomical and mycological investigations. In addition, lately, was evaluated antibacterial activity of *Chaetomium strumarium* strain RR1, an endophytic ascomycete of this plant.
On the whole, the different phases of this study are here reported and can be interrelated. However, they support our initial hypothesis, that the therapeutic effect of the hellebore's rhizomes extract is due to metabolites reputedly produced by an endophytic fungus.

Key words: *Helleborus bocconei* subsp. *intermedius*, *Ranunculaceae*, endemic plant, endophytic fungi, folk veterinary medicine, pneumonia.

Introduction

Nowadays, the main objective of ethnobotany is to document traditional knowledge about plants before it disappears and to explore and preserve the heritage of the folk medicine (Cámara-Leret & al. 2014). On the basis of the documentation of indigenous knowledge on the folk use of plants, in some countries ethnobotanical surveys have been used for the discovery of new drugs. The further development of these phytotherapeutical resources comes just from the experimental research.

The biological and ethnopharmacobotanical study on Sicilian hellebore can also be seen in this context (Spadaro 2006).

The medicinal properties and the toxic effects of some species of the genus *Helleborus* L. were pointed out by different authors. In Sicily, according Pignatti (1982), the genus *Helleborus* (*Ranuculaceae*) is only represented by *H. bocconei* subsp. *siculus* (Schiffner)

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Merxm. & Podl [= *Helleborus bocconei* subsp. *intermedius* (Guss.) Greuter & Burdet], commonly known as Sicilian hellebore or “radicchia”. In some mountainous areas of the Island, the rhizomes of this plant, harvested in a particular month of the year (May) and dried, are used in traditional veterinary practice for treating pneumonia in domestic animals, cattle and horses in particular (Raimondo & Lentini 1990). The same use – with rhizomes of other *Helleborus* species or subspecies – is reported from various other areas of Mediterranean Europe (Viegi & al. 2003).

According to the traditional knowledge on this medicinal remedy in some rural communities, it was considered appropriate to carry out experimental researches on *H. bocconei* subsp. *intermedius* from Sicily in order to highlight the therapeutic effect on which is based the local use of the hellebore’s dried rhizomes in the folk veterinary medicine for treating pneumonia in domestic animals.

Materials and methods

This study is referred to *H. bocconei* subsp. *intermedius* (Fig.1) and subsequently to *Chaetomium strumarium* (J. N. Rai, J. P. Tewari & Mukerji) P. F. Cannon RR1 (Fig. 2).

The examined materials were collected in different seasons, between April and September 2010, in the locality Grotta del Garrone, near Monte Pizzuta (Piana degli

Fig. 1. *Helleborus bocconei* subsp. *intermedius* in the locality Grotta del Garrone (Piana degli Albanesi, Palermo).

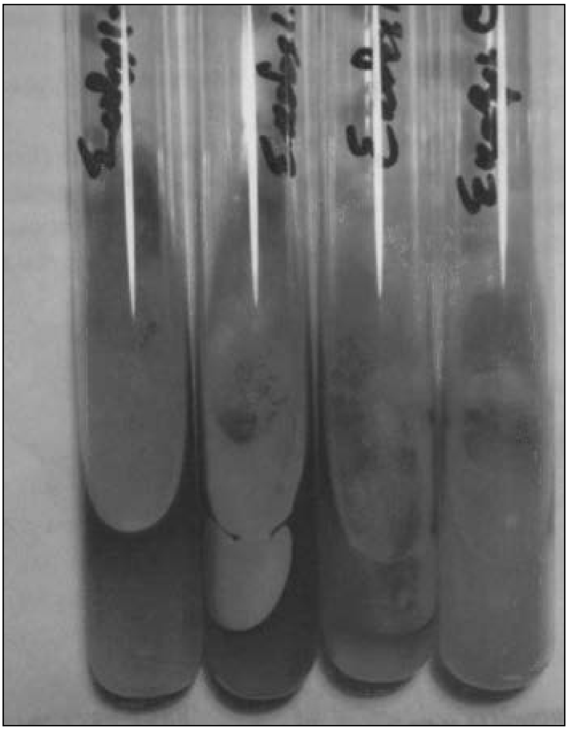

Fig. 2. *Chaetomium strumarium* strain RR1: colony on Mycological agar.

Albanesi, Palermo). A voucher specimen (No. 3/10) is kept in PAL (Spadaro & al. 2014).

C. strumarium RR1, an endophytic fungus, was isolated from different organs (root, rhizome, stem and leaf) of *H. bocconei* subsp. *intermedius* with surface-sterilizing method (Bayman & al. 1997). Molecular characterization of the strain RR1 endophyte, a non-sporulating fungus, based on the internal transcribed spacer (ITS) region of the rRNA gene sequences was done (Spadaro & al. 2014).

This microfungus maintained as stock culture was utilized in the antibiotic property assays. The strain was maintained in Czapek-Dox Agar (DIFCO) plate at 27°C and transferred to a new medium at 15 days intervals.

Results and discussion

The results of the various investigations have been extremily promising. Phytochemical tests have permitted the isolation and characterization of new biologically active molecules; in particular, two new furostanol saponins helleboroside A and helleboroside B were isolated from the hellebore's rhizomes methanolic extract along with the furospirostanol saponin and two ecdysones: ecdysterone and polypodyne B (Spadaro 2006; Rosselli & al. 2006). The extracts of rhizomes and aerial parts of the plant showed antibacterial properties (Rosselli & al. 2007). Some compounds, specifically furostanol saponins and ecdysones, isolated from the methanolic extract of the rhizomes, were tested against rat C6 glioma cells showing a significant cytotoxicity (Rosselli & al. 2009). Additional, morpho-anatomical studies have revealed the presence of different endophytic and commensal fungi in all organs of the plant (Fig. 3), which could be isolated and cultured. One of the isolates has been identified as the endophytic fungus *Ciborinia allii* (Sawada) L. M. Kohn (sub: *Botrytis byssoidea* J. C. Walker), which is also widely present in soil (Spadaro & al. 2007). Further fungal isolates include *C. strumarium,* strain RR1*,* an endophytic ascomycete the identity of which was confirmed by molecular analyses (Spadaro & al. 2014). This endophyte was constantly found and - by preliminary antibiosis assays - has a remarkable antibacterial activity not on a single species but on the complex of species commonly present in soil (Spadaro & al. 2011). When cultured, it developed plentifully; in Mycological agar, the development of RR1 strain is rapid, tumultuous, perfectly centrifugal. RR1 endophyte produced only sterile mycelium and was not taxonomically identifiable by morphological study. To obtain sporulation different media were utilized PDA, CYA and MEA 2%. No sexual or asexual reproductive structures were observed; in MEA 2% cultures up to 90 days old, some pseudoparenchymatous hyphal aggregations cleistotecial-like, were observed. For taxonomic attribution the strain was subjected to the molecular analysis of ITS region (Spadaro & al. 2014). Recently, the filtered broth from these cultures was used in antibiotic property assays (Spadaro & al. 2011); the tests were positive. In recent literature (Ranadive & al. 2013), *C. strumarium* is reported among the fungi with antimicrobial activity.

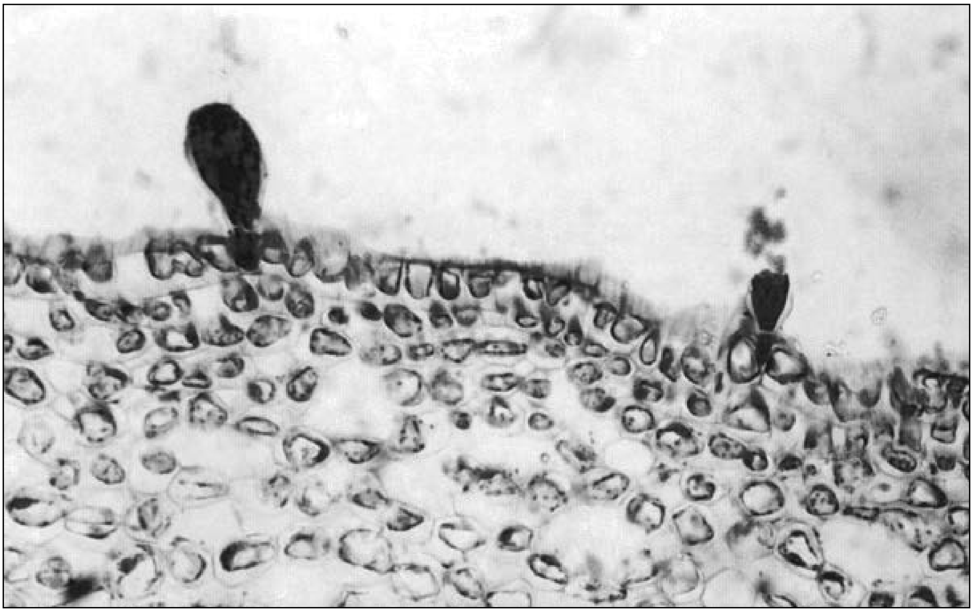

Fig. 3. Detail of cross section of floral peduncle of *Helleborus bocconei* subsp. *intermedius* (×200) highlighting pseudoparenchymatous hyphal aggregations of the endophyte.

Conclusions

As evidenced by the results, this study was particularly stimulating for significant elements of biological and ethnopharmacobotanical importance. Firstly, it is very important the relationship between endophytic microorganisms and Sicilian Hellebore in order to explain the traditional use of dried rhyzomes of *H. bocconei* subsp. *intermedius* in the veterinary treatment of pneumonia in domestic animals. According to these findings and considering the importance of endophytic microorganisms as sources of new biologically active molecules, further mycological analyses of *H. bocconei* subsp. *intermedius* from Sicily are considered advisable (Spadaro & al. 2014).

Particular attention was given to the antibacterial activity of *C. strumarium* strain RR1, one of the endophytic microfungi isolated from this plant and resulted recurrent in the subsequent isolations. In fact, this interesting endophyte grows in the living tissues of the host plant and therefore. we studied the mycelium development and tested the antibacterial activity. The filtered broth from these cultures was used in antibiotic property assays. The tests were positive; the detailed results are forthcoming. They support our initial hypothesis, that the therapeutic effect of the hellebore's rhizome extract is due to metabolites produced by an endophytic fungus. This phenomenon appears particularly relevant and could explain the antibacterial activity of the plant in the folk veterinary medicine.

It remains to be seen whether the plant itself, devoid of the microfungus, produces the same therapeutically effective metabolites that are present in the extracts of plants from the wild or from outdoor cultivation. The study of the Sicilian hellebore, beyond its biological interest, has potential for its relevance for therapeutic applications both in veterinary and human medicine.

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Fungi in archaeological areas*

Abstract

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This review include the data concerning the presence of representations of fungi since prehistoric times. Particular attention is paid to their use in magical rituals, in nutrition and as a remedy for certain diseases. The work also examines some examples of megaliths whose shape recalls that of a mushroom, and the role of mushrooms in anthracological studies. Finally, data on the presence of mushrooms, some of them rare, of reforested areas and residual dune systems within the Archaeological Park of Selinunte are reported.

Key words: archaeology, anthracology, human diet, Selinunte, Sicily.

Introduction

Since prehistoric times, man has always been attracted to fungi (Karg & al. 2012), which he considered both magic elements of nature (Akers & al. 2011), a source of food (Cheung 2008) and, a remedy for various diseases (Wilford 1998).

Fungi has been also involved in ancient religious beliefs, sickness and health, religion and war. The Roman emperor Claudius was murdered, by his wife Agrippina, by poisonous mushrooms of the genus *Amanita* Pers. The fungi were also considered by some cultures as the rottenness of life while for others they were a delicious food (Bertelsen 2013). The ancient Egyptians as plants of immortality considered mushrooms, “a gift from the God Osiris” (Abdel-Azeem & al. 2016).

Many populations used mushrooms in rituals since they believed in their properties able to produce super human strength and to mitigate human fatigue (Geng & al. 2017) while Chinese culture has treasured mushrooms as a health food, an “elixir of life” (Valverde & al. 2015).

Even in the case of mushrooms, archaeological sites are an important reservoir of information (Santiago & al. 2016).

In this review paper is reported a summary of the information on the use of fungi in prehistory, anthracological research and, in ancient human diet. The presence of some interesting fungal cenosis in archaeological areas of Sicily (southern Italy) is also highlighted.

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Prehistoric use of mushrooms

Approximately 9000 years BC, the Saharan aboriginal tribes of North Africa used muhsrooms (possibly *Psilocybe mairei* Singer) in magic rituals (Samorini 1992). This is testified in stone paintings by mushroom head' depiction created by Sandawe indigenous ethnic group of Tanzania and the rock art of Bradshaw in Western Australia (Pettigrew 2011).

In northeastern Siberia, Dikov (1971) discovered fungoid petroglyphs referred to the hallucinogic *Amanita muscaria* (L.) Lam. on rocks in the Pegtymel River region.

The Spanish mural in the municipality of Villar del Humo (Spain) depict a mushroom with pileus and stipe very similar to those of *P. hispanica* Guzmán (Guzmán 2012).

The ancient Greek drink "Kykeon", usually refers to a psychoactive compounded brew, also containing *Psilocybe* species, used at the climax of the Eleusinian Mysteries to break a sacred fast (Naples 2013). In the town of Eleusis (West Attica, Greece) there is a stele on which Persephone appears to be passing to Demeter an hallucinogenic mushroom (Wasson & al. 1978).

The native American cultures (Olmec, Zapotec, Maya and, Aztec) had symbols, statues and paintings which indicate that they consumed "teonanácatl" (*P. mexicana* R. Heim), especially during religious rituals, as a way to communicate with deities (Carod-Artal 2015). Also the tribes of Nahua, Mazatec, Mixtec were involved in mushroom use for similar reasons (Camporesi 1998).

Mushroom megaliths

Megalithic natural rock formations with the shape of mushrooms can be observed in the former regions of Macedonia, Anatolia and, Thrace. In some cases, these structures have been modified by human intervention to increase their fungal likeness (Spasova 2015). Mushrooms rock formation are also reported from Cappadocia (Turkey) (Sarikaya & al. 2015). The "stem" is constructed by limestone and volcanic ash, while the cap is of lahar or ignimbrite. The rocks are usually ornamented with carvings, paintings and, folkloric motifs which indicate the psychoactive activity of mushrooms (Guzmán 2008).

In the archaeological site of Aryannoor (Kerala, India), the megalithic monuments known as kuda-kallu resemble mushrooms or have a parasol-shape (Samorini 1995). In modern times, these forms were taken up by the German architect Jürgen Mayer, who designed the Metropol Parasol in Seville (Spain).

Fungi in anthracological research

The remains of wood charcoals from archaeological excavations and natural deposits are very useful tools for anthracological studies in several regions (Ludemann & Nelle 2015). The fungal hyphae can be preserved within the wood charcoal after the burning process (Schweingruber 1982).

A huge number of fungi, mainly belonging to the class *Basidiomycetes*, are responsible for wood degradation (Stamets 2005). The *Basidiomycetes*, some *Ascomycetes* and Imperfect fungi, can attack both Angiosperms and Gymnosperms, and can even decompose the heartwood of living conifers (Moskal-del Hoyo 2010). Brown-rot, white-rot, and soft-rot fungi are responsible of wood decay and cause different types of morphological changes in branches (Xu & Goodell 2001), logs and, stumps (Karadelev & al. 2017a, 2017b; Venturella 2017).

The analysis of the type of decay of wood is generally possible on the basis of morphological parameters but some difficulties may occur in the case of mixed decayed patterns. This is primarily due to the interactions that occur, especially in the case of *Basidiomycetes*, between the different fungal species that colonize the wood (Boddy 2000).

A wide diversity of soil bacterial, archaeal and, fungal communities were isolated from archaeological layers in Monte Iato settlement in Sicily (Siles & al. 2018).

Fungi in ancient human diet

Dried mushrooms formed part of the human diet of archaeological populations (O'Regan & al. 2016) while Hamilton & al. (2009) reported a rare example of mushrooms-based diet in pigs during the Neolithic.

The use of mushrooms by Greek, Egyptian, Roman, Chinese, and, Mexican civilizations in diets and health has been documented throughout human history (Gargano & al. 2017). Egyptian pharaohs considered mushrooms to be food reserved only for royalty; common people were not allowed to touch them (Abdel-Azeem & al. 2016). There is clear evidence that mushrooms were used as food by hunter-gatherers in the Palaeolithic. Micro remains recognized as bolete mushrooms (*Boletus* sp. pl.) were found in a human dental calculus in the El Mirón cave in Spain (Power & al. 2015).

The well- preserved Iceman Ötzi or Similaun Mummy from the Chalcolithic Europe (3500 - 1700 BC) carried, among the numerous items of his equipment, a "Black Matter" prepared from *Fomes fomentarius* (L.) Fr. and two objects on the leather thongs as fragments of *Fomitopsis betulina* (Bull.) B.K. Cui, M.L. Han & Y.C. Dai (Peintner & al. 1998). Ötzi certainly benefited from the antibacterial, anti-parasitic, antiviral, anti-inflammatory, anticancer, neuroprotective, and immunomodulating properties of *F. betulina* (Pleszczyńska & al. 2017). In particular, Ötzi used the medicinal mushrooms against whipworm (*Trichuris trichiura* L., 1771) infections and to purge his bowels (Dickson & al. 2000). The use of *F. betulina* as a laxative by prehistoric peoples living in Northern Europe is also reported by Wilford (1998).

Fungi in the Archaeological Park of Selinunte

The Archaelogical Park of Selinunte (S.-W. Sicily) is included in the SIC (Sites of Community Interest) named "Dunal system Capo Granitola, Porto Palo e Foce del Belice" (code ITA010011) (La Rosa & al. 2007). The area is characterized by a dunal system, wetlands, reforestations with *Pinus halepensis* Mill. and *Eucalyptus camaldulensis* Dehnh, evergreen sclerophyllous vegetation with a prevalence of *Pistacia lentiscus* L. and maquis dominated by *Anagyris foetida* L. with scattered woods of *Quercus calliprinos* Webb.

In the conifers wood there is a prevalence of very common mycorrhizal species such as *Amanita ovoidea* (Bull.) Link, *Neoboletus erythropus* (Pers.) C. Hahn, *Suillellus queletii* (Schulzer) Vizzini, Simonini & Gelardi, *Suillus granulatus* (L.) Roussel and, *S. collinitus* (Fr.) Kuntze, saprotrophs [*Agaricus silvicolae-similis* Bohus & Locsmándi, *A. xanthodermus* var. *xanthodermus* Genev., *Clitopaxillus alexandri* (Gillet) G. Moreno, Vizzini, Consiglio & P. Alvarado, *Gymnopus dryophilus* (Bull.) Murrill], and parasitic [*Chroogomphus rutilus* (Schaeff.) O. K. Mill.].

The reafforestation of *E. camaldulensis* wood hosts a very interesting and infrequent species, *Lyophyllum buxeum* (Maire) Singer, which is located near the coast on sandy substrates.

As far as mycorrhizal species are concerned, as already noted by Venturella & Gargano (2008), the ecological characteristics of the Mediterranean area prevent eucalyptus plants from maintaining the same number of mycorrhizal species as those found in the coastal areas of Australia.

In the sandy coastal areas, where the Mediterranean scrub vegetation is present with a prevalence of *P. lentiscus*, we can observe *Battarrea phalloides* (Dicks.) Pers., a species typical of dry, sandy localities, sunny edges, and in clearings of different types of decidous, mixed, and coniferous woodlands (Lantieri & al. 2009) which is included in Armenia, Austria, Czech Republic, France, Germany, Hungary, FYR Macedonia, Poland, Serbia, Spain, and, UK Red Lists.

The presence of *B. phalloides* along the sandy coasts of southern Sicily confirms the mycological affinities between these areas and similar environments of the coasts of North Africa and Tunisia in particular (Ouali & al. 2018).

A few number of basidiomata of *Xerula mediterranea* (Pacioni & Lalli) Quadr. & Lunghini were collected in the rear dunes characterized by vegetation belonging to *Crucianelletalia maritimae* Sissing 1974.

Discussion and Conclusions

In conclusion, it can be said that mushrooms accompany man in his evolution. They contribute at various levels to the historical reconstruction of events that occurred in archaeological sites. Their presence on various substrates confirms the high diversity of these organisms, which represent the largest group present in nature after insects.

In the case of the Archaeological Park of Selinunte, since the mushrooms are mainly located near the residual dune systems, it is necessary to strengthen the actions of protection and conservation of these habitats in order to preserve their integrity and trying to put a stop to the progressive anthropization and erosion. The actions to be taken for the protection of the wooded areas inside the archaeological sites are also necessary because, although they are mainly represented by exotic species, they host a rich contingent of fungal species, some of which are infrequent.

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New additions to the exotic vascular flora of continental Portugal

AbstractNew additions to the exotic vascular flora of continental Portugal

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In this paper, based on mainly recent bibliography and some own field observations, 105 more taxa (neophytes) are added to the catalogue of the exotic (or xenophytic) naturalized or subspontaneous vascular flora of continental Portugal, which includes now 772 taxa (species, subspecies, varieties and hybrids), a growth corresponding to more than 15 % of the previous total number of 667 taxa, since our last reassessment, published in 2012 (Almeida & Freitas 2012), and our earlier surveys (Almeida & Freitas 2006; Almeida 1999).

Key words: Continental Portugal; exotic species; naturalized flora; neophytes; subspontaneous flora; vascular plants; xenophytes.

Introduction

After studying this subject for more than twenty years (since 1996), and given the importance of this kind of checklist, I thought it would be a good idea to update the list of the xenophytic flora of continental Portugal.

At the present time (2018), I conclude that the exotic naturalized or subspontaneous flora of continental Portugal includes now at least 772 neophytic taxa (species, subspecies, varieties and hybrids), 272 more than the number of 500 taxa attained at our original work on this theme (Almeida 1999).

As we have written before (Almeida & Freitas 2000; Almeida & Freitas 2001; Almeida & Freitas 2012), the expansion of exotic invasive plants is threatening the Portuguese native flora, representing a severe environmental problem, as it happens in many other parts of the World.

More than 100 years ago, Professor Robert Chodat already noticed: «C’est une des caractéristiques du Portugal que la grande abondance de mauvaises herbes d’origine étrangère» (Chodat 1913).

And, more recently, as Professor Werner Greuter so eloquently said: «Portugal has the reputation of being particularly “rich” in aggressive alien plants and that reputation is fully confirmed (...). From *Eucalyptus* to *Carpobrotus*, many naturalized exotics work together in putting the country’s rich native flora at risk» (Greuter 2002).

Materials and methods

The species are arranged in alphabetic order. Classification used in this paper follows modern concepts: APG III (2009) and APG IV (2016) for the delimitation of families, Flora Iberica (Castroviejo & al., 1986–2019) for the majority of taxa, Greuter & von Raab-Straube (2006+, 2008), for the family *Compositae* (*Asteraceae*), and Tutin & al. (1980) for the family *Gramineae* (*Poaceae*). Ecological classification of the referred taxa follows Kornas (1990). Phytotypes or plant life-forms are given according to Raunkiaer classification (1934).

These 105 new taxa are mainly from recent (or ancient, in some cases) bibliographic references, but also from observations in the field and personal communications, and represent an increment of more than 15 % to the exotic flora of continental Portugal, since our last survey (667 taxa), published in 2012 (Almeida & Freitas 2012).

These 772 exotic taxa represent more than 20 % (more than one fifth) of the total number of taxa of the continental Portuguese vascular flora, which includes about 3800 taxa (species, subspecies, varieties and hybrids), according to our recent estimations (Almeida 2009; Almeida & Freitas 2012).

Results

1. ***Acer campestre*** L. (*Sapindaceae*)
Phanerophyte, from Eurasia, subspontaneous in Portugal: Beira Litoral, probably introduced in an accidental way, as an ornamental or for soil protection (Sánchez Gómez & Güemes 2015).

2. ***Adiantum raddianum*** C. Presl (*Pteridaceae*)
Hemicryptophyte, from Tropical America (Franco & Rocha Afonso 1971); epoecophyte, recently (2015) found naturalized in walls in Sintra, in the Portuguese province of Estremadura (Sánchez Gullón & al. 2017); already cited for continental Portugal by A. Lawalrée, revised by J. R. Akeroyd & A. M. Paul (1993) and by Christenhusz & von Raab-Straub (2013).

3. ***Aeonium arboreum*** (L.) Webb & Berthel. subsp. ***holochrysum*** (H.-Y. Liu) Bañares (= *Aeonium arboreum* (L.) Webb & Berthel. var. *holochrysum* H.-Y. Liu) (*Crassulaceae*)
Chamephyte or phanerophyte, from Macaronesia: Canary Islands; epoecophyte or diaphyte, introduced as an ornamental species, found subspontaneous at Estremadura: Setúbal, Portinho da Arrábida, for the first time in 1971 by A.R. Pinto da Silva, A.N. Teles and M.H. Ramos Lopes (Silva & al. 2015a; Silva & al. 2015b).

4. ***Agapanthus praecox*** Willd. sensu lato (*Amaryllidaceae*)
Geophyte, from South Africa; diaphyte, subspontaneous as a garden escape: Beira Litoral (Coimbra, 10.VII.1998, J.D. de Almeida 6, COI; own observ. & photos).

5. ***Agave americana*** L. var. ***marginata*** Trel. (*Amaryllidaceae*)
Hemicryptophyte, from North America; epoecophyte, escaped from ornamental culture,

naturalized in central and Southern Portugal: Algarve (Smith & Figueiredo 2007; Silva & al. 2015b).

6. ***Agave americana*** L. subsp. ***americana*** × ***Agave salmiana*** Otto ex Salm-Dyck var. ***salmiana*** (*Amaryllidaceae*)
Hemicryptophyte, of hybrid origin; epoecophyte, escaped from ornamental culture, naturalized in Southern Portugal: Algarve (Smith & Figueiredo 2007).

7. ***Ageratina ligustrina*** (DC.) R. M. King & H. Robinson (= *Eupatorium ligustrinum* DC.) (*Asteraceae*)
Phanerophyte; diaphyte, probably, from North America, recently (2015) found naturalized in Portugal: Sintra (province of Estremadura) (Sánchez Gullón & al. 2017).

8. ***Ageratina riparia*** (Regel) R. M. King & H. Robinson (= *Eupatorium riparium* Regel) (*Asteraceae*)
Hemicryptophyte; diaphyte, probably, from North America, recently (2017) found naturalized in Portugal: Sintra (province of Estremadura) (Sánchez Gullón & al. 2017).

9. ***Alisma gramineum*** Lejeune (*Alismataceae*)
Helophyte or Hydrophyte, from the Holoarctic Region; ephemerophyte or arvense epoecophyte, collected by F.C. Fontes, ca. 1955, in the ricefields of Coruche, province of Ribatejo (Talavera & Balao 2010).

10. ***Alocasia macrorrhizos*** (L.) G. Don (= *Arum macrorrhizon* L.) (*Araceae*)
Cryptophyte (geophyte); maybe an agriophyte, probably introduced as an ornamental plant, recently (2015) found in three localities of the littoral provinces of Beira Litoral and Douro Litoral (Verloove & Alves 2016).

11. ***Araucaria columnaris*** (G. Forst.) Hook. (= *Cupressus columnaris* G. Forster) (*Araucariaceae*)
Phanerophyte, from New Caledonia; epoecophyte, commonly cultivated in Portugal with natural regeneration (Franco 1943).

12. ***Artemisia arborescens*** L. (*Asteraceae*)
Phanerophyte, from the Mediterranean Region; agriophyte, already cited for several provinces of continental Portugal by Brotero (1804) and Mariz (1894), recently considered as an exotic species in the Iberian Peninsula by Benedí (2019).

13. ***Azolla cristata*** Kaulf. (*Azollaceae*)
Hydrophyte, from North America; agriophyte, naturalized in Portugal at least since 1920 (Pinto da Silva 1940; Vasconcellos 1940; Pinto da Silva & Rainha 1948; Reed 1962; Almeida 1986; Lawalrée & Jermy 1993; Christenhusz & von Raab-Straub 2013).

14. ***Baccharis spicata*** (Lam.) Baillon (= *Eupatorium spicatum* Lam.) (*Asteraceae*)
Phanerophyte, from South America; agriophyte, recently (2015) found naturalized in

Portugal, in the province of Douro Litoral (Plantas invasoras em Portugal 2017a; Verloove & al. 2017).

15. ***Campsis grandiflora*** (Thunb.) Schumann (= *Bignonia grandiflora* Thunb. = Tecoma *grandiflora* (Thunb.) Loisel.) (*Bignoniaceae*)
Phanerophyte, from Eurasia: China; diaphyte, subspontaneous in Beira Litoral: Coimbra (IX.2015, own observ. and photos) and Douro Litoral: Maia (2012, 2014, C.M. Silva, pers. comm.).

16. ***Cardamine oculta*** Hornem. (*Brassicaceae*)
Hemicryptophyte, from Asia, naturalized in many countries of Western Europe and the Western Mediterranean Region (Marhold 2009), recently found in Portugal (2011) in three littoral provinces: Beira Litoral, Douro Litoral and Minho (Verloove & Alves 2016).

17. ***Carthamus creticus*** L. (*Asteraceae*)
Therophyte, from the Mediterranean Region, endemic Mediterranean species, rarelly introduced in continental Portugal (López González 2014).

18. ***Carthamus lanatus*** L. (*Asteraceae*)
Therophyte, from the Mediterranean Region, endemic Mediterranean species, introduced in continental Portugal (López González 2014).

19. ***Casuarina cunninghamiana*** Miq. (*Casuarinaceae*)
Phanerophyte, from Australia; cultivated in Portuguese gardens and streets and rarely naturalized some provinces of continental Portugal: Alto Alentejo, Beira Litoral, Estremadura (Rocha Afonso 1990).

20. ***Casuarina stricta*** Aiton (*Casuarinaceae*)
Phanerophyte, from Australia; cultivated in Portuguese gardens and streets and rarely naturalized some provinces of continental Portugal: Algarve, Beira Litoral, Estremadura (Rocha Afonso 1990).

21. ***Cenchrus clandestinus*** (Chiov.) Morrone (= *Pennisetum clandestinum* Chiov.) (*Poaceae*)
Rhizomatous hemicryptophyte; diaphyte, recently (2015) found as a casual plant in a lawn at the province of Beira Litoral (Verloove & Alves 2016)

22. ***Centaurea solstitialis*** L. s. l. (*Asteraceae*)
Diaphyte; Therophye or Hemicriptophyte, from the Mediterranean Region; diaphyte, escaped from cultivation at the Botanical Garden of the University of Coimbra (Beira Litoral) (VII.2012, own observ. and photos).

23. ***Chaenomeles japonica*** (Thunb.) Lindley (*Rosaceae*)
Phanerophyte, from Eurasia; epoecophyte, introduced as an ornamental species, abundantly found in fruit, naturalized at Beira Litoral: Cantanhede (IX.2015, own observ. & photos).

24. ***Chlorophytum comosum*** (Thunb.) Jacques (*Asparagaceae*)
Geophyte, from Tropical and Southern Africa; epoecophyte, introduced as an ornamental species, was found forming a well-established population at Beira Litoral: Figueira da Foz, Quiaios, flowering near the margin of Lagoa das Braças (XI.2015, own observ. & photos).

25. ***Cichorium endivia*** L. (*Asteraceae*)
Therophyte, possibly from Asia; diaphyte, largely cultivated in continental Portugal (Mariz 1894; Greuter 2006+), and sometime escaped from cultivation in three Portuguese provinces: Baixo Alentejo, Beira Litoral and Estremadura (Talavera & Talavera 2017).

26. ***Cirsium scabrum*** (Poir.) Bonnet & Barratte (*Asteraceae*)
Hemicryptophyte, from the Mediterranean Region; epoecophyte, casually introduced, found naturalized at Beira Litoral: Coimbra, since 2011 (Carapeto 2016).

27. ***Citrullus lanatus*** (Thunb.) Matsum. & Nakai (*Cucurbitaceae*)
Therophyte, from Africa (Mabberley 2008); diaphyte, introduced as an edible plant for its succulent fruits (watermelons), recently (2015) found escaped from cultivation in the province of Beira Litoral (Verloove & Alves 2016).

28. ***Cotyledon orbiculata*** L. (*Crassulaceae*)
Chamephyte, from South Africa; diaphyte or epoecophyte, introduced as an ornamental species, found at Estremadura: Cascais, Malveira da Serra, by V. Silva, VIII.2014 (Silva & al. 2015a).

29. ***Crassula campestris*** (Eckl. & Zeyh.) Endl. (*Crassulaceae*)
Therophyte, from South Africa; epoecophyte, casually introduced, found at Algarve: Vilamoura, 14.I.2007, by D.J. Nicolle (E.J. Clement in Verloove & Sánchez Gullón, 2008).

30. ***Crassula ovata*** (Miller) Druce (*Crassulaceae*)
Chamaephyte; diaphyte, introduced as an ornamental plant, found escaped from cultivation at Estremadura: Oeiras, 1999, with other *Crassulaceae* (VI.1999, own observ. & photos).

31. ***Crataegus azarolus*** L. (*Rosaceae*)
Phanerophyte, from the Eastern Mediterranean Region (Franco 1968: 77), found as a cultivated, naturalized or perhaps native species at several Spanish provinces (Muñoz Garmendia & al. 1998); shrubby ornamental plant, rarelly cultivated in Portugal, possibly subspontaneous – one only individual fructifying in an oakwood at Estremadura: Torres Novas (Jorge Capelo in Facebook 31.VIII.2014).

32. ***Cucurbita moschata*** Duchesne (*Cucurbitaceae*)
Therophyte, from America (Mabberley 2008); diaphyte, introduced as an alimentar and medicinal plant, recently (2015) found escaped from cultivation in the province of Beira Litoral (Verloove & Alves 2016).

33. ***Cyathea*** sp. (*Cyatheaceae*)
Phanerophyte, from the Tropics; diaphyte, subspontaneous or escaped from cultivation in Estremadura: Serra de Sintra: "Monserrate vs. Tapada das Roças, ad fossulis solo humoso humido sabuloso-granitico, 300 m s.m. (ASC 2315, 5 Set. 1985: LISU)" (Pinto da Silva & al. 1991, sub Alsophila sp.).

34. ***Cyclosorus dentatus*** (Forsskal) Ching (= *Christella dentata* (Forsskal) Brownsey & Jermy) (*Thelypteridaceae*)
Hemicryptophyte, from tropical and subtropical regions; ruderal diaphyte, found escaped from cultivation at Beira Litoral: Botanical Garden of the University of Coimbra, I.1999, XI.2010, V.2012, observations. This is a "vigorously growing species, readily propagated from spores, often establishing spontaneously in pots of other ferns" (Page & Bennel 1986).

35. ***Cyperus papyrus*** L. (*Cyperaceae*)
Geophyte, from Africa and the Mediterranean Region; epoecophyte, introduced as an ornamental species, was found forming a well-established population at Beira Litoral: Figueira da Foz, Quiaios, near the margin of Lagoa das Braças (XI.2015, A. C. Matos, pers. comm.); Sánchez Gullón & al. (2017) also indicate the very recent (2017) presence of this species in the Spanish province of Huelva.

36. ***Dahlia imperialis*** Ortgies (*Asteraceae*)
Tuberous geophyte, from Tropical America; diaphyte, with vegetative propagation, introduced as an ornamental plant in Beira Litoral: Coimbra, alt. ca. 80 m (IV.2015, XI.2015, own observ. & photos).

37. ***Digitaria ciliaris*** (Retz.) Koeler (= *Panicum ciliare* Retz.) (*Poaceae*)
Therophyte, from Temperate and Tropical Asia; epoecophyte, naturalized in Portugal in the province of Algarve at least since 1972 (Wilhalm 2009), also recently found in the province of Beira Litoral (Verloove & Alves 2016).

38. ***Digitaria violascens*** Link (*Poaceae*)
Hemicryptophyte, from Temperate and tropical Asia; epoecophyte, naturalized in Douro Litoral: Vila do Conde: Vairão; introduced at the Botanical Garden of Porto, now becoming an invasive species (P. Alves in Facebook 10.IX.2014); detected also in several other places in the provinces of Minho, Douro Litoral and Beira Litoral (Verloove & Alves 2016).

39. ***Egeria densa*** Planchon (*Hydrocharitaceae*)
Cryptophyte (Hydrophyte), from South America; agriophyte; This aquatic perennial herb was cited for continental Portugal: Minho by Marchante & al. (2014); found escaped from cultivation at Beira Litoral: Botanical Garden of the University of Coimbra, XI, 2010 (V.2012, own observ. & photos).

40. ***Elaeagnus angustifolia*** L. (*Elaeagnaceae*)
Phanerophyte, from Eurasia; agriophyte or epoecophyte, recently (2014) found naturalized in continental Portugal: Baixo Alentejo: Grândola, in secondary dunes (Carapeto 2016).

41. ***Eleocharis caduca*** (Delile) Schult. (*Cyperaceae*)
Hemicriptophyte, from Tropical Africa; agriophyte, naturalized in ricefields, dams, lakes and other wet places, at Beira Litoral, Estremadura (Verloove & Sánchez Gullón 2010).

42. ***Eragrostis barrelieri*** Daveau (*Poaceae*)
Therophyte, from the Mediterranean Region (Tutin 1980); agriophyte, probably, naturalized in Minho: Ponte de Lima, by the river Lima, where it was recently (2015) discovered (Verloove & Alves 2016).

43. ***Eragrostis mexicana*** (Hornem.) Link (*Poaceae*)
Hemicryptophyte; ruderal epoecophyte, naturalized at Alto Alentejo (Verloove & Sánchez Gullón 2012).

44. ***Euonymus japonicus*** Thunb. (*Celastraceae*)
Phanerophyte, from Japan (Mabberley 2008); diaphyte, introduced and widely cultivated as an ornamental shrub, recently (2015) found escaped from cultivation in the province of Beira Litoral: Praia da Barra (Verloove & Alves 2016).

45. ***Euryops chrysanthemoides*** (DC.) B. Nord. (*Asteraceae*)
Phanerophyte, from South Africa; diaphyte, introduced as an ornamental plant, recently (2015) found escaped from cultivation in the province of Beira Litoral (Verloove & Alves 2016).

46. ***Fallopia*** × ***bohemica*** (Chrtek & Chrtková) J. P. Bailey (*Polygonaceae*)
Epoecophyte, naturalized at Douro Litoral: Vairão (P. Alves in Facebook 2015).

47. ***Fraxinus excelsior*** L. subsp. ***excelsior*** (*Oleaceae*)
Phanerophyte, from Eurasia; diaphyte, found naturalized in Beira Alta: Trancoso (Sampaio 1936) and Trás-os-Montes e Alto Douro: Bragança (Aguiar 2000).

48. ***Fraxinus ornus*** L. (*Oleaceae*)
Phanerophyte, from Eurasia, recently found naturalized in Beira Alta (Andrés 2012).

49. ***Fuchsia boliviana*** Carrière (*Onagraceae*)
Phanerophyte, from South America, found naturalized in Estremadura: Sintra, at least since 2009, possibly as an ergasiophyte (Sánchez Gullón & al., 2017).

50. ***Geitonoplesium cymosum*** (R. Br.) R. Br. (*Asphodelaceae*)
Geophyte; ruderal diaphyte, found escaped from cultivation in Beira Litoral: Botanical Garden of the University of Coimbra, in a calcareous wall (VI.2013, II.2016, own observ. & photos).

51. ***Gnaphalium filagineum*** DC. (= *Gamochaeta filaginea* (DC.) Cabrera) (*Asteraceae*)
Therophyte; from South America (Argentina, Brasil and Uruguay), found naturalized in Estremadura, Costa da Caparica, between Almada and Sesimbra, VI.2010, as an epoecophyte (Sánchez Gullón & Verloove 2015).

52. ***Helianthus tuberosus*** L. (*Asteraceae*)
Cryptophyte (geophyte), from North America; agriophyte; This rhizomatous herb was recently (2015) found naturalized by the rivers Leça, Ferreira and Vouga, in the littoral provinces of Douro Litoral and Beira Litoral (Verloove & Alves 2016); also found present in the province of Beira Alta (Güemes 2019).

53. ***Jacaranda mimosifolia*** D. Don (*Jacaranda ovalifolia* R. Br.) (*Bignoniaceae*)
Phanerophyte, escaped from ornamental cultivation, widely cultivated, found as a casual diaphyte or epoecophyte, subspontaneous or escaped from cultivation in continental Portugal (cf. Marchante & al. 2014), Beira Litoral: Coimbra, at the base of a calcareous wall (X.2010; XI.2018, own observ. & photos).

54. ***Jasminum nudiflorum*** Lindley (*Oleaceae*)
Phanerophyte, from Eurasia (N China); diaphyte, found escaped from cultivation in Beira Litoral: Botanical Garden of the University of Coimbra, in a calcareous Wall (I.2008; II.2016, own observ. & photos).

55. ***Juncus tenuis*** Willd. (*Juncaceae*)
Hemicryptophyte; agriophyte from North America, accidentally introduced, recently found (since 2009) in the provinces of Minho and Trás-os-Montes e Alto Douro (Verloove & Alves 2016; Alves & al. 2018).

56. ***Kalanchoe* × *houghtonii*** D. B. Ward (= *K. daigremontiana* Raym.-Hamet & Perrier × *K. delagoensis* Eckl. & Zeyh.) (*Crassulaceae*)
Chamaephyte; epoecophyte or agriophyte, recently recorded in Estremadura near Lisboa, "showing signs of moving from domestic gardens to the natural vegetation in Cascais and Estoril" (Smith & al. 2015); also found subspontaneus in the city of Coimbra (Beira Litoral) (VI.2014, own observ. & photos).

57. ***Lagarosiphon major*** (Ridley) Moss (*Hydrocharitaceae*)
Submersed hydrophyte; agriophyte from South Africa; found naturalized in Beira Litoral, Baixo Alentejo and the Algarve, at least since 2010 (Sánchez Gullón & al. 2010; Carapeto 2016; Plantas invasoras em Portugal 2017).

58. ***Landoltia punctata*** (G. Mey.) Les & D. J. Crawford (= *Lemna punctata* G. Mey. = *Spirodela punctata* (G. Mey.) Tompson) (*Araceae*)
Floating hydrophyte, with a subcosmopolitan distribution, found naturalized in Portugal as an hemiagriophyte: Douro Litoral (Galán 2007b) and Estremadura (Sánchez Gullón & Verloove 2016).

59. ***Lemna minuta*** Kunth (*Araceae*)
Floating hydrophyte; agriophyte from tropical America, collected in Portugal at least since 1941, in Douro Litoral, near Porto, and other places (Galán de Mera & Castroviejo 2005; Galán de Mera & al. 2006; Galán 2007a; Verloove & Alves 2016).

60. ***Linum usitatissimum*** L. (*Linaceae*)
Therophyte; epoecophyte, introduced in the past by culture for domestic and industrial uses, naturalized in several dispersed places of the Iberian Peninsula, including several Portuguese provinces: Alto Alentejo, Algarve, Baixo Alentejo, Beira Baixa, Estremadura, Minho, Ribatejo, Trás-os-Montes e Alto Douro (Franco 1971; Martínez Labarga & Muñoz Garmendia 2015).

61. ***Lippia alba*** (Miller) N. E. Br. ex Britton & P. Wilson (= *Lantana alba* Miller) (*Verbenaceae*)
Phanerophyte, from North America; probably an epoecophyte, introduced as an ornamental plant, recently (2015) found naturalized in Beira Litoral: Sernada (Verloove & Alves 2016).

62. ***Lolium remotum*** Schrank (*Poaceae*)
Therophyte; epoecophyte, introduced in the past with the culture of flax, naturalized in continental Portugal (Terrell 1968; Valdés & Scholz 2009).

63. ***Ludwigia peploides*** (Kunth) P. H. Raven subsp. ***montevidensis*** (Sprengel) P. H. Raven (=*Jussiaea montevidensis* Sprengel) (*Onagraceae*)
Helophyte, from South America; agriophyte, also naturalized in some other European and Mediterranean countries (Zotos & al. 2016; von Raab-Straube 2018), was found in the Portuguese province of Beira Litoral: Oliveira do Bairro, margin of the river Cértima, also in rice-fields (Verloove & Alves 2016).

64. ***Lysimachia nummularia*** L. (*Primulaceae*)
Chamaephyte; agriophyte; this species, native from several European and Mediterranean countries, but not from the Iberian Peninsula (Villar 1997), was recently found subespontaneous in Baixo Alentejo, “detectada a alastrar em valas no sul do país”, where it is spreading, mainly as an aquatic plant (Marchante & al. 2014).

65. ***Medicago coronata*** (L.) Bartalini (*Fabaceae*)
Therophyte; epoecophyte, probably introduced in the past with some culture, was found in Estremadura near Lisboa: cerca dos Jerónimos and Parque de Monsanto; and Oeiras, pr. Carnaxide (Coutinho 1935; Teles & al. 1973; Almeida 2005).

66. ***Nandina domestica*** Thunb. (*Berberidaceae*)
Phanerophyte, from East Asia; diaphyte, found escaped from cultivation in Beira Litoral: inside the arboretum of the Botanical Garden of the University of Coimbra, VI.2011, III.2016, observ. and photos. Invasive species in the SE of the USA (Mabberley 2008).

67. ***Narcissus* × *medioluteus*** Miller (= *Narcissus poeticus* L. × *Narcissus tazetta* L., *Narcissus* × *biflorus* Curtis) (*Amaryllidaceae*)
Cryptophyte (geophyte) of hybrid origin, probably from S. France, introduced as an ornamental plant and found naturalized or escaped from cultivation in continental Portugal (Webb 1980).

68. ***Narcissus pseudonarcissus*** L. subsp. ***pseudonarcissus*** (*Amaryllidaceae*)
Cryptophyte (geophyte), from SW Europe; agriophyte, probably introduced as an ornamental plant, subspontaneous in continental Portugal (Aedo 2013).

69. ***Narcissus tazetta*** L. (*Amaryllidaceae*)
Cryptophyte (geophyte), from the Mediterranean Region; agriophyte, introduced as an ornamental plant, sometimes subspontaneous or escaped from cultivation in continental Portugal (Aedo 2013) and the Azores (Franco & Rocha Afonso 1994).

70. ***Oenothera lindheimeri*** (Engelm. & A. Gray) W. L. Wagner & Hoch (= *Gaura lindheimeri* Engelm. & A. Gray) (*Onagraceae*)
Hemicryptophyte, from North America: USA; epoecophyte or diaphyte, found naturalized in the Algarve: Monchique, Caldas de Monchique, 4.XII.2010 (Verloove & Sánchez Gullón 2012).

71. ***Opuntia leucotricha*** DC. (*Cactaceae*)
Phanerophyte, from North America (Mexico), escaped from ornamental cultivation, found as an escaped casual plant (diaphyte) in Lisboa, Estremadura (Silva & al. 2015b).

72. ***Opuntia stricta*** (Haw.) Haw. (= *Cactus strictus* Haw.) (*Cactaceae*)
Phanerophyte, from North America (Mexico), escaped from ornamental cultivation, found as a naturalized and invasive plant (agriophyte) in the Tapada da Ajuda, Lisboa, Estremadura (Vasconcellos 1940; Monteiro & al. 2005: 193; Silva & al. 2015b).

73. ***Osteospermum ecklonis*** (DC.) Norl. (= *Dimorphotheca ecklonis* DC.) (*Asteraceae*)
Phanerophyte or chamaephyte, from South Africa; diaphyte or ruderal epoecophyte, found naturalized in Portugal in Estremadura: Cascais, since 2012 (Silva & al. 2015a).

74. ***Oxalis dillenii*** Jacq. (*Oxalidaceae*)
Geophyte; epoecophyte, from North America, also presente in several Spanish provinces, and also in several European countries (Sánchez-Pedraja 2015), was found naturalized in lawns very recently (2018), in the province of Trás-os-Montes e Alto Douro (TM): Bragança (Carlos Aguiar, personal communication).

75. ***Paspalum notatum*** Flüggé var. ***saurae*** Parodi (= *Paspalum saurae* (Parodi) Parodi) (*Poaceae*)
Hemicryptophyte; epoecophyte, from South America, was found naturalized in lawns some years ago (2001), and more recently (2015) in the province of Douro Litoral (Verloove & Alves 2016).

76. ***Pelargonium cucullatum*** (L.) L'Hér. subsp. ***cucullatum*** (= *Geranium cucullatum* L.) (*Geraniaceae*)
Phanerophyte, from South Africa; epoecophyte or agriophyte, found in Estremadura, near Cabo da Roca, where it can be locally common (Crespo 2015).

77. ***Pelargonium zonale*** (L.) L'Hér. ex Ait. (= *Geranium zonale* L.) (*Geraniaceae*)
Phanerophyte, from South Africa; diaphyte, found at Estremadura: Setúbal: Vila Nogueira de Azeitão, by J. Gomes Pedro, VI.1980: LISE 89179 (Sousa Dias & al. 1982); sometimes naturalized in some littoral areas of the Iberian Peninsula (Crespo 2015).

78. ***Pennisetum setaceum*** (Forsskål) Chiovenda (= *Phalaris setacea* Forsskål = *Cenchrus setaceus* (Forsskål) Morrone) (*Poaceae*)
Hemicryptophyte, from South Asia and North and East Africa; ruderal epoecophyte, probably introduced as an ornamental species, recently found naturalized in the Algarve (Marchante & al. 2014).

79. ***Persicaria pensylvanica*** (L.) M. Gómez (= *Polygonum pensylvanicum* L.) (*Polygonaceae*)
Therophyte; agriophyte, from North America (USDA, Agricultural Research Service, National Plant Germplasm System 2018), already found subspontaneus in several European countries (Uotila 2017), recently (2015) found naturalized in three littoral provinces of Portugal: Minho, Douro Litoral and Beira Litoral (Verloove & Alves 2016).

80. ***Platycladus orientalis*** (L.) Franco (= *Thuja orientalis* L.) (*Cupressaceae*)
Phanerophyte, from East Asia; diaphyte or epoecophyte, subspontaneous in continental Portugal (Franco 1986; von Raab-Straube 2014).

81. ***Psilotum nudum*** (L.) P. Beauv. (= *Lycopodium nudum* L.) (*Psilotaceae*)
Rhizomatous geophyte or chamaephyte, from the Intertropical Regions (Castroviejo 1986); diaphyte or ruderal epoecophyte, introduced by cultivation in the Botanical Garden of Coimbra (Beira Litoral), from where it have been escaping and spreading in the city of Coimbra. (2010–2016, own observ. & photos).

82. ***Pyracantha crenulata*** (D. Don) M. Roemer (*Rosaceae*)
Phanerophyte, from Eurasia; diaphyte or epoecophyte, subspontaneous or escaped from cultivation in continental Portugal: Beira Litoral: Figueira da Foz, Serra da Boa Viagem (IX.2015, own observ. and photos).

83. ***Rhus typhina*** L. (*Anacardiaceae*)
Phanerophyte, from North America: Canada and USA; agriophyte, possibly, naturalized in the Portuguese province of Trás-os-Montes e Alto Douro (Güemes & Sánchez-Gómez 2015).

84. ***Romulea rosea*** (L.) Ecklon (= *Ixia rosea* L.) (*Iridaceae*)
Criptophyte (bulbous geophyte), from South Africa; possibly a diaphyte, introduced as an ornamental bulbous plant, found naturalized in the Portuguese province of Minho, 2013 (Araújo 2013).

85. ***Salix alba*** L. var. ***vitellina*** (L.) Ser. (= *Salix vitellina* L.) (*Salicaceae*)
Phanerophyte, from unknown origin, introduced by cultivation, possibly at all the

Portuguese provinces, near streams (Portela-Pereira in Flora-On: Flora de Portugal Interactiva 2014), also cultivated in gardens and for economic reasons (Bingre & al. 2007), frequently planted in Europe, including Portugal (Pereira Coutinho 1899; Rechinger & Akeroyd 1993; Blanco 1993).

86. ***Sedum pachyphyllum*** Rose (*Crassulaceae*)
Chamaephyte, from North America: Mexico; diaphyte, introduced as an ornamental plant, found escaped in Estremadura: Oeiras, with other Crassulaceae (VI.1999, own observ. and photos).

87. ***Senecio inaequidens*** DC. (*Asteraceae*)
Hemicryptophyte; agriophyte, from South Africa, of probable casual recent introduction (2009), present in the Littoral North of continental Portugal: provinces of Minho and Douro Litoral (Alves & Verloove in Flora-On 2018; Lourenço & al. 2018).

88. ***Senecio tamoides*** DC. (*Asteraceae*)
Scandent phanerophyte, from South Africa, Swaziland and Zimbabwe; this climbing plant was found naturalized in continental Portugal: Douro Litoral, Estremadura and Minho (Honrado & al. in Andresen & al. 2004; Marchante & al. 2014; Silva & al. 2015b). Greuter (2006+; 2008) doesn't mention the naturalization oe the presence of this species in Europe or in the Mediterranean Region.

89. ***Sicyos angulatus*** L. (*Cucurbitaceae*)
Therophyte; agriophyte, from North America, established as an alien in many European countries (Henning & al. 2017), recently (2015) found naturalized in river margins and basins of rivers of two Portuguese provinces: Minho and Douro Litoral (Verloove & Alves 2016).

90. ***Solanum chacoense*** Bitter subsp. ***chacoense*** (*Solanaceae*)
Geophyte, from South America; epoecophyte, introduced in Douro Litoral: Botanical Garden of Porto, starting to become invasive and slowly spreading in the vicinity (P. Alves in Facebook 14.VII.2014).

91. ***Solanum sisymbriifolium*** Lam. (*Solanaceae*)
Therophyte, from South America; epoecophyte, already naturalized in Spain (Del Monte & Aguado 2003; Sanz-Elorza & al. 2004; Sobrino Vesperinas & Sanz-Elorza 2012; Valdés 2012), recently found in Terra Quente, province of Trás-os-Montes e Alto Douro (Jardim Botânico da Universidade de Trás-os-Montes e Alto Douro 2018); this species has been used frequently as as trap crop for potato cyst nematodes (Scholte 2000; Timmermans 2005; Cabral 2015).

92. ***Solidago gigantea*** Aiton (*Asteraceae*)
Cryptophyte (Geophyte), from North America; agriophyte or epoecophyte, introduced as an ornamental, in the Algarve (Sánchez Gullón & Verloove 2013; Aedo 2019), and also in the province of Beira Litoral (Verloove & Alves 2016).

93. ***Symphyotrichum laeve*** (L.) Á. Löve & D. Löve (= *Aster laevis* L.) (*Asteraceae*)
Hemicriptophyte, from North America; ruderal epoecophyte naturalized in the Algarve: Monchique (Verloove & Sánchez Gullón 2012).

94. ***Symphyotrichum pilosum*** (Willd.) G. L. Nesom (= *Aster pilosus* L.) (*Asteraceae*)
Hemicriptophyte, from North America; ruderal epoecophyte naturalized in the Algarve: São Brás de Alportel, Serra do Caldeirão (Quinto Canas 2014).

95. ***Symphyotrichum* × *salignum*** (Willd.) G. L. Nesom (= *Aster* × *salignus* Willd.) (*Asteraceae*)
Hemicriptophyte, from hybrid origin; ruderal epoecophyte naturalized in Douro Litoral: Área Metropolitana do Porto (Honrado & al. in Andresen & al. 2004). Greuter (2006+; 2008) confirms the naturalization of this hybrid in almost all Europe.

96. ***Tanacetum balsamita*** L. (*Asteraceae*)
Hemicryptophyte, from the Eastern Mediterranean Region; diaphyte, traditionally cultivated as a medicinal plant, already cited for several provinces of continental Portugal by Brotero (1804) and Mariz (1894), also recently considered as a subspontaneous exotic species in Northern Portugal (province os Trás-os-Montes e Alto Douro) and the Iberian Peninsula by Soriano (2019).

97. ***Taxodium distichum*** (L.) Rich. (= *Cupressus disticha* L.) (*Cupressaceae*)
Phanerophyte, from North America; agriophyte, found well naturalized and seeming to spread in the margin of Lagoa das Braças (Beira Litoral: Figueira da Foz, Quiaios) (XI.2015, own observ. & photos).

98. ***Triglochin palustre*** L. (*Juncaginaceae*)
Helophyte, from Eurasia and North America (Holoarctic); diaphyte; plant from mountain bogs, probably introduced (VI.1886) and now extinct in continental Portugal: Minho (Talavera 2010).

99. ***Vitex agnus-castus*** L. (*Verbenaceae*)
Phanerophyte, from the Mediterranean Region; agriophyte, naturalized at the margins of streams in Southern Portugal (Gomes 2014), possibly subspontaneous in Trás-os-Montes e Alto Douro: "quasi spontanea in paludosis nonnulis Transmontanae." (Brotero 1804; Coutinho 1913; Coutinho 1939; Sampaio 1947); Not cited for Portugal by the recent floras and studies about exotic flora, ethnobotany or flora and vegetation: (Tutin 1972; Franco 1984; Aguiar 2000; Almeida 1999; Almeida & Freitas 2003; Almeida & Freitas 2006; Almeida & Freitas 2012; Carvalho 2005; Flora-On; World Checklist of Selected Plant Families 2010; Euro+Med PlantBase 2015) except in Flora Iberica (Plaza & Pujadas Salvà 2010) who gives this species as possibly spontaneous in Trás-os-Montes e Alto Douro, maybe based on the reference of Brotero (1804), and Aguiar & al. (2007) as an alien species.

100. ***Vitis* × *instabilis*** Ardenghi, Galasso, Banfi & Lastrucci (= *Vitis riparia* Michaux × *Vitis rupestris* Scheele) (*Vitaceae*)

Phanerophyte, hybrid of two North American species, escaped from cultivation, found naturalized as an agriophyte or an epoecophyte (2015) in the provinces of Douro Litoral and Beira Litoral (Verloove & Alves 2016).

101. ***Vitis*** × ***koberi*** Ardenghi, Galasso, Banfi & Lastrucci (= *Vitis berlandieri* Planchon × *Vitis riparia* Michaux) (*Vitaceae*)
Phanerophyte, hybrid of two North American species, escaped from cultivation, found naturalized as an epoecophyte or diaphyte at Estremadura: Palmela (Silva & al. 2015a).

102. ***Vitis*** × ***novae-angliae*** Fernald (= *Vitis labusca* L. × *Vitis riparia* Michaux) (*Vitaceae*)
Phanerophyte, artificial hybrid of two North American species, escaped from cultivation, found naturalized as an agriophyte in riparian woodland, since 2015, in the provinces of Minho and Douro Litoral (Verloove & Alves 2016).

103. ***Vitis rupestris*** Scheele (*Vitaceae*)
Phanerophyte, North American species, escaped from cultivation, found naturalized as an epoecophyte or diaphyte at Estremadura: Palmela (Silva & al. 2015a).

104. ***Yucca gloriosa*** L. (*Asparagaceae*)
Phanerophyte, escaped from ornamental cultivation; North American species, recently (2015) found naturalized, probably as an epoecophyte, in the province of Beira Litoral (Verloove & Alves 2016).

105. ***Yucca gigantea*** Lem. (*Yucca elephantipes* Regel ex Trel.) (*Asparagaceae*)
Phanerophyte, escaped from ornamental cultivation, widely cultivated, found as a casual diaphyte at Estremadura and Ribatejo (Chodat 1909; Portela Pereira 2013; Silva & al. 2015b).

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Thermal insulation role and possible exploitation of *Posidonia oceanica* detritus in the Mediterranean area*

Abstract

Calvo, R.: Thermal insulation role and possible exploitation of *Posidonia oceanica* detritus in the Mediterranean area. — Fl. Medit. 28: 279-285. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

The paleoendemic seagrass *Posidonia oceanica* (L.) Delile represents a key species of the most important and productive ecosystem in subtidal habitats of the Mediterranean Sea. This species is the most common seagrass in Sicily where it forms dense and extensive beds, which are characterized by high coverage and primary production values. The beaching of *P. oceanica* detritus (banquette) can be an environmental, economic and social problem, if it comes into conflict with a number of activities (tourism, bathing establishments, etc.). Even though seagrasses play a fundamental ecological role in limiting coastal erosion and promoting the origin of the coastal dunes, the presence of *P. oceanica* detritus along the coasts can negatively decrease the tourism value of beaches. As a result, according to national and regional laws and guidelines, local authorities are required to remove banquette and to accumulate it in landfills. In this survey, the ancient exploitation and current uses of *P. oceanica* detritus are reported according to literature data. Moreover *P. oceanica* detritus were used to replace soil in an experimental installation located at the University of Palermo. Meanwhile, continuous temperature values measurements by using hobo data logger sensors were carried out. The results confirm the thermal insulation role of this material and highlight potential applications in the field of Soil Bioengineering.

Key words: seagrasses, soil bioengineering, circular economy, Sicily.

Introduction

The world population is expanding incessantly, and economic and demographic growth are leading to the exploitation of the environment and the reduction of natural resources, with potentially important impacts on global climate change (Vörösmarty & al. 2000).Therefore, more efficient management of resources is necessary, based on the modification of sustainable objectives of environmental policies and strategies and lower consumption of resources. Actions are needed to promote the transition from a linear economy

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*Extended and enriched version of the poster presented at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

model to a circular one, consisting of a continuous positive development cycle that preserves and improves natural capital, optimizing the use of resources (MacArthur 2013).

P. oceanica (L.) Delile is an endemic seagrass found in the Mediterranean Sea, where it forms extensive meadows in the marine infralittoral zone (Duarte 1991). This species is the most common seagrass in Sicily, covering a surface of about 76,000 ha and growing at a depth of 0-50 m (Calvo & al. 2010). In particular, along the western coasts of Sicily *P. oceanica* meadows form dense and extensive beds, which are characterized by high coverage and primary production values.The seagrass plays a fundamental ecological role in limiting coastal erosion and promoting the establishment of the coastal dune system (Boudouresque & Meinesz 1982; Simeone & De Falco 2012; Boudouresque & al. 2016). As a consequence of phenological process, the beached detritus of *P. oceanica* (banquette) are widely considered a problem by local inhabitants, conflicting with many economic activities such as coastal tourism, bathing, etc. As a result, local authorities are required to remove *banquette* and dispose them in landfills. In fact, Italian legislation considers these plant biomasses as a special kind of solid waste material to be disposed to landfills, thus resulting in an enormous loss of organic materials, nutrients and useful biomolecules (Saidi & al. 2009), with additional problems associated with their transport to landfills.

Circular no. 35792/2009, issued by the Sicilian Regional Administration, proposes a management option that consists in the reuse of biomass in landscape reconstruction, as a compost in agriculture or as environmental restoration workin coastal areas (Legislative Decree 75/2010 reforming and revision of the fertiliser guidelines, pursuant to Article 13 of Law no 88 of 7 July 2009).

In this regard, Soil and Water Bioengineering uses plants as living building material in environmental and landscape development works. Such works with low environmental impact promote biodiversity and, in addition, offer a promising strategy for mitigation and adaptation to climate change (Duarte & al. 2013). Thus, the use of adequate, sustainable, easy to find and low-cost materials is essential for the achievement of these objectives. From the viewpoint of the circular economy, the reuse of *P. oceanica* detritus has a double beneficial effect. It constitutes a solution to the problem of waste disposal and an opportunity for the creation of local and low-cost new products.

Considering the great availability of detritus resulting from the annual cleaning of beaches from the leaves of *P. oceanica* in Sicily, the aim of present work is to test if this detritus could exert a thermal insulation role with potential applications in the field of Soil Bioengineering. For this pourpose an experimental installation located at the University of Palermo were set up, where different treatments consisting of mixtures of *P. oceanica* detritus-soil composed were assembled in modular structures.

State of art of multiple-uses of *P. oceanica* detritus

The uses of beached *P. oceanica* detritus date back to prehistoric history. In fact, the occurrence of vegetable biomass was detected in the Lazaret's Cave (Nice), where dissected *P. oceanica* detritus were used to build beds (De Lumeley & al. 1969). The ancient Egyptians made seaball to make shoes (Tackolom & Drar 1954). Along the coasts of North Africa, in Spain and Balearic Islands (Terrados & Borum 2004), the beached leaves of *P.*

oceanica were used for the construction of roofs and bricks for the construction of walls and shafts (Trotter 1915). A rich macrofauna (gastropods, crustaceans, annelids and insects) inhabits the banquettes (Deidun & al. 2009). Whatever the role of the *P. oceanica* debris in the diet of the harboured fauna, banquettes are very important as a physical structure that provides detritivorous and predatory species with refuge from environmentally stressful conditions (Colombini & al. 2009) and top predators such as sea birds (Bartoli & Prévot 1978; Bartoli & Holmes 1997). *P. oceanica*, because of the high content of cellulose, may be suitable for the production of paper (McRoy & Helfferich 1980). The detritus of *P. oceanica* have found a greater field of application in agriculture as organic substance to increase the fertility of soil (Cocozza & al. 2009; Parente & al. 2009; Montesano & al. 2014; Mininni & al. 2015; Pirrera & al. 2017; Calvo 2018). The thermo-absorbent properties of *P. oceanica* leaves, combined with their low density and high porosity (Milchakova 2014), allowed its use as thermal insulator in Greece (Sordina 1951).

Some uses in traditional medicine were confirmed as well as antibacterial and antifungal activity of leaves extracts. Gokce and Haznedaroglu (2008) have conducted a study on diabetic rats, which showed how the oral intake of the extracts of *P. oceanica*, reduces blood glucose and induces blood vessel protection.

Researches on the possible use of *P. oceanica* in cosmetics were introduced by the Company Egadi Natural Cosmetics which defined a protocol of green collection on *P.oceanica* beached and has obtained an extract with excellent antioxidant properties for a new line of treatment cream.

Finally, several projects have provided for the use of *P. oceanica* detritus. In the whole Mediterranean area there are different experiences of composting, thanks to the high presence of beached detritus of *P. oceanica* along the coasts. In Tunisia, for example, the compost was used as substrate for the cultivation of vegetables and, in particular, tomato (Verlodt & al. 1983). In Italy, experimental activities of composting and the use of the compost were carried out by serveral authors (Cocozza & al. 2011; Mininni & al. 2015; Montesano & al. 2014). *P. oceanica* detritus were also recently used in a Soil Bioengineering project to the Municipality of Custonaci (province of Trapani, Sicily) (Pirrera & al. 2017).

Materials and Methods

The construction of modular structures was made with organic waste materials, namely detritus of *P. oceanica* and vine pruning (vine shoots). In this regards, vine shoots were assembled in the form of fascines to constitute the basic element used to create a fascinate module, a linear Soil and Water Bioengineering work with anti-erosive, consolidation and stabilization functions, while the detritus of *P. oceanica* were used as a growing medium, to permit it, after planting with native species, an evolution toward a more natural substrate. Finally continuous temperature values measurements using hobo data logger sensorswere carried out whitin different mixtures.

A small prototype of fascinate has been set up in experimental fields at the University of Palermo. (38°06’27.73 “N; 13°20’59.48” E). The work 20 m long, is structured in 12

fascines.The fascines were subsequently filled with 30 liters of substrate composed of several mixtures of detritus of *P. oceanica*-soil according to the scheme:
– no. 3 fascine filled with 100% of *P. oceanica* detritus;
– no. 3 fascine filled with 80% soil - 20% of *P. oceanica* detritus;
– no. 3 fascine filled with 100% soil;
– no. 3 fascine as control.

Temperature values inside the fascines was measured from July to November 2017 by using hobo data logger sensors. The data were recorded continuously every 30 minutes only in a) the external environment, b) inside the *P. oceanica* detritus (5 cm depth) contained in fascines and c) in the soil (5 cm depth) next to the installation. On the whole, 18.603 temperature values were acquired.

Results

During summer, temperature values ranging between 36.6°C in *P. oceanica* detritus and 55.1°C in the external environment. Instead, in autumn the minimum temperature values measured were 5.6°C in the external environment and 9.7°C in the detritus of *P. oceanica*. Moreover, maximum and minimum temperature values registered in the soil were 43.2 °C and 11.9°C (Fig. 1).

Lowest average temperature values were recorded in *P. oceanica* detritus inside fascines, both in the summer period (25.7±3.6) and throughout the measurement period (21.8±5.2) (Table 1).

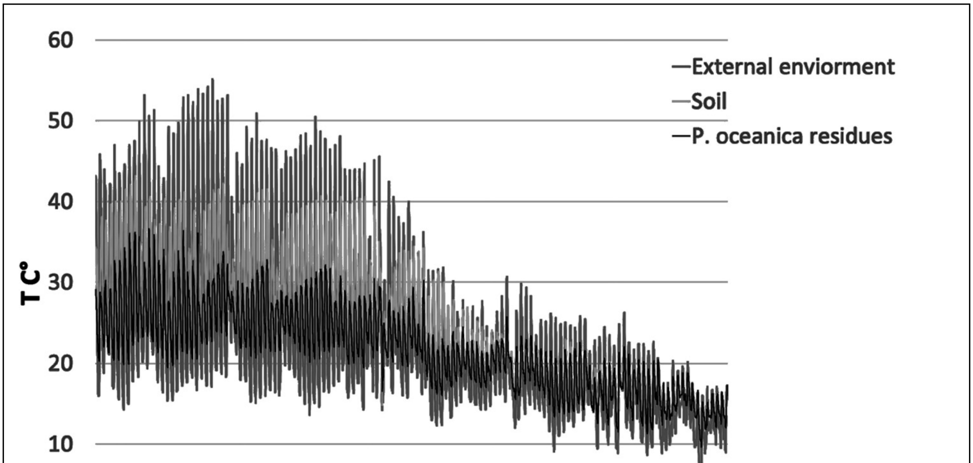

Fig. 1. Temperature values recorded from July to Sempember 2017 during the experiment.

Table 1. Average temperature values (±SD) recorded in the experimental installation.

Dates	External temperature (mean±SD)	P. oceanica detritus (mean±SD)	Soil (mean±SD)
14-31 July 2017	29.6±10.2	26.4±4.2	31.2 ±5.1
01-31 August 2017	29.1±10.9	26.4±3.2	30.7±5.0
01-30 September2017	23.1±7.2	25.5±3.1	25.5±5.0
01-31 October 2017	17.8±4.2	18.3±2.6	19.0±2.0
01-20November 2017	13.7±3.2	15.2±2.2	15.8±1.6
14 July - 21 September2017 (Summer)	28.0±10.0	25.7±3.6	29.8±5.2
22 September – 20 November 2017 (Autumn)	16.8±4.6	17.5±3.0	18.5±3.0
14 July - 20 November 2017	22.7±9.7	21.8±5.2	24.5±7.1

Discussion and Conclusions

In the framework of an efficient use of resources and a good waste management, this study underlines the high insulating capacity and the value of *P. oceanica* detritus as a replacement for the plant substrate. In fact, using *P. oceanica* detritus a significant attenuation of maximum and minimum daily temperature values was observed at level of root system, comparing with soil and external environment (Figure 1). Hence, this study suggests that beached of *P. oceanica* detritus, in addition to finding application as thermal insulation in buildings (Sordina 1951; Milchakova 2014), can also be used to promote the rooting and growth of plants that find application for their biotechnical characteristics in the field of Soil Bioengineering (Tuttolomondo & al. 2017).

Moreover, the use of *P. oceanica* detritus, widely detectable in Sicily and in the Mediterranean basin, represents a valuable example of low cost, sustainable use, energy efficiency and complete respect of the environment. In this context it is also necessary to consider the opportunity to raise public awareness of the importance of seagrass and the beached detritus for the preservation of coastal ecosystems.

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The contribution of starch grain and phytolith analyses in reconstructing ancient diets*

Abstract

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Starch grains and phytoliths are often found trapped in dental calculus or on the surface of lithic grinding tools. In the last decades, their analysis provided new information about the dietary habits of ancient populations, a topic that has recently become the object of numerous researches by archaeobotanists, archaeozoologists and anthropologists. The study of these micro-remains not only indicates which plants were used for feeding purposes but may also highlight our ancestors' ability to manipulate food.

Key words: starch grains, food plants, grinding tools, dental calculus.

Introduction

Numerous papers are currently devoted to the study of ancient diets, which can provide useful information for an understanding of the economic development of ancient cultures – specific technologies for the production and use of food crops, commerce, food manipulation etc. – and also the physiological adaptation processes of the human organism to the chemical components of food. Moreover, the study of the ancient human nutrition might shed new light on the essentials of the human diet and possibly contribute to the prevention of modern chronic degenerative diseases (Eaton 2006). Regarding the exploitation of food plants, direct information comes from the findings of seeds and fruits during archaeological excavations, especially in hearths and deposits; but these findings become more and more scarce as we regress in time. Therefore, archaeobotanists started to pay attention to micro-remains which could be found on the surface of ancient tools used for processing plant materials or were trapped in dental calculus: principally starch grains and phytoliths.

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These residues are not the most legible evidence to be interpreted among plant remains although they are, sometimes, the only available finds. Furthermore, when they are found on grinding tools or in dental calculus, they can offer accurate information. Indeed, through their analysis, it is possible not only establish which plants were used for feeding purposes but also deduce cultural information on food preparation, with very important implications when we think that we have very scarce knowledge of dietary habits in the Paleolithic period.

Plant remains on tool surfaces

In the Mediterranean area, the first important results in this type of research are those related to studies on the epi-Paleolithic site of Ohalo in Israel (Piperno & al. 2004; Nadel & al. 2012). These findings demonstrated that wild cereals, mainly *Hordeum* and *Avena*, were not only collected but also ground to make flour, a product which is easy to preserve but that requires a specific preparation before consumption. Thus, the discovery has highlighted the local population's ability to manipulate food.

Regarding Europe, the first study on grinding tools was performed on artefacts found in Mugello, Italy (Fig. 1), in an area now submerged by the waters of the Bilancino reservoir (Aranguren & al. 2007; Revedin & al. 2010). The site was a seasonal camp dating to the

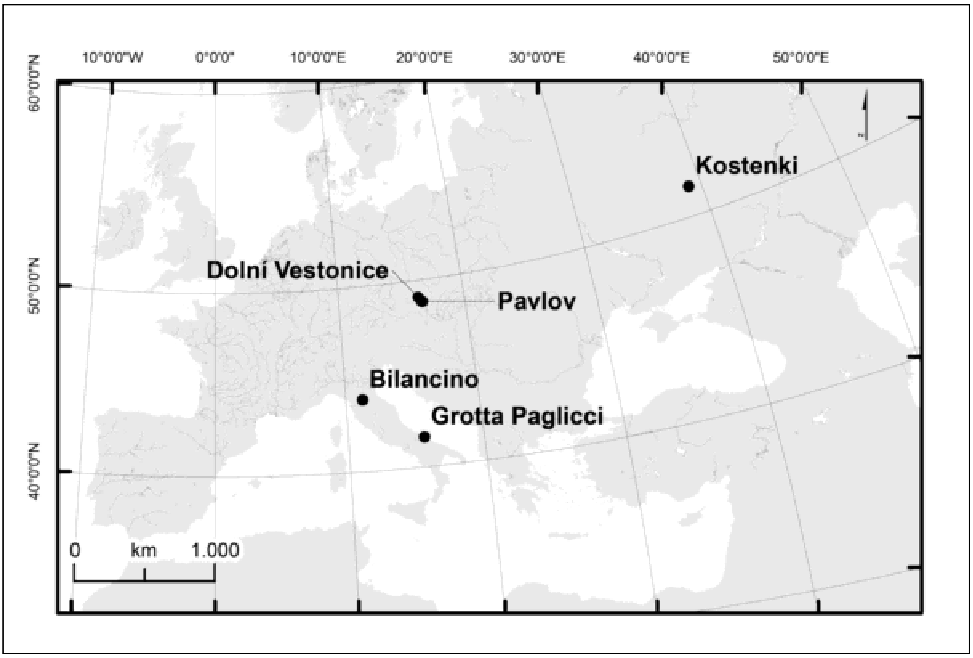

Fig. 1. Palaeolithic sites where starch analysis on grinding tools revealed plant processing, indicating that the production of flour has been a widespread practice across Europe for at least 30,000 years.

Gravettian, in the middle-upper Paleolithic, a period characterized by a colder climate than the present one. The site is located in an open area characterized by numerous wetland plants (Mariotti Lippi & Mori Secci 2002). The analysis of these tools revealed traces of use compatible with grinding. By washing their surfaces, it was possible to recover starch grains, which allowed us to establish that they were tools used for the grinding of plant materials. In particular, a portion of the starch grains had a morphology very similar to those of the caryopses of wild grasses and the rhizome of *Typha*, a part of the plant that can easily be ground once dry. Other grains have a morphology which did not allow their attribution to a specific plant.

Similar analyses were also carried out on grinding tools coming from other famous Paleolithic sites, such as Kostenki in Russia and Pavlov and Dolni Vestonice in the Czech Republic (Fig. 1). Plant micro-remains - and especially starch grains – were found on these artefacts as well (Revedin & al. 2010).

The mere finding of starch grains is important evidence in itself, as it places these tools in a different context from that of the tools used to grind minerals for dyes. But the identification of the plant remains is also of great interest.

The attribution of the starch grains to a specific plant is fairly difficult for two main reasons. First, the number of detectable features on the grains is quite limited: we can analyse size, presence and shape of the hilum, shape and position of the cross formed under polarized light, and very little else. Second, there is scarce reference material, as the existing atlases are mainly dedicated to the flours in use nowadays. Moreover, the same plant may produce starch grains which differ in shape and/or dimension (see for example Fig. 2), and only some of those are identifiable.

The identification requires the examination of the morphology of the starch grains of many plants. For this purpose, the knowledge of the flora present around the archaeological site at the time of its occupation is very useful to reduce the number of plants to be considered. A great indication of the past environment comes from other archaeobotanical analyses, mainly pollen analysis.

Another important information which may be deduced from the analysis of the starch grains on tool surfaces involves the treatment of the food plant material before processing. The study carried out on a pestle-grinder from Paglicci in Apulia, Italy (Mariotti Lippi & al. 2015, Fig.1), revealed that the starch grains had been treated thermally in the absence of water (perhaps toasted) before grinding, as attested by their swelling in water/glycerin solution (Fig. 3).

Grinding is generally done for material that has been previously dried, but here the behavior of the grains attests to a proper thermal treatment, probably used to accelerate the drying in a time of colder climate than the present. The Grotta Paglicci has a very long history of human occupation from about 39,000 years ago to the middle of the nineteenth century. The pestle-grinder comes from the Gravettian levels, dated to 32,000 years BP. The grains found on the tool were attributed to caryopses and acorns. In particular, the grinding of the caryopses is attested both by the scarce phytoliths and the numerous starch grains. Many of them have been attributed to *Avena*, very likely *Avena barbata*. The starch grains on the tool of the Grotta Paglicci are currently the oldest documentation of the grinding of cereals in the world and of the use of cereals in Europe.

Concerning phytoliths, they are more rarely recorded in noticeable amount than the starch grains on the surface of the grinding tools. Liu & al. (2013) suggested that the

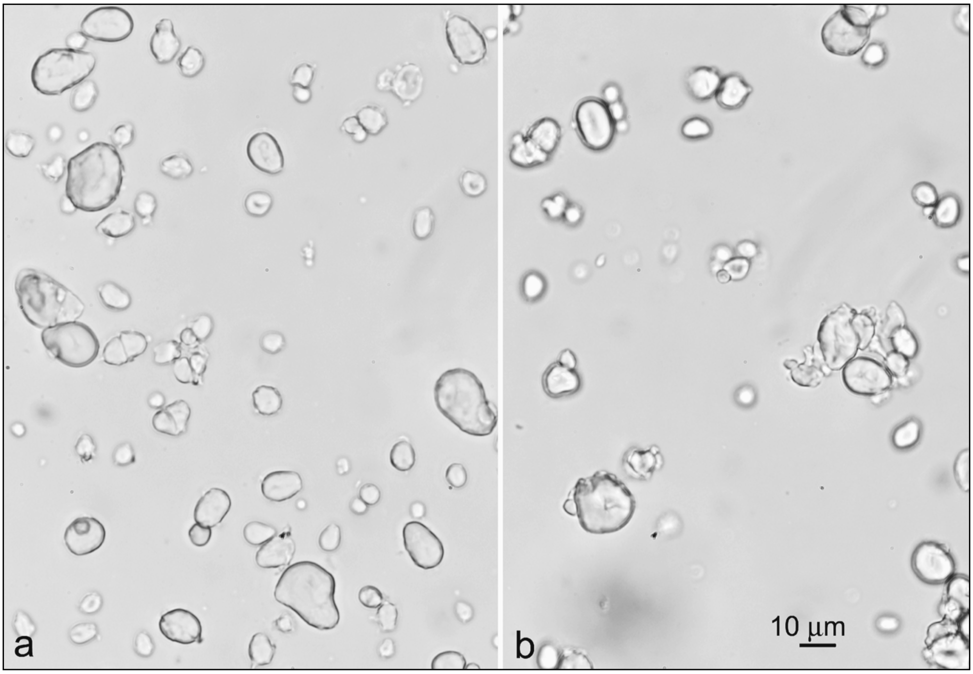

Fig. 2. Starch grains obtained by grinding the acorns of *Quercus ilex* (a) and *Q. pubescens* (b). Note the remarkable variety of morphotypes.

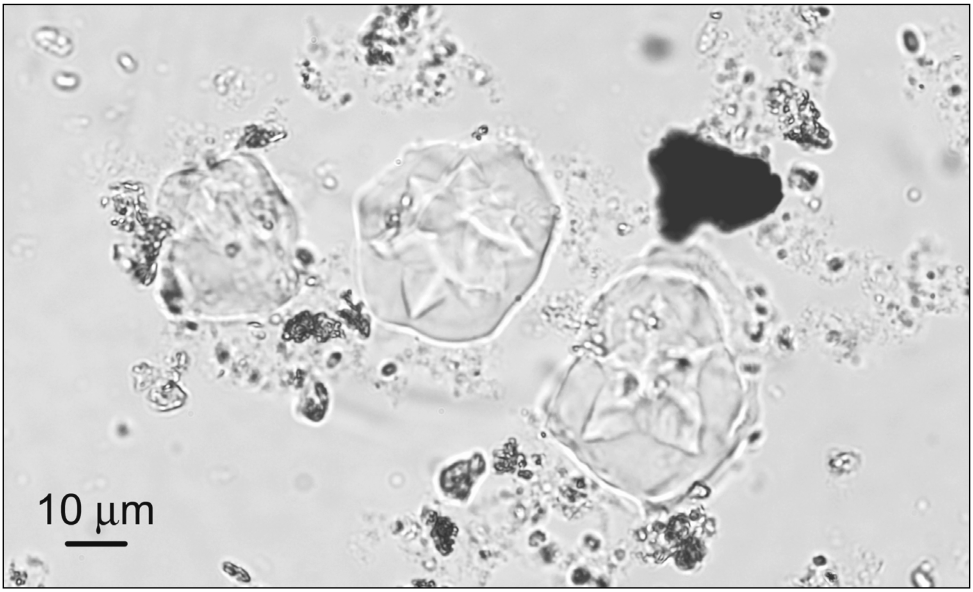

Fig. 3. Gelatinized and swollen starch grains from the Paglicci grinding stone.

scarcity of phytoliths may be due to the grinding of plant portions which do not produce large amounts of silicified bodies, such as cereal caryopses after dehusking.

The study of grinding tools provides further information inferred from the size distribution of the plant remains on the surface of the grinders, since different parts of the tool may collect remains of different sizes. Together with traces of use, the distribution of the remains suggests the usage motions of the grinder and, consequently, may also provide valuable information for studies on the human anatomy. Indeed, asymmetrical developments of the arms are detectable in females from the Mesolithic to the Iron Age and may be the direct consequence of the change in the grinding methods (Sladek & al. 2016).

Finally, we must emphasize the cultural relevance of the grinding process (Revedin & al. 2015), which provided humans with an edible product which was not only easy to preserve but also easy to transport, a characteristic of primary importance for nomadic populations of hunters and gatherers.

Plant remains in dental calculus

While we always find a larger quantity of starch grains than phytoliths on grinding tools, when we analyze dental calculus the quantities of both can vary a great deal. Tartar incorporates minute particles and fragments of whatever is present and whatever is introduced in the oral cavity. This is due to its chemical nature and process of formation (Warinner & al. 2015) that make the calculus act as a trap for various debris and become a veritable archive of information on the lifestyle, health state, hygiene, activities, and dietary habits of the ancient populations. Obviously, the kind of the information obtained depends on the nature of the residues found on the calculus (Radini & al. 2017).

Over the past two decades, dental calculus has become the object of an increasing number of investigations. Concerning plant remains embedded in the tartar matrix, studies on human and non-human teeth has provided valuable data for reconstructing a comprehensive view of diets in the past (e.g. Lalueza Fox & Pérez-Pérez 1994; Lalueza Fox & al. 1996; Henry & Piperno 2008). In Italy, analyses of dental calculus are not numerous. Nonetheless, the study of plant remains in dental calculus may complement the information obtained through other examinations. At the Grotta dello Scoglietto, a cave located on the Western slope of the Uccellina Mountain range, Italy, the analysis of the teeth of nine individuals has demonstrated the consumption of cereals such as wheat, barley and millets during the Copper-Bronze Age (Mariotti Lippi & al. 2017). These finds have enriched our knowledge of the food spectrum already shown by the previous analysis of stable isotopes (Varalli & al. 2015).

As already mentioned, starch grain analysis offers the opportunity to collect data about plant exploitation and alimentary uses and the treatments and manipulations of plant matter. This information may be inferred also from grains recovered in dental calculus. Regarding phytolith analysis, these remains may confirm and enrich the known list of the plants that were introduced in the oral cavity, for dietary or not dietary purpose (Radini & al. 2016) or even accidentally.

As in the case of the starch grains, it must be noted that morphological studies on the phytolith morphology are scarce and a single taxon may produce a wide variety of phy-

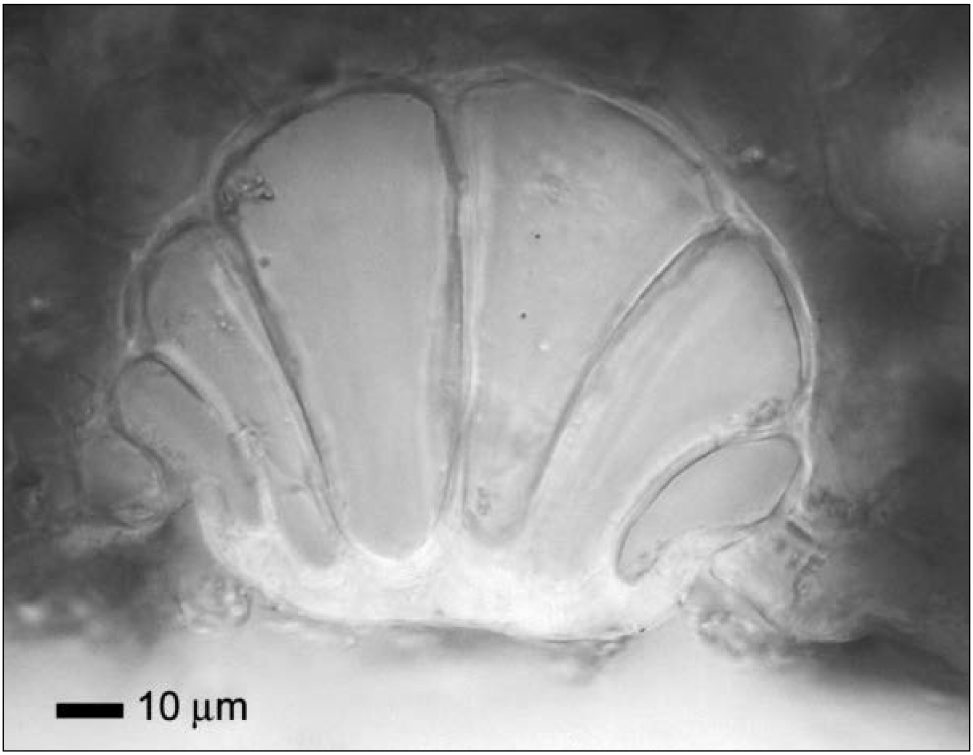

Fig. 4. Bulliform cells/phytoliths in a leaf of *Festuca exaltata*: note the difference of size of the adjacent cells. (courtesy Prof. A. Papini, Dr. D. Attolini and Mr. C. Tani, involved with the author in studying the phytoliths of *Festuca*).

tolith morphotypes: a phenomenon indicated as "multiplicity". Moreover, the same morphotypes may occur with a wide dimensional range in the same part of the plant (Fig. 4). At the same time, similar morphotypes may be produced by different taxa - "redundancy" - both related and unrelated. And, finally, despite attempts (see for example Madella & al. 2005), scholars have still not developed a univocal nomenclature for the different morphotypes, and this is an obstacle for the comparison of phytoliths found in diverse archaeological sites.

In conclusion, even with these limitations, the study of starch grains and phytoliths has allowed us to highlight our ancestors' ability to manipulate food already during the Stone Age. And the study of the starch grains attests to the use of wild cereals – more exactly oats – in Europe over 30,000 years ago. All this, well before the beginning of agriculture.

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Human activities trigger change in marine landscape*

Abstract

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Biodiversity is undergoing rapid and worrying changes, partially driven by anthropogenic activities. Human impacts and climate change (e.g. increasing temperature and ocean acidification), which act at different spatial scale, represent the most serious threats to biodiversity and ecosystem structure and function. In this overview, the effects of anthropogenic pressures on unique and valuable Mediterranean systems, such as *Cystoseira* sp. pl. forest and *Posidonia oceanica* meadows, are examined. These complex systems, characterized by a high associated biodiversity, are regularly exposed to natural and anthropogenic pressures. Due to the central role they have for several important ecological processes in marine ecosystems, their loss can lead dramatic consequences. Since these ecosystems are often unable to recover naturally, it is necessary to reinforce their resilience. Therefore, reintroduction by transplantation and reforestation methods have been recently proposed. Considering future increase in anthropogenic and climatic pressures, understanding how these systems respond to stressors and preserving their resilience should be an essential component of any conservation management plan.

Key words: biodiversity, *Cystoseira* forest, stressors, *Posidonia oceanica* meadows, Mediterranean Sea.

Introduction

The Mediterranean Sea, even though representing a small part of the world's oceans, is inhabited by an unusually rich and diverse biota. It hosts approximately 17,000 species (Bianchi & Morri 2000; Coll & al. 2010). As a result, the Mediterranean Sea is considered as a true hotspot of biodiversity (Bianchi & Morri 2000; Boudouresque 2004; Coll & al. 2010), even by virtue of the high rates of endemic species it supports (25%, Boudouresque 2004), for instance the neo-endemism (of Pliocenic origin) *Cystoseira* genus, considered a key-stone genus with 30 endemic species into the Mediterranean (Cormaci & al. 2012) and the paleo-endemism (of Tethyan origin) *Posidonia oceanica* (L.) Delile. The western basin shows a higher rate of endemism than the eastern basin, appearing to be an active center of endemism (Boudouresque 2004).

Within the Mediterranean Sea, Sicily and circum-Sicilian Islands, as a consequence of their geographical position between the western and eastern sectors, and due to the numerous diverse habitats occurring along their coasts, which are washed by three different seas (Tyrrhenian, Ionian and South Mediterranean) are high-biodiversity areas (Coll & al. 2010; Giaccone & al. 2010; Domina & al. 2018).

At the same time, the Mediterranean Sea is among the most impacted Sea, as a consequence of different anthropogenic pressures on marine ecosystems which are significantly affecting biodiversity and are predicted to increase in the future (Coll & al. 2010, 2012; Lejeusne & al. 2010; Katsanevakis & al. 2013). The Mediterranean is currently experiencing a decline in the number of species and a deterioration of habitats, related to increase of human population, habitat modification and loss, pollution, coastal urbanization, overexploitation and the intentional or indirect introduction of Non-Indigenous Species (NIS, i.e. organisms introduced outside of their natural range) and climate changes, i.e. acidification and warming (Coll & al. 2010; Lejeusne & al. 2010; Zenetos & al. 2012; Katsanevakis & al. 2013; Bianchi & al. 2014).

In the Mediterranean Sea, several valuable, productive and unique habitats, including *Cystoseira* sp.pl. forest and *P. oceanica* meadows, supporting high biodiversity and providing essential ecological goods and services, are under threat (Coll & al. 2010; Lejeusne & al. 2010; Telesca & al. 2015; Boudouresque & al. 2017 and references therein). The sensitivity of these systems to a variety of stressors, makes them particularly vulnerable and susceptible to human pressures which can cause their decline and/or loss.

The aim of the present paper is to overview the effects of anthropogenic activities on these two sensitive Mediterranean coastal communities, *Cystoseira* sp. pl. forest and *P. oceanica* meadows, which are currently under threat in several areas, focusing on Sicilian habitats, also providing examples of management and conservation strategies.

Materials and methods

We looked for scientific papers, grey literature and reports, in order to obtain a representative number of relevant documents. A search was performed using standard scientific databases. The research criteria were based on a list of key terms such as "*Posidonia oceanica*" or "*Cystoseira*" or "*Cystoseira* canopies" or "Fucales" and "status" or "decline" or "regression" or "recovery" and "human impact" or "pressure" or "threat" and "restoration" or "transplantation" or "reforestation" and "Mediterranean Sea" or "Sicilian".

Results and Discussion

Cystoseira *sp. pl. forests*

In the Mediterranean Sea, species belonging to the genus *Cystoseira* (*Sargassaceae*) are the most important canopy-forming algae in shallow rocky bottoms (Ballesteros 1990a, 1990b; Giaccone & al. 1994).

Currently, 41 taxa belonging to the genus *Cystoseira* are reported for the Mediterranean Sea (Cormaci & al. 2012; Taşkin & al. 2012). These long-living brown macroalgae are ecologically relevant as keystone species (Paine 1969) and habitat-forming species (Gianni & al. 2013). They have a fundamental role in sustaining the biodiversity and performing numerous ecosystem services such as controlling spatial habitat heterogeneity, providing high primary production and food, nutrient cycling, suitable habitats, protection from predators and shelter from disturbance (Ballesteros & al. 2009; Sales & al. 2012; Mineur & al. 2015).

For these reasons *Cystoseira* species are listed as “of community interest” according to the Habitat Directive (92/43/EEC), and are considered as reliable indicators of environmental quality in Mediterranean coastal waters (Ballesteros & al. 2007), according to the Water Framework Directive (WFD, 2000/ 60/EC) and Marine Strategy Framework Directive (MSFD, 2008/ 56/EC) (Orlando-Bonaca & al. 2013). Five species are on the list of protected species (Annex I) of the Bern Convention and all the species, except *Cystoseira compressa* (Esper) Gerloff & Nizamuddin, are included in the List of endangered and threatened species of the Annex II of the Barcelona Convention (UNEP, Decision IG.21/09) and are considered vulnerable by several international organizations (i.e. IUCN, RAC/SPA, MedPan).

Anthropogenic pressures

Cystoseira species are particularly sensitive to a variety of anthropogenic stressors such as urbanization, pollution, trampling, overfishing (of large sea urchin predator fish) and climate change (Milazzo & al. 2002; Sales & al. 2011; Mineur & al. 2015; Thibaut & al. 2015; Blanfuné & al. 2016). Consequently, over the last few decades, most of the *Cystoseira* species have experienced a severe decline in many Mediterranean regions and have retracted their ranges (Thibaut & al. 2005; Mangialajo & al. 2008; Iveša & al. 2016; Bulleri & al. 2018). The causes of decline of Mediterranean Sargassaceae are multiple and act not only in a cumulative but also in a synergic way. Recently, it has been suggested the hypothesis of a possible role of the microbial communities in contributing to the declines of populations of *Cystoseira* sp. pl. in the Mediterranean Sea (Mancuso & al. 2016).

As consequence of these pressures, *Cystoseira* systems may shift from a complex and productive state to alternative states with simpler, poorly organised and less-productive communities that are able to inhibit recolonization by canopy-forming species (Connell 2005; Gorman & al. 2009; Perkol-Finkel & Airoldi 2010; Thibaut & al. 2014 and references within; Rindi & al. 2017; Chemello & al. 2018). For instance, pollution can lead to a shift to ephemeral opportunistic species and, affecting the resistance to the invasion and the resilience of the system, can enhance the growth and spread of alien species such as *Caulerpa cylindracea* Sonder (Fig. 1A) (Diez & al. 2014; Gennaro & Piazzi 2014; Gennaro & al. 2015; Piazzi & Ceccherelli 2017). In turn, opportunistic species are unable to avoid the spread of *C. cylindracea* which prevents the recovery of native populations by facilitating the persistence of alternative assemblages (Piazzi & Ceccherelli 2017). Overfishing of large sea urchin predator fish cause an increase in sea urchin density which may lead to a shift to a simpler community, dominated by turf-forming or encrusting coralline algae, the so-called ‘barren ground’ (Fig. 1B) (Thibaut & al. 2005; Airoldi & al. 2008; Hereu & al. 2008; Sala & al. 2012; Tsiamis & al. 2013; Templado 2014; Agnetta & al. 2015). The sea urchin *Paracentrotus lividus* (Lamarck, 1816) would have a leading role in the formation of barren areas (Agnetta & al. 2015). Indeed, by removing the base of the alga, prepares the substratum for the colonization by encrusting algae (Agnetta & al. 2013).

Instead, the role of *Arbacia lixula* L., which settles in encrusting coralline algae, is the maintainance of ‘barren ground’ (Bonaviri & al. 2011; Privitera & al. 2011). At Ustica

Fig. 1. A) A population of *Caulerpa cylindracea*; B) a “barren ground” (photo by Paola Gianguzza); C) the infralittoral fringe with *Cystoseira amentacea*.

Island, a barren ground interspersed with patches of *Cystoseira* sp. pl. was recently observed by Gianguzza & al. (2010).

The regression of *Cystoseira* sp. pl. forests is mainly related to overfishing and NIS rather than to warming (Boudouresque & al. 2017 and references within). Due to the dramatically accelerating rate of NIS introductions and due to the intense shipping traffic, the Mediterranean Sea may be considered as a true hotspot of marine bioinvasions (Rilov & al. 2009). To date, almost 1000 marine NIS (equivalent to ca. 6% of the total flora and fauna) have been introduced in the Mediterranean (Zenetos & al. 2012). It has been ascertained that alien species may have significant environmental (substitution of native species; biodiversity loss; habitat modifications and alterations in community structure), socio-economic and human health impacts (Vilà & al. 2011; Jeschke & al. 2014; Katsanevakis & al. 2014), consequently they are recognized as one of the major threats to biodiversity. For instance, *Caulerpa taxifolia* (Vahl) C. Agardh, *C. cylindracea* and *Asparagopsis taxiformis* (Delile) Trevisan can outcompete with *Cystoseira* sp. pl., mainly with species growing in the infralittoral fringe such as *Cystoseira amentacea* (C. Agardh) Bory (Fig. 1C), which is a particularly vulnerable area, being subjected to a range of anthropogenic disturbances (Boudouresque & al. 1995; Thompson & al. 2002; Piazzi & Ceccherelli 2006; Mannino & Balistreri 2017; Mannino & al. 2017).

Status along the Sicilian coasts

According to Giaccone & al. (2010), who depicted the ecological status of coastal waters around Sicily, in Tyrrhenian areas (e.g. Ustica Island, the Aeolian Islands) communities with *Cystoseira* sp. pl. (*C. amentacea*, *C. brachycarpa* J. Agardh, *C. sauvageuana* Hamel, *C. spinosa* Sauvageau, *C. zosteroides* (Turner) C. Agardh) were well structured. Conversely, in the Straits of Sicily (e.g. Pantelleria Island and Linosa Island) and the Ionian Sea (Maddalena Peninsula), disappearance of the above-mentioned species of *Cystoseira* and the resulting communities (excluding those occurring in shallow water), and their substitution by less-structured communities of *Dictyotaceae*, *Sphacelariaceae* and *Udoteaceae* were observed. The disappearance of *Cystoseira* in these areas was related by the authors to an increase in the temperature of superficial waters caused by global climate change, together with changes in the deep circulation of the eastern Mediterranean basin recorded in the last 30 years. More recently, Mancuso & al. (2018) observed at Portopalo di Capo Passero the loss of *Cystoseira humilis* Kützing and a notable decrease in the cover of *C. compressa* with respect to previous data (Giaccone & al. 1992).

Management and restoration strategies

The threat of declining/losing *Cystoseira* species is increased by the low dispersal capacity of most *Cystoseira* species, due to rapid egg fertilization and zygote sinking, which makes difficult natural recovery. To stimulate the natural restoration of lost populations, the setting up of Marine Protected Areas (MPAs) could be certainly useful but probably not sufficient. Therefore, artificial reforestation may be a valuable tool to improve the restoration of extinct populations (Falace & al. 2018 and references within).

Nowadays, the interest in habitat restoration is increasing according to the Biodiversity Strategy to 2020 (Target 2; European Commission, 2011), which recommends the restoration of valuable species, such as *Cystoseira* sp. pl. forests, into areas where their historical presence is recorded and the pressures that led to their loss are no longer acting (Mangialajo & al. 2013; Falace & al. 2018).

For *Cystoseira* reforestation, among the techniques now available, transplantation of juveniles or adult thalli is the most used method (Falace & al. 2006; Susini & al. 2007; Sales & al. 2011; Perkol-Finkel & al. 2012; Gianni & al. 2013). Outplanting (culturing germlings, obtained from fertile receptacles, in the laboratory and transferring them into the field), providing many healthy specimens without depleting natural populations, appears to be a more ecologically sustainable technique (Falace & al. 2006; Sales & al. 2015). Since large numbers of germlings are necessary for outplanting in large-scale restoration actions, efficient and cost-effective seedling production system must be planned (Falace & al. 2018). However, restoration of canopy forests makes sense only within the framework of an effective and rapid management of local stressors. Reducing local human impacts would represent the most effective strategy for the conservation and recovery of these systems, but, whenever this is not sufficient, restoration projects can help.

Posidonia oceanica *meadows*

Mediterranean seagrass meadows, such as *P. oceanica*, constitute a major component of coastal marine ecosystems, which provide goods and services in coastal areas (Pergent & al. 2014).

P. oceanica is a slow-growing species endemic of the Mediterranean Sea, where it is the dominant seagrass and it can form meadows or beds extending from the surface to 40–45m depth (Fig. 2A).

According to Telesca & al. (2015), the total known area of *P. oceanica* meadows in the Mediterranean Sea was found to be 1,224,707 ha (12,247km^2). In Italy (337,611 ha) it was characterized by a rather continuous distribution along continental and insular coasts, and it covers 76,000 ha of Sicilian coastal areas (Calvo & al. 2010; Telesca & al. 2015).

Seagrass meadows are presently experiencing a decline globally (Orth & al. 2006), as consequence of several threats, which places them among the most threatened ecosystems (Waycott & al. 2009). Since *P. oceanica* is also susceptible to regression as response to specific impact (Orth & al. 2006; Marbà & al. 2014), its presence and abundance is considered as an indicator of the environmental quality of the coastal zone. Therefore, *P. oceanica* has become one of the main targets of the protection and management of the Mediterranean marine environment (Pergent 1991; Boudouresque & al. 2012). Indeed, the European Union's Habitat Directive (92/43/ CEE) included *P. oceanica* beds among priority habitats (Habitat 1120), and more recently, the Marine Strategy Framework Directive (MFSD) (2008/56/EC) selected *P. oceanica* as representative species of the angiosperm quality elements for the Mediterranean marine environment.

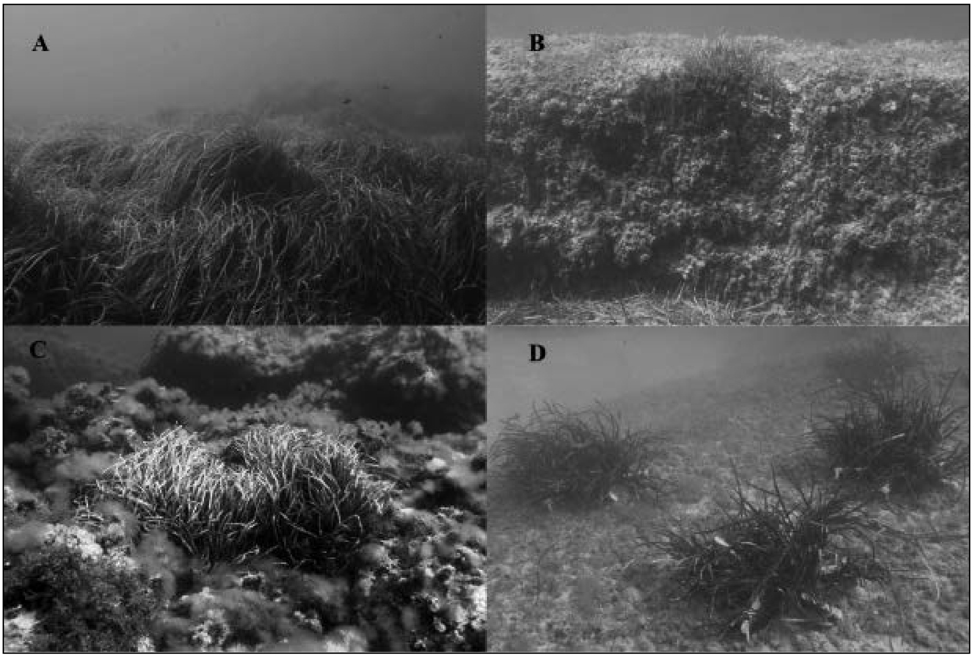

Fig. 2. A) *Posidonia oceanica* meadow; B) *Posidonia oceanica* dead *matte* (photo by Antonino Scannavino); C) the NIS *Lophocladia lallemandii*; D) an underwater anchor modular system for restoration of *Posidonia oceanica* meadows (photo by Antonino Scannavino).

P. oceanica is listed as a species of Least Concern within the International Union for the Conservation of Nature Red List of Threatened Species (IUCN 2015) and included in Annex I of the Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats, 1979) as a protected species. The habitat has been also identified as a priority under the European Commission Habitats Directive (92/43/EEC), and in several European countries the species and/or the habitat are under specific legal protection (Boudouresque & al. 2012).

Anthropogenic pressures

P. oceanica meadows are presently experiencing significant regression generally linked to anthropogenic pressures, such as coastal development, pollution, turbidity, resuspension of sediments, boat anchoring, fish trawling, dredging (Milazzo & al. 2002; Boudouresque & al. 2009; Badalamenti & al. 2011; Abadie & al. 2016). Pressures linked to global change, i.e. the introduction of NIS, warming and sea level rise, can be considered to be among the main responsible of *P. oceanica* regression (Short & Neckles 1999; Boudouresque & Verlaque 2002; Marbà & Duarte 2010; Pergent & al. 2014, 2015). As consequence of its regression, *P. oceanica* may be substituted by “warm” affinity species of lower structural complexity, such as *Cymodocea nodosa* (Ucria) Ascherson (which is also a pioneer species in the succession, allowing for the settlement of *P. oceanica* meadows), *Halophila stipulacea* (Forsskål) Ascherson, or other NIS. Warming is responsible for a reduction of its range near its warm limit and an increase of its range near its cold limit, whereas sea level rise causes a reduction of its lower limit (Boudouresque & al. 2017 and references within). Trawling removes the upper layer of rhizomes of the dead *matte* (Fig. 2B). Anchoring of small leisure boats scars the dead *matte*, whereas the anchor of large boats may remove huge blocks of *matte* (Ganteaume & al. 2005; Boudouresque & al. 2012). Anchoring has a direct adverse effect on cover and shoot density of *P. oceanica* meadow (Francour 1994; Francour & al. 1999; Milazzo & al. 2002). The introduction of NIS, such as *C. taxifolia* and *C. cylindracea*, able to enter into competition with native seagrasses, is a major concern (Boudouresque & al. 2009). Stressed and degraded meadows constitute a very favorable environment for the development of NIS, and this development could in turn exacerbate the regression of seagrass meadows (Fig. 2C). Both invasive *Caulerpa* species are able of invading sparse *P. oceanica* meadows, but fail when shoot density of *P. oceanica* is high (Meinesz & Hesse 1991; Klein & Verlaque 2008).

Status along the Sicilian coasts

P. oceanica is the most common seagrass along Sicilian coasts, whose meadows show the most extensive bottom coverage of all the Italian regions after Sardinia (Calvo & al. 2010).

According to these authors, along the Sicilian coasts, *P. oceanica* is commonly found in a good condition in respect to average Mediterranean conditions. This is demonstrated by the high levels of productivity, leaf biometry and flowering performance which have been recorded. Genetic diversity is also high, with the exception of isolated meadows such as the *Posidonia* banks and the Stagnone of Marsala. Several factors may explain the health status of Sicilian meadows, such as relatively low anthropogenic pressure, sedimentation rate and favourable temperature and photoperiod (Calvo & al. 2010 and references within). In particular, along the western coast of Sicily favorable ecological conditions and highly pristine natural conditions have allowed the development of one of the largest *P. oceanica* meadows in the Mediterranean. Wide and dense *P. oceanica* meadows are present on the sea floor of the calcareous Egadi Archipelago and the island of Lampedusa. In the volcanic islands (Aeolian, Ustica, Pantelleria and Linosa Islands) *P. oceanica* beds settle on rock or volcanic sands mixed with biogenic calcareous detritus. A decline of *P. oceanica* meadows has been observed in "Stagnone di Marsala" (Tomasello & al. 2009; Calvo & al. 2010), a semi-enclosed coastal lagoon along the western coasts of Sicily (Italy), where seagrass forms reef, atoll and tiger meadow types. Signs of evident regression have been also found for meadows close to urban and industrial areas (e.g. Gulfs of Palermo and Augusta).

Management and restoration strategies

Due to the fundamental role played by *P. oceanica* meadows along Mediterranean coasts, and the obvious regression to which they have been subjected, it is crucial to undertake actions to mitigate the threats, promote conservation practices and restore the previous conditions. For seagrass habitat recovery it is necessary to identify and limit and/or eliminate the causes of degradation (Hobbs & Norton 1996). The management of direct impacts, certainly helping recovery and promote resilience, can take an extremely long time from dozens to hundreds of years (González-Correa & al. 2005; Badalamenti & al. 2011; Fraschetti & al. 2013). Full recovery of *P. oceanica* meadows is considered irreversible in human time-scale, because it is a slow-growing species with a low recovery rate a low recovery rate, low flowering and high rates of fruit abortion and predation (Balestri & Cinelli 2003; Díaz-Almela & al. 2006). Transplantation is considered a possible option for speeding up seagrass habitat restoration (Fonseca & al. 1994). The use of vegetative fragments as planting units has proved more effective than seeds, which are less available (Balestri & Cinelli 2003; Díaz-Almela & al. 2006; Terrados & al. 2013). Transplant donor populations of *P. oceanica* with the highest genetic variability showed the best growth performance (Procaccini & Piazzi 2001). Terminal plagiotropic cuttings with three leaf bundles resulted suitable material for transplanting (Piazzi & al. 1998). A careful habitat selection for seagrass transplantation is also needed (van Katwijk & al. 2009). Dead *matte* results the most suitable substratum for *P. oceanica* planting (Di Maida & al. 2013; Terrados & al. 2013). Another focal point of marine restoration projects is monitoring of transplant performance. A monitoring period should last at least 3 years for the selection model outcome and at least 6 years for evaluating the effectiveness of restoration projects (Pirrotta & al. 2015). Limiting anchorage and craft fishing to protect transplants, at least until their stabilization, is also needed.

A new transplantation technique, based on anchor modular system with six arms constructed of starch-based biodegradable materials (bioplastic Mater-Bi), may be an effective technique to successfully restore *P. oceanica* habitat (Fig. 2D) (Scannavino & al. 2014). Cultivated seedlings of *P. oceanica* can be also transplanted in the field with relatively high success and thus can be an important management tool for seagrass restoration (Balestri & al. 1998; Domínguez & al. 2012; Terrados & al. 2013). Since *P. oceanica* fruits are increasingly available in many countries, they may be planted in selected suitable areas to create reservoirs of juveniles for future restoration activities.

Conclusions

Unhealthy *Cystoseira* assemblages and *P. oceanica* meadows are at high risk from anthropogenic and climatic stressors. Since anthropogenic stressors and global change are expected to increase in the coming decades, a strong effort at global scale is required in order to establish and/or implement effective conservation plans for these valuable ecosystems.

A successful conservation plan is possible by reducing anthropogenic stressors and improve the resilience of these systems to future anthropogenic and climatic pressures (Folke & al. 2004; Boudouresque & al. 2009; Sales & al. 2011; Pergent & al. 2014; Strain & al. 2014, 2015).

Additional management strategy can be restoration and protection within MPAs (Susini & al. 2007; Gianni & al. 2013). MPAs are without any doubt precious tools for the management and governance of biodiversity in the Mediterranean (IUCN 2010). For decades the creation of marine reserves has been considered the only means to restore natural communities and protect marine ecosystems.

MPAs may play a fundamental role in the conservation of *Cystoseira* sp. pl. forests and *P. oceanica* meadows, guaranteeing protection from several impacts and representing the source of propagules for the restoration of lost or degraded systems. Unfortunately, the aesthetic appeal of reserves and the facilities provided, together with the increased public awareness of nature, contribute to creating massive tourism in MPAs (Badalamenti & al. 2000).

Moreover, monitoring plans are also required in order to describe how these populations are changing over time, and implement integrated coastal zone management actions for the protection, conservation and/or restoration of these unique, valuable and unfortunately sensible ecosystems (Calvo & al. 2010; Pergent & al. 2014; Mancuso & al. 2016). The creation of early-warning systems, able to valuate early signs of suffering or decline, could be crucial for monitoring these habitats. Since intensive scientific monitoring programs are very expensive, Citizen Science (involvement and active participation of volunteers: tourists, fishermen, divers) could be a useful tool for providing information and scientific data and also to improve the communication between scientists and citizens (Mannino & al. 2018).

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Pampean-grassland heterogeneity on the intersection of science, art, and culture*

Abstract

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Since prehistoric times, temperate grasslands have provided favorable habitat for human subsistence. Ease of exploitation, however, has caused that temperate grasslands are among the most destroyed terrestrial ecosystems. The region known as the Pampas or Rio de la Plata Grasslands, extending over some 750,000 sq. km in central eastern Argentina, Uruguay and southern Brazil, comprises the largest temperate grassland area in the southern hemisphere. Flat topography, humid temperate climate, grassy natural vegetation, and absence of large native herbivores have conditioned multiple aspects of human life in the region, like patterns of population settlement, techniques for acquisition and transportation of goods, aesthetic preferences, and social structure. In this article, we present some writers inspired by the Pampas, we briefly summarize the main results of scientific research on the drivers of vegetation physiognomy and heterogeneity in the Pampas, based on the invaluable floristic database compiled by Professor Rolando J. C. León, and we sketch one of Professor León´s scientific-historic tours to the Pampas. Finally, we call attention to currently threats to the persistence of Pampean Grassland.

Key words: Rio de la Plata grasslands, climatic drivers, vegetation survey, biological invasions.

Introduction

Temperate grasslands have provided habitat for human subsistence since prehistoric times. These ecosystems, characterized by open grassy vegetation, occur in regions where factors such as drought, fire, or herbivory have prevented tree dominance (Walter 1970; Bond & Keeley 2005; Sankaran & al. 2008). Grasslands have been recognized and appreciated around the world, receiving local names like *prairies*, *veldts*, or *pampas*, and have become home for some renowned cultures. In these regions, cultural and economic history cannot be dissociated from the characteristic provision of basic resources for human life, so readily accessible for use for animal herding and agriculture. Ease of exploitation, how-

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ever, has caused that temperate grasslands are among the terrestrial ecosystems with highest extension of destroyed area and smallest proportion of area devoted to nature protection (Hoekstra & al. 2005).

The region known as the Pampas or Rio de la Plata Grasslands, extending over some 750,000 sq. km in central eastern Argentina, Uruguay and southern Rio Grande do Sul in Brazil, from 28ºS to 38ºS, comprises the largest temperate grassland area in the southern hemisphere (Hudson 1895; Parodi 1947; Cabrera 1976; Soriano 1992; Gibson 2009). The essential characteristics of this vast region are flat topography, humid temperate climate, natural vegetation dominated by coarse grasses with virtually no trees, and absence of large native herbivores. These characteristics have conditioned multiple aspects of human life in the region, from patterns of population settlement, to techniques for acquisition and transportation of goods, perceptions and appreciations of space, time, and effort, aesthetic preferences, social structure, and the history of human competition for resources and power. Since the arrival of the Spaniards to the Río de la Plata in the sixteenth century, aboriginal peoples from the Pampas were gradually displaced from the plains (Hudson 1895). This determined a deep transformation in the pattern of land occupation and use, as the aboriginals had lived in nomadic communities wandering on the plains in the pursuit of livelihood, whereas the European colonists who replaced them settled as small groups on fixed locations widely separated from each other (Sarmiento 1874). After European settlement, the land was incorporated into cattle herding. As a result, vegetation physiognomy and landscape structure of the Pampas started a process of unprecedented changes. Tall dominant grasses were replaced by shorter gramineous species and exotic forbs by effect of fire and grazing by confined animals, and runoff patterns were deeply modified by canals, railways, and later by roads and highways constructed across the region (Hernández 1882; Hudson 1895; Sbarra 1964). In recent decades, the area devoted to cattle production was greatly reduced due to the expansion of increasingly sophisticated crop agriculture (Baldi & al. 2006; Viglizzo & al. 2011). This is resulting in further transformations of the Pampas, where nowadays vegetation comprises large areas of species-poor crop fields and fallow land covered by short turf or invaded by shrubs or exotic trees, and human-population density has dropped dramatically (Ghersa & al. 2002; Hora 2018).

Because the national economy is highly dependent on agricultural exports, the history of exploitation of the Pampas has been in good measure modulated by state initiatives. These range from the historical distribution of land, to the building of transportation infrastructure, interventions in the market of agricultural products and services, and the continued development of technology and human resources. In particular, botanical studies of the Pampas, acquired impulse in the twentieth century in the context of state universities and research institutes. Distinguished botanists produced a corpus of knowledge of plant taxonomy and phytogeography that has served as the basis for a currently active field of ecological research in the region. An essential contribution to the progress of vegetation ecology in the Pampas is the life-long work of Professor Rolando J.C. León (1932 – 2015) to characterize their compositional heterogeneity. Systematic vegetation surveys conducted over the years by Professor León and his disciples across the region produced an invaluable database of floristic information that allows exploring the drivers of species distribution and community composition at varying spatial scales, and serves as a detailed reference for assessing the ongoing transformation of the grassland. In addition, Professor León was an extremely active and committed educator who, both in and outside the academy, taught botany and ecology as articulated with history, art, and literature in the Pampas and elsewhere. He often led students and researchers from overseas on scientific-historic tours across the Pampas to appreciate the amazing natural diversity concealed under the apparent homogeneity of the grassland. In this article, we present some art and literature inspired by landscape of the Pampas, we give a brief summary of the main results of scientific research on the drivers of the physiognomy and heterogeneity of vegetation in the Pampas, and we sketch one of Professor León´s scientific-historic tours to the Pampas. Finally, we call attention to current threats to the persistence of Pampean Grassland.

Literature

Since colonial times, Argentine culture has been marked by a tension between contrasting valuations of countryside and city life experiences. This tension originates, at least in part, in the fact that Spanish conquerors had little interest in the Pampas, as the grassland offered neither precious metals nor abundant people to enslave, and concentrated their attention on the services produced by the cities (Hora 2018). For them, the plain appeared as an obstacle for travelling and transportation, especially because of the lack of navigable waterways, the difficulty for finding water, and the softness of the soil, where vehicles often became stuck in the mud (D´Orbigny 1998). Under this tension, rural and city people of the Pampas have tended to look on each other with suspicion (D´Orbigny 1998; Sarmiento 1874) and developed two separate literary traditions.

Rural people, the *gauchos*, produced a type of anonymous orally-transmitted poetry (known as *payada*) reflecting their refusal to accept rules, intolerance to alien manners, violence, and a mixture of melancholy and witty irony associated with the harshness and isolation of their lives (D´Orbigny 1898; Sarmiento 1874). This literary genre entered in the cannon of Argentine literature when José Hernández published his epic poem *Martín Fierro* in 1872: *"Mi gloria es vivir tan libre / Como el pájaro del cielo: / No hago nido en este suelo / Ande hay tanto que sufrir, / Y naides me ha de seguir / Cuando yo remuento el vuelo*" ("My glory is to live as free / as the bird in the skies: / I don´t nest in this land / where there´s so much to be suffered / and nobody shall follow me / when I take flight"). It also shows up in the well-appreciated Argentine folklore, as for example in *Coplas del payador perseguido* by Atahualpa Yupanqui: *"Yo sé que muchos dirán / que peco de atrevimiento / si largo mi pensamiento / pal rumbo que ya elegí / pero siempre he sido ansi; /galopiador contra el viento… "*("I know that many will say / I´m falling into impertinence / if I let my thoughts go free/ the way I´ve already chosen / but I´ve always been so / a galloper against the wind…").

In the cities, an abundant literature produced by cultured writers has reflected the environment and the life in the Pampas. Writers in this tradition have been people with a strong rural experience often because they belonged to landowner families or had otherwise grown up or travelled extensively in the countryside. Here we can only mention a few examples.

A recurrent theme in this literature is the incommensurability and emptiness of the plain, making it difficult to discriminate land from sky. See for example a fragment of the epic *La Cautiva*, by Esteban Echeverría (1837): *"Gira en vano, reconcentra / su inmensidad, y* *no encuentra / la vista, en su vivo anhelo / do fijar su fugaz vuelo / como pájaro en el mar ...”* (“Spins in vain, gathers / its immensity, and fails / the eager eye to find /where to rest its fleeting flight/ like a bird over the sea …”); or this one of *Facundo*, the foundational essay by Domingo F. Sarmiento (1874): *“ ... el horizonte siempre incierto, siempre confundiéndose con la tierra entre celajes y vapores tenues que no dejan en la lejana perspectiva señalar el punto donde el mundo acaba y principia el cielo”* (“… the horizon ever uncertain, ever confused, with the land among cloudscapes and thin vapors that impede fixing in the far distance the point where the world ends and the sky begins.”). The vastness of the plain has also provoked the awe from the celebrated writer Jorge Luis Borges in his story *El Fin* (*Ficciones*, 1944): “*Hay una hora de la tarde en que la llanura está por decir algo; nunca lo dice o tal vez lo dice infinitamente y no lo entendemos, o lo entendemos pero es intraducible como una música…”* (“There is a time in the afternoon when the plain is on the verge of saying something. It never says it, or perhaps it says it endlessly and we fail to understand it, or we understand it butit is untranslatable like music …”). The immensity of the plain and the comparative minuteness of the plants covering it are the likely causes of the literary preference for a panoramic view. Some authors, however, have displayed also amazing powers of description at conveying a closer view of elements from the Pampas, though often choosing the once relatively exceptional trees. See for example, a gaze on a *tala* (*Celtis ehrenbergiana* (Klotzsch) Liebm.) thicket by Sara Gallardo in her novel *Los galgos, los galgos* (1968): “*No era solo de talas ese monte sino también y en segundo grado de acacias negras, individuos de cuerpo gris, medio calvos, con hoja fresca pero insuficiente, como señores de edad mediana irreprochables y tediosos de los cuales uno solo, que zumbaba como un poste eléctrico, nos inspiró interés. Cuando su examen nos condujo a un agujero hirviente de abejas emprendimos la retirada.*” (“Not just of*talas* was that thicket but also and in second term of black *acacias*, gray bodied individuals, halfway bald, with fresh though insufficient leaves, like irreproachable and boring middle-aged gentlemen among which only a single one, which buzzed like an electric pole, attracted our attention. When the examining of it took us to a hole boiling with bees, we marched in retreat.”).

Scientific research

While documenting patterns of landscape heterogeneity through rigorous observation and quantitative methods, Dr. Rolando León and his disciples contributed to the construction of a large database of floristic evidence. The information contained in this database allowed answering interesting questions about determinants of diversity at different scales. As part of those studies, it was necessary to geo-reference some vegetation samples to allow them to be linked with climatic and land use information. While doing this, it was surprising to find at each step, that Google Earth images seemed copied from the field map made by Dr. Rolando León during the ‘70s in the era before the GPS (Fig. 1).

On the broadest scale, a recent overview involving studies in Brazil, Uruguay and Argentina (Andrade & al. 2018) explored the complete gradient in floristic composition over the entire extension of the Pampean Grasslands to generate the consensus species list, a first step towards enhanced understanding of the biogeography and ecology in the Rio de

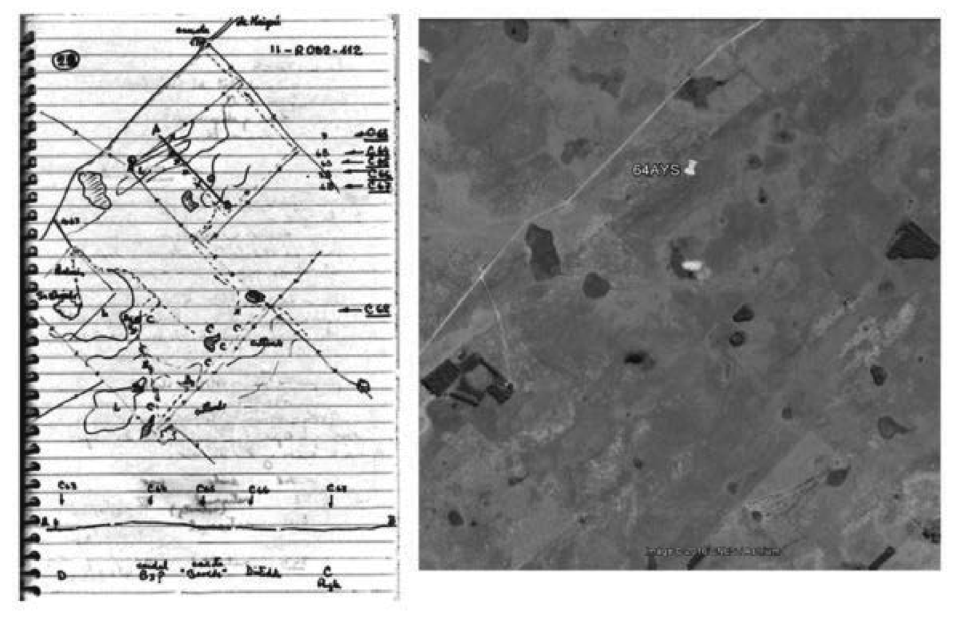

Fig. 1. Vegetation *releves* were georeferenced to generate links with the climatic and land use information.The capture from Google Earth seemed copied from the field map made by Dr. León in the era before GPS.

la Plata grassland biome. The number of almost 5 thousand vascular plant species across a total extent of 750 000 km^2 clearly establishes the Río de la Plata grasslands as a highly biodiverse region in South America. The high species richness found in this region is likely due to its location in a biogeographical overlap zone: the subtropical to temperate transition (Andrade & al. 2018). The East-West gradient in vegetation heterogeneity was also studied for remnant grasslands located on high agronomic potential soils along a five degree-east-west transect in the Rolling Pampa (Burkart & al. 2011). In this gradient the main driving factor of floristic heterogeneity was water availability, determined by climate and soil characteristics. These remnant grasslands which cover small areas as isolated stands are hot spots of native biodiversity(Fig. 2), as more than 80% of the species recorded in early vegetation surveys are still present there (Burkart &al. 2011).

Another study focused on the zonal community (mesophytic grasslands) but spread over a large scale (i.e. along a 600km gradient of five degrees latitude) assessed the relative importance of climate and land fragmentation by agriculture as controls of the diversity and composition of the grasslands (Perelman & al. 2017). Mesophytic grasslands on fertile soils, which have been largely replaced by crops due to their agricultural aptitude, are surrounded by matrices with varying proportions of remnant grassland and crop fields in different Pampean subregions (Baldi &al. 2006; Viglizzo & al. 2011). A multivariate analysis method applied to order samples using as the sole input the list of plant species present in each site, with no addition of any geographical or climatic information, revealed the exis-

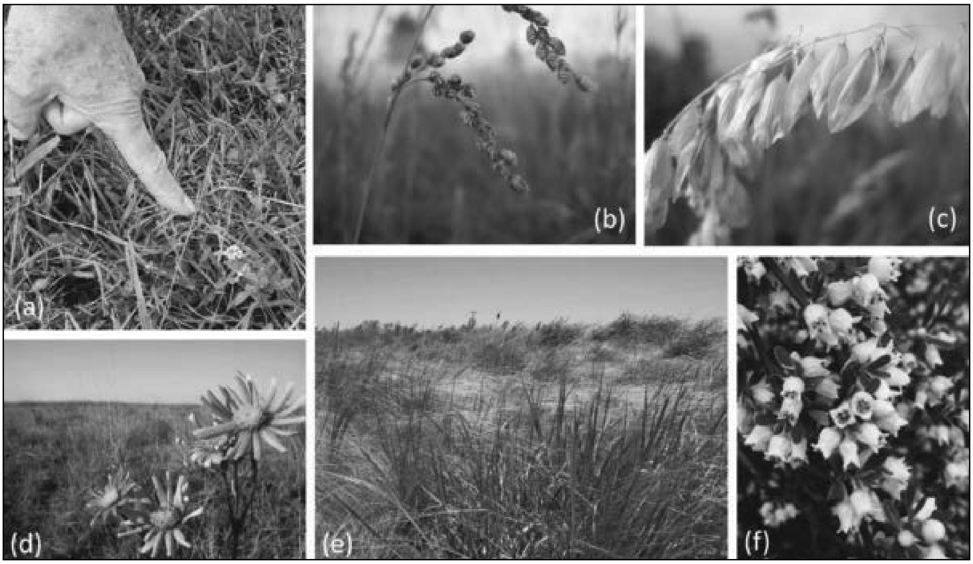

Fig. 2. Details of native species embellishing the grassland in the Pampas. The textures and colors of grasses and forbs certainly enhanced the beauty of these lands, inspiring naturalist and artists. (a) The hand of Prof. Rolando León pointing to *Borreria dasycephala* (Cham. & Schltdl.) Bacigalupo & E.L. Cabral. This white flowered forb is a cool-season species characteristic of mesophytic meadows across the Pampas (Leon & al. 1979; Burkart & al. 1990). (b) *Briza subaristata* Lam. and (c) *Melica brasiliana* Ard. are cool-season grasses that co-dominate grassland (Burkart & al. 2011). Flowers and fruits of these grasses embellish the grassland during December. (d) The colorful *Senecio pulcher* Hook. & Arn. contrasts with the grayish-green background of the Flooding Pampa grasslands during early summer. This yellow hearted daisy is the delight of both, bugs and photographers. (e) View of a tussock grassland. The combination of cool-season (e.g. *Nasella trichotoma* (Nees) Hack. ex Arechav, golden spikes) and warm-season grasses (e.g. *P. quadrifarium* Lam., green tussock leaves) maintains continued primary production in the year. (f) The delicate flowers of *Discaria americana* Gillies & Hook. contrast with their strong, pugnant aroma. This shrub is typical of the western, sandy grassland of the Inland Pampa. Photos: (a) Marina Omacini. (b-f) Pedro Tognetti.

tence of species turnover among the mesophytic grasslands of different subregions (Perelman & al. 2017). But, more surprisingly the pattern of site distribution in the ordination graph resembled the geographic location of the samples!. Underlying variables controlling the water-energy dynamics: mean annual precipitation, inter-annual precipitation variability and minimum temperature are associated to latitude in this region. At the same time landscape fragmentation and variability of intra-annual precipitation are related to continentality or distance from the Atlantic Ocean. Climatic factors associated to latitude were also strong determinants of regional diversity: gamma diversity decreased linearly with increasing distance from the Equator, as did the rate of species accumulation with expanding area. By contrast, the current diversity in the sites of remnant vegetation showed association with the pattern and intensity of agricultural perturbation, as local species richness was more influenced by landscape fragmentation and remaining grassland cover. Moreover, the main environmental factor that explained the variation in local richness in multiple regression models was mean patch size of native grassland (Perelman & al. 2017). It seems that local diversity in these zonal grasslands is no longer coupled with factors linked to biogeographic, evolutionary and dispersal history that modeled the regional flora and still drive gamma diversity.

In previous studies, we analyzed cross-scale vegetation patterns in a more limited 90000km^2 area of natural grasslands in the Flooding Pampa where most of the area was still devoted to extensive rangeland (Fig. 3a & 3b; Perelman & al. 2001, 2007). In the Flooding Pampa, soil salinity and flooding are the primary underlying cause of coordinated species turnover. At very fine spatial scales associated with topographic features that determine the intensity and duration of the floods we can observe large proportion of the entire variation in species composition. The main floristic change is related to topographic differences, sometimes just a few meters apart but more often only tens of centimeters, that determine the intensity and duration of the floods, and to halomorphic differences of the

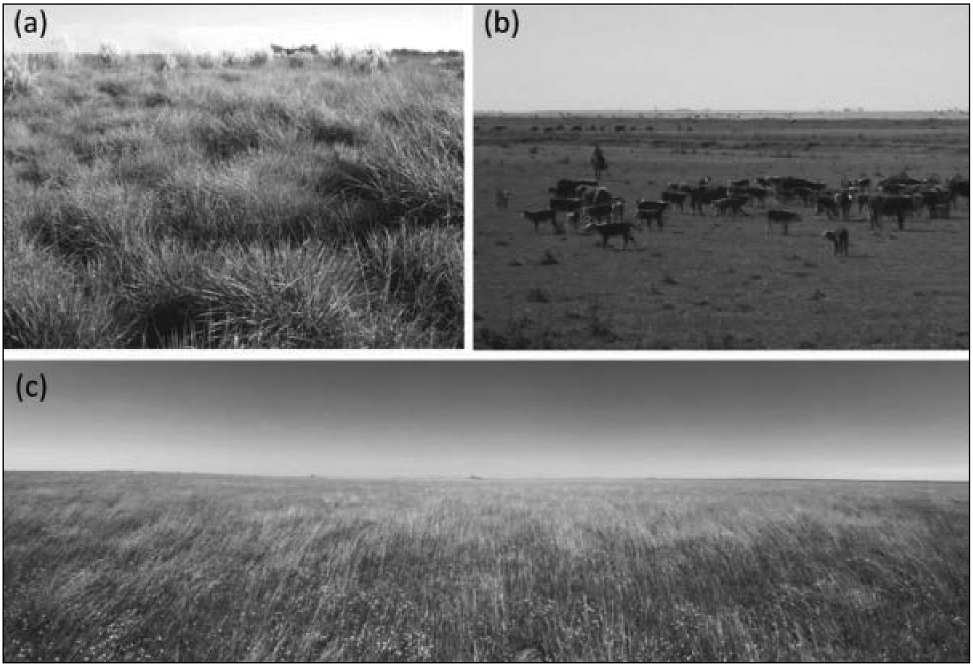

Fig. 3. Landscape views of the Pampas, with their infinite horizon. (a) Grassland stand near C. Casares, Buenos Aires, dominated by tall tussock grasses, *Paspalum quadrifarium* Lam. and *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn. These two species might have formed the matrix in the pristine communities. (b) Gauchos herding cattle, near Pila, Buenos Aires. Cattle, sheep, and horses introduced by Europeans deeply changed the physiognomy of the Pampas (Hudson 1895). (c) Early summer view of a grassland in the Flooding Pampa, near Pila, Buenos Aires. Across the region, the grassland hosts numerous exotic species like *Lolium multiflorum* Lam., the gold colored grass, and *Lotus tenuis*, the yellow flowers (Perelman & al. 2007). Photos: Pedro Tognetti.

soils (Batista &León 1992; Batista & al. 2005; Burkart & al. 1990).The most extended communities are those exposed to prolonged floods where the dominant species are *Setaria geminate* Forssk*, Leersia hexandra* Sw.*, Danthonia montevidensis* Hack. & Arechav.*, Nassella formicarum* (Delile) Barkworth*, Paspalum dilatatum* Poir.*, Eleocharis* species, *Jarava plumosa* (Spreng.) S.W.L. Jacobs & J. Everett, *Nassella neesiana* (Trin. & Rupr.) Barkworth and *Panicum gouinii* E. Fourn.*,* and those exposed to brief floods, with important presence of *Bromus catharticus* Vahl*, Piptochaetium stipoides* (Trin. & Rupr.) Hack. ex Arechav.*, P. bicolor* (Vahl) E. Desv., *Melica brasiliana* Ard. , *Nasella trichotoma* (Nees) Arechav., *Paspalum dilatatum* Poir.*, Jarava plumose* (Spreng.)*, Nasella neesiana* (Trin. & Rupr.) Barkworthand *Bothriochloa laguriοides* (DC.) Herter. These grasslands received a very important contribution both in species richness and biomass of alien species introduced with European colonization and domestic livestock. Functional group composition differed widely between the native flora dominated by perennial species in equal proportions of grasses and herbs and the exotic flora with predominance of annual winter-growing herbs of euroasiatic origin (Fig. 3c; Perelman & al. 2001, 2007; Poggio & al. 2015). Moreover, revisited grassland exposed to moderate grazing intensity during 35 yr (Fig. 4) showed clear differences in richness changes, in degree of homogenization and in species turnover during this period (Puhl & al. 2014), suggesting that the effect of human activities varies among plant communities.

The lack of trees in the Pampas intrigued scientists and travelers visiting these remote lands (Darwin 1878;Schmider 1929;Walter 1967;Yasawa 1989). Interestingly, at the time of Spaniard settlement, some native woody species (e.g. *Phytolaca dioica* L., *Acacia bonaerensis* Hook. & Arn., *Celtis erhenbergiana* (Klotzsch) Liebm.) were concentrated along river banks or ancient calcareous shell deposits (Ghersa &al. 2002; Ellenberg 1962), but until quite recently the plain was covered exclusively by grasslands. The fact that an area with an average annual rainfall of 600-1000 mm was not covered by forests originated a centennial discussion (Walter 1967; Chaneton & al. 2012), without a unique solution and

Fig. 4. View (left) from the bridge (right) over the Buñirigo stream in the North of the Flooding Pampa, near the places where Rolando León, Silvia Burkart and Chiara Movia began the first inventory of physiography and plant communities of the region (Leòn & al. 1979), one of the sites resurveyed after 35 years (Puhl & al. 2014). Photo credit María Zorzón.

with multiple hypotheses (Yazawa 1989). For example, Darwin (1878) suggested that wind would be limiting forest development, whereas Ulrich Schmieder (1929) proposed that it is an anthropogenic grassland originated from the use of fire. This discussion generated "The Pampas problem", as a special case of grasslands existing under these climatic conditions (Schmieder 1929). Lately, other hypotheses were based on water deficit, on soil mineralogy, and on climatic fluctuations (Walter 1967), also on the geological youth of this region (Parodi 1940; Chaneton & al. 2012), and on the competitive exclusion of tree seedlings by grasses (Parodi 1940; Facelli & Leon 1986; Chaneton & al. 2012). Whatever the cause, the limits of the Pampas grassland with the shrub steppes and xerophytic forests that surround it were delineated many times (León & Anderson 1983).

Nowadays trees have become a central element in the life and culture of the inhabitants of the Pampas. Both trees and settlers are newcomers to these lands, with the colonial advance and the establishment of new land uses increased tree abundance (Ghersa & León 2001; Ghersa &al. 2002). On the one hand, native woody species such as *Acacia bonaerensis* Hook. & Arn., or *Celtis erhenbergiana* (Klotzsch) Liebm., were planted (and nursed!) mainly to be build vegetated fences, limiting the movement and giving shelter to livestock (Sbarra 1964; Ghersa & León 2001). On the other hand, the greatest woody advance was from exotic tree species (Zalba & Villamil 2002; Ghersa & al. 2002), including species of numerous genera such as *Eucalyptus* and *Casuarina* from Australia, *Fraxinus*, *Pinus*, and *Gleditsia* from North America, *Ulmus*, *Platanus, Ligustrum* and *Melia* from the Eurasia *Acacia* and *Phoenix* from Africa, etc.

Currently the main concern of Pampean scientists and landowners, it is not the lack of trees but the spontaneous woody establishment and invasion. Different species of trees encroach over agricultural lands, pastures, and grasslands throughout the entire region (Zalba & Villamil 2002; Ghersa & al. 2002; Mazia & al. 2010), blocking the typical Pampas' horizon. Even though native woody species are still present, conspicuous tree establishment and invasion involves exotic species. For instance, *Melia azedarach* L. invades grasslands and savannas in the eastern areas, while the European *Ulmus* invades pastures and roadsides in the driest grassy areas of the west (Facelli &Leon 1986). The invasion of *Gleditsia triacanthos* L. in the Pampas grasslands has been well-studied (Mazia & al. 2001; Chaneton & al. 2004; Mazia & al. 2010; 2013). Supporting the idea of a climatic constraint to the establishment of trees, the invasion of *G. triacanthos* is more pronounced in humid years (Mazia & al. 2010). Interestingly, seed predation by rodents was higher for native than for exotic tree species (Busch & al. 2012), suggesting a differential biological filter among native and exotic species. Together, these evidences contribute to the idea that the geomorphological youth of the Pampas could limit the generation of genotypes adapted to these climatic conditions that, together with grass competition and periods of drought, could limit the advance of native trees in the pampas (Walter 1967; Chaneton & al. 2012).

An ecological and cultural journey into the Pampas

We propose a 700 km journey into the field to recognize the heterogeneity of the Pampas and to explore remnants of the natural grassland (Fig. 5). The journey covers two sub regions with contrasting relief, hydrology, and land-use history, first the Rolling Pampas, and second the Flooding Pampa, the highest expression of the Pampas flat spirit (Oyarzabal & al. 2018). A good supplementary reading for our journey is Ghersa & Leon (2001), who provide descriptions of present-day Pampean landscape and its history since the arrival of Europeans and the introduction of cattle.

Our trip begins by travelling to the north of the city of Buenos Aires, across the Rolling Pampas, where fluvial landforms offer the background to the visible imprint of culture (Ghersa & Leon 1999, 2001). Dense population and industrial compounds do not hide the typical valleys and hills of this region. On the San Isidro cliffs, the "*Quinta Pueyrredón*" offers a view of the banks of Rio de la Plata and the lion-colored river itself. Nowadays, this property houses a Municipal Historical Museum, as it is a landmark in South American

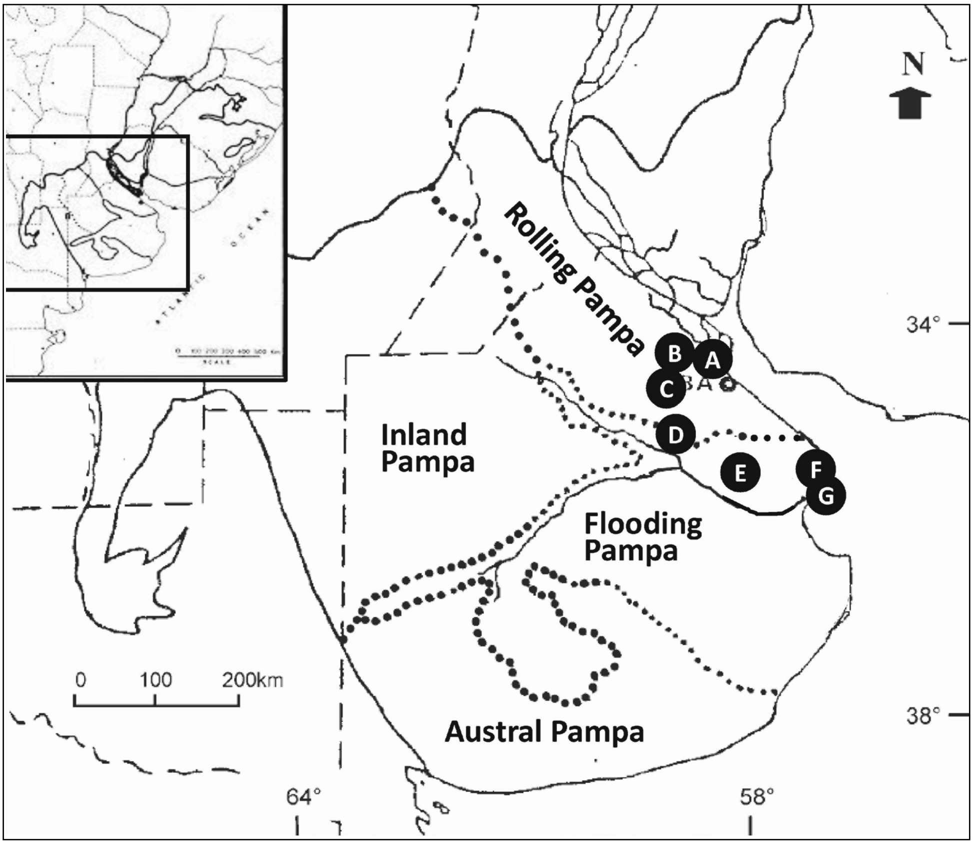

Fig. 5. A tour across the Pampas. Rolling Pampa: (a) Quinta Pueyrredón; (b) Lujan river; (c) La Blanqueada, one of the typical '*Pulperias*' (countryside tabern) where gauchos gathered; (d) Tall tussock grassland remnants. Flooding Pampa: (e) Flat landscape of the Flooding Pampa. (f) *Celtis ehrenbergiana* (Klotzsch) Liebm.thickets (*talares*) over coastal strips of shell deposits; (G) Coastal marsh *Spartina densiflora* Brongn. grassland (adapted from Soriano & al. 1991).

history (http://museopueyrredon.org.ar/ Fig. 6a). The cliffs witnessed the first meetings between aboriginals and Europeans back in the early sixteenth century. In 1810, Cornelio Saavedra, a leader of the May Revolution, departed from here to establish the first Government of what later became Argentina. In the colonial style gardens, a historical tree witnessed the birth of three countries: an *algarrobo* (*Prosopis alba* Griseb.) shelters us with the same shade in which José de San Martín and Juan Martín de Pueyrredón planned the Liberating Expedition of Southern South America. In fact, trees of different species of *Prosopis* characteristic of the Espinal phytogeographical province are represented in the garden (*P. affinis* Spreng. (ñandubay), *P. caldenia* Burkart; Cabrera 1976), as well as other tree species from the river bank thickets such as *tala* (*Celtis ehrenbergiana* (Klotzsch) Liebm.) and *ceibo* (*Erythrina crista-galli* L.) described by the Jesuit priest Thomas Falkner (Falkner 1774). These trees provided essential fire wood for the very first settlers of Buenos Aires (D´Orbigny 1998) and are easily identified, along with the *ombú* (*Phytolaca dioica* L.), in paintings by Prilidiano Pueyrredón, the distinguished Argentine landscape painter who portrayed the Pampas in the nineteenth century — (https://www.bellasartes.gob.ar/coleccion/obra/3170).

Continuing our journey towards the northwest, we leave the river behind and enter the Rolling Pampas. Driving along Provincial Route 41 to the city of Mercedes, we cross a landscape deeply modified by human activity. Soybean (*Glycine max* L.), maize (*Zea mays* L.), or wheat (*Triticum aestivum* L.) fields, and sown pastures alternate with gated neighbourhoods, malls, and industrial buildings (Fig. 6b). In the valley of the River Lujan, we find narrow corridors of grassland vegetation dominated by native grasses of the genera *Nasella*, *Paspalum*, *Aristida* and *Piptochaetium*, and shrubs of genera *Baccharis*, and *Vernonia*. The ancient atmosphere and meals from the Pampas are experienced in traditional taverns (*pulperías*) in San Antonio de Areco (Fig. 6c). The *pulpería* served as grocery store, bar, social club, and fighting arena for the rural life. "La Blanqueada" is a National Historical Museum (http://www.sanantoniodeareco.com/pulperia-la-blanqueada), as it is the setting of "*Don Segundo Sombra*", a traditional masterpiece of Argentine literature, written by Ricardo Güiraldes.

Our journey continues on route 41, forming a wide arch around Buenos Aires suburbs, toward the city of General Belgrano across the Salado River and into the lowlands of the Flooding Pampa. Crossing the Salado is a meaningful event as this river used to be the limit of European civilization in the Pampas, and significant historical outposts are distributed along its banks. In the Flooding Pampa, we have the opportunity to enjoy the apparent limitlessness of the plain. Sharpening our view, we might also learn to perceive and value the subtle topography of the paleo-dunes and depressions generated under desert climate during glaciation times and of shallow valleys of slow meandering watercourses (Tricart 1973; Burkart & al.1990). In the Flooding Pampas, grasslands are usually grazed by cattle year-round, and the horizon often looks still uninterrupted by trees. There are some grassland stands dominated by *Paspalum quadrifarium* Lam., a native tall tussock grass known as redstraw (Fig. 6 c; Perelman & al. 2003), that are host of a high diversity of native plant and animal species. Near the city of Castelli, we visit remnants of humid grassland communities with characteristic species like *Leersia hexandra* Sw., *Paspalidium geminatum* (Forssk.) Stapf and *Carex phalaroides* Kunth. (Fig. 6d).

Finally, on the trip back to Buenos Aires along PR 11, we visit the coastal landscape where strips of tala(*Celtis ehrenbergiana* (Klotzsch) Liebm.) thicket occupy old marine

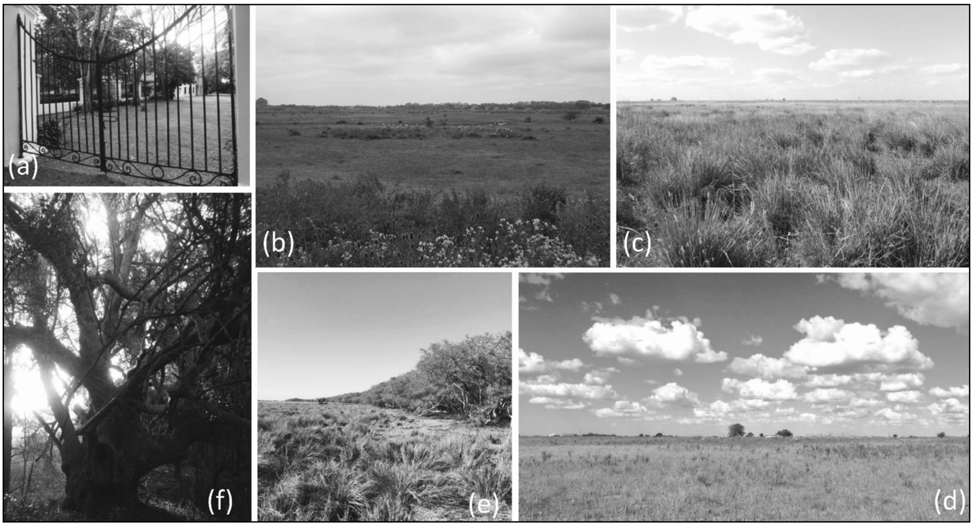

Fig. 6. Images from some the tour across the Pampas grasslands. We purposely present B&W photos to invite future travelers to enjoy the live colours and tints of these lookouts. (a) Gates of the Quinta Pueyrredón. General José de San Martin walked through this gate before starting his military campaign to free Southern South America from Spain. (b) Valley in the Rolling Pampas seen from the upland. This region is characterized by well-defined watersheds tributaries of the Paraná river and Rio de la Plata. (c) Tall tussock grassland dominated by *Paspalum quadrifarium* Lam. near General Belgrano, Buenos Aires. (d) Cloudy, flat landscape, with small tree clusters surrounding houses. These trees were planted by settlers to provide shelter, shade, and wood. Later, some of the planted species have invaded the grassland. (e) Long and narrow *Celtis ehrenbergiana* (Klotzsch) Liebm. thicket (*talar*) in contact with a stand of *Spartina densiflora* Brongn. coastal marsh grassland. These lineal forests support a great plant and animal biodiversity, but are also prone to invasion. (f) Sun flecks inside a 'talar' inspired Sara Gallardo to one of the passages of her novel "Los galgos, los galgos" (1968). Photos: (a,f) Marina Omacini; (b-e) Pedro Tognetti.

shell deposits parallel to the coastline which alternate with lowlands covered by tall grasslands dominated by *Sporobolus densiflorus* Brongn. In the thickets, the dominant *tala* (*C. ehernbergiana,* Fig. 6f) is accompanied by *molle* (*Schinus longifolius* (Lindl.) Speg.), *coronillo* (*Scutia buxifolia* Reissek), and *blanquillo* (*Sebastiania brasiliensis* Spreng.) among other woody native species. This forest is nowadays deeply degraded as numerous native species have become infrequent while numerous invading exotics,such as *ligustro* (*Ligustrum lucidum* W.T. Aiton), *acacia negra* (*Gleditsia triacanthos* L.), *almez* (*Celtis australis* L.), *mora* (*Morus* sp. pl.), or *paraíso* (*M. azedarach* L.), often attain dominance (Fig. 6e). Between the forested strips, the *S. densiflorus* graslands (*espartillares*) occupy low longitudinal bands the last of which runs along the muddy coastline dug up by innumerable crabs (Fig. 6e).On returning to the city of Buenos Aires, the travellers can the aftertaste of the Pampas, with Argentine folk music by Eduardo Falú or Francisco Giacobbe, who composed under the inspiration of this wonderful grassland.

Threats to the persistence of Pampean Grassland

As other regions over the world, the Pampas are threatened by human activities that fragment the landscape and cause deep changes in ecosystem structure and function(León & al. 1984; Laterra 1997;Ghersa & Leon 1999, 2001; Laterra & al. 2003; Burkart & al. 2005; Baldi & al. 2006; Chaneton & al. 2002; Tognetti & Chaneton 2015).Transformation of the grassland into crop fields, orchards, cattle feedlots, and tree plantations, within landscapes traversed by elevated highways and artificial waterways, expose the ecosystems to exotic plants and animals and altered disturbance regimes. Under these new conditions, persistence of the Pampean grassland is seriously compromised (Tognetti & Chaneton 2015), and the characteristic open horizon of the region might be condemned to disappear forever.

Conservation strategies for the Pampas must consider that the native grassland not necessarily regenerates after cessation of land use. Secondary succession after land abandonmentfollows contrasting pathways depending on whether previous human perturbation was livestock grazing, agriculture, or tree plantation, and depending on the characteristics of the landscape in different sub regions of the Pampas (Suding & al. 2004; Tognetti 2010; Rodriguez & al. 2016). While spontaneous recovery of the native vegetation appears possible in certain cases (Leon & Oesterheld 1982; Cuevas & Zalba 2009), post-agricultural recovery requires specific restoration intervention (Tognetti & Chaneton 2012), because succession tends to be arrested in a state dominated by exotic plants like the wintergrass *Festuca arundinacea* Schreb. and the summer grasses *Cynodon dactylon*(L.) Persand *Sorghum halepense* (L.) Pers (Omacini & al. 1995; Omacini & al. 2005; Tognetti & al. 2010; Tognetti & Chaneton 2012). Our studies suggest that the dominance of these exotic species may be associated with change in the composition of the regional flora (Ghersa & León 1999; Chaneton & al. 2002) and with the paucity of native vegetation remnants in agricultural landscapes (Burkart & al. 2011; Perelman & al. 2017).Consequently, conservation of the grassland requires active management measurements specific for each sub region of the Pampas.

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Emilio Badalamenti & Tommaso La Mantia

Handroanthus heptaphyllus (*Bignoniaceae*) in Sicily: a new casual alien to Italy and Europe

Abstract

Badalamenti, E. & La Mantia, T.: *Handroanthus heptaphyllus* (Bignoniaceae) in Sicily: a new casual alien to Italy and Europe. — Fl. Medit. 28: 331-338. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Handroanthus heptaphyllus (*Bignoniaceae*) is an ornamental tree native to different regions of South America (Brazil, Argentina, Bolivia, and Paraguay). Here we report from Sicily the first case of natural regeneration in Europe.

Key words: non-native plants, Mediterranean, naturalization.

Introduction

Invasive alien plants (IAP) are increasingly considered one of the main threats for biodiversity conservation, human health and activities, as well as ecosystem services (Pimentel & al. 2001; Vilà & al. 2011). Furthermore, climate change is strongly expected to exacerbate the spread and impacts of IAP in the next decades, both in natural ecosystems and agricultural areas (Gritti & al. 2006). This may occur because IAP are generally characterized by high ecological plasticity, notable tolerance to sub-optimal conditions, and, definitely, they should much more suited to cope with rapid changes of environmental conditions than native counterparts (Porté & al. 2011). Future global scenarios also showed that the biodiversity of Mediterranean ecosystems could be more negatively affected by invasive taxa than any other biogeographical region in the next century (Sala & al. 2000). For these reasons, the proliferation of invasive species has attained increasing concern in the overall strategies of biodiversity conservation and preservation of native habitats worldwide (Tilman & al. 2017).

The observation of the early signs of natural reproduction by alien plants plays a very important role for the invasive management and study at least for two reasons. From an ecological point of view, it allows to assess the rapidity of the passage from a stage to the subsequent along the introduction-naturalization-invasion process. The second aspect concerns the invasive management, the cost of which is widely known to be strictly connected to the stage of the naturalization process attained by the species. The crucial importance of early detection and prompt responses to tackle invasive alien species has recently been highlighted within the Regulation (EU) No 1143/2014 of the European Parliament and of the Council (available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1143&from=en). Among different possible pathways, the introduction for ornamental purposes, in gardening or horticulture, is by far the most relevant for the entry of invasive alien plants (Mayer & al. 2017). For instance, such category accounts for about 94% of all the introduced plants in Australia (Groves & al. 2005). Hence, the investigations on plants introduced for such purposes are important. Artificial areas may be considered the nursery areas where alien taxa experience familiarity with the abiotic characters of the introduced range, as well as starting the integration within local biotic communities (Badalamenti & al. 2015).

In the last few years, the number of reports about woody species found as casual or naturalized species in Sicily has constantly increased (Villari & Zaccone 1999; Raimondo & Domina 2007; Pasta & al. 2012, 2016; Domina & al. 2013; Cambria & al. 2015; Badalamenti & al. 2018) along with studies about the main reasons for their natural spread (Badalamenti & al. 2014). As part of specific surveys on regional alien flora, the first records of natural regeneration of *Handroanthus heptaphyllus* (Vell.) Mattos in Sicily are here reported, also representing the first known case throughout Europe.

Material and methods

Periodic observations of cultivated mature individuals were carried out randomly in the last 5 years in many green areas of Palermo city (parks and gardens). Only individuals originating from seed were considered. Systematics and nomenclature of *Handroanthus* and *Tabebuia* follow Grose & Olmstead (2007). For the morphological description and the characterization of the species see Venturella & al. (1990) and Gentry (1992).

Results

Field surveys

We found natural regeneration by *Handroanthus heptaphyllus* in green areas within the campus of University of Palermo). The survey area is represented by a row of street trees about 50 m long, exclusively composed of mature *Handroanthus heptaphyllus* individuals, and their surroundings. Natural regeneration from seed has been regularly observed since 29 July 2013 until November 2018. More than 50 seedlings were found growing at the base of sidewalks, whereas 3 individuals were found growing inside manholes (Fig. 1). As soon as a little amount of plant litter is released, an abundant seedling emergence is observed, with a density higher than 1.5 seedling/m^2. The protection from direct sunlight and as well as water and nutrient accumulation provided by litter seem to play a key role in early phases of life. The farthest individual is found inside a manhole at about 15 m of distance from mother plants; it is well developed and it can be considered definitely established. Such evidence clearly shows the high water requirements of this species. Regeneration by root sprouts has also been observed.

Fig. 1. *Handroanthus heptaphyllus* individual coming out from a manhole in the campus of University of Palermo (Photo by E. Badalamenti).

Nomenclature and specimina visa

Handroanthus heptaphyllus (Vell.) Mattos ≡ *Bignonia heptaphylla* Vell. ≡ *Tabebuia heptaphylla* (Vell.) Toledo ≡ *Tecoma heptaphylla* (Vell.) Mart. (Fam. *Bignoniaceae*)
= *Tecoma ipe* K. Schum. ≡ *Tabebuia ipe* (K. Schum.) Standl.

ITALY (SIC): Palermo, Campus of University (WGS84 38°06’19.06”N, 13°21’01.93”E), 42 m a.s.l., sidewalks and manholes, 29 Jul 2013, *E. Badalamenti* (SAF).

Native range

Handroanthus heptaphyllus is a tree species native to sub-tropical and tropical areas of different states of South America (Brazil, Argentina, Bolivia, and Paraguay), where it colonizes notable wet Atlantic forest stands in coastal and low-altitude areas, from 130 to less than 800-1,000 m a.s.l. (Gentry 1992; Lozano & Zapater 2008). The climate of native regions is tropical warm, considerably wetter than Sicilian sites, with annual rainfall of 800-1,500 mm, mild winters and not too hot summers due to the positive effect of frequent precipitation (Lozano & Zapater 2008). *Handroanthus* is insect-pollinated and with wind-dispersed seeds (Sanchez-Azofeifa & al. 2013; Mori & al. 2015).

Handroanthus is a plant species of high conservation value for the Atlantic forest and it is used for the good characteristics of wood and the reforestation for ecological purposes to re-establish complex forest stands (Mori & al. 2015). For these reasons, specific strategies for *ex-situ* conservation have been developed, including micropropagation (Duarte & al. 2016) and cryopreservation of seeds, which are orthodox, yet they are characterized by short viability, not lasting more than 2 months in natural conditions (Higa & al. 2011). Several studies have also been carried out on the genetic variability of *Handroanthus* and on the effects of climate change on its future distribution and on the possibilities of effective future conservation of the different native populations (Mori & al. 2015; Scarante & al. 2017).

Handroanthus heptaphyllus *as an alien species*

Handroanthus heptaphyllus does not have reached a considerable spread outside cultivation all around the world, suggesting our observations are not frequent and the invasive potential of the species is currently low (Randall 2017). For instance, in Florida *Handroanthus* is included among the possible non-native species alternatives to well-known invasive species (Knox & al. 2013). However Hodel & al. (2017) for California state: "*…liberate great quantities of seeds, many of which germinate in the landscape and become weeds*". This could be a quite recent process as the species lacks in recent databases of the same area (Cal-IPC 2006). In Europe, nor *Tabebuia* sp. or *Handroanthus* sp. are listed in the most recent database of alien species (DAISIE 2009) as well as in Euro+Med (2006+) database. In Italy, since the second half of the 19th century, some *Tabebuia* or *Handroanthus* sp. were introduced, including *Tabebuia rosea* (Bertol.) DC. and *Handroanthus serratifolius* (Vahl) S.O.Grose (≡ *Tabebuia s.* (Vahl) G. Nicholson) (Maniero 2000). However, no species has been reported hitherto as casual or naturalized species, neither in the most updated checklist of the Italian alien vascular flora (Galasso & al. 2018; Domina & al. 2018). Seven species belonging to *Bignoniaceae* are naturalized or casual alien plants in Italy, including three lianas: *Campsis radicans* (L.) Bureau, *Catalpa bignonioides* Walter, *C. ovata* G. Don and *C. speciosa* Teas, *Dolichandra unguis-cati* (L.) L.G. Lohmann, *Jacaranda mimosifolia* D. Don, and *Tecomaria capensis* (Thunb.) Spach. Interestingly, the occurrence of this plant family in the Italian alien flora has more than doubled in the last forty years (Viegi & al. 1974; Galasso & al. 2018).

The introduction history in Sicily

In the Sicilian flora, until recently *Bignoniaceae* was only represented by *Jacaranda mimosifolia* and *Tecomaria capensis*, both considered as casual species (Raimondo & al. 2010). Then, *Dolichandra unguis-cati* (sub *Macfadyena unguis-cati* (L.) A. H. Gentry) and *Campsis radicans* were also observed in the wild in Palermo city (Stinca & al. 2012) and Linosa island (Pasta & al. 2017), respectively. *Handroanthus heptaphyllus* is commonly cultivated as ornamental species in the urban streets of Palermo (Giardina & al. 2007), whereas its distribution in the region seems to be quite limited as it lacks in many parks and public gardens (Bazan & al. 2005), as well as in all the circum-sicilian islands (Domina & Mazzola 2008). It is used as ornamental species especially for its beautiful and impressive flowering which occurs from mid-April to mid-May, before the emission of new leaves. It has been recently introduced in Sicily so that the historical account of its occurrence here is extremely precise and detailed, different from other alien woody species. Such information is very valuable to evaluate the rapidity of the invasion process and hence to understand the invasive potential of the species. In 1982, the first seeds, coming from the province of Corrientes (NE Argentina), were introduced by Prof. Francesco Maria Raimondo at the Palermo Botanical Garden (Venturella & al. 1990). After the germination and the storage in a cold greenhouse the following year, in 1985 nine individuals were planted outside. From 1986 onward, some experimental trials were carried out in the open field in several municipalities in Sicily, at altitudes ranging from 15 and to 1,000 m a.s.l., in different ecological contexts (Venturella & al. 1990; Ilardi & Mazzola 1992). The species proved to be well suited to the use in coastal habitats and hilly areas, lower than 250 m a.s.l., such as the green areas within the Palermo Botanical Garden. As far as propagation is concerned, sowing gave bad results, whereas the vegetative reproduction via woody cuttings was excellent (Venturella & al. 1990). Subsequently, the first flowering was observed in 7 years old individuals and the first fruiting the next year (Ilardi & Mazzola 1992). The germination trial showed that seedling emergence was more than >70% but with rapid loss of germinating power. Furthermore, some individual exhibited a good growth rate, exceeding 5 meters in height and reaching 60 cm of trunk circumference in full sunlight 8 years after planting. Despite a rapid adaptation to local climate conditions, no sign of natural regeneration had been observed up to now in Sicily.

Conclusions

Our observations suggest that *Handroanthus heptaphyllus* has to be considered as a casual alien species in Sicily. In effect, the natural regeneration is still not so abundant and widespread to consider the species as fully naturalized and capable of establishing long-lasting populations without human assistance. However, it should be emphasized that the naturalization process started no more than 10 years after the planting of the mother plants, a rather short time for a tree species. However, the very limited occurrence of wild individuals elsewhere strongly complicates the chance to forecast the evolution and future spread of this species in Sicily and in the Mediterranean basin.

Definitely, the species does not seem bound to invade semi-natural or natural formations of particular interest in the next future. However, the abundance of regeneration indicates that it has found ideal conditions for reproduction in a relatively short time frame. Therefore, *Handroanthus heptaphyllus* could be included among the alien plant species cultivated in green ornamental areas that may spread and be fully naturalized establish in urban environments, such as gardens or villas, as in the cases of other non-native species like *Koelreuteria paniculata* Laxm. (Raimondo & Spadaro 2006).

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Mohamed Fennane & Mohamed Rejdali

Moroccan vascular plant Red Data Book: A basic tool for plant conservation*

Abstract

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Morocco's ecosystems, like the ones of the other southern and eastern Mediterranean countries, have been for decades undergoing very harsh anthropo-zoogenic pressure. Threats of regression or even extinction of plant (and animal) species are real and serious. Researchers and decision makers are all encouraged to work hard for the conservation of the national biodiversity. In order to achieve this goal with full knowledge, an inventory of the situation seemed essential. This is how the idea of a Red Data Book emerged.

The project "Red Data Book of the vascular flora of Morocco" is currently very well advanced. A first version was published, between November 2016 and November 2018, in ten fascicles, via the website of the Tela-Botanica Association, in order to collect suggestions, comments and complements from the botanical community.

The Red Data Book deals with all the existing or doubtful plant species in Morocco, whatever their status: natural, naturalized or adventitious. They are classified according to the IUCN Red List Categories (World Union for Nature), slightly amended. For Categories VU (Vulnerable), EN (Endangered) and CR (Critically Endangered) species, the following information is provided: biological type, world distribution and distribution in Morocco.

The Red Data book also provides an updated national floristic inventory, with updated nomenclature and taxonomy.

Key words: vascular flora, inventory, Morocco, IUCN Red List.

Introduction

For decades, the IUCN Red List has provided a global assessment of the threat status of species and their extinction risk and has played a major role in influencing conservation strategies. Many countries have used it as a basis for the preparation of National Red Lists and Books.

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*Extended and enriched version of the oral presentation given at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

The first known list of Morocco, by Sauvage (unpulished list) was distributed by IUCN in 1970s. This list of nearly 500 species, almost all national endemics, remained for a long time the one adopted by the IUCN with very slight modifications.

In 1998 was published a catalog of more than 1600 species, endemics, rare or very rare in Morocco (Fennane & Ibn Tattou 1988). This work has remained up to now the main source of information of threatened flora.

In 2015, were published more details on endemic monocotyledons (Rankou & al. 2015). As research and knowledge advance, the "official" Red List of Morocco is regularly enriched and improved by IUCN on its web page "iucnredlist.org".

The project "Red Data book of the vascular flora of Morocco", object of this article, is also the occasion to draw up an inventory of the national vascular flora at a time when the pressure and the threats on the whole of the biodiversity are more and more intense and a source of major concern.

Alarming context

It is worth noting that Morocco, with a population exceeding 35 millions (Haut Commissariat au Plan 2018), depends heavily on agriculture and livestock. Such dependence combined with the irrational management of plant communities and species, has caused several degradation problems. Over grazing in forests, *Stipa tenacissima* L. steppes and alpine vegetation has led to the vulnerability of many species some of which have become rare and threatened with extinction. It was reported by Ellatifi (2012) that Morocco forest domain was losing about 10.000 hectares per year. As for plant species, preliminary studies showed that over one thousand plant species are either rare or threatened of extinction (Fennane & Ibn Tattou 1998).

The green heritage is subject to strong pressure because of the various ways humans use plants for their survival and wellbeing. For centuries, it has been customary to use plants as a major source for therapy and folk medicine. It is also common to use plants for timber, industrial purposes and as fuel wood and energy as well as utensils in daily life. This wide reliance on plants threatens their sustainability and requires special care and particular attention to make the best and sustainable use of them.

Governance and planning policies and management

The over exploitation of Morocco's natural resources is exacerbated by dubious and unfortunate modes of governance and management. The main ones are:

- Inappropriate modes of exploitation;
- Lack of rigour and firmness in monitoring operating markets;
- Difficulty in controlling and regularizing pastoral activities;
- Predominance of the economic component over the ecological one;
- Absence or low adoption of the ecosystem approach.

Legislation vs Protection and Conservation

Despite the many legislative efforts made during the last decades, overall, legislation for the protection and conservation of national biodiversity remains far behind the quick changing patterns of use and rate of exploitation.

The current state can be summarized as follows:

- Laws in force mainly concern: water, forest estates, agricultural domains, rangelands, hunting and fishing;
- A unique law on protected areas (Loi 19-07, 2010);
- CITES law: national list of protected species (Loi 29-05, 2015), comprising only nine species;
- Absence of regional lists of protected species;
- Absence of national lists of threatened ecosystems and habitats;
- Administrative and executive staff with little or no qualification in floristic competence.

Material and method

The present paper is a summary of a presentation of the finding of a research work leading to the production of a "Red data Book of the Moroccan vascular flora".

New updated data on the Moroccan flora are provided and discussed, especially on endemic, rare or endangered species. They all come from the analysis of ten fascicles prepared in the framework of this project and distributed in digital format by the Tela-Botanica association on its website "tela-botanica.org" between November 2016 and November 2018 (Fig. 1).

Red data Book of the Vascular Flora of Morocco

The main features of the projected book are the following:

- All Moroccan vascular flora (indigenous + naturalized + adventitious), including species of doubtful presence covered;
- Updated Nomenclature and Taxonomy;
- IUCN Red List category (IUCN 2012), slightly adapted to the proposals of Fennane & Montmollin (2015); the categories are: EX (Extinct), RE (Regionally Extinct), CR (Critically Endangered), EN (Endangered), VU (Vulnerable), NT (Not Threatened), LC (Least Concern), DD (Data Deficient), NA (Not Applicable);
- Biological type, World distribution and distribution in Morocco for threatened categories (VU, EN and CR);
- Detailed bibliography, especially about geographical distribution.

Quantitative and qualitative analysis

a. Total flora (Figs. 2 & 3, Tables 1 & 2)

The total Moroccan vascular flora is about 4,800 species, including:

- 90 hybrids;
- 298 naturalized or adventitious;
- 482 of doubtful presence;
- 144 of dubious taxonomic status;

The eight richest families (more than 100 species) (Table 2), are the same as those designated in the work of Fennane & Ibn Tattou (2012), namely: *Asteraceae, Fabaceae,*

CARYOPHYLLACEAE Juss.

Agrostemma L.

Agrostemma githago L. — LC

Arenaria L.

Arenaria aggregata (L.) Loisel. — B2ab(ii,iii) EN$_{(e)}$
Gypsophila aggregata L. ; *Arenaria capitata* Lam.

Ch. Méditerranée occidentale. Au Maroc et en Algérie, ***subsp. mauritanica*** (Batt.) Maire **(•A)** : signalé par [Maire 1916:263] [CPM:207] [FAN9:158] [Quézel & Santa 1962:334] dans 3 localités dont deux frontalières : jbel Doug sur l'Atlas saharien et Ghar Rouban au sud de Oujda ; la 3ème localité, Djelfa, se situe au Centre nord de l'Algérie.

Arenaria armerina Bory **(•I)** — NT

Ch. Péninsule Ibérique méridionale. HA-4-5 MA R-2-3.

Arenaria cerastioides Poir. — LC

Arenaria dyris Humbert **(•)** — B2ab(ii,iii) VU$_{(e)}$

Ch. HA-5 (Ayachi ; Mâasker) [CPM:208, 982] [FAN9:164]. Cette endémique est encore relativement bien présente [Taleb & Fennane 2008:132] grâce à ses habitats assez difficilement accessibles : fissures des rochers de hautes montagnes. Principales menaces actuelles : stress climatique ? et dégradation anthropique.

Arenaria emarginata Brot. — LC

Arenaria grandiflora L. — B2ab(ii,iii) VU$_{(e)}$

Ch. Méditerranée occidentale.

Fig. 1. Extract from "Eléments pour un Livre rouge de la flore vasculaire du Maroc, Fasc. 5". Edit. Tela-Botanica, january 2018.

Table 1. Number of species* by IUCN Red List Category (* incl. adventitious, naturalized and hybrids).

	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Pteridophyta	18	3	29	5	1	8	7	2	73
Gymnospermae	1	-	9	2	3	2	1	-	18
Dicotyledonae	802	284	1536	345	238	266	284	17	3772
Monocotyledonae	262	116	337	62	43	49	67	1	937
Total	1083	403	1911	414	285	325	359	20	4800

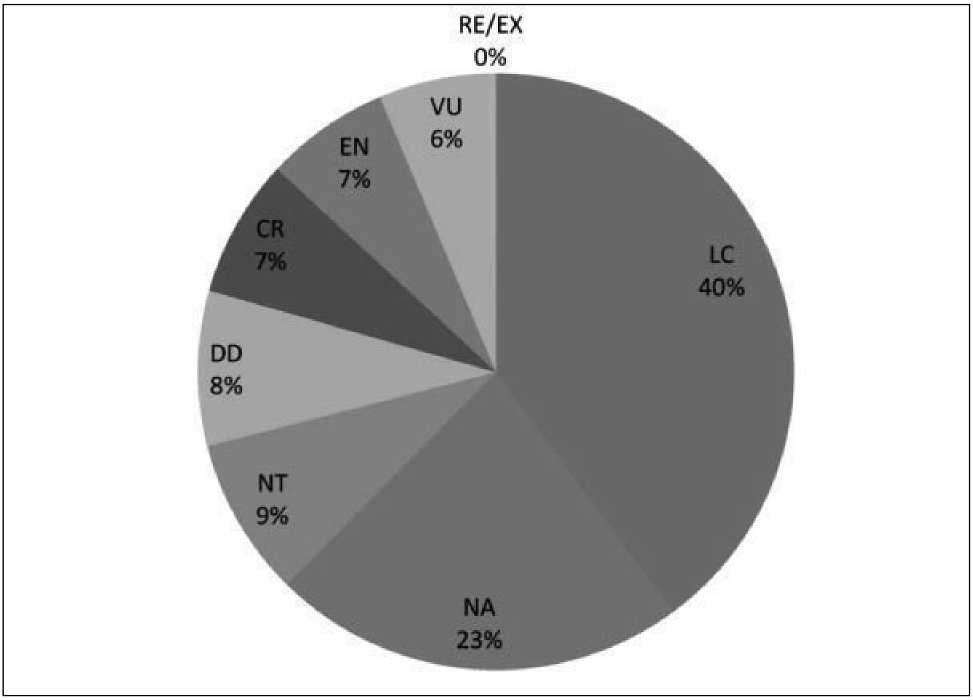

Fig. 2. Percentage of different IUCN Red List Categories.

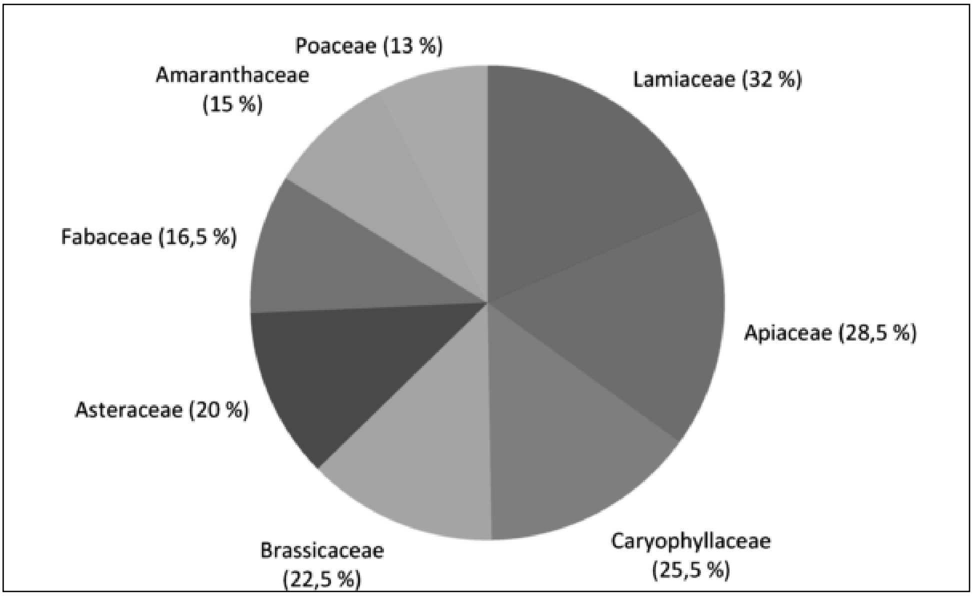

Fig. 3. Percentage of threatened species (VU, EN, CR) in the main families (> 100 sp).

Table 2. Number of species* in the main families (> 100 sp) by IUCN Red List Category (* incl. adventitious, naturalized et hybrids).

	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Asteraceae	124	48	276	58	32	53	44	5	640
Fabaceae	107	40	220	41	25	35	21	3	492
Poaceae	136	59	184	29	16	15	31	0	470
Lamiaceae	58	24	59	23	21	26	30	1	242
Brassicaceae	44	13	104	24	24	21	9	1	240
Caryophyllaceae	23	8	115	20	19	18	20	0	223
Apiaceae	30	15	78	10	12	15	26	1	187
Amaranthaceae (incl. Chenopodiaceae)	26	15	53	0	3	7	7	1	112

Table 3. Biological types / IUCN Red List Categories.

	NA	DD	LC	NT	VU	EN	CR	RE	Total
Phanerophytes /Nanophaneroph.	79	20	152	56	35	28	19	1	390
Chamephytes	63	39	162	65	55	59	70	0	513
Hémicryptoph.	177	92	330	106	74	70	113	1	963
Geophytes	79	49	152	29	35	39	36	5	424
Therophytes /Th-bisannuals	248	127	817	93	46	68	60	8	1467
Hydrophytes	19	18	26	10	6	6	7	0	92

Table 4. Number of endemics / IUCN Red List Categories.

Endemics	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Moroccco	117	35	56	113	100	141	163	4	729
Morocco + Algeria	35	32	44	37	24	30	29	3	234
Morocco + Iberian Peninsula	61	24	27	36	34	39	43	2	266
Morocco + Algeria + Iberian Peninsula	10	15	78	16	11	11	0	1	142

Poaceae, Lamiaceae, Brassicaceae, Caryophyllaceae, Apiaceae and Amaranthaceae (incl. Chenopodiaceae).

23 % of the species are in the Category NA (Not Applicable): hybrids + adventitious + naturalized + species of dubious presence + species of dubious taxonomic status (Fig. 2).

20 % of native species are threatened (categories VU, EN, CR) (Fig. 2). The *Lamiaceae* are more threatened (32 % the species) (Fig. 3). Members of the *Poaceae* appear to be the least threatened (13 % of species) (Fig. 3).

b. Biological types (Table 3)
The main observations are:
55.7% of therophytes are in the LC category;
35.8% of chamaephytes are threatened (VU, EN, CR);
19.5% of the hydrophytes are insufficiently known (DD).

c. Endemism (Table 4, Figs. 4 to 9)
The main observations are:
55.3% of Moroccan endemic are threatened (VU, EN, CR);
43.6% of Moroccan-Iberian endemics are threatened (VU, EN, CR);
35.4% of Moroccan-Algerian endemics are threatened (VU, EN, CR).

d. Species extincted or presumed extincted (Table 5)
49 species are extincted or presumed extinct:
13 Moroccan endemics;
7 Moroccan-Iberian endemics;
5 Moroccan-Algerian endemics;
12 woody species (Ch, Nph, Ph);
9 geophytes;
28 herbaceous species (Th, Th-b, Hém).

Table 5. Extinct or presumed extinct species.

Family	species	Biological type	Endemism
Pteridaceae	*Paragymnopteris marantae* (L.) K.H. Shing	GR	
Pteridaceae	*Pteris incompleta* Cav.	GR	
Adoxaceae	*Adoxa moschatellina* L.	GR	
Amaranthaceae	*Atriplex rosea* L.	Th	
Apiaceae	*Carum asinorum* Litard. & Maire	Hém	Morocco
Apiaceae	*Carum foetidum* (Batt.) Drude	Hém	Morocco, Algeria, Iberian peninsula
Araliaceae	*Hydrocotyle vulgaris* L.	Th	
Asteraceae	*Andryala atlanticola* H. Lindb.	Th-b	Morocco

Table 5. continued.

Asteraceae	*Andryala maroccana* (Caball.) Maire	Ch	Morocco, Algeria
Asteraceae	*Centaurea ducellieri* Batt. & Trab.	Hém?	Morocco
Asteraceae	*Crepis salzmannii* Babc.	Hém	Morocco, Algeria
Asteraceae	*Cynara tournefortii* Boiss. & Reut.	G	Morocco, Iberian Peninsula
Asteraceae	*Rhaponticum longifolium* (Hoffm. & Link) Soskov	Hém	Morocco, Iberian Peninsula
Boraginaceae	*Echium arenarium* Guss.	Th (Th-b)	
Boraginaceae	*Heliotropium antiatlanticum* Emb.	Ch	Morocco
Brassicaceae	*Maresia nana* (DC.) Batt.	Th	
Caryophyllaceae	*Moehringia glochidisperma* J.M. Monts.-Marti	Hém (GR)	Morocco
Cistaceae	*Halimium ocymoides* (Lam.) Willk	Ch	Morocco, Iberian Peninsule
Cistaceae	*Helianthemum pomeridianum* Dunal	Ch	Morocco, Algeria
Convolvulaceae	*Ipomoea sagittata* Poir.	GR?	
Fabaceae	*Ononis tridentata* L.	Nph	Morocco, Iberian Peninsula
Fabaceae	*Ononis villosissima* Desf.	Th	Morocco, Algeria
Fabaceae	*Trifolium acutiflorum* Murb.	Th	Morocco
Fabaceae	*Trifolium sylvaticum* Gérard	Th	
Fabaceae	*Vicia fairchildiana* Maire	Th	Morocco
Fabaceae	*Vicia leucantha* Biv.	Th	
Gentianaceae	*Centaurium barrelieroides* Pau	Th	Morocco
Hypericaceae	*Hypericum australe* Ten.	Ch	
Lamiaceae	*Clinopodium acinos* (L.) Kuntze	Th Th-b	
Lamiaceae	*Galeopsis angustifolia* Hoffm.	Th	
Lamiaceae	*Glechoma hederacea* L.	Hém	
Lamiaceae	*Marrubium atlanticum* Batt.	Ch	Morocco
Lamiaceae	*Marrubium werneri* Maire	Ch	Morocco
Lamiaceae	*Micromeria brivesii* Batt.	Ch	Morocco
Lamiaceae	*Phlomis italica* L.	Ch, Nph	Morocco, Iberian Peninsula
Lamiaceae	*Sideritis imbricata* H. Lindb. f.	Ch	Morocco
Lamiaceae	*Stachys brachyclada* Noë ex Coss.	Th	
Malvaceae	*Malva microphylla* (E. G. Baker) J. Molero & J.M. Monts.	Th?	Morocco
Menyanthaceae	*Menyanthes trifoliata* L.	HyF (GR)	
Orchidaceae	*Orchis palustris* Jacq.	G	
Poaceae	*Agrostis nebulosa* Boiss. & Reut.	Th	Morocco, Iberian peninsula

Table 5. continued.

Poaceae	*Agrostis nevadensis* Boiss.	Hém	Morocco, Iberian Penisula
Primulaceae	*Cyclamen africanum* Boiss. & Reut.	GT	
Primulaceae	*Lysimachia ephemerum* L.	Hém	
Ranunculaceae	*Ranunculus rectirostris* Coss. & Durieu	Hém	Morocco, Algeria
Rosaceae	*Prunus padus* L.	Nph, Ph	
Rosaceae	*Spiraea hypericifolia* L.	Nph	
Rubiaceae	*Oldenlandia capensis* L. f.	Th	
Scrophulariaceae	*Verbascum densiflorum* Bertol.	Th-b(Hém)	

Practical interest

The analysis of the data of the Red Book of the Moroccan vascular flora presented above, although concise, shows interesting features, that can provide guidance to researchers and decision-makers for the good of the national phytodiversity.

We give here (Tables 6, 7 and 8) those that seem most important to us, with concrete and practical proposals and recommendations for each of the three following levels: Knowledge (Table 6), Exploitation / Valorization (Table 7) and Protection / Conservation (Table 8).

Table 6. Observations and recommendations concerning Knowledge.

Observations	Recommendations
49 extincted or presumed extincted species of Moroccan flora	To check / search in the field
810 species (21 %) threatened: 240 VU ; 275 EN ; 292 CR	Danger and types of threats to be studied
780 sp. (20 %) of NA Category (doubtful taxa, dubious presence, hybrid, naturalized...)	More laboratory research and field investigation
282 sp. (7 %) of DD Category	More laboratory research and fieldinvestigation
362 sp. (57 %) threatened Moroccan endemic: 240 VU ; 275 EN ; 292 CR	More laboratory research and field investigation Specific research on endemics
76 sp. (36 %) Moroccan endemic + threatened Algerian: 20 VU ; 30 EN ; 26 CR	Bilateral work and projects Morocco / Algeria
90 sp. (44 %) Moroccan endemic + Ibérian Peninsula threatened: 26 VU ; 29 EN ; 35 CR	Bilateral work and projects Morocco / Iberian Peninsula

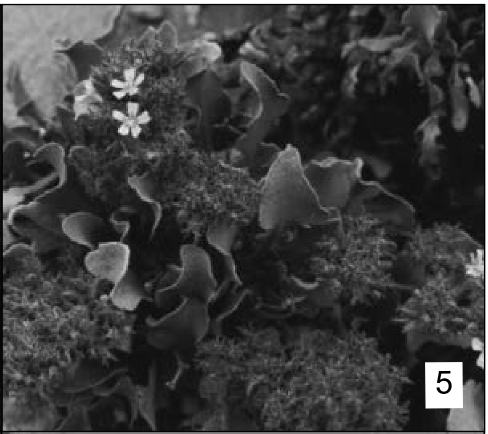

Fig. 4. *Adenocarpus artemisifolius*, Moroccan endemic [CR] (Ph. Msanda).
Fig. 5. *Limoniastrum weygandiorum*, Moroccan endemic [CR] (Ph. Thiaudière).
Fig. 6. *Caralluma joannis*, Moroccan endemic [CR] (Ph. Sébastien).
Fig. 7. *Echiochilon simonneaui*, Moroccan endemic [CR] (Ph. Garcin).
Fig. 8. *Helianthemum grosii*, Moroccan endemic [CR] (Ph. Dobignard).
Fig. 9. *Euphorbia mazicum*, Moroccan endemic [CR] (Ph. Chatelain).

Table 7. Observations and recommendations concerning Exploitation / Valorisation.

Observations	Recommendations
1574 species (41 %) of LC category	Expand exploitation / valorisation operations to LC taxa to ease the pressure on those threatened
362 sp. (57 %) threatened Moroccan endemics	Maximum precaution , rigor and restrictions for exploitation
77 sp. (32 %) of threatened *Lamiaceae* (mainly Aromatic and medicinal plants)	Rigor, organization and control of exploitation ofthe aromatic and medicinal plants

Table 8. Observations and recommendations concerning Protection / Conservation.

Observations	Recommendations
Large number of endangered species (810, i.e. 21%) of all biological types and thus diverse environments Insufficient knowledge of threats dangers and species responses	Ecosystem approach for : - Maximum protection of species - Protect habitats Approach centered around 'key' species, patrimonial, emblematic…
57 % of threatened Moroccan endemics : 292 CR ; 275 EN ; 240 VU.	Priority species for *in situ* and *ex-situ* conservation programs and actions

Conclusion

The Red Data Book of Morocco's vascular flora provides an update of information on the vascular flora of the country in terms of inventory, taxonomy and nomenclature. From this point of view, it is a basic reference for researchers to focus and prioritize their studies.

In terms of management, protection and conservation of biodiversity, this book is a tool at the service of decision-makers for the choice of species and the target regions of programmes and practical actions.

This first version of the Red Data Book could be subject to corrections, additions and modifications. In all cases, this is a work that needs to be regularly reviewed and updated according to the progress of research on the flora, on the one hand, and the evolution of the ranges of the species on the other hand. This cannot be achieved without the support of a large number of motivated and committed researchers in the laboratory and in the field.

Acknowledgment

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Ch. Kyriakopoulos, G. Kamari, I. Kofinas & D. Phitos

Potentilla greuteriana* (*Rosaceae*), a new species from Mt. Taigetos (S Peloponnisos, Greece)

Abstract

Kyriakopoulos, Ch., Kamari, G., Kofinas, I. & Phitos, D.: *Potentilla greuteriana* (*Rosaceae*), a new species from Mt. Taigetos (S Peloponnisos, Greece). — Fl. Medit. 28: 351-364. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

Potentilla greuteriana Kyriak., Kamari, Kofinas & Phitos is described as a new species of *P.* sect. *Plumosistylae,* known from two localities (summit Xerovouni and Langada gorge) on Mt. Taigetos (S Peloponnisos). The habitat of this new *Potentilla* species is black bituminous, deeply karstified limestone. The closest relative of *P. greuteriana* is *P. arcadiensis,* which is distributed on the neighbouring Mt. Parnonas (E Peloponnisos), but belongs, to *P.* sect. *Crassinerviae.* The main morphological differences between the new species and its related taxa of *P.* sect. *Crassinerviae* (*P. ulrichii, P. nerimaniae, P. davisii*) and *P.* sect. *Plumosistylae* (*P. libanotica* and *P. isaurica*) are discussed. Additionally, the conservation status of the new species is provided.

Key words: Greek flora, *Potentilla,* conservation, endemism, taxonomy.

Introduction

The high diversity of the flora of Greece, rich in endemic and rare plant species, is a consequence of the country's geological history, which has resulted in the formation of a multitude of isolated areas and habitats along the flora's migratory pathways, from Anatolia to central and northern Europe. Peloponnisos is the southern part of the Greek mainland and, at the same time, of the Balkan Peninsula. Mt. Taigetos is one of the main biodiversity hotspots of mainland Greece, with a high percentage of endemic and rare taxa (Phitos & al. 2009), having strong phytogeographical connections with other mountains of Peloponnisos (examples being the endemic monotypic genus *Phitosia crocifolia* (Boiss. & Heldr.) Kamari & Greuter, *Achillea taygetea* Boiss. & Heldr., *Crepis heldreichiana* (Kuntze) Greuter occurring also on Mt. Parnonas; *Globularia stygia* Orph. and *Teucrium aroanium* Boiss. occurring also on Mt. Chelmos, etc.) and of Crete (*Herniaria parnassica* subsp. *cretica* Chaudhri,

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*Extended and enriched version of the oral presentation given at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

Ranunculus subhomophyllus (Halácsy) Vierh., occurring also on the Lefka Ori range). The study of these connections is the subject of the first author's PhD thesis.

Several new taxa have recently been described from Mt. Taigetos and its surroundings, such as: *Allium orestis* Kalpoutz. & al. (Kalpoutzakis & al. 2012), *Campanula kamariana* Kyriak. & al. (Kyriakopoulos & al. 2017), *Geranium kikianum* Kit Tan & Vold (Tan & al. 2011) and also *Asperula lutea* subsp. *griseola* Greuter, *Ballota nigra* subsp. *anomala* Greuter, *Lolium scholzii* Greuter, *Nepeta hystrix* Greuter and *Trifolium michaelis* Greuter (Greuter 2012).

Potentilla L. is one of the largest *Rosaceae* genera, mostly Holarctic in distribution, though some of its representatives are also found on the mountains of southeast Asia (see Eriksson & al. 1998; Dobeš & Paule 2010; Dobeš & al. 2013). Wolf (1908), the monographer of the genus, recognized ca. 300 *Potentilla* species and divided the genus into two sections, based on the presence (*P.* sect. *Trichocarpae*) or absence (*P.* sect. *Gymnocarpae*) of hairs on the carpels, six subsections based on the shape of the pistils and the insertion of the styles, and several lower-ranking groups that are his main units of classification. Wolf's classification was adopted and modified by others, such as Juzepčuk (1941), who upgraded Wolf's subsections to subgenera and his groups to sections, and also Pawłowski (1965), who separated *P.* subg. *Fragariastrum* (Ser.) B. Pawł. into two sections (*P.* sect. *Fragariastrum* Ser. and *P.* sect. *Plumosistylae* B. Pawł.). Ball & al. (1968), in Flora Europaea, divided the genus *Potentilla* into 5 subgenera, among them the subg. *Fragariastrum* (Heister ex Fabr.) Reichenb., which was further divided into two sections, i.e. sect. *Fragariastrum* and sect. *Plumosistylae,* according to Pawłowski (1965). Later, Soják (1987) divided Wolfs' *Potentilla* sect. *Trichocarpae* Th. Wolf into 19 sections, based on flower and anther structure and style shape. Moreover, by using molecular phylogenetic methods, a better understanding of the origin of subfamily *Rosoideae* Arn. of *Rosaceae* Juss. and of *Potentilla* itself has been achieved (see Eriksson & al. 1998, 2003; Potter & al. 2007; Lundberg & al. 2009).

Recently, Soják (2008), while presenting a new genus-level classification of the *Potentilleae* Sweet, suggested its division into two subtribes, i.e. *Potentillinae* J. Presl and *Fragariinae* Torr. & A. Gray, based on morphological characters, which is consistent with the phylogenetic tree by Eriksson & al. (1998), who proposed that *Potentilla* contains ca. 485 species of annual, biennial and perennial herbs, several of hybridigenous origin. According to phylogenetic reconstructions (Dobeš & Paule 2010), *Potentilla* s. str. comprises mainly herbaceous species, representing 24 of the 31 series distinguished by Wolf (1908).

In Greece, there are 26 taxa of *Potentilla* (eight in Peloponnisos), three of which are endemic. These include the submontane *Potentilla arcadiensis* Iatroú (Iatroú 1985) from Mt. Parnonas, E Peloponnisos, and two mountain species, *P. kionaea* Halácsy (Halácsy 1888) from Mt. Giona, Sterea Hellas and *P. deorum* Boiss. & Heldr. (Boiss. & Heldr. 1856) from Mt. Olimbos, NC Greece (Strid 1986).

In July 2011, Ioannis Kofinas, during a visit to the Langada climbing area of Mt. Taigetos, noticed an interesting *Potentilla* chasmophyte with robust and richly leafy flowering stems, growing on vertical rocks. On August of the following year (Aug 5, 2012) during a field survey by the first author on N Taigetos, west of the Xerovouni peak (1523 m), an additional, larger population with the same characteristics was found. The substrate in the two above localities, where this species grows, is black bituminous, deeply karstified limestone. Macroscopically, it resembles *P. arcadiensis* (*P.* sect. *Crassinerviae*), endemic to the neighbouring Mt. Parnonas (SE Peloponnisos), from which, however, it differs morphologically in several features, such as its strongly supine flowering stems and visibly compact inflorescences with short pedicels, attributes that rather point to representatives of *P.* sect. *Plumosistylae,* such as *P. libanotica* Boiss. and *P. isaurica* (P. H. Davis) Pawł. from S Anatolia.

In this paper we describe these *Potentilla* plants from Mt. Taigetos as a new species, which is related to the neighboring *P. arcadiensis* (*P.* sect. *Crassinerviae*) from Mt. Parnonas and also to the Anatolian taxa *P. libanotica* Boiss. (Boissier 1872) and *P. isaurica* B. Pawł. (Pawłowski 1965) of *P.* sect. *Plumosistylae.* We also clarify the relationships of the new species with other close relatives.

Materials and methods

For the description of the new species, both living and dried material of all related *Potentilla* taxa from Greece and S-SE Anatolia & E Mediterranean area was used. The herbarium material that we also used for comparisons is deposited in the following Herbaria: B, E, L, P, Herb. Phitos & Kamari (UPA) and UPA (acronyms follow Thiers 2018).

Morphological observations were carried out under a Zeiss stereomicroscope. For taxonomic identification, scientific papers and floras (Boissier 1872; Juzepčuk 1941; Pawłowski 1965; Ball & al. 1968; Schiman-Czeika 1969; Peşmen 1972; Iatroú 1985; Soják 1987, 2008; Duman & Mill 1999; Tan & Iatroú 2001; Parolly & Nordt 2002) were used. The collection localities for all species were georeferenced and the distributions were mapped using the freeware GIS software QGIS 2.18 (2017), and Image Editor GIMP 2.8.22.

A detailed comparison between the new species and other morphologically related taxa is given in Table 1.

Results

Potentilla greuteriana Kyriak., Kamari, Kofinas & Phitos **sp. nov.** (Figs. 1 & 2).

Diagnosis: *Potentilla greuteriana* differs from its related Greek endemic *P. arcadiensis* by the absence of digitate leaves, longer petioles, different indumentum of 1.2-1.5 mm long glandular and 1.0-1.2 mm long simple hairs, larger leaflets, longer stipules and auricles of the basal leaves, dense inflorescences with much shorter pedicels (7-10 mm against 15-35 mm long), glabrous petals, and usually pubescent to almost plumose, rarely glabrous, persistent styles.

P. greuteriana is related to the members of *P.* sect. *Plumosistylae.* It differs from its closest relatives in that section, *P. libanotica* and *P. isaurica,* by its indumentum (long glandular and slightly shorter simple hairs), the longer leaflets, shorter epicalyx segments and petals, anther shape (ovate to obovate rather than globose) and smaller achenes. Additionally, it differs from *P. libanotica* by the number of leaflet teeth (5-6 rather than 6-9) and seed hairiness (apex pilose to pubescent) and from *P. isaurica* by the obtuse rather than acute teeth and the shape of the petals (obovate to ovate instead of elliptic).

Fig. 1. Individual of *Potentilla greuteriana* from its *locus classicus* on the summit Xerovouni of North Taigetos.

Type: Greece: S Peloponnisos: Nomos Arkadias: Mt. N Taigetos, W-SW of Xerovouni summit, 37° 09'N, 22° 13' E, alt. c.1150 m, with *Pinguicula cristallina* subsp. *hirtiflora, Campanula asperuloides, Teucrium aroanium* etc., on vertical karstified limestone rocks, 9 Jul 2017, Ch. Kyriakopoulos 2334 (Holotype: Herb. Phitos & Kamari, UPA!). Isotypes: ACA! and PAL-Gr!

Description: Perennial, densely tufted to pulvinate. Flowering stems several, decumbent-ascending, 8-24(-27) cm long, 1-2 mm in diameter, longer than basal leaves, densely clothed with 1.2-1.5 mm long, erect to erect-patent glandular hairs and equally numerous, up to 1.0-1.2 mm long, patent simple hairs. Leaves in rosettes, long-petiolate, trifoliolate, green to yellowish-green, concolorous, smooth, almost sericeous, with apressed long hairs along the nerves, and a mixture of short and long hairs to the rest of the surface, with scattered 2-4 celled, <0.5 mm long glandular hairs along the leaflet margins; leaflets obovate, cuneate at base, terminal: (20-)25-38(-44) × (10-)15-28 mm, lateral: (20-)22-35 × (10-)15-26 mm, terminal tooth of leaflets equalling or shorter than the first lateral teeth; margins crenate (-serrate), lateral teeth 4-6(-7) on either side; petiole 3-6(-7.2) cm long, with erect glandular hairs up to 2 mm long and patent-erect simple hairs up 1mm long (length ratio almost 1:2); stipules lanceolate-acuminate, 2.0-2.4 × 0.6-0.7 cm, with auricles 0.8-1.3 cm long, with simple apressed hairs, up to 0.8 mm long and shorter, scattered glandular along both margins, green, becoming yellowish-green at

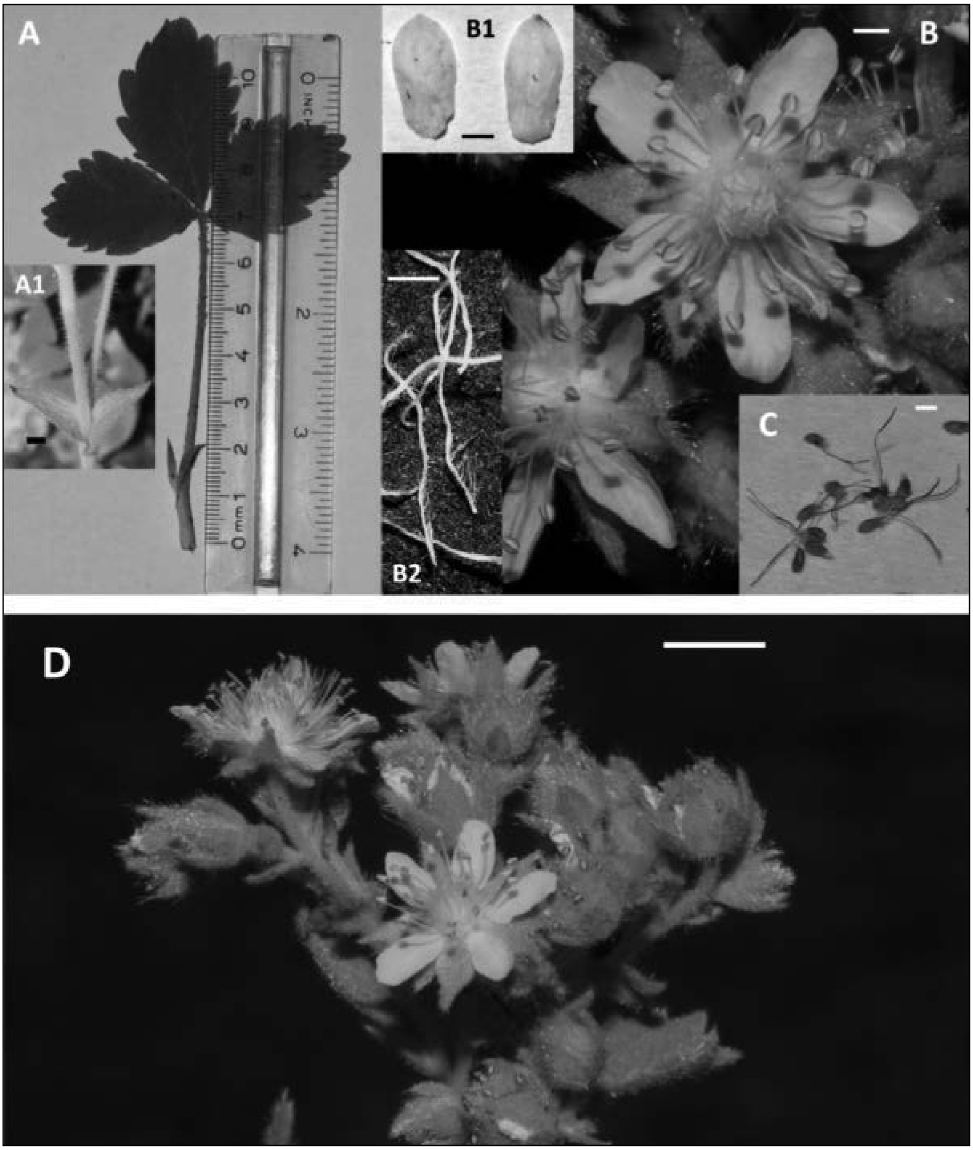

Fig. 2. *Potentilla greuteriana* sp. *nova:* **A,** basal leave, petiole, stipules; **A1,** stipules of cauline leaves; **B**, flower; **B1**, petals; **B2**, styles; **C**, achenes with persistent styles; **D**, inflorescense. – Scale bars A-C = 1 mm; D.= 5 mm.

the base. Cauline leaves similar but smaller, with green, broader stipules, leaflets with 4-5 teeth, the larger 27-32(-37) × 18-22(-26) mm, in the middle of the stems (4th-5th from the bracts), diminishing upwards. Inflorescence a compact, terminal, rather dense cyme, ca. 12-30(-40) flowered, densely to moderately villous with long (≤1.2 mm) patent simple hairs and erect glandular (≤1.2-1.5 mm long). Bracts foliaceous, usually less than 1.5-2.0 × 0.7-1.1 cm, with up to two teeth each side. Pedicels 7-10(-15) mm long, slender (diameter 0.5-0.8 mm). Flowers relatively small. Epicalyx segments 5, narrowly ovate-lanceolate, acute, ca. 3-3.5 × 1-1.5 mm, not visible in front view of the perianth, with patent simple and sparse, short glandular hairs. Calyx densely sericeous-villous, (7-)8-9(-11) mm in diam., moderately accrescent in fruit; divided into 5 sepals (4-4.5 × 1.5-2.0 mm), indumentum with long erecto-patent simple hairs chiefly on the abaxial face, slightly larger than the epicalyx segments, cuneate to truncate at base. Petals white, with an obovate to obovate-oblong, rounded to broadly obtuse apex and a rounded to cuneate base, slightly longer than the sepals, 3.2-4.5 × 2.5-3 mm, glabrous. Stamens ca. 30; filaments 2.5-3.5 mm long, pilose in proximal 5/6, more loosely so in the distal 1/2, anthers pale yellowish with reddish margins, ovate to obovate, 0.4-0.5 × 0.3 mm. Style subapical, usually pubescent (for 1/3-1/2 of its length) or rarely glabrous, ca. 3-4 mm long, filiform (nematostylous). Nutlets ivory, kidney-shaped, distinctly compressed, 0.9-1.3 × 0.9 mm, smooth, apex pilose, margin narrowly winged, with persistent style.

Phenology: *Potentilla greuteriana* flowering from mid-June to mid-August. Fruiting from late August to the end of September.

Distribution and Habitat: *Potentilla greuteriana* is a narrow endemic of Mt. Taigetos (S Peloponnisos). Based on current data, its area of occurrence (Fig. 4) is limited to two, disjunct areas, on the rocky systems of North Taigetos, west of the summit Xerovouni and at suitable habitats of Langada gorge, in Central Taigetos. *P. greuteriana* is a typical chasmophyte. It grows on shady or half-shaded places, on vertical rocks, which consist of gray to black bituminous (containing solid organic ingredients), karstified limestone, capable of providing the flora that grows on it with the needed water (Fig. 3). The species appears to have adapted to the particular features of that limestone substrate, its dense root network effectively penetrating and absorbing water and nutrients from it.

Potentilla individuals on the Xerovouni summit grow at an altitude of ca. 1150-1200 m in N-NE exposure, while those of the Langada climbing area grow at an altitude of 750-800 m in S-SE exposure (Fig. 3).

Together with *Potentilla greuteriana* on the summit of Xerovouni, N Taigetos, there also grows the carnivorous *Pinguicula crystallina* subsp. *hirtiflora* (Ten.) Strid (this is the first report of its presence on N Taigetos, which constitutes its southernmost known occurrence) and, additionally, some Peloponnese endemic taxa, e.g. *Globularia stygia*, *Teucrium aroanium*, *Campanula asperuloides* (Boiss. & Orph.) Engl., *Minuartia pichleri* Maire & Petitm, etc.

In Langada gorge, *Potentilla greuteriana* co-exists with the following endemic taxa: *Asperula boryana, Campanula asperuloides, Carum depressum* Hartvig & Kit Tan, *Inula verbascifolia* subsp. *methanaea* (Hausskn.) Tutin and *Stachys candida* Bory & Chaub., whereas the local endemic *Hypericum taygeteum* Quézel & Contandr. is found nearby.

Conservation status: *Potentilla greuteriana* is a narrow endemic with a very limited area of occurrence in specialized habitats. Based on in-situ observations, it appears that a necessary condition for the species survival is the uninterrupted supply of water through the capillaries of the calcareous rocks on which it occurs. Possible changes of

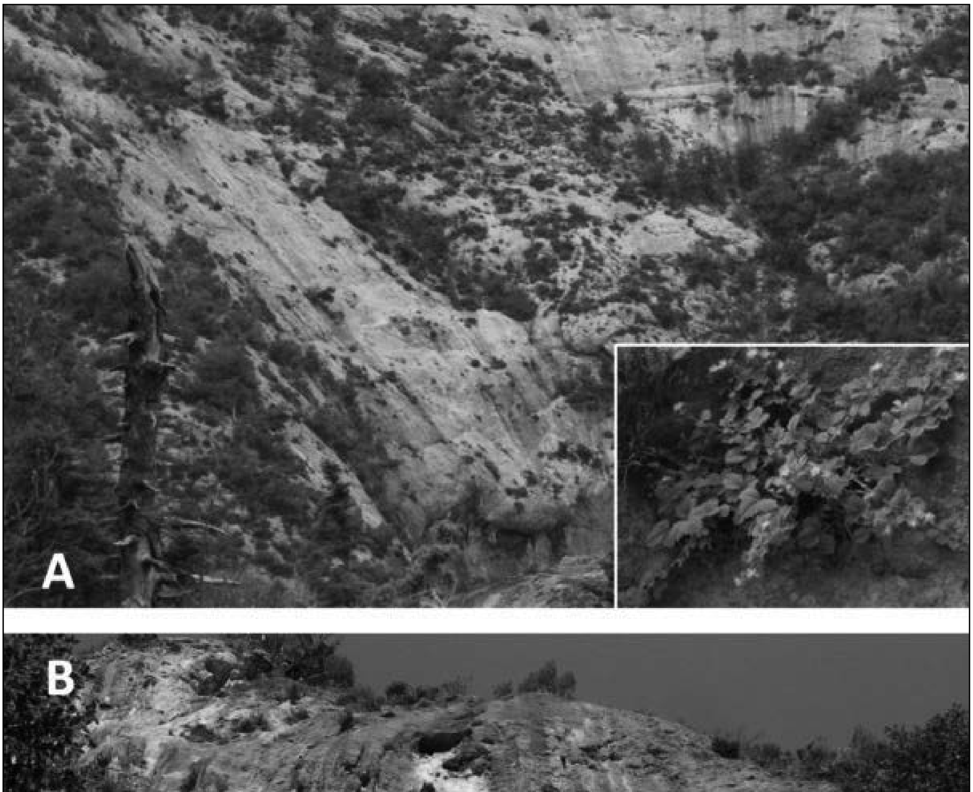

Fig. 3. Biotopes of the typical chasmophyte species *Potentilla greuteriana*: **A**, the summit area of Mt. Xerovouni (*locus classicus*) of the north Taigetos and **B**, the climbing area of Langada gorge in central Taigetos.

water potential of the karstified limestone systems, on which it grows, may cause a population decline. The subpopulation of the Langada area occupies an area of less than 300 × 50 m (< 1 km^2) and consists of 100-150 mature individuals, while the subpopulation of N Taigetos (Xerovouni) develops over an area of 250 × 30 m (< 1 km^2) and consists of 400-600 mature individuals. Moreover, the subpopulation of the former locality is potentially threatened by the fact that the area is used as a climbing field. Following the IUCN (2017) criteria, the taxon should be categorized as Endangered (EN), on the basis of its restricted distribution [restricted, extent of occurrence (EOO <100 km^2) and area of occupancy (AOO<100 km^2)], the fact that no more than 750 mature individuals were counted, and the high possibility of erosion of the substrate as a result of human activities (climbing) [B1ab(i,ii,iii,iv), B2ac(i,ii,iii,iv)].

Etymology: The species is named after Werner Greuter, Professor Emeritus of Plant Systematic, Nomenclature and Phytogeography of the world flora and especially expert of the Greek and Cretan flora, for his 80th birthday.

Discussion: *Potentilla greuteriana* is one more new stenoendemic taxon of Mt. Taigetos (S Peloponnisos). It is related to the Greek endemic *P.* (sect. *Crassinerviae*) *arcadiensis* from Mt. Parnonas (SE Peloponnisos), but also to the Anatolian endemics *P. isaurica* & *P. libanotica* (*P.* sect. *Plumosistylae*), which spread around S Turkey, Syria and Lebanon (see Fig. 4).

The only close relative of *Potentilla greuteriana* in Greece is *P. arcadiensis* (Fig. 5), which, however, according to Iatroú (1985), is a distinct and geographically isolated

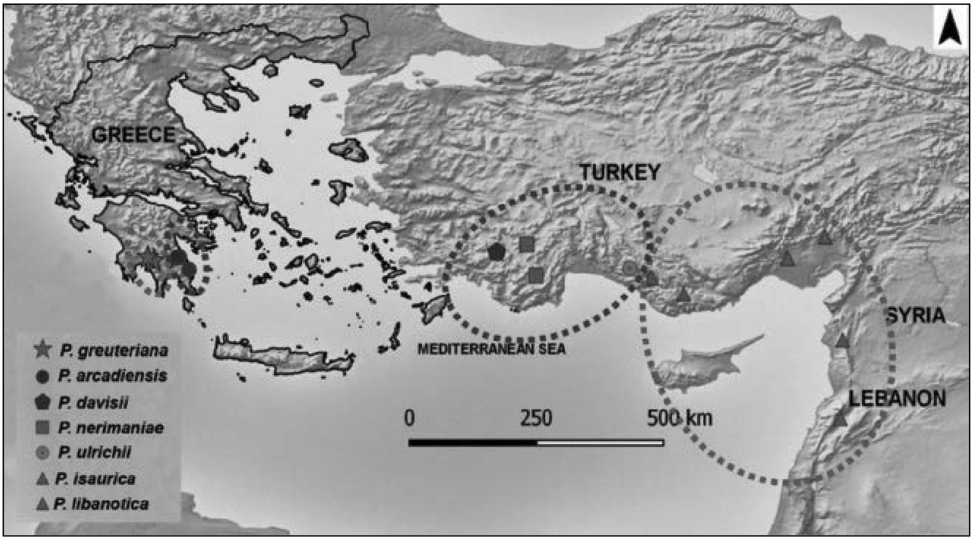

Fig. 4. Distribution map of the two *Potentilla* Greek endemic species and their related species in S & SW Anatolia, Syria and Lebanon.

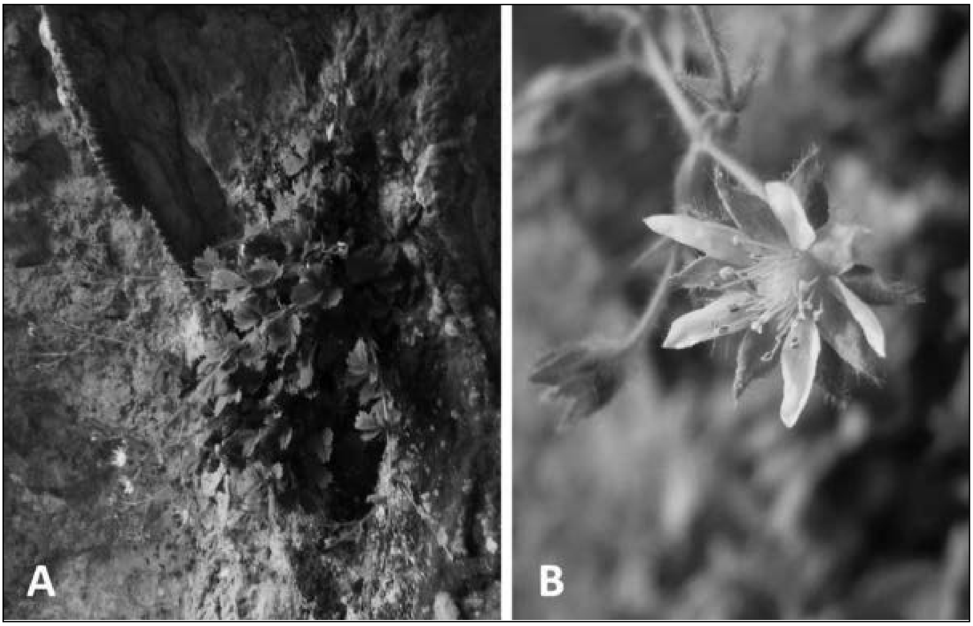

Fig. 5. *Potentilla arcadiensis* from its *locus classicus* at the Monastery of Elona, Mt. Parnonas: **A**, individual; **B**, inflorescense and flower.

species without any other close relatives in Greece. *P. arcadiensis,* in contrast to *P. greuteriana,* exhibits 1-2 digitate basal leaves, a feature that, according to Iatroú (1985), “suggests an intermediate position between the species of the E and W Mediterranean area”. The diploid chromosome number of *P. arcadiensis*, 2*n* = 14, is an additional character of the representatives of the *Crassinerviae* group, such as *P. crassinervia* Viv., *P. valderia* L. and *P. haynaldiana* Janka (Contadriopoulos 1962; Baltisberger 2006). Based on this chromosome number, along with the hairlessness of styles and some other morphological features, Iatroú (1985) suggested that *P. arcadiensis* belongs to *P.* sect. *Fragariastrum* Ser., group *Crassinerviae.*

Additionally, *P. nerimaniae* Duman and *P. davisii* Mill & Duman, described by Duman & Mill (1999) from S & SW Anatolia, were also classified in *P.* (subg. *Fragariastrum*) sect. *Crassinerviae* (Th. Wolf) Juz. The taxa of *P.* sect. *Crassinerviae* differ from those of *P.* sect. *Plumostistylae* mainly by the predominant indumentum of simple hairs, ± hiding the much shorter glandular hairs, loose inflorescences, flowers with long pedicels, pilose filaments, achenes with scrobiculate-reticulate surface etc (see Table 1).

Potentilla ulrichii Parolly & Nordt, which was described more recently (Parolly & Nordt 2002), also from S Anatolia, was classified in *P.* sect. *Crassinerviae* and placed in the *P. nerimaniae* group, together with *P. davisii* and *P. arcadiensis.* This species is also considered a close relative of *P. libanotica* and *P. isaurica* (Table 1).

However, *P. libanotica* and *P. isaurica,* together with *P. saxifraga* De Not. (a taxon growing in the lowland and the middle altitudinal level of Mediterranean Alps) were clas-

Table 1. Morphological features of *Potentilla greuteriana* and its relatives (bold letters denotes the main differences of the Greek endemic species of Peloponnisos).

	Potentilla* sect. *Plumosistylae			*Potentilla* sect. *Crassinerviae* p.p. (*P. nerimaniae* group)			
Taxon	***P. greuteriana***	***P. libanotica***	***P. isaurica***	***P. arcadiensis***	***P. ulrichii***	***P. nerimaniae***	***P. davisii***
Stem (length in cm)	8-25(-27)	5-20	5-20	10-25(-30)	(5-)10-35, decumbent to ascending, rarely erect	5-15, decumbent to ascending, rarely erect	5-12
Stem leaves	numerous	numerous	numerous	numerous	sparse	sparse	sparse
Petioles (cm)	**4-7**, thin	5-7, stout	3-5, stout	**3-5**, thin	5-12, thin	1-7, thin	≤10, stout
Indumentum	simple hairs, longer glandular hairs	glandular hairs dominant, glutinous	glandular hairs dominant, glutinous	simple hairs, shorter glandular hairs	simple hairs dominant, ± hiding the much shorter glandular hairs	simple hairs dominant, ± hiding the much shorter glandular hairs	simple hairs dominant, ± hiding the much shorter glandular hairs
Leaves	ternate, not bicoloured	ternate, green, not bicoloured	ternate,green, not bicoloured	ternate **(1-2 basal digitate),** not bicoloured	ternate, (distinctly) bicoloured	ternate, (weakly) bicoloured	ternate, bicoloured
Leaflet size (mm)	25-38(-44) × 15-26(-28)	15-25 × 10-20	15-20 × 8-15	15-25 × 10-18	(20-)25-60(-70) × (15-)20-35(-45)	(7-)10-25 × (6)10-20	15-30 x 12-20
Leaflet margin	crenate-serrate	crenulate-serrate, rarely dentate	dentate to crenate-serrate	crenate-serrate	dentate	dentate	crenulate-serrate
Lateral teeth of leaflets	5-6	6-9	3-5(-6)	5-6(-7)	(6-)8-9(-10)	(3-)4(-5)	(4-)5-7(-10)
Tip of teeth	obtuse	± obtuse	± acute	obtuse	acute	acute	obtuse
Inflorescence	**compact cyme, 12-30(-40) flowers**	compact cyme	compact cyme	**loose cyme, 15-20(-30) flowers**	loose, ± corymbose cyme, (10-)15-30 flowers	loose, cymose	loose, cymose
Pedicels (length in mm)	**7-10(-15), stout**	≤12, stout	≤10, stout	**15-35, ± thin**	(10-)12-20(-35), thin	10-30, thin	10-30, thin
Epicalyx segments (mm)	**≤3.5 × 1.5,** **shorter than sepals**	4-6.5 × 1.5-2.2, equal to sepals	4-6.5, equal to sepals	**3.5-5.5, equal to sepals**	4-5 × 1-1.5(-2), equal or slightly smaller than sepals	2-4, shorter or as long as the sepals	6-10, equal to sepals
Petals length (mm)	**3.2-4.5 × 2.5-3**	5-7.5 × 2.6-4.1	6-8	**4.5-6 × 2-2.5**	4.5-6(-7)	5-5.5	6-10
Petals shape	**obovate to broadly oblong**	obovate to ovate	elliptic	**oblong to narrowly oblong**	obovate	obovate	obovate-orbicular
Petals apex	**rounded, glabrous**	rounded ± retuse, glabrous	± acute, apex glabrous	**usually acute, pubescent**	rounded to broadly obtuse, glabrous	obtuse or shallowly retuse, glabrous	obtuse, glabrous
Filaments	glabrous, **base not dilated**	glabrous, base not dilated	glabrous, base not dilated	glabrous, **base dilated**	pilose, base dilated	pilose, base dilated	pilose, base dilated
Anthers	**ovate to obovate often with base cordate,** yellowish with reddish margins	globose, yellow	globose, reddish	**oblong**, yellowish with reddish margins	oblong, yellowish	oblong, yellowish	oblong, yellowish
Style	**usually pubescent** or rarely glabrous, **persistent**	plumose, persistent	plumose, persistent	**glabrous, caducous**	glabrous, caducous,	glabrous, caducous	glabrous, caducous
Achenes (mm)	Smooth, 0.9-1.3, apex pilose, margin narrowly winged	Smooth, 1.2-1.8, pubescent	Smooth, apex loosely pilose	Smooth, 0.7-1.0, apex pilose, margin narrowly winged	Scrobiculate-reticulate, 1.6-1.8 × 0.9, glabrous, margin narrowly winged	Scrobiculate-reticulate 1.5-2.0, glabrous	Scrobiculate-reticulate, apex pilose
Altitudinal range (m)	**750-1200**	1450-2100	1100-1700	**450-650**	300-550	1350-1950	1370-1630

sified by Pawłovski (1965) in *P.* sect. *Plumosistylae* because of their main morphological features, which are the non-deciduous, persistent and plumose (for up to ¾) styles and the almost globose anthers. The same classification is also followed by Soják (1987), who added to the morphological features of *P.* sect. *Plumosistylae* the slender filaments not dilated at the base, and stems with numerous leaves. According to the above characters, *P. greuteriana* probably belongs to *P.* sect. *Plumosistylae.* The main morphological features commonly found in *P.* sect. *Plumosistylae,* are: numerous leaves on flowering stems (with 5-8 unequal leaves, the largest in the middle of the stems), short-pedicellate flowers [length 0.6-1.2(-1.5) cm], glabrous filaments, glabrous petals, subterminal, filiform, persistent styles pubescent for 2/3-3/4 of their length, and smooth achenes (Table 1).

Potentilla greuteriana also shows some similarities to *P. arcadiensis* of *P.* sect. *Crassinerviae,* from which, however, it differs mainly by the bigger size [(25-38(-44) × 15-26(-28) mm] of the always trifoliolate leaves; the indumentum of the flowering stems and pedicels, which consists of longer (12-15 mm) glandular and shorter (10-12 mm) englandular hairs; the longer [10-18(-24) mm] stipules of the basal leaves, with significantly longer (8-12 mm) auricles; the epicalyx segments significantly shorter than the sepals; the shorter, glabrous petals, the styles usually pubescent for 2/3-3/4 of their length, persistent on the achenes; and more significantly the shorter [7-10(-15) mm] pedicels and the compact inflorescences (see Table 1).

Kechaykin & Shmakov (2016) in their revision of *Potentillinae* J. Presl, using molecular data and based on morphological differences, classified *Fragariastrum* Heist. ex Fabr. and *Tormentilla* L. as separate genera and included in them several *Potentilla* species. For example, *P. arcadiensis* and some of its Anatolian relatives are included in *Fagariastrum* sect. *Plumosistylae* (Pawłowski) Kechaykin & Shmakov (*P.* sect. *Plumosistylae* Pawłowski). This new classification of *P. arcadiensis* is uncertain because it does not display any of the key characters of *F.* sect. *Plumosistylae,* such as: anthers globose; style persistent in fruit and plumose at least in its lower half etc. (see: Pawłowski 1965: 79; Ball & al. 1968: 47). Detailed molecular data from *P. arcadiensis* and *P. greuteriana,* as well as from taxa of both *P.* sect. *Plumosistylae* and *P.* sect. *Crassinerviae,* could help elucidate the relationships of the two Greek endemic *Potentilla* species and their relatives.

Identification key to the Greek and the S-SE Anatolian & E Mediterranean *Potentilla* species related to *P. greuteriana.*

1. Loose inflorescence 2
-. Compact inflorescence 5
2. Petals pilose, oblong, acute .... ***P. arcadiensis***
-. Petals glabrous, obovate, obtuse 3
3. Achenes pubescent, leaflet margins crenulate to serrate .... ***P. davisii***
-. Achenes glabrous, leaflet margins dentate 4
4. Lateral teeth of leaflets (3-)4(-5), epicalyx segments 2-4 mm long .... ***P. nerimaniae***
-. Lateral teeth of leaflets (6-)8-9(-10), epicalyx segments 4-5 mm .... ***P. ulrichii***
5. Petal shape elliptic, lateral teeth of leaflets 3-5(-6), acute .... ***P. isaurica***
-. Petal shape obovate to ovate, lateral teeth of leaflets 5-9, obtuse 6
6. Lateral teeth of leaflets 5-9, achenes pilose, styles plumose .... ***P. libanotica***
-. Lateral teeth of leaflets 5-6, achenes pilose only at the apex, styles usually pubescent or rarely glabrous .... ***P. greuteriana***

Specimens seen

Potentilla greuteriana

GREECE: S Peloponnisos: Prov. Arkadias: Mt. N Taigetos, W-SW of Xerovouni summit, 37° 09'N, 22° 13' E, 1150-1200 m, 5 Aug 2012, *Ch. Kyriakopoulos* & *Chr. Papagiannopoulos* 1300 (Herb. Phitos & Kamari, UPA); ibidem: 24 Jun 2013, *Ch. Kyriakopoulos* 1530 (Herb. Phitos & Kamari, UPA); ibidem: 23 Juy 2013, *Ch. Kyriakopoulos* 1697 (Herb. Phitos & Kamari, UPA); ibidem: 16 Jul 2015, *Ch. Kyriakopoulos* 2240 (Herb. Phitos & Kamari, UPA); ibidem: 24 Sept 2015, *Ch. Kyriakopoulos* 2249 (Herb. Phitos & Kamari, UPA); ibidem: 11 May 2016, *Ch. Kyriakopoulos* 2264 (Herb. Phitos & Kamari, UPA); ibidem: alt. c. 1150 m, with *Pinguicula cristallina* subsp. *hirtiflora, Campanula asperuloides, Teucrium aroanium* etc, on vertical karstified limestone rocks, 9 Jul 2017, *Ch. Kyriakopoulos* 2334 (Holotype: Herb. Phitos & Kamari, UPA; Isotypes: ACA and PAL-Gr).

GREECE: S Peloponnisos: Prov. Lakonias: Mt. Taigetos, Langada gorge, on vertical limestone cliffs, 37° 04' N, 22° 18' E, 750-800 m, 31 Jul 2011, *Ch. Kyriakopoulos* 895 (Herb. Phitos & Kamari, UPA); ibidem: 22 Jun 2012, *Ch. Kyriakopoulos* & *E. Kartsonas* 968b, (Herb. Phitos & Kamari, UPA); ibidem: 25 Jun 2012, *Ch. Kyriakopoulos* 1103 (Herb. Phitos & Kamari, UPA); ibidem: with *Campanula asperuloides*, 5 Aug 2012, *Ch. Kyriakopoulos* & *Chr. Papagiannopoulos* 1310 (Herb. Phitos & Kamari, UPA).

Potentilla arcadiensis

GREECE: E Peloponnisos: Arkadia: Mt. Parnonas, in declivibus orientalibus montis Parnon; ad Monasterium Elona, in rupestribus calc., alt. c. 550 m, 7 Jul 1983, *G. Iatrou* 1911 (Holotype: UPA); ibidem: the nunnery of Agios Nikolaos Sintzas, c. 6.4 km, SW the village of Leonidion, steep, calcareous rocks mostly to the N and SE of the nunnery, 37° 0.8' N, 22° 49' E, alt. 550-600 m, 30 May 2003, *Th. Constantinidis* & *E. Kalpoutzakis* 10677 (Herb. Phitos & Kamari, UPA); ibidem: monastery of Panagia Elona, vertical limestone cliffs after the monastery entrance, 37° 09' N, 22°45' E, alt. 500 m, 10 Jul 2016, *Ch. Kyriakopoulos* 2293 (Herb. Phitos & Kamari, UPA).

Potentilla davisii

TURKEY: C2 Denizli: Acipayam, Bozdag, Olukbaîi, above Geyran Yayla, 1450 m, rocks, 4 Aug 1997, Aytaç 7648 (Isotype E00075639); Bozdag, near Geyran Yayla, 4500 ft, rocks, 16 Jul 1947, Davis 13334 (Paratype E00146056); ibidem: 5000-5500 ft, Davis 13435 (Paratype E00146055).

Potentilla isaurica

TURKEY: C2 Antalya: Vil. Antalya (Isauria): Kargi Chai, between Durbanas and Derince valley, in cliffs, fl. white, 25 Aug 1947, *Davis* 14466 (Holotype E00010703, Paratype K000762317);
C4 Antalya: Alanya, Dimçayi vadisi, 1200 m, 10 Oct 1992, *Duman* 4677 & *Karaveliogullari* (E00077481).

Potentilla libanotica

LEBANON: Liban, in mount Libano, 1837, Aucher-Eloy 1457 (P03342030); In declivita Libani borealis occidentalibus, prope pagum Ehden, 1450-1700 m, 30 Jun-2 Jul 1910, *Bornmüller* 11766 (E00146058); Bcharré [sentier des Cèdres] (Liban), 1800 m, 14 August 1927, *Gombault* 17 (P03342020); Mt. Lebanon, Akoura, 2000 m, 30 Jul 1932, *Louis* [Frères Maristes d'Alep] s.n. (P04173512); ibidem: Aqoura, 31 Jul 1932, *Gombault* 1981 (P03342018, P03342019, P03342021, P03342018).

SYRIA: Hadret, 1822, *Ehrenberg* 322 (L.1901646); Syria, 1846, *Pinard* s.n. (E00409399).

TURKEY: C5 Içel: Kapudschi Dere, an Felsen, 1896, *Siehe* 643 (E00146059); Osmaniye: Amanus: Mont de Düldül, 1500-2000 m, 15 Aug 1911, *Haradjian* 3890 (E00409400).

Potentilla nerimaniae
TURKEY: C2 Antalya: Elmali, Çiglikara, 1900-1950 m, on calcareous rocks, 1 Aug 1995, *Duman*, *Ekici* & *Duran* (Duman 5978), (Isotype E00009314).

Potentilla ulrichii
TURKEY: C3 Antalya: Abzweig der Straße Manavgat - Akseki, nahe Ahmetler SW Muratiçi, 500 m, überhängende, schattige Kalkwand, Exp. E, 15 Oct 2000, *Ulrich* 121 (Holotype B100293986); Balme, nahe Ahmetler sudwest l. Murtiçi, 360 m, Exp. NW, 23 Apr 1997, *Ulrich* (paratype E00084587); near Ahmetler, crevices of limestone rocks, 330 m, Exp. N, 26 Aug 1998, *Ulrich* (Paratype E00077698).

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The Botanical Record of Archaeobotany Italian Network - BRAIN: a cooperative network, database and website*

Abstract

Mariotti Lippi, M., Florenzano, A., Rinaldi, R., Allevato, E., Arobba, D., Bacchetta, G., Bal, M. C., Bandini Mazzanti, M., Benatti, A., Beneš, J., Bosi, G., Buonincontri, M., Caramiello, R., Castelletti, L., Castiglioni, E., Celant, A., Clò, E., Costantini, L., Di Pasquale, G., Di Rita, F., Fiorentino, G., Furlanetto, G., Giardini, M., Grillo, O., Guido, M., Herchenbach, M., Magri, D., Marchesini, M., Maritan, M., Marvelli, S., Masi, A., Miola, A., Montanari, C., Montecchi, M. C., Motella, S., Nisbet, R., Orrù, M., Peña-Chocarro, L., Pepe, C., Perego, R., Rattighieri, E., Ravazzi, C., Rottoli, M., Rowan, E., Sabato, D., Sadori, L., Sarigu, M., Torri, P., Ucchesu M. & Mercuri, A.M.: The Botanical Record of Archaeobotany Italian Network - BRAIN: a cooperative network, database and website. — Fl. Medit. 28: 365-376. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

The BRAIN (Botanical Records of Archaeobotany Italian Network) database and network was developed by the cooperation of archaeobotanists working on Italian archaeological sites. Examples of recent research including pollen or other plant remains in analytical and synthetic papers are reported as an exemplar reference list. This paper retraces the main steps of the creation of BRAIN, from the scientific need for the first research cooperation to the website which has a free online access since 2015.

Key words: archaeobotany, network, database, Italy, Mediterranean.

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*Extended and enriched version of the poster presented at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

Introduction

Italy is an extraordinary cradle of cultural heritage located at the centre of the Mediterranean basin, hotspot of biodiversity, rich of habitats (Blasi 2010; Bartolucci & al. 2018) and scenery for incessant migrations and trade over the last millennia. Scholars from every side of the world come to this country to study the long-term coexistence between Culture and Nature, an interaction that has resulted in an uncountable number of archaeological sites.

Therefore, it is not a surprise that an interdisciplinary research field like archaeobotany, joining archaeology and botany, is so well developed that the study of pollen and other plant remains is more and more introduced in the archaeological projects planned in Italian sites (e.g. Roman Peasant Project: Bowes & al. 2015; SicTransit: www.sicilyintrasition.org) or considered in the vegetation history of the Mediterranean area (e.g. Mercuri & Sadori 2014; Fyfe & al. 2018). The archaeobotanical approach has been especially developed for the understanding of the relationships between people and environment, genesis and developing of cultural landscapes (De Pascale & al. 2006; Perego & al. 2011; Di Rita & Melis 2013; Di Rita & al. 2018), features and spread of cultivated species (Orrù & al. 2013; Sabato & al. 2015, 2017; Ucchesu & al. 2016, 2017; Bosi & al. 2017), links between plant processing and the religious value of food (Celant & Fiorentino 2017; Primavera & al. 2018), uses in medicinal preparations (Giachi & al. 2013), understanding of particular practices like metallurgy (Toffolo & al. 2018). The study of economic transformations under environmental/climate changes is investigated by considering plant exploitation and managing in prehistoric periods (de Marinis & al. 2005; Di Rita & al. 2010; Fiorentino & al. 2013; Cremaschi & al. 2016; Melis & al. 2018; Sadori 2018) and in historical ages (Greek: Florenzano 2016; Roman: Caramiello & al. 2013; Montecchi & Mercuri 2018; Moser & al. 2018; Bosi & al. 2018; Medieval and Renaissance: Bandini Mazzanti & al. 2005; Bosi & al. 2009; Rottoli 2014; Buonincontri & al. 2017). The research is usually highly interdisciplinary promoting a holistic and ecological approach to knowledge (Stagno & al. 2014; Vittori Antisari & al. 2016; Benvenuti & al. 2017; Arobba & al. 2018), also connecting palaeoecology with historical perspective (Izdebski & al. 2016), historical ecology (Moreno & Montanari 2008; Molinari & Montanari 2016), ecology (Marignani & al. 2017) and conservation themes (Bosi & al. 2015; Piovesan & al. 2018). Land cover and land use are explored in interdisciplinary investigations carried out through the analyses of pollen, non-pollen palynomorphs, microcharcoals, seeds and fruits, woods/charcoals, and less frequently via starch grains, phytoliths and other plant parts (Revedin & al. 2010; Guido & al. 2013; Mariotti Lippi & al. 2015; Pini & al. 2016a, 2016b; Mariotti Lippi & al. 2017). The research demonstrates that palynology is not only able to reconstruct long-term and regional vegetation history (Sadori & al. 2013), as well as the fire history of certain regions (e.g. Lago di Como: Martinelli & al. 2017), but this versatile science is also useful to known the 'where, when and how' of cultural landscapes development at ecological, formal and cognitive levels (Mercuri 2014). Indeed, the different approaches complement each other, highlighting the power of archaeobotany as a basic tool in reconstructing the history of past cultures and societies (Sadori & al. 2010; Celant & al. 2015).

From the scientific cooperation to the network

In 2014, the 9th EPPC European Palaeobotanical and Palynological Conference was held in Padua and saw the joint action of many Italian scholars in the fields of palaeobotany, palynology and archaeobotany. This stimulated the preparation of the book 'La Storia delle piante fossili in Italia/Palaeobotany of Italy' (Kustatscher & al. 2014) which deals with the long and illustrious history of the Italian palaeobotanical studies and the classical and modern methods for analyzing plant remains. The last paper of this book (Mariotti Lippi & al. 2014) consists of the first synthesis on the main researches (more than 200 research papers) and approaches on the botanical investigation on archaeological sites in Italy.

In this central Mediterranean country, archaeobotany was born during the first half of the 18th century when plant remains from archaeological excavations of the Vesuvian area became the focus of interest for a number of scholars (Borgongino 2006). The well-preserved plant remains were exhibited in Palazzo Caramanico (the Royal Palace) at Portici, near Naples. Starting with the researches in Palaeolithic sites, which shed light on the diet of the hunter-gatherer populations, the paper takes into consideration the origin of agriculture, the plant resource exploitation and human impact in the Bronze Age and Iron Age, cultivation and landscape management during the Roman Period up to the Middle Ages.

As an output of that congress, moreover, a volume on 'Changing flora and vegetation in Italy through time' was edited by Bertini & al. (2015) as special issue of the Review of Palaeobotany and Palynology hosted seventeen papers/syntheses on Permian and Triassic, Jurassic, Messinian, up to Pliocene, Pleistocene and Holocene vegetation history, probably one of the best examples of trans-chronological overview of Palaeobotany with high-level scientific examples. Three papers especially focused on archaeobotanical general (Roman harbours: Sadori & al. 2015) and site-centered themes (Fiorentino & Parra 2015; Mercuri & al. 2015a). Moreover, in a synthesis on the archaeobotanical research on Italian contexts (Mercuri & al. 2015b), fifteen archaeobotanist teams working on records collected from archaeological sites put together their data to write the first paper on the 'state of the art' of the archaeobotanical research in this country.

After that joint paper, the data collected were organised in a database that is free online and ready to be improved at www.brainplants.successoterra.net (formerly https://brainplants.unimore.it/index.html).

The database-network BRAIN

BRAIN - Botanical Record of Archaeobotany Italian Network was firstly introduced at the MedPalyno2015 Congress in Rome. It is a database of archaeobotanical research and analyses from archaeological sites in Italy. Under request, this database is now integrated with sites close to archaeological sites (off-sites, or near-sites: Mercuri & al. in press), and from sites located in the Mediterranean countries (Fig. 1).

Following the idea that archaeobotany is a key tool 'for the understanding of the biocultural diversity', the web site hosts the inventory of the archaeological researches including pollen, palynomorphs, seeds/fruits, wood, charcoals and other plant remains analyses,

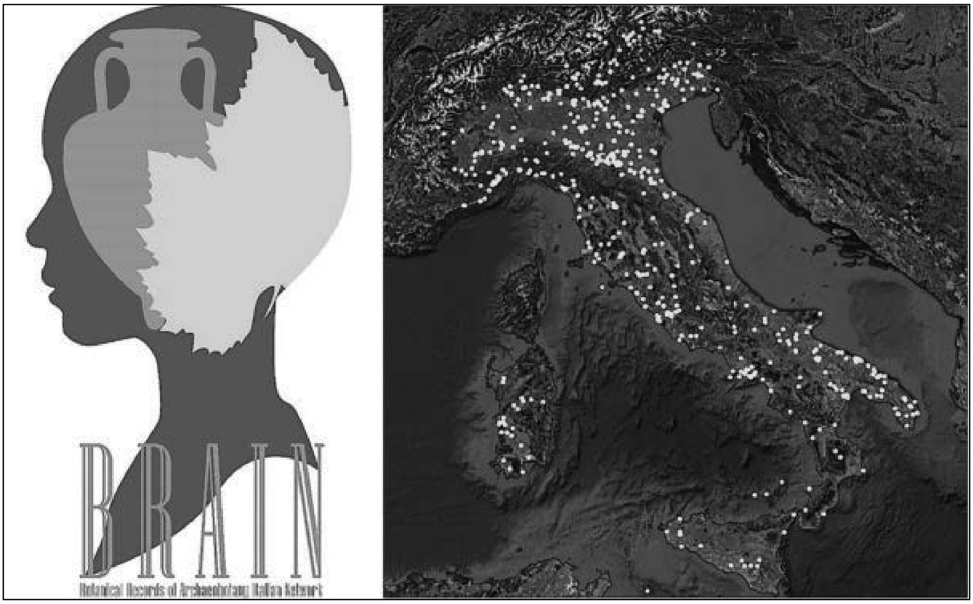

Fig. 1. BRAIN: The Logo (left) puts together humans and plants in one design whose profile recalls a female entity like science, botany and archaeobotany (by Serena Ferretti, Reggio Emilia). Distribution map of the sites in BRAIN (right).

fruitfully used to deepen the history of past vegetation, land cover, land-uses and palaeoethnobotany.

Currently, BRAIN includes >660 sites which has been object of archaeobotanical studies, among which 110 in Emilia Romagna, 74 in Apulia, 67 in Lombardy, 64 in Latium, and 39 in Tuscany. The studies have been mainly carried out on Neolithic (119), Bronze age (117), Iron Age (97), Roman (192), and Medieval contexts (119) (Fig. 2).

The website consists of six pages, two of which are especially dedicated to the database including Sites and References. Site position and density are immediately visible in a map while three graphs show updated statistics on the number of sites per area, or Cultural period, or type of plant remain. References may be sorted in alphabetical order, or author names. The first section included only On-sites; recently, three new sections were added: Off-sites, Spot records, and Extra-Italy. New contributors are welcomed.

BRAIN network is a useful instrument for both single and joint researches. The website is also a good way to publicize the impressive work done in the field of archaeobotany in the Italian on-sites (archaeological) or near-sites (human-related environmental sites) and makes the archaeobotanical data available for archaeological researches and studies on conservation and biodiversity on a long-term perspective.

The huge amount of data produced in the last few decades demonstrates that Botany has a key role in improving the knowledge of cultural/archaeological and natural heritage. The increase of the number of papers on archaeobotany (as evinced from BRAIN) shows the versatility and increasing importance of this science in the last years (Fig. 3).

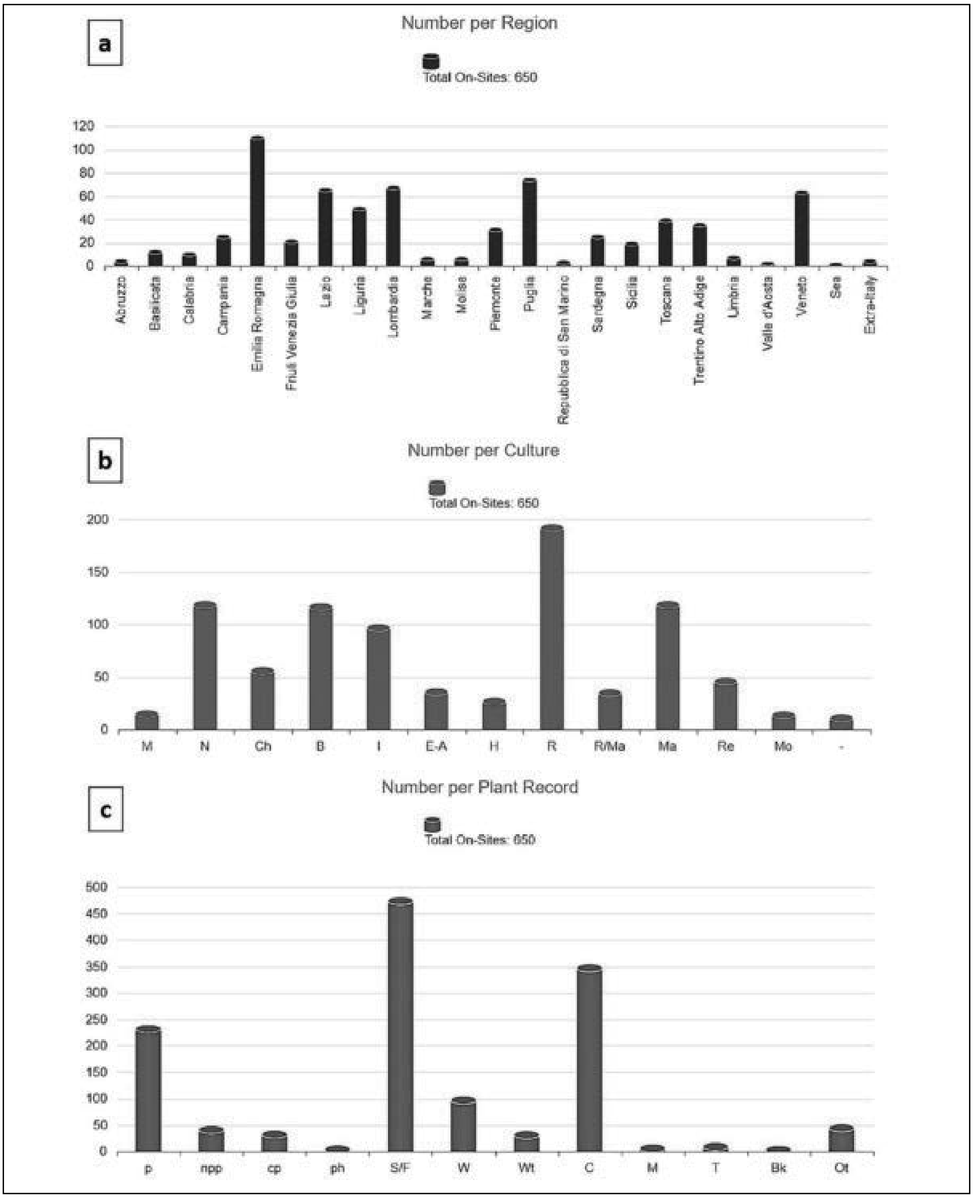

Fig. 2. BRAIN database: real-time statistics on the sites (retrieved October 12, 2018, from https://brainplants.unimore.it/sites.html): a) number of on-sites per region; b) on-sites per culture (M = Mesolithic; N = Neolithic; Ch = Chalcolithic; B = Bronze age; I = Iron age; E-A = Etruscan-Archaic period; H = Hellenistic period; R = Roman age; Ma = Medieval ages; Re = Renaissance; Mo = Modern age); c) on-sites per type of botanical record (p = pollen; npp = non-pollen palynomorphs; cp = micro-charcoal particles; ph = phytoliths; S/F = seed and fruit; W = wood; Wt = wood tool; C = charcoal; M = mould; T = textiles; Bk = basketry; Ot = adobe, bread or similar food, leaves and microsporophylls, mastic, moss, plant tissues, ropes, straw, wick).

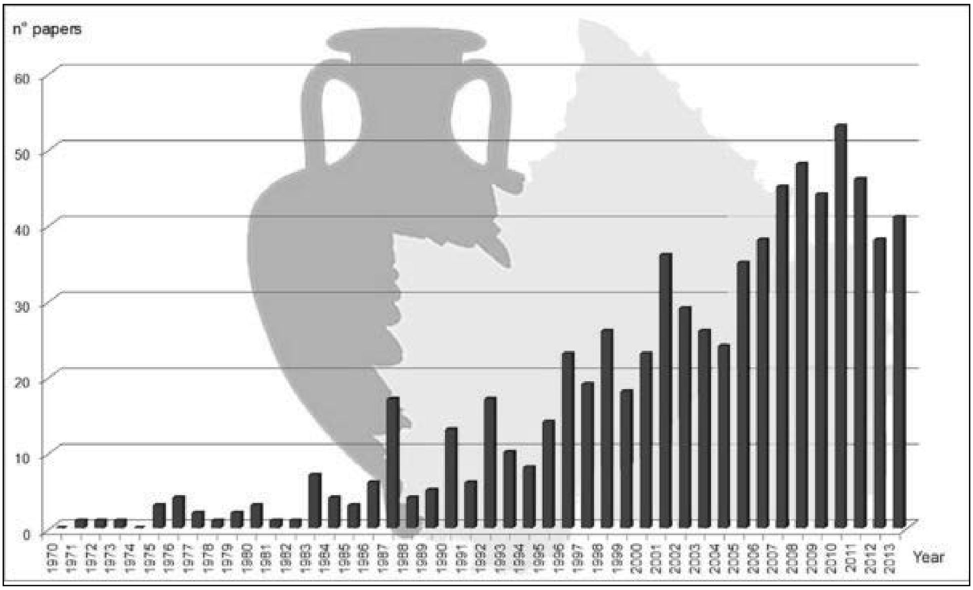

Fig. 3. Number of published archaeobotanical studies according to the list in the BRAIN website. Note the increase in time.

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MML and AMM planned the contribution and wrote the text, with the help of AF and RR; all Authors read and contributed to the synthesis.

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Gianniantonio Domina

The floristic research in Italian archaeological sites*

Abstract

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Italy is one of the richest countries in historical and artistic heritage. The occurrence of vascular plants on monuments has always been analysed with some concern about conservation issues of the buildings. In order to present a framework of floristic research done in Italy within the archaeological areas and monumental sites in the country, the list of the basic references is presented. These 97 contributions are divided by publication date, area, and main historical period or civilization to which the complex refers. The most studied archaeological areas belong to the Roman civilization and occur in Latium and Sicily.

Key words: Vascular flora, Mediterranean area, management, artistic heritage.

Introduction

The Mediterranean Basin was the cradle of several civilizations that not only have profoundly changed the landscape but left numerous remains. Italy is one of the richest countries in historical and artistic heritage. The Central Institute for Catalogue and documentation of Italy (Istituto Centrale per il Catalogo e la Cocumentazione) lists 781 archaeological areas or parks and 622 main monumental complexes (http://www.catalogo. beniculturali.it); the number of individual monuments would exceed several thousand. Natural flora in monumental areas is seen with some concern because plants can damage monuments with their roots, can give the appearance of neglect, obstruct site access for visitors or conceal the monuments (Kanellou & al. 2017). In some case, trees or shrubs grown on ancient monuments have to be prudentially kept in the site as they provide stability to the structures and their removal could be dangerous. In the past (Romantic era) or in some peculiar situations (archaeological area of Angkor, in Cambodia, or Tikal, in Guatemala), they are considered to characterize the archaeological excavation, giving the visitor the idea that the site is still unexplored.

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*Extended and enriched version of the oral presentation given at the International Symposium "Botany at the intersection of Nature, Culture, Art and Science", Selinunte, 28-30 June 2018.

The interest on the flora of archaeological sites in Italy dates back to the XVII Century. Panaroli (1643) reports 337 different plants (identified at species or genus level) growing on the Flavian Amphitheatre in Rome. The scope of floristic inventories can more focus on biological features of the plants growing into archaeological areas (e.g. Ceschini & al. 2006) or the list can be accompanied by the indication of their dangerousness for the monument with the indications for their management (Signorini 1995).

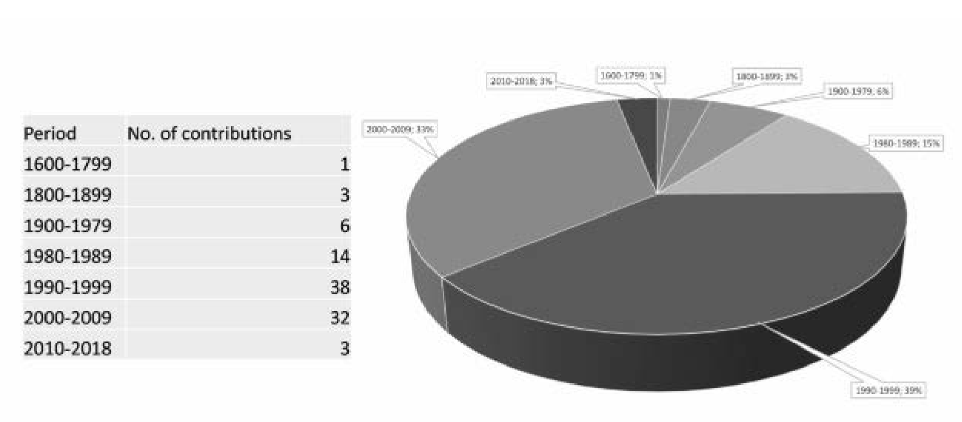
A first account of floristic references on archaeological areas is given in Caneva & Ceschin (2012). The aim of this paper is to present an updated framework of floristic research done in Italy within the archaeological areas and monumental sites in the country.

Material and Methods

The list of basic references concerning the flora (Higher plants, Bryophytes or Lichens) of archaeological sites located in Italy is presented as Electronic Supplementary File (ESF1). Each record includes authors, title, publication date, geographic area with geographical coordinates, main historical period or civilization to which the complex refers, the nature of the contribution (abstract, article, a chapter of Book or an entire book) and its editorial collocation (national or international). Thesis, doctoral thesis and unpublished research have been excluded. The main historical periods or civilizations considered are Greek (from 800 BC to 296 BC), Etruscan (from 800 BC to 396 BC), Punic (from 800 BC to 238 BC), Roman (from 753 BC to 476 AC), Medieval (from 476 to 1350), Renaissance (from 1351 to 1600), and Modern (from 1600 to today). Basic analysis is presented in figures 1-3.

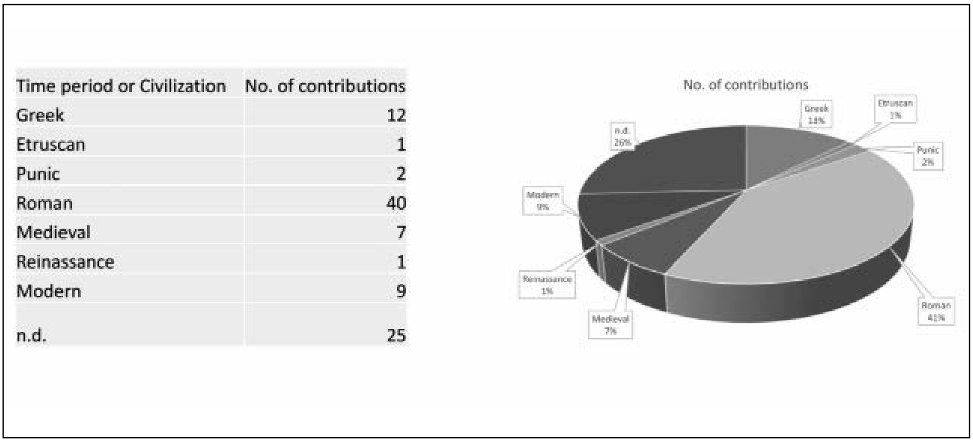
Results

Overall 97 references have been collected: 13 conference abstracts, 73 full articles, 10 book chapters and 1 complete book. The period in which the largest number of contribu-



Period	No. of contributions
1600-1799	1
1800-1899	3
1900-1979	6
1980-1989	14
1990-1999	38
2000-2009	32
2010-2018	3

Fig. 1. Chronological distribution of the considered publications.

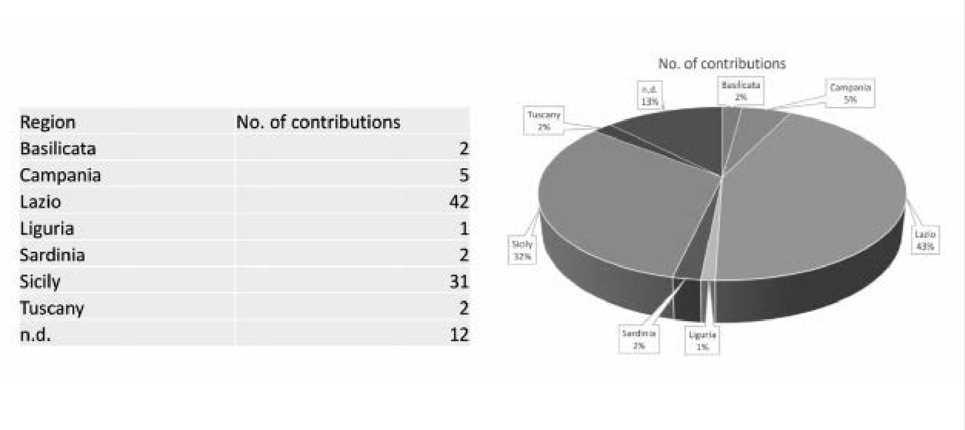


Time period or Civilization	No. of contributions
Greek	12
Etruscan	1
Punic	2
Roman	40
Medieval	7
Reinassance	1
Modern	9
n.d.	25

Fig. 2. The main historical periods or civilizations considered.

tions (38) was published was between 1990 and 1999. In the following decade (2000-2010) there was a slight decrease (32 contributions). In the last eight years (2011-2018) only 3 articles have been published. This is probably due to the limited interest by high ranked scientific journals in floristic research. Similar considerations can be deduced from the low number of contributions (only 21) published in international journals or international conference proceedings.

The most investigated regions are Lazio, with 42 contributions and Sicily with 31. However, in Sicily the studied sites are widespread in the region; in Latium the large part of contributions is focused on the area of Rome. Campania, Tuscany, Sardinia, Basilicata and Liguria have between one to five contributions. The resting 13 regions completely lack this kind of studies (Fig. 4).



Region	No. of contributions
Basilicata	2
Campania	5
Lazio	42
Liguria	1
Sardinia	2
Sicily	31
Tuscany	2
n.d.	12

Fig. 3. Geographical distribution of the considered publications.

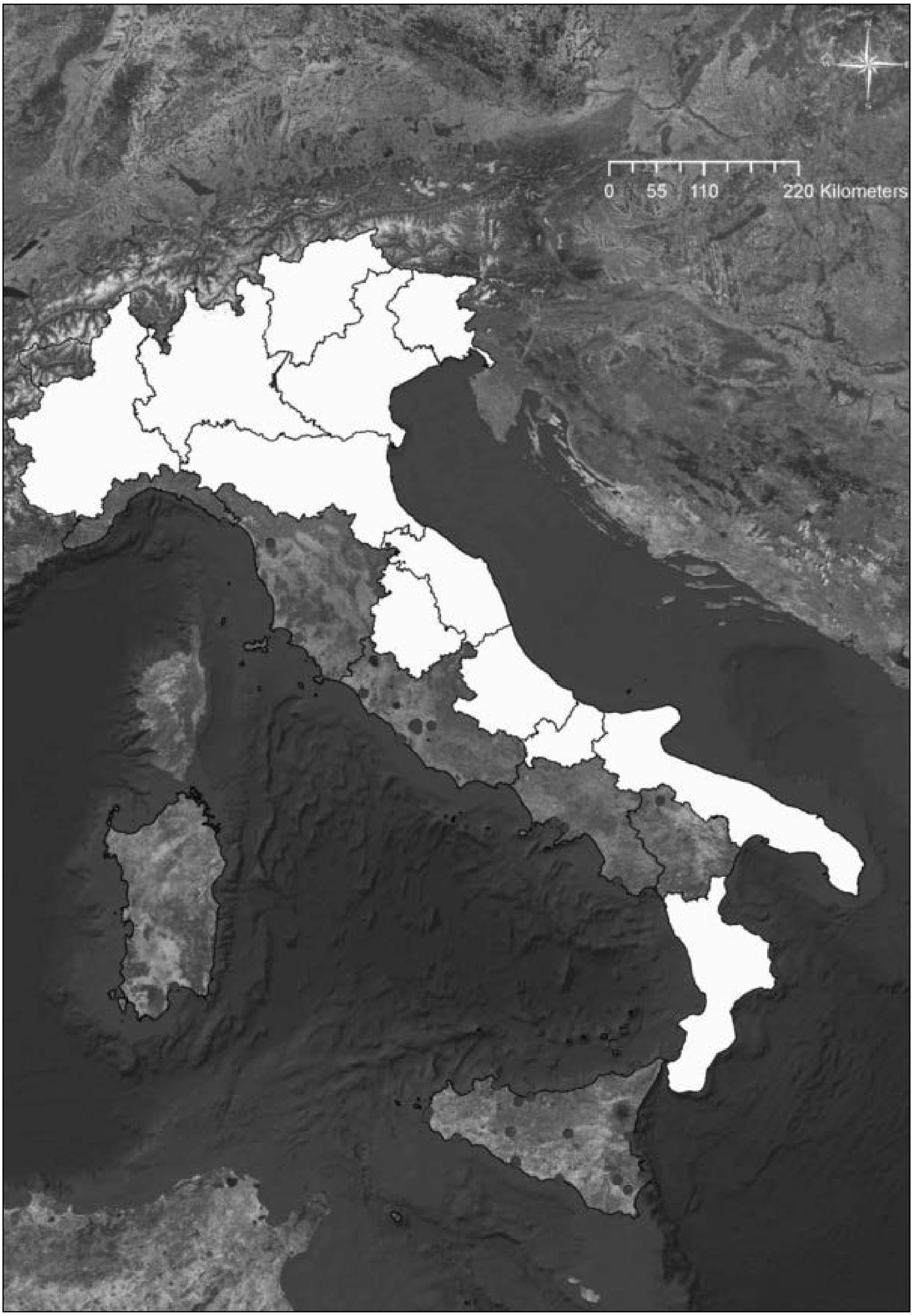


Fig. 4. Map of the studied sites, in grey are marked the Italian administrative regions lacking of studies.

The most studied archaeological areas or single monuments belong to the Roman civilization. Even if, in many cases, it is not easy to attribute a monument to a precise historical epoch because different buildings, over time, have been re-adapted and used by the civilizations that have succeeded each other. A significant example is the castle of Milazzo in Sicily. It stands on a hill that, since 4000 AC, saw the flowering of different civilizations. The castle was built in 829 by the Arabs and was modified by the Swabians, the Angevins, the Aragonese, the Spanish, the Austrians, the British, the Bourbons, everyone has built or modified parts of the building that, over time, was used as noble residence, fortress or prison (Micale 1982). Hence the difficulty of considering the monumental complex belonging to one of the different civilizations that have followed.

With the exception of the single Flavian Amphitheatre in Rome (the Colosseum), which has become a case study with 8 published contributions from the XVII Century to nowadays, there are no studies published on most of the sites and monuments in Italy.

The floristic lists of species found in archaeological sites indicate that these florulas are subsets of the floras growing in the surroundings. There are few but interesting cases of species that spread from historical human settlements. *Poterium spinosum* L. (*Rosaceae*) occurs in Eastern and Central Mediterranean (Kurtto 2009). This species is widespread and abundant in East Mediterranean and occurs only near historical Greek settlements in Peninsular Italy, Sardinia, Sicily and Tunisia (Caruso 2013). This distribution and the traditional use as a medicinal plant (Bachrach 2007) would justify a deliberate spread of this plant that then naturalized in the areas close to human settlements. From the biological point of view, the florulas of archaeological areas are influenced by environmental factors and land use. The climate affects the archaeological areas in the same way as the surroundings, but the microclimate due to the buildings and the maintenance of the site can lead to variations on the biological spectrum. For example, by comparing the biological spectrum presented for the area of Neapolis in SE Sicily by Corbetta & al. (2002) with that of the whole Sicilian flora (Raimondo & Spadaro 2011) there is a higher percentage of therophytes than other forms. This can be explained with the periodical mowing in this area that favours the spread of plants typical of arid grasslands and of weeds of crops.

Discussion and conclusions

Knowledge and management of the flora on cultural heritage is a phenomenon affecting the entire globe. Botanical studies on archaeological areas should be not only limited to the protection of monuments but have to give the guidelines for the introduction of new plant elements to support the current fruition of the areas compatible with the original landscape (Caneva 1999). The study of flora occurring in the archaeological area and in its surroundings allow to select which species can be maintained or planted without excessive management costs.

This review can be a stimulus for scholars and managers in order to undertake targeted campaigns of prospecting of the biological component occurring in these areas and of deepening knowledge on its management in order to preserve this historical and artistic heritage. Researchers should send the results of their research to international journals with a large pool of readers. From what has been stated above it is evident that the botanical prospecting in archaeological areas is still very limited, lacking entirely in several regions. On the contrary, the botanical researches in archaeological sites including the analyses of pollen, palynomorphs, seeds/fruits, wood, charcoals and other plant remains may be used to deepen the history of past vegetation, land cover, land-uses; indeed, archaeobotany is a still growing field of research. As reported by Mariotti Lippi & al. (2018) all the Italian regions have recent studies in archaeobotany. Each year about 45 articles have been published on this field and their number has constantly grown from in the last decades.

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Ridha El Mokni & Duilio Iamonico

Three new records of *Senecioneae* (*Asteraceae*) for the allochthonous Tunisian flora: occurrence and taxonomic notes

Abstract

El Mokni, R. & Iamonico, D.: Three new records of *Senecioneae* (*Asteraceae*) for the allochthonous Tunisian flora: occurrence and taxonomic notes — Fl. Medit. 28: 385-392. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

New records of allochthonous vascular Tunisian flora are here discovered. All the new taxa (*Jacobaea erucifolia* s.str., *Kleinia mandraliscae,* and *Senecio angulatus*) belong to the tribe *Senecioneae* (*Asteraceae*). Updated nomenclature, description and national distribution are provided for each species. *K. mandraliscae* is here reported for the first time from North Africa.

Key words: aliens, *Compositae*, *Jacobaea*, *Kleinia*, *Senecio*, North Africa.

Introduction

Senecioneae is one of the largest tribes in *Asteraceae* Bercht. & J. Presl (ca. 3000-3100 species and 150-155 genera), has a worldwide distribution, and exhibits remarkable morphological and ecological diversity (see e.g., Nordenstam 2007; Pelser & al. 2006, 2007, 2010). *Senecio* L. is the largest genus of the tribe including 1000-1250 species with a cosmopolitan distribution (APG III 2009; Pelser & al. 2010; APG IV 2016). Molecular and phylogenetic investigations (see e.g., Pelser & al. 2006, 2007, 2010; Milton 2009;) showed that this genus is non-monophyletic. As a consequence, some groups were split off (e.g. *Jacobaea* Mill., *Roldana* La Llave & Lexarza, *Delairea* Lemaire; see e.g. Barkley, 2006; Pelser & al. 2007), while other ones were merged with *Senecio* (see e.g., *Aetheolaena* Cass., *Culcitium* Humb. & Bonpl., *Lasiocephalus* Schlecht.; see e.g., Pelser & al. 2010; Salomón & Freire 2014).

As part of the ongoing researches aiming at improving the knowledge on the Tunisian non-native vascular flora and specially on *Asteraceae* (see e.g., El Mokni & El Aouni 2011; El Mokni & Iamonico 2018; Iamonico 2013a, 2013b, 2015, 2017; Iamonico & Hjertson 2015; Iamonico & Managlia 2015; Iamonico & Peruzzi 2016), three new *Senecioneae* taxa for the Tunisian flora were found during field work carried out in the period 2013-2018 from Jendouba (NW-Tunisia), Bizerta (NE-Tunisia), and Monastir Provence (CE-Tunisia). These three taxa are: *Jacobaea erucifolia* (L.) G. Gaertn. B. Mey. & Scherb subsp. *erucifolia*, *Kleinia mandralis-*

cae Tineo, and *Senecio angulatus* L. f. Descriptions, general and local distribution, taxonomic notes and original photographs are presented for each newly reported taxon.

Materials & Methods

The work is based on extensive field prospections with literature analysis, and in the personal collection of one of the authors (R. El Mokni) which is deposited in the Herbaria of the Faculty of Pharmacy of Monastir and of the Faculty of Sciences of Bizerta (not listed in Index Herbariorum). Taxons identification follows Fournier (1977), Rowley (1994), GISD (2015) (Retrieved from http://www.iucngisd.org/gisd/species.php?sc=1603), Podsiedlik & al. (2016) and Smith & al. (2017), with additional comments based on the authors' observations of the collected specimens.

Results & Discussion

1. *Jacobaea erucifolia* (L.) G. Gaertn. B. Mey. & Scherb subsp. ***erucifolia***, Oekon. Fl. Wetterau 3(1): 208. 1801 ≡ *Senecio erucifolius* L., Fl. Suec. (ed. 2) 291. 1755.

Lectotype (designated by Kadereit In Jarvis & Turland, 1998: 366): "*Jacobaea incana repens herba*" in Barrelier 1714: 96, t. 153).

Flowering period: August to October.

Notes on general distribution: *Jacobea erucifolia* subsp. *erucifolia* is an euro-asiatic species (Greuter 2006+), that is considered as introduced in North America (Konechnaya 2002). In North Africa, the taxon is currently recorded in Algeria only, but as doubtfully occurring (Greuter 2006+; APD 2018).

Occurrence in Tunisia and status of naturalization: Tunisian plants grow along road margins or in abandoned fields after seasonal cultivations, in the government of Jendouba (Fig. 1 A). Since the taxon was found only at two localities, we consider this occurrence as not-native. In particular, only about twenty individuals were observed, and this appears to be an occasional resulting from the use of imported seed mixtures for gardening purposes or for feeding domesticated birds drained to cultivated areas. According to Pyšek & al. (2004), and Richardson & Pyšek (2006) *Jacobea erucifolia* s.str. is considered as casual in Tunisia.

Specimina Visa: TUNISIA: Jendouba (Fernana), herbaceous formations along road margins of cultivated areas, 36°38′ 49″N, 08°41′30″E, 261 m a.s.l., 27 September 2013, El Mokni (Personal Herbarium of Ridha El Mokni at the Faculty of Sciences of Bizerta); Jendouba (Boussalem), abandoned fields after seasonal cultivations of *Solanaceae* and *Fabaceae* taxa 36°36′ 53″N, 08°58′58″E, 154 m a.s.l., 11 Otober 2013, El Mokni (Personal Herbarium of Ridha El Mokni at the Faculty of Sciences of Bizerta).

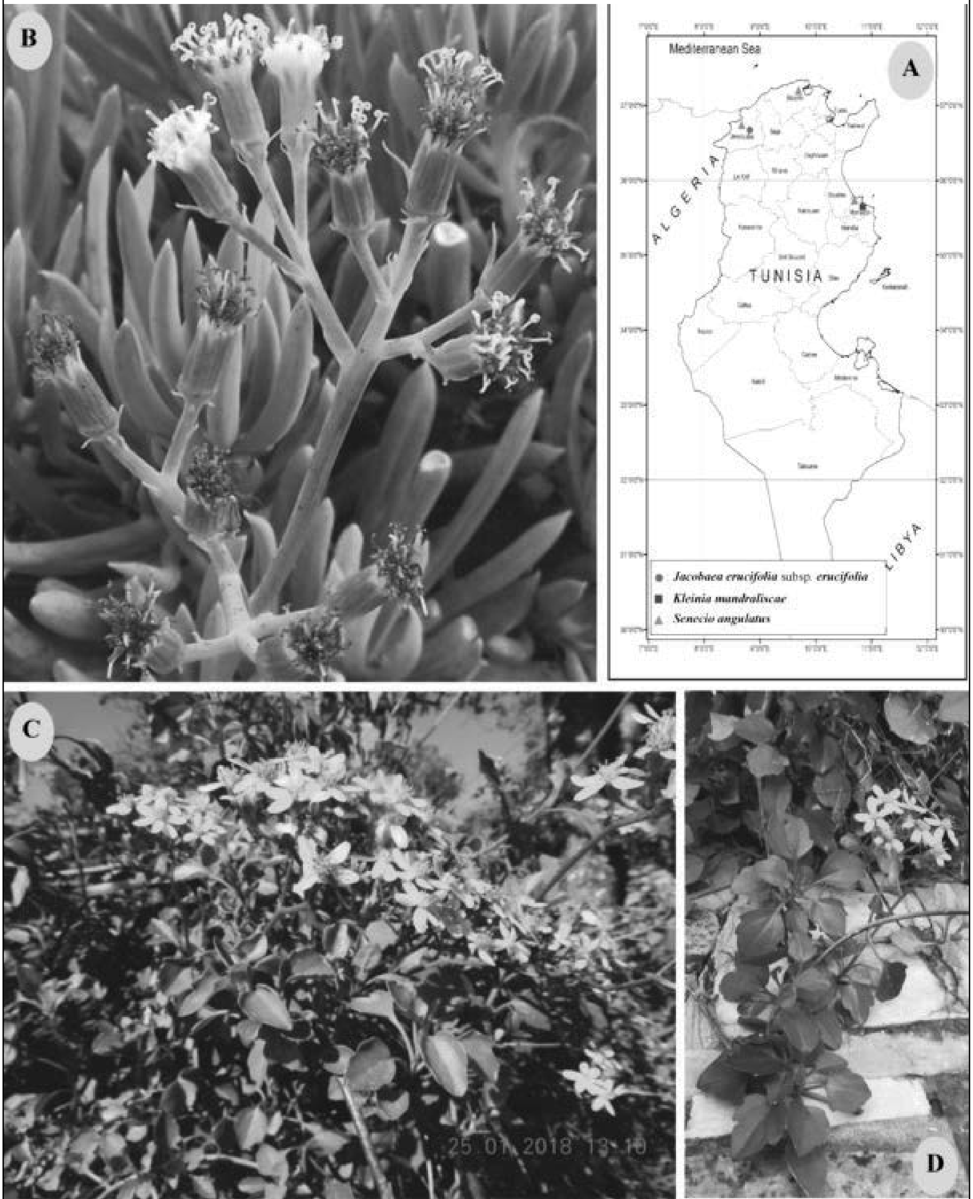

Fig. 1. A) Map of different localities of the new records in Tunisia; B) *Kleinia mandraliscae*, in blooming period (within local coastal rocky of Monastir, Center of Tunisia); C) *Senecio angulatus*, habit in blooming period (within Kroumiria region, North-western of Tunisia); D) *S. angulatus* within Bizerta town, North-eastern of Tunisia). Photos by Ridha El Mokni.

2. ***Kleinia mandraliscae*** Tineo, Ann. Agric. Siciliana 3: 315. 1855 ≡ *S. mandraliscae* (Tineo) H.Jacobsen, Sukkulentenk. 4: 90. 1951 ≡ *Senecio talinoides* subsp. *mandraliscae* (Tineo) G.D.Rowley, Cact. Succ. J. (Los Angeles) 62(6): 283. 1990 ≡ *Curio talinoides* var. *mandraliscae* (Tineo) P.V.Heath, Calyx 6(2): 55. 1999.

Lectotype (designated by Domina & al. 2005: 7): Sicily, "Vulcano, rimessa da Enrico Pirajno Barone di Mandralisca, il primo che la rinvenne in detta isola, vulgo Erva di Caddi", 08-10-1855, E. Pirajno s.n. (PAL).

Flowering period: November to December (-January).

Notes on general distribution: the 'Blue Chalk Sticks' is an upright, blue grey succulent with long fleshy leaves having pointed tips is native to the Cape Region of South Africa (Pignatti 1982; Pasta 2003; Domina 2005). This taxon is reported within the Mediterranean basin, as naturalized to the Aeolian Islands, as casual alien in Sicily (Greuter 2006+; Galasso & al. 2018), and as alien (with unknown status) in Spain. No records were made up till now for North Africa (see Greuter 2006+; APD 2018).

Occurrence in Tunisia and status of naturalization: we found *Kleinia mandraliscae* only in one Tunisian locality, a coastal rocky of Monastir city (Fig. 1 A). We consider this occurrence as occasionally introduced, resulting from seed escaped from cultivation of ornamental plants. One small population was observed (about 3-5 plants). According to Pyšek & al. (2004) and Richardson & Pyšek (2006) *K. mandraliscae* is casual for Tunisia.

Taxonomic notes: *Senecio mandraliscae* is still a "mysterious taxon, probably a hybrid" between *S. talinoides* and *S. citriformis.* It can be distinguished from the similar *S. talinoides* in young stage by the short branches and leaves. It is the bluest of the "talinoides" with a waxy white coating that protects it from hot, sunny, and dry conditions (Rowley 2002).

Specimina Visa: TUNISIA: Monastir, in local coastal rocky within *Crithmum maitimum* communities, 35°46′ 04″N, 10°50′34″E, 1 m a.s.l., 13 December 2017, El Mokni (Personal Herbarium of Ridha El Mokni at the Faculty of Pharmacy of Monastir), idem 35°46′ 04″N, 10°50′34″E, 1 m a.s.l., 11 January 2018, El Mokni (Personal Herbarium of Ridha El Mokni at the Faculty of Pharmacy of Monastir).

3. ***Senecio angulatus*** L. f. Suppl. Pl.: 369. 1782.

Lectotype (designated by Iamonico, 2017: 284, Figure 1): South Africa, *Caput bonae Spei*, *Thunberg s.n.* (UPS-19537!).

Flowering period: May to January (April to May in other parts of Africa; see e.g., Wells & al. 1986; Paczkowska & Chapman 2000; Navie & Adkins 2008).

Notes on general distribution: *Senecio angulatus* is a native to South Africa (NGRP 2013), and introduced as an ornamental to many other countries in S-America, Asia, Australia and Europe and the Mediterranean basin (see e.g., Greuter 2006+; Ugarte & al. 2011; Murray & Phillips 2012; GISD 2015). In North Africa, the taxon was cited only for Lybia as cultivated in large scale (Greuter 2006+; APD 2018) and more recently as occurring in Algeria (Miara & al. 2018).

Occurrence in Tunisia and status of naturalization: *Senecio angulatus* grows only within very local ancient buildings and sometimes overlaps with lianas of dune formations. Since the taxon was found only at three localities (Fig. 1 A), we consider its occurrence as not-native. In particular, only about 5-6 clumped plants were observed. According to Pyšek & al. (2004), and Richardson & Pyšek (2006) *Senecio angulatus* is to be considered as casual in Tunisia.

Taxonomic notes: other similar and sometimes confused *Senecio* species are *Delairea odorata* and *Senecio tamoides*, which can be distinguished being weak-stemmed climbers, not shrubs, and having thinner textured leaves, which are sharply, not bluntly, angular.

Specimina Visa: TUNISIA: Monastir, in ancient buildings within *Opuntia ficus-indica* and *Ephedra fragilis* communities, 35°46′ 14″N, 10°47′34″E, 21 m a.s.l., 13 December 2016, El Mokni (Personal Herbarium of Ridha El Mokni at the Faculty of Pharmacy of Monastir); Bizerta in ancient buildings within the center of the town, 37°16′ 15″N, 09°52′24″E, 9 m a.s.l., 10 February 2017, El Mokni (Personal Herbarium of Ridha El Mokni at the Faculty of Pharmacy of Monastir); Jendouba (Fernana-Aîn Draham), colonising by climbing on the toasting seats of a private garden 36°43′45″N, 08°40′44″E, 778 m a.s.l., 25 January 2018, El Mokni (Personal Herbarium of Ridha El Mokni at the Faculty of Pharmacy of Monastir).

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M. L. Gargano, G. Mandracchia, G.Venturella & R. Calvo

A revision of *Tamarix* specimens (*Tamaricaceae*) kept in the BCN herbarium of Barcelona (Spain)

Abstract

Gargano, M. L, Mandracchia, G., Venturella, G. & Calvo, R.: A revision of *Tamarix* specimens (*Tamaricaceae*) kept in the BCN herbarium of Barcelona (Spain). — Fl. Medit. 28: 393-397. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

The taxonomy of genus *Tamarix* L. is notoriously controversial and many taxa are still not or wrongly identified. A huge number of tamarisk specimens are kept in the most important herbaria of Spanish universities but many labels needs a deep nomenclatural revision. The *Tamarix* collection in Universitat de Barcelona (BCN) is composed by 158 samples, collected in different Comunidades Autónomas de España, and corresponding to 14 taxa.

Key words: Tamarisks, taxonomy, floristics, distribution, Iberian Peninsula.

Introduction

According to Flora Iberica the tamarisks flora of Spain is represented by seven taxa (Castroviejo & al. 1993). Additional ecological data are reported in the Spanish Global Biodiversity Information Facility (Otegui & al. 2013).

In Catalunya, Gargano & al. (2009) identified *T. arborea* (Ehrenb.) var. *subvelutina* Boiss. among the cultivated plants located along the Passeig Maritim de la Barceloneta, in the town of Barcelona.

However, a huge number of tamarisks specimens are kept in the most important herbaria of Spanish universities but many labels needs a deep nomenclatural revision.

As already highlighted in other European countries, the review of the herbarium samples is not only useful to verify the distribution in a territory of each taxon but can also demonstrate the presence of species not yet reported allowing the verification of their existence in nature (Venturella & al. 2012; Mandracchia & al. 2017).

In this paper, we provided a revision of tamarisk specimens kept in the Herbarium of the University of Barcelona (BCN).

Materials and Methods

Since the habitus, shape and color of inflorescences of tamarisks are the main features which lead to taxonomic confusion and misidentification of taxa we adopted for the revision of specimens the same methodology proposed by Baum (1978) and, more recently, by Alaimo & al. (2013) and Mandracchia & al. (2017).

In particular, the dried leaves and racemes were re-hydrated in boiled water at 90°C for 2-4 minutes. The flowers were observed under stereomicroscope to separate the disk and the stamens by using laboratory tweezers.

A distribution map of tamarisk species in Spain, based on the identification of herbarium samples, is also provided.

Herbarium materials

The specimens kept in BCN were collected in the last century and includes the collection of Sennen (1926) and recent accessions derived from a PhD thesis (Royo Pla, unpublished results).

From the analysis of the herbarium labels it was not possible to understand with certainty whether the species were spontaneous, cultivated or naturalised.

Therefore, in this publication we have only reported in the Electronic Supplementary File 1 (ESF 1) the information contained in the labels and we have carried out a nomenclatural update of each specimens.

Each herbarium specimens was pre-emptively catalogued and photographed together with a close view of the label. The labels of specimens kept in BCN are mainly filled out by hand and in italics.

Using web sites and the Spanish cartographic system we obtained the right references of localities of collection and the name of the administrative units (Comunidades Autónomas).

The selected 140 specimens belongs to 13 Comunidades Autónomas de España.

Results

The collection of tamarisks kept in BCN is composed by 158 specimens. This number refers to the samples included in herbarium prior of our nomenclatural update. The specimens has been collected in different Comunidades Autónomas de España from the beginning of last century until 2000 and corresponding to 14 taxa.

A specimens shows intermediate characters between *Tamarix arborea* (Sieb. ex Ehrenb.) Bge. and *T. canariensis* Willd., two specimens are characterized by mixed features of *T. africana* Poiret and *T. boveana* Bge., eight specimens have intermediate characters between *T. gallica* L. and *T. canariensis* Willd.

Owing to the bad conditions of conservation and/or the lacking of floral elements other seven specimens were unidentified.

Therefore the investigation was concentrated on the remaining 140 herbarium samples (ESF 1: Table 1).

52 specimens (37%) corresponds to *T. arborea* (Sieb. ex Ehrenb.) (i.e. 51 to *T. arborea* var. *arborea* and 1 to *T. arborea* var. *subvelutina* Bge.). 27 specimens (19%) were identified as *T. canariensis*, 24 specimens (16%) can be attributed to *T. africana* [in particular, 14 corresponding to *T. africana* var. *africana* (1 cultivated) and 10 to *T. africana* var. *fluminensis* (Maire) Baum]. 11 specimens (8%) corresponds to *T. parviflora* DC. (6 cultivated and 5 naturalized) while 8 specimens (6%) corresponds to *T. gallica*. *T. chinensis* Lour. (2) *T. dalmatica* Baum. (1); *T. mannifera* (Ehrenb) Bge. (3); *T mascatensis* Bge. (1); *T. meyeri* Boiss. (7); *T. octandra* (M.B.) Bge (1); *T. rosea* Bge. (1); *T. tetragyna* Ehrenb. (1); *T. boveana* Bge. (1).

Conclusions

In addition to *T. africana*, *T. mascatensis* Bge., *T. canariensis*, *T. gallica*, *T. parviflora*, *T. boveana* and, *T. dalmatica* Baum already reported from Spain by Cirujano (1993), we provide new distributive data about *T. meyeri* Boiss. and *T. mannifera*, two species never reported from Spain.

In BCN, specimens of *T. boveana*, *T. dalmatica* and, *T. mascatensis*, already reported from Spain by Tutin & al. (1968), are also kept while *T. chinensis* Lour., *T. octandra* (M.B.) Bge., *T. rosea* Bge. and, *T. tetragyna* Ehrenb. are new records from Spain.

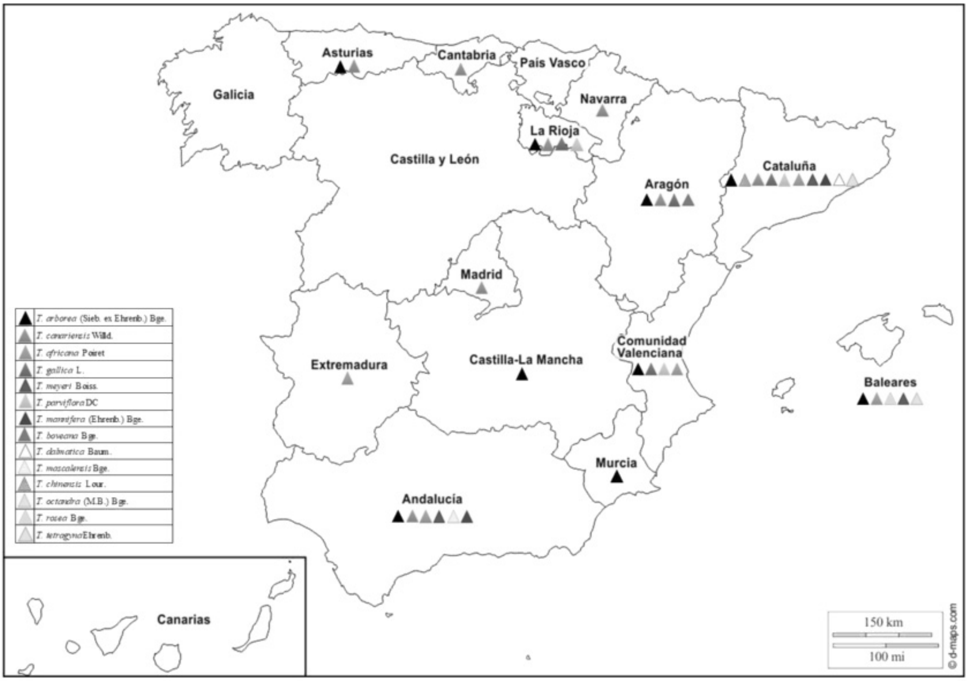

Fig. 1. Up-to-date distribution map of *Tamarix* species in Spain according to the revision of BCN herbarium.

The most investigated Comunidad Autónoma is Catalunya (10 taxa) followed by Andalucía (6 taxa). Four tamarisks species are reported from La Rioja, Aragón, and Islas Baleares. *Tamarix arborea* var. *arborea* and *T. arborea* var. *subvelutina* are widely distributed in Spain.

The revision of BCN Herbarium (ESF 1) permitted also to draw up a new distribution map of *Tamarix* species in Spain (Fig. 1).

The samples BCN 30693 and BCN 58918 are reported in the labels from two different localities of the Comunidad Autónoma of Extremadura, respectively in Sesimbra and Cascais (ESF 1: Table 2). However, these two localities, belongs to Portugal. For this reason, *T. arborea* var. *arborea* is not reported in the new distribution map for the Comunidad Extremadura (Fig. 1).

Five herbarium labels contains wrong data on the Comunidades Autónomas, or the localities or do not report any indication of Comunidades Autónomas (ESF 1: Table 3).

The results of this study could be an incentive for botanists to expand the floristic exploration of the genus *Tamarix* in Spain. Similarly to what have been already noted in other territories (Gargano 2018) the introduction of some species from south-eastern countries as ornamental or to redevelop coastal environments stimulate in most cases their diffusion in nature that does not exclude the possibility of finding new species for the Spanish flora.

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Is the traditional use of “salep” in the Bulgarian Rhodopes hazardous for the wild populations of terrestrial orchids?

Abstract

Mincheva, I., Petrova, A., Yordanova, M. & Kozuharova, E.: Is the traditional use of “salep” in the Bulgarian Rhodopes hazardous for the wild populations of terrestrial orchids? — Fl. Medit. 28: 399-418. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

In Bulgaria and the eastern Mediterranean, dried tubers of terrestrial orchids are known as “salep”, which also refers to ground tuber powder and the beverage made from this powder. Collection of “salep” from wild populations was shown to be hazardous factor for the native populations. In this preliminary study we investigate how popular “salep” is in the Bulgarian Rhodopes and to what extent it is collected and utilized. Distribution maps were constructed based on personal data, data from Herbaria, and publications from the Bulgarian part of the Rhodopes. During 2014 and 2015 we performed semi-structured interviews in different locations in the Rhodopes in order to evaluate the popularity, use and collection of “salep”. The initial data obtained from the interviews indicate that “salep” is not popular amongst the local people in the Rhodopes and especially Central Rhodopes. Most informants responded that “they have never heard of “salep”. Some informants responded that they know the name but details about use are blurring. For the moment the local human activity does not threaten the wild orchid populations, but permanent monitoring in necessary.

Key words: *Orchidaceae*, Rhodopes Mts, conservation, distribution, Bulgaria.

Introduction

The common name of genus *Orchis* in Bulgaria is “salep” (Stojanov 1964). In Bulgaria and the eastern Mediterranean, dried tubers of terrestrial orchids are known as “salep”, which also refers to ground tuber powder and the beverage made from this powder (Kasparek & Grimm 1999; Kreziou & al 2016). In Turkey, “salep” is used in ice-cream production (dundurma), confectionery and beverages. Turkish “salep” is produced from wild orchids. The “bulbs” are collected by villagers when the plants are in flower and it is easy to locate them. The whole plant is dug out together with its tubers. The wrinkled brown mother tubers, source of the blooming orchid is thrown away. The swollen daughter tuber grown to produce new tubers is boiled in order to prevent the sprouting and processed for “salep” production (Kasparek & Grimm 1999). “Salep” is derived from at least 30 species from the genera *Aceras, Anacamptis*, *Barlia*, *Dactylorhiza,* *Himantoglossum*, *Ophrys, Orchis,* and *Serapias* (Kasparek & Grimm 1999; Sezik 2002; Ertug 2004; Tamer & al. 2006; Ghorbani 2014a, 2014b). By the year 1999 it is estimated that about 10-20 million orchid tubers are collected annually in Turkey which is a signal for threatening of the wild populations (Kasparek & Grimm 1999). The amount of annual export in eighteenth century was evaluated to 6.5 tons (Ari & al. 2005). Most of the species exported before are now within endangered plant classes. Even though the CITES forbids or restricts international commercial trade of wild orchids and despite all the laws that have been put into effect, the pulling of these wild "salep"orchids has been continued since 1974 for interior trade. "Salep" orchids, *Orchis* sp. div. are amongst the merchandised medical and aromatic herbs used in Turkey. The legislation regulations are not enough effective for protection (Tecimen & al. 2010; Akbulut Bayramoglu 2013; de Boer & al. 2017; Molnár & al. 2017). Even though "salep" is not commonly consumed in Iran, the current orchid collection boom in that country is driven by international demand, particularly from Turkey, Pakistan and India, and the resultant high prices. This is a hazardous factor for the native populations (Ghorbani 2014a, 2014b; de Boer & al. 2017). This is a signal that monitoring of the harvesting and trade should be performed even in countries where wild orchids are not traditionally harvested as "salep" and used in traditional medicine and for food. After the tubers and rhizomes are collected it is impossible to identify the species and therefore various molecular techniques have gained widespread use as an important tool associated with the preservation and identification of endangered plant resources (Ari & al. 2005; Ghorbani 2014).

Traditional use of "salep" and harvesting from the wild populations in the mountains of Greece and Albania is a hazard for the native populations of some orchids. Selected species in the genera *Anacamptis, Dactylorhiza* and *Orchis* were found to be used for the production of *"salep"* in Greece at present time (Kreziou & al. 2016).

In Bulgaria, salep used to be collected historically (Stojanov & Kitanov 1960). The collecting steadily had declined during the last decades of the past century (Mitrev & al. 1978; Hardalova & al. 1994). The collecting, buying up and trade of "salep" were forbidden at 1995. In the area of the study, Vassileva (Vassileva & Vichotsevskyi 1974; Vassileva pers. commun, 1998) registered extreme decline of a population of rare *Orchis provincialis* near Chakalarovo village in Eastern Rhodopes due to collecting for salep from a single herbalist. Nowadays, according to the Medicinal Plant Act (2000) in Bulgaria 19 species of the family that are considered medicinal but their collecting is forbidden. The taxa under protection of the Biological Diversity Act (2000, 2007) are 30. In this preliminary study we investigate how popular "salep" is in the Bulgarian Rhodopes and to what extent it is collected and utilized.

Material and methods

Distribution of some orchids in the Rhodopes

Potentially all species from the genera *Anacamptis, Dactylorhiza, Gymnadenia, Himantoglossum, Neotinea, Ophrys, Orchis, Platanthera, Serapias* could be used for *"salep"*, even though many of these taxa make small populations with sporadically occurring individuals, which is not convenient for mass collection. We focused on some orchids of potential importance for production of “salep” namely the genera *Anacamptis* *Dactylorhiza*, *Neotinea* and *Orchis*. We chose these genera because they were found to be used for the production of “*salep” in* North Greece at present time – nearest area to the Rhodopes by Kreziou and co authors (Kreziou & al. 2016). From these genera we selected 24 taxa for this investigation because they are distributed in the Rhodopes (Table 1, nomenclature mainly after Euro+Med (2006-2017). Despite our concerns about the taxonomical problems in the group *Dactylorhiza cordigeta, D. baumanniana* and *D. pindica* we included the first two in this research and built distribution maps considering the fact that they occur in the studied area and might be used as is in Greece.

The distribution maps were constructed based on personal observations of the authors in the Bulgarian part of the Rhodopes; data from the Personal Database on the distribution of *Orchidaceae* species in Bulgaria of Petrova, A., Venkova, D. & Gerasimova, I. (containing personal data as well as data from Bulgarian Herbaria SO, SOM SOA and 6 internationally not registered herbaria of regional Natural history museums), and publications focused on orchids in Rhodopes Mts (Gerasimova & al. 1998; Petrova & al. 2001; Gerasimova & al. 2003, Petrova 2004; Trifonov 2005; Petrova & Assyov 2008).

The conservation status of the species is based on Bulgarian legislation acts and Red List of Bulgarian Vascular Plants (Petrova & Vladimirov 2009).

Ethnobotany data collection

Study sites. The present study is part of a larger ethnobotanical survey carried out in different localities of Rhodopes Mountains during June 2014 and September 2015. We selected study sites in 30 villages both in Central and East Rhodopes (Fig. 1).

Ethnobotanical evaluation. Semi-structured interviews were held among 76 persons (42 women and 34 men, at average age of 60, range 30-80) in different locations in the Central Rhodopes and 105 persons (59 women and 46 men, at average age of 60, range 30-80) persons from the East Rhodopes. Informants were asked: 1) do they know what is salep” and what is it used for; 2) do they use/collect themselves “salep”; 3) do they know someone else to use and collect “salep” for home use; 4) are they aware for orchids trade connected with *“*salep*”* production.

Data analysis. Ethnobotanical data were analyzed and summarized by using Microsoft excel and statistics to determine relative frequencies of citations. Data from the audio records of the interviews were transformed in Microsoft excel tables. Descriptive statistics was used to analyze the data obtained.

Result and discussion

Distribution of some orchids in the Rhodopes

More than 85 % of the orchid species recorded for Bulgarian flora are presented in the Rhodopes (Assyov & al. 2012; Yordanova 2016). The list of the selected species of the genera *Anacamptis, Dactylorhiza, Neotinea* and *Orchis* is presented in Table 1. The known distribution of the studied species is presented on Maps (Electronic Suplementary File 1). It is quite uneven. This is in some degree result of unevenly distributed botanical studies and those of the orchids over the area. Rich of taxa regions are those with lime-

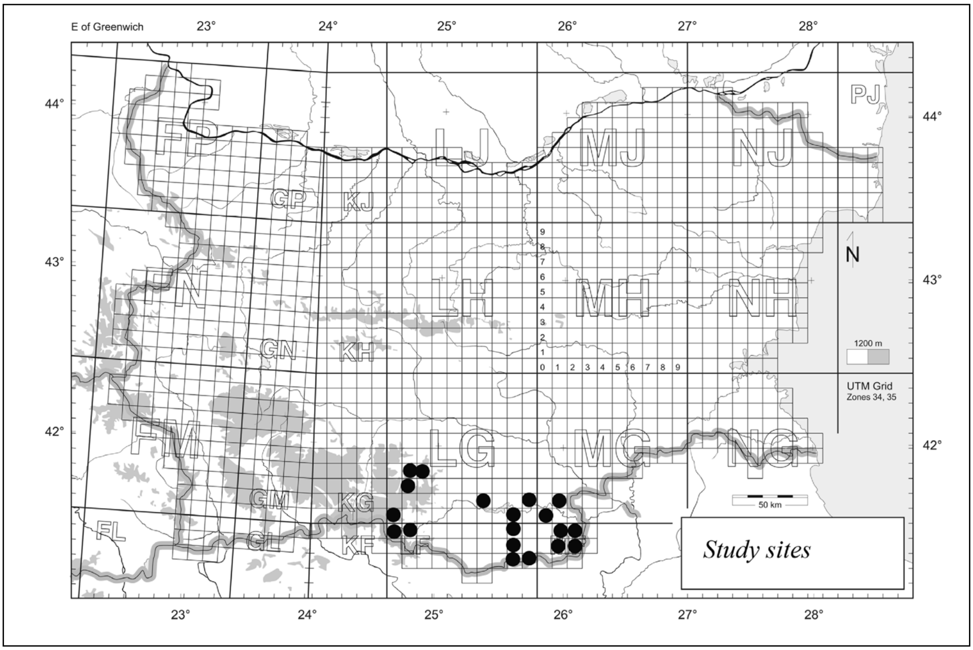

Fig. 1. Study sites in the Bulgarian Rhodopes Mountains.

stone terrain: Smolyan-Trigrad area and Dobrostan massiv south of Assenovgrad in the Central Rhodopes and Ivailovgrad area in the Eastern Rhodopes. Despite the fact that the mountains are characterized by high orchid species richness, our observations are that populations of most of the taxa are not numerous, and often in localities are presented by sporadic individuals. Species with numerous populations are mostly those of genus *Anacamptis*: *A. laxiflora*, *A. morio*, *A. papilionaceae*, *A. pyramidalis* as well as *Dactylorhiza cordigera*, and *D. sambucina*. Extremely rare with single populations are *Dactylorhiza kalopissii* and *Orchis spitzelii*.

Repeated observations during the last 2 decades showed considerable changes of the local distribution and the state of many populations. Factors with a negative impact are: abandonment of former meadows and pastures and their overgrowing with shrubs, especially in remote areas; destroying of wet and mesic grasslands because of resort’ development in Pamporovo, Chepelare, Tsigov Chark and other areas; building of mini water power station - *Orchis militaris* and *Orchis spitzelii* were not reconfirmed in the area of Trigrad-Chairite (KG81) after such construction works.

Ethnobotany data collection

Many informants responded that they have never heard of “salep” especially in Central Rhodopes Mts. (Table 2). In the Central Rhodopes Mts. the informants who responded that they know the name, mainly new the application as a beverage (80.9%). There were several reports for “salep” as medicinal plant, but the informants

Table 1. Orchids that might be used for „salep" production which we selected as object of this investigation distributed in the Rhodopes Mts.

Taxon	Orchids recognized as medicinal plants Medicinal Plants Act 2000	Orchids protected by Biological Diversity Act 2002, 2007	CITES	Orchids listed in the Bulgarian Red Data List
Anacamptis coriophora (L.) R. M. Bateman, Pridgeon & M. W. Chase	+	+	+	
Anacamptis laxiflora (Lam) M. Bateman, Pridgeon & M. W. Chase	+	+	+	VU
Anacamptis morio (L.) R.M. Bateman, Pridgeon & M.W.Chase.	+		+	
Anacamptis palustris subsp. *elegans* (Heuff.) R. M. Bateman, Pridgeon & M. W. Chase			+	
Anacamptis papilionacea (L.) R. M. Bateman, Pridgeon & M. W. Chase	+	+	+	VU
Anacamptis pyramidalis (L.) Rich.			+	VU
Neotinea tridentata (Scop.) R.M. Bateman, Pridgeon & M.W. Chase.	+		+	
Neotinea ustulata (L.) R.M.Bateman, Pridgeon & M.W.Chase.	+		+	VU
Orchis pallens L.	+		+	
Orchis mascula (L.) L. subsp. *mascula* s. l.	+		+	
Orchis mascula subsp. *speciosa* (Mutel) Hegi			+	
Orchis militaris L.	+	+	+	EN
Orchis provincialis Lam. & DC.	+	+	+	CR
Orchis purpurea Huds.	+		+	
Orchis simia Lam.	+		+	
Orchis spitzelii W. D. J. Koch	+	+	+	CR
Dactylorhiza baumanniana J. Hölzinger & Künkele			+	
Dactylorhiza cordigera (Fr.) Soó			+	
Dactylorhiza incarnata (L.) Soó,		+	+	EN
Dactylorhiza romana (Sebast.) Soó			+	VU
Dactylorhiza kalopissii E.Nelson		+	+	CR
Dactylorhiza saccifera (Brongn.) Soó			+	
Dactylorhiza sambucina (L.) Soó,			+	
Himantoglossum jankae Somlyay, Kreutz & Óvári	+	+	+	VU

(14.3%) did not know particular application. Only one of all reports (4.8%) was for application against kidney problems. In the East Rhodopes Mts. the informants who responded that they know the name, knew the application as a beverage (100%). Persons who knew about its use got the information years ago from herb collectors or grandparents. The "salep popularity" is higher in East Rhodopes compared to the

Table 2. Informant reports.

	Central Rhodopes Mts. Percent of reports	East Rhodopes Mts. Percent of reports
Do not know what is „salep”	73.7%	24.8%
Know what is „salep”	26.3%	75.2%
Collect tubers for home use	1.3%	1.0%
Collect tubers of orchids to sell it	0%	0%
Know someone buys tubers of orchids but the informant do not collect personally	1.3%	0%

Central Rhodopes (Table 2) but yet nowadays it is practically not used and collected. One of our informants reported that in the area of Madjarovo (East Rhodopes) no human destruction is detected. He observes the populations of orchids every flowering season. He only noted that the goats eat the flowers of *Orchis mascula* s. l. but they never touch the flowers of *Anacamptis pyramidalis*. Additionally he reported that “salep” used to be a traditional drink in the village of Mandrica (inhabited by ethnic Albanians) and it was sold by special persons. Nowadays even though the traditions in the village in other human activities are still alive no one collects and uses “salep”.

One informant reported collection for trade purpose with market outside of Bulgaria from some company located in town of Yambol, which is outside of the territory of studied area. Collection for trading purpose of all *Orchis* species in Bulgaria is forbidden for more than a decade according to the Medicinal plant act Promulgated, State Gazette No. 29/7.04.2000. The fact that despite the restrictions of low some illegal trade is mentioned indicates that the problem is of potential of importance and should not be neglected.

Conclusions

The initial data obtained from the interviews indicate that “salep” is not popular amongst the local people in the Rhodopes and especially in the Central Rhodopes. For the moment the local human activity does not threaten the wild orchid populations by collecting “salep”. However monitoring is necessary in order to detect increased collection activity on time in order to prevent damages, because the populations of the orchids in the Rhodopes are usually consisted of small numbers of individuals and therefore are vulnerable.

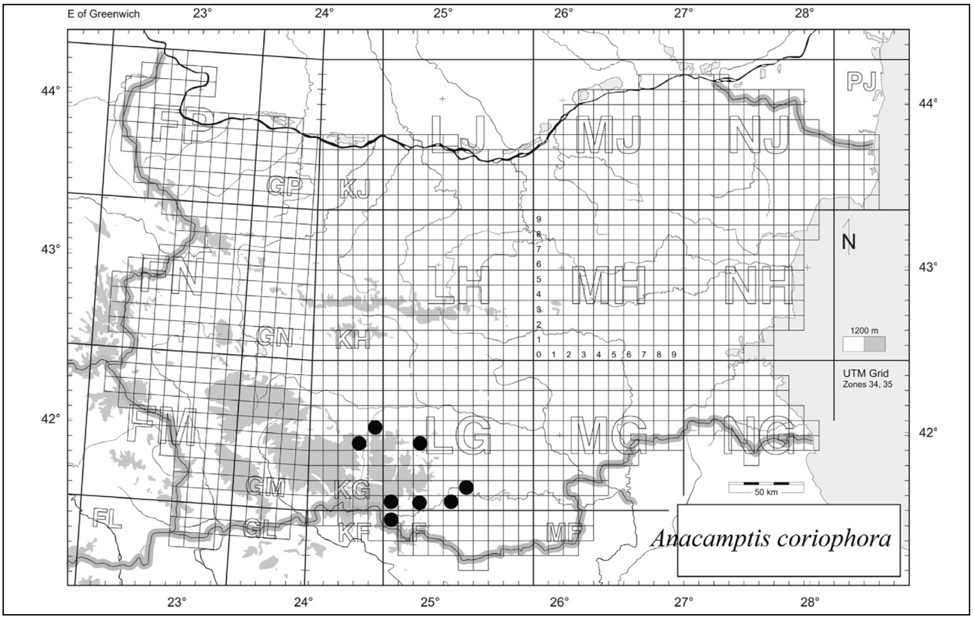

Fig. 2. Distribution of *Anacamptis coriophora* (L.) R.M. Bateman, Pridgeon & M.W. Chase (= *Orchis coriophora* L.).

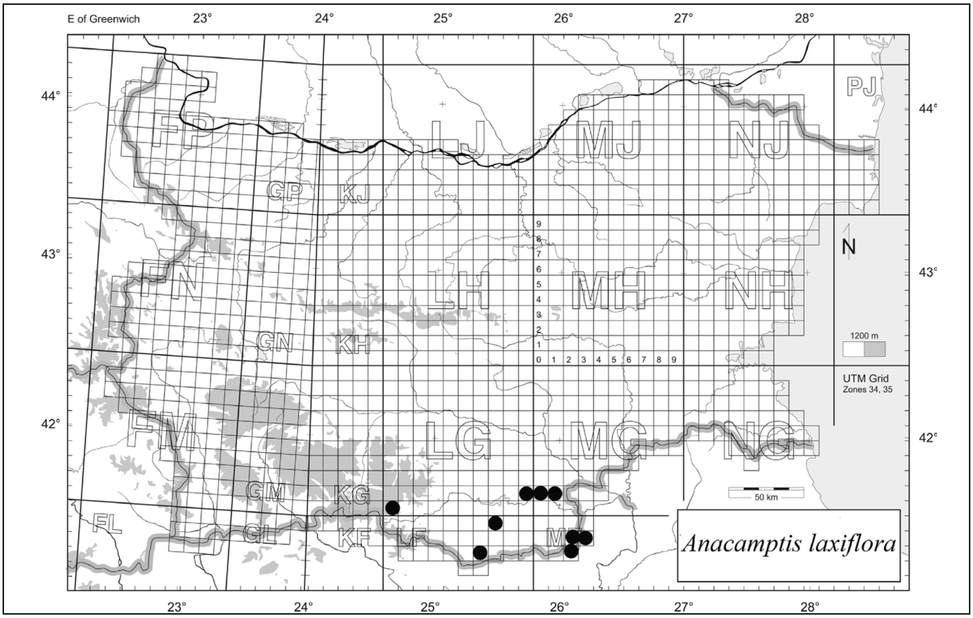

Fig. 3. Distribution of *Anacamptis laxiflora* (Lam) M. Bateman, Pridgeon & M.W. Chase (= *Orchis laxiflora* C. A. Mey.).

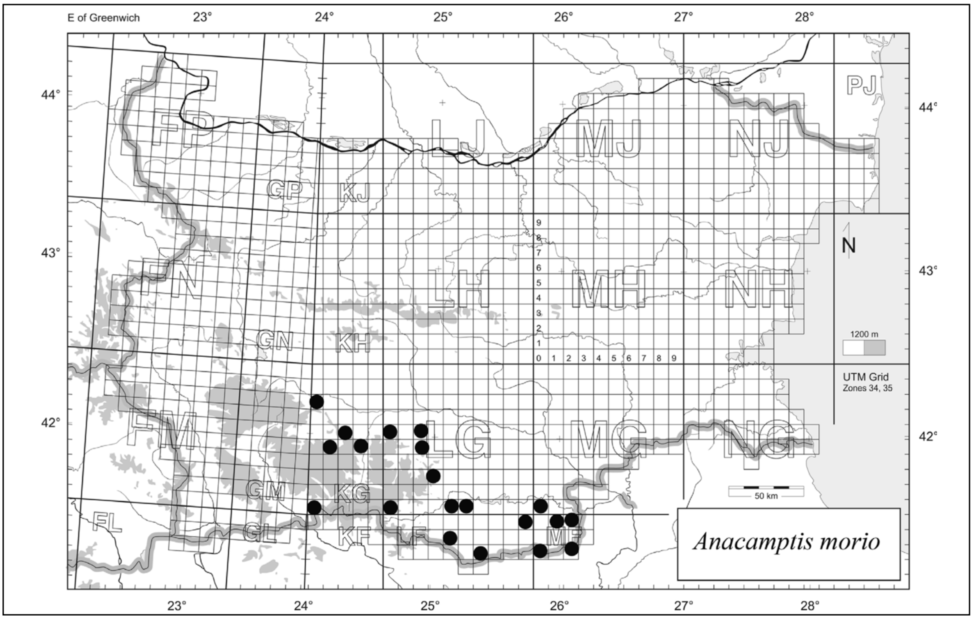

Fig. 4. Distribution of *Anacamptis morio* (L.) R.M. Bateman, Pridgeon & M.W. Chase. (= *Orchis morio* L.).

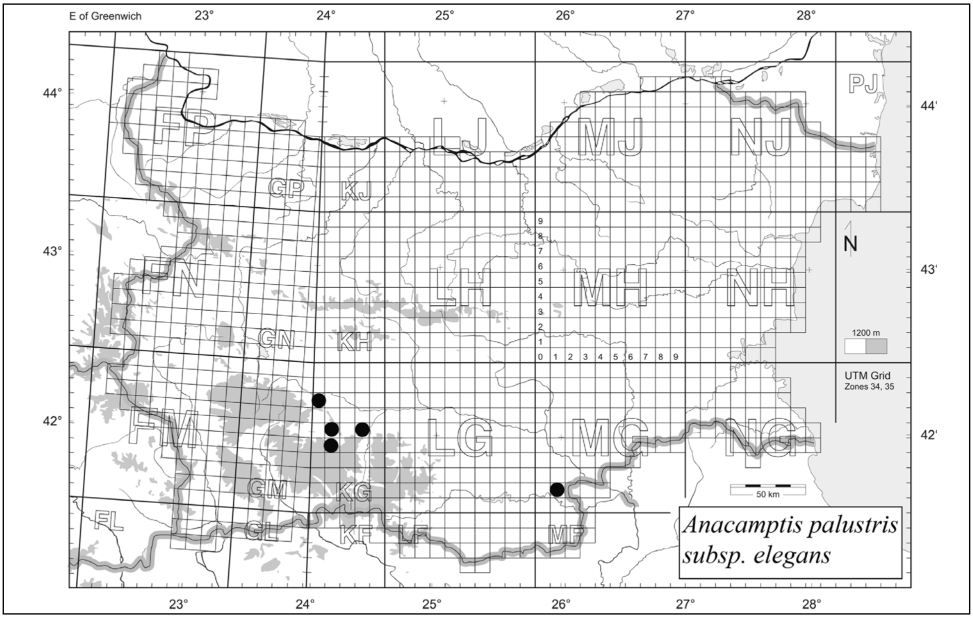

Fig. 5. Distribution of *Anacamptis palustris* subsp. *elegans* (Heuff.) R.M. Bateman, Pridgeon & M. W. Chase (= *Orchis elegans* Heuff.).

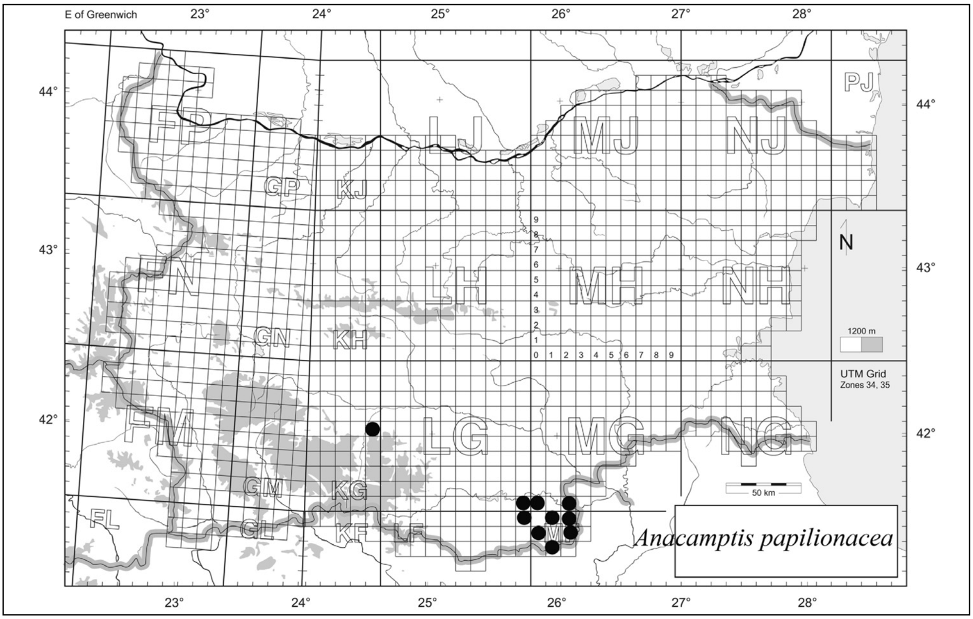

Fig. 6. Distribution of *Anacamptis papilionacea* (L.) R.M. Bateman, Pridgeon & M.W. Chase (= *Orchis papilionacea* L.).

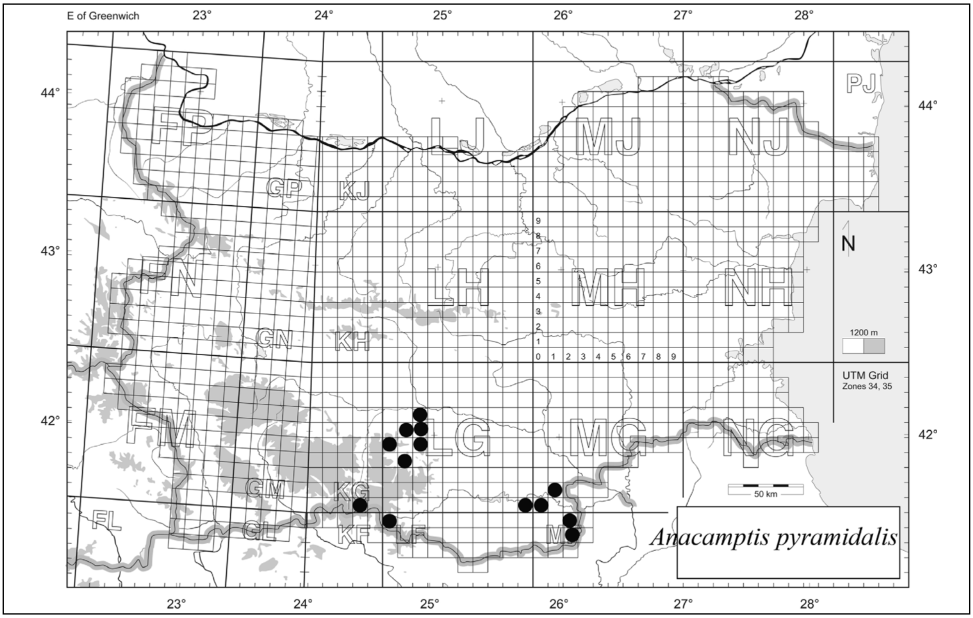

Fig. 7. Distribution of *Anacamptis pyramidalis* (L.) Rich.

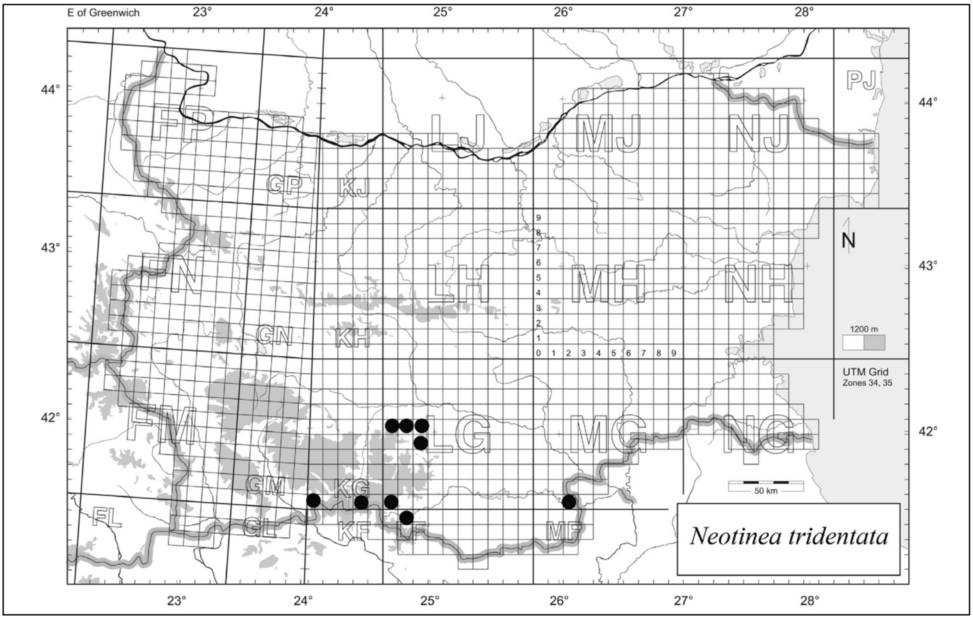

Fig. 8. Distribution of *Neotinea tridentata* (Scop.) R.M. Bateman, Pridgeon & M.W. Chase. (= *Orchis tridentata* Scop.).

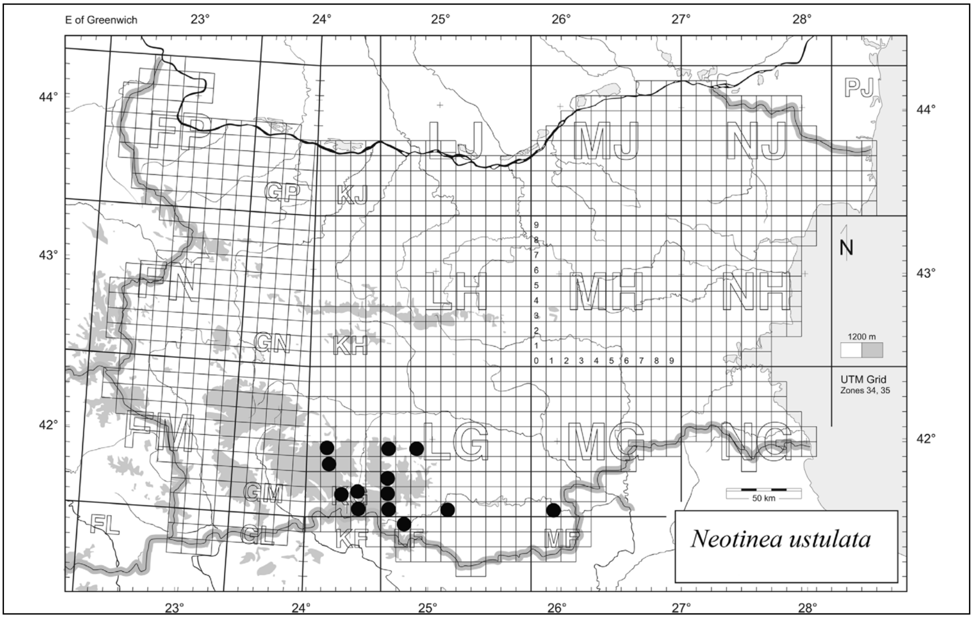

Fig. 9. Distribution of *Neotinea ustulata* (L.) R.M. Bateman, Pridgeon & M.W. Chase. (= *Orchis ustulata* L.).

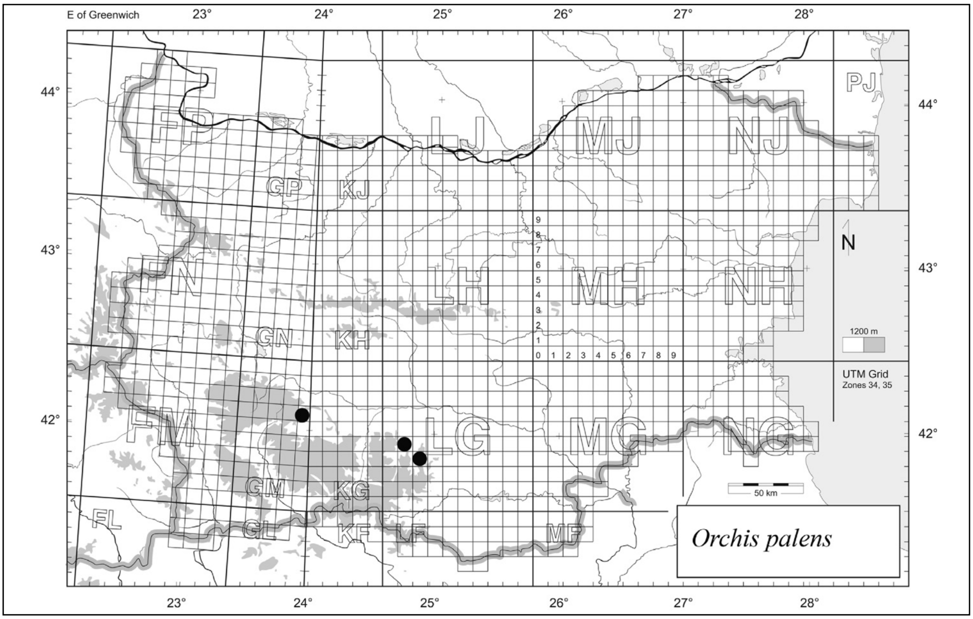

Fig. 10. Distribution of *Orchis pallens* L.

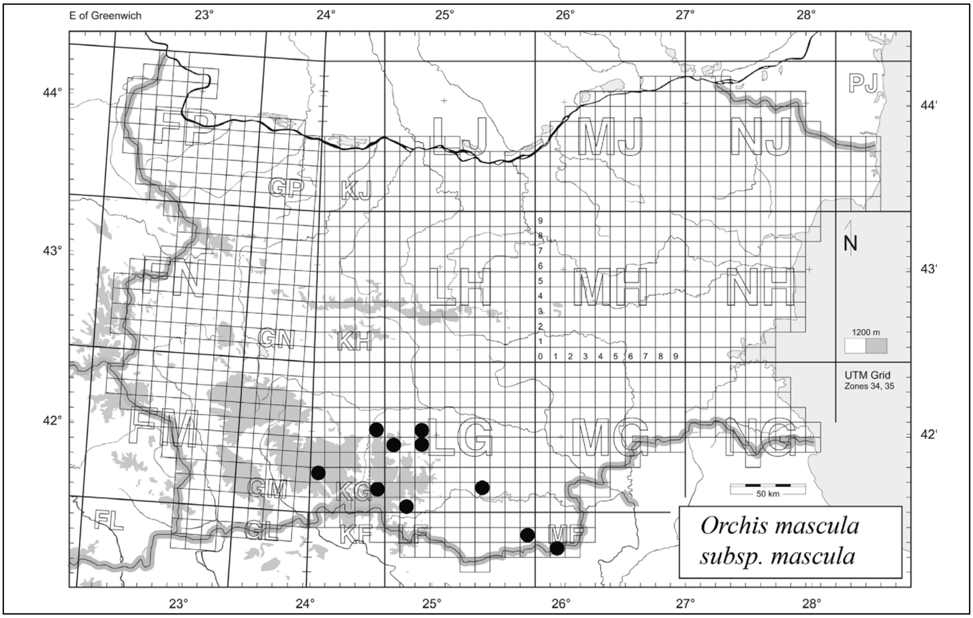

Fig. 11. Distribution of *Orchis mascula* (L.) L. subsp. *mascula* s. l. (= *Orchis pinetorum* Boiss. & Kotschy).

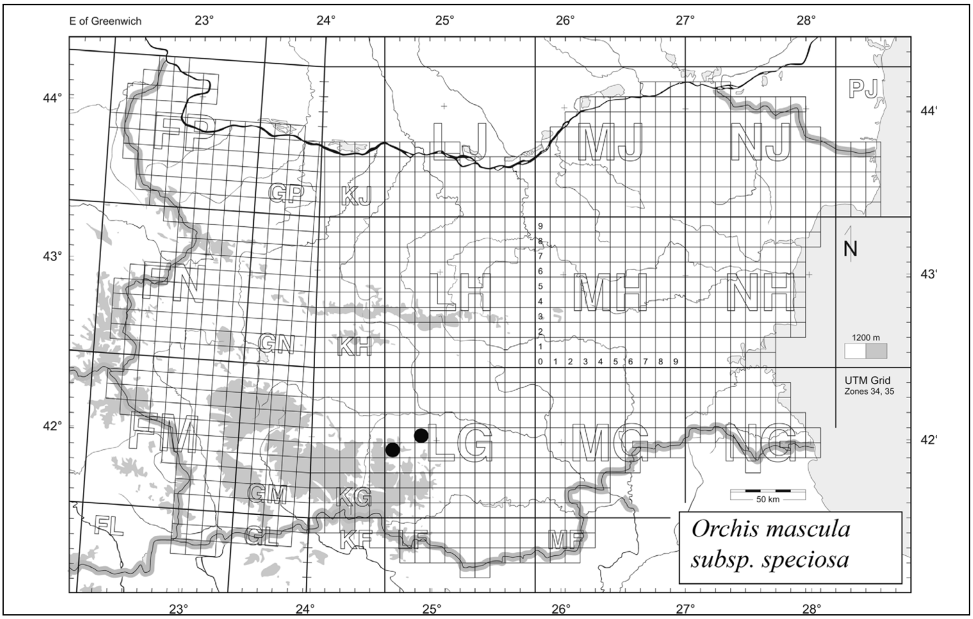

Fig. 12. Distribution of *Orchis mascula* subsp. *speciosa* (Mutel) Hegi (= *O. ovalis* F.W. Schmidt).

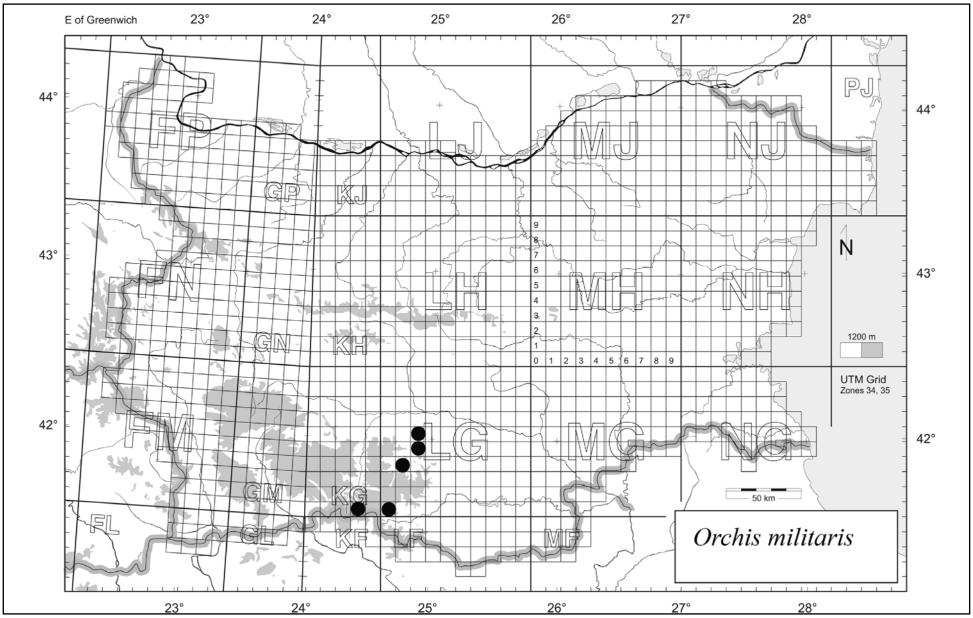

Fig. 13. Distribution of *Orchis militaris* L.

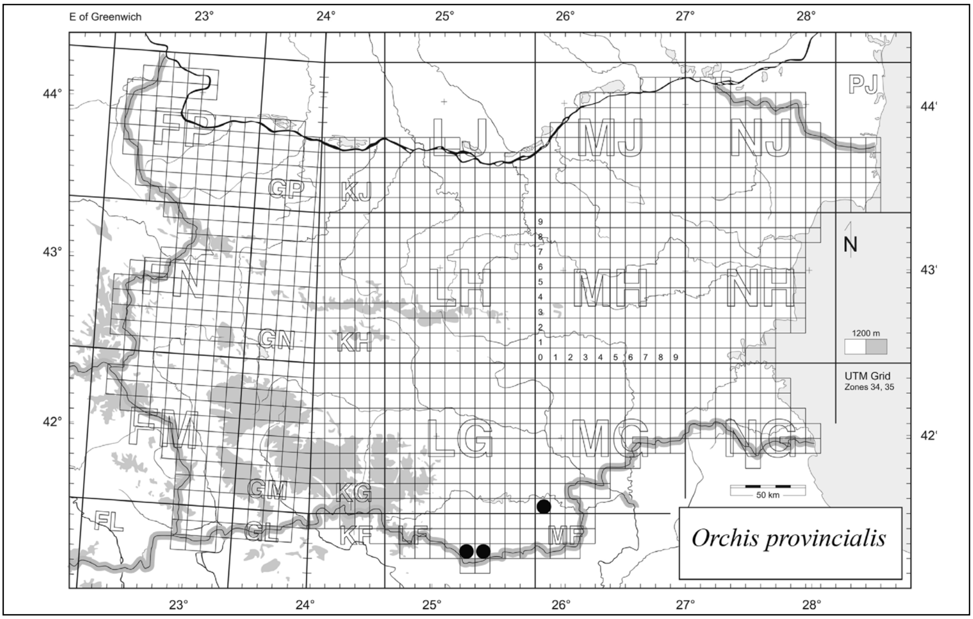

Fig. 14. Distribution of *Orchis provincialis* Lam. & DC.

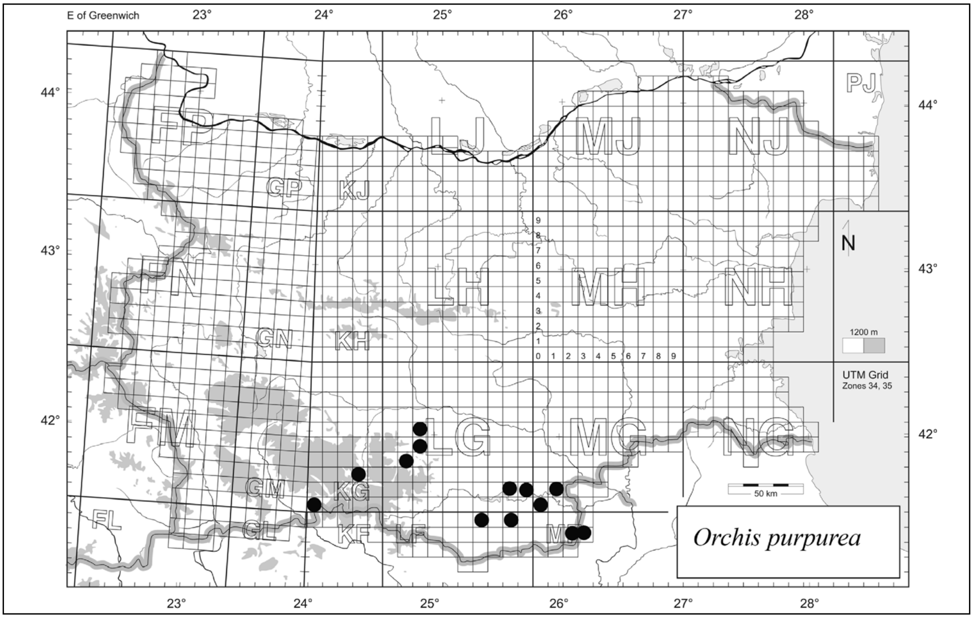

Fig. 15. Distribution of *Orchis purpurea* Huds.

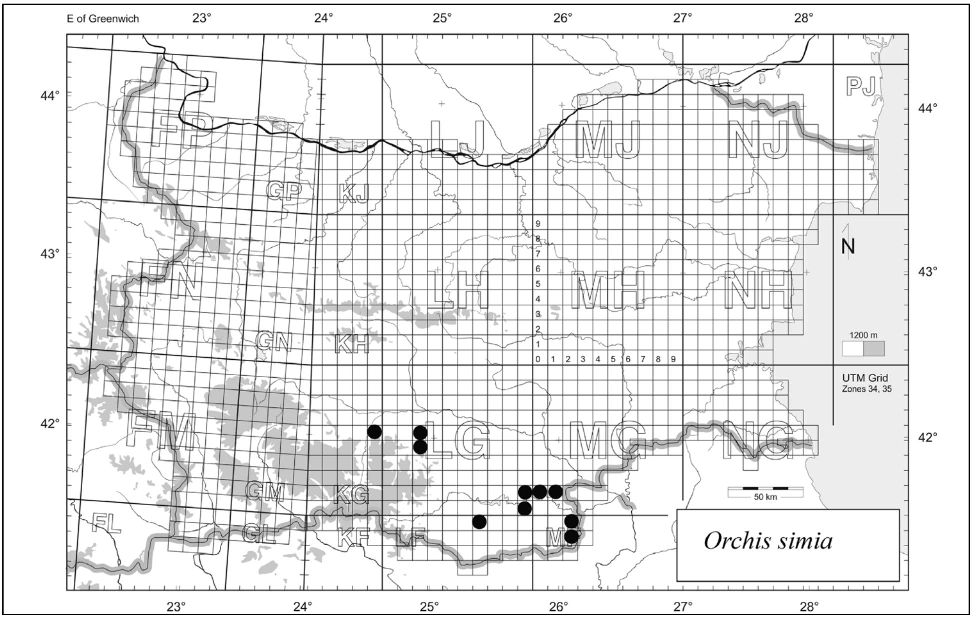

Fig. 16. Distribution of *Orchis simia* Lam.

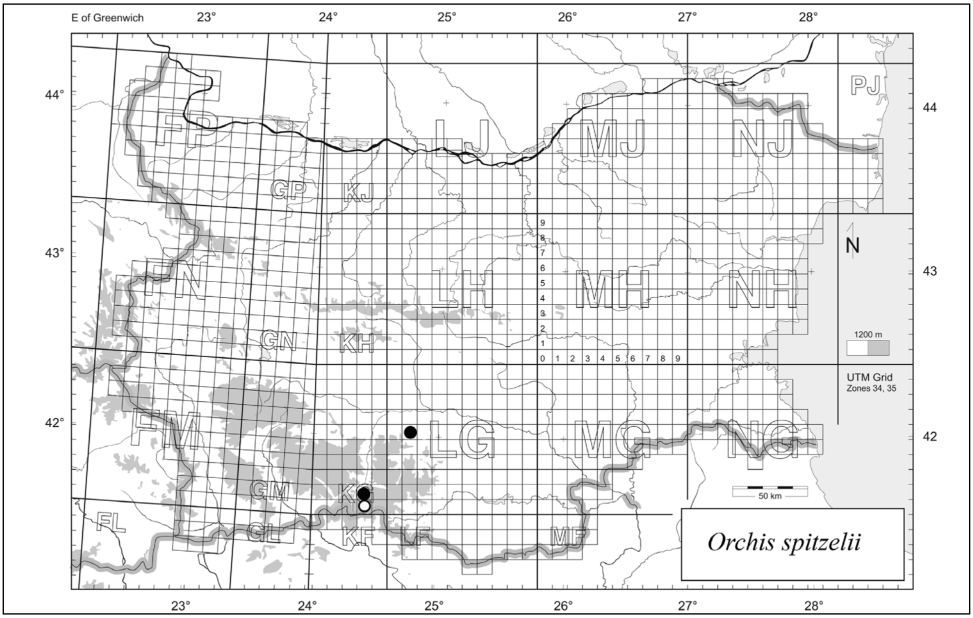

Fig. 17. Distribution of *Orchis spitzelii* W.D.J. Koch. Note: ○ – population possibly destroyed by development activity.

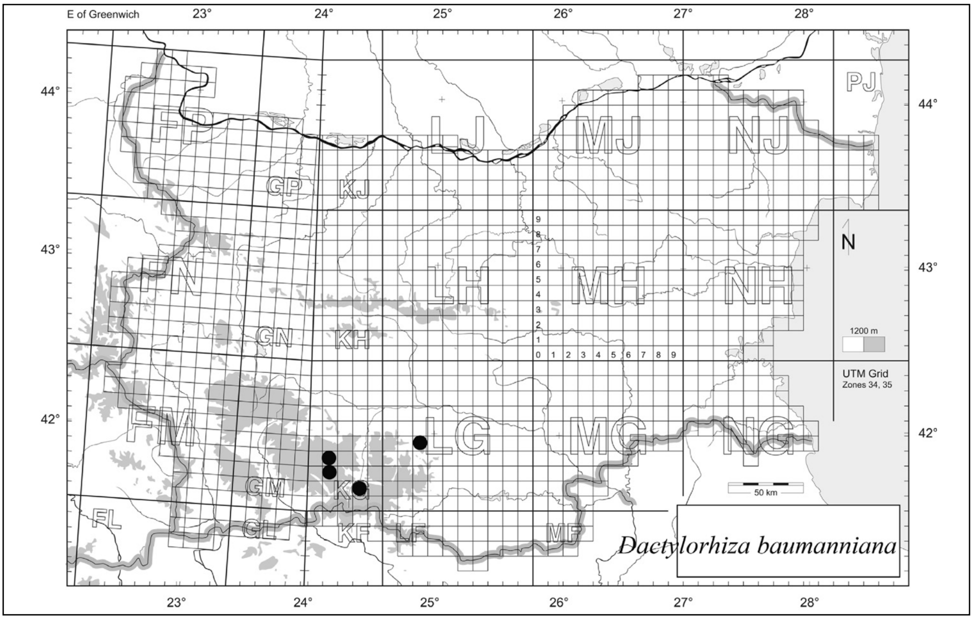

Fig. 18. Distribution of *Dactylorhiza baumanniana* J. Hölzinger & Künkele.

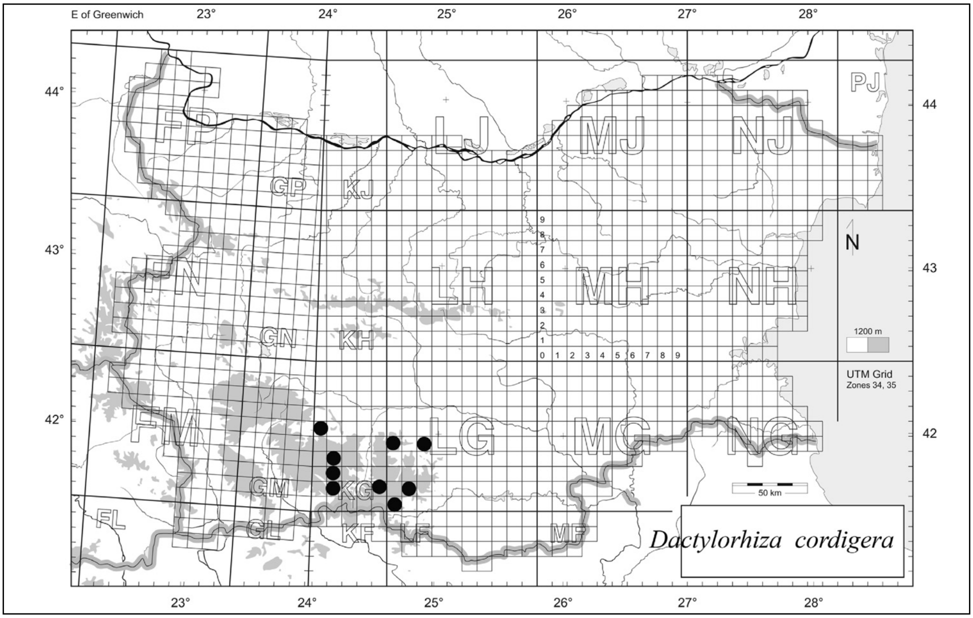

Fig. 19. Distribution of *Dactylorhiza cordigera* (Fr.) Soó.

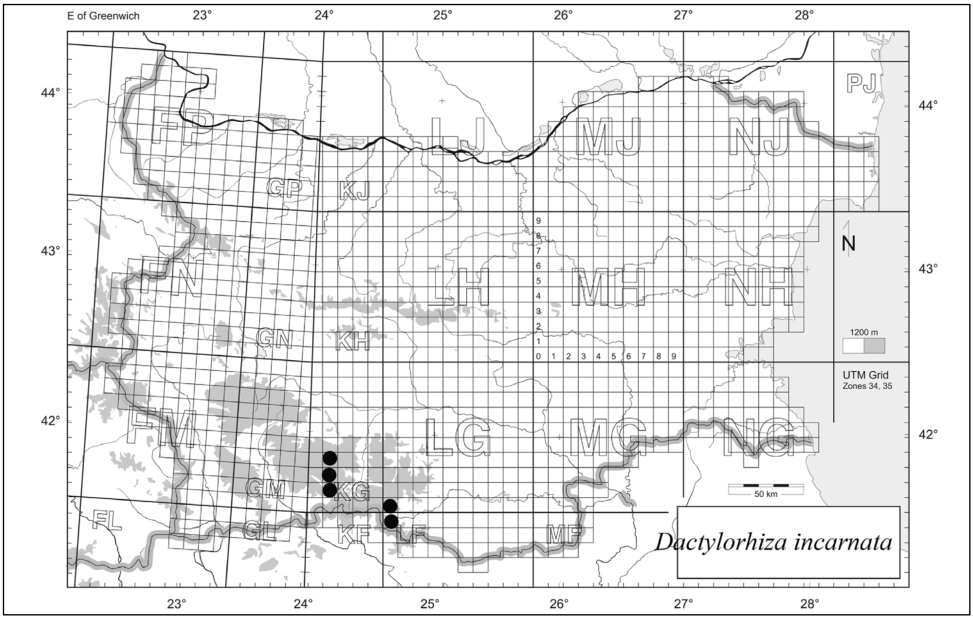

Fig. 20. Distribution of *Dactylorhiza incarnata* (L.) Soó.

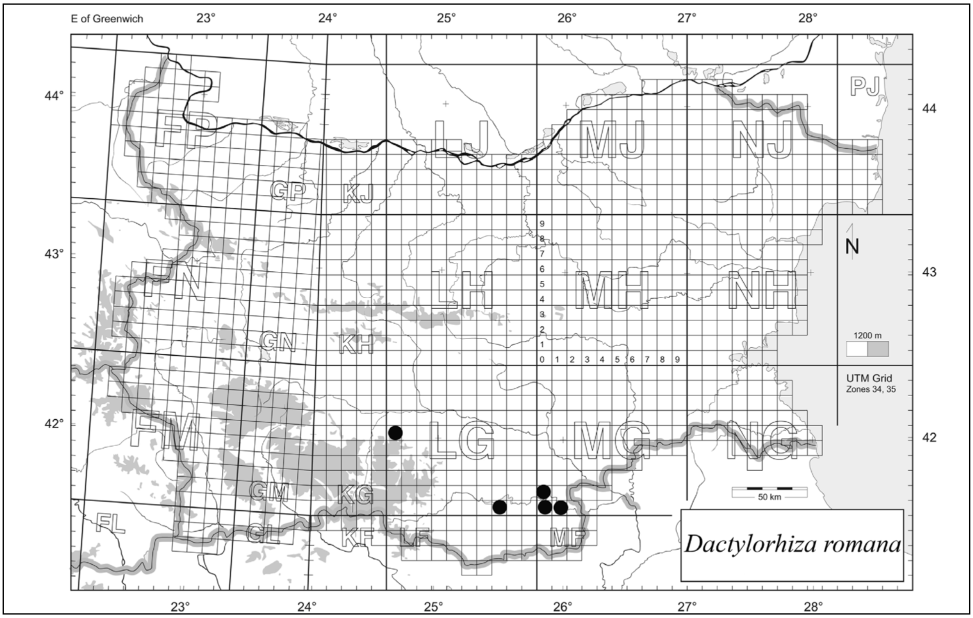

Fig. 21. Distribution of *Dactylorhiza romana* (Sebast.) Soó.

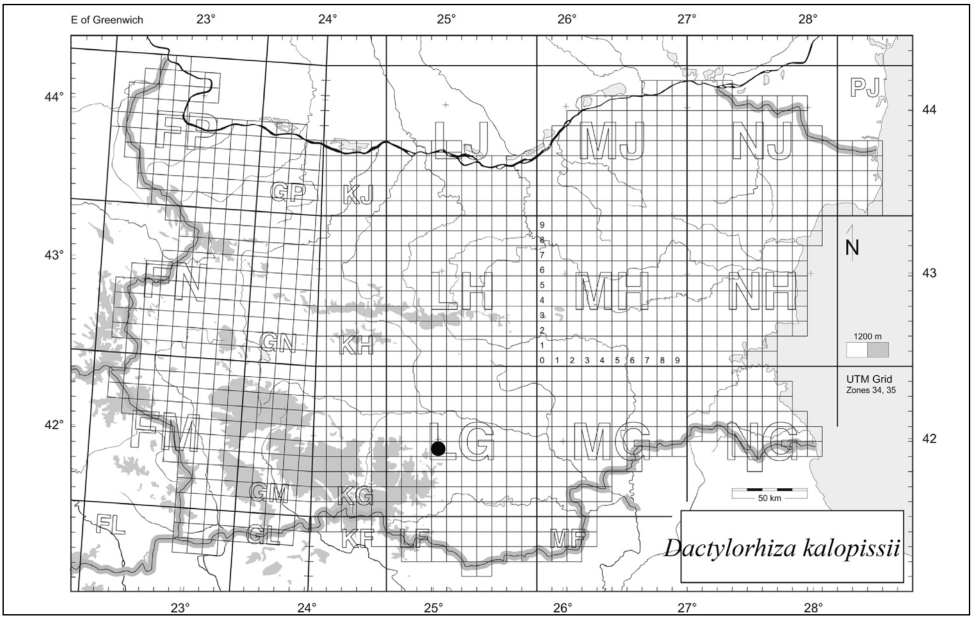

Fig. 22. Distribution of *Dactylorhiza kalopissii* E. Nelson.

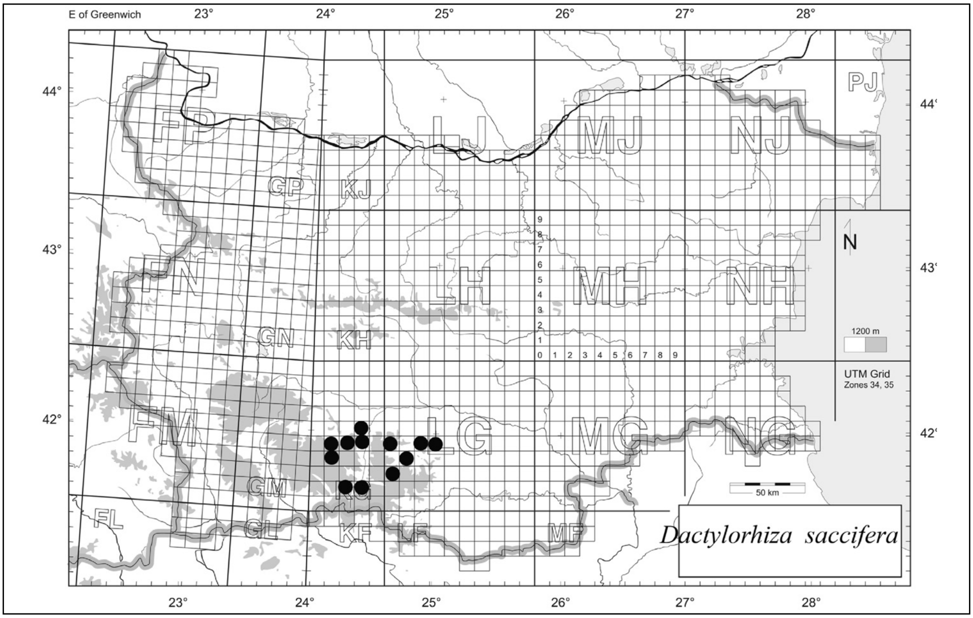

Fig. 23. Distribution of *Dactylorhiza saccifera* (Brongn.) Soó.

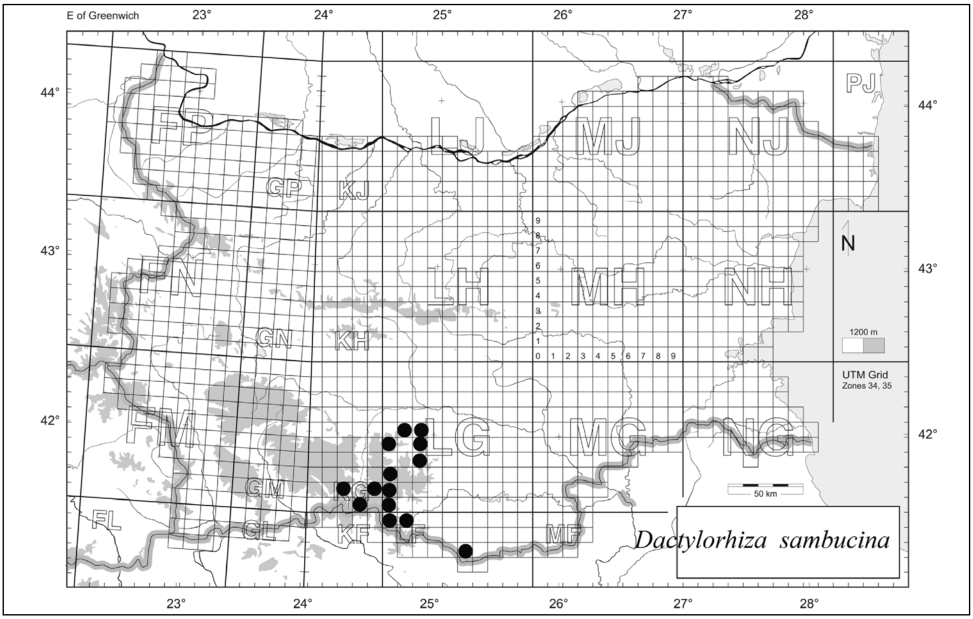

Fig. 24. Distribution of *Dactylorhiza sambucina* (L.) Soó.

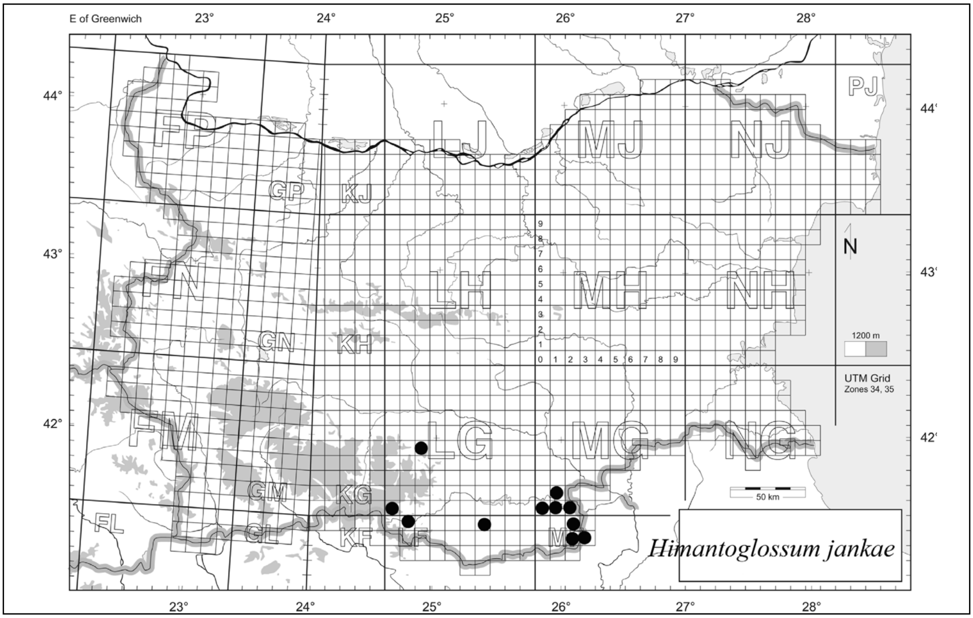

Fig. 25. Distribution of *Himantoglossum jankae* Somlyay, Kreutz & Óvári (= *H. caprinum* auct. pl., non (M. Bieb.) Spreng.).

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Mediterranean plant karyological data – 28

edited by G. Kamari, C. Blanché & S. Siljak-Yakovlev

Abstract

Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds): Mediterranean plant karyological data – 28. — Fl. Medit. 28: 419-445. 2018. — ISSN: 1120-4052 printed, 2240-4538 online.

This is the twenty-eight of a series of karyological data from Mediterranean area, peri-Alpine communities and the Atlantic Islands, in English or French language. It comprises contributions on 27 taxa: *Alnus*, *Erythronium*, *Genista*, *Leucanthemum*, *Melittis*, *Orchis*, *Stachys*, *Scorzonera* from Bosnia-Herzegovina and F.Y.R.O.M. by F. Pustahija, N. Bašić & S. Siljak-Yakovlev (Nos 1935-1942); *Taraxacum* from Turkey by B. Gürdal & N. Özhatay (Nos 1943-1954); *Centaurea*, *Cichorium*, *Glebionis*, *Pallenis*, *Lactuca*, *Phagnalon*, *Silybum* from Morocco by A. Gounssa, K. Hormat, A. El Aboudi, F. Ezzahra, F. El Alaoui Faris & M. Arahou (Nos 1955-1961).

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F. Pustahija, N. Bašić & S. Siljak-Yakovlev

Chromosome numbers and genome size data for some Balkan species

Abstract

Pustahija, F., Bašić, N. & Siljak-Yakovlev, S.: Chromosome numbers and genome size data for some Balkan species. [In Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds), Mediterranean plant karyological data - 28]. – Fl. Medit. 28: 420-428. doi: 10.7320/FlMedit28.420

Chromosome numbers and metaphase plates are given for eight species, seven from Bosnia and Herzegovina (*Alnus* × *pubescens*, *Erythronium dens-canis*, *Genista tinctoria*, *Leucanthemum vulgare*, *Melittis melissophyllum*, *Orchis mascula*, *Stachys recta*), and one species from F.Y.R.O.M. (*Scorzonera austriaca*). Chromosome counts and genome sizes are discussed.

Keywords: karyology, *Alnus*, *Erythronium*, *Genista*, *Leucanthemum*, *Melittis*, *Orchis*, *Stachys*, *Scorzonera*, Bosnia and Herzegovina, F.Y.R.O.M.

1935. ***Alnus* × *pubescens*** Tausch. — 2*n* = 4x =28 & 2*n* = 6x = 42 (Figs 1a & 1b).

BH: Kreševo, schist, 43° 49’ 33,35” N, 18° 02’ 28,19” E, 770 m a.s.l., 10 Nov 2007, private herbarium of N.B.

Alnus × *pubescens* Tausch. is a deciduous tree from *Betulaceae* family, considered as hybrid between black [*Alnus glutinosa* (L.) Gaertn] and grey alder [*A. incana* (L.) Moench]. According to relevant literature this taxon is registered in Belarus, Bosnia and Herzegovina, Croatia, the Czech Republic, Ireland, Latvia, Poland, Serbia and Sweden.

The tetraploid chromosome number 2*n* = 28 is reported by Siljak-Yakovlev & al. (2010), and octoploid 2*n* = 56 by Helms & Jørgensen (1925). The hexaploid chromosome number 2*n* = 42 is given here for the first time. We confirm, also, a tetraploid 2*n* = 28 chromosome number in the same population. Genome size of tetraploids is 2C = 1.05pg (Siljak-Yakovlev & al. 2010).

1936. ***Erythronium dens-canis*** L. — 2*n* = 2x = 24 (Fig. 1c).

BH: Matinski Vis, Maglaj, serpentine, 44° 28’ 16,67” N, 17° 58’ 23,01” E, 925 m a.s.l., 10 Apr 2008, private herbarium of F.P.

Erythronium dens-canis L. is a bulbous herbaceous perennial flowering plant (*Liliaceae*), native to central and southern Europe; the only naturally occurring species of genus in Europe.

The diploid chromosome number 2*n* = 24 confirms previous reports of Hrubý (1934), Delay (1947), Capineri & al. (1978), Sopova & Sekovski (1982), Rosselló & al. (1987), Krichphalushi (1989), and García Martínez (2001), but differs from 2*n* = 4x = 48 (Siljak-Yakovlev & al. 2010). The measured genome sizes are for tetraploids 2C = 49.98 pg (Siljak-Yakovlev & al. 2010), then 2C = 52.91 pg (Vesely & al. 2011) and 2C = 59.80 pg (Zonneveld & al. 2005) for unknown ploidies.

1937. *Genista tinctoria* L. — 2*n* = 4x = 96 (Fig. 1d).

BH: Katranica, MuškeVode, Kladanj, serpentine, 44° 14’ 10,36” N, 18° 34’ 46,62” E, 791 m a.s.l., 29 Sept 2016, private herbarium of F.P.

Genista tinctoria L. is a variable deciduous shrub of the family *Fabaceae*, native to Europe and western Asia, but widely cultivated as a horticultural species.

The tetraploid chromosome number 2*n* = 96 established for one population growing on serpentine substrate is in accordance with previous data on this variable species (Semerenko & Blazhevich 1979; Semerenko & Shvets 1989; Siljak-Yakovlev & al. 2010; Pustahija & al. 2013), but diploids are more frequently determined (Čehov 1931; Tischler 1934; Santos 1945; Garajová 1959; Gadella & Kliphuis 1966; Krusheva 1975; Semerenko & Blazhevich 1979; Pogan & al. 1982; Van Loon & Setten 1982; Gallego Martín & al. 1988; Cubas & al. 1998). Siljak-Yakovlev & al. (2010) and Pustahija & al. (2013) estimated the genome size for tetraploids, 2C = 3.34 pg.

1938. *Leucanthemum vulgare* (Vaill.) Lam. — 2*n* = 8x =72 (Fig. 1e).

BH: Katranica, MuškeVode, Kladanj, serpentine, 44° 14’ 11,57” N, 18° 34’ 15,64” E, 832 m a.s.l., 14 Aug 2008, private herbarium of F.P.

Leucanthemum vulgare (Vaill.) Lam., *Asteraceae*, is a typical grassland perennial flowering plant, native to Europe and the temperate regions of Asia, introduced to North America, Australia and New Zealand.

Different chromosome numbers are given in the literature: 2*n* = 18 (Žukova 1964; Polatschek 1966; Čuksanova & al. 1968; Nagl & Ehrendorfer 1974; Khandjian 1975; Morton 1977; Rostovtseva 1979; Teppner 1980; Strid & Andersson 1985; Lippert & Heubl 1989; Probatova & al. 1989; Vogt 1991; Dempsey & al. 1994; Albers & Pröbsting 1998; Dmitrieva 2000; Probatova 2000; Vogt 2000; Gregor Hand 2009), 2*n* = 18 + 1B (Khandjian 1975), 2*n* = 36 (Žukova 1964; Čuksanova & al. 1968; Morton 1977, 1981; Arohonka 1982; Marchi & al. 1983; D’Ovidio 1984; Dmitrieva 1987; Parfenov & Dmitrieva 1987; Parfenov & Dmitrieva 1988b; Lippert & Heubl 1989; Lavrenko & al. 1991; Lavrenko & al. 1992; Stepanov & Muratova 1995; Lövkvist & Hultgård 1999), 2*n* = 36 + 1B (Parfenov & Dmitrieva 1988a; Dmitrieva 2000), 2*n* = 54 (Parfitt 1981; Lippert & Heubl 1989), 2*n* = 72 (Lippert & Heubl 1989; Siljak-Yakovlev & al. 2010; Pustahija & al. 2013), and 2*n* = 90 (Favarger & Villard 1965) for this aggregate, and our chromosome number determination of $2n = 72$ is in accordance with previous reports for octaploids. Pustahija & al. (2013) estimated genome size for diploids (2C = 10.54 pg); Nagl & Ehrendorfer (1974), Marchi & al. (1983), Band (1983) and Pustahija & al. (2013) for tetraploids (2C = 11.55, 25.35, 21.30 and 20.20 pg, respectively); and Siljak-Yakovlev & al. (2010) for octaploids (2C = 32.69 pg). Bai & al. (2012) estimated 2C = 10.20 and 17.60 pg for unknown ploidy levels.

1939. ***Melittis melissophyllum*** L. — $2n = 2x = 30$ (Fig. 1f).

BH: Katranica, Muške Vode, Kladanj, serpentine, 44° 14’ 11,57” N, 18° 34’ 15,64” E, 832 m a.s.l., 14 Aug 2008, private herbarium of F.P.

Melittis melissophyllum L., *Lamiaceae*, is herbaceous perennial flowering plant in the monospecific genus *Melittis*, native to central and southern Europe.

The diploid chromosome number $2n = 30$ is in accordance with the most available literature data (Bakšay 1958; Pogan 1982; Rosselló & al. 1987; Tasenkevitch & al. 1989; Siljak-Yakovlev & al. 2010). However, the $2n = 24$ was also reported by Strid and Franzen (1981) and $2n = 30 + 1\text{-}2B$ by Dobea & al. (1997). Genome size of diploids was 2C = 0.95 pg (Siljak-Yakovlev & al. 2010).

1940. ***Orchis mascula*** (L.) L. — $2n = 2x = 42$ (Fig. 2g).

BH: Mliništa, Glamoč, limestone, 44° 14’ 08,37” N, 16° 49’ 50,43” E, 1204 m a.s.l., 13 May 2008, private herbarium of F.P.

Orchis mascula (L.) L., *Orchidaceae*, is tuberous perennial herbaceous plant, native to Eurasia and North Africa.

The diploid chromosome number $2n = 42$ is stable for the species and coincides with data obtained by different authors (Hagerup 1938; Heusser 1938; Vermeulen 1949; Skalińska & al. 1957; Gadella & Kliphuis 1963; Kliphuis 1963; Averyanov & al. 1985; D’Emerico & al. 2002; Bernardos 2004). Genome size has not been estimated to date.

1941. ***Scorzonera austriaca*** Willd. — $2n = 2x = 14$ (Fig. 1h).

F.Y.R.O.M.: Pčinja canyon, near Veles, May 2009.

Scorzonera austriaca Willd., highly polymorphic complex, is a perennial plant of *Asteraceae* family, native to the central and south-east Europe and Temperate Asia.

The diploid chromosome number $2n = 14$ counted here agrees with previously reported (Tarnavschi 1938; Sosnovec 1960; Dvorak & Dadakova 1977; Brullo & al. 1978; Strid & Franzen 1983; Kuzmanov & al. 1986; Stepanov 1992; Idei 1996). Estimated genome size for this species was 2C = 10.68 pg (Siljak-Yakovlev & al. 2010).

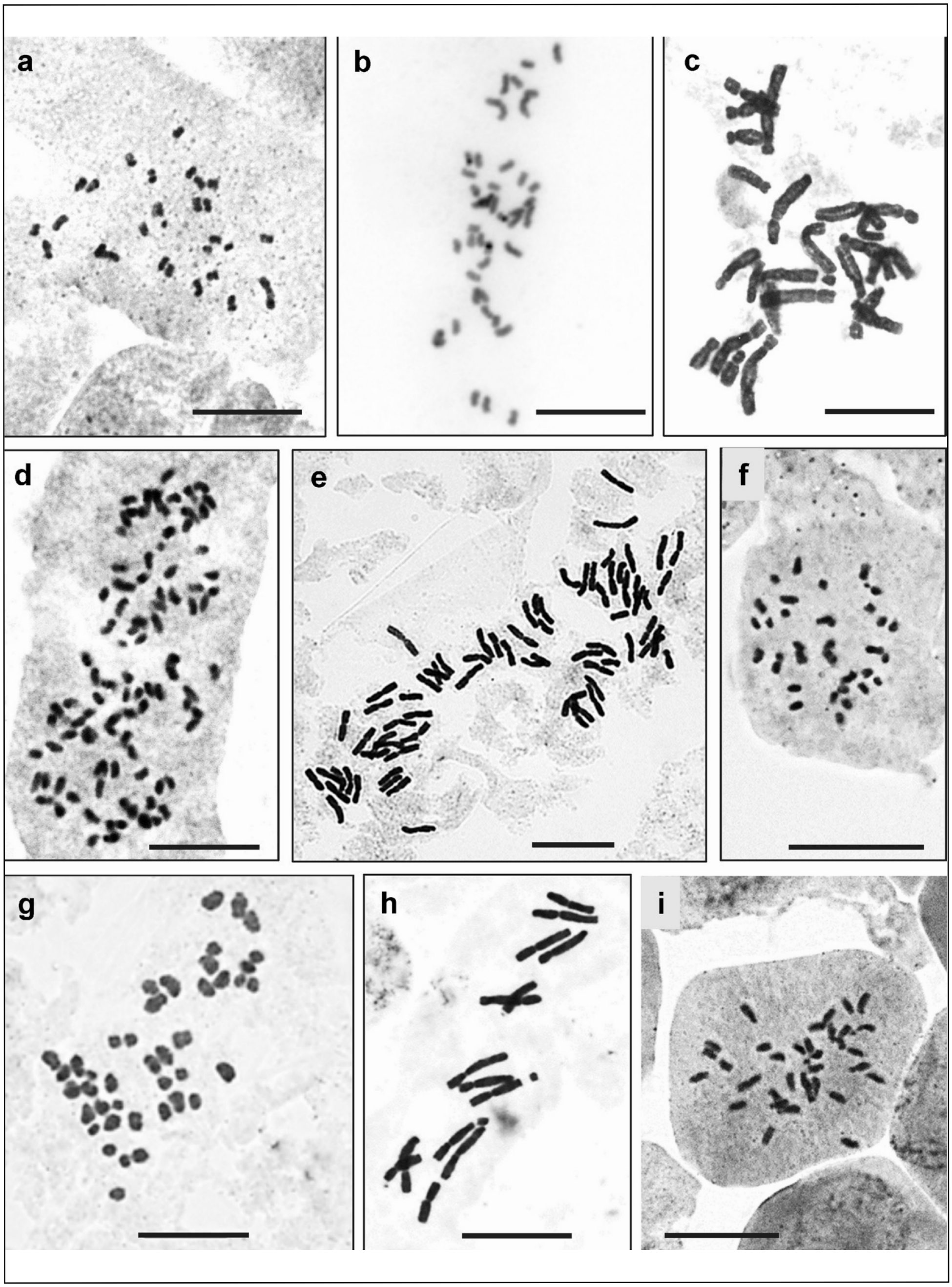

Fig. 1. Mitotic methaphase plates of: **a,** *Alnus pubescens*, 2*n* = 4x =28; **b,** *Alnus pubescens*, 2*n* = 6x = 42; **c,** *Erythronium dens-canis*, 2*n* = 2x = 24; **d,** *Genista tinctoria*, 2*n* = 4x =96; **e,** *Leucanthemum vulgare*, 2*n* = 8x =72; **f,** *Melittis melissophyllum*, 2*n* = 2x = 30; **g,** *Orchis mascula*, 2*n* = 2x = 42; **h,** *Scorzonera austriaca*, 2*n* = 2x = 14; **i,** *Stachys recta*, 2*n* = 2x = 32 + 1B. – Scale bars = 10 µm.

1942. ***Stachys recta*** L. — 2*n* = 2x = 32 + 1B (Fig. 1i).

BH: Katranica, Muške Vode, Kladanj, serpentine, 44° 14’ 10,12” N, 18° 34’ 14,01” E, 824 m a.s.l., 14 Aug 2008, private herbarium of F.P.

Stachys recta L., *Lamiaceae*, is an herbaceous perennial plant, natively widespread from Europe to the Caucasus and Asia Minor.

The diploid chromosome number 2*n* = 32 + 1B confirms previous reports for the variety *chrysophea* (Siljak-Yakovlev & al. 2010; Pustahija & al. 2013), but differs from 2*n* = 32 (Pólya 1949), 2*n* = 32-34 (Verlaque & al. 1987), 2*n* = 34 (Lang 1940; Favarger 1959; Koeva-Todorovska 1978; Kliphuis & Wieffering 1979; Cusma Velari & Lausi 1980; Pogan & al. 1982; Van Loon & Setten 1982; Baltisberger & Lenherr 1984; Baltisberger 1988; Lippert & Heubl 1989; Baltisberger 1990a, 1990b; Dobea & al. 1997; Siljak-Yakovlev & al. 2010), and 2*n* = 48 (Delay 1947). Estimated genome size for species on limestone was 2C = 1.73 pg (Siljak-Yakovlev & al. 2010), and 2C = 1.83 pg for variety *chrysophea* on serpentine (Siljak-Yakovlev & al. 2010; Pustahija & al. 2013).

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Bahar Gürdal & Neriman Özhatay

Karyological study on 12 species of the genus *Taraxacum* (*Asteraceae*) grown in Turkey

Abstract

Gürdal, B. & Özhatay, N.: Karyological study on 12 species of the genus *Taraxacum* (*Asteraceae*) grown in Turkey. [In Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds), Mediterranean plant karyological data - 28]. – Fl. Medit. 28: 429-439. doi:10.7320/FlMedit28.429

The somatic chromosomes and karyotypes of 12 *Taraxacum* species were determined. All studied species were collected from natural habitats in Marmara Region, NW Turkey. The chromosome numbers of *Taraxacum aznavourii* ($2n = 24$), *T. gracilens* ($2n = 24$), *T. hyberniforme* ($2n = 32$) and T. pseudobrachyglossum ($2n = 24$) are reported here for the first time. The basic chromosome number was found as $x = 8$ and all the examined taxa are triploid or tetraploid. All the examined species of the sections *Erythrosperma* and Palustria are triploids ($2n = 3x = 24$), while of the section *Scariosa* all are tetraploids ($2n = 4x = 32$), with the exception of T. minimum, which is both triploids and tetraploids. The detailed karyotype features of the 12 *Taraxacum* species are also presented.

Keywords: *Compositae*, chromosome numbers, karyotype, Marmara Region.

Introduction

The genus *Taraxacum* Wiggers is widely distributed in various habitats around the world. The west and central Asian regions are the ancestral centre of *Taraxacum*. The highest species and character diversities of this genus are found especially in Turkey, Iran, Afghanistan, the West Himalayas, North-Central China and the Southern Caucasus (Richards 1973).

Taraxacum species could undergo apomixis or sexual reproduction. Approximately 90% of *Taraxacum* species are apomictic. Generally, sexual *Taraxacum* species are diploid and apomictic species are polyploid (Richards 2003). On the other hand some tetraploids of the section *Piesis* are found to be sexual by Kirschner & al. (1994). In cases where apomictic and diploid sexual plants co-exist, the sexual species differ from the apomicts in size (Valentine & Richards 1967).

Diploid and apomictic species commonly co-exist in *Taraxacum* populations in Central Europe. In Europe, the Netherlands is the northern distribution limit for sexual species; polyploidy apomicts are present at higher latitudes (Dijk van 2003; Dijk Van & al. 2009).

According to Kirscher & al. (1994), sexual *Taraxacum* species have a limited geographical distribution. *Taraxacum serotinum* (Waldst. & Kit.) Fisch. (sect. *Dioszegia*) and *T.*

bessarabicum (Hornem.) Hand.-Mazz. (sect. *Piesis*) are the only sexual species with a wide distribution.

Classifying *Taraxacum* is complicated given the similar morphologies of species within this genus and the presence of apomixes and sexual reproduction (Kirschner & Štěpánek 1996, 2012). In these respect karyological data are useful for systematic classification of *Taraxacum*.

In Turkey, the genus *Taraxacum* is represented by 57 taxa, 18 of which are endemic. These taxa are grouped into 12 sections: *Dioszegia*, *Erythrocarpa*, *Erythrosperma*, *Macrocornuta*, *Oligantha*, *Orientalia*, *Palustria*, *Piesis*, *Primigenia*, *Scariosa*, *Sonchidium*, and *Taraxacum*. The chromosome numbers of 30 *Taraxacum* species occurring in Turkey are recorded in the literature (Doll 1975, 1976b; Richards 1968, 1969; Gedik & al. 2014; Kirschner & Stepanek 1985, 1998; Drabkova & al. 2009). Among these species, seven are diploid (2*n* = 2x = 16), 12 are triploid (2*n* = 3x = 24), four are tetraploid (2*n* = 4x = 32), one is hexaploid (2*n* = 48), and six species have two ploidy levels are recorded for other. The chromosome numbers of almost all *Taraxacum* species from Turkey have been counted by Doll (1975, 1976a). The species mentioned above were collected by Prof. K. Walther from West Anatolia.

The aim of this study is to determine the chromosome number and karyotype features which are important to indicate apomixis or sexual reproduction, of 12 *Taraxacum* species from Turkey.

Sect. Erythrosperma

1943. *Taraxacum aznavourii* Soest — 2*n* = 3x = 24 (Figs 1A & 2A).

Tu: A2(A) Bursa: Uludağ, Kirazlı yayla, 1363 m, 20 Sept 2013, *B. Gürdal 169-16, H. Gürdal* (ISTE 101782).

Taraxacum aznavourii is an endemic taxon of the Turkish flora. The chromosome number of this species is 2*n* = 24, triploid. Its karyotype formula is 2*n* = 3x = 16m + 2m-SAT + 6sm = 24. Its chromosome lengths range between from 1.35 to 2.81 μm. Its M_{CA} and CV_{CL} values are 20.18 and 19.343, respectively (Table 1). The present study is the first report of the chromosome number and karyotype of this species.

1944. *Taraxacum buttleri* Soest — 2*n* = 3x = 24 (Figs 1B & 2B).

Tu: A3 Sakarya: Taraklı, Karagöl yaylası yolu, 1114 m, 18 May 2014, *B. Gürdal 716-54, M. Koçyiğit, N. & E. Özhatay* (ISTE 102545).

The chromosome number of this species is 2*n* = 24, triploid. Its karyotype formula is 2*n* = 3x = 20m + 1m-SAT + 3sm = 24. Its chromosome lengths range from 0.50 to 0.99 μm. Its M_{CA} and CV_{CL} values are 11.43 and 22.541, respectively (Table 1). This species was previously reported also as a triploid (2*n* = 24) (Doll 1976b).

1945. ***Taraxacum gracilens*** Dahlst. — 2*n* = 3x = 24 (Figs 1C & 2C).

Tu: A2(A) Bursa: Uludağ, Kirazlı yayla civarı, 1505 m, 26 May 2013, *B. Gürdal 160-16, H. Gürdal* (ISTE 101779).

The chromosome number of *Taraxacum gracilens* is 2*n* = 24, triploid. Its karyotype formula is 2*n* = 3x = 18m + 6sm = 24. Its chromosome lengths range from 1.12 to 2.12 µm. Its M_{CA} and CV_{CL} values are 22.98 and 18.141, respectively (Table 1). The present study is the first to report the chromosome number and karyotype of this species.

1946. ***Taraxacum pseudobrachyglossum*** Soest — 2*n* = 3x = 24 (Figs 1D & 2D).

Tu: A1(E) Tekirdağ: Hayrabolu, Ortaca'ya giderken, 3 km kala, 158 m, 22 Apr 2014, *B. Gürdal 583-59, M. Koçyiğit* (ISTE 102404).

The chromosome number of this endemic species is 2*n* = 24, triploid. The karyotype consists of 2*n* = 3x = 24m chromosomes. Its chromosome lengths range from 1.07 to 1.72 µm. Its M_{CA} and CV_{CL} values are 5.97 and 15.365, respectively (Table 1). The present study is the first to report the chromosome number and karyotype of this species.

1947. ***Taraxacum turcicum*** Soest — 2*n* = 3x = 24 (Figs 1E & 2E).

Tu: A2(A) Bursa: Uludağ, Karabelen piknik alanı, 1359 m, 26 May 2013, *B. Gürdal 140-16, H. Gürdal* (ISTE 101772).

The chromosome number of the endemic *Taraxacum turcicum* is 2*n* = 24, triploid, as previously reported by Doll (1975). Its karyotype formula is: 2*n* = 3x = 13m + 2m-SAT + 9sm = 24. Its chromosome lengths range from 1.16 µm to 3.03 µm. Its M_{CA} and CV_{CL} values are 23.53 and 30.667, respectively (Table 1).

1948. ***Taraxacum waltheri*** R.Doll — 2*n* = 3x = 24 (Figs 1F & 2F).

Tu: A3 Sakarya: Sapanca gölü güneyi, S.Ü. Kırkpınar MYO arkasında mesire alanı, 37 m, 17 Apr 2015, *B. Gürdal 845-41, H. Gürdal* (ISTE 107341).

The chromosome number of this endemic species is 2*n* = 24, triploid, as previously reported by Doll (1976b). Its karyotype formula is: 2*n* = 3x = 20m + 1m-SAT + 3sm = 24. Its chromosome lengths range from 1.10 to 2.29 µm. Its M_{CA} and CV_{CL} values are 16.28 and 21.034, respectively (Table 1).

Sect. *Palustria*

1949. ***Taraxacum scaturiginosum*** G. E. Haglund — $2n = 3x = 24$ (Figs 1M & 2M).

Tu: A1(E) Tekirdağ: Hayrabolu, Emiryakuplu'dan Ortaca'ya 6 km kala, 141 m, 22 Apr 2014, *B. Gürdal 579-59, M. Koçyiğit* (ISTE 102400).

The chromosome number of this species is $2n = 24$, triploid. Its karyotype formula is given as $2n = 3x = 24$ metacentric chromosomes. Its chromosome lengths range from 1.02 to 2.02 µm. Its M_{CA} and CV_{CL} values are 9.09 and 25.819, respectively (Table 1). The chromosome number of this species has been previously reported as $2n = 3x = 24$ and $2n = 4x = 32$ (Rice & al. 2014; Richards 1969).

Sect. *Scariosa*

1950. ***Taraxacum aleppicum*** Dahlst. — $2n = 4x = 32$ (Figs 1G & 2G).

Tu: A1 (A) Çanakkale: Çan, Kocayayla çıkı°ı, mera, 306 m, 2 Nov 2013, *B. Gürdal 362-17, M. Koçyiğit* (ISTE 102302).

The chromosome number of this species is $2n = 32$, tetraploid, as previously reported by Doll (1976b). Its karyotype formula is $2n = 4x = 28m + 4sm = 32$. Its chromosome lengths range from 0.67 to 1.49 µm. Its M_{CA} and CV_{CL} values are 11.86 and 21.649, respectively (Table 1).

1951. ***Taraxacum hellenicum*** Dahlst. — $2n = 4x = 32$ (Figs 1H & 2H).

Tu: B1 Çanakkale: Evciler-Çavulu arası, Çavulu'ya 3 km kala, 332 m, 3 Nov 2013, *B. Gürdal 427-17, M. Koçyiğit* (ISTE 102324).

The chromosome number of this species is $2n = 32$, tetraploid, as previously reported by Doll (1976b). Its karyotype formula is $2n = 4x = 30m + 2m\text{-}SAT = 32$. Its chromosome lengths range from 1.15 to 2.38 µm. Its M_{CA} and CV_{CL} values are 8.99 and 19.631, respectively (Table 1).

1952. ***Taraxacum hyberniforme*** Soest Dahlst. — $2n = 4x = 32$ (Figs 1I & 2I).

Tu: A1 (A) Çanakkale: Lapseki, Balcılar-Umurbey yolu, Balcılar'dan 1 km sonra, çam altı, 240 m, 2 Nov 2013, *B. Gürdal 379-17, M. Koçyiğit* (ISTE 102310).

The chromosome number of this species is $2n = 32$, tetraploid. Its karyotype formula is $2n = 4x = 27m + 5m\text{-}SAT = 32$. Its chromosome lengths range from 1.36 to 2.62 µm. Its

M_{CA} and CV_{CL} values are 7 and 20.316, respectively (Table 1). The present study is the first report of the chromosome number and the karyotype of *Taraxacum hyberniforme*.

1953. ***Taraxacum hybernum*** Steven — $2n = 4x = 32$ (Figs 1J & 2J).

Tu: A1 (A) Çanakkale: Bayramiç, Karaibrahimler'den Cazgırlar'a giderken 1 km kala, 383 m, 2 Nov 2013, *B. Gürdal 405-17, M. Koçyiğit* (ISTE 102319).

The chromosome number of this species is $2n = 32$, tetraploid. Its karyotype consists of $2n = 4x = 22m + 2m\text{-SAT} + 8sm = 32$ chromosomes. Its chromosome length range between 1.66 and 2.98 µm. Its M_{CA} and CV_{CL} values are 14.86 and 16.324, respectively (Table 1). A previous study reported the chromosome number of this species as $2n = 24$ and $2n = 32$ (Doll 1975).

1954. ***Taraxacum minimum*** (Brig. ex Guss.) N. Terracc. — $2n = 3x = 24$ (Figs 1K & 2K) & $2n = 4x = 32$ (Figs 1L & 2L).

Tu: A2 (A): Yalova: Selimiye, Onno Tunç anıtı civarı, çayırlık, 716 m, 25 Oct 2013, *B. Gürdal 233-77, M. Koçyiğit* (ISTE 101811). – Figs 1K & 2K.

— A1 (A) Çanakkale: Ezine, Gökçebayır'dan Mecidiye'ye 3 km kala, zeytinlik arası, 125 m, 3 Nov 2013, *B. Gürdal 448-17, M. Koçyiğit* (ISTE 102330). – Figs 1L & 2L

Two polyploidy levels (triploid and tetraploid) are obtained for different populations. The chromosome number of the population from Yalova is given as $2n = 32$, tetraploid. Its karyotype formula is $2n = 4x = 32 = 19m + 5m\text{-SAT} + 8sm = 32$. Its chromosome lengths range from 1.06 to 3.21 µm and its M_{CA} and CV_{CL} values are 8.76 and 28.675, respectively (Table 2). Moreover, the chromosome number of the population from Çanakkale (ISTE 102330) is $2n = 24$, triploid. Its karyotype formula is $2n = 3x = 20m + 4m\text{-SAT} = 24$. Its chromosome lengths range from 1.20 to 3.06 µm and its M_{CA} and CV_{CL} values are 9 and 28.75, respectively (Table 1).

The chromosome number of this species has been previously reported as $2n = 16$ and $2n = 32$ (Richards 1969; Brullo & al. 1997).

Results and Discussion

The karyological studies revealed that the basic chromosome number of *Taraxacum* is $x = 8$. In the literature, satellite chromosomes have been observed in some species (Erlandsson, 1939; Singh & al. 1974; Krahulcova, 1993; Sato & al. 2007; Grzesiuk & al. 2008; Fazili & al. 2011; Kula & al. 2013). According to Mogie & Richards (1983), satellite chromosomes are absent from the most primitive sections of *Taraxacum*, which are geographically distributed between the Mediterranean Region and Central Asia. Plants in these sections are characterised by large, uniform and metacentric chromosomes and are diploid.

Table 1. Karyological features of studied *Taraxacum* species. **CLR**, chromosome length range; **THL**, total haploid chromosome length; $\mathbf{M_{CA}}$, mean centromeric asymmetry; $\mathbf{CV_{CL}}$, variation coefficient of chromosome length; **KF**, karyotype formula.

***Taraxacum* species**	**2*n***	**CLR (µm)**	**THL (µm)**	M_{CA}	CV_{CL}	**KF** m-SAT
Sect. *Erythrosperma*						
T. aznavourii	24	1.35– 2.81	17.46	20.18	19.343	16m + 2m-SAT + 6sm
T. buttleri	24	0.50 – 0.99	5.595	11.43	22.541	20m + 1m-SAT + 3sm
T. gracilens	24	1.12 – 2.12	12.916	22.98	18.141	18m + 6m
T. pseudobrachyglossum	24	1.07 – 1.72	10.725	5.97	15.365	24m
T. turcicum	24	1.16 – 3.03	16.259	23.53	30.667	13m +2m-SAT + 9sm
T. waltheri	24	1.10 – 2.29	13.719	16.28	21.034	20m + 1m-SAT + 3sm
Sect. *Palustria*						
T. scaturiginosum	24	1.02 – 2.02	11.431	9.09	25.819	24m
Sect. *Scariosa*						
T. aleppicum	32	0.67 – 1.49	9.459	11.86	21.649	28m + 4sm
T. hellenicum	32	1.15 – 2.38	14.178	8.99	19.631	30m + 2m-SAT
T. hyberniforme	32	1.36 – 2.62	15.974	7.00	20.316	27m + 5m-SAT
T. hybernum	32	1.66 – 2.98	19.979	14.86	16.324	22m + 2m-SAT + 8sm
T. minimum	24	1.20 – 3.06	16.952	9.00	28.75	20m + 4m-SAT
	32	1.06 – 3.21	17.305	8.76	28.675	19m + 5m-SAT + 8sm

Satellite chromosomes have not been observed in sections: *Spectabilia*, *Alpina* and *Celtica*. These sections, however, have been reported to possess chromosomes that carry at least one subterminal NOR (nucleolar ratio) region. A satellite chromosome has been observed in each haploid chromosome set of plants in sections: *Macrocornuta*, *Ceratophora*, *Mongolica*, *Tibetana*, *Parvula*, *Kashmirana*, *Erythrocarpa* and *Palustria*. In section *Hamata*, two satellite chromosomes are found in each triploid cell. The number of chromosomes with the satellites is highly variable in sections *Alpestria*, *Fontana*, *Obliqua*, *Erythrosperma*, *Naevosa*, *Crocea* and may vary even at the same foci and even at the same root (Mogie & Richards 1983). In our study, we observed satellites in the karyotypes of *T. aznavourii, T. buttleri, T. hellenicum, T. hyberniforme, T. hybernum, T. minimum, T. turcicum* and *T. waltheri* (sect. *Erythrosperma* and *Scariosa*). In the karyotype of *T. scaturiginosum* (sect. *Palustria*) satellites were not observed. Section *Scariosa* generally comprises tetraploid species in this study. The other sections investigated in this study comprise triploid species. Previous studies on the karyology of *Taraxacum* were based on chromosome number. Recently, however, the karyotype formula with the chromosome number has been reported (Gedik & al. 2014; Sato & al. 2012, 2015).

Gedik & al. (2014) reported karyotype formula and THL of *T. bellidiforme* Van Soest., *T. revertens* G. Hagl. beside the chromosome numbers. Satellites are seen in these species. The chromosome numbers are found 2*n* = 24 for *T. bellidiforme*; 2*n* = 24 and 2*n* = 32 for *T. revertens*. The THL values of *T. bellidiforme* and *T. revertens* are 28.56 and 32.67, respectively. Intrachromosomal asymmetry index and interchromosomal karyotype asymmetry indexes are also calculated in their study. Fazili & al. (2011) found chromosome number of *Taraxacum officinale* of Kashmir as a triploid (2*n* = 3x = 24) with and it shows that the karyotype exhibits Stebbins IA class of asymmetry, which is the most symmetrical

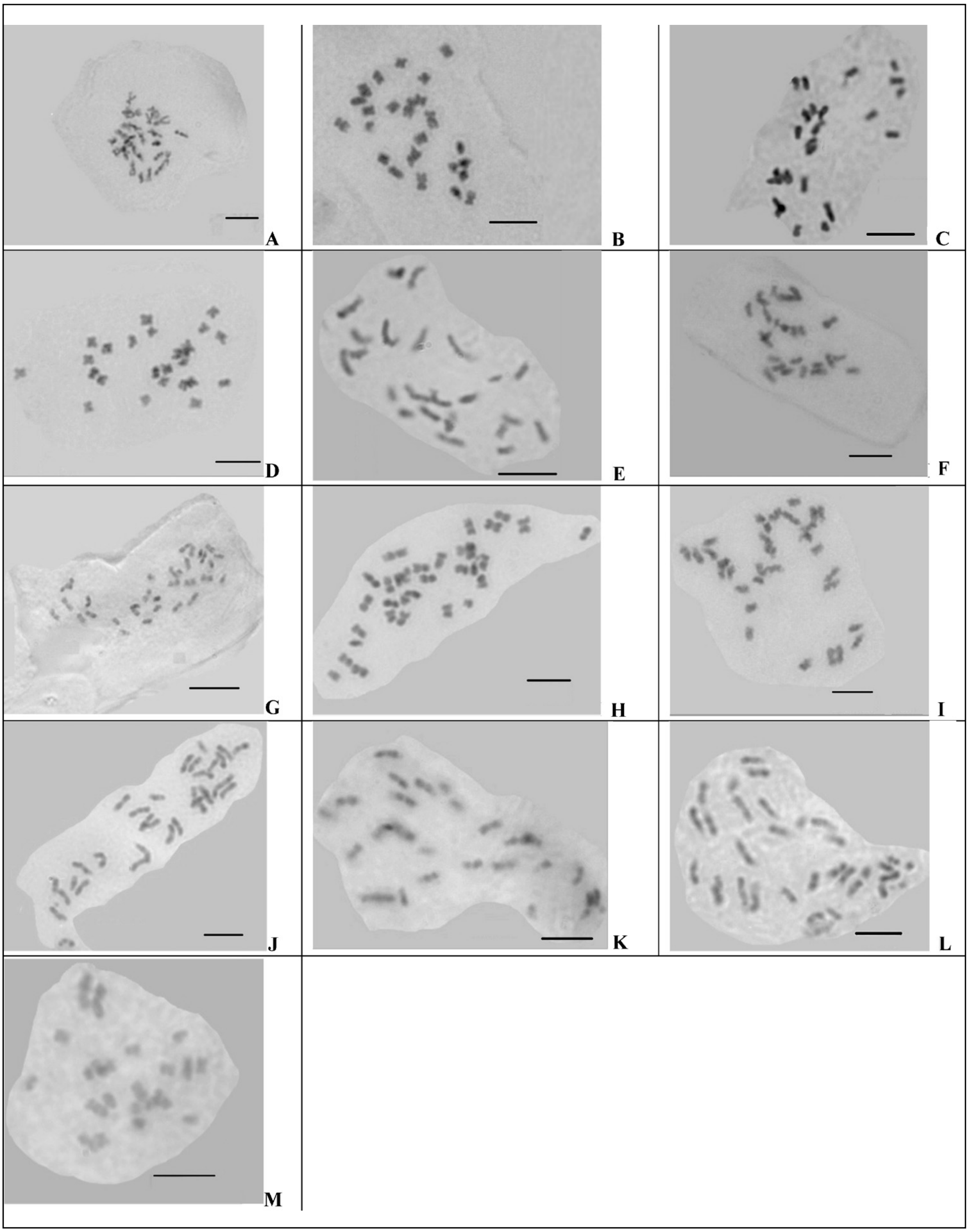

Fig. 1. Mitotic karyotypes of 12 *Taraxacum* species: **A**, *T. aznavourii*, 2*n* = 3x = 24 (ISTE 101782); **B**, *T. buttleri*, 2*n* = 3x = 24 (ISTE 102545); **C**, *T. gracilens*, 2*n* = 3x = 24 (ISTE 101779); **D**, *T. pseudobrachyglossum*, 2*n* = 3x = 24 (ISTE 102404); **E**, *T. turcicum*, 2*n* = 3x = 24 (ISTE 101772); **F**, *T. waltheri*, 2*n* = 3x = 24 (ISTE 107341); **G**, *T. aleppicum*, 2*n* = 4x = 32 (ISTE 102302); **H**, *T. hellenicum*, 2*n* = 4x = 32 (ISTE 102324); I, *T. hyberniforme*, 2*n* = 4x = 32 (ISTE 102310); **J**, *T. hybernum*, 2*n* = 4x = 32 (ISTE 102319); **K & L,** *T. minimum*, 2*n* = 3x = 24 (ISTE 101811) & 2*n* = 4x = 32 (ISTE 102330); **M**, *T. scaturiginosum*, 2*n* = 3x = 24 (ISTE 102400). – Scale bars = 5 µm.

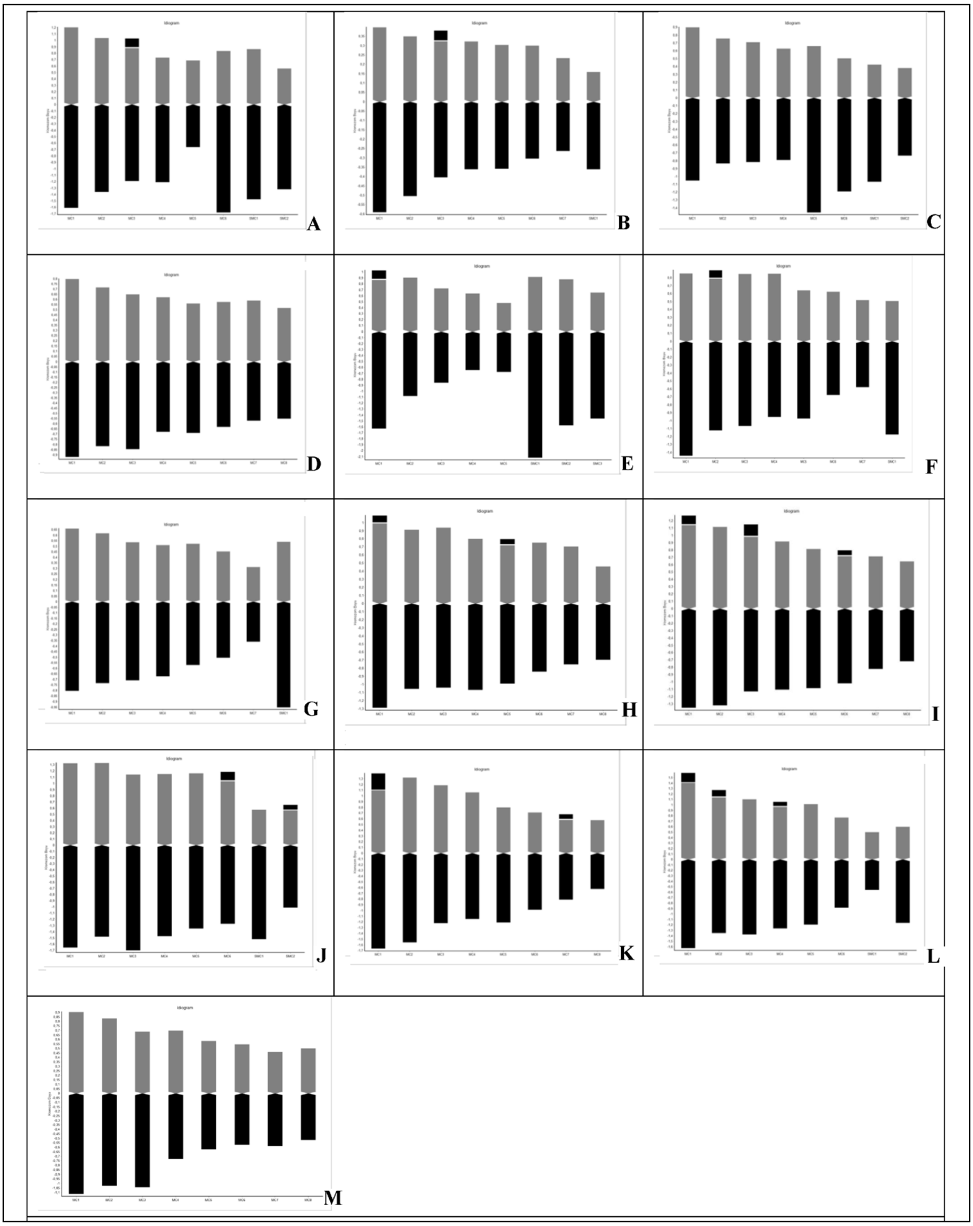

Fig. 2. Idiograms of 12 *Taraxacum* species: **A**, *T. aznavourii*, 2*n* = 3x = 24 (ISTE 101782); **B**, *T. buttleri*, 2*n* = 3x = 24 (ISTE 102545); **C**, *T. gracilens*, 2*n* = 3x = 24 (ISTE 101779); **D**, *T. pseudobrachyglossum*, 2*n* = 3x = 24 (ISTE 102404); **E**, *T. turcicum*, 2*n* = 3x = 24 (ISTE 101772); **F**, *T. waltheri*, 2*n* = 3x = 24 (ISTE 107341); **G**, *T. aleppicum*, 2*n* = 4x = 32 (ISTE 102302); **H**, *T. hellenicum*, 2*n* = 4x = 32 (ISTE 102324); **I**, *T. hyberniforme*, 2*n* = 4x = 32 (ISTE 102310); **J**, *T. hybernum*, 2*n* = 4x = 32 (ISTE 102319); **K & L,** *T. minimum*, 2*n* = 3x = 24 (ISTE 101811) & 2*n* = 4x = 32 (ISTE 102330); **M**, *T. scaturiginosum*, 2*n* = 3x = 24 (ISTE 102400).

class and considered as primitive. Mártonfiová (2013) reported different TCL (total chromosome length) values for different c-metaphases coming from one meristem of *T. linearisquameum* Soest.

In this study, the detailed karyotypes of all studied species are provided for the first time. The previously reported chromosome numbers of *T. buttleri*, *T. turcicum* and *T. waltheri* (sect. *Erythrosperma*) correspond with our results of $2n = 24$. In this study, the chromosome numbers of the other three members of section *Erythrosperma* that are *T. aznavourii*, *T. gracilens* and *T. pseudobrachyglossum* are reported for the first time. Similar to other members of section *Erythrosperma*, *T. aznavourii*, *T. gracilens* and *T. pseudobrachyglossum* have a chromosome number as $2n = 24$. As previously reported in the literature, we found that the chromosome number of *T. scaturiginosum* (sect. *Palustria*), is $2n = 24$; however, the chromosome number of this species has also been reported as $2n = 32$ (Rice & al. 2014; Richards, 1969). We found that the chromosome number of *T. aleppicum* and *T. hellenicum* (sect. *Scariosa*), is $2n = 32$, as previously reported by Doll (1976a). The chromosome number of *T. hybernum* was formerly reported as $2n = 24$ and 32 (Doll, 1975). In this study, however, the chromosome number of this species is $2n = 32$. The chromosome number of *T. minimum* has been reported as $2n = 16$ and $2n = 32$ (Richards 1969; Brullo & al. 1997). The first record ($2n = 16$) indicated that the species is sexual. However, given that one species cannot simultaneously contain sexual and apomictic individuals; this result was likely caused by misidentification. In this study, we found that the chromosome numbers of these species are $2n = 24$ and $2n = 32$.

Recent studies have reported M_{CA} (mean centromeric asymmetry) values in addition to CV_{CL}, CV_{CI}. The CV_{CL} values found in this study ranged from 15.365 to 30.667. Based on M_{CA} and CV_{CL} values, *T. pseudobrachyglossum* has the most symmetric karyotype, whereas *T. turcicum* has the most asymmetric karyotype. M_{CA} and CV_{CL} are positively correlated.

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A. Gounssa, K. Hormat, A. El Aboudi, F. Ezzahra, F. El Alaoui Faris &
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Karyological investigation of seven Moroccan *Asteraceae*

Abstract

Gounssa, A., Hormat, K., El Aboudi, A., Ezzahra, F., El Alaoui Faris, F. & Arahou, M.: Karyological investigation of seven Moroccan *Asteraceae*. [In Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds), Mediterranean plant karyological data - 28]. – Fl. Medit. 28: 440-445. doi: 10.7320/FlMedit28.440

The chromosome number of seven wild Moroccan species belonging to the *Asteraceae* family has been investigated for the first time in the region of Rabat-Salé-Kinétra (Morocco), using the root-tip squash. All these species show a diploid chromosome number which ranged from 2*n* = 18 to 2*n* = 34. Thus, we obtained for the following species: *Centaurea calcitrapa* 2*n* = 20, *Cichorium intybus* 2*n* = 18, *Glebionis segetum* 2*n* = 18, *Pallenis spinosa* subsp. *maroccana* 2*n* = 10, *Lactuca serriola* 2*n* = 18, *Phagnalon rupestre* 2*n* = 18, *Silybum marianum* 2*n* = 34. These findings are discussed and compared with other results from elsewhere.

Keywords: *Compositae*, cytotaxonomy, chromosome number, Moroccan flora.

The *Asteraceae* family, with around 24,000-30,000 species and 1600-1700 genera, is well represented within angiosperms and is distributed around the world except for Antarctica (Friis & Balslev 2005; Funk & al. 2009). Many members of this family are used as aromatic and medicinal plants. Antifungal, antimicrobial, antibacterial and insecticide activities were also found in several species (Kordali & al. 2005; Romagnoli & al. 2005; Funk & al. 2009). In Moroccan vascular flora, the *Asteraceae* family ranks first in terms of specific wealth, with 550 species and 126 subspecies belonging toaround 128 genera. *Centaurea* being the richest genus with 51 species. Moreover, according to the rate of endemics, this family is ranked third with 24% right after *Lamiaceae* and *Plumbaginaceae* with respectively 40 % and 28% (Fennane & Ibn Tattou 2012). In terms of aromatic and medicinal plants, *Asteraceae* with 36 species rank first, followed by *Lamiaceae*, *Apiaceae* and *Fabaceae* with respectively 30, 28 and 20 species (Fennane & Rejdali 2016).

Concerning geographical distribution, the most important part of Moroccan vascular flora is found in semi-arid and sub-humid regions (Sauvage 1960; Fennane & Ibn Tattou 1999; Hammada & al. 2004), which is part our study area, Rabat-Salé-Kinétra, according to Emberger's bioclimatic subdivisions (Sauvage 1963).

Karyological studies on Moroccan flora are quite limited (El Alaoui-Faris & al. 2011), especially in *Asteraceae*. Thus we can quote as preliminary studies on this family: Humphries & al. 1978; Humphries 1979, 1981; Talavera & al. 1984; Molero & Montserrat

Martí 1986; Favarger & al. 1980; Galland 1990; Valdés & Parra 1997; Valdés & al. 1998; Vogt & Oberprieler 1993, 2008, 2012; Oberprieler & Vogt 1993; Oberprieler 1994; Hellwig & al. 1994; Kilian & al. 1995 and El Alaoui-Faris & al. 2010).

The aim of this study is to provide the chromosome number of some spontaneous taxa that belong to *Asteraceae* family in the region of Rabat-Salé-Kénitra, and to compare it with the chromosome numbers found in other populations and countries.

1955. ***Centaurea calcitrapa*** L. — 2*n* = 2x = 20.

Ma: Salé, national road 1, Avenue Ouali Al Had Sidi Mohamed, 34° 3’ 50.425” N, 6° 47’ 46.316” W (RAB 108852).

Centaurea is the richest genus in the *Asteraceae* in Morocco, with 51 species, 24 subspecies. Sixteen species and five subspecies being strictly endemic to Morocco (Fennane & Ibn Tattou 2012; Fennane & al. 2014). The present chromosome count regarding this species, 2*n* = 20 and the basic number x = 10, seems to be the first conducted in Morocco. Our count is in accordance with former counts conducted in Italy-Palermo (Colombo & Marcenò 1984), Portugal (Queirós & Viera 1990), Spain in Zaragoza province (Hellwig 1994) and Egypt (Kamel 2004).

1956. ***Cichorium intybus*** L. — 2*n* = 2x = 18.

Ma: Rabat, Avenue Mohamed Ben Abdellah Erregragui, 33° 59’ 23.827 N, 6° 51’ 49.409” W. Road P4029, 34° 1’ 2.434” N, 6° 44’ 5.623” W (RAB 108854).

There are two species in the genus *Cichorium* L. in Moroccan flora, *C. intybus* L. and *C. pumilium* Jacq. (Fennane & al. 2014). As far as we know, our count is the first chromosome report from Morocco for this species, and it corroborates previous counts obtained in the United States of America in Los Angeles Co (Tomb & al. 1978), Wisconsin (Löve 1981b), Pakistan in Thatta (Razaq & al. 1994) and Spain in Puente de Alba (Ortega-Olivencia & al. 2004). The basic chromosome number x = 9 of the genus is also confirmed by our result.

1957. ***Glebionis segetum*** (L.) Fourr. — 2*n* = 2x = 18.

Ma: Salé, national road 1, 34° 5’ 43.508” N, 6° 45’ 48.056” W. Road P4029, 34° 1’ 3.042” N, 6° 44’ 4.261” W (RAB 108849).

Glebionis counts in Morocco two annual species: *G. coronaria* (L.) Spach and *G. segetum* (L.) Fourr. (Fennane & al. 2014). This species was cytologically investigated for the first time in Morocco within populations in the province of Tetouan, Fès and Chefchaouene respectively by Vogt & Oberprieler 1993, 1994, 2008). Our count is also in agreement with numerous previous reports from Portugal in Castro Verde (Queiros 1973) and the Mediterranean area e.g. Italy, in Sicily (Löve 1981a), Apulia and Sardinia (Paciolla & al. 2010), Cyprus in Paphos (Vogt & Aparicio 1999). Our results confirmed the basic chromosome number x = 9, which is the most common is the genus *Glebionis*.

1958. ***Lactuca serriola*** L. — 2*n* = 2x = 18.

Ma: Salé, Avenue Jbel Toubkal, 34° 4' 36.649" N, 6° 47' 0.635" W (RAB 108850).

Lactuca genus presents seven species and two subspecies in Morocco. Our count is in agreement with that reported for two Moroccan populations sampled in Guercif area, Taza (Vogt & Oberprieler 2012) and with other previous reports in different countries, Italy-Valley of Aosta (Gadella & Kliphuis 1970), Portugal-Lisbon (Queiros 1973), United States of America-California (Keil & Pinkava 1976), Spain-Sevilla (Gallego 1981), Egypt (Kamel 2004), Japan in Karuizawa (Matoba & al. 2007), and other countries (Mejías 1993). All these counts have shown that the basic number of this species is x = 9.

1959. ***Pallenis spinosa*** **subsp.** ***maroccana*** (Aurich & Podlech) Greuter — 2*n* = 2x = 10.

Ma: Salé, forest Ain Houla, 34° 1' 59.563" N, 6° 47' 27.585" W (RAB 108851).

The genus *Pallenis* is represented in Moroccan flora by five species (Fennane & al. 2014). The subject of our investigation is endemic subspecies to Morocco and Algeria. Its chromosome number 2*n* = 10 was reported for the first time in material from Morocco by Oberprieler & Vogt (1993) in populations from Beni Mellal (Middle Atlas) and Marrakech (High Atlas). They also confirmed this number later in other Moroccan populations from Meknes and Ouezzane (Vogt & Oberprieler 2012). Our count is also in agreement with the previous results from Portugal in Coimbra (Queiros 1973), Italy in Toscana, Garfagnana, North of Gallicano (Löve 1982), Arquà Petrarc, Euganean Hills (Marcucci & al. 2005) and Spain in Cordoba (Ubera 1979), Navarra, Taffala (Valdés Castrillón & Parra Martín 1998). The genus *Pallenis* has two basic numbers x = 5 and x = 6. The endemic subspecies *maroccana* has the basic chromosome number x = 5 (Oberprieler & Vogt 1993; Vogt & Oberprieler 2012).

1960. ***Phagnalon rupestre*** (L.) DC. — 2*n* = 18.

Ma: Kénitra, lake Sidi Boughaba, 34° 15' 10.264" N 6° 40' 9.35" W. Rabat, Avenue Ibn Hazm, 34° 0' 37.915" N, 6° 50' 21.447" W (RAB 108855).

The genus *Phagnalon* is represented in Morocco by ten species and eight subspecies. Six species and seven subspecies are endemic to Morocco; one species is endemic to Morocco, Algeria and the Iberian Peninsula (Fennane & al. 2014).

Our count is in agreement with the former reports based on Moroccan plants emanated from the province of Taza, Tetouan, Beni-Snassen, and Ouezzane (Oberprieler & Vogt 1993; Vogt & Oberprieler 2008, 2012), and with other reports from Spain in the province of Alicante and in Barcelona (Gadella & al. 1966), the Canary Islands-Lanzarote (Van Loon 1974), and Mallorca (Luque & al. 1984). Throughout the literature and our results, x = 9 appears to be the only basic number of this species.

1961. ***Silybum marianum*** (L.) Gaertn. — 2*n* = 2x = 34.

Ma: Salé, road P 4029, 34° 1' 2.395" N, 6° 44' 5.661" W (RAB 108853).

The genus *Silybum* in represented in Morocco by two species: *S. eburneum* Cross. & Dur. and *S. marianum* (L.) Gaertn. (Fennane & al. 2014). As far as we know, this is the first chromosome report of this species in Morocco and confirms other counts on populations from Spain in Valencia and Granada (Gadella & al. 1966), Portugal in Vila Velha de Ródão (Fernandes & Queiros 1971) and the Canary Island in Lanzarote, Valle de Rincon (Van Loon 1974). Our result supports the basic number x = 17.

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