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Contents

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Floristic research in Morocco: achievements and future trends

Abstract

Fennane, M., Ibn Tattou, M., El Oualidi, J., Taleb, M. S., Benkhnigue, O., Khamar, H. & Moujahdi, C.: Floristic research in Morocco: achievements and future trends. — Fl. Medit. 33: 5-16. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

The main lines of the history of knowledge about the vascular flora of Morocco are presented. Names of some famous authors and notable publications are indicated.
The report drawn up shows that the general floristic inventory is fairly well known; but for many species, there are still more or less big taxonomic and/or chorological gaps.
Moroccan floristic research is currently in a bad situation. While waiting for better days, there is a way to keep the flame of this research alive by benefiting from the advantages of computer tools; efforts should be directed towards the creation and development of databases and electronic flora. The aim is to capitalize existing information, update it and disseminate it to the widest possible public, in particular researchers, students and biodiversity managers.

Key words: botanical history, Flora, checklist, database, North Africa.

Introduction

The data and reflections, shared in this work, are concerning the fields that are mainly related to taxonomy (i.e., description and delimitation of taxa) and to floristics, in particular the inventory aspects (i.e., catalogs), identification keys (i.e., Floras) and geographical distribution of species.

In this context, we could say that the second decade of the twenty-first century was marked by the completion of three major syntheses on the vascular flora of Morocco, viz the “Flore pratique du Maroc” (Fennane & al. 1999-2014), the “Index Synonymique de la Flore d’Afrique du Nord” (Dobignard & Chatelain 2010-2013) and the “Livre Rouge de la flore vasculaire du Maroc” (Fennane & al. 2021).

In our opinion, these three references present the end of a stage and should open the way to another one that is certainly part of the continuity, and that must imperatively be different and innovative in order to: on the one hand capitalize, develop and further clarify the scientific knowledge acquired, and on the other hand, exploit better, protect and conserve the national phytodiversity.

We discuss the future of research on the vascular flora of Morocco with great caution viewing the bad position in which it currently finds itself and viewing the little hope for a change of trend in the short term, or even in the medium term. We have discussed this subject fifteen years ago (Fennane 2008), and unfortunately today, we believe that the situation is more than gloomy.

From now on, in the digital era, there is no doubt that the study, management / valorization and protection /conservation of flora cannot be developed without the precious support of databases and electronic flora. The challenge is great for the country, especially since on the scientific level, research activities continue to decline. Worse still, the training of young specialists is almost absent.

Since the dawn of time, thanks to the efforts of many generations of researchers and practitioners (professional or amateur managers), we have been able to:

1) know the national plant heritage better and better;
2) take advantage of its goods for our physical and moral comfort;
3) protect / conserve the flora for our daily needs, but also as a sustainable resource towards future generations.

Today, we believe that a page has been turned in the study of our vascular flora and another is on the way to be opened. For the first page, what are the major achievements? For the second one, what are the possible expectations? These are the main questions presented and discussed in this article.

Historical overview and current context

Under no circumstances, we cannot pretend here to give a complete list of the authors and/or previous works on Moroccan flora. This is simply an impossible mission for some obvious reasons: many historical documents have disappeared over time and those that have come down to us are not always easily accessible. Only few researchers have taken the time and trouble to search the archives to shed light on the past. Therefore, today we have a good knowledge of authors and works that present the most important benchmarks, especially during the second millennium. Below is a selection of these benchmarks. For further details, the interested reader may consult the following references: Renaud (1935), Sauvage (1954), Sauvage (1975), Ibn Tattou & Fennane (1989), Bellakhdar (1991), García & Carabaza (2009), Valdés (2021).

Pre-Linnaean period

Ninth - Eleventh centuries

- Abou-Hanifa Dinawari (820 - 895): “Grand Dictionnaire des Plantes”, about 50 new species are described.
- Ibn Wahchiya (??? - 930): translated and enriched the book “L’Agriculture nabatéenne”; the first classification trial.
- Ibn Djoljol, Andalus: published in 982 a work on the plants studied by Dioscorides and on other news.
- Ibn Wafid (1008 - 1075), Andalus: brilliant agronomist; responsible of the Botanical Garden of Toledo.
- Ibn Bassal (11th century), Toledo: agronomist; author of the book “Diwan al filaha”.

- Ibn Al Hajjaj (11th century), Córdoba: author of several books on agriculture.
- Abulcassis (936 - 1013), Córdoba: surgeon, author of "Kitabet-tesrif" that includes several volumes on medicinal plants.
- Ibn Beklarech (11th century), Zaragoza: author of the book "Al mustaâni" that discusses the materia medica with a large focus on plants of Spain and the Maghreb.
- Al Bekri (1014 - 1094), Córdoba: good expert of Maghreb plants, cited extensively by Ibn Al Baytar.

Twelfth and Thirteenth centuries

- At-Tighnari (1073 - 1118), Andalus: Book "Zahrat Al Boustane".
- Abou El-Kheir Al-Ichbili (1108 - 1179), Seville: book "ûmdat at-tabib fi ma'arifat al-nabat", plant classification trial.
- Al-Hadj Al-Gharnati (12th century): books "Traité d'agriculture" and "Dictionnaire de botanique".
- Charif Al-Idrissi (Sebta, 1100 - 1165): geographer, naturalist; book "Traité de géographie (1154)", rich in information on plants of Morocco, Algeria and the Iberian Peninsula.
- Al Ghafiqui (12th century), Andalus: book "Kitab al aduiya al moufrada", description of several plants of Morocco and Spain.
- Ibn Al-Âwwam, Seville: book "Kitab Al Filaha", treats more than 600 sp. of plants.
- Rachid-Eddin Ibn Essouri (Sour, 1177 - 1241): botanist.
- Abou El-Abbas An-Nabati (Seville, 1165 - 1239): book "Ar-rihla", presents observations of travels through Spain, North Africa and the Middle East, a hundred new plant species are described.
- Ibn Al-Baytar (Malaga, 1197 - Damas, 1248): book "Jaamiâ al-moufradate" (traité des simples), it contains 1400 sp., most plants.
- Abdallah Ben Salah: botanist who lived in Seville and Sebta?

Sixteenth and Seventeenth centuries

- Al-Wazir Al-Ghassani (Fez, 1548 - 1610), physician of the King Ahmed Al-Mansour: book "Hadiqat al azhar fi charh mahiyat al-ûchoub wa lâaqar", classification based on that of "Ûmdat at-tabib".
- Spotswood, surgeon in Tangier: published in 1696 "*Phytologia*Tingitana", list of about 600 sp. from Tangiers.

Post-Linnaean period (1750 - today)

Pioneers of botanical research in Morocco

- Broussonet Ch. A. (1761 -1807)
- Desfontaines R. L. (c. 1751 -1833)
- Poiret J. L. M. (1755 -1834)
- Schousboe P. K. A. (1766 -1832)
- Webb P. B. (1793 -1854)
- Cosson E. S. C. (1819 -1889)
- Ball J. (1818 -1889)
- Balansa B. (1825 -1891)
- Battandier J.-A. (1848 -1922)
- Braun Blanquet J. (1884 -1980)
- Caballero A. (1877 -1949)

- Litardière (De) R. V. (1888 -1957)
- Emberger L. (1897 -1969)
- Font Quer P. (1888 -1964)
- Gattefossé J. (1899 -1960)
- Guinea E. (1907-1985)
- Hooker J. D. (1817 -1911)
- Humbert H. J. (1887 -1967)
- Jahandiez E. (1876 -1938)
- Maire R. (1878 -1949)
- Mauricio H. (1860 -1937)
- Murbeck S. S. (1859 -1946)
- Pau C. (1857 -1937)
- Pitard C. J. (1873 -1927)
- Salzmann P. (1781 -1852)
- Sennen F. (1861 -1937)
- Trabut L. (1853 -1929)
- Weiller M. (1880 -1945)
- Wilkzek E. (1867-1948)

Contemporary authors (deceased)
- Sauvage Ch. (1909 -1980)
- Vindt J. (1919 - 1993)
- Raynaud Ch. (1939 - 1993)
- Ozenda P. (1920-2019)
- Nègre R. (1922 -2014)
- Quézel P. (1926 -2015)
- Benabid A. (1952 - 2016)
- Mathez J. (1940 - 2018)

Main works of current use (old or recent) in Morocco
List in chronological order:
- Flora atlantica (923 p., 263 pl.). Desfontaines (1798-1799)
- Spicilegium florae maroccanae (1627 sp.). Ball (1878)
- Compendium Florae atlanticae (2 tomes). Cosson (1881, 1887)
- Flore de l'Algérie (2 volumes). Battandier &Trabut (1888, 1895)
- Catalogue des plantes du Maroc, vol. 1, 2 et 3. Jahandiez & Maire (1931 - 1934)
- Catalogue des plantes du Maroc, vol. 4. Emberger & Maire (1941)
- Catalogo de la flora del Rif oriental. Sennen & Mauricio (1933)
- Catalogo razonado de las plantas del Sahara espanol. Guinea (1948)
- Flore du Maroc : analytique, descriptive et illustrée (2 fasc., ouvrage inachevé). Sauvage & Vindt (1952, 1954)
- Flore de l'Afrique du Nord (16 vol., ouvrage inachevé). Maire (1951-1986)
- Flore des régions arides du Maroc occidental (2 vol.). Nègre (1961, 1962)
- Nouvelle Flore de l'Algérie et des Régions désertiques méridionales (2 vol.). Quézel & Santa (1962, 1963)

- Flore du Sahara. Ozenda (1977, 1991, 2004)
- Med-Checklist : Inventaire critique des plantes vasculaires des pays circumméditerranéens (ouvrage inachevé, 4 vol. parus sur 6 prévus). Greuter & *al.*, eds. (1984-2008)
- Catalogue des plantes vasculaires rares, menacées ou endémiques du Maroc. Fennane & Ibn Tattou (1998)
- Flore pratique du Maroc (3 vol.). Fennane, Ibn Tattou, Ouyahya, El Oualidi & Mathez, eds. (1999-2014)
- Catalogue des plantes vasculaires du Nord du Maroc (2 vol.). Valdés, Rejdali, Achhal, Jury & Montserrat, eds. (2002)
- Flore vasculaire du Maroc, inventaire et chorologie, vol. 1. Fennane & Ibn Tattou (2005)
- Flore vasculaire du Maroc, inventaire et chorologie, vol. 2. Ibn Tattou & Fennane (2008)
- Index synonymique de la flore d'Afrique du Nord (5 vol.). Dobignard & Chatelain (2010-2013).
- Livre Rouge de la flore vasculaire du Maroc. Fennane, avec la collaboration de Ibn Tattou & El Oualidi (2021).

The vascular flora of Morocco: quantitative and qualitative analysis

The statistics published in the literature on the number of plant species that exist in Morocco are sometimes remarkably different depending on the sources (Tab. 1). Nothing surprising, in so far as the appreciations and the scientific approaches are not necessarily the same, in particular on the taxonomic and chorological levels. Thus, for example, according to the authors, the same taxon: 1) can be accepted at different ranks (species, subspecies, variety); 2) can be counted present, doubtful or absent; 3) can be considered native, of questionable nativeness or exotic.

Table1. Number of species in Morocco according to recent bibliography.

Number of species	Reference
4500 native sp.	Benabid (2014) (in arabic)
4173 native + exotic sp. (p.p.)	Fennane, Ibn Tattou, Ouyahya, El Oualidi & Mathez, eds. (1999-2014)
4707 native sp. and subsp. 647 exotic sp. and subsp.	Dobignard & Chatelain (2010-2013)
3913 native sp. 261 sp. of doubtful presence 55 hybrid sp. 220 exotic sp.	Fennane & Ibn Tattou (2012)
4800 sp., whose: - 144 of dubious rank (species?) - 482 of doubtful presence - 90 hybrid - 298 exotic (naturalized or weeds)	Fennane & Rejdali (2018)
3842 native sp. c. 500 sp. of doubtful presence	Fennane, Taleb & Rejdali (2022)

As far as we are concerned here, the numbers put forward come from the exploitation of an unpublished database (Vascular flora of Morocco, Scientific Institute, Mohammed V University in Rabat), regularly updated. They complement each other (and compare each other) with others from more or less recent work, in particular: Fennane & Ibn Tattou (2012), Fennane & Rejdali (2018); Fennane & al. (2021, 2022). In this context, we are now able to draw up a fairly precise table of all the flora and its remarkable fractions such as the endemic and the rare or threatened ones.

Native flora

The vascular flora, native in Morocco, counts approximately 3800 species, to which one can add nearly 80 hybrids. The number of subspecies is around 1400, of which nearly 40 % are type subspecies (e.g., *Ephedra fragilis* Desf. subsp. *fragilis*), the others are additionals (e.g., *Ephedra fragilis* subsp. *cossonii* (Stapf) Maire).

For the higher ranks, 140 families (according to APG III classification, updated in Angiosperm Phylogeny Website "www.mobot.org") and 979 genera (including 2 hybrids: *Rapistrella* and *Trachycnemum*) are listed, always with the same names at the top of the list. Thus, the first ten families, in decreasing order of species richness, are: *Asteraceae* (128 genera / 540 species), *Fabaceae* (57 / 403), *Poaceae* (122 /330), *Brassicaceae* (86 / 212), *Caryophyllaceae* (32 / 202), *Lamiaceae* (30 / 195), *Apiaceae* (55 / 157), *Plantaginaceae* (18 / 122), *Amaranthaceae* (32 / 77), *Boraginaceae* (26 / 75). For genera, there are *Silene* (67 sp.), *Ononis* (55), *Teucrium* (53), *Astragalus* (51), *Centaurea* (50), *Trifolium* (42), *Euphorbia* (39), *Carex* (37), *Erodium* (36), *Orobanche* (33), *Linaria* (32), *Helianthemum* (31), *Ranunculus* (29), *Vicia* (25).

In terms of biological types (or forms), herbaceous plants (hemicryptophytes, geophytes, therophytes) constitute nearly three-quarters of the national spectrum; half (c. 1400 species) are annuals. Woody plants (phanerophytes, nanophanerophytes, chamaephytes) are around 900 species, among which almost a third are trees or shrubs.

The native vascular flora of Morocco shows great richness, within which two fractions are very important to us and deserve special attention: the endemic flora and the threatened one.

Endemic flora

The vascular flora of Morocco does not contain any endemic family. On the other hand, at the level of genera and species, the originalities are significant. Seventeen genera (including one hybrid, *Trachycnemum*) and 620 species are restricted to the national territory.

The endemic genera are mostly *Brassicaceae* (*Ceratocnemum, Crambella, Fezia, Hemicrambe, Roripella, Rytidocarpus, Trachycnemum, Trachystoma*). The others belong to six different families: *Apiaceae* (*Pseudoridolfia, Sclerosciadium*), *Asteraceae* (*Heliocauta, Nivellea*), *Amaranthaceae* (*Traganopsis*), *Campanulaceae* (*Feeria*), *Fabaceae* (*Hesperolaburnum*), *Orobanchaceae* (*Bartsiella*) and *Amaryllidaceae* (*Hannonia*). *Trachystoma* is represented by three species; the others are all monospecific.

For species, we count 620 strict endemics (plus 8 others, probably shared with neighboring countries), 16.3% of the national inventory. We can also add to this number 25 hybrid species, including probably 3 shared with neighboring countries.

On a larger geographical scale, endemism confirms the affinities and floristic originalities common to Morocco and its neighboring countries. 5 genera (4 *Brassicaceae* (*Cordylocarpus, Foleyola, Kremeriella, Rapistrella, Zahora*) and one *Lamiaceae* (*Saccocalyx*)) are shared with Algeria and one (*Celtica*) with the Iberian Peninsula. For the species level, ca. 200 are shared with Algeria and about the same with the Iberian Peninsula; ca. 135 species exist at the same time in Morocco, Algeria and the Iberian Peninsula.

In Morocco, endemic species can be found in all regions, but not with the same abundance. Unsurprisingly, the mountain ranges host the most of them: High-Atlas (330), Middle-Atlas (220), Anti-Atlas (170) and Rif (150).

Floristic endemism in Morocco is characterized not only by its richness (i.e., total number of species), but also by its taxonomic diversity: 52 families and 253 genera contain several endemic species. The families at the top of the list are: *Asteraceae, Fabaceae, Lamiaceae, Brassicaceae, Caryophyllaceae, Apiaceae, Poaceae* (Tab. 2). This order changes, sometimes significantly, if we look at the percentage of endemics per family. For example, the *Lamiaceae* take the 1st place (35 % of its species are endemic), while this family is in the 3rd place according to its total number of endemics and in the 6th place according to its total number of species (Tab. 2). In contrast, the *Poaceae* comes in the 15th place (9 % of endemic species), while the family is the 7th according to the total number of endemics and the 3rd according to the total number of species. For the level of the genera, the first ten names on the list are almost the same which recur in the literature following more or less different orders. According to our numbers (Tab. 2), the ten most notable genera, in terms of endemic richness and/or the rate of endemism, are: *Teucrium, Silene, Centaurea, Ononis, Astragalus, Linaria, Erodium, Euphorbia, Vicia* and *Lotus*.

Table 2. Families and genera that are notable by rate and/or number of endemics.

	Total of species	**Endemic number**	**Rate (%) endemic**	**Rank according to endemic rates**	**Rank according to Endemic number**	**Rank according to Total of species**
Families						
Lamiaceae	195	69	35.4	1	3	6
Plumbaginaceae	47	16	34	2	9	15
Asteraceae	540	125	23.2	3	1	1
Apiaceae	157	33	21	4	6	7
Brassicaceae	212	41	19.3	5	4	4
Fabaceae	403	73	18.1	6	2	2
Caryophyllaceae	202	36	17.8	7	5	5
Papaveraceae	48	8	16.7	8	12	14
Geraniaceae	50	8	16	9	13	13
Plantaginaceae	122	19	15.6	10	8	8

Table 2. continued.

Euphorbiaceae	45	7	15.5	11	14	16
Rosaceae	58	9	15.5	12	11	12
Boraginaceae	75	11	14.6	13	10	10
Ranunculaceae	60	6	10	14	15	11
Poaceae	330	29	8.8	15	7	3
Amaranthaceae	77	4	5.2	16	16	9
Genera						
Teucrium	53	27	51	1	1	3
Silene	67	20	30	2	2	1
Centaurea	50	13	26	3	3	5
Ononis	55	13	23.6	6	4	2
Astragalus	51	12	23.5	7	5	4
Linaria	32	8	25	4	6	11
Erodium	36	7	19.4	9	7	9
Euphorbia	39	7	18	10	8	7
Vicia	25	6	24	5	9	16
Lotus	29	6	20.7	8	10	13
Ranunculus	29	3	10.3	11	11	14
Helianthemum	31	3	9.7	12	12	12
Orobanche	33	3	9.1	13	13	10
Carex	37	2	5.4	14	14	8
Trifolium	42	2	4.8	15	15	6
Juncus	27	0	0	16	16	15

Threatened flora

We consider here the threatened flora as defined by the IUCN (IUCN 2012a and 2012b). Thus, all the species classified in the Categories “CR” (critically endangered), “EN” (danger of extinction) and “VU” (vulnerable) of the IUCN Red List.

According to data from the book “Livre rouge de la flore vasculaire du Maroc” (Fennane & al. 2021), the threatened flora in Morocco contains nearly a thousand species, distributed approximately equally between the three categories “CR “ (37 %), “EN” (33 %) and “VU” (30 %). Unfortunately, nearly two thirds of national endemic species are concerned: 153 “CR”, 140 “EN” and 100 “VU”.

All regions of Morocco are home to threatened endemic species; the High-Atlas, the Middle-Atlas and the Anti-Atlas are in the lead with 150, 105 and 78 species respectively.

Flora of doubtful presence

Examination of the bibliography relating to the inventory of the flora of Morocco shows that there are approximately 560 vascular species of doubtful presence on a national scale. Among them, 15 are hybrids, 20 are of questionable taxonomic rank, 40 are national endemics, 100 are woody species (phanerophytes, nano-phanerophytes or chamaephytes).

Exotic flora

The exotic flora in Morocco is quite present, especially that voluntarily imported by human, since the dawn of time, for his needs of food, health, recreation.Thus, it is difficult to pronounce about the number of introduced species. In addition, for undesirable species (brought by humans involuntarily or by other means: rivers, winds, birds, etc.), there are nearly 200; most are herbaceous, generally qualified as weeds. It should be noted that over time, some of these exotics succeed to adapt to their new environments and end up settling there permanently and becoming part of the local flora.

Little-known flora

The book "Livre rouge de la flore vasculaire du Maroc" (Fennane & al. 2021) shows that there are about 1500 species for which there is a lack of information on the systematic levels (doubtful taxonomic rank, hybrid?) and/or chorological (uncertain presence, native or exotic state?, poorly known geographical distribution). Two thirds of these species are classified in Category "NA" (IUCN criteria: not applicable) of the IUCN Red List and one third are classified in Category "DD" (insufficient data).

Review and perspectives

The data presented in this article gives a mixed review about the current state of knowledge on the vascular flora of Morocco. On the one hand, we note with satisfaction the existence of important basic references: Catalogs, Flores (determination tools). However, on the other hand, we regret very much the persistence of many gray areas: about 1500 species are little-known (i.e., doubtful taxonomic rank, presence in Morocco to be confirmed, presence status unknown). In addition, we must add that even for a number of species whose presence is confirmed, the geographical distribution within the country is only vaguely known. Research in the field, and in herbaria, again and again reveals interesting surprises in terms of taxa that are new for science (recent examples: *Verbascum ifranensis* Khamar & al. 2017; *Centaurea ibn-tattoui* Chambouleyron & al. 2014; *C. peltieri* Homrani Bakali & Susanna 2021; *C. achilleifolia* Homrani Bakali & Susanna 2022), for Morocco or for different regions of the country.

The management (exploitation, development, protection, etc.) and the conservation (*in-situ* and *ex-situ*) of phytodiversity cannot be properly carried out without sufficiently precise knowledge of the species from all points of view: taxonomic, biological, ecological, chorological. This is to say and to recall the essential role of scientific research, which is stagnant today, if not in regression, with no concrete signs of recovery in the short or even the medium terms.

Conclusion

At present, the vascular flora of Morocco is relatively accessible through important synthesis works (catalogs, Floras, monographs, etc.) that give a general view of the overall

inventory, but they remain insufficient for managers to properly make efficient decisions for the conservation of biodiversity.

The role of researchers today is therefore to bring to light more information on our flora, but also to capitalize on it and present it in an accessible way to the public, as wide as possible, on different media, including digital tools. The constitution of databases and electronic Floras must retain all our attention. Their advantages are undeniable: continuous updating / corrections in real time; very wide dissemination of information; work in group for large number of collaborators; relatively low cost.

Certainly, Moroccan botany is not living its best days, but the flame of hope must remain alive with the digital era and all the possibilities they offer to maintain contacts and support the efforts of all those interested in knowing, exploiting, protecting and conserving the flora.

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Article

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Non-native shrubby species of *Euphorbia* (*Euphorbiaceae*) in Tunisia

Abstract

El Mokni, R.: Non-native shrubby species of *Euphorbia* (*Euphorbiaceae*) in Tunisia. — Fl. Medit. 33: 17-29. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

Botanical surveys undertaken in several regions of Tunisia (N Africa), mainly around salty wetlands and flats and along railways since 2015, yielded new records of non-native shrubby plants of the genus *Euphorbia*. These included *Euphorbia canariensis*, *E. cotinifolia* subsp. *cotinoides*, *E. cooperi* var. *cooperi*, *E. cyathophora*, *E. milii*, *E. pulcherrima*, *E. tirucalli* and *E. trigona*. Among these records, three (*E. cotinifolia* subsp. *cotinoides*, *E. cooperi* var. *cooperi*, and *E. cyathophora*) are new for the non-native flora of the Mediterranean area, one for the non-native flora of the continental Africa (*E. canariensis*) whereas *E. trigona* and *E. milii* var. *splendens* are first reports to the non-native flora of N Africa. Moreover, *Euphorbia pulcherrima* is here assigned as first report for the non-native flora of the continental N Africa and *E. tirucalli* is confirmed as an established taxon and its distributive area is here updated. Distributions and brief morphological descriptions are given for each of these new records. Notes on their habitats and their main distinguishable features together with field photographs are also provided.

Key words: floristics, aliens, succulents, new records, N Africa.

Introduction

In parallel to the increase of the industry of ornamental plants, flowering pot plants, flower bulbs and tree and nursery crops throughout the world, the rate of naturalizing plants is going faster and the number of naturalized/established (sometimes invaders) aliens is rising gradually in many countries worldwide. Within the Mediterranean area, in Europe (see e.g. Sanz Elorza & al. 2004; Capdevilla Argüelles & al. 2006; DAISIE 2009; Arianoutsou & al. 2010; Galasso & al. 2018; Domina 2021) as in many countries of N Africa (see e.g. Vilà & al. 1999; Meddour & El Mokni 2016; Sakhraoui & al. 2019; Meddour & al. 2020), the number of alien plant species is growing rapidly. Such alien flora includes a large number of families and genera where only 4 annual species were attributed to genus *Euphorbia* L. subg. *Chamaesyce* (Meddour & al. 2020).

Euphorbia, with around 1840 species distributed worldwide, is one of the most diversified Angiosperm genera of flowering plants (Esser & al. 2009; Horn & al. 2012; Riina & Berry 2012+). *Euphorbia* species occupy a wide range of habitats and exhibit great diversity growth forms including many kinds of prostrate, ascending, erect and small ephemeral

herbaceous annuals or perennial, trees, woody perennials, shrubs and many types of cactus-like succulents (Horn & al. 2012). *Euphorbia* has been subdivided in to 4 subgenera: *Chamaesyce* Raf., *Esula* Pers., *Euphorbia* L. and *Rhizantium* (Boiss) Wheeler (Bruyns & al. 2006). The subgenus *Euphorbia* is known as the subgenus encompassing all succulent species with a pair of thorns axillating the leaves, and it is very diverse in Africa (Bruyns 2006).

In continuation with our previous records of succulents at national scale or even for the whole N Africa (see e.g. El Mokni & al. 2019, 2020, 2022; El Mokni & Verloove 2021a, 2021b, 2022; El Mokni 2022), we present here new casual non-native shrubby succulent species of the genus *Euphorbia* for Tunisia, the Maghreb, N Africa, continental Africa and the Mediterranean area.

Material and Methods

Floristic field investigations carried out in Tunisia, mostly between 2015 and 2022, revealed new national records and even new records for N Africa and the Mediterranean area. Almost all taxa, observed in few (3-7) individuals, were not previously reported from either Tunisia, N Africa or sometimes the Mediterranean area. Records here reported are documented by a brief description of each taxon and infraspecific taxa, whenever present. Further comments on habitats of occurrence and taxonomic notes with closer or infraspecific taxa are also presented. For the identification and description numerous sources were consulted, mainly Eggli (2002), and the Encyclopedia of Succulents (2022) (retrieved from http://www.llifle.com/Encyclopedia/SUCCULENTS/Family/Euphorbiaceae/Euphorbia/). Reported taxa (species, and infraspecific taxa) are arranged alphabetically. Nomenclature is mostly in accordance with classifications of the *Euphorbiaceae* (see e.g. Bruyns & al. 2006; Bruyns 2012; Reveal 2012; Yang & al. 2012; Hassemer & al. 2017; Nobarinezhad & al. 2018; Tropicos 2022).

Results

Among the shrubby, succulent cacti-form and thorny species of *Euphorbia*, eight species are here reported for Tunisia belonging to two subgenera and five sections (subg. *Chamaesyce* with two sect. and subg. *Euphorbia* with three sect.).

Euphorbia canariensis L. Sp. Pl. 1: 450. 1753.
(*Euphorbia* subg. *Euphorbia* L. sect. *Euphorbia* L.)
First report for the non-native flora of the continental Africa.
Morphology (Fig. 1. F-G). *Euphorbia canariensis* is a small succulent shrub, 1 to 3(–4) m high. It clumps profusely from the base, one **trunk** may produce more than 150 branches; **stems** fleshy, stout, highly succulent, columnar, upright growing, deep green to reddish, 4 (rarely 5 or 6) angled up to 8 cm in diameter slightly spiraled; **edges** are obtuse and of a brown colour; **spines** dark shining in pair, perfectly regular, straight to cow-

horn shaped; **cyathium** dark red to reddish-green, surrounded by an involucrum consisting of 1 leaf with 5 division, which have externally 5 glands alternating with them; **male flowers** naked monandrous, articulated with their pedicel surrounding the female, which is in the centre; **female flowers** naked solitary; **ovarium** stalked; **stigma** three forked; **capsules** maroon red on adult plants.

Distribution. *Euphorbia canariensis* is endemic to Canary Islands (POWO 2021). In Europe as in continental Africa, no report till now (Euro+Med 2006+; APD 2022).

Habitat in Tunisia. *Euphorbia canariensis* occurs on the edge of an area where many *Opuntia* sp. pl. are growing up, within Tunis region (NE Tunisia).

Specimen visa (new records). TUNISIA: Tunis, 20.07.2020, *R. El Mokni s.n.* (Herb. Univ. Monastir!).

Euphorbia cotinifolia L. subsp. ***cotinoides*** (Miq.) Christenh., Harvard Pap. Bot. 7: 3. 2002.

≡ *E. cotinoides* Miq., Linnaea 21: 473. (1848); ≡ *Alectoroctonum cotinoides* (Miq.) Klotzsch & Garcke, Monatsber. Königl. Preuss. Akad. Wiss. Berlin 1859: 248. (1859).

(*Euphorbia* subg. *Chamaesyce* Raf. sect. *Alectoroctonum* (Schltdl.) Baill.)

First report for the non-native flora of the Mediterranean area as casual.

Morphology (Fig. 1. A-B). An evergreen tree plant; **trunk** up to 17 cm thick; **branches** spreading, dark red; **leaves** 3-whorled; petiole 2–9 cm, less reddish; leaf blade ovate-rounded, 2–6 × 2–4 cm, both surfaces red, base subtruncate, margin entire, apex obtuse; main vein prominent at both surfaces, lateral veins numerous pairs, reticulate before reaching margin; **cyathia** numerous, peduncle ca. 2 cm; involucre broadly campanulate, ca. 4 × 2.5–3 mm, lobes 4–6, triangular, pilose on margin; glands 4–6, dark green, rounded, appendages white, lobed; **male flowers** numerous, bracts linear; **female flowers** exserted from involucre; ovary 3-angular, with vertical furrows, conspicuous; **capsule** 3-angular-ovoid, ca. 5 × 6 mm, smooth, glabrous; **seeds** subglobose, ca. 3 mm in diam., brown, adaxially dark striate; caruncle absent. Flowering and fruiting period, from April to November (see more in Ma & Gilbert 2008).

Distribution. This subspecies has a native range from Mexico to Bolivia and Trinidad. It was introduced as ornamental to Bangladesh, Benin, Cayman Is., China Southeast, Comoros, Dominican Republic, Hainan, India, Leeward Island, Puerto Rico, Taiwan, Windward Island and with no report in the Mediterranean area (POWO 2022a; APD 2022). It was also cultivated and escaped in Fujian, Hainan, Taiwan and widely cultivated in greenhouses of C and N China and throughout the tropics (see more in Ma & Gilbert 2008).

Habitat in Tunisia. *Euphorbia cotinifolia* subsp. *cotinoides* was found along roadside not far from planted ornamentals in the region of Tabarka, Jendouba (NW Tunisia).

Notes. *Euphorbia cotinifolia* subsp. *cotinoides* differs from the typical subspecies most obviously by its ovate-rounded leaf blade; subtruncate at the base and obtuse in the apex (*vs*. orbiculate, apically rounded leaf blades in the subsp. *cotinifolia*) (see more in Ma & Gilbert 2008).

Specimen visa (new records). TUNISIA: Jendouba, Tabarka, 15.10.2021, *ibidem*, 13.10.2022, *R. El Mokni s.n.* (Herb. Univ. Monastir!).

Euphorbia cooperi N.E. Br. ex A. Berger, Sukk. Euph. 83. 1907 var. ***cooperi***
(*Euphorbia* subg. *Euphorbia* L. sect. *Euphorbia* L.)
First report for the non-native flora of the Mediterranean area as casual.
Morphology (Fig. 2. A-C). A spiny, succulent tree that can reach 6-7 m in height; **trunk** is dark gray or brown and bears the scars of the old branches; branches thick, light green showing five to six ribs lined with pairs of black spines; **leaves** very small, rapidly caducous; **inflorescence** yellowish-green on the terminal segments; **flowers** yellowish green, small (4 mm) bisexual, sessile, arranged in 3 parallel rows along the ridges between the spines towards the tips of the branches, clustered in cymes each with by 3 cyathia with the male flowers at the tip in the centre of the row, and the bisexual flowers below on the outside; **capsule** large, 3-lobed berry-like capsule, 15 × 8 mm long and green in colour with red markings that changes from red to purple when ripe throwing seeds away (Hyde & al. 2021).
Distribution. *Euphorbia cooperi* var. *cooperi*, native from Zimbabwe to South Africa (POWO 2022c). In Europe as in North Africa, no report till now (Euro+Med 2006+; APD 2022).
Habitat in Tunisia. *Euphorbia cooperi* var. *cooperi* on the edges of the metro railway in the region of Monastir (CE Tunisia).
Notes. Three varieties have been recognised for *Euphorbia cooperi* (var. *cooperi*, var. *calidicola* L.C. Leach and var. *ussanguensis* (N.E. Br.) L.C. Leach). The taxon reported here is belonging to *E. cooperi* var. *cooperi*. This latter differs mainly by having branch segments conical-ovate with 3-6 solid winged ridges, much longer than wide (*vs*. much thinner wings on the segments, which are normally wider than long in var. *calidicola* however branch segments are almost circular, (3)4–6(8)-angled; angles stoutly winged in var. *ussanguensis*) (cfr. Hyde & al. 2021).
Specimen visa (new records). TUNISIA: Monastir, Touza, 16.12.2019, *ibidem*, 24 & 26.07.2021, *R. El Mokni s.n.* (Herb. Univ. Monastir!).

Euphorbia cyathophora Murray. Comment. Soc. Regiae Sci. Gott. 7: 81. 1786.
≡ *Poinsettia cyathophora* (Murray) Klotzsch & Garcke in Monatsber. Königl. Preuss. Akad. Wiss. Berlin 1859: 253.1859; ≡ *Euphorbia heterophylla* var. *cyathophora* (Murray) Griseb., Fl. Brit. W. I.: 45. 1859.
(*Euphorbia* subg. *Chamaesyce* Raf. sect. *Poinsettia* (Graham) Baill.)
First report for the non-native flora the Mediterranean area as casual.
Morphology (Fig. 1. C-D). An herbaceous to shrubby annual plant, erect to ascending, grows up to 1.50 m high, glabrous or loosely hairy, with multicellular hairs; **stem** is hollow, cylindrical with ribbed older, hollow, glabrous or sparsely pubescent, more or less yellow, containing a white latex. It bears leaves along its entire length or only at the apex in older plants; **leaves** are simple, stalked, the lower leaves alternate, while the upper leaves are opposite. The blade shape is variable. The terminal leaves are fully red or white colored; **flowers** are small and greenish-yellow, they are contained in small cups bearing on the edge, a small gland flattened bilobed; **capsule** is globose to three quarters out of the cup. (see more in Le Bourgeois & al. 2008).
Distribution. With a native range from C USA to N Central Argentina, the plant was introduced in many countries all over the world but no report from N Africa and the Mediterranean area (POWO 2022b).

Habitat in Tunisia. *Euphorbia cyathophora* was found as an alien (seven individuals in an area of 4 m^2) growing with native herbaceous plants in an oasis within the region of Douz, Kebili (SW Tunisia).

Notes. *Euphorbia cyathophora* is almost similar to *E. heterophylla* L. from which it can be easily recognized by the color of the base of the bracts (often red to pinkish at base in *E. cyathophora vs.* completely green with the very base whitish in *E. heterophylla*), the cyathial glands (with flattened in *E. cyathophora vs.* round opening in *E. heterophylla*), and the seeds (apex truncate in *E. cyathophora vs.* acute in *E. heterophylla*) (see e.g. Silva & al. 2014).

Specimen visa (new records). TUNISIA: Douz, Kébili, 17.11.2021, *M. Kalboussi s.n.* (Herb. Univ. Monastir!).

Euphorbia milii var. ***splendens*** (Bojer ex Hook.) Ursch & Leandri in Mém. Inst. Sci. Madagascar, Sér. B, Biol. Vég. 5: 148. 1954.

≡ *E. splendens* Bojer ex Hook. in Botanical Magazine 56: pl. 2902. 1829.; ≡ *Lacanthis splendens* (Bojer ex Hook.) Raf. in Flora Telluriana 2: 94. 1836[1837]; ≡ *Sterigmanthe splendens* (Bojer ex Hook.) Klotzsch & Garcke in Abh. Königl. Akad. Wiss. Berlin 1859: 100. 1859[1860]; ≡ *Tithymalus splendens* (Bojer ex Hook.) M. Gómez in Fl. Habanera, Fanerog. 153. 1897.

(*Euphorbia* subg. *Euphorbia* L. sect. *Goniostema* Baill. ex Boiss.)

First report for the non-native flora of N Africa as casual.

Morphology (Fig. 2. F-G). An erect shrubby, succulent, spiny, **stem** terete, bark brown to grayish; younger **branches** about 8 mm in diam; **spines** in spirals or indistinct rows, not on spine shields, solitary or in groups of 3 or more, 16–25 mm long, grey to brown; leaves alternate or in indistinct rows, subsessile; blade ovate to ovate-elliptic 1.5–6 × 0.8–2 cm, base attenuate to rounded, margin entire, apex obtuse to acute or mucronate, venation hardly visible; **cyathia** several in exserted dichasia with long peduncles; **bracts** at branching 2 mm long, membranous, inconspicuous; **bracts** below cyathia in pairs, red or yellow or white or in various colours, showy and petaloid, 1–2 cm long; **cyathia** sessile in bracts, glands 4, without appendages; **capsules** and seeds not seen; **seeds** 3-4 mm long, brownish (Welzen & Chayamarit 2021).

Distribution. Originating to Central Madagascar, *Euphorbia milii* aggr is widely cultivated elsewhere. In Europe as in continental North Africa, no report till now for this taxon as casual, only in Morocco and Canary Islands where *Euphorbia milii* s. l. was cited as cultivated (Euro+Med 2006+; APD 2022).

Habitat in Tunisia. *Euphorbia milii* var. *splendens* occurs on coastal clayey slopes in the region Monastir where it seems escaping from pots or through the discharge of ornamental plant waste into the area (CE Tunisia).

Notes. *Euphorbia milii* var. *splendens* closely resembles to *E. milii* var. *milii*. It differs from *E. milii* s. str., however, by several morphological characters: it forms larger shrubs (up to ca. 2 m tall) with sprawling stems and spreading branches (up to ca. 1-2 cm thick), whereas *E. milii* var. *milii* is a semi-prostrate shrub (up to ca. 1.5-1.8 m tall) with climbing stems (up to ca.1 cm in diameter). Moreover, leaves are ovate (up to ca. 1.5–6 × 0.8–2 cm) with sometimes yellow cyathophylls in *Euphorbia milii* var. *splendens* rather than obovate (up to ca. 1–5(–6) × 1.5–2 cm) with brilliant red cyathophylls in *E. milii* var. *milii*.

Fig. 1. Casual shrubby species of *Euphorbia* from Tunisia: A-B) *Euphorbia cotinifolia* subsp. *cotinoides*; C-D) *E. cyathophora*; E) *E. pulcherrima*; F-G) *E. canariensis.* Photographs A-B & E-G by R. El Mokni, Photographs C-D by M. Kalboussi.

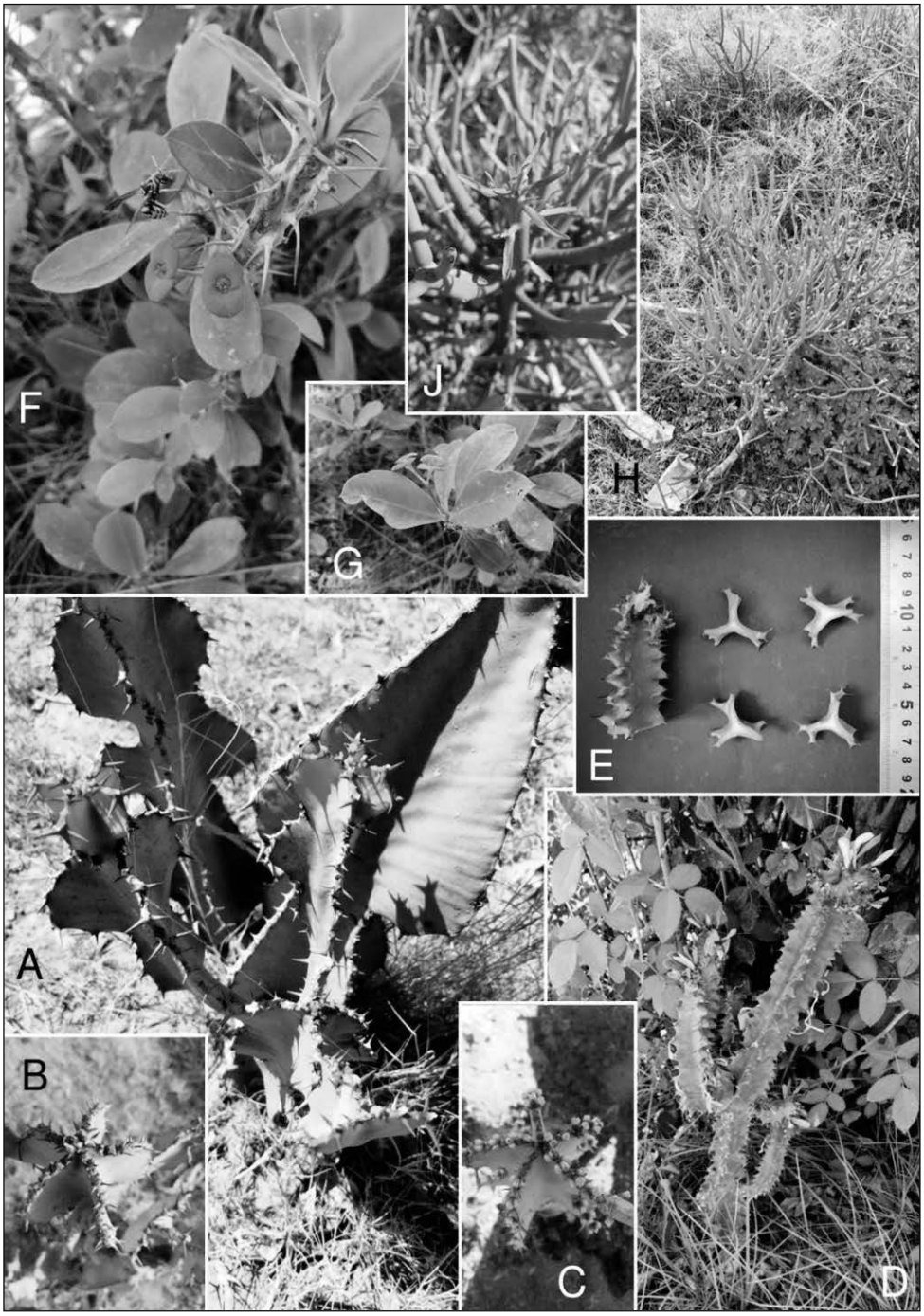

Fig. 2. Casual shrubby species of *Euphorbia* from Tunisia: A-C) *E. cooperi* var. *cooperi*; D-E) *E. trigona*; F-G) *E. milii* var. *splendens*; H & J) *E. tirucalli.* Photographs by R. El Mokni.

Specimen visa (new records). TUNISIA: Monastir, 26.07.2021, *R. El Mokni s.n.* (Herb. Univ. Monastir!).

E. pulcherrima Willdenow ex Klotzsch, Allg. Gartenzeitung 2: 27. 1834.
≡ *Poinsettia pulcherrima* (Willd. ex Klotzsch.) Graham in Edinburgh New Philos. J. 20: 412. 1836.
(*Euphorbia* subg. *Chamaesyce* Raf. sect. *Poinsettia* (Graham) Baill.)
First report for the non-native flora of the continental N Africa (and the Maghreb) as casual.
Morphology (Fig. 1. E). A shrubby tree (up to 3 m tall); **stem** up to 8 cm in diameter, not to slightly branched; **bark** light brown, smooth; **branchlets** hollow; **leaves** alternate, green; **stipules** as small scales, caducous; **petioles** about 5–7 cm long, subglabrous; **blades** ovate-elliptic and sometimes panduriformly lobed, about 12–17 × 6–9 cm, chartaceous, base acute or obtuse with very base acute, margin entire, apex acuminate, glabrous above, slightly brighter and distinctly pubescent below, venation distinct, not triplinerved, with almost 16–17 pairs of sideveins; **cyathia** grouped in an apical pseudo-umbel, glabrous, their bracts enlarged, leaflike, with a pedicel of 1–3 cm, narrower than stem-leaves, green with red midrib or completely red; **peduncles** 4–5 mm long; **involucres** about 5 × 4–5 mm; **gland** only 1 about 5 mm wide, without appendage; **ovary** with a pedicel of c. 3 mm; **stigmas** united into a style column of 1–5 mm, free stigmas completely bifid; **capsules** not seen, described as green, sulcate, with a somewhat fleshy pericarp; **seeds** not seen, described as 10 mm long, smooth (Welzen & Chayamarit 2021).
Distribution. Native to Mexican tropical forests from Sinaloa, W Mexico, to Guatemala (Steinmann, 2002), *Euphorbia pulcherrima* was vegetatively propagated as ornamental, known as a contemporary symbol of Christmas in many parts of the world (Ecke & al. 2004). The plant was reported as an alien in India and in the Canary Islands (Negi & Hajra 2007; APD 2022) and now widely cultivated in tropical and subtropical regions around the earth. In Europe as in continental North Africa, no report till now (Euro+Med 2006+; APD 2022).
Habitat in Tunisia. *Euphorbia pulcherrima* was found along roadside on waste area in the region of Monastir (CE Tunisia).
Notes. *Euphorbia pulcherrima* can be confused with *E. cyathophora* and *E. heterophylla* from which the plant differs mainly by its shrubby habit up to 3 m tall (*vs.* herbal habit up to 1.5 m tall for both *E. cyathophora* Murray and *E. heterophylla*), its cyathial bracts leaf-like, often deep red throughout (*vs.* uppermost leaves usually white in *E. heterophylla* or red in *E. cyathophora* at base only) and by its cyathia 4–5 mm in diameter (*vs.* cyathia less than 2 mm in diameter for both other species) (see e.g. Ma & Gilbert 2008; Silva & al. 2014).
Specimen visa (new records). TUNISIA: Monastir, 03.02.2021, *R. El Mokni s.n.* (Herb. Univ. Monastir!).

Euphorbia tirucalli L. in Sp. Pl. 1: 452. 1753.
≡ *Arthrothamnus tirucalli* (L.) Klotzsch & Garcke in Monatsber. Königl. Preuss. Akad. Wiss. Berlin 1859: 251. 1859; ≡ *Tirucalia tirucalli* (L.) P.V.Heath Calyx 5(3): 93. 1996.
(*Euphorbia* subg. *Euphorbia* L. sect. *Tirucalli* Boiss.)

Second report as an established alien for the non-native flora of Tunisia (with an extended area of occurrence) and the continental N Africa (El Mokni & al. 2019; APD 2022)

Morphology (Fig. 2. H & J). A shrubby, succulent and woody tree up to 3 m tall, without spines, monoecious or staminate only, usually leafless, with dichotomous or whorled branching; **branches** elongate, only 3–6 mm in diameter, slightly tomentose at apex; **stipules** very small (about 0.3 mm), glandular; **leaves** alternate, obovate-linear, 10–15 × 1–2 mm, very soon caducous; **cyathia** green, in subsessile, capitate glomerules, tomentose to glabrous, many-flowered glomerules often with staminate flowers only; **cyathial glands** 4, about 0.5 × 1–1.5 mm; **pistillate flowers** tomentose, with a distinct perianth; **capsules** exserted, about 7 mm long, glabrescent; **seeds** brown and often mottled, 4 × 3 mm, smooth, carunculate (Welzen & Chayamarit 2021).

Distribution. see El Mokni & al. (2019).

Habitat in Tunisia. The new record is assigned in the region of Mahdia (CE Tunisia), in the right edge of the railways from Mahdia to Bekalta with ruderal plants. Also, one more locality was recorded more recently from Kasserine to Gafsa (CW Tunisia), in the right side within plantations of *Opuntia ficus-indica* (L.) Mill.

Notes. *Euphorbia tirucalli* shows similarities with *E. aphylla* Brouss. ex Willd. in their habits, nevertheless the latter is caracterised by its very tiny leaves, scale-like ephemeral and quickly fall off thus the entire plant appears leafless (*vs.* leaves alternate, obovate-linear, 10–15 × 1–2 mm in *E. tirucalli*) (see e.g. Bramwell & Bramwell 2001; Ma & Gilbert 2008).

Specimen visa (new records). TUNISIA: Kasserine, 27.05.2022, *R. El Mokni s.n.* (Herb. Univ. Monastir!).

Euphorbia trigona Mill. in The Gardeners Dictionary: eighth edition no. 3. 1768.
= *E. hermentiana* Lem. L'Illustration Horticole 5(Misc.): 63. 1858.
(*Euphorbia* subg. *Euphorbia* L. sect. *Euphorbia* L.)

First report for the non-native flora of N Africa as casual.

Morphology (Fig. 2. D-E). Succulent shrubs or trees; **stems** and **branchlets** 4–6 cm in diameter, indistinctly constricted into oblong segments to 10-25 cm long with three wing-like angles and carry short, divergent paired **spines**, reddish-brown, later dark up to 6 mm long; **leaves** lanceolate to drop-shaped, varying from 7 to 9 mm and deciduous, to 3–5 cm and more persistent; **cyathia** solitary or in groups, bracts paired to 3.5 × 4 mm, ovate, obtuse, dentate, glands 5 to 2.2 mm; **bracteoles** approximately 2.5 mm, obovate, apex fringed; **stamens** numerous, filaments jointed, 2.6 mm; **female flowers** erect, ovary about 3.7 mm across, 3–celled, style 3, ovule 1; **capsule** to 7 mm, 3–lobed, 3.5 mm, obovoid (cf. India Biodiversity Portal 2016).

Distribution. *Euphorbia trigona*, native to Angola, Congo, Gabon and Malawi (Govaerts 2016) is widely commercialized as an ornamental, hedge plant and pot-plant across tropical subtropical and temperate regions. This species has the potential to escape from cultivation. In North America (Cuba and Belize) and India, where this species has become naturalized, it grows to form thickets in disturbed sites and abandoned gardens in dry and semiarid sites where it mostly spreads vegetatively by cuttings and stem fragments (see e.g. Balick & al. 2000; Oviedo & al. 2012; Govaerts 2016). In Europe, the taxon is reported only from Spain and in Canary Islands as present only in captivi-

ty/cultivation (Ortiz 2016). The taxon is not reported yet to continental North African (APD 2022).

Habitat in Tunisia. *Euphorbia trigona* occurs in the region of Monastir (CE Tunisia) within roadside in the shade of some cultivated *Rosa* sp.

Notes. *Euphorbia trigona* can be confused to *E. lactea* Haw. which is also triangular, with similar pattern on the branches. However, this latter differs mainly by having more spreading and less winged branches. In addition, *E. triangularis* Desf. ex A. Berger is repeatedly mistaken for the similar-sounding name *E. trigona*. However, it differs mainly by showing spreading, 3-5-edged branches.

Specimen visa (new records). TUNISIA: Monastir, 28.07.2021, *ibidem*, 25.10.2022, *R. El Mokni s.n.* (Herb. Univ. Monastir!).

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Article

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Two new species alien to the flora of Morocco: *Amaranthus spinosus* (*Amaranthaceae*) and *Cardamine occulta* (*Brassicaceae*)

Abstract

Sukhorukov, A. P., Léger, J.-F. & Chambouleyron, M.: Two new species alien to the flora of Morocco: *Amaranthus spinosus* (*Amaranthaceae*) and *Cardamine occulta* (*Brassicaceae*). — Fl. Medit. 33: 31-38. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

During field investigations in Morocco, two new alien species, *Amaranthus spinosus* (*Amaranthaceae*) and *Cardamine occulta* (*Brassicaceae*), were discovered as new to the country. Additionally, *C. occulta* seems to be the first record for continental Africa. The distribution and ecology of these species are discussed.

Key words: alien flora, new records, chorology, North Africa.

Introduction

Habitats linked to human activities host a large number of nitrophilous and synanthropic species. They are the major centres for the introduction and expansion of non-native species, these datasets provide a rich source of information on biological invasion and habitat homogenization (Domina & al. 2019; Panitsa & al. 2020).

During a field trip in Morocco in autumn 2021, the authors collected *Amaranthus spinosus* L. and *Cardamine occulta* Hornem.: two species that appear to be new plants alien to the flora of the country. Complementary field investigations were then undertaken in 2022, to better determine the actual distribution of these taxa.

Materials and methods

A field trip was made on the Atlantic coastline of Morocco from October 31 to November 19, 2021, to collect autumnal species of this area. Fifty-nine stations were inventoried from Tangier to Tan-Tan (ca. 1000 km). The collected plants are stored in herbaria ECWP, MW and RAB. Complementary field investigations were performed from January to July 2022 in the Rabat region, where *Amaranthus spinosus* and *Cardamine occulta* had been discovered during the previous autumnal trip.

Results and discussion

Over 500 herbarium vouchers were collected during this autumnal trip. Identification of specimens revealed two new records of vascular plants for Morocco: *A. spinosus* and *C. occulta.*

***Amaranthus spinosus* L.** (Fig.1)
(*Amaranthaceae*)
New localities:

Morocco (Fig. 2): Mehdia, Sidi Boughaba, 34.20760/-6.68136, 20 m a.s.l., roadside, 6.11.2021, *M. Chambouleyron, J.-F. Léger & A. Sukhorukov s. n.* (ECWP, MW); Temara, 33.90615/-6.98740, 10 m a.s.l., ornamental roadside plantations, 8.1.2022, *J.-F. Léger s. n.* (ECWP); Kenitra, 34.24959/-6.61133, pavement, 13.2.2022, *J.-F. Léger s. n.* (ECWP); Sidi Bouknadel, 34.10387/-6.73310, cultivation, 13.2.2022, *J.-F. Léger s. n.* (ECWP); Sidi Taïbi, 34.14895/-6.71762, ornamental tree nursery, 13.2.2022, *J.-F. Léger s. n.* (ECWP, RAB113705); Rabat, 34.01152/-6.85022, garden, 20.2.2022, *J.-F. Léger s. n.* (ECWP); Skhrirat, 33.85889/-7.04947, wasteland, 27.2.2022, *J.-F. Léger s. n.* (ECWP); Rabat, 34.01890/-6.82586, 20 m a.s.l., pavement, 19.7.2022, *J.-F. Léger s. n.* (ECWP); Mohammadia, 33.67762/-7.41388, 15 m a.s.l., sewage run-off, 23.7.2022, *J.-F. Léger s. n.* (ECWP); Casablanca, 33.57655/-7.55093, 60 m a.s.l., nursery, 23.7.2022, *J.-F. Léger s. n.* (ECWP).

Fig. 1. Image of *Amaranthus spinosus* (Mehdia, Sidi Boughaba, 6.11.2021, *M. Chambouleyron*).

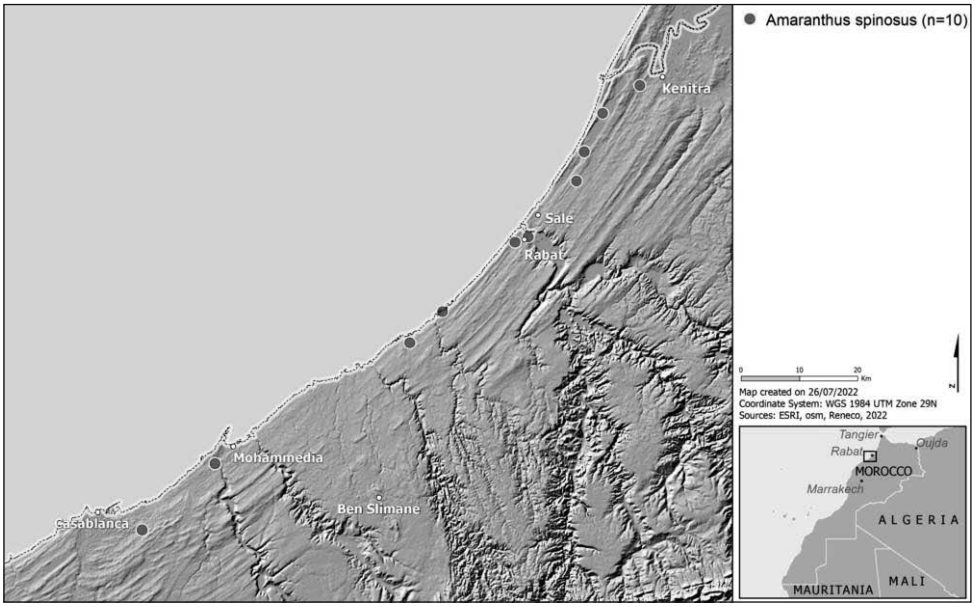

Fig. 2. Records of *Amaranthus spinosus* on North-Atlantic plains of Morocco.

Amaranthus spinosus is easily recognizable due to its annual habit and the presence of two spines on leaf nodes. It originates from the tropics of America (Sauer 1967) and since recently is considered an invasive plant in many tropical countries of the world (e.g. Waterhouse 1994; Singh & Dahiya 2002; Bojian & al. 2003; Sukhorukov & al. 2021). Some records from subtropical and temperate countries are also known (e.g. Robbrecht & Jongepier 1986; Gonen & Urgur 2000; Mohamadzadeh & al. 2005; Klaassen & Kwembeya 2013; Iamonico 2015). In continental North Africa, *A. spinosus* was reported from Egypt (Tackholm & El Gazzar 1977) and recently from Tunisia (Iamonico & El Mokni 2018).

The species is reported neither in Morocco in major floristic accounts (Ouyahya 1999; Rutherford & Jury 2002; Dobignard & Chatelain 2011; Dobignard 2022; Fennane 2022; African Plant Database 2022) nor in sources specializing in weeds (Observatoire du Sahara et du Sahel 2020; EPPO Global Database 2022; Invasive Species Compendium 2022) and at the Global Biodiversity Information Facility (2022). More locally, Atlantic plains of northern Morocco are well inventoried since distant past because botanists' team from the Institut Scientifique Chérifien (now known as Institut Scientifique de Rabat) has been located in Rabat since 1920, and many field studies have been conducted in the Rabat region (*s. l.*) during one century (e.g. Boitel 1921; Perrin de Brichambaut 1951; Sauvage 1961; Bouhache & al. 1994; Bensellam & al. 1997; Dobignard 2009; Zidane & al. 2010; Tanji & al. 2015; Khamar & al. 2021). Thus, the introduction of *A. spinosus* into the region seems to be recent. Our field observations are centred around Casablanca-Kenitra Region corresponding to "Maâmora/Zemmour/Zaër" (Man-3) and Chaouïa/Doukkala (Mam-1) geographical units (as delimited by Fennane & Ibn Tattou 2005). Just as in other African

countries (Baker & Clarke 1909; Hutchinson & Danziel 1927; Maire 1962; Germishuizen 2003), *A. spinosus* grows at disturbed sites in Morocco (pavements, roadsides, wastelands, cultivations, and gardens) where it is already abundant (where we found it: several individuals to over 1000 per locality). We consider it a locally naturalized plant in Morocco. Additional research in nurseries, eutrophic cultivated fields or ruderal places in other regions of Morocco will also probably lead to additional records of this species.

***Cardamine occulta* Hornem.** (Fig. 3)
(*Brassicaceae*)
New localities:

Morocco (Fig. 4): Mehdia, Sidi Boughaba, 34.20781/-6.68234, 20 m a.s.l., Plants nursery, 6.11.2021, *M. Chambouleyron, J.-F. Léger & A. Sukhorukov s. n.* (ECWP, MW); Kenitra, 34.28782/-6.52110, greenhouse, 13.2.2022, *J.-F. Léger s. n.* (ECWP); Rabat, 34.01314/-6.83082, flower pot, 20.2.2022, *J.-F. Léger s. n.* (ECWP); Sidi Taïbi, 34.20574/-6.67491, greenhouse, 26.2.2022, *J.-F. Léger s. n.* (ECWP, RAB113706).

This annual species from East Asia is still often confused with other species of *Cardamine* L., especially *C. hirsuta* L. and *C. flexuosa* With., and some significant differences between these species have been summarized in several papers (e.g. Marhold & al. 2016; Dalavi & al. 2019; Hruševar & al. 2021).

Fig. 3. Herbarium specimen of *Cardamine occulta* (Mehdia, Sidi Boughaba, 6.11.2021, *M. Chambouleyron, J.-F. Léger & A. Sukhorukov s. n.* (ECWP).

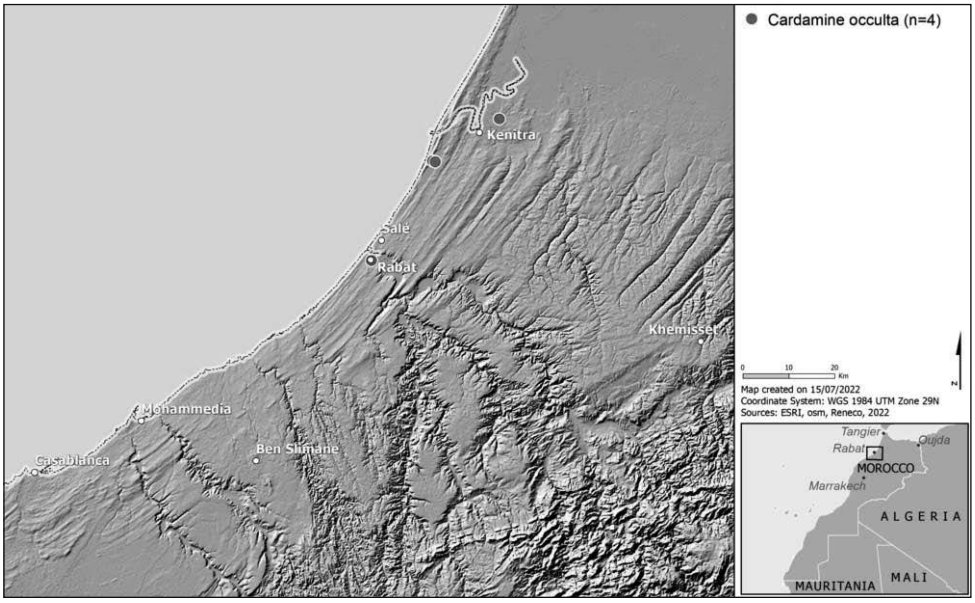

Fig. 4. Records of *Cardamine occulta* on North-Atlantic plains of Morocco. Out of four records, only three are shown on the map because two locations are too close to each other.

Cardamine occulta was recently found in many European countries (e.g. Marhold & al. 2016; Verloove 2018; Dzhus 2019; Leostrin & Mayorov 2019; Pliszko 2020; Hruševar & al. 2021) as well as in Central and North Americas (Rollins 1993; POWO 2022; unpubl. data by A. Sukhorukov as collected in Grenada, West Indies).

Our collections seem to be the first records of *C. occulta* in continental Africa and have not been mentioned earlier in any accounts (e.g. African Plant Database 2022; Global Biodiversity Information Facility 2022; Invasive Species Compendium 2022), but it was recently found on the Canary Islands (Verloove & Reyes-Betancort 2011, sub *C. flexuosa* auct. on With.). Nonetheless, due to its strong resemblance with *C. flexuosa* (present in Morocco and Algeria) and with *C. hirsuta* (a common species in North-West Africa) and to historical repeated confusion of these species with each other in Europe since time immemorial, we assume that this taxon has been overlooked in North Africa. Our field observations are centred around Rabat-Kenitra Region, corresponding to the "Maâmora/Zemmour/Zaër" (Man-3) geographical unit (as delimited by Fennane & Ibn Tattou 2005).

In the countries where *C. occulta* has been introduced, it has mostly been found in urban and disturbed areas (e.g. flower pots, roadsides, and pavements) (Marhold & al. 2016; pers. obs. by A. Sukhorukov in Moscow, Russia). In Morocco, we found it only in plant nurseries and greenhouses, which is precisely the most common way to introduce this species in many countries, according to Marhold & al. (2016); the same situation was also noted in Grenada (West Indies) by one of us (A. Sukhorukov, pers. obs.). Although it is regarded as an invasive species in Europe by Marhold & al. (2016), this status is not appropriate here in Morocco judging by our field observations, where found only several or up

to a few hundred individuals in very artificialized habitats: inside nurseries and flower pots. Its eventual expansion is worth studying.

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Article

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Georgi Kunev & Gabriela Petrova

First report of *Tripleurospermum rosellum* (*Asteraceae*) from Bulgaria and its distinction from the allied *T. oreades* and *T. caucasicum*

Abstract

Kunev, G. & Petrova, G.: First report of *Tripleurospermum rosellum* (*Asteraceae*) from Bulgaria and its distinction from the allied *T. oreades* and *T. caucasicum*. — Fl. Medit. 33: 39-48. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

Tripleurospermum rosellum is here reported as native to Bulgarian flora for the first time based on materials gathered in the East Rhodope Mts. The revision of herbarium materials revealed that the taxon has been collected from several different localities in the same region of the country over the past 80 years. A detailed presentation on its morphology, distribution and habitat characteristics in Bulgaria are presented. The Greek collections of *Tripleurospermum oreades* are to be referred to *T. rosellum*. The species is also confirmed for the mainland of European Turkey.

Key words: new record, misidentification, revision, the Balkans, ruderal species, East-Mediterranean.

Introduction

Tripleurospermum Sch.Bip. (*Asteraceae*) is a monophyletic lineage within *Anthemideae* tribe (Inceer & al. 2018). It is a critical genus of about 40 species, distributed almost exclusively in the Northern hemisphere with exception of *Tripleurospermum inodorum* (L.) Sch. Bip, being distributed globally (POWO 2021). With nearly 30 species, half of which were reported endemic, Turkey has been considered its main center of diversity (Inceer & Ozcan 2021).

In Bulgaria, the most recent treatment of the genus (Kuzmanov 2012) includes *T. inodorum*, *T. tenuifolium* (Kit.) Freyn., *T. caucasicum* (Willd.) Hayek, and *T. disciforme* (C. A. Mey.) Sch. Bip.. Notably, Kuzmanov (2012) did not discuss the earlier described *T. anchialense* M. Král (Kral 1990).

During a phytosociological study performed by the first author in the period 2018–2020, in the East Rhodope Mts., Bulgaria, a representative of the genus *Tripleurospermum* was registered. It drew attention due to its perennial habit, low, ascending, unbranched stems, each bearing a single capitulum, and unusually early flowering – late April. The species has been collected from several different localities in different developmental stages during this period. Our study showed that the collected specimens do not correspond

to any of the taxa within *Tripleurospermum* reported from Bulgaria. Further comparison with herbarium collections and a crosscheck with relevant literature sources proved that its correct taxonomic identity is *Tripleurospermum rosellum* var. *album* E. Hossain.

The similar *T. oreades* (Boiss.) Rech. f. has been reported from a single site in Northeast Greece, which represents the sole European record of that taxon (Strid & Lassen 2000). Its close proximity (40 km in SW) to the sites of *T. rosellum* in Bulgaria impelled us to compare collections from both sides of the Greek-Bulgarian border. Examination of representative material conclude that all of it belongs to *T. rosellum.*

The aim of the current paper is to report *T. rosellum* as a member of the Bulgarian flora and to confirm its occurrence in Northeast Greece and continental European Turkey. Our conclusions are supported by a detailed description of its morphology (incl. photographs and SEM micrographs), distributional notes and habitat indications.

Materials and Methods

The specimens collected by us were deposited at SO and SOM (herbarium acronyms follow Thiers 2022). Identification is based on the treatments of Boissier (1875) and Hossain (1975), further corroborated with the aid of additional relevant literature (Hayek 1931; Kay 1976; Pobedimova 2000; Inceer & al. 2012; Inceer & Ozcan 2021), and comparison with specimen images, including types, kept at BR, K, E, WU, P, JE, and G (G–BOIS), and with photographs of live plants (Dimopoulos & al. 2021; Danin & Fragman-Sapir 2021). Herbarium collections of *Tripleurospermum*, *Matricaria* and *Chamaemelum* kept in Bulgarian herbaria (SO, SOM and SOA) were revised. The list of examined specimens is presented in Annex 1. Cauline leaf and a capitulum with not fully matured fruits of *T. oreades* collected in Greece were studied and compared with Bulgarian samples. Our key and morphological descriptive data of the discussed taxa is based on the cited specimens. Cypsela morphology was studied by SEM, selected micrographs being shown in Fig. 1, additional micrographs with higher resolution being enclosed in Annex 2. The distribution of the taxon in Bulgaria is mapped at a scale 1:300 000. Habitat characteristics and species lists at the studied sites are based on our personal observations. Climatic characteristics of the investigated region are presented according to numerical weather prediction model (Climate-Data 2021).

Results and discussion

Tripleurospermum rosellum var. ***album*** E. Hossain in Notes Roy. Bot. Gard. Edinburgh 32: 254 (1973), (Fig. 1, Annex2: Fig. 1s).

Caespitose perennial. Rhizome short, branched. Stems 1–20, ascending, narrowly ribbed, 10−30(–40) cm tall, unbranched or rarely with 1–3 branchlets, each bearing single capitulum (Fig. 1A), glabrous or with scattered trichomes. Leaves, 1–2 pinnatisect, alternate, sessile, the basal ones crowded, the middle cauline leaves sparse, segments linear-filiform, mucronate, with sparse trichomes or glabrous. Capitula radiate, 25–35 mm in dia. (ligules included). Receptacle hemispherical or broadly ovoid-conical (Fig. 1B).

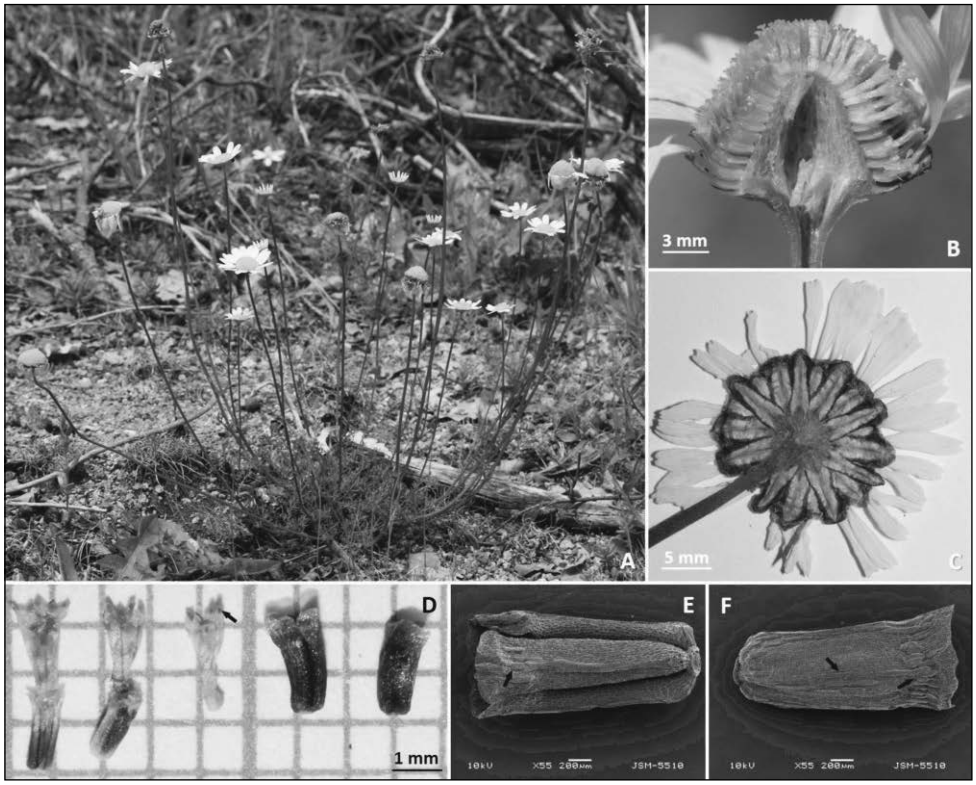

Fig. 1. Habitus (A), capitulum cross-section (B), involucral bracts (C), cypselae in different development stages and disk flowers (D) with black arrow pointing the glandules on the tips of corolla lobs (all extracted from exsiccates), fruit SEM micrographs with black arrows pointing the characteristic mucilaginous cells on adaxial (E) and abaxial (F) surface of *Tripleurospermum rosellum* from East Rhodope Mts., Bulgaria. Photos for the Fig. 1A, B, C and D made by Georgi Kunev.

Involucral bracts (Fig. 1C) entire, arranged in up to five rows, the outer ones shorter than the inner, oblong-triangular to subspatulate, glabrous or with sparse trichomes, weakly keeled, their margins more or less widely membranous, weakly undulate, pale brown or brown. Inner involucral bracts obovate, subglabrous or glabrous, their margins pale brown, entire, lacerate or apically bilobed. Ligules 8−13 x 2.2−2.8 mm, white. Disc flowers 1.8–2.3 mm long, corolla lobes and throat yellow, with a single verruciform apical gland, corolla tube whitish (Fig. 1D). Cypselae 1.8−2.2 × 0.7−1.1 mm, distally wider – 0.8−1.1 mm, occasionally slightly constricted just below the corona, base truncate, 0.7−0.8 mm wide (Fig. 1E-F, Annex 2). Immature fruits whitish, gradually and irregularly darkening to dark brown or blackish during maturation (Fig. 1D). Abaxial surface reticulate, with two yellowish, oval glands at the base of the corona. Adaxially 3-ribbed, the lateral ribs narrower than the median one. Cypselae mucilaginous (Annex 2, Fig.1s D). Corona (pappus) 0.4–0.7 mm long, 1/3–1/4 as long as the cypsela body, translucent, whitish or brownish, usually

with one median lobe, seldom trilobed or entire (not lobed). Median lobe obtuse, free (divided to its base), broadly obovate, its margins irregularly undulate. Flowering period: April and May. 2*n*=2x=18, 4x=36 [samples originates from Bolu, NW and Rize, NE Turkey respectively] (Inceer & Beyazoglu 2004; Inceer & Hayirlioglu-Ayaz 2010).

Distinction of morphologically similar taxa

Tripleurospermum rosellum is morphologically similar to *T. oreades* and *T. caucasicum* (Enayet Hossain 1975), both of which have recently been considered as conspecific (POWO 2021; Greuter 2021), and with controversial taxonomic value. We here accept their specific distinctness, using several characters for their discrimination (Table 1).

The Greek and Bulgarian material studied possess glands at the tip of disk corolla lobes; the corona of cypselae is usually lobed, with obtuse, obovate lobes; the median cypsela rib is distinctly broader than the lateral ones; all these features are typically present in *T. rosellum*. Therefore, we conclude that the Bulgarian and Greek collections initially reported as *T. oreades* (Strid & Lassen 2000) are better treated as *T. rosellum* var. *album*.

To our knowledge, the only references for the occurrence of this taxon in European Turkey are from Gökçeada island (Seçmen & Leblebici 1978; Inceer & Hayırlıoğlu-Ayaz (2014). Here, we confirm the presence of the species on the mainland of European Turkey based on material collected in the Istanbul area (*B. Davidoff* , SOM 79928, sub *Chamaemelum inodorum* (L.) Vis, Annex 1).

In Bulgaria, *T. rosellum* has been misidentified as *T. inodorum*, *T. tenuifolium* or *T. caucasucum* (Annex 1), so here we present an updated key to ease the identification of the representatives of the genus in Bulgaria.

Key to the Bulgarian species of *Tripleurospermum*

1 Capitula discoid ..... ***T. disciforme***
1*. Capitula radiate **2**
2 Plants annual or biennial **3**
2* Plants perennial **4**
3 Plants annual; cypselae obpyramidal, abaxially rugose, corona short ..... ***T. inodorum***
3* Plants biennial; cypselae obovoid-oblong, abaxially smooth or rugulose, corona absent ..... ***T. tenuifolium***
4 Stem branched; corona of cypselae short, truncate; species of saline costal habitats ..... ***T. anchialense***
4* Stem simple; corona of cypselae large, lobed **5**
5 Capitula up to 35 mm in dia.; lobs of disc flowers glandular; corona lobs obtuse-obovate, cypselae mucilaginous; species of ruderal or semi-ruderal habitats, at up to 400 m of elevation ..... ***T. rosellum***
5* Capitula usually larger than 35 mm in dia.; lobs of disc flowers eglandular; corona lobs acute, cypselae devoid of mucilage; species of subalpine or alpine meadows, above 1500 m of elevation ..... ***T. caucasicum***

Distribution and habitat in Bulgaria

Tripleurospermum rosellum has not been reported previously from the territory of Bulgaria (Kuzmanov 2012; Stoyanov & al. 2021). The revision of herbarium materials of

Table. 1. Comparative characters of three morphologically related species of *Tripleurospermum*, based on personal observations or extracted from the following references: (Boiss 1875; Enayet Hossain 1975; Pobedimova 2000; Kuzmanov 2012; Inceer & al. 2012; Dimopoulos & al. 2021; Danin & Fragman-Sapir 2021; GBIF 2022).

Character/species	*T. rosellum*	*T. oreades*	*T. caucasicum*
Habitus	Caespitose perennial	Caespitose perennial	Rhizomatous perennial
Stem leaf arrangement	Stem usually leafy in lower half only	Stems usually leafy for more than 1/2 of its length	Stem usually leafy in lower half only
Indumentum	Plants glabrous or subglabrous	Usually apressed-pubescent	Glabrous or subglabrous
Capitula size	Capitula medium-sized, up to 35 mm in dia.	Capitula medium-sized, up to 35 mm in dia.	Capitula usually large, 35 – 50 mm in dia.
Outher involucral bracts	Oblong-triangular or subspatulate, margins broad, usually pale brown	Acutely triangular, margins moderately broad, brown	Oblong-triangular, margins broad, dark brown or blackish
Ligules	White or pale pink	White	White
Lobes of disc flowers	Glandular-tipped	Eglandular	Eglandular
Corona of cypselae/cypsela body length ratio	1/3 – 1/4	1/3 – 1/4	1/2 – 1/3
Corona morphology	Lobate, lobes obtuse, obovate, white-translucent	Lobulate, lobes obtuse-triangular, white-translucent	Deeply 3-lobed, lobes acute; margins toothed, brown, entirely or distally
Ribs	Median rib broader than lateral ones	Ribs more or less equal in width	Ribs more or less equal in width
Mucilaginous cells	Present	Present	Absent

the genera *Tripleurospermum*, *Matricaria*, and *Chamaemelum* kept in Bulgarian herbaria (SO, SOM and SOA) has shown that the taxon has been collected repeatedly in the past 80 years, but was apparently misidentified (Annex 1).

In the country, the species so far has been recorded only in the East Rhodope Mts. (Fig. 2), a region with established phytogeographical connections with the eastern Mediterranean and Aegean areas through the valleys of the Arda and Maritza rivers.

The region is influenced by transitional Continental-Mediterranean climate (Velev 2002). Mean annual temperatures for the different localities ranges from 12.0°C to 13.3°C, while the average temperature for January exceeds 0°C in all know sites of the taxon. Annual precipitation ranges from 640 to 900 mm, with maximum precipitation in December.

In all Bulgarian sites, the species displays ruderal behavior. It was found on eroded slopes and bare ground, on roadsides, field margins, in overgrazed pastures, in grassland or scrub communities of low density, and open thermophilous woodlands mostly of deciduous oaks or pine groves, in xeric to xero-mesic conditions, at up to 400 m of elevation. It was most often observed in sunny locations or in the sunniest spots of scrub or woodland.

The substrates were mostly siliceous, on ground trampled by sheep herds or compacted by vehicle traffic.

T. rosellum var. *album* typically participates in communities with numerous annual species; such as *Myosotis ramosissima* Rochel, *Aphanes arvensis* L., *Crepis sancta* (L.) Bornm., *Vicia sativa* L., *Helianthemum salicifolium* (L.) Mill., *Ornithopus compressus* L., *Psilurus incurvus* (Gouan) Schinz & Thell., *Moenchia mantica* (L.) Bartl., and *Geranium columbinum* L. Among the associated perennial grasses are: *Poa bulbosa* L., *Chrysopogon gryllus* (L.) Trin., *Achnatherum bromoides* (L.) P. Beauv., *Bothriochloa ischaemum* (L.)

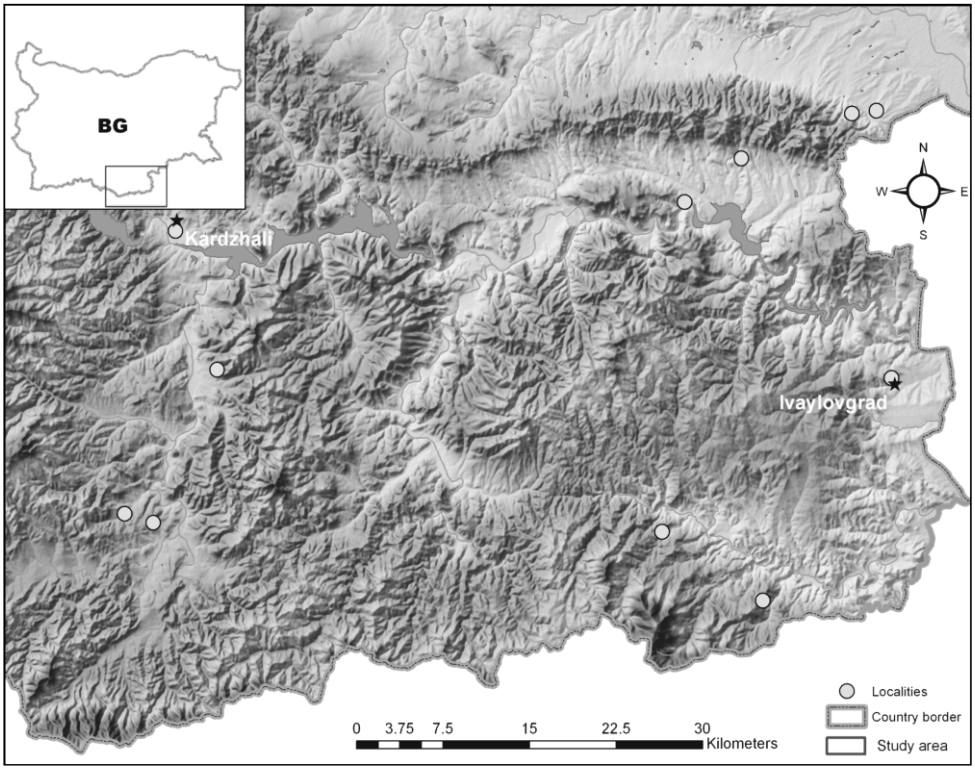

Fig. 2. Distribution of *Tripleurospermum rosellum* in Bulgaria. Map design by Gabriela Petrova.

Keng, *Avenula pubescens* (Huds.) Dumort., and *Agrostis castellana* Boiss. & Reut.. On rare occasions, the species has been observed in open scrub communities or sparse woodlands with *Juniperus communis* L., *J. deltoides* R. P. Adams, *Genista rumelica* Velen., *Cistus creticus* L., *Quercus frainetto* Ten., *Q. dalechampii* Ten. *Q. pubescens* Willd. and *Pinus nigra* J. F. Arnold.

In Bulgaria, *T. rosellum* could be observed only for a short period between end of April and mid-May. For this reason and because of its superficial resemblance with other *Anthemideae* (e.g. *Anthemis cretica* L., *Anthemis rumelica* (Velen.) Stoj. & Acht.), the species was probably overlooked until now.

Conclusion

Tripleurospermum rosellum is here added to the Bulgarian flora as a native species. Particularly, in Greece, it is replacing *T. oreades* with which it had been confused. In Bulgaria it is represented only by its white-ligulate variety. In the country, it is documented up to now only from the East Rhodope Mts. Since the taxon was registered in about ten relatively distant localities with several tens to several hundred individuals and it is more or less ruderal with the ability to produce abundant number of seeds, we consider that at present it does not require any conservation measures. Based on the revision of herbarium collections, the taxon is confirmed also for the territory of Northeast Greece and continental European Turkey. We assume that it is more widespread on the territory of Bulgaria, but was probably overlooked, due to its short flowering period, misinterpretation, and gaps in floristic sampling.

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The authors are grateful to prof. Huseyin Inceer, Karadeniz Technical University, for useful comments on the identity of Bulgarian materials of *Tripleurospermum rosellum* var. *album*. We also owe thanks to prof. Arne Strid for providing samples of his Greek collections identified as *T. oreades* for study and comparison. Thanks are due to prof. Rossen Tzonev, Sofia University, prof. Ali Kavgaci, Karabuk University, and Dr Salza Palpurina, Department of Botany at NMNHS for providing some of the reference cited here.

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Annex 1.
List of examined specimens

Tripleurospermum rosellum (Boiss. & Orph.) Hayek
Bulgaria:
1. In graminosis prope urbem Mastanli (Momchilgrad) in m. Rhodope orientalis, 6.05.1938, N. Stojanoff (**SO** 75602, sub *Matricaria inodora* L.);
2. East Rhodope Mts., in the shrubs on the slopes above Mezek village, 5.05.1940, *B. Kitanov* (**SO** 75629, sub *Matricaria trichophylla* Boiss.);
3. In abandoned fields, close to Borislavtsi village, Haskovo Province, East Rhodope Mts., 16.05.1980, *D. Delipavlov* (**SOA** 38461, 38462 sub *Matricaria perforata* Mérat);
4. In the field of the "Complex experimental station" Kardzhali, 25.04.1980, *D. Delipavlov* (**SOA** 43259, 43260 sub *Matricaria perforata* Mérat);
5. West side of the main ridge, southeast exposition, Ivaylovgrad Municipality, 13.04.1988, *M. Genovski* (**SOM** 154996, sub *Tripleurospermum* af. *caucasicum* (Willd.) Poir.);
6. East Rhodope Mts., N from the entrance of the Thracian Tumulus at Mezek, at a side of a dirt road, 165 m, 41.73677°N, 26.10172°E, 12.05.2019, *G. Kunev* (**SO** 108125, **SOM** 177475);
7. East Rhodope Mts., N from Malki Voden, on a dirt road through a forest of *Quercus frainetto*, 280 m, 41.69895°N, 25.96137°E, 17.05.2020, *G. Kunev* (**SOM** 177476);
8. East Rhodope Mts., E from Kazak, Haskovo Province, in pasture at the side of the road, 400 m, 41.41160°N, 25.88371°E, 4.05.2021, *G. Kunev* (**SO** 108123);
9. East Rhodope Mts., E from Karchovsko, Kardzhali Province, eroded place at the side of a dirt road, 415 m, 41.41207°N, 25.35591°E, 13.05.2019, *G. Kunev* (**SO** 108124);
10. East Rhodope Mts., W from Borislavtsi, Haskovo Province, side slope of road embankment, 213 m, 41.66493°N, 25.90287°E, 12.05.2019, *G. Kunev* (**SO** 108126);
Turkey:
11. In campis sirca Constantinopolem: ad stationem Bijuk–Han, 2.05.1913, *D. Davidfoff* (**SOM** 79928, sub *Chamaemelum inodorum* (L.) Vis.);
Greece:
12. In monte Malevô Laconiae prope Hagios Petros, rarissime, alt. 3000' (915m), April-May 1857, *Theodoros G. Orphanides* 778 (isotype, **BR** 0000005533459, sub *Chamaemelum oreades* Boiss.,

photo!), also isotypes examined as photos!: **K** 000929379, 000929380, 000929381; **E** 00385814; **WU** 0076323; **P** 03723155; **JE** 00017345; **G** 00764361, 00764362;

13. Thrace, Nomos of Evros, Eparchia of Souflion: 17.5 km from Dadia along the road to Loutros, serpentine, open, gravelly patches and small stream in deciduous oak woodland, 400 m, 41°06'N, 26°06'E, 7.5.2000, *Strid* & *Lassen* 50427 (collection represented in **B**, **G**, **LD**, herb. *A. Strid*, herb. *Kit Tan*, sub *Tripleurospermum oreades* (Boiss.) Rech. f.).

Tripleurospermum oreades (Boiss.) Rech.f.

Turkey:

14. In Monte Tauro, Aestate 1836, *Th. Kotchy* 296 (isolectotype, **G** 00764344, photo!); also isolectotypes examined as photos!: **K** 000929384, 00092935, 000929386

Annex 2.

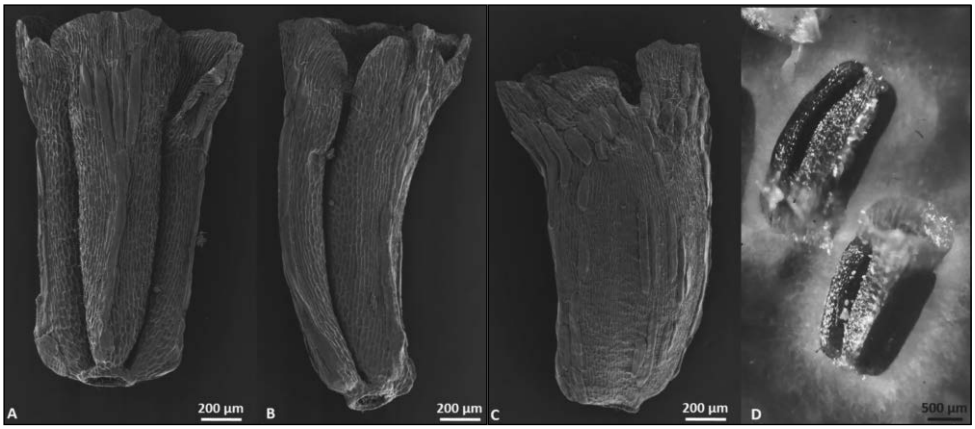

Fig. 1s. SEM morphographs (A, B and C) and photographs (D) of cypselae of *Tripleurospermum rosellum* from East Rhodope Mts., Bulgaria. Features as lobate corona with obtuse-obovate lobs, truncate base, broad median rib, reticulate surface, and mucilaginous cells are all well represented on the morphographs. Mucilage envelope stained with iodine in pale orange (D), photographed under stereomicroscope (×4).

Article

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https://doi.org/10.7320/FlMedit33.049
Version of Record published online on 20 March 2023

Duilio Iamonico & Gianniantonio Domina

Studies on the genus *Atriplex* (*Chenopodiaceae*) in Italy. VIII. Names published by Vincenzo Tineo and Michele Lojacono-Pojero

Abstract

Iamonico, D. & Domina, G.: Studies on the genus *Atriplex* (*Chenopodiaceae*) in Italy. VIII. Names published by Vincenzo Tineo and Michele Lojacono-Pojero . — Fl. Medit. 33: 49-59. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

The typification of the *Atriplex* names published by Vincenzo Tineo and Michele Lojacono-Pojero is discussed. *Atriplex ambigua*, *A. dealbata*, *A. graeci*, *A. halimoides*, *A halimoides* var. *glomerata*, *A. halimoides* var. *perglauca*, *A. polyphylla*, and *A. ratundifolia* are neo- or lectotypified on specimens preserved at FI or PAL and synonymized with *A. glauca* (= *A. dealbata*), *A. halimus* (= *A. halimoides* = *A. halimoides* var. *glomerata* = *A. halimoides* var. *perglauca*), *A. rosea* (= *A. ambigua* = *A. graeci*) and *A. tornabenei* (= *A. polyphylla* = *A. rotundifolia*). The Tineo's *A. arenaria*, previously considered as replaced synonym of *A. tornabenei*, is clarified and typified (neotype) on a specimens deposited at FI.

Key words: *Atriplex halimus*, *Atriplex rosea*, nomenclature, new synonymy, typification.

Introduction

Atriplex L. (*Chenopodiaceae* Vent.) includes about 260 species distribuited in arid and semi-arid regions of Eurasia, America, and Australia (Sukhorukov & Danin 2009). According to Kadereit & al. (2010) the majority of *Atriplex* taxa are to be considered as part of a monophyletic clade, including *Obione* Gaertn., *Teutliopsis* (Dumort.) Čelak., and other segregates.

As part of ongoing studies on the genus *Atriplex* (see e.g., Iamonico 2010, 2011, 2012a, 2012b, 2013, 2017; Iamonico & Sukhorukov 2014; Iamonico & El Mokni 2019; Iamonico & Bovio 2023) and on the typification of Lojacono-Pojero's names (Aghababyan & al. 2008; Domina & al. 2014a; Di Gristina & al. 2017), this contribution deals with the names of *Atriplex* taxa described by Tineo (1827) in his *Catalogus Plantarum Horti Regii Panormitani* and by Lojacono-Pojero (1907) in his *Flora Sicula*.

Materials and methods

The paper is based on an extensive analysis of literature, and examination of the specimens preserved in the Herbaria FI, G, K, LECB, LINN, NAP, P, PAL, RO, and W

(acronyms according to Thiers 2023 [continuously updated]). The taxonomic revision is based on the morphology of the investigated specimens.

The articles cited throughout the text are those of the *Shenzhen Code*, hereafter reported as "ICN" (Turland & al. 2018).

Typification of the names

Atriplex ambigua Lojac., Fl. Sicul. (Lojacono) 2(2): 286. 1907.

Lojacono-Pojero (1907: 286) described *Atriplex ambigua* through a detailed diagnosis, also reporting the habitat and provenance ("Luoghi marittimi, Trapani" = "Maritime places, Trapani [NW Sicily]"); moreover, morphological comparisons with *A. laciniata* L. and *A. platysepala* Guss. were given. By implication, this refers to material collected by Lojacono himself.

We traced at PAL one folder bearing (bottom-right corner) the following original label (Lojacono-Pojero's handwriting): "Atriplex, ambigua Lojac. | mihi | pro nomine ubi". This folder includes seven mounted specimens (PAL58450, PAL58451, PAL58452, PAL58453, PAL58454, PAL58455, and PAL58456; images available at http://147.163.8.207/herbarium_vsimple_en.asp). No date of collection or locality are mentioned on the individual specimens; nonetheless, it is reasonably certain that all these plants were collected before 1907, because later on Lojacono-Pojero did not deposit any material in PAL, as he subsequently moved to Messina (Domina & al. 2014b). So, these specimens can be considered original material. This agrees with the opinion of Aghababyan & al. (2008), who considered as original material the specimens housed in PAL with Lojacono's handwriting even in the absence of a date. According to the Art. 8.3 of ICN (Ex. 9) the above montioned sheets can be considered as a single specimen and they are here designated as the lectotype of the name *Atriplex ambigua*.

The taxonomic identity of *Atriplex ambigua* is complex. In fact, none of the Lojacono-Pojero's material bears mature fruits, a feature (especially the kranz-anatomy of the bracteoles) that is important for the reliable identification of *Atriplex* species (see, e.g., Castroviejo 1990; Akeroyd 1993; Iamonico 2017). Giardina & al. (2007: 59), in their catalogue of Sicilian plants, listed *Atriplex ambigua* as a distinct species but express taxonomic "doubt, perhaps close to *A. laciniata*"; on the other hand, The Plant List (2013a) and POWO (2023a) reported *A. ambigua* as, respectively, an "unresolved name" and an "unplaced name". Note that the Linnaean name *A. laciniata* was incorrectly interpreted by most Italian authors and the Italian concept of this species is included in the current *A. tatarica* group *sensu* Uotila (2011), particularly in *A. tatarica* L. (see e.g., Iamonico & Sukhorukov 2014; PFAI 2023+). This groups includes, for Italy, *A. tatarica*, *A rosea* L., and *A tornabenei* Guss., which are herbaceous annuals with fruiting bracteoles of triangular or rhombic shape, fused for up to one half of their length (Iamonico 2017). On the basis of protologue information and the morphology of the extant PAL specimens, *A. ambigua* is an annual herbaceous species, placed by Lojacono-Pojero (1907) in the informal group "*Herbaceae*", with fruiting bracteoles transversely rhombic (width > lenght), smooth, with obsolete reticulate veins, entire or scarcely dentate margins, with prominent laciniae (original description: "sepalis fruct. ... *laevibus obsolete nerv.-reticulatis integris, magis latis*

quam longis late rhombeis integerrimis rarius parcissime subdentatis auriculas satis productis prominulis ...”), and with flowers grouped in glomerules arranged in in terminal, basally leafy spikes (“*Fruct. in spica termin.* [terminali]” in the description of the group “*Herbaceae*”). This combination of characters, especially the size of the fruiting bracteoles and inflorescenc structure (axillary glomerules and terminal leafy spikes) allows us to identify *A. ambigua* as *A. rosea* as currently understood (see e.g., Iamonico & Sukhorukov 2014; Iamonico 2017). Since no earlier citation of *A. ambigua* as a synonym of *A. rosea* was found, we here consider a new synonymy.

Atriplex arenaria Tineo, Cat. Pl. Hort. Panorm.: 276. 1827. (*A. tornabenei (‘tornabeni’)* Guss., Fl. Sicul. Syn.: 589. 1843.

Tineo (1827: 276-277) for his newly proposed species *Atriplex arenaria* provided a diagnosis, the provenance (“*Crescit in maritimis arenosis Cataniae*: nella Rina di Catania”), and the flowering and fruiting times (“*Floret et fructificat Septembri, Octobri*”). Tineo’s name is a later homonym of the previously validly published *A. arenaria* Nutt. (Nuttal 1818) and is therefore illegitimate (Art. 53.1 of ICN). Gussone (1843: 589) proposed the name *A. tornabenei* providing a description and reporting Tineo’s illegitimate *A. arenaria* as a synonym. Iamonico (2013: 54-55, 57) discussed Gussone’s name and lectotypified *A. tornabenei* using a Cupani’s illustration (“T. III” *Atriplex marina minor supina lanceolato foliola incano semine tricuspide alata*) published in *Panphyton Siculum* (Cupani 1713; see Iamonico 2013: fig. 1) since no specimens of original material are in extant; Cupani’s illustration was designated as a lectotype for both *A. tornabenei* and *A. arenaria*, which were considered by Iamonico (2013) as homotypic synonyms (*A. tornabenei* as *nomen novum* of Tineo’s *A. arenaria* non Nuttal). Iamonico (2013) also designated an epitype using a specimen preserved at FI (barcode FI002557) collected by V. Tineo at Catania. However, since Tineo (1827: 276-277) did not cite Cupani (1713) in the protologue, Iamonico’s lectotype cannot be retained for Tineo’s name (Cupani’s illustration is not part of the original material for *A. arenaria*) and a different type should be designated. No original material for *A. arenaria* was found and, according to the Art. 9.8 of ICN, a neotypification is required. We designated FI002557 as the neotype of Tineo’s name *A. arenaria*, being the only found specimen collected by V. Tineo at Catania (*locus classicus* of *A. arenaria*).

Atriplex dealbata Lojac. Fl. Sicul. (Lojacono) 2(2): 280. 1907.

Lojacono-Pojero (1907: 280) provided a detailed diagnosis and stated “In Sicilia in Herb. Pan.” [Herbarium Panormitanum] where he must have used at least one specimen previously identified as *Atrilpex littoralis* (“...pro *A. littorale*! determinata”).

One specimen, deposited at PAL (PAL58541), bears some parts of one plant and the following label: “*Atriplex littorali | fila 11 posto 9*”. Even though both the locality and the date of collection are lacking on the label, note that Lojacono-Pojero (1907: 281) in the protologue of *Atriplex dealbata* stated “in Herb. Pan. (*s. nom. nec indicatione loci spec.*) a manu Auctoris mihi ignotus pro *A. littorale*! determinata”. This specimen was seen by Lojacono-Pojero, who revised the entire herbarium in Palermo to compile his “Flora Sicula”, we considered PAL58541 as part of the original material for *A. dealbata* and, being the single specimen referred to in the protologue (syntype; Art. 9.6 of ICN), desig-

nate it as the [obligate] lectotype (perhaps even the holotype, Art. 9.1 of ICN). On the basis of the morphology of that specimen, as well as the description given by Lojacono-Pojero (1907), *A. dealbata* is a perennial, suffruticose plant woody at the base, with branches glabrous to furfuraceous, leaves alternate, linear to oblong-elliptic, with entire margins, flowers arranged in dense glomerules or spikes, fruiting bracteoles triangular-rhombic, warty and with denticulate margins. This combination of characters agrees with *A. glauca* especially concerning the shape of the fruiting bracteoles which is diagnostic for this species in comparison with the related *A. halimus* [Giardina & al. (2007: 57-58) treated *A. dealbata* as a synonym of *A. littoralis*, but *A. littoralis* differs being an annual herb (see e.g., Akeroyd 1993; Iamonico 2017); The Plant List (2013b) and POWO (2023a) treated *A. ambigua* as, respectively, an "unresolved name" and an "unplaced name"]. Note that Lojacono-Pojero (1907: 279-281) did lot listed *A. glauca* among the shrubby taxa, which were: *A. halimus* (currently an accepted species), *A. halimoides* (= *A. halimus* s. str.; see the taxonomic treatment in the present paper), *A. dealbata*, and *A. bocconei* Guss. (= *A. glauca* according to Iamonico 2011).

Atriplex graeci Tineo, Cat. Pl. Hort. Panorm.: 277. 1827.

Tineo (1827: 277) provided a detailed diagnosis, as well as mentioning the habitat ("*Crescit in pratis arillosis, ad vias*"), the provenance ("*prop*e *Panormum*; nel piano della Consolazione, nei Colli"), and the phenology ("*Floret, fructificat Augusto, Septembri*").

There is a specimen at PAL (PAL58483), where Tineo's herbarium is preserved (Stafleu & Cowan 1986: 365; HUH Index of botanists 2013 onwards), bearing one plant with leaves and fruits and the following original label: "*13 7bre* [September] *1827* | *Atriplex Graeci Nob.* [Nobis] | *Atriplex rosea Guss. Syn.* | *Palermo Colli*". This specimen is clearly part of the original material used by Tineo (1827: 277) to describe *Atriplex graeci*. We also traced two further sheets (PAL58486 and PAL58489) including labels with localities cited in the protologue, i.e., respectively, "*Consolazione*" (plus the month of collection, "*luglio*" = July) and "*Colli*". Since the year of collection is lacking, we cannot be sure that these plants were collected before 1827. However, at least the specimen PAL58489, collected at "*Colli*", could be a duplicate of PAL58483, and Tineo could have reported the locality only [Piana dei Colli, generically referred to as "Colli"]. We here designated PAL58483, which morphologically matches Tineo's diagnosis, as the lectotype of the name *Atriplex graeci*. According to the current opinion (see e.g., Akeroyd 1993; Sukhorukov 2006; Iamonico 2017), *A. graeci* can be synonymized with *A. rosea*.

Atriplex halimoides Tineo, Cat. Pl. Hort. Panorm.: 277. 1827.

This species was validly published by Tineo (1827: 227) who provided a diagnosis, mentioned the provenance ("*Crescit in inundatis prope Catanam*; nella Piana"), the phenology ("*Floret, et fructificat Augusto, Septembri*"), and the statement "Affinis *A. roseae*, sed certe diversa".

Two pertinent specimens were found at PAL (PAL58502 and PAL58500), both bearing branches of plants with leaves and fruits. PAL58502 was collected at "*Piana di Catania, Oct.* [October] *1826*" according to the original label by Tineo and it is part of the original material for the name *Atriplex halimoides*. PAL58500 includes a label "*Agosto* | *Atriplex halimoides Tin* | *Catania*", without the collection year. We prefer to designate PAL58502

as the lectotype of *A. halimoides* because it certainly belongs to the original material and is more complete than PAL58500. The lectotype can be identified as *A. halimus* as currently circumscribed (see e.g., Akeroyd 1993; Sukhorukov 2006; Iamonico 2017).

Atriplex halimoides var. ***glomerata*** Lojac., Fl. Sicul. (Lojacono) 2(2): 280. 1907. and ***A. halimoides*** var. ***perglauca*** Lojac., Fl. Sicul. (Lojacono) 2(2): 280. 1907.

These two varieties were described by Lojacono-Pojero (1907: 280) by the following short diagnoses and provenances: "Ramis floriferis abbreviatis spicis *densioribus*, *tortuosis dense glomeratis* Trapani" (var. *glomerata*), and "udinque *farinosa*, *pulverulenta*, *viridi glauca aenea.* Ubi? Herb. Pan. !" (var. *perglauca*).

Concerning *Atriplex halimoides* var. *glomerata* one specimen is deposited at PAL (PAL58505), with the following label: "*Trapani*" [Todaro's handwriting], "*A. halimoides Tin. var.*" [Lojacono-Pojero's handwriting]"). Todaro's annotation is earlier than that by Lojacono-Pojero who accepted the Todaro's identification as *Atriplex halimoides*, but specified that the plant is referred to a variety. PAL58505 lacks the date of collection but with certainty, as it belongs to Tineo's herbarium and was seen by Lojacono-Pojero who reviewed the entire herbarium of Palermo during the preparation of his Flora Sicula. PAL58505, matches the diagnosis; it is the best possible, if not the only, candidate as lectotype of the name *Atriplex halimoides* var. *glomerata*. This specimen is idenfiable as *A. halimus* (see, e.g., Akeroyd 1993; Sukhorukov 2006; Iamonico 2017).

Under the name *A. halimoides* var. *perglauca*, there is at PAL one folder labelled: "R. [Regio] ORTO BOTANICO DI PALERMO | *Atriplex halimoides Tin. var. perglauca mihi | majo ubi? Sicilia! | impossibile determinare senza frutto*". The folder includes three specimens (PAL58496, PAL58497, and PAL58498) associated to the following. Despite the fact that the date of collection is lacking, the annotation "*mihi*" allows to consider it as [part of?] the original material for the name *Atriplex halimoides* var. *perglauca*. These PAL sheets, which are part of the same specimen (see Art. 8 Ex. 9 of ICN), matches the Lojacono-Pojero's diagnosis and are here designated as the lectotype of the name *Atriplex halimoides* var. *perglauca*. They are identifiable as *A. halimus* (see e.g., Akeroyd 1993; Sukhorukov 2006; Iamonico 2017).

Atriplex polyphylla Lojac., Fl. Sicul. (Lojacono) 2(2): 282. 1907.

Lojacono-Pojero (1907: 282) described *Atriplex polyphylla* in detail and given the provenance ("Arene del littorale occident., Trapani" = Sands of the western shore, Trapani). Lojacono-Pojero's name is illegitimate, being a later homonym of *A. polyphylla* Phil. (Art. 53.1 and 53.2), published 16 years earlier (Philippi 1891: 73). No specimens that might be considered as original material can be found in the PAL.

Concerning the identity of *Atriplex polyphylla*, by examining the protologue, note firstly that the author placed the name subsequent to "*A. tornabenei* Tin. (ex p.)". Moreover, he stated (at the end of the treatment): "Questa pianta ... credo non deve confondersi colla vera *A. tornabenei* ..." (= This plant, I believe, is not to be confused with true *A. tornabenei* ..."). So, it appears that Lojacon-Pojero's notion of *A. polyphylla* comes close to that of *A. tornabenei*. When comparing the descriptions of these two species in *Flora Sicula*, one finds only two clear differential characters, viz.: the leaf margin ("Foliis...integerrimis" in *A. polyphylla* vs. "parce angul-dent. subintegris"

in *A. tornabenei*) and the number of flowers per glomerule ("Glomeruli fructiferi 2-5-flor." vs. "Flo. axillar. ... subsolitariis"). However, according to the current opinion (see e.g., Castroviejo 1990; Iamonico 2013, 2017), the margins of the leaf blades in *A. tornabenei* vary from entire to irregularly sinuate-lobed, whereas the number of flowers per glomerule is 2 to 5. By consequence, we consider Lojacono-Pojero's notion of *A. polyphylla* as as currently included in *A. tornabenei*.

Atriplex rotundifolia Lojac., Fl. Sicul. (Lojacono) 2(2): 286. 1907.

Lojacono-Pojero (1907: 282), after the detailed description, reported several localities ("Luoghi arenosi della parte Orient., Vaccarizzo", "Siracusa alle saline", and "Girgenti, d'Orlando") where the plants were collected by V. Tineo ("Tin").

We found two specimens identified as *Atriplex rotundifolia* at PAL: PAL58631 and PAL58697. PAL58631 includes one plant (with leaves and fruits) collected by Lojacono, with the original label "*Atriplex rotundifolia Lojac. mihi* | *Sicilia*". However, since label data and protologue information do not coincide, we consider this specimen as unsuited for lectotypification purposes. Even so, PAL58631 can serve to illustrate Lojacono'Pojero's notion of *Atriplex rotundifolia.* It is identifiable as *A. tornabenei* as currently understood (see e.g., Castroviejo 1990, Iamonico 2013, 2017). Concerning the second specimen (PAL58697), it was collected by N. Citarda at "*Girgenti*" (currently Agrigento, a city of SW-Siciliy), which is one of the localities cited by Lojacono-Pojero (1907: 282) in the protologue.

In the protologue of *Atriplex rotundifolia* (Lojacono-Pojero 1907) includes "*A. Tornabenei* Tin. pr. parte", and at the end of the species treatment, he added: "La descrizione di Tin. abbraccia chiaramente tanto la vera *A. Tornabenei* che questa che descrivo sotto un nome mio" (= "Tineo's description clearly encompasses both real *A. tornabenei* and this one, which I here describe under a name of mine"). Lojacono-Pojero (1907) accepted to recognize *A. tornabenei* (species no. 5 in his *Flora Sicula vs*. no. 4 for *A. rotundifolia*). His descriptions of *A. rotundifolia* and *A. tornabenei* differ in a single point only, viz. the shape of cauline leaves which are "subconformibus [± similar to the basal leaves, described as suborbicular with a truncate base to oblong-ovate with large marginal lobes]" in *A. rotundifolia*; but oblong-lanceolate in *A. tornabenei*. In other respects (habit, inflorescence, and flowers) both species are described in equal or near equal terms. The specific epithet *rotundifolia* chosen by Lojacono-Pojero (1907) refers to leaf shape. However, according to current concepts (see, e.g., Castroviejo 1990; Iamonico 2013, 2017), the leaf shape in *A. tornabenei* varies from ovate to lanceolate and rhombic to deltate, with margins entire to irregularly sinuate-lobed. By consequence, we include *A. rotundifolia* in *A. tornabenei* [Giardina & al. (2007: 57-58) listed *A. rotundifolia* as a synonym of *A. tatarica*, whereas The Plant List (2013d) and POWO 2023d) treat *A. ambigua* as, respectively, an "unresolved name" and an "unplaced name"].

All things considered, we here designate the specimen PAL58631 as the lectotype of the name *Atriplex rotundifolia* and synonymze this name with *A. tornabenei*.

Taxonomic treatment

Atriplex glauca L., Cent. Pl. 1: 34. 1755.

Lectotype (designated by Castroviejo 1987: 474): [icon] *Atriplex maritima Hispan. frutescens and procumbens Tourn.*" in Dillenius (1732: 46, t. 40, f. 46); image of the lectotype available at https://bibdigital.rjb.csic.es/viewer/10700/?offset=#page=94 &viewer=picture&o=bookmark&n=0&q=

= *Atriplex dealbata* Lojac., Fl. Sic. 2(2): 280. 1907.

Lectotype (designated here): ITALY, s.l., s.d. (sub *Atriplex littoralis*), *s. c. s. n.* (PAL58541!; image of the lectotype available at http://147.163.8.207/zoomify/view_img.asp?ic=58541).

Atriplex halimus L., Sp. Pl. 2: 1052. 1753 ≡ *Chenopodium halimus* (L.) Thumb., Prodr. Pl. Cap.: 48. 1794 ≡ *Schizotheca halimus* (L.) Fourr., n.s., Ann. Soc. Linn. Lyon 17: 143. 1869.

Neotype (designated by Brenan in Turril & Milne-Redhead 1954: 14): Herb. Linn. No. 1221.1 (LINN!); image of the lectotype available at http://linnean-online.org/10762/.

= *Atriplex halimoides* Tineo, Cat. Pl. Hort. Panorm.: 277. 1827.

Lectotype (designated here): ITALY, Piana di Catania, 10/1826, *V. Tineo s. n.* (PAL58502!); image of the lectotype available at http://147.163.8.207/zoomify/view_img.asp?ic=58502

= *Atriplex halimoides* var. *glomerata* Lojac., Fl. Sic. 2(2): 280. 1907.

Lectotype (designated here): ITALY, Trapani [manu Todaro], s. d., *s. c. s. n.* (PAL58505!); image of the lectotype available at http://147.163.8.207/zoomify/view_img.asp?ic=58505

= *Atriplex halimoides* var. *perglauca* Lojac., Fl. Sic. 2(2): 280. 1907.

Lectotype (designated here): ITALY, Sicilia, s. d., *M. Lojacono-Pojero s. n.* (PAL58496!, PAL58497!, and PAL58498!); image of the sheet (single specimen according to the Art. 8.2-Ex.9 of ICN) available at http://147.163.8.207/herbarium_vadv_en.asp.

Atriplex rosea L., Sp. Pl., ed. 2, 2: 1493. 1763 ≡ *Chenopodium roseum* (L.) E. H. L. Krause, Deutschl. Fl., ed. 2, 5: 183. 1901.

Neotype (designated by McNeill & al. 1983: 553): Herb. Haller, "Semen a Zinnio sub nomine Atriplex seminis capsula aculeata" (P-HA).

= *Atriplex graeci* Tineo, Cat. Pl. Hort. Panorm.: 277. 1827.

Lectotype (designated here): ITALY, Palermo, Colli, 13/09/1827, *V. Tineo s. n.* (PAL58483!); image of the lectotype available http://147.163.8.207/zoomify/view_img.asp?ic=58483

= *Atriplex ambigua* Lojac., Fl. Sic. 2(2): 286. 1907, ***syn. nov.***

Lectotype (designated here): ITALY, Sicily, s.d., *M. Lojacono-Pojero s.n.* (PAL58450!, PAL58451!, PAL58452!, PAL58453!, PAL58454!, PAL58455!, and PAL58456!, images of the sheets (single specimen according to the Art. 8.2-Ex.9 of ICN available at http://147.163.8.207/herbarium_vsimple_en.asp).

Atriplex tornabenei Tin. ex Guss., Fl. Sicul. Syn.: 589. 1843 ≡ *Atriplex laciniata* var. *tornabenei* (Tin. ex Guss.) Fiori & Paol., Fl. Anal. It. 1: 306. 1896–1898 ≡ *Atriplex tatarica* subsp. *tornabenei* (Tin. ex Guss.) C. Blanché, Molero & Rovira, Butl. Inst. Catalana Hist. Nat. 51: 117. 1984.

Lectotype (designated by Iamonico 2013: 57, Fig. 1):—[Icon] *Atriplex marina minor supina lanceolato foliola incano semine tricuspide alata*, T. III in Cupani (1713).

Epitype (designatedby Iamonico 2013: 57):—ITALY, Sicily, Catania, Spiaggia, s. d. [Ex Tineo in Maggio 1847], *V. Tineo s.n.* (FI002557!); image of the lectotype available at http://parlatore.msn.unifi.it/types/search.php

= *Atriplex arenaria* Tin., Cat. Pl. Hort. Panorm.: 276. 1827 *nom. illeg. non* Nuttall (1818: 198).

Neotype (designated here):—ITALY, Sicily, Catania, Spiaggia, s. d. [Ex Tineo in Maggio 1847], *V. Tineo s. n.* (FI002557!); image of the lectotype available at http://parlatore.msn.unifi.it/types/search.php

= *Atriplex polyphylla* Lojac., Fl. Sic. 2(2): 282. 1907, *nom. illeg. non* Philippi (1891: 73).

= *Atriplex rotundifolia* Lojac., Fl. Sic. 2(2): 282. 1907.

Lectotype (designated here): ITALY, Sicilia, s. d., *M. Lojacono-Pojero s. n.* (PAL58631!); image of the lectotype available at http://147.163.8.207/zoomify/view_img.asp?ic=58631

Selected specimens examined

Atriplex glauca. SPAIN, Murcia, Los Nietos (Mar Menor), en arenales nitrofocatos, 12 April 1984, *J. P. Peris & G. Stübimg s. n.* (FI!); *ibidem* (RO!); Alacantí, Santa Pola, matojares nitrohalófilos, 22 April 1984, *A. Aguilella & I. Mateu s. n.* (FI!). Granada, Cullar Baza, salt marsh, 22 June 1988, leg. *B. Valdés et al. s. n.*, det. *M. Watson* (FI!); ibidem, det. *P. Wilkin s. n.* (FI!); Almería, Campohermoso, S-facing limestone bank at edge of cultivated area, 17 April 1994, *S. L. Jury s. n.* (FI!); Tenerife, 15 November 1988, *S. Castroviejo 10436SC* (P01182765!). UNKNOWN COUNTRY, s.d. *P. Arduino* (LINN-1221.6!).

Atriplex halimus. ALGERIA, Biskra, in argillosis subsalsis, 24 October 1903, *L. Chevalier 613* (K000243881!). FRANCE, Bouches-du-Rhône, bordi de la Mediterraneé aux S. Marces de la Mer (Bouches du Rhone), 09 November 1882, *R. Neyra s.n.* (RO!). ISRAEL, Jordan valley, banks of Jordan near Kinnereth, 30 November 1951, *M. Zohary & A. Fahn s.n.* (RO!). ITALY, Basilicata, Pomarico, September 1883, *coll. illeg. s.n.* (RO!); Calabria, abbonda sui fianchi dei Colli pr. Crotone, lungi dal mare, 26 October 1935, *G. Lusina s.n.* (RO!); Scogliera Còrica a S di Amantea, 11 September 1975, *De Stefani s.n.* (PAL108191!); Lazio, zona litoranea presso Civitavecchia verso S. Marinella, 30 October 1980, *B. Anzalone s.n.* (RO!); Parco Nazionale del Circeo, Caprolace, October 1989, *B. Anzalone s.n.* (RO!); Liguria, Ager nicaaensis, ad marginem agrorum et in ripis torrentis Magnon, 4 October 1904, *A. Goiran & Adr. Fiori s.n.* (FI!); Marche, Ancona-Falconara, siepi, 18 July 1947, *A. Bettini s.n.* (FI!); Puglia, Gravina, 19 August 1933, *G. Carasso s.n.* (RO!); Sardegna, nelle siepi di Cagliari (inselvatichita), August (XIX sec.), *s.c. s.n.* (RO!); Sicilia, sopra le Cave vulcaniche di Catania, *s.d.* (XIX century), *s.c.* (RO!); *Catania*, *s.d.* (August), *V. Tineo s.n.* (PAL58502!, sub *A. halimoides*); Lipari, *s.d.*, *s.c.* (PAL58493!, sub *A. halimoides*);

Ustica, 1854, *s.c.* (PAL58509!; Toscana, Isola di Pianosa (Livorno), Cala Giovanna, 20 September 1999, *R. M. Baldini et L. Vivona s.n.* (FI!); Umbria, lago Trasimeno (Perugia), 23 July 1955, *F. Palombini s. n.* (FI!). PORTUGAL, Buarcos, nas muralhas, September 1888, *A. Moller s.n.* (RO!); Algarve, Portináo, Praia da Rocha, nos morros proximos da poaia, 15 September 1961, *A. Raimondo s. n.* (RO!). SPAIN, Canary Islands, Gran Canary, Jileta, 29 December 1887, *Kuntze s. n.* (K000243889!).

Atriplex rosea. CYPRUS, Limassol, zypern archäologischen Gelände des Heiligtumsder Aphrodite, 22 June 1996, *Walter 7920* (W!). ITALY, Lazio, Cerenova (Lido di Cerveteri), spiaggia, paludi, ruderi, ecc., 23 October 1977, *B. Anzalone s. n.* (RO!); Ladispoli-Cerenova, loc. Campo di Mare, September 1985, *B. Anzalone s. n.* (RO!); Sicilia, Palermo, 1847, *V. Tineo s.n.* (K000898528!), Palermo, Colli, s. d.[XIX century], *V. Tineo s. n.* (PAL58489!, sub *A. graeci*); Palermo, Consolazione, s. d. (July) [XIX century], *V. Tineo s. n.* (PAL58486!, sub *A. graeci*); Palermo, s.d., *V. Tineo s.n.* (LECB!, sub *A. graeci*); presso il semicerchio della Barchetta della Marina, September 1849, *V. Tineo s. n.* (PAL58679!, sub *A. graeci*); Sferracavallo, September 1846, *V. Tineo s. n.* (PAL58485!, sub *A. graeci*); Sicilia, *V. Tineo s.n.* (K000898529!, sub *A. graeci*). SPAIN. Madrid: Colemar de Oreja prés de Madrid, 19 September 1980, *Sag 1007* (P!).

***Atriplex tornabenei*.** ITALY, Campania, Napoli al Fusaro, Bagnoli, October 1826, *s. c. s. n.* (sub *A. laciniata*) (NAP!); Pozzuoli, August 1844, *s. c. s. n.* (NAP!); Ischia, alla marina di Casamicciola, August 1860, *G. Gussone s.n. s. n.* (NAP!); tra il Fusaro e Torre Gaveta, in arenosis maritimis, June 1912, *M. Guadagno s. n.* (NAP!); Campi Flegrei, Coroglio, September 1919, *N. Terracciano s. n.* (NAP!); Lazio, Tarquinia, Pian di Spille, spiagge, 1 m s.l.m., 01 October 2004, *M. Iocchi et F. Bartolucci s. n.* (FI!, APP!); Puglia, Bari, località Fesca a circa 100 m dalla foce del torrente Tiflis, sabbie ciottolose, 2 m s.l.m., 08 September 2011, *D. Iamonico & V. Buono s. n.* (RO!); Sicily, Mazara del Vallo, Capo Feto, Posidonia Banquettes, (WGS84: 37.659993N, 12.538759E), 1 m a.s.l., 5/11/2020, *G. Domina & G. Barone s. n.* (PAL), Palermo, Solanto, s. d. [XIX century], *V. Tineo s. n.* (NAP!), *ibidem*, July, *V. tineo s.n.* (PAL58635!), *Girgenti*, s. d. [XIX century], *N. Citarda s. n.* (PAL58697!, sub *A. graeci*).

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Une nouvelle ptéridophyte pour la flore algérienne: *Isoëtes delilei* (*Isoëtaceae*)

Abstract

Medjahdi, B. & Letreuch-Belarouci, A.: Une nouvelle ptéridophyte pour la flore algérienne: *Isoëtes delilei* (*Isoëtaceae*). — Fl. Medit. 33: 61-65. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

A new pteridophyte for the Algerian flora: *Isoëtes delilei* (*Isoëtaceae*). — In the present work we report a new pteridophyte for Algeria: *Isoëtes delilei*, a species presents in France, Spain and Portugal, and recently discovered in Morocco. This species is on the world and national red lists in the countries where it is reported. With the only one station here reported, it is certainly a critically endangered species in Algeria, needing urgent protection measures.

Key words: *Isoëtes*, temporary ponds, conservation, Western Algeria.

Introduction

La flore ptéridophytique de l'Algérie comprend 69 taxon spécifiques et infraspécifiques réparties sur 16 familles et 27 genres, plus de 75 % présente un degré de rareté plus ou moins important (Eflore Maghreb 2022). La famille des *Isoëtaceae* ne comporte qu'un seul genre. Ce dernier est représenté actuellement par 5 espèces (*Isoëtes durieui* Bory, *I. histrix* Bory, *I. gymnocarpa* (Gennari) A. Braun, *I. tiguliana* Gennari et *I. longissima* Bory). Cette espèce contient 4 sous espèces (*I. longissima* subsp. *longissima*, *I. longissima* subsp. *intermedia* (Trab.) Troìa & Greuter, *I. longissima* subsp. *adspersa* A.Braun) Troìa & Greuter et *I. longissima* subsp. *perralderiana* (Milde) Troìa & Greuter). La dernière sous espèces est une endémiques algérienne.

Les espèces du genre *Isoëtes* ont une répartition large mais souvent rare (Troìa & al. 2016). En effet les isoètes sont principalement des espèces des milieux lacustres, aquatiques ou semi-aquatiques (étangs, mares et cours d'eau, en écosystème lentique), bien que certaines espèces (par exemple: *I. histrix* et *I. durieui*) poussent sur des sols humides qui se dessèches en été. Les cinq espèces présentent en Algérie sont liées aux milieux acides, d'où leur rareté plus ou moins importante. Il faut rappeler qu'une très grande partie de l'Algérie du nord est caractérisé par du substrat calcaire et que les rares régions à substrat

acides sont concentrées à l'est du pays. Les milieux de prédilection de ces ptéridophytes sont donc très limités, et aussi très menacées puis qu'ils sont quasiment occupés par l'agriculture (terrains plats et humides). En fin beaucoup d'anciennes stations de ces ptéridophytes ont été détruite par l'urbanisation ou par l'agriculture ou desséchée suite aux changements du régime des pluies (changement climatiques) (Medjahdi & al. 2013).

Nous avons entrepris depuis quelques années l'étude de ce groupe d'espèce dans la région de Tlemcen. Nous n'avons trouvé quelques stations d'*Isoëtes gymnocarpa* et *I. histrix.* Cette année nous avons trouvé une nouvelle station d'*Isoëtes*. L'examen des sporanges (sans voile) et la forme particulière de la corme nous ont ramener à rattacher notre échantillon à *Isoëtes delilei* (Bory) Rothm.

Description de l'espèce

Plante vivace amphibie (aquatique en hiver et début de printemps, se maintient ensuite en phase terrestre après exondation et disparait en été) ; à corme hypogé sans phyllopodes (beaucoup plus profond que les autres espèces d'Isoëtes de la région et très difficile à déterrer), de forme plus ou moins rectangulaire ; à feuilles nombreuses (9–18), fines et fragiles, de 10–25 cm de long, vert claire, dilatées à la base (Fig. 1). Sporanges nus, non recouverts de voile, ce qui distingue bien cette espèce de *I. longissima* (Fig. 2). Macrospores subsphériques à côtes angulaires saillantes (Fig. 3) (Prelli 2002 ; Dobignard 2022).

Description de la station

L'*Isoëtes delilei* a été trouvé dans une mare temporaire située dans la forêt d'Ifry dans la région de Ain fezza à 10 km à l'Est de la ville de Tlemcen (Nord-ouest algérien) au point géographique : 34° 54' 54.5''N 1° 12' 20.9'' W et 960 m d'altitude. La dite mare est entourée par un matorral de *Quercus suber* L. en mélange avec *Quercus ilex* subsp. *ballota* (Desf.) Samp., *Pistacia lentiscus* L., *Cistus monspeliensis* L., *Rhamnus alaternus* L. subsp. *alaternus, Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz, *Cistus creticus* subsp. *eriocephalus* (Viv.) Greuter & Burdet., etc. Au centre d'une clairière dominée par une pelouse humide, la mare occupe une surface d'une centaine de mètre carré avec une profondeur ne dépassant pas les 10-15 cm. Elle est dominée pendant la phase d'inondation à 80% par l'Isoëtes qui est accompagnée par *Ranunculu trilobus* Desf., *Spergularia bocconei* (Scheele) Asch. & Graebn., *Rumex conglomeratus* Murray. Pendant la phase d'asséchement les précédentes espèces cèdent la place à *Eryngium pusillum* L., *Lythrum thymifolia* L., *Lotus subbiflorus* Lag., *Lepidum coronopus* (L.) Al-Shehbaz, *Plantago coronopus* L. subsp. *coronopus* et *Juncus bufonius* L. et après la fin du cycle végétatif de l'*Isoëtes* apparait *Pulicaria arabica* (L.) Cass. et *Carlina lanata* L.

Chorologie de l'espèce

Isoëtes delilei a été décrite pour le première fois sous le nom d'*I. setacea*. Ce dernier est actuellement considéré comme homonyme illégitime. En effet le nom *I. setacea* a été donné

Fig. 1. Aspect général de l'*Isoëtes delilei* (la taille de la pièce de monnaie est 28,50 mm).

à deux espèces déférentes. Une première (*I. setacea* Lam.) décrite par Lamarck (1789) dans un lac au Massif central en France (Lac Saint Andéol), et une deuxième (*I. setacea* Bosc ex Delile) décrite 38 ans après par Delile (1827) dans des mares temporaires dans les bois de Grammont à Montpellier (sud de la France). La première correspond actuellement à *I. lacustris* L. et la deuxième correspond à *I. delilei* (Greuter & Troìa 2015).

I. delilei est une espèce de la méditerranée occidentale (France, Espagne, Portugal) récemment découvert au Maroc (Prelli 2001). L'espèce est présente au Maroc dans les

Fig. 2. Sporange nu ce qui distingue cette espèce de l'*Isoëtes longississima.*

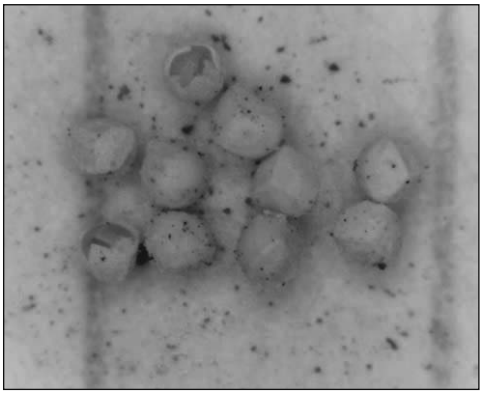

Fig. 3. Megaspores de l'*Isoëtes delilei.*

régions de Sidi-Bettache (entre Casa blanca et Rabat) et Jebilet (Marrakech) (Dobinard 2022). Une autre station est donnée pour *I. lacustris* dans la base Eflore maghreb, mais il s'agit sans doute d'une confusion puis que l'espèce récoltée par S. L. Jury en 1993 dans la région de Taza est identifiée sous le nom d'*I. setacea* Lam. au lieu de *I. setacea* Bosc ex Delile transformée directement en *I. lacustris* (taxon des régions tempérées et froides de l'hémisphère Nord).

L'isoète de Delile n'a jamais été signalé en Algérie. Cette station est donc la première en Algérie. Mais il semble que l'espèce est sous observée car souvent confondue avec *I. longissima* s. l. qui est sympatrique. Donc probablement plus répondu surtout à l'Est du Pays où abondent les dayas et petites mares temporaires peu profondes des terrains siliceux.

Conservation de l'espèce

L'espèce est partout considérée comme menacé avec un statut de menace allant de NT (Quasi menacée - espèce proche du seuil des espèces menacées ou qui pourrait être menacée si des mesures de conservation spécifiques n'étaient pas prises, en Europe et dans le monde) (Rhazi 2016) et VU (vulnérable en France) (MNHN & OFB 2003-2022.). Au Maghreb l'espèce avec les trois stations du Maroc et la station de l'Ouest Algérien l'espèce est en danger critique (CR) (MNHN & OFB 2003-2022.). Il faut rappeler que beaucoup de stations de ptéridophytes rares ont été détruit ces dernières années en Afrique du Nord. La présente station se trouve dans une situation critique actuellement avec l'ouverture d'une piste (la réhabilitation d'une ancienne piste forestière). La piste est complètement revêtue par du gravier calcaire ce qui risque de changer la composition chimique de la mare qui se trouve sur substrat gréseux. L'ouverture de la piste a aussi facilité l'accès aux bergers et aux touristes qui pollues et piétines (parfois stationnement des voitures sur les isoètes) la végétation de la mare. Des mesures urgentes doivent être prises par la conservation des forêts de la wilaya de Tlemcen pour protéger cette mare et l'*Isoëtes delilei*.

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Article

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Fruit phenotypic diversity in *Chamaerops humilis* (*Arecaceae*), in semi-arid and sub-humid regions of Morocco

Abstract

Nekhla, H., El Ghadraoui, L., lahrizi, L., El Hanafi, L., Zahri, A., Harrach, A. & Saouab, F.-E.: Fruit phenotypic diversity in *Chamaerops humilis* (*Arecaceae*), in semi-arid and sub-humid regions of Morocco. — Fl. Medit. 33: 67-81. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

The aim of this work is to determine the phenotypic variability of fruits of *Chamaerops humilis* (*Arecaceae*) according to the climatic conditions. Three hundred accessions were sampled from three climatically different regions of Northern Morocco: Sefrou, Fez, and El Hajeb. They were examined, in order to evaluate the morphological variability of *C. humilis* fruits and identify its morphotypes, in order to ensure a better valuation of the species and to maintain its sustainable development. Nine characters have been examined, including five quantitative characters and four qualitative. Comparison of means tests and principal component analysis were used to assess the variation in the morphological characters of dwarf palm fruits based on the regions. Hierarchical clustering was performed to identify *C. humilis* morphotypes. There was variability in dwarf palm fruit morphological characters in the three regions studied. The results revealed a great variation between individuals for the majority of the studied populations. The data collected from the field showed that the population originating from El hajeb presents fruits of large size, weight and shape that varied between oval and round-oblong, with an orange-brown color at maturity. On the other hand, the populations originating from the regions of Fez and Sefrou are characterized by less developed fruits, with smaller size, and a color generally red-brown and sometimes brown concerning the mature fruits.

Key words: *Chamaerops*, morphological variability, climatic conditions, North Africa.

Introduction

Chamaerops humilis L., also known as dwarf palm, is a shrub that normally in nature reach more than 1 m in height and a trunk less than 1m (Damerdji 2011). It grows naturally in arid areas with a hot and dry climate. It is very tolerant to drought and also very resistant to cold. It can survive at low temperatures up to -12°C (Hasnaoui 2008). In addition, it is a thermophilic species that supports high temperatures above 30°C. *C. humilis* is considered as an index of degradation of forest formations, as it contributes to the structure of

many ecosystems, because of its adaptation to environmental and anthropic constraints. This species is most often found on calcareous soils, although it can develop on all kinds of soils, it is often found in a sunny and dry location where the substrate is sandy or rocky, but never covering dune areas (Merlo & al. 1993).

The fruits of *Chamaerops humilis* are oblong drupes with brown epicarp with fine grooves. Physiological and morphological maturity occurs in September or October (Uhl & Dransfield 1988). It is the most beneficial part of this plant, as it contains significant quantities of chemical compounds (saponins, coumarins, polyphenols, tannins, flavonoids, etc.), essential nutrients and functional properties that can be exploited for various useful applications (Giovino & al. 2015).

C. humilis and its fruits, occupy an important place in the daily life of the populations, whose use is anchored in the common memory of the populations, this plant is a good example since it contributes to the development of several fields has to say: Fruits and leaves of *C. humilis* have internal use against diabetic disease, digestive disorders and against kidney stones (El hilaly & al. 2003; Benali & al. 2013; Medjati 2014) Similarly, *C. humilis* fruits have shown important antioxidant and antimicrobial activity (Giovino & al. 2015).

Ecologically, the fruits of this plant are a food source for some animal species. At the food level, the fruits are consumed because of their nutritional and sensory assets (Merlo & al. 1993).

Climate is one of the most important environmental factors affecting plant physiology and ecology. Climate change and altered biogeochemical cycles can alter the environmental determinism of plant species, first affecting their physiology, then their phenology and finally their distribution (Parmesan 2006). The primary climate variables that affect plant life are light, temperature, and precipitation (Jamieson & al. 2012). The effect of each of these variables influences the productivity of plant species. This was shown in a study conducted by (Akabassi & al. 2021) on *Picralima Nitida* (Stapf) T.Durand & H.Durand which showed that climatic zones have a significant influence on the morphological characteristics and fruit production of the species studied. In addition to climate, soil type also has an effect on morphological variation in forest species (Chadare & al. 2008).

In spite of the assets that *C. humilis* represents, it remains among the most neglected species at different ecological, nutritional, therapeutic and other levels. Moreover, this plant heritage is exposed to an increasing anthropic pressure and subjected to severe ecological effects (Hammi & al. 2007). This leads to the regression of its area of distribution. This repetitive pillage constitutes a veritable menace to the preservation and renewal of this biological resource, as well as to the ecological equilibrium of the mediums. Giovino & al. (2023) state that Morocco is very important for *C. humilis* biogeography because from this area the species showed two probable patterns of independent spread and further differentiation. The southern populations from Morocco are isolated from the resting ones and in particular high-altitude populations are well distinct from the morphological and genetic points of view (Giovino & al. 2021). It is, therefore, necessary to explore this fragile resource which is in advanced degradation, to maintain its sustainable development. It is within the framework of this perspective, that we have conducted the present work, which consists in determining the morphological variability of the fruiting characters *of C. humilis* according to the climatic conditions of the regions. And to identify the fruit morphotypes that are important to maintain the sustainable development of this species in Morocco.

Material and Methods

Study Area

The present work was carried out in three semi-arid and sub-humid regions of North Morocco: Sefrou, Fez and El Hjeb (Fig. 1). These areas are characterized by precipitation ranging from 438 to 612 mm, average annual temperatures ranging from 27.5 to 35°C and a diversified soil nature (Nekhla & al. 2021). Each area characteristics are summarised in Table 1.

Sampling

Sampling was conducted between August and October 2018 when the *Chamaerops humilis* fruits were in the maturing phase. Purposive sampling was used to select the plants from which we collected fruit in each region. To decrease the chance of sampling close relatives, sampled palms were separated by at least 200 meters (Okello & al. 2018). From each sampled plant, 10 fruits were randomly collected. Fruits collected from each plant were pooled and stored in a single bag (Okello & al. 2018). For morphology some characters used were based on a list of descriptors available for the date palm species (Rizk & Sharabasy 2007). Fruits collected were prepared by cleaning them and drying them in the open air (Okello & al. 2018). The weight of the fruits was measured using an analytical balance

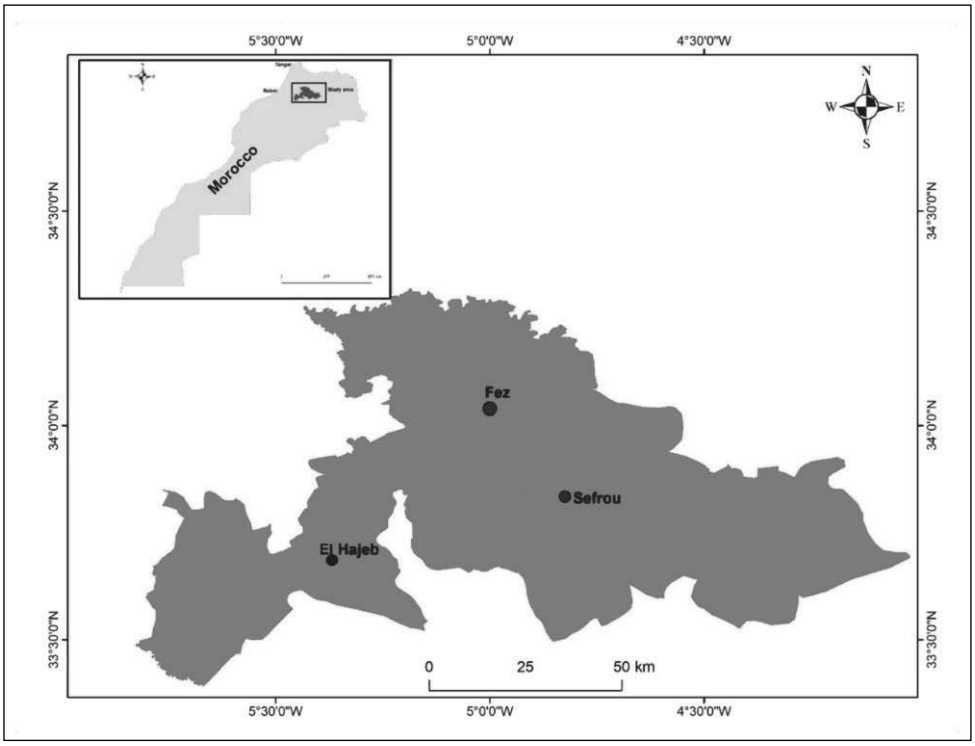

Fig. 1. Location of sampling stations.

Table 1. Attributes of the study sites of *Chamaerops humilis* fruit samples collection**.**

Region	Sefrou	Fez	El Hajeb
Coordinates	33°49′54″ *N* 4°49′40″*O*	34°02′13″*N* 4°59′59″ *O*	33°41′45″ *N* 5°22′00″ *O*
Rainfall (mm)	468	438	612
Altitude (m)	850	400	1050
m C°	2.6	4	2
Climate	Semi-arid to temperate winter	Semi-arid to temperate winter	Sub-humid to cool winter
Soil type	Clay-Silty	Clay –Silty Sandy	Bedrock

m: average of the minimums of the coldest month; N: North; O: West.

(Sartorius Entris 64-1S). A digital caliper (Carrera Precision Instrument, reading at 0.01 mm) was used to measure the length, width, and thickness of the fruits (Salako & al. 2019). In this study the morphological parameters employed are those used by Rizk & Sharabasy (2007). A total of 10 fruit characters were used; five quantitative and five qualitative.

Quantitative characters:
Length (L-Fr);
Width (Wi-Fr);
Thickness (T-Fr);
Weight (We-Fr);
Caliber (C-Fr).

Qualitative characters:
Shape (round oblong, ovate);
Apex (depressed, acute);
Base (truncate, acute);
Unripe colour (green, orange);
Mature colour (reddish brown, brun brown, orange-brown, orange)

Photographs of the plants contain the fruit, and of the fruits picked were taken to document their morphology and any difference was noted.

Data Analysis

For each quantitative character, we determined mean, standard deviation, coefficient of variation, minimum and maximum were determined using SPSS version 19 software. The

analysis of variance (ANOVA) was performed for each character to determine the difference in the mean between the three regions. The post-hoc test (Tukey test) was used to precisely and specifically determine the significative difference between the groups for the different phenotypic characters. The correlation between different characters studied was estimated by Pearson Correlation Coefficient to assess the morphological variability of the dwarf palm fruit according to geographical regions

The collected data were subjected to principal component analysis (PCA) to determine the nature and degree of diversity among the individuals studied, and hierarchical ascending classification (HCA) to define the resemblance measures between the individuals, using R-STUDIO version 1.3.1093 software.

Results

Descriptive statistical analysis

The examination of the results indicates that there was high variability for *Chamaerops humilis* fruits (%) in the population of Fez, also there was low variability in the fruit caliber (%) in the population of El Hajeb.

As shown in Table 2, we notice that most of the quantitative characters differ significantly from one station to another bringing out important information. The El Hajeb population owns fruits of large size: length (mm), width (mm), thickness (16. 75± 1.52 mm), weight (g), and caliber (mm). However, the populations of Fez and Sefrou have fruits of approximately equal sizes: length to mm, width to mm, weight to , caliber to mm, respectively. In contrast, the thickness of the fruit varies from one population to another. It is to mm respectively for the station of Sefrou and Fez.

Correlations between characters

The Correlations for quantitative characters are presented in table 3. The majority of these correlations are highly significant ($r > 0.6$). The highest correlations are those associating morphological characters with climatic conditions. All recorded correlations are positive. A strong positive correlation was recorded between thickness, height and weight ($r = 0.7$) ($p \leq 0.001$), ($r = 0.7$) ($p \leq 0.001$). Similarly, length and width had a strong correlation ($r = 0.7$) ($p \leq 0.001$).

Qualitative characters

The qualitative characters were able to effectively discriminate phenotypically the studied populations. Fruit shape and mature fruit color showed important variability, whereas less diversity was observed in terms of fruit apex and base shape. The sampled *Chamaerops humilis* fruits had a shiny skin that was fused with the flesh. The mesocarp was orange in color and fibrous in texture (Fig. 2f). Fruits sampled at El Hajeb were diversely round-oblong and ovoid in shape with truncated bases and depressed apices (Fig. 2d). Fruits from Sefrou and Fez presented the most diverse characters with different shapes, bases and apices (Fig. 2 a, b). The colour of unripe fruits was green, and the maturing fruits carried the orange color (Fig. 2 c, e). The color of ripe fruits is different across the three sample sites. Almost all fruits sampled at El Hajeb were orange-brown at maturity

Table 2. Statistical indexes of measured quantitative fruit characters of *Chamaerops humilis* in the populations of Sefrou, Fez, and El Hajeb.

Population / Character		Sefrou	Fez	El Hajeb
Lengh (mm)	$Mean$	$19.89 *** \pm 2.12$	$19.18 *** \pm 2.11$	$21.63 *** \pm 1.71$
	$Min - Max$	$15.5 - 23.55$	$12.91 - 23.06$	$18{,}01 - 25{,}37$
	$CV\%$	**10.667**	**11.021**	**7.896**
Width (mm)	$Mean$	$15.61 *** \pm 1.82$	$15.67 *** \pm 1.71$	$18.34 *** \pm 1.49$
	$Min - Max$	$12.02 - 19.92$	$11.61 - 18.95$	$14.24 - 22.36$
	$CV\%$	**11.633**	**10.906**	**8.114**
Thickness (mm)	$Mean$	$11.00 *** \pm 1.72$	$13.07 *** \pm 1.63$	$16.75 *** \pm 1.52$
	$Min - Max$	9.89 18.45	9.4 17.04	13.81 21.36
	$CV\%$	**12.272**	**12.468**	**9.052**
Weight (g)	$Mean$	$2.65 *** \pm 0.67$	$2.23 *** \pm 0.71$	$3.90 *** \pm 0.71$
	$Min - Max$	1.09 4.1	1.03 3.85	2.23 5.75
	$CV\%$	**25.278**	**31.829**	**18.223**
Caliber (mm)	$Mean$	$17.75 *** \pm 1.77$	$17.42 *** \pm 1.83$	$20.00 *** \pm 1.34$
	$Min - Max$	14.19 21.40	12.26 20.91	17.46 ± 23.47
	$CV\%$	**9.978**	**10.479**	**6.687**

(86%) as shown in Table 4. While the fruits sampled in Sefrou were either brown-reddish (67%), brown (33%). As well as the fruits sampled in Fez were brown (52%) and brown-reddish (48%).

Morphological diversity

The results in Table 5 show that the first three components explained nearly 86.67 % of the total variability; they were used to analyse the morphological variability of the accessions.

The correlogram of Fig. 3 shows the correlations between the principal components of the

Table 3. Pearson correlations between quantitative characters.

	Lengh	Width	Thickness	Weight	Caliber	Rainfall	Altitude
Lengh	1						
Width	0.719 ***	1					
Thickness	0.507 **	0.618 ***	1				
Weight	0.453 *	0.594 **	0.724 ***	1			
Caliber	0.577 **	0.664 ***	0.735 ***	0.676 ***	1		
Rainfall	0.452 *	0.589 **	0.702 ***	0.717 ***	0.575 **	1	
Altitude	0.395 *	0.423 *	0.614 ***	0.623 ***	0.458 *	0.837 ***	1

$*** \; p < 0.001; ** \; p < 0.01; \; * \; p \leq 0.05$

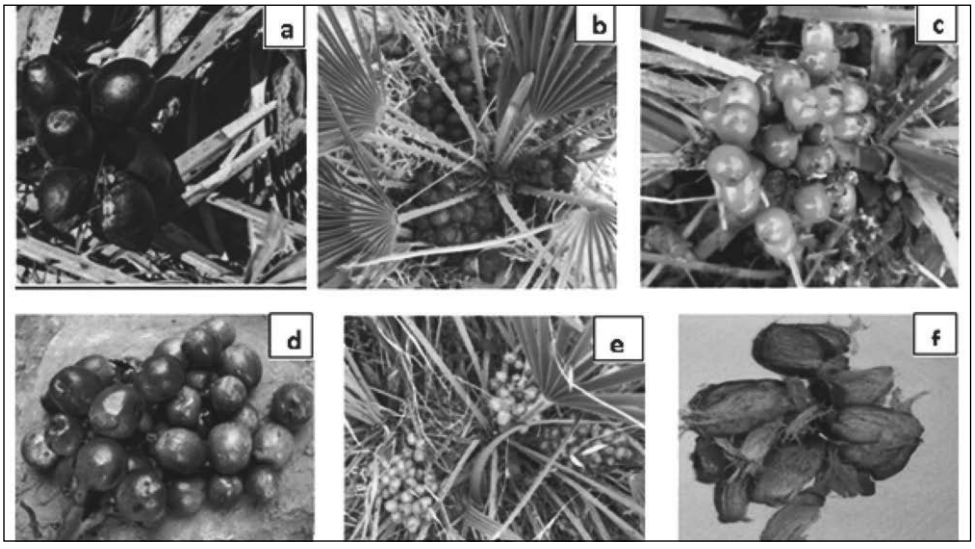

Fig. 2. Different aspects of *Chamaerops humilis* fruits in different regions: (a) Mature fruits in Fèz, (b) Mature fruits in Sefrou, (c) Immature fruits green in colour, (d) Mature fruits in El Hajeb, (e) fruits at the beginning of maturation, (f) Orange and hairy mesocarp.

Table 4. Fruit qualitative characters in the different populations.

Character	Category	Sefrou %	Fes %	El Hajeb %
Fruit shape	Ovate	69	83	46
	round-oblong	31	17	54
Fruit apex	Depressed	66	63	100
	Acute	34	37	–
Fruit base	Truncate	85	79	100
	Acute	15	21	–
Fruit colour-unripe	Green	100	100	100
Fruit colour-mature	Brown-reddish	67	48	–
	Brown	33	52	–
	Orange-brown	–	–	86
	Orange	–	–	14

PCA and the initial variables, we can see that the good correlation related to intensive colour and size of the circle. The majority of correlations are highly significant. The component 1 is well correlated with morphological and climatological parameters, however the second and third components are least correlated with some morphological. The component 1 explained 65.88 % of the variability, which was positively correlated with (L-Fr), (Wi-Fr), (T-Fr), (We-Fr) and (C-Fr). It is also defined on the positive side by altitude and precipita-

Table 5. Value of variations accumulated for Axis 1, Axis 2 and Axis 3 and Axis 4 resulting from the analysis.

	Axe 1	Axe2	Axe 3	Axe 4
Eigenvalues	4.61	0.92	0.53	0.30
Total variance (%)	65.88	13.16	7.63	4.34
Cumulative total variance (%)	65.88	79.04	86.67	91.02

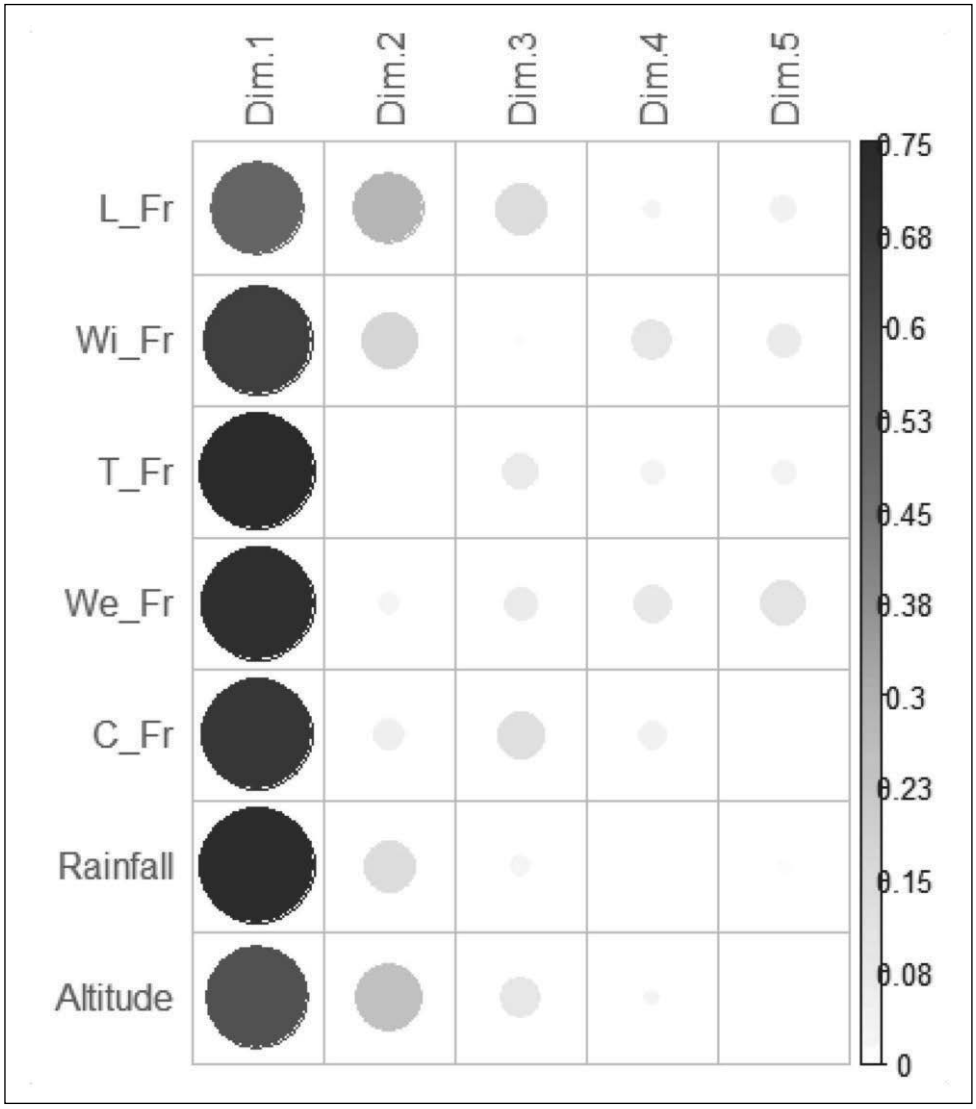

Fig. 3. Correlation between variables and principal components of the PCA.
L_Fr: Length of fruit, **Wi_Fr**: width of fruit, **T_Fr**: Thickness of fruit, **We_Fr**: weight of fruit, **C_fr**: Caliber of fruit.

tion (Fig 3 and 4). These results explain the separation and resemblance of the individuals.

Projection of individuals and variables on axis 1, 2 according to "climate".

Figure 5 shows the distribution of individuals according to climate. The PCA allowed us to represent three population groups that are clearly discriminated. The

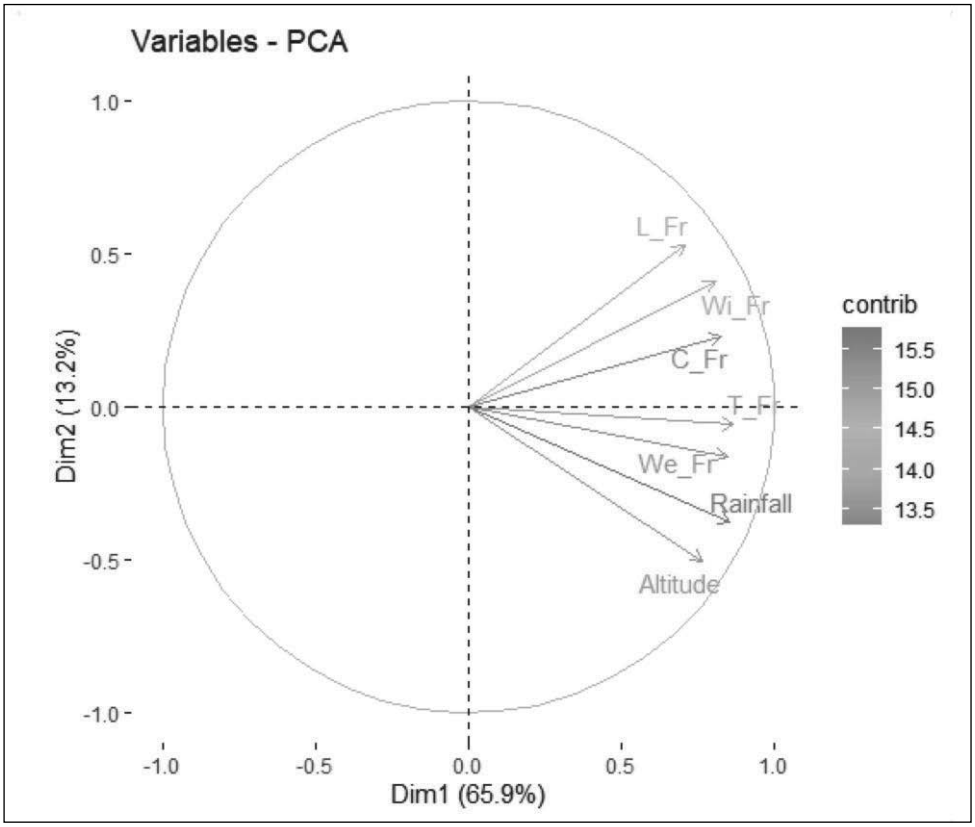

Fig. 4. Contribution of the variables to principal axes (Dim1, Dim2).
L_Fr: Length of fruit, **Wi_Fr**: width of fruit, **T_Fr**: Thickness of fruit, **We_Fr**: weight of fruit, **C_Fr**: Calibe of fruit.

first category is identified by the population of Fez. The second group belongs to the population of Sefrou, the two stations Fez and Sefrou are characterized by a semi-arid climate and the third group is distinguished by the population of El Hajeb which is characterized by a sub-humid climate.

The graphical representation (Fig. 6) showed that the morphological characters and climatic parameters that are correlated with axis 2 correspond to the fruits of El Hajeb. This shows that the population of El Hajeb is characterized by climatological conditions compatible for the development of morphological characters of the fruits of the plant in comparison with the populations of Sefrou and Fez. These results may strengthen the hypothesis of an effect of geographical sites on the morphological characterization of the species and also show that the bioclimatic stage seems to play a preponderant (decisive) role in the discrimination of the provenances studied. All this will give us the impression that the structuring of natural populations of *Chamaerops humilis* in Morocco reflects the existence of phenotypic structures adapted to the type of climate.

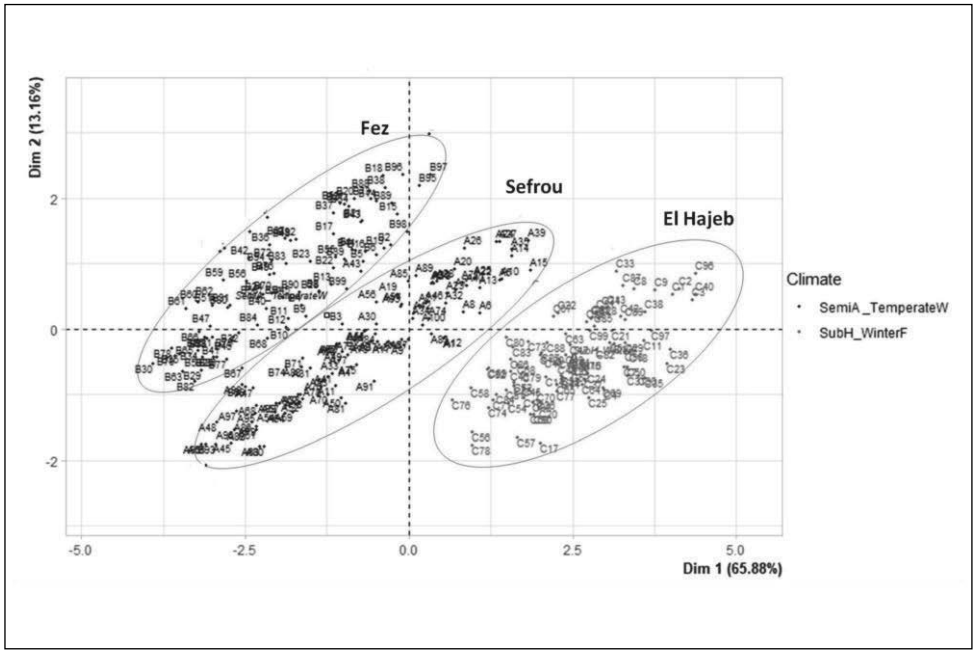

Fig. 5. Dispersion of individuals according to the climate factors.

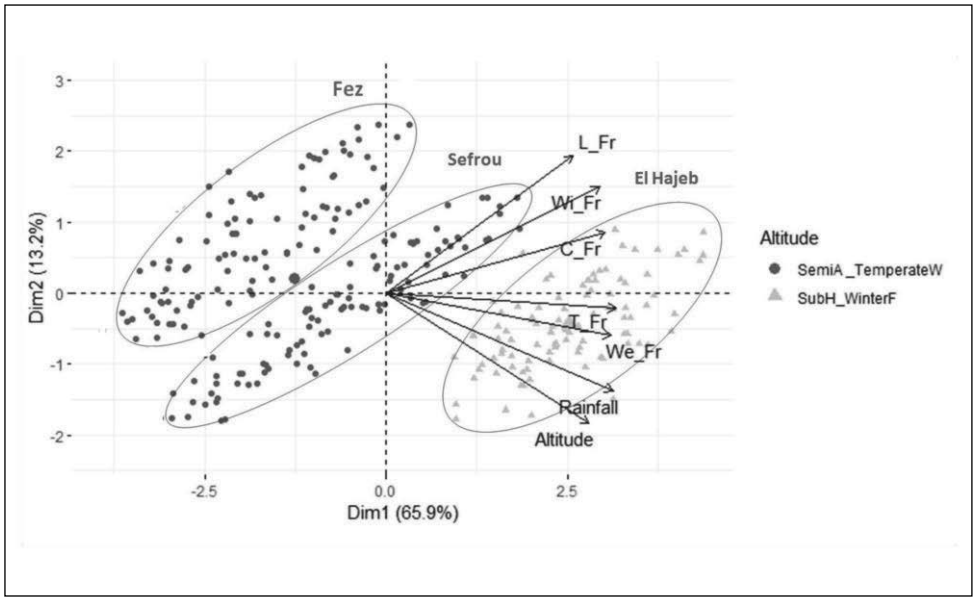

Fig. 6. Biplot of the populations and parameters studied in the axes (1, 2).
L_Fr: Length of fruit, **Wi_Fr**: width of fruit, **T_Fr**: Thickness of fruit, **We_Fr**: weight of fruit, **C_fr**: Caliber of fruit.

Hierarchical classification

The sampled individuals were classified into three morphotypes using hierarchical clustering (Fig. 7). Morphotype C corresponds to the El Hajeb population, which is characterized by individuals with large fruits (Length, Width, Thickness, Weight, and Caliber). Morphotypes A and B correspond to the population of Sefrou and Fez, these morphotypes are characterized by fruits of smaller size. The approximation of morphotypes A and B is explained by geographical proximity. In view of these results, the studied populations present an important heterogeneity between individuals and their morphological parameters.

From the dendrogram analysis, samples of each region appear to have no overlap with samples from other regions. But this cannot be taken into consideration to determine the clusters since advanced markers would be needed to genotype (Haider & al. 2015).

Discussion

A great diversity was observed at the level of quantitative characters in the sample of the individual study of the fruit according to different geographical origins. A great variability was also observed in the qualitative characters of *Chamaerops humilis* fruit. This result is in agreement with those obtained in previous studies showing that the geographical of the plant material was sufficient to obtain a reasonable structuring in the groups (Barnes 1977; Julier & al. 1995). The statistical analysis revealed three populations which are morphologically distinct from each other, with Sefrou and Fez having the most diverse

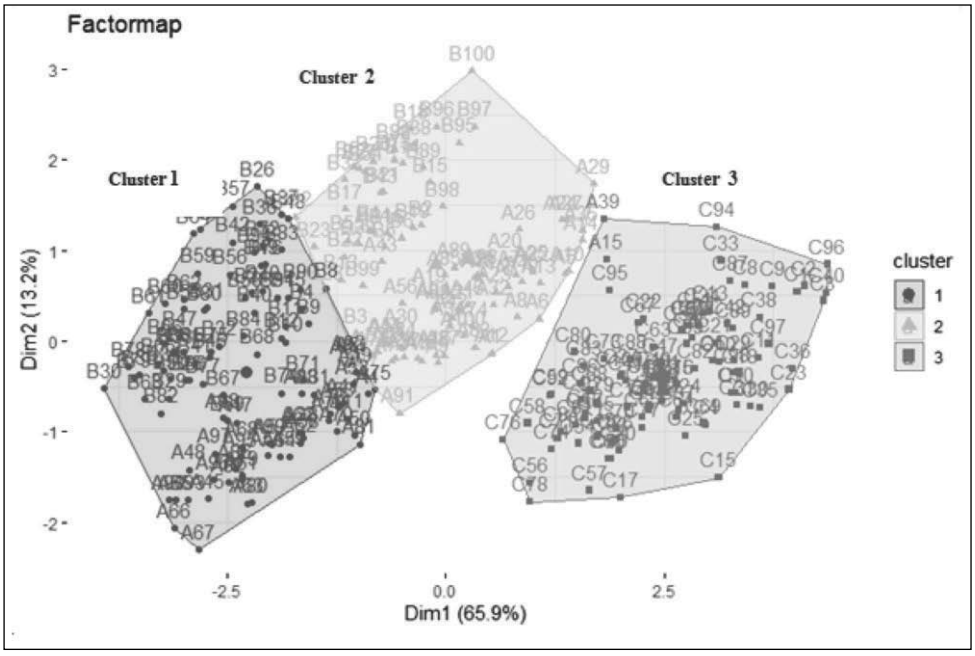

Fig. 7. Morphotype of *Chamaerops humilis* from the hierarchical ascending classification.

fruits. The mature fruits varied from orange-brown, reddish-brown, to brown. *C. humilis* fruits are generally green when unripe, these results are in accord with (Stauffer & al. 2017) who reported that unripe fruits are green in colour, but when they become ripe they turn orange-brown, reddish-brown to brown.

In this study, we found that fruit weight varied from 2.23 to 3.90 g. Low fruit weight in semi-arid stations (Sefrou and Fez) could be related to phenotypic plasticity due to resource limitation (Sultan 2003).Our obtained results are in agreement with other studies that indicated that fruit size seemed to be larger in areas without water stress (Stauffer & al. 2017).

Most fruits have an oval shape, depressed at the apex and truncate at the base. On the contrary there are fruits that have a round-oblong shape, they distinguish the region of El hajeb. This indicates that the fruits in the regions studied are heterogeneous. *Chamaerops humilis* is morphologically varied, as seen by the clustering of samples into separate groups. Therefore, the different morphotypes determined in our study might not be directly influenced by their environmental factors. Within samples from the same population, cluster analysis revealed phenotypic diversity and heterogeneity.

This variability is intimately related to the environmental conditions of the species which gives it the capacity to modify some of its biological characteristics to face the climatic conditions which prevail in its environment of life.

In fact, the majority of the minimal data obtained for fruit were collected in the least watered and hottest area, as for the populations of Fez and Sefrou, and the opposite for the population of El Hajeb. This variation can also be related to the roots extension absorbing the maximum of mineral elements that are essential for the nourishment of plants and for the biochemical reactions inside cells. These results are in agreement with Schwinning and Ehleringer (2001) showing that the depth of the root system play a major role in water use trade-offs for arid ecosystems.

To this essential factor, other secondary contributors can also be added, such as the anthropogenic effects and parasitic attacks which can affect flowering and fruit ripening (Jones 2015; Agbo & al. 2018). The examination of the morphological variability is an essential task to determine results that meet the interests of rural populations, variety selection and species conservation (Jones 2015). Our study showed a variation in morphological characteristics of *Chamaerops humilis* fruit due to environmental conditions, but further work is needed to study molecular diversity to assess the variation caused by the genotype.

Conclusion

This work evaluated the variability in morphological characters of *Chamaerops humilis* fruit and identified its morphotypes. The results show that there is variability in fruit characters by region. The study of morphological characters of *C. humilis* fruit accessions through the correlation matrix indicates the close relationship between morphological characters and climate parameters. Moreover, the PCA revealed differences between the studied characters and allowed us to bring out three well distinguished populations of dwarf palm. The group of the El Hajeb region was the most interesting, expressing the best values for fruit seize (length, width, thickness and weight). The distribution of individuals in each region correlates with environmental parameters.

Therefore, further study at the technological and molecular levels is needed to elucidate these similarities and differences. This variation is generally explained by the close relationship between the distribution of individuals and climate parameters.

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Article

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F. Conti, D. Palermo, B. Santucci, M. Miglio, M. Paolucci, E. De Santis, V. Giacanelli & F. Bartolucci

Additions to the vascular flora of the central and southern Italy

Abstract

Conti, F., Palermo, D. Santucci, B., Miglio, M., Paolucci, M., De Santis, E., Giacanelli, V. & Bartolucci, f.: Additions to the vascular flora of the central and southern Italy. — Fl. Medit. 33: 83-89. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

In this paper new floristic records for 21 units are reported. In particular, 8 taxa are native, 1 is cryptogenic and 12 aliens, 9 are new or confirmed for Molise, 7 are new or confirmed for Abruzzo, 1 reported as doubtful for Abruzzo, 2 are new for Lazio and Basilicata, 1 is new for Marche. Two alien taxa are new to Italy: *Acer tataricum* subsp. *tataricum* and *Campanula grandis* subsp. *grandis*. The last one is new to Europe.

Key words: alien species, native species, vascular flora, floristics.

Introduction

Although the flora of Italy has been extensively studied (Bartolucci & al. 2018; Galasso & al. 2018), it still reserves many new findings as attested by numerous contributions and the column of "notulae" as reported in the reports on plant biodiversity in Italy (Bartolucci & al. 2021, 2023). The increase in floristic knowledge of central Italy depends on the existence of the Centro Ricerche Floristiche dell'Appennino (University of Camerino - Parco Nazionale del Gran Sasso e Monti della Laga) through its investigations and also thanks to the collaboration of expert friends who the Center manages to catalyze. The present work is a further contribution to the knowledge of the flora of central and southern Italy like others recently published (e.g., Conti & al. 2016, 2017, 2018, 2019, 2022, 2023; Bartolucci & al. 2019, 2022a). Unpublished floristic findings in the central and southern Italy are here presented. Most of the new floristic records concern Molise and Abruzzo, a few Marche, Lazio and Basilicata administrative regions.

Materials and Methods

The investigated area is located in the central and southern Italy, and comprises the territories of Marche, Lazio, Abruzzo, Molise and Basilicata administrative regions. Floristic

data were collected during field investigations carried out mainly during 2022. Some other specimens collected in the past have been revised. Herbarium specimens are preserved in APP (code follows Thiers 2023).

Nomenclature follows the checklists of the Italian native (Bartolucci & al. 2018) and alien (Galasso & al. 2018) vascular flora and subsequent updates summarized in the Portal to the Flora of Italy (2023; see also Martellos & al. 2020). Taxa are categorized in native and aliens and ordered alphabetically.

For each taxon, the following information is provided: current accepted name; family; reason(s) for its inclusion in this report; current invasiveness status (only for the alien units); examined herbarium materials, with details about the location (in Italian, according to the information reported on the herbarium labels), UTM coordinates (datum WGS84), altitude, habitat, collection date, collector(s), and herbarium storage code; any additional notes.

Results

Natives

Centaurium tenuiflorum subsp. ***acutiflorum*** (Schott) Zeltner (*Gentianaceae*)
Subspecies new for the flora of Basilicata.
Gravina tra Matera e Montescaglioso (Matera), 25.04.1991, *F. Conti & A. Manzi s.n.* (APP No. 64850).

Centranthus calcitrapae (L.) Dufr. subsp. ***calcitrapae*** (*Valerianaceae)*
Species new for the flora of Molise and doubtfully occurring in Abruzzo.
Campomarino (Campobasso), loc. Ramitelli, UTM WGS84: 33T 510258 E 4641838 N, macchia pioniera su duna consolidata, 5 m, 27.04.2022, *D. Palermo s.n.* (APP No. 66451).
The species was recorded also in Abruzzo (Bartolucci & al. 2018) based on Gravina (1812 as *Valeriana calcitrapa*) and Biondi & Galdenzi (2012) for "Monte Piselli" and "il Vallone". During several field investigations in the mentioned localities we have not been able to find this species; furthermore its preferential habitat is not present. Also, in the locality "Distretto di Sulmona alle colline di Pantaniello" reported by Gravina (1812) the presence of this species is not probable. Consequently, its presence in Abruzzo is doubtful.

Crepis bursifolia L. (*Asteraceae*)
Criptogenic species new for the flora of Molise.
Termoli (Campobasso), loc. passeggiata di Rio Vivo, UTM WGS84 33T 499879 E 4649952 N, ambiente urbano, su marciapiede, 10 m, 09.05.2022*, D. Palermo s.n.* (APP No. 66452).

Festuca jeanpertii subsp. ***campana*** (N.Terracc.) Markgr.-Dann. (*Poaceae*)
Subspecies new for the flora of Lazio.
Picinisco (Frosinone), San Gennaro prati, 800 m, 25.05.1991, *F. Conti s.n.* (APP Nos. 30512, 30513, 30524, 30528); *ibidem*, M. Cavallo, pascolo montano, 1800-2000 m, 07.08.1992, *F. Conti s.n.* (APP No. 30519).

A comprehensive understanding of the variability of the whole aggregate *Festuca circummediterranea* (to which this taxon belongs), across its entire distributional range is still lacking and the separation of the currently accepted taxa has recently been regarded as questionable (Foggi & al. 2009, Foggi & Tison 2014; Ardenghi & al. 2016).

Malva parviflora L. (*Malvaceae*)
Species new for the flora of Molise.
Montenero di Bisaccia (Campobasso), loc. Calanchi di Montenero, UTM WGS84: 33T 480269 E 4651386 N, coltivo a vigneto, 60 m, 06.06.2022, *D. Palermo s.n.* (APP No. 66456).

Pulmonaria officinalis L. subsp. ***officinalis*** (*Boraginaceae*)
Species new for the flora of Basilicata.
Muro Lucano (Potenza), Vallone dell'Arco, presso il torrente, radura, 480 m, 04.06.2003, *F. Conti & D. Tinti s.n.* (APP No. 5505).

Senecio ovatus subsp. ***stabianus*** (Lacaita) Greuter (*Asteraceae*)
Subspecies new for the flora of Marche.
Acquasanta (Ascoli Piceno), Cascata "La Volpara", margini del bosco, 1250 m, 31.07.2006, *F. Conti, D. Tinti, A. Manzi & P. Minghetti s.n.* (APP No. 21449).

Silene vulgaris subsp. ***commutata*** (Guss.) Hayek (*Caryophyllaceae*)
Subspecies new for the flora of Molise.
San Massimo (Campobasso), Monti del Matese, loc. Grotta delle Ciaole, UTM WGS84: 33T 448118 E 4590087 N, pendio erboso delimitato da costone roccioso di natura calcarea a sud-ovest e faggeta a nord-ovest, 1680 m, 11.06.2022, *D. Palermo s.n.* (APP No. 66453); *ibidem*, 5.06.2016, *D. Palermo s.n.* (APP No. 59518).
In this locality, S. *vulgaris* subsp. *commutata* forms large populations.

Symphytum bohemicum F.W. Schmidt (*Boraginaceae*)
Species new for the flora of *Lazio.*
Roma (Roma), Parco della Caffarella, canale a nord del F. Almone, UTM WGS84: 33T 293950 E 4637942 N, rive, 14 m, 03.04.2016, *F. Conti & V. Giacanelli s.n.* (APP No. 62783).
In the area was recorded *S. officinale* of which *S. bohemicum* was considered a synonym (Iamonico 2022). Recently, *S. bohemicum* has been re-evaluated (Koblová & al. 2022).

Aliens

Acer tataricum L. subsp. ***tataricum*** (*Sapindaceae*)
Casual alien subspecies new for the flora of Italy and Abruzzo.
Avezzano (L'Aquila), presso Paterno, UTM WGS84: 33T 376082 E 4657665 N, siepe, 680 m, 15.12.2022, *B. Santucci s.n.* (APP No. 66467).
Close to this locality, a few hundred meters away, there is an abandoned nursery where there are four individuals of *A. tataricum* subsp. *tataricum* which gave rise to naturalization.

Campanula grandis Fisch. & C.A. Mey. subsp. ***grandis*** (*C. latiloba* A. DC. subsp. *latiloba*) (*Campanulaceae*)
Naturalized alien species and subspecies new for the flora of Europe, Italy and Abruzzo.
Lucoli Alto (L'Aquila), scarpata e muretto a secco lungo la strada, 1060 m, 15.06.2022, *R. Soldati & E. De Santis s.n.* (APP Nos. 66469, 66470, 66471, 66472).
The species, and the two currently accepted subspecies (subsp. *grandis* and subsp. *rizeensis* (Güner) Lammers), are endemic to Turkey (Castroviejo & al. 2023; POWO 2023).

Capparis orientalis Veill. (*Capparaceae*)
Naturalized alien species confirmed for the flora of Abruzzo.
Ortona (Chieti), castello, UTM WGS84: 33T 451121 E 4689775 N, mura, esp. SE, 49 m, 09.12.2022, *F. Conti & V. Giacanelli s.n.* (APP No. 66464); Civitella del Tronto (Teramo), Via Ferdinando II di Borbone, UTM WGS84: 33T 391076 E 473637 N, mura, 573 m, 01.01.2023, *F. Bartolucci s.n.* (APP Nos 66465, 66466).
The previous records for the flora of Abruzzo (Abbate 1903 as *C. rupestris*), Teramo, Atri, Civitella del Tronto, Penne (Di Giuseppe 1909 as *C. rupestris*; Zodda 1954, 1967 as *C. spinosa* var. *inermis* Turra) were referred with doubt to *C. orientalis* (Bartolucci & al. 2018).

Capparis spinosa L. (*Capparaceae*)
Naturalized alien species confirmed for the flora of Molise.
Termoli (Campobasso), loc. porto di Termoli, UTM WGS84: 33T 499861 E 4650078 N, ambiente urbano su parete in laterizi; la specie è molto diffusa sulle mura del borgo vecchio della città, 12 m, 08.06.2022*, D. Palermo s.n.* (APP Nos. 66458, 66459).
The species was recently added to Molise without invasiveness status (Bartolucci & al. 2022b) based on the generic citation of the species in Conti & al. (2005).

Dichondra micrantha Urb. (*Convolvulaceae*)
Naturalized alien species new for the flora of Molise.
Termoli (Campobasso), via Roma, UTM WGS84: 33T 499652 E 4650185 N, ambiente urbano sottoposto a calpestìo, specie osservata anche in diversi altri punti nell'ambito urbano, 18 m, 05.10.2022, *D. Palermo s.n.* (APP No. 66457).

Hypericum calycinum L. (*Hypericaceae*)
Naturalized alien species new for the flora of Molise.
Pescolanciano (Isernia), UTM WGS84: 33T 444927 E 4614803 N, luogo erboso su ciglio stradale, 760 m, 01.10.2022, *D. Palermo s.n.* (APP 66454).

Nicotiana glauca Graham (*Solanaceae*)
Casual alien species new for the flora of Abruzzo.
Atessa (Chieti), Contrada Piazzano 70, UTM WGS84: 452166 E 4664553 N, muro in mattoni di un'abitazione abbandonata, 80 m, 20.10.2022, *M. Paolucci s.n.* (observed but not collected).

Oenothera glazioviana Micheli (*Onagraceae*)
Casual alien species new for the flora of Molise.

Pescolanciano (Isernia), UTM WGS84: 33T 444927 E 4614803 N, ciglio stradale, 760 m, 21.08.2022, *D. Palermo s.n.* (APP No. 66455).

Parthenocissus inserta (A. Kern.) Fritsch (*Vitaceae*)
Naturalized alien species new for the flora of Abruzzo.
Pescara (Pescara), Pineta d'Avalos, siepi, 0-4 m, 10.05.2003, *F. Conti s.n.* (APP No. 7698).

Sedum praealtum A. DC. (*Crassulaceae*)
Naturalized alien species new for the flora of Abruzzo and status change, from casual to naturalized alien, for the flora of Italy.
Atessa (Chieti), contrada Querceto, UTM WGS84: 33T 452630 E 4662857 N, bordo strada comunale, 128 m, 28.12.2022, *M. Paolucci s.n.* (APP No. 66474); Bomba (Chieti), all'ingresso nord del paese, UTM WGS84: 33T 447367 E 4654349 N, rupe lungo la strada, 410 m, 28.12.2022, *M. Paolucci* (obs.).

Symphyotrichum ×versicolor (Willd.) G.L.Nesom (*Asteraceae*)
Naturalized alien species new for the flora of Abruzzo and status change, from casual to naturalized alien, for the flora of Italy.
Civita di Bagno (L'Aquila), UTM WGS84: 33T 370691 E 4686070 N, margine stradale, 598 m, 12.09.2018, *F. Bartolucci s.n.* (APP Nos 59603, 59611).

Vicia lens (L.) Coss. & Germ. subsp. ***lens*** (*Fabaceae*)
Casual alien species new for the flora of Molise.
Campomarino (Campobasso), loc. Fantine, UTM WGS84: 33T 507304 E 4642729 N, margini della duna consolidata e massicciata ferroviaria, 4 m, 27.04.2022, *D. Palermo s.n.* (APP No. 66450).

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Article

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Abbès Tanji

Two new annual weeds in Morocco: *Amaranthus palmeri* and *Chenopodium ficifolium* subsp. *ficifolium* (*Amaranthaceae*)

Abstract

Tanji, A.: Two new annual weeds in Morocco: *Amaranthus palmeri* and *Chenopodium ficifolium* subsp. *ficifolium* (*Amaranthaceae*). — Fl. Medit. 33: 91-99. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

During recent field surveys with special emphasis on the weeds occurring in Moroccan farmlands and gardens, two new weed species were discovered for the first time in the country. *Amaranthus palmeri* plants have been collected in October 2020 along streets in Rabat and in a corn field in Tit Mellil (East of Casablanca), it is to be considered naturalized in Morocco. *Chenopodium ficifolium* subsp. *ficifolium* plants have been observed in a public garden in February 2022 in Berrechid, it is to be considered casual alien in Morocco. These reports indicate that Morocco needs more thorough botanical explorations especially in urban areas and agroecosystems. Both species enrich the *Amaranthaceae* of the country, but could be a threat to biodiversity, sustainable agriculture, food security, and human livelihoods.

Key words: alien species, new weeds, description, distribution, taxonomy.

Introduction

In Morocco, there are nearly 200 introduced weed taxa, involuntarily brought by humans or by other means such as rivers, winds, birds, etc… (Fennane & al. 2023). Exotic plants coming into areas outside their natural range threaten biodiversity and pose a huge global threat to sustainable agriculture, food security, and human livelihoods (see e. g. Lambdon & al. 2008; Early & al. 2016; Gervilla & al. 2019; Arianoutsou & al. 2021). Furthermore, their spread and impact is growing due to climate change, globalisation, trade, and tourism.

Some of these exotics succeed to adapt to their new environments and end up settling there permanently and becoming invasive (Tanji & Taleb 1997; Tanji, 2020; Fennane & al. 2023). For instance, *Amaranthus spinosus* L., found in 2022, is now expanding in gardens, streets, and roadsides of Casablanca, Mohammedia, Rabat, and Kénitra (Sukhorukov & al. 2023). *Cardamine occulta* Hornem. was collected in 2022 in greenhouses, flower pots, and nurseries in Rabat and Kénitra (Sukhorukov & al. 2023). *Oxybasis glauca* was observed in Laayoune and Ad-Dchira (Chambouleyron & al. 2022). *Cenchrus longispinus* (Hack.)

Fernald, found in 1985, is now invading the Loukkos irrigated perimeter (Tanji 2020). *Dinebra retroflexa* (Vahl) Panz., recently discovered in 2015, is now invasive in summer crops in the Gharb and Tadla irrigated perimeters (Tanji 2020). *Solanum elaeagnifolium* Cav., found in 1944 in Casablanca near the seaport, is now located throughout the country (Bouhache 2010; Ben-Ghabrit & al. 2019). *Heterotheca subaxillaris* (Lam.) Britton & Rusby, seen near Kénitra in 2000, is now invading roadsides in Kénitra, Sidi Yahya, and Salé (Fennane & al. 2014). *Arctotheca calendula* (L.) Levyns, collected in Chaouen, North of Morocco, in 1928 (Jahandiez & Maire 1934), is now distributed in Taza, Rabat, and along the Atlantic Ocean coastline (Ibn Tattou, pers. comm.).

During the floristic surveys in Moroccan cultivated crops and gardens, two new weed species were collected for the first time in the country. Photos, descriptions, distributions, and impacts of these newly introduced species were provided in the present note.

Materials and methods

Live plants of *Amaranthaceae* s. lat. were collected from cultivated fields and public gardens during the period 2020-2022, in various Moroccan locations. The *Amaranthus* species was found at both flowering and fruiting stages, whereas *Chenopodium* plants were removed from public gardens at the vegetative stage, planted in pots, and kept outdoors at home until maturity. Specimens of collected plants are preserved at the National Herbarium of the Institut Scientifique, Université Mohammed V, Rabat. For the identification of these taxa, various references and websites were used including the "Flore Pratique du Maroc" (Fennane & al. 1999), "Biodiversité végétale du Sud-Oued Marocain" (Peltier, www.teline.fr), "Flore du Maroc" (Dobignard, www.floramaroccana.fr), "efloramaghreb" (www.efloramaghreb.org), Fuentes-Bazan & al. (2012), "Flora Gallica" (Tison & de Foucault 2014), and Iamonico (2015). For the nomenclature, various references and websites were used including "African Plant database" (http://africanplantdatabase.ch), "Plants of the World Online" (https://powo.science.kew.org), "World Flora Online" (www.worldfloraonline.org), "Flora of North America" (http://beta.floranorthamerica.org), "CABI" (www.cabi.org/isc), "EPPO global database" (https://gd.eppo.int), and "Tela Botanica" (www.tela-botanica.org).

Results

Amaranthus palmeri S. Watson

Amaranthus palmeri is a new species to be added to the flora of Morocco. In fact, Fennane & al. (1999) and Dobignard (www.floramaroccana.fr) cite 11 *Amaranthus* taxa : *A. albus* L., *A. blitoides* S. Watson, *A. blitum* L., *A. cruentus* L., *A. deflexus* L., *A. graecizans* L. subsp. *silvestris* (Vill.) Brenan, *A. hybridus* L., *A. hypochondriacus* L., *A. muricatus* (Moq.) Hieron, *A. retroflexus* L., and *A. viridis* L.

Distribution and ecology in Morocco

Several plants of *A. palmeri* have been found on October 2, 2020, in Rabat and in an irrigated corn (*Zea mays* L.) field near Tit Mellil, East of Casablanca (33° 30′ 36″ N, 7°

23′ 41″ W, 180 m altitude) (Fig. 1). They were at the flowering and fruiting stages, and stems were 2 to 3 m tall and drew my attention. They were growing in an area where daily temperatures in summer usually exceed 30 C, nightly temperatures are around 20 C, and the photoperiod is 14 hours. Palmer amaranth is therefore considered, under local climatic conditions, a summer annual weed naturalized in Morocco.

Description

Several references provided detailed descriptions of Palmer amaranth plants (Ward & al. 2013; Roberts & Florentine 2022, etc.). The plant is dioecious, erect, up to 3 m tall, with a deep taproot system. Stems are reddish-green, highly branched. Leaves are alternate, obovate (1.5–7 × 1–3 cm), with entire margins, glabrous, petioled, some with a whitish V-shaped central spot. The synflorescence is structured as erect linear spikes (up to 60 cm) along with several small clusters of flowers (2 to 4 mm). Bracts of pistillate flowers are 4–6 mm, longer than tepals. Bracts of staminate flowers are 4 mm long, equaling or longer than outer tepals. Tepals of pistillate flowers are 1.7–3.8 mm, acuminate, mucronulate. Tepals of staminate flowers are unequal, 2–4 mm, apex acute. Inner tepals have prominent midribs excurrent as rigid spines. Utricles are tan to brown, obovoid to subglobose, 1.5–2 mm, shorter than tepals. Fruits are obovoid, small (about 1.5 mm diameter), with thin walls and containing a single small (about 1 mm diameter) dark-red to brown seed.

Chorology

Native to the North American Southwest (from southern California to Texas) and northern Mexico, alien, often invasive in North America as well as in South America and other continents (see e.g. POWO 2023) where populations spread in urbanized and agricultural areas by human activities e. g. trade and tourism. In the Mediterranean region and surrounding areas, it was recorded in Tunisia, Egypt, Israel, Turkey, Greece, Italy, France, Spain, and Portugal (Dobignard & Chatelain 2011; Tison & De Foucault 2014; Iamonico & El Mokni 2017; Torra & al. 2020; APD 2023; CABI 2023; Danin & Fragman-Sapir 2023; EPPO 2023), and it was recently found in South Africa by Sukhorukov & al. (2021).

Notes

Amaranthus palmeri is an herb with C4 photosynthetic pathway which translates into a very fast-growing, competitive weed that can grow 0.18–0.21 cm per growing degree day (Horak & Loughin 2000). Palmer amaranth interference reduced dry edible bean yield by 77% at a weed density of 2 plants m^{-1} row compared to the weed-free control (Miranda & al. 2021). Each plant is able to produce 200,000 to 600,000 seeds when growing without plant competition (Keeley & al. 1987). It is among the most troublesome and economically important weed species as a result of its high genetic diversity, a deep root system, rapid growth rate, high fecundity, high competitiveness, high water use efficiency, tolerance to high temperatures and drought, and ability to develop herbicide resistance (Ward & al. 2013; Leon & Van Der Laat 2021; Roberts & Florentine 2021; Milani & al. 2021). Menges (1987 & 1988) reported inhibition of crop growth resulting from Palmer amaranth's allelopathic properties. Considering the potential economic impact of this species, the EPPO Panel on Invasive Alien Plants suggested its addition to the EPPO Alert List (EPPO 2023). Palmer amaranth possesses toxic properties including high concentrations of nitrates and oxalates that are harmful to livestock (Yu & al. 2021).

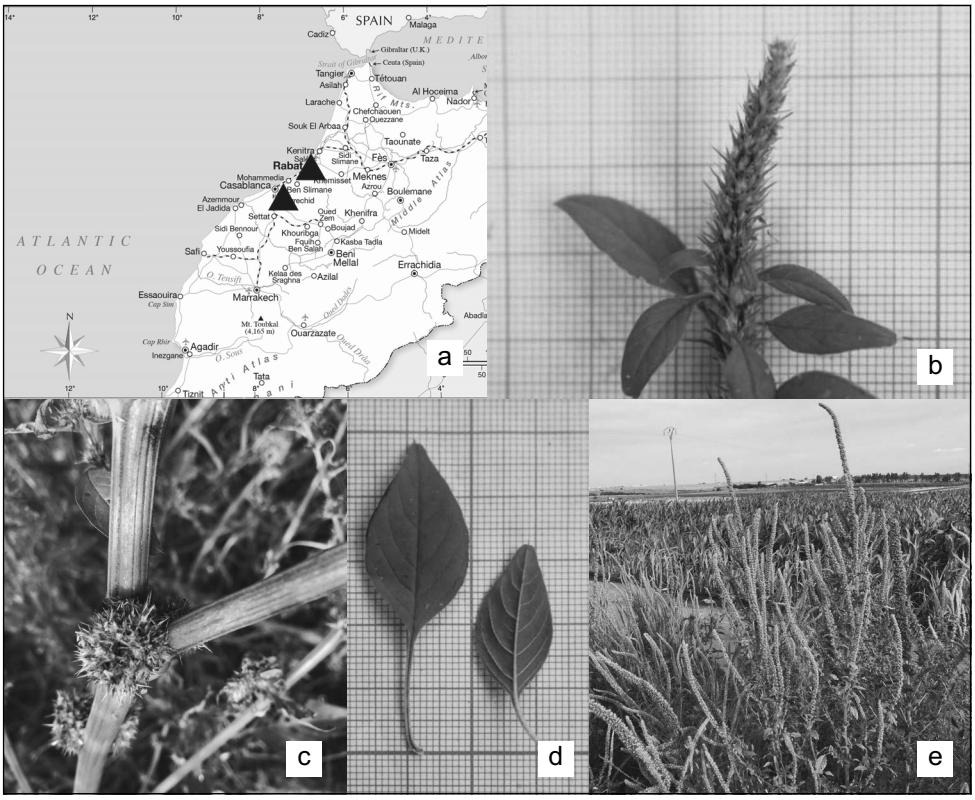

Fig. 1. *Amaranthus palmeri*: a) distribution in the map of Morocco; b) details of the inflorescence; c) stem; d) leaves; e) habit. Photos by the author.

Chenopodium ficifolium Sm. subsp. ***ficifolium***
≡ *C. album* subsp. *ficifolium* (Sm.) Hook. f.

Chenopodium ficifolium subsp. *ficifolium* is a new species to be added to the flora of Morocco. In fact, Dobignard (2023) cite only 3 *Chenopodium* taxa: *C. album* L. subsp. *album*, *C. album* L. subsp. *opulifolium* (WDJ) Koch & Ziz) Batt., and *C. vulvaria* L. However, several other *Chenopodium* cited by Fennane & al. (1999) were recently rearranged in other genera such as *Blitum, Chenopodiastrum*, *Dysphania*, and *Oxybasis* (Dobignard 2023).

Distribution and ecology in Morocco

In Morocco, two plants of *Chenopodium ficifolium* subsp. *ficifolium* were found for the first time on February 12, 2022, in a public garden in Berrechid, 20 km South of Casablanca (33° 15′ 33″ N, 7° 34′ 53″ W, 220 m altitude) (Fig. 2). Both plants were at the vegetative stage. They were removed, planted in a pot, and kept outdoors at home until maturity. In February, daily temperatures are usually 20 to 25 C, nighlty temperatures are 10 to 15 C, and the photoperiod is 12 hours. Figleaved goosefoot is therefore considered a fall/winter annual plant (Fig. 2). It is a new weed, and is to be considered as a casual alien.

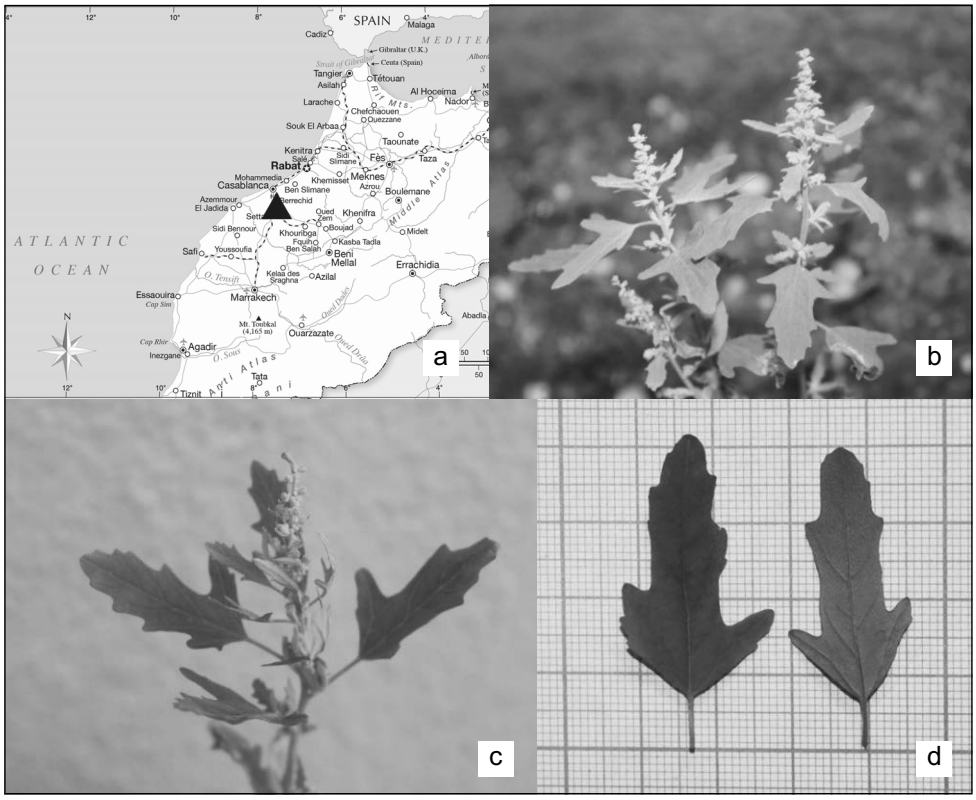

Fig. 2. *Chenopodium ficifolium* subsp. *ficifolium* : a) distribution in the map of Morocco; b) habit; c) inflorescence; d) leaves. Photos by the author.

Description

Plant description has been reported in various references (″Flora of North America″ 2023; HYPPA, 2023; ″Tela Botanica″ 2023; WFO 2023; etc…). Fig-leaved goosefoot stems are erect, green, striate, 20-50 cm tall. Leaf blades are ovate-oblong, 2.5–5 × 1–3.5 cm. Their margins are usually 3-lobed. The central lobes are subentire to sinuate-dentate, and the lateral lobes are positioned in proximal 1/3 or near base of leaf blade. Flowers are in terminal panicles on upper branches. The perianth has 5 segments, connate at base into 0.3 mm tube; lobes ovate, 0.5–0.9 × 0.5–0.8 mm, apex acute, farinose, keeled, covering fruit at maturity; stamens 5; stigmas 2, 0.3 mm. The utricles are depressed-ovoid; pericarp nonadherent, smooth. Seed are horizontal, black, 1 mm in diameter.

Chorology

Fig-leaved goosefoot is native to the mountains of South and Central Europe and Western Asia (Flora of North America 2023). It is found in the 5 continents, and is usually distributed in housing neighborhoods, roadsides, vacant lots, fields, orchards, and pastures (POWO 2023; WFO 2023). In the Mediterranean region and surrounding areas, it was

reported in Algeria, Egypt, Israel, Turkey, Greece, Italy, France, and Spain (Dobignard & Chatelain 2011; Tison & de Foucault 2014; Hannachi 2019; Mosyakin & de Lange 2020; APD 2023; Danin & Fragman-Sapir 2023; EPPO 2023; Heap 2023; POWO 2023; www.efloramaghreb.fr 2023).

Notes

Figleaved goosefoot is a weed in Kuwait (Mathew & al. 2012), Tajikistan (Nowak & al. 2014), New Zealand (Mosyakin & de Lange 2020), and Korea (Kim & al. 2019). It is a weed that has resisted to the atrazine herbicide in Germany and Switzerland (Heap 2023).

Various compounds were isolated from *Chenopodium ficifolium* plants (Gohar & al. 2002). Furthermore, Le Dang & al. (2010) found that extracts of *C. ficifolium* have insecticidal properties for controlling *Aphis gossypii* infesting cucumber plants. Subedi & al. (2021) reported that *C. ficifolium* is a potential diploid model system for the genetic study of quinoa.

Two subspecies are usually recognized within *Chenopodium ficifolium*: subsp. *ficifolium* and subsp. *blomianum* (Clemants & Mosyakin 2003). These subspecies are distinguished mainly by their pericarp, seed testa sculpture, and leaf shape (Mosyakin 2016). The subsp. *blomianum* occurs in southern and southeastern Asia as well as in the USA, and differs from *C. ficifolium* subsp. *ficifolium* in having leaves with spreading basal lobes almost perpendicular to the central lobe and seeds with shallow elongate depressions (Mosyakin 2016). Clemants & Mosyakin (2003) reported that in Europe *C. ficifolium* occasionally hybridizes with other species, including *C. album.*

Conclusion

Two new aliens belonging to *Amaranthaceae* s. lat. have been discovered for the first time in Morocco in human-made habitat (urban areas and agroecosystems). They were probably introduced into the country by tourists, imported animals, crop seed, vehicles, or machinery. These newly introduced weed species indicate that the country needs more thorough botanical explorations. They inevitably enrich the Flora of Morocco, but pose a huge global threat to biodiversity, sustainable agriculture, food security, and human livelihoods. In fact, *Amaranthus palmeri* and *Chenopodium ficifolium* subsp. *ficifolium* have the capacity to become invasive weeds in agricultural systems, cities, and uncropped areas.

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Article

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Flora diversity and distribution across some Lebanese archeological sites

Abstract

Massaad, M., Merheb, J. & Chalak, L.: Flora diversity and distribution across some Lebanese archeological sites. — Fl. Medit. 33: 101-109. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

With the aim of recording the present flora present across the Lebanese archeological sites, a survey including 15 different sites located in various bioclimatic regimes was conducted. The inventory documented 262 taxa from 32 families, encompassing 87 species and 75 genera. The most frequently occurring species were *Cichorium intybus* and *Hyoscyamus aureus*. Among the reported species, 14.95% were found to be endemic species to either Lebanon or the Eastern Mediterranean region, 2.35% were alien species, 28.73% were unique species; i.e. observed only in one site. This survey showed a first insight into the flora present in Lebanese archaeological sites and highlighted the role of these sites in harboring rich floral diversity. Thus, it is of fundamental importance to strengthen the conservation and protection efforts of the archaeological sites' natural landscape and its sustainable utilization along the cultural heritage.

Key words: ruins, plant species, conservation, diversity, Mediterranean.

Introduction

Located on the eastern side of the Mediterranean Sea, Lebanon is a small country with a total surface area of 10,452 km² and characterized by a mountainous topography, and the presence of nine bioclimatic regimes (Jomaa & al. 2008; Chalak & al. 2016). The country is considered to have one of the highest densities of floral diversity across the Mediterranean basin and home to 2600 different plant species (Tohme & Tohme 2014). Besides, Lebanon is part of the Mediterranean biodiversity hotspot, one of 25 such recognized threatened areas around the world by Conservation International (Chalak 2016).

Since antiquity, the Lebanese territory has been home to several civilizations perceived today by the presence of more than 350 different archaeological sites across the country. These sites are distributed across various bioclimatic regions, and ecological habitats, varying widely in size ranging between 3 and 25 hectares (Kabalan & Stănciulescu 2018). However, major sites are managed and largely protected, while other are left somehow unmanaged. Normally, archaeological sites comprise an excavated zone and a surrounding

peripheral protective 'buffer zone' harboring several species of the local flora conquering the walls, rubbles, and fallow areas of the sites (Talhouk & al. 2014).

The conservation of the cultural landscape, which is defined as the combined work of man and nature, helps in ensuring human and environmental well-being (Panitsa & al. 2021). Hence, it is of societal priority to conserve the historic landmarks, which contributes to the country's cultural heritage, along with maintaining national biodiversity (Krigas & al. 1999; Aslan & Amatov 2005; Iatrous & al. 2007; Motti & Stinca 2011; Caschin & al. 2014; Papafotiou & al. 2017; Cicinelli & al. 2018; Dahmani & al. 2020; Panitsa & al. 2021). Explorations and studies in Lebanon have been mainly focused on assessing the floral biodiversity of high mountains and natural reserves. However, as to our knowledge, there are no data related to the vascular flora found in the important archeological sites across Lebanon. Such surveys are particularly valuable in preserving the cultural, archeological, and natural landscape. To fill this gap, we analyzed in this study the floral diversity present in 15 different Lebanese archeological sites, in an aim to provide a scientific baseline on the existing diversity and its proper management.

Materials and Methods

The study was carried out from March until May 2021. Research work was performed in 15 different archeological sites located in different bioclimatic regions: Thermo-Mediterranean, Eu-Mediterranean and Supra-Mediterranean (Luterbacher & al. 2012) extending along the four edges of the Lebanese territories (Fig. 1). The floristic data was collected based on field observations done by the authors on their botanical explorations of the selected sites. Plant species were identified according to Mouterde (1984), Tohme & Thome (2014) and on the Lebanese flora digital data base (www.lebanese-flora.org). Species names mentioned in this article follow Tohme & Thome (2014).

The number of occurrences of each species in the different archeological sites was reported. Species were considered unique when observed only in one site. Moreover, species were examined for their state of endemism either to the Eastern Mediterranean region, Lebanon, Syria, and Palestine or strictly to Lebanon.

Chi-squared test of independence (χ^2) was used to test the distribution of flora between the 15 archeological sites and significance was set at $P = 0.05$. All statistical analysis and plots were generated using R studio.

Results

In the 15 surveyed archaeological sites, 262 taxa were recorded, including 87 species belonging to 75 genera and 32 families. The list of plant species observed in this study is reported in the Electronic Supplementary File (ESF) 1. The three most represented families are: *Asteraceae* (15%) with 13 species, *Poaceae* (13%) with 11 species and *Fabaceae* (7%) with 7 species. The other 29 families each with 6 species or less include the remaining 56 species (Fig. 2, 3). A snapshot of some of the observed plant species are shown in Fig. 4. Our findings showed an unevenness distribution among the study sites ($\chi^2 = 31.93$ df = 14,

p< 0.01, CV = 24.54). the number of species per sites ranged from 9 to 27 with an average of 12.82 ± 5.27. The highest number of species was recorded in the Citadels of Byblos and Anjar with 27 plant species in each site. While the lowest number of species was recorded in Sidon Sea Castle and Qsarnaba Roman Temple with 9 and 10 species respectively (Fig. 3). The Eu-Mediterranean regime recorded the highest number of species followed by the Thermo- Mediterranean and Supra- Mediterranean regimes with an average of 21 ± 5.56, 18.3 ± 7.19 and 14.2 ± 3.06 species respectively.

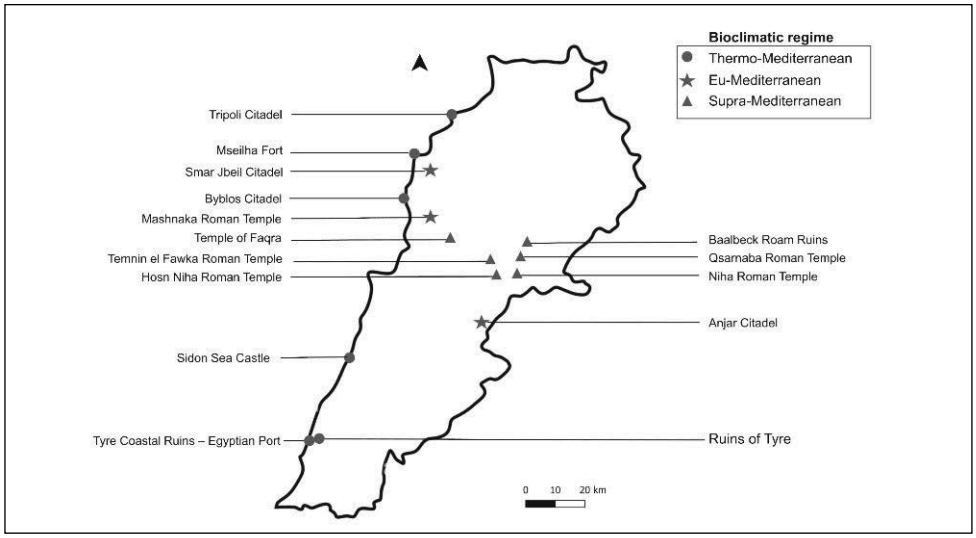

Fig. 1. The 15 Lebanese archeological sites analyzed in this study with their respective bioclimatic regime.

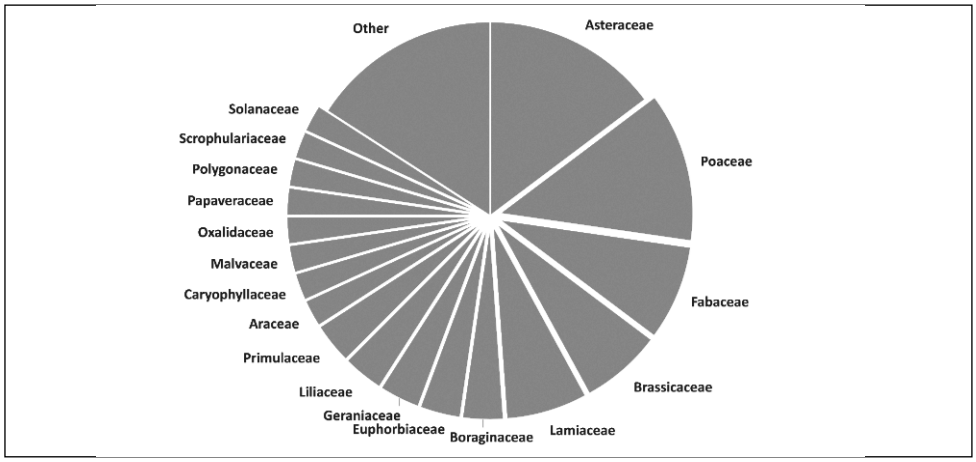

Fig. 2. Taxonomic richness by family observed across the 15 Lebanese archeological sites analysed in this study.

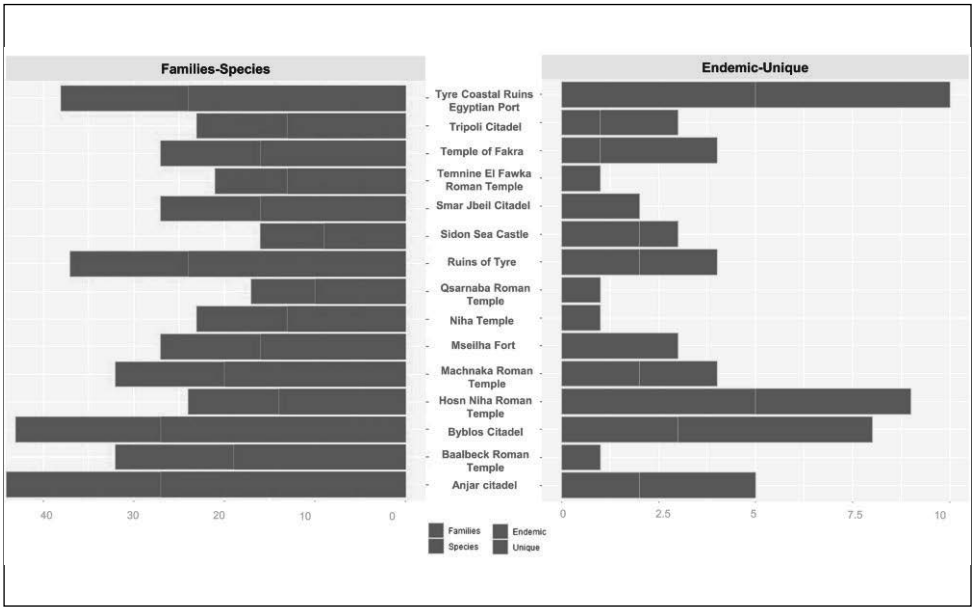

Fig. 3. Number of species and families reported across the 15 Lebanese archeological sites, analysed and classified by their endemism to the eastern Mediterranean region and their uniqueness, i.e. observed only in one site.

In whole, out of the 87 species observed, the following 10 species are classified as endemic to the Eastern Mediterranean Region; *Alopecurus utriculatus* Banks & Sol., *Arum Hygrophilum* Boiss., *Crepis palaestina* (Boiss.) Bornn., *Cyclamen persicum* Mill., *Hyoscyamus aureus* L., *Lamium moschatum* Mill., *Origanum syriacum* L., *Trifolium clypeatum* L. and *Tripleurospermum oreades* (Boiss.) Rech. One species is endemic to Lebanon, Syria and Palestine, *Arum palaestinum* Boiss., and two are strictly endemic to Lebanon *Prunus agrestis* (Boiss.) Mouterde and *Salvia libanotica* Boiss. & Gaill. The Coastal Ruins of Tyre and citadel of Byblos hold the highest count with five endemic species in each site.

In addition, 25 species were reported only in one site and were not observed in any different locations; hence, they were considered as unique species. In the Roman temple of Hosn Niha and Tyre Coastal Ruins, five unique species were found in each site where two and one of them respectively are also endemic (Fig. 3). As to alien or invasive species, only two species were recorded, *Bidens pilosa* subsp. *radiata* Schl. and *Oxalis pes-caprae* L.

Among the documented taxa in this study, *Cichorium intybus* subsp. *intybus* L. and *Hyoscaymus aureus* L. were the most recorded plant species in the 15 study sites; they were found in eight different archeological sites. *Anthemis chia* L., *Diplotaxis erucoides* (L.) DC. and *Senecio vulgaris* L. were the second most frequent species as they were present in seven sites, while *Crepis sancta* (L.) Balcock, *Euphorbia helioscopia* L., *Lamium moschatum* Mill., *Parietaria judaica* L., *Trifolium resupinatum* L., and *Veronica persica* Poir. were found in six sites (Fig. 4).

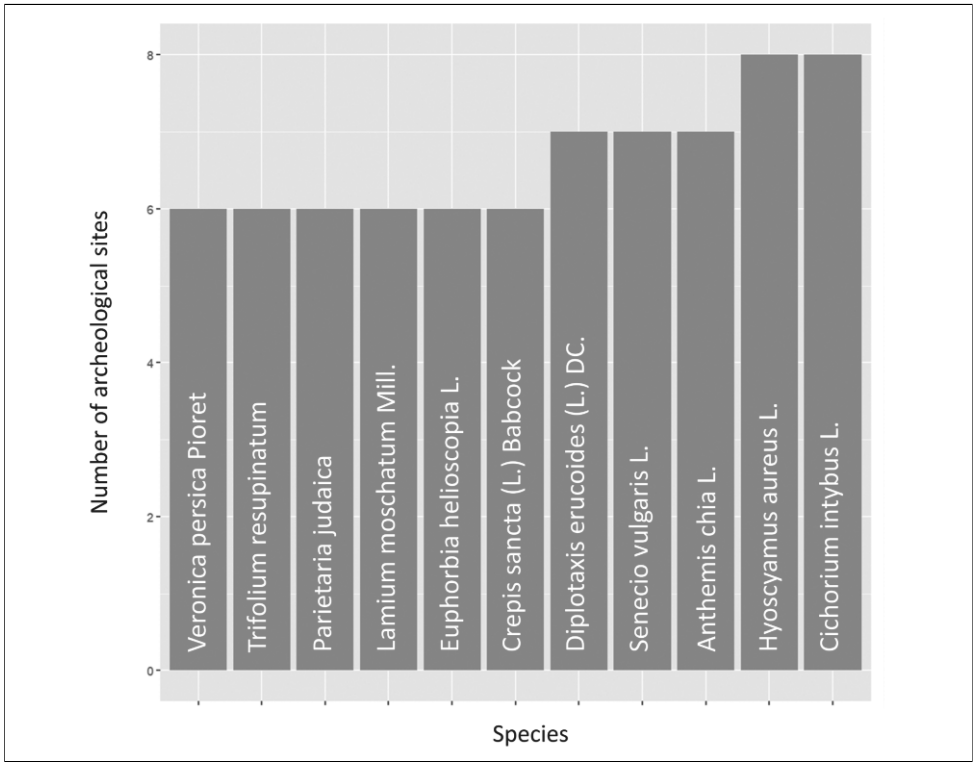

Fig. 4. Most frequent species in this study with respect to number of sites.

Discussion

This study revealed the existence of an important and diversified flora scattered across different Lebanese archaeological sites. The first annotated checklist presented here, surveyed 15 archeological sites located in different geographic areas and bioclimatic regimes in Lebanon.

The highest count of species was observed in the citadels of Anjar and Byblos along with both archaeological sites located in the city of Tyre, ranging between 27 and 24 species per site, this could be due to their large buffer zones surrounding the citadels and ruins in addition to their proper management as these two sites are listed in as World Heritage Sites (Talhouk & al. 2014). Moreover, according to Bou Dagher-Kharat & al. (2018) the coastal area of Byblos was defined as an important plant area (IPA). While Sidon Sea Castle had the lowest count of species which could be attributed to its geographical location on a small island adjacent to the salty sea waves with just a narrow ramp linking it to the mainland.

At the national context, when comparing our results to previous plant biodiversity assessment missions conducted across the nation, *Prunus agrestis* (Boiss.) Mouterde was also reported as less common or rare (Chalak & al. 2014; Chalak & Hamadeh 2015; Bou Dagher-Kharat & al. 2018). Numerous species of the Lebanese wild flora were also report-

ed having economic importance such as *Origanum syriacum* L., *Laurus nobilis* L., and *Ficus carica* L. (Baydoun & al. 2015, 2017).

Internationally, comparing between the flora of Lebanese archaeological sites and those present across Mediterranean sites reveals some similarities. For instance, the most commonly found species in our sites, e.g Cichorium *intybus* L., *Hyoscyamus aureus* L., *Parietaria judaica* L. *Senecio vulgaris* L., *Euphorbia helioscopia* L., *Trifolium resupinatum* L., *Veronica persica* Poir., and *Anthemis chia* L. were all reported in several Mediterranean archeological sites located mainly in Italy and Greece (Krigas & al. 1999; Aslan & Amatov, 2005, Iatrous & al. 2007; Motti & Stinca, 2011; Ceschin & al. 2014; Papafotiou & al. 2017; Cicinelli & al. 2018; Dahmani & al. 2020; Motti & al. 2020). However, due to both the richness of biodiversity and high level of endemism in the country, some species observed in our study, precisely *Arum palaestinum* Boiss., *Crepis palaestina* (Boiss.) Bornn., and *Prunus agrestis* (Boiss.) Mouterde were not reported in any other similar Mediterranean studies, proving the significant uniqueness of the flora present in Lebanese archeological sites.

Nowadays plant biodiversity is facing globally severe threats mainly due to anthropogenic factors, where in our inventory this was clearly observed through the management of these archaeological sites by weeding and removal of plants growing on the walls and between the ruins, like in Sidon Sea castle and citadel of Tripoli. Human interference was also reported through the habitat loss and fragmentation of the buffer zones surrounding the excavated sites that harbor the majority of plant species. In some locations, buffer zones are used to build additional constructions to the site for touristic purposes mainly, such as ticket and info desks, souvenir shops, and toilets. Visitors tend also to cause further threats to the flora by polluting the site premises. Additional threats are imposed by local people through the performance of some agricultural activities like in Hosn Niha Roman Temple where part of the zone adjacent to the ruins are planted with fruit trees or being grazed by small ruminants. Other threatening factors, include invasive alien species like those reported in our study; *Bidens pilosa radiata* Schl. and *Oxalis pes-caprae* are widely spreading in the country and are causing conflict with the native and indigenous species.

Although plants contribute to the natural landscape of the archaeological sites, their role is controversial as they may possess threats on the structure of archaeological sites (Domina 2018). If not properly managed, vascular plants may cause deterioration, a process defined as the undesirable changes in the properties of a materials caused by vital activities of living organisms (Papafotiou & al. 2017; Cicinelli & al. 2018). Growing flora may lead to cracks, collapse, fissures, and detachment of archaeological materials (Motti & Stinca 2011; Bartoli & al. 2017; Motti & al. 2020; Celesti-Grapow & Ricotta 2021).

Future perspectives

Based on our observations, these archeological sites play an important role in the conservation of diverse and endemic flora. Here we provide the following recommendations that should be adapted for appropriate management and preservation.

Implementing methodologies which include plant management practices in coordination with the archaeological conservation protocols such as adapting selective weeding programs and keeping deep rooted plants from destroying stones and walls.

Educating visitors and tourists on the importance of both the natural and cultural complex of the site.

Further protection and conservation of the natural landscape surrounding the excavated sites should be implemented by creating the ancillary botanical gardens in Lebanese archeological sites. Buffer zones surrounding the excavated sites are ideal for the implementation of this. Based on our survey, Hosn Niha Roman Temple known for its prominent neglected structure, serves as a perfect spot for the application of this concept, since its harbors unique, endemic, and rich flora diversity.

Acknowledgment

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Article

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The Balkan endemic *Centaurea grbavacensis* (*Asteraceae*) ─ New evidence on variation, typification, and distribution, with karyological studies

Abstract

Phitos, D., Niketić, M., Kipopoulos, E. & Kamari, G.: The Balkan endemic *Centaurea grbavacensis* (*Asteraceae*) ─ New evidence on variation, typification, and distribution, with karyological studies. — Fl. Medit. 33: 111-129. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

Centaurea grbavacensis, a Balkan endemic species of North Macedonia and N and C Greece, has been thoroughly studied throughout its distribution, based on living, photographic and herbarium material as well as literature. It was found that all forms of the species grow in both Greece and North Macedonia. We studied the variation of the main morphological features, especially for the Mt. Olympos (Greece) subpopulations. It was found that spine length of the involucral phyllaries varies significantly within individuals and subpopulations, irrespective of flower colour (the typical colour is dark brownish purple, whereas in *C. grbavacensis* f. *lutea* it is yellow). Therefore, *C. grbavacensis* f. *spinescens* cannot be maintained as a separate taxon. A karyological study of the two colour forms was performed, and karyotype photos are provided for the first time. The chromosome number, $2n = 2x = 22$, was confirmed and the karyotype morphology is mentioned.

Key words: *Centaurea*, endemism, taxonomy, variation, distribution, karyology.

Introduction

Rohlena (1935) was first to recognize *Centaurea grbavacensis* (Rohlena) Stoj. & Acht. as a new taxon, initially described it as a variety of *Centaurea immanuelis-loewii* Degen, which also had been based on plants from southern former Yugoslavia, known today as North Macedonia.

Centaurea grbavacensis belongs to *C.* sect. *Acrocentron* (Cass.) DC., a section of c. 100 species mainly found in the Mediterranean region (Font & al. 2002, 2009). Micevski (1975), in his relevant publication on some species of the section, treated the variation of *C. grbavacensis* by formally recognising three formae: f. *grbavacensis* (Fig. 1), f. *spinescens* Rohlena (Fig. 2) and f. *lutea* Micevski (Figs 3 and 4). The said variation is not surprising in view of the relatively wide distribution of the species.

Centaurea grbavacensis is a characteristic and attractive Balkan endemic. The most noticeable and interesting feature of its variation is flower colour. *C. grbavacensis* was

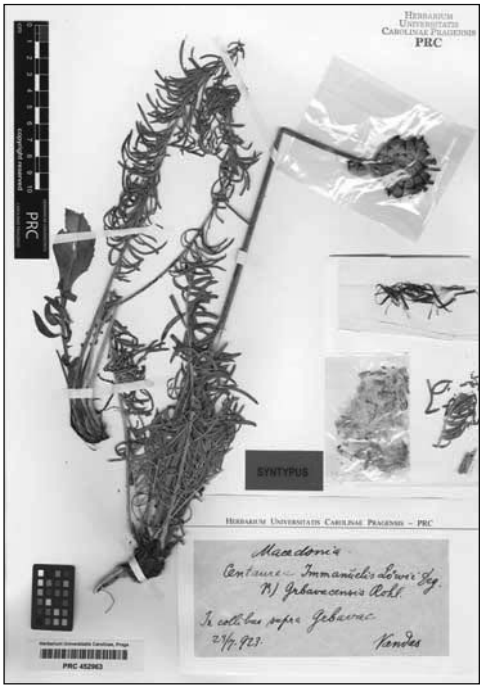


Fig. 1. The lectotype (PRC 452963) of *Centaurea grbavacensis* f. *grbavacensis,* designated here.

Fig. 2. The holotype specimen (PRC 452966) of *Centaurea grbavacensis* "f. *spinescens*" Rohlena.

considered endemic to North Macedonia until 1976 (Dostál 1976). It has been well studied throughout its scattered distribution in North Macedonia and all its forms (as recognized by Micevski 1975) have often been found to coexist in the same local population (Map 1, Appendix 1). The yellow flower colour, first informally referred to as *Centaurea immanuelis-loewii* "fl[ore] luteo" by Soška (1938: 230), was known, so far, only in the northernmost distribution area of the species (Map 1, Figs 3 and 4), where it grows side by side with the typical colour form (Map 1, Fig. 5).

Centaurea grbavacensis is also found in central and northern Greece (close to the border with North Macedonia). The oldest herbarium specimen of the species from Greece, collected on 18.6.1930 by Erik Wall at "Kleinovo (Kapeo)", [South Pindos, locality located 35 km SW of Kalambaka] (Lundberg 2022; specimen [S No S10-6204] currently unavailable for study). In 1976, Voliotis, while studying the flora of Mt. Voras, collected *C. grbavacensis* on 15.6.1976 (*Voliotis 1186*: Voliotis 1979: 214); Greuter, in 1976, found it on Mt. Tzena (*Greuter 14108*, 30.7.1976) and Strid & Kjellson, again in the same year 1976, on the north-eastern foothills of Mt. Olympos (Strid 1980).

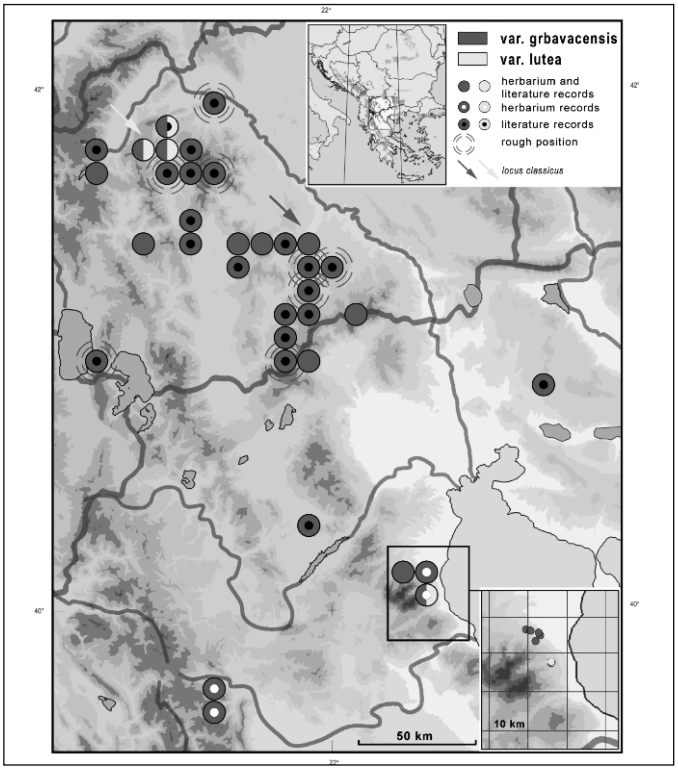
Several additional records were later added from Mt. Tzena (Strid & Papanikolaou 1981; Strid & Andersson 1985; Wagenitz & Gamal-Eldin 1985; Gamal-Eldin & Wagenitz 1991; Chasapis & al. 2016, 2020; Chasapis 2017) and from Mt. Olympos (Gamal-Eldin & Wagenitz 1991; Routsi 1993; Routsi & Georgiadis 1999; Pappas 2020).

Fig. 3. The herbarium sheet (BEOU 37322) of *Centaurea grbavacensis* f. *lutea* collected by *N. Košanin* (label written by T. Soška), only 2.5 km from Kapina (cited in Soška 1938, as "*Centaurea grbavacensis* fl[ore] flavo").

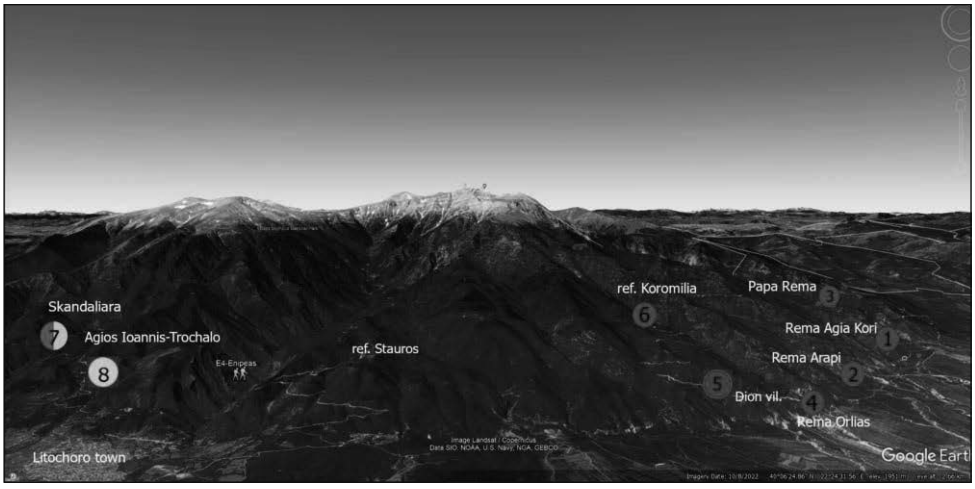
Fig. 4. Holotype specimen of *Centaurea grbavacensis* f. *lutea,* collected by *Micevski* at Gostivarsko, Suva Gora, Jul. 1968 (MCF).

There is also a reference from Langadá (Symes 2019), close to Kalochori (Prov. Thessalonikis), which, however, we have not yet verified. All the above records are of the typical colour form of *C. grbavacensis*; up to date the spiny form ("f. *spinescens*") is not recorded to occur in Greece.

In 2015 Ms Themis Nasopoulou, member of the Olympus National Park Management Agency, together with Assist. Prof. G. Fotiadis, found plants of *C. grbavacensis* with yellow flowers on Mt. Olympos, at the place named Skandaliara, Agios Ioannis – Trochalo, (Figs 6a & 6b); this was the first time such plants were observed in Greece. In the same locality, Ms Nasopoulou also found individuals with the typical flower colour (Figs 6c & 6d). Photographs of flower heads from Mt. Olympos, showing both colours together, were posted on the Internet in May 2016 by Vasileiadis (2016). Several more recent photo posts of yellow-flowered *C. grbavacensis* plants from the same locality on Mt. Olympos followed, as Eleftherios Kipopoulos (co-author of this paper) found and studied *C. grbavacensis* in several localities on that mountain (Map 2).



Map 1. Total geographical distribution of *Centaurea grbavacensis*.



Map 2. Distribution of *Centaurea grbavacensis* on Mt. Olympos, Greece: red circles stand for the typical form, yellow circles for f. *lutea.* Locality numbers (see Appendix 1) are shown within the circles.

Material and Methods

Herbarium material from the whole distribution range in North Macedonia and north and central Greece was used (Maps 1 & 2), kept in the herbaria ATH, ATHU, B, BEO, BEOU, C, EGE, G, GOET, HUTH, K, LD, M, MCF, P, PRC, S, SKO, UPA, WU (abbreviations according to Thiers 2022+) and in the private herbarium "*Phitos & Kamari*" (deposited at UPA). The cited records from living and herbarium material or from literature are listed in Appendix 1. Distribution is mapped using a 10 × 10 km squares grid, based on the Military Grid Reference System (MGRS) of Greece (Lampinen 2001).

Living plants kept in cultivation at the University of Patras, originating from Mt. Olympos, were used for karyological study, which followed is the classical squash technique by Östergren & Heneen (1962), with some small modifications (especially in the pretreatment: 00.03% v/w aqueous 8-hydroxyquinoline, in 5 °C, for 3h). Details of the squash technique and the karyotype morphology have been reported in previous papers (Kamari 1992; Samaropoulou & al. 2013; Bareka & al. 2015).

Fig. 5. Specimen of *Centaurea grbavacensis* (in Flora Exsiccata Macedonica) with two individuals belonging to the two colour forms of the species, collected by *Teofilovski* (30.5.1999) in Suva Gora, North Macedonia.

Results and Discussion

Variation

The most noticeable variable features in *Centaurea grbavacensis* are flower colour, size of the apical spines of the involucral bracts (phyllaries) of the capitula (flower heads), especially of the outer middle phyllaries, as well as the segment shape of the basal leaves (simple-intact or sickle-shaped). In particular, the colour of the flowers varies significantly. The typical flowers have dark brownish-purple colour and appear to occur in almost all species subpopulations or populations (Maps 1 & 2, Figs 1, 2, 5, 6c & 6d, 7, 8).

Early literature (Soška 1938: 230) and herbarium material from North Macedonia show that individuals of *Centaurea grbavacensis* with yellow flowers are scattered in three very close localities or subpopulations in the northern part of the species distribution (Map 1). For example, according to Teofilovski (2011) both forms abound in the lower parts of the Treska gorge (Fig. 5), while upstream from the village Zdunje f. *lutea* is prevalent and on the peak Visoka Čuka (Zdunje) that variant no longer exists. On the other hand, in most of the populations or subpopulations scattered in North Macedonia, individuals of otherwise typical *C. grbavacensis* vary in the length of their phyllary spines (Fig. 2, Map 1).

In Greece, the most populations consist of typical plants with dark purplish-brown flowers only. Additionally, on Mt. Olympos, where several scattered subpopulations of *Centaurea grbavacensis* occur (Map 2), we also observed predominance of the typical flower colour (f. *grbavacensis*), but considerable variation in phyllary spine length (Fig. 8). However, on Mt. Olympos, in two subpopulations in the SE part of its range plants with yellow flowers (f. *lutea*) are prevalent (Figs 6a & 6b & 9); in subpop. no 8 (Map 2), not individuals with dark brownish-purple flowers have so far been observed.

It is noteworthy that from the abundant living and photographic material of *Centaurea grbavacensis* studied from Mt. Olympos, we observed that plants with spiny phyllaries (with spines up to 10 mm long, corresponding to "f. *spinescens*") coexist with spineless ones in several localities, irrespective of flower colour (Fig. 6a-b, Fig. 8a-d).

We conclude that, as the length of the phyllary spines varies significantly among the individuals of both colour forms of the species, "f. *spinescens*" cannot be considered as a separate taxon.

With regard to the variation of the segment shape of the basal leaves, our observation on living plants from Mt. Olympos, and of photographs of herbarium specimens (notably the type material of *C. grbavacensis*) and can be summarised as follows: individuals with flowers of brownish-purple colour tend to have basal leaves with simple (entire), falcate or straight segments spreading at a right angle from the leaf rachis. Conversely, individuals with yellow flowers have basal leaves with toothed or deeply lobed segments, but sometimes a few with an undivided lamina (Figs 1 & 2). However, as the mentioned differences in basal leaf shape are not significantly diagnostic for the two different flower colour types.

On Mt. Tzena, *Centaurea grbavacensis* coexists with *C. kotschyana* Heuff, with which it shares the dark brownish-purple flower colour, but which is easily distinguished by a combination of stem and leaf characters: However, *C. kotschyana* has leafy stems and undivided basal leaves, whereas in *C. grbavacensis* the stems are consistently leafless stem and the basally crowded leaves are pinnatisect to bipinnatisect, with numerous linear or linear-lanceolate ultimate segments arranged in different planes.

Fig. 7. Natural habitat (**a**) and capitula (**b** and **c**) of the typical form of *Centaurea grbavacensis*, from Mt. Olympos (Map 2, subpop. no. 6), at the Refuge Koromilia (photos by E. Kipopoulos).

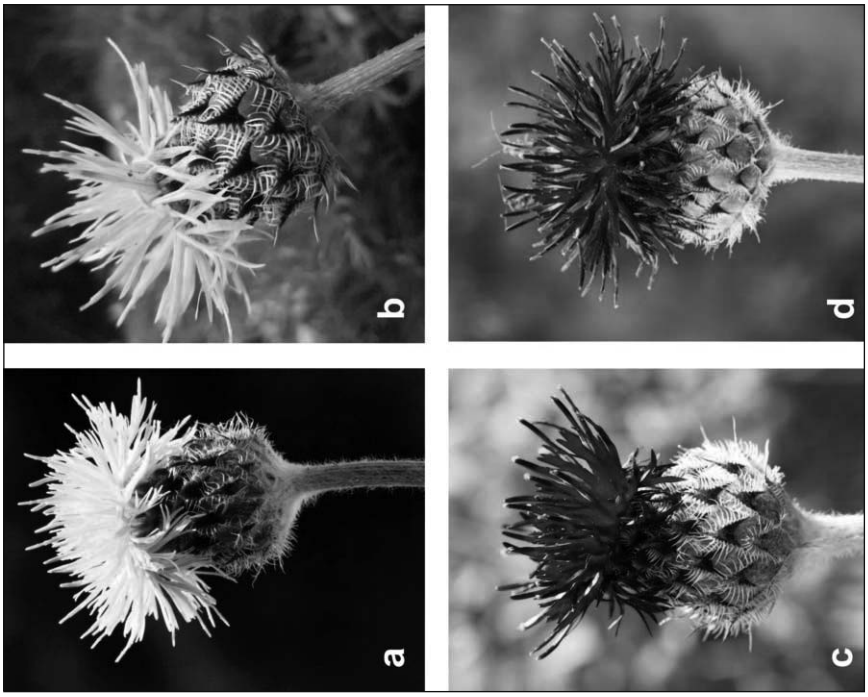


Fig. 6. Capitula of *Centaurea grbavacensis,* individuals from Mt. Olympos (Map 2), at place named Scandaliara (subpop. no. 7): **a** and **b,** f. *lutea;* **c** and **d,** f. *grbavacensis* (photos by Th. Nasopoulou).

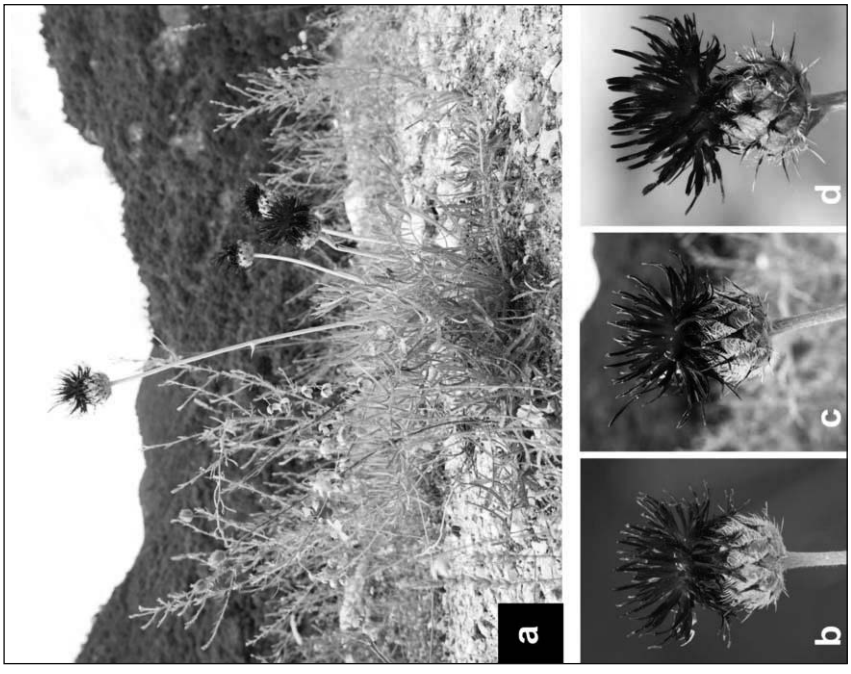


Fig. 8. Natural habitat (**a**) and capitula (**b, c, d**) of the typical form of *Centaurea grbavacensis*, from Mt. Olympos (Map 2, subpop. no. 2), varying much in the length of phyllary spines (photos by E. Kipopoulos).

Fig. 9. Plants (**a** and **b**) in their natural habitat and capitulum (**c**) of *Centaurea grbavacensis* f. *lutea,* from Mt. Olympos (Map 2, subpop. no. 8) (photos by E. Kipopoulos).

According to Micevski (1975), *Centaurea grbavacensis* is also similar to *C. immanuelis-loewii* Degen (both having dark brownish-purple flowers); he regards all Yugoslav (North Macedonian) records of the latter as belonging to the former.

In Greece, the two species *Centaurea grbavacensis* and *C. immanuelis-loewii* never grow together and can be distinguished easily by their stems and habit. *C. immanuelis-loewii* has numerous branched stems with leaves, while *C. grbavacensis*, consistently, has unbranched, leafless stems.

Typification of *Centaurea grbavacensis*

Centaurea grbavacensis (Rohlena) Stoj. & Acht., Stud. Centaur. Bulg.: 39. 1935 ≡ *Centaurea immanuelis-loewii* var. *grbavacensis* Rohlena in Věstn. Král. České Společn. Nauk. Tř. Mat. Přír. 1935(3): 4.1935 ≡ *Colymbada grbavacensis* (Rohlena) Holub in Preslia 46: 228. 1974.

= *Centaurea atropurpurea* var. *soskae* Stoj. & Acht., Stud. Centaur. Bulg.: 40. 1935 ≡ *Centaurea atropurpurea* subsp. *soskae* (Stoj. & Acht.) Dostál in Bot. J. Linn. Soc. 71: 195. 1976.

= *Centaurea immanuelis-loewii* [var. *grbavacensis* Rohlena] f. *spinescens* Rohlena in Věstn. Král. České Společn. Nauk. Tř. Mat. Přír. 2: 4 (1935), **syn. Nov.**

Lectotype: (Designated here by Phitos, Niketić & Kamari): North Macedonia (FYRoM): "Macedonia. In collibus supra Grbavac, pr. Prilep (Brno)", 23.7.1923, *Vandas* (PRC 452963!). — Fig. 1. (http://herbarium-prc.natur.cuni.cz/jacq-viewer/viewer.html?rft_id=prc_452963; Isolectotypes: PRC 452961!, 452964!, 452965!, 452966!).

Perennial herb. *Stems* usually 1–2, rarely many, 20–50 cm tall, erect, rarely with secondary stems, always leafless, woody at the base, usually glabrous above. *Basal leaves* petiolate, pectinate, 8–35 cm long, sparsely arachnoid, with numerous pairs of usually falcate segments (10-)15–55 × (1-)1.5–4.5 mm, subentire or dentate or lobed. *Phyllaries* in several series, 4-8 mm broad, arachnoid, almost completely covered by 3–8 mm long appendages. *Appendages* ± triangular, 5-8-3-6 mm, with a black, ciliate, distinctly decurrent border and ending in a (2-)2.5–6(-10) mm long spinule; *cilia* c. 15–20 on each side, c. 3–5.5 mm long, dark brown at base, with silvery tips. *Flowers* dark brownish-purple or yellowish to yellow, the marginal ones slightly radiating. *Achenes* 4–5 mm long, bearded at base; *pappus* bristles 6–8(-9) mm long, brownish, those of the inner row 1.2–2 mm long.

Two forms are being recognized:

C. grbavacensis (Rohlena) Stoj. & Acht. f. ***grbavacensis***

— *Flowers* dark brownish-purple.

C. grbavacensis f. ***lutea*** Micevski in Godišen Zborn. Přír.-Mat. Fak. Univ. Skopje, Biol. 27-28: 183. 1975.

Holotype: Gostivarsko, Suva Gora, Jul. 1968, *Micevski* (MCF!). Fig. 4.

— *Flowers* yellowish to yellow.

Micevski (1975: 183) described *Centaurea grbavacensis* f. *lutea* referring to "*C. immanuelis-loewii* fl. luteo" of Soška (1938: 230), which is a descriptive designation, not a validly published name. Even though Micevski failed to use the term "type" referring to the single specimen he cited for his f. *lutea,* thus apparently failing to meet the requirements of valid publication of that time (Turland & al. 2018: Art. 7.11 & 40.1), the name is nevertheless validly published under Art. 40.2. The fact that, in the German summary, two localities are mentioned for f. *lutea* is not tantamount to the inclusion of more than one specimen in the new taxon (see Turland & al. 2018: Art. 40 Note 2).

Plants with clearly spiny phyllaries, named "f. *spinescens*" or corresponding to the relevant description, have not been reported from Greece, so far. However, our study of the photographic material collected over the years on Mt. Olympos by E. Kipopoulos, showed

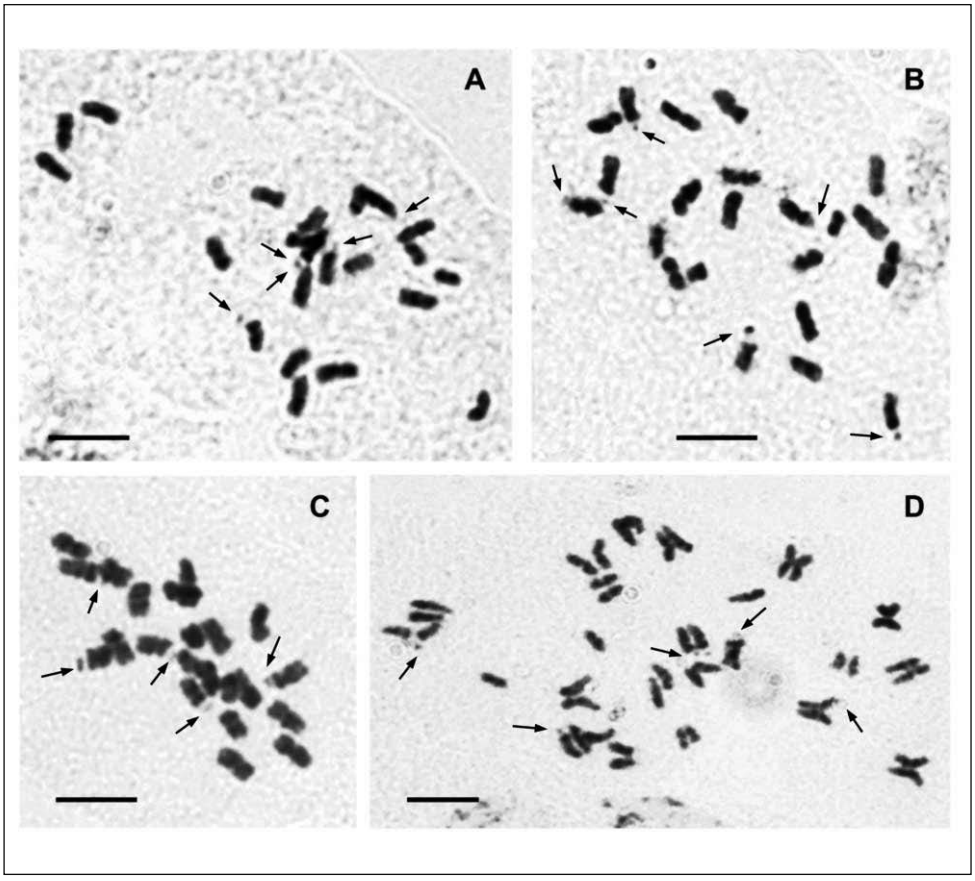


Fig. 10. Karyotypes of *Centaurea grbavacensis*: **a** and **b,** mitotic metaphase plates of the typical form; **c,** mitotic metaphase and **d,** mitotic anaphase plate of f. *lutea.* – Arrows indicate the SAT-chromosomes; Scale bars = 10 μm.

that in the locality Rema Arapi (subpop. no. 2 in Map 2) a majority of otherwise typical plants of *C. grbavacensis* have up to 10 mm long phyllary spines (Fig. 9) and according to Rohlena (1935: 4) correspond to his "f. *spinescens*".

The same kind of phyllary variation was also observed in several subpopulations of Mt. Olympos.

Additionally, we can here report, for the first time, that the same kind of variation in phyllary spines also exists in yellow-flowered plants (f. *lutea*) in material from subpop no. 7 (Map 2) on Mt. Olympos (Fig. 6), some of which, based on spine length, would correspond to "f. *spinescens*". Probably, further study of all subpopulations of *C. grbavacensis* will show that throughout the species distribution the appearance of spiny phyllaries is a variable character, and that spiny plants appear in both colour forms recognized here.

Distribution

Centaurea grbavacensis is a Balkan endemic that occurs in North Macedonia, north and central Greece (Map 1, Appendix 1), where it forms small, scattered subpopulations.

In three subpopulations in the northern part of North Macedonia (Map 1), both colour forms of *C. grbavacensis* coexist, and several subpopulations show strong variation in length (up to 10 mm) of the phyllary spines, even on single plants.

In Greece (Map 1) the typical colour form of C. *grbavacensis* predominates. The exception is Mt. Olympos (Map 2), where several scattered subpopulations of typical, dark-purple flowered C. *grbavacensis*, grow on the NE slopes (Figs 7 & 8), but in the two only subpopulations of the SE slopes, also f. *lutea* appears. In subpop. no. 7 (Map 2) some typical, dark-purple flowered plants also exist (Fig. 6), but in the subpop. no. 8 (Map 2), only yellow-flowered plants have been observed, so far (Fig. 9).

Even though the flora of Mt. Tzena and Mt. Voras of N Greece has been well studied, no yellow-flowered plants of *C. grbavacensis* have been reported from there, in spite of the shorter distance separating these mountains from northern North Macedonia.

We conclude that yellow-flowered plants (f. *lutea*) only occur in few localities in the northern and southern the periphery of the total species range (Map. 1).

Karyology

In *Centaurea* sect. *Acrocentron* (Cass.) DC., to which *C. grbavacensis* belongs, there are two basic chromosome numbers: x = 11, that is considered ancestral and is known only from diploid taxa, and x = 10, found in both diploids and polyploids (up to deca- and endecaploids, with 2*n* = 100 and 2*n* 110 chromosomes: Phitos 1970, 1971; Phitos & Kamari 1973). Several taxa of *C.* sect. *Acrocentron* have been studied karyologically (Dittrich 1966; Runemark 1967; Gardou 1969; Phitos 1970, 1971; Phitos & Kamari 1973; Damboldt & Matthäs 1975; Phitos & Georgiadis 1981; Georgiadis & Christodoulakis 1984; Routsi & Georgiadis 1988, 1999; Routsi 1993; Font & al. 2008, 2009; Uysal & al. 2009; Ranjbar & Negaresh 2013; Zografidis & al. 2023).

For *Centaurea grbavacensis* the chromosome number 2*n* = 2x = 22 has been reported by Strid & Andersson (1985: 205) and Wagenitz & Gamal-Eldin (1985), in individuals with dark brownish-purple flowers from the SE summit of Mt. Tzena. Additionally, Routsi (1993) and Routsi & Georgiadis (1999) reported the (presumably erroneous) chromosome number 2*n* = 2x = 20 in material of the same taxon from Mt. Voras (Pozar).

Karyologically examined material (from Greece: Mt. Olympos)

C. grbavacensis f. ***grbavacensis*****:** Inter locum Dion et refugion Koromilia, 40° 08' 48.14" N 22° 26' 58.52" E, alt. 435 m, 13.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari* no 29508) (subpop. no. 5, Map 2). **—** Figs 10a-b.

C. grbavacensis f. ***lutea*****:** Agios Ioannis-Trochalos: ad margines viae sylvaticae inter vicum Litochoro et locum Scandaliara, 40° 04' 46.81" N, 22° 28' 52.18" E, alt. 806 m, 13.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari* no 29507) (subpop. no. 8, Map 2). **—** Figs 10c-d.

We counted $2n = 2x = 22$ chromosomes in both colour forms of *Centaurea grbavacensis,* on material from Mt. Olympos (see above). The chromosome number in both forms is diploid, the karyotypes are symmetrical and include metacentric (m) and submetacentric (sm) chromosomes. Two chromosome pairs in the karyotypes of both forms bear satellites. These two pairs of sm-SAT chromosomes bear spherical satellites on their shorter arms and are usually well visible. In some cases, we observed a third pair of small spherical satellites, but these are not always visible (in Figs 10a, 10c & 10d we observed five, and in Fig. 10b, six satellites). The karyotype formula is $2n = 2x = 8m+8sm + 6sm\text{-}SAT = 22$ chromosomes, varying in size from 3.0 to 5.7 μm.

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Appendix 1. Referred and studied specimens of the Balkan endemic *Centauea grbavacensis* s.l. from its total geographical distribution.

Centaurea grbavacensis* f. *grbavacensis

NORTH MACEDONIA:

Kavadarci (MGRS EL78):

Grbavec ["Grbavac"] as *Centaurea immanuelis-loewii* Degen var. *grbavacensis* Rohlena, 1923.07.23, Macedonia: Vrcholy nad Grbavcem, leg. *K. Vandas* (Brno), *no 5084* (PRC 452957; PRC 452958. The original specimen was divided onto following sheets (bar-coded units) in 2010: PRC 452957 (Fig. 2) & PRC 452958); supra Grbavac, leg. *K. Vandas* (Brno), s.n. (PRC 452959; PRC 452960); in collibus supra Grbavac, 1923.07.23, leg. *K. Vandas* (Brno), s.n. **Lectotype**: PRC 452963 (Fig. 1). [Isolectotypes: PRC 452961; PRC 452964; PRC 452965; PRC 452966] (B, GB, PRC).

Drenovo ("Raec") gorge: Anthyllido-Centauretum grbavacensis (Kostadinovski 2014).

Prilep:

Sivec (MGRS EL48)**:** in saxosis marmoreis montis Sivec, leg. *T. Soška* (BEO 26622); in saxosis marmoreis montis Sivec (s.n. BEOU); leg. *V. Lindtner* (26625 BEO); leg. *T. Soška* (BEO 26623, 26624); leg. *T. Soška* (BEO 26617) (as "*C. immanuelis-löwii*", revised by K. Micevski); leg. *O. & E. Behr* (B); (Micevski 1975) ("B, MCF, S"); (Matevski & Konstadinovski 2003); (Matevski & al. 2015).

Prilep (MGRS EL47)**:** near to the city (Stojanoff & Achtaroff 1935) (Herb. Prague).

Pletvar pass (MGRS EL58)**:** (Matevski & Konstadinovski 2003).

Mt. Kozjak (MGRS EL58)**:** stony places on limestone (Micevski 1975) ("MCF"); (Matevski & Konstadinovski 2003).

Treskavec (MGRS EL48)**:** (Melovski & al. 2012).

Trojaci (MGRS EL68)**:** ad virum, leg. *T. Nocolov* (B).

Poreč:

Kapina (MGRS EM12)**:** leg. *O. Grebenščikov* (BEO 26621) (as "*C. immanuelis-löwii*", revised by K. Micevski); within the distillery in the forest, leg. *O. Grebenščikov* (BEO 26620) (as "*C. immanuelis-löwii*", revised by K. Micevski); leg. *V. Lindtner* (BEO 26618); solo dolomitico, alt. ca. 750 m s.m., leg. *T. Soška*, det. *T. Krstić*, (BEO 26615) (as "*C. immanuelis-löwii*", revised by K. Micevski); alt. ca 800 m s.m., leg. *V. Lindtner* (BEO 26614) (as "*C. immanuelis-löwii*", revised by K. Micevski); solo dolomitico, alt. ca 750 m s.m., leg. *V. Lindtner*, det. *T. Krstić* (BEO 26612, 26613) (as "*C. immanuelis-löwii*", revised by K. Micevski); (Soška 1938) (as "*C. immanuelis-löwii*"); (Micevski 1975) ("BEO"); (Matevski 2010).

Kula (MGRS EM13)**:** Soška (1938) (as "*C. immanuelis-löwii*").

Kula-Kapina (MGRS EM13)**:** in a mixed pine-oak coppice forest, leg. *P. Černjavski* (BEO 26616) (as "*C. immanuelis-löwii*", revised by K. Micevski).

Poreč (MGRS EM11)**:** Soška (1938) (as "*C. immanuelis-löwii*").

Gorna Belica ["Belica"] (MGRS EM21)**:** (Soška 1938) (as "*C. immanuelis-löwii*"); (Micevski 1975) ("MCF").

Mt. Karadžica (MGRS EM21, EM22)**:**

Boro Pole ["Boropolje"]: (Soška 1938) (as "*C. immanuelis-löwii*").

Mt. Jakupica (MGRS EM31)**:** (Melovski & al. 2012).

Makedonski Brod (MGRS EL29)**:**
Barbaros: stony places on limestone (Micevski 1975) ("SKO"); (Matevski & Konstadinovski 2003); (Melovski & al. 2012); (Matevski & al. 2015).
Debrešte: 41° 22' 21.81" N, 21° 39' 21.14" E, Globulario-Centaureetum grbavacensis, Astragalo-Helianthemetum marmorei (Matevski & al. 2015).

Mt. Bukovik:
Bukovik (MGRS DM82)**:** in saxosis marmoreis, leg. *T. Soška* (s.n. BEOU) (as "*C. grbavacensis* var. *soškae*"); (Micevski 1975).
Straža (MGRS DM81)**:** (Ivanovski 2011); (Melovski & al. 2012).

Mt. Nidže (= Mt. Voras) (MGRS EL63)**:** (Melovski & al. 2012).

Mt. Ljuben (MGRS EL08)**:** in saxosis marmoreis, leg. *T. Soška* (s.n. BEOU) (as "*C. grbavacensis* var. Soškae"); (Micevski 1975); (Melovski & al. 2012).

Nova Breznica ["Pusta Breznica"]:
Treska Gorge (MGRS EM12, EM13)**:** in pratis saxosis ca. 1000 m prope pag., leg. *P. Černjavski* (S 10-6207) [https://www.gbif.org/occurrence/search?taxon_key=3127657]; (Matevski & Konstadinovski 2003).
Mt. Kozjak (MGRS EM13)**:** (Matevski 2010); (Matevski & al. 2015).

Mariovo:
Satoka (MGRS EL65)**:** (Micevski 1975).
Crna Reka (MGRS EL76, EL77)**:** (Micevski 1975).
Tikveš Lake (MGRS EL87)**:** (Melovski & al. 2012).
Toplik (MGRS EL64)**:** (Matevski 2014); (Matevski & al. 2015).
Sekulova Tumba (MGRS EL65)**:** (Matevski 2014); (Matevski & al. 2015).
Labinica (MGRS EL64)**:** (Matevski 2014); (Matevski & al. 2015).

Skopje (MGRS EM34)**:** (Matevski & al. 2015).

Mt. Suva Gora:
Suva Gora (MGRS EM02)**:** 41.78902° N, 21.05255° E, leg. *B. Zlatković, A. Teofilovski* (*40031* BEOU); Novaković & al. (2022); (Melovski & al. 2012).
Zaječec (MGRS EM13)**:** (Teofilovski 2011).
Lukovica (MGRS EM13)**:** (Teofilovski 2011). – Fig. 5.
Rečište (MGRS EM13)**:** (Teofilovski 2011).

Majdans gorge (MGRS EL75)**:** (Jovanovski & al. 2016).

Mt. Galičica (MGRS DL83)**:** (Globulario-Centauretum grbavacensis) (Ćušterevska 2016).

GREECE:

Mt. Voras (MGRS EL73)**:**

Loutra Pozar: Steinige Abhänge der Therma – Schlucht (Loutra Pozar, häufig, 15.6.1976, leg. *D. Voliotis 1186* (Voliotis 1979: 214); **Pozar,** 12.VIII.1987, leg. *Th. Georgiadis 6939* (UPA): Routsi 1993; WNW of **Loutra Arideas**, 40.966667° N, 21.9° E (?); **Schlucht des Nikolaon-Baches**, 4,6 km nordwestlich Loutra Loutrakiou, 40.98655° N, 21.86485° E: Unnamed Rd.; **Pozar (**GBIF 2022).

Mt. Tzena (MGRS EL95)**:**

Dytikí Makedonía. Macedonia occ. (distr. Almopia), montes **Kožuf**, in letere meridionali verticis Tzena, alt. 1700 m, in fissuris et scanilibus rupium calcareum praeruptarum, flores atropurpurei, 30.7.1976, leg. *W. Greuter no 14108* (B, BEO, C, G, UPA); ibidem: Voliotis (1983); ibidem: Gamal-Eldin & Wagenitz (1991: 493); ibidem: Routsi 1993 (UPA); stony and rocky limestone places with sparse vegetation, alt. 700-1800 m., Font & al. (2002; 2008; 2009); **Nomos Pellas, Mt. Tzena**, 41.151956° N, 22.171624° E, 1930 m.; **E slopes of the SE summit,** c. 1800-2060 m, rocky places in alpine grassland, limestone,19.8.1979, *A. Strid & K. Papanikolaou 16687* (B, C, EGE, G): Strid & Papanikolaou (1981); ibidem: Strid & Andersson (1985: 205); sparse bunch of thermophyllous deciduous trees, 35.1800 E 45.54700 N, 17.10.2009, alt. 1340 m, leg. *M. Chasapis no 416*; in phryganic ecosystems, 350830 E, 4552590 N, 24.5.2012, alt. 720 m, leg. *M. Chasapis no 1914*: Chasapis (2017: 41); Chasapis & al. (2020: 60).

Prov. Thessakloniki, Langadas (MGRS FL72)**:**

Kalochori: meadows in gentle hills near Dorkada: Symes (2019).

Mt. Koziakas (Kleinovo) (MGRS EJ38, EJ39)**:** Kapeo, 18.6.1930, leg. *Erik Wall*, catal. no S10-6204 (S). https://www.gbif.org/occurrence/1096744876 Klinovos (Kleinovo)

Kozani (Skopos) (MGRS EK76)**:** Northern Greece, The Pindhos Mountains: Bennallick & Green (2017).

Mt. Olympos:

Agia Kori (MGRS FK14)**:** (Map 2, subpop. no 1): 40° 09’ 41.02” N 22° 24’ 21.52” E, alt. 370 m, 16.06.2019, *E. Kipopoulos* (obs. & photos); limestone, *E. Routsi* & *E. Karavokyrou 119* (UPA); *Th. Georgiadis* & *E. Routsi 7346* (UPA): Routsi 1993.

Rema Arapi (MGRS FK24)**:** (Map 2, subpop. no 2): 40° 09’ 30.03” N 22° 25’ 12.60” E, alt. 317 m, 19.06.2019 & 22.06.2019, *E. Kipopoulos* (obs. & photos). – Fig. 8; 40° 9’ 23.51” N 22° 25’ 23.27” E, alt. 450 m, 26.05.2020, *E. Kipopoulos* (obs. & photos).

Papa Rema (MGRS FK14)**:** (Map 2, subpop. no 3). N foothills, along forest road on the E side of Papa Rema ravine, alt. 400-600 m, 18.6.1976, *Strid & Kjellsson 11342* & *11521* (ATH, C); ibidem: Schlucht, 430 m, steiniger Steilhang, *Wagenitz 3608* (GOET): Gamal-Eldin & Wagenitz (1991); ibidem: Routsi 1993 (UPA); ibidem: Pappas (2020).

Rema Orlias (MGRS FK24)**:** (Map 2, subpop. no 4): 40° 09’ 12.45” N 22° 26’ 40.34” E, alt. 235 m, 03.06.2020, *E. Kipopoulos* (obs. & photos).

Dion to Koromilia (MGRS FK24)**:** (Map 2, subpop. no 5): Inter locum Dion et refugion Koromilia, 40° 08’ 48.14” N 22° 26’ 58.52” E, alt. 435 m, 13.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari 29508*); ibidem: alt. 400-600 m, 23.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari 12953*); ibidem: 40° 8’ 48.70” N 22° 26’ 58.02” E, alt. 445 m, 05.06.2022, *E. Kipopoulos* (obs. & photos).

Koromilia (MGRS FK24)**:** (Map 2, subpop. no 6): Refugion Koromilia, 40° 8’ 0.33” N 22° 26’ 4.43” E, alt. 1012 m, 28.06.2020, *E. Kipopoulos* (obs. & photos). – Fig. 7.

Agios Ioannis-Trochalo (MGRS FK23)**:** (Map 2, subpop. no 7), place named Scandaliara: 40° 4’ 48.73” N 22° 28’ 55.18” E, alt. 785 m, *Th. Nasopoulou* (obs. & photos). – Figs 6c & 6d.

Centaurea grbavacensis* f. *lutea

NORTH MACEDONIA:

Mt. Suva Gora:
Suva Gora (MGRS EM02)**:** Holotype: Gostivarsko, Suva Gora, Jul. 1968, leg. *K. Micevski* (183 MCF). – Fig. 4; ibidem: 41.78902°N, 21.05255°E, leg. *Zlatković & A. Teofilovski 40023* (BEOU); Novaković & al. (2022).
Zaječec (MGRS EM13)**:** (Teofilovski 2011).
Lukovica (MGRS EM13)**:** (Teofilovski 2011). – Fig. 5.
Rečište (MGRS EM13)**:** (Teofilovski 2011).
Zdunje (MGRS EM13)**:** Visoka Čuka (Teofilovski 2011).

Poreč (MGRS EM12)**:**
Kapina: leg. *H. Oehm* (BEO) (as "*C. immanuelis-löwii* fl. lutei", revised by K. Micevski); 2.5 km from Kapina, leg. *N. Košanin* (label written by T. Soška) (BEOU): Soška (1938).
Oča ["Onča"] river: Kozji do, in glareosis, leg. *N. Košanin* (BEOU 37322) (as *C. immanuelis-loewii*). – Fig. 3.

GREECE:

Mt. Olympos
Agios Ioannis-Trochalo, place Scandaliara (MGRS FK23)**:** (Map 2, subpop. no 7): 40° 04' 48.73" N 22° 28' 55.18" E, alt. 785 m, *Th. Nasopoulou* (obs. & photos). – Figs 6a & 6b.
Agios Ioannis-Trochalo (MGRS FK23)**:** (Map 2, subpop. no 8): ad margines viae silvaticae inter vicum Litochoro et locum Scandaliara, 40° 04' 59.66" N 22° 28' 48.08" E, alt. 800 m, 29.05.2020, *E. Kipopoulos* (obs. & photos). – Fig. 9; ibidem: 40° 04' 46.81" N 22° 28' 52.18" E, alt. 806 m, 13.07.2021., *E. Kipopoulos* (Herb. *Phitos & Kamari 29507*); ibidem: 40° 04'59.66" N 22° 28' 48.08" E, alt. 700-850 m, 23.07.2021, *E. Kipopoulos* (Herb. *Phitos & Kamari 29512*).

Article

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Floristic composition of *Spiraea hypericifolia* (*Rosaceae*) shrubberies of Georgia (Caucasus)

Abstract

Lachashvili, N., Kereselidze, K., Eradze, N. & Khetsuriani, L.: Floristic composition of *Spiraea hypericifolia* (*Rosaceae*) shrubberies of Georgia (Caucasus). — Fl. Medit. 33: 131-156. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

The floristic composition of *Spiraea hypericifolia* shrubberies distributed in Georgia is studied for first time. 256 species of vascular plants, which belong to 172 genera and 49 families, were recorded. Leading families by content number of species are: *Poaceae* - 28 species (10.9%), *Asteraceae* – 27 (10.5%), *Fabaceae* – 20 (7.8%), *Rosaceae* – 18 (7%), *Brassicaceae* – 16 (6.3%), *Lamiaceae* – 16 (6.3%), *Apiaceae* – 11 (4.3%), *Caryophyllaceae* – 11 (4.3%), *Asparagaceae* – 7 (2.7%). Spectrum of life forms is as follows: phanerophytes – 37 species (14.4%), chamaephytes – 8 (3.1%), hemicryptophytes – 109 (42.6%), geophytes – 33 (12.9%), therophytes – 69 (27%). Based on the analysis of the systematic structure of the flora, the composition and ratio of chorotypes and the composition of life forms, 4 main directions of florogenetic connections were identified: Mediterranea, South-West Asia, Europe and Eurasian steppe. It can be concluded that the formation of the *Spiraea hypericifolia* shrubberies in Georgia took place under the influence both of the Ancient Mediterranean and Boreal floristic centers. Nevertheless, the Ancient Mediterranean connections are more expressed. The dominance of local (Caucasian) species in the spectrum of chorotypes (14%) emphasizes the originality of the studied shrubberies.

Key words: systematic structure, chorotypes, life forms, florogenetic connections.

Introduction

The distribution area of the Iberian Spirea (*Spiraea hypericifolia* L.) extends from southwestern Europe (Iberian Peninsula) to China and Mongolia including southern parts of East Europe and Siberia, Crimea, Caucasus eco-region, Balkan Peninsula (Bulgaria), Middle Asia and partially South-West Asia.

The hypsometric range of the species in the Caucasus extends from the foothills to the subalpine belt.

Indications for the occurrence of plant communities of Iberian Spirea shrubberies in different regions of the Caucasus can be found in numerous scientific papers (Takhtadjan 1941; Rubtsov 1956; Prilipko 1970; Lachashvili & al. 2013; Fayvush & Aleksanyan 2016,

etc.). However, they do not contain any information on the distribution patterns, phytosociological structure and floristic composition of *S. hypericifolia* shrubberies.

In the Caucasus shrubberies dominated by *S. crenata* and/or *S. hypericifolia* are mainly distributed from foothills to middle mountain belt (Rubtsov 1956). But in the southern part of the South Caucasus (Armenia) they are common in the subalpine belt (Fayvush & Aleksanyan 2016).

In Georgia, particulary in the Tbilisi environs and on the Iori plateau, scant information about *Spiraea hypericifolia* shrubberies is available in the publications by Kakulia (1942) and Sakhokia (1961).

Recent research has revealed that shrubberies of *Spiraea hypericifolia* are one of the interesting and important components of the Eastern Georgia vegetation. In particular, Iberian Spirea shrubberies are one of the main and characteristic formations of the Tbilisi area vegetation (Lachashvili & al. 2013; Lachashvili & Eradze 2017). Its distribution patterns and typological composition in the Tbilisi environs are studied, the list of floristic composition and spectrum of the life forms are given (Lachashvili & al. 2019). In addition, in the context of digression successions of post-forest vegetation of the Tbilisi vicinity, the Iberian Spirea shrubberies are discussed in monograph of Lachashvili & al. (2015). The existence of Iberian Spirea communities on Iori plateau, particulary, in the David Gareji protected landscape is confirmed in the article by Lachashvili and Kereselidze (2020).

Spiraea hypericifolia formation is interpreted differently by researchers. Part of researchers (Rubtsov 1956; Sakhokia 1961; Prilipko 1970; Lachashvili & al. 2013; Lachashvili & al. 2015; Lachashvili & Eradze 2017; Lachashvili & al. 2019; Lachashvili & Kereselidze 2020, etc.) attribute it to the hemixerophilous shrubberies of shibliak type, and some researchers attribute it to the so-called steppe scrubs and consider it to belong to the Boreal vegetation (Fayvush & Aleksanyan 2016; Kamelin 2017).

The aim of our research was to determine the distribution area of Iberian Spirea formation in Georgia; study its floristic composition; and based on the analysis of the systematic structure of flora, composition of chorotypes and life forms to identify the main floristic connections.

Materials and Methods

Collection of floristic and phytosociological data was carried out over 2005-2021.

While separating the chorotypes, we were guided by the principles and methods of Ivanishvili (1978), Portenier (2000a, 2000b) and Gagnidze (2004). The concepts of Brovich (1989) as well as Meusel and Jager (1989) and the phytogeographical zoning of Earth by Takhtajian (1978) are also taken into account. As in our previous articles (Lachashvili & al. 2020; Lachashvili & al. 2021) emphasis was placed on detail when distinguishing chorotypes. Mono, double, triple, and in some cases quadruple regional chorotypes are separated. The chorotypes were selected in four major groups: (1) Boreal, (2) Ancient Mediterranean, (3) "conjunctive" and (4) widespread. Such methods have allowed us to analyze in detail. The borders of the Ancient Mediterranean and Boreal regions are defined according to Takhtajan (1978). Caucasus and Caucasian endemics are discussed in the boundaries of Caucasus eco-region (Solomon & al. 2013).

Taxa and their authors are given according to international plant databases [Euro+Med (2006-), The Plant List (2013), GBIF.org (2022), IPNI (2022), POWO (2022), Tropicos.org (2022), WFO (2022)].

The spectra of life forms are based on the classifications of Raunkiaer (1934) and Serebryakov (1964).

Soils and related terms are given according to Urushadze (1999, 2016). Climatic data are reconciled with data of Loladze (1967, 1970), Gobejishvili (2012) and Bolashvili & al. (2018).

Results

Description of the study area. – As a result of our research, it was found that the distribution area of the *Spiraea hypericifolia* formation in Georgia includes the central and western parts of the Iori Plateau, the foothills of the eastern endings of the Trialeti Ridge, the Kverknaki Ridge and the Shida Kartli Plain hills; rare on the northern foothills of the Saguramo Ridge and the southwestern foothills of the Gombori Ridge (Fig. 1).

The physical-geographical conditions of the area are more or less heterogeneous, which is primarily due to the characteristics of the climate and soil.

Distribution area of Iberian Spirea scrubs in Georgia is mainly located in moderately humid subtropical climate region. Nevertheless, different parts of the area belong to various climatic zones and are characterized by more or less different parameters.

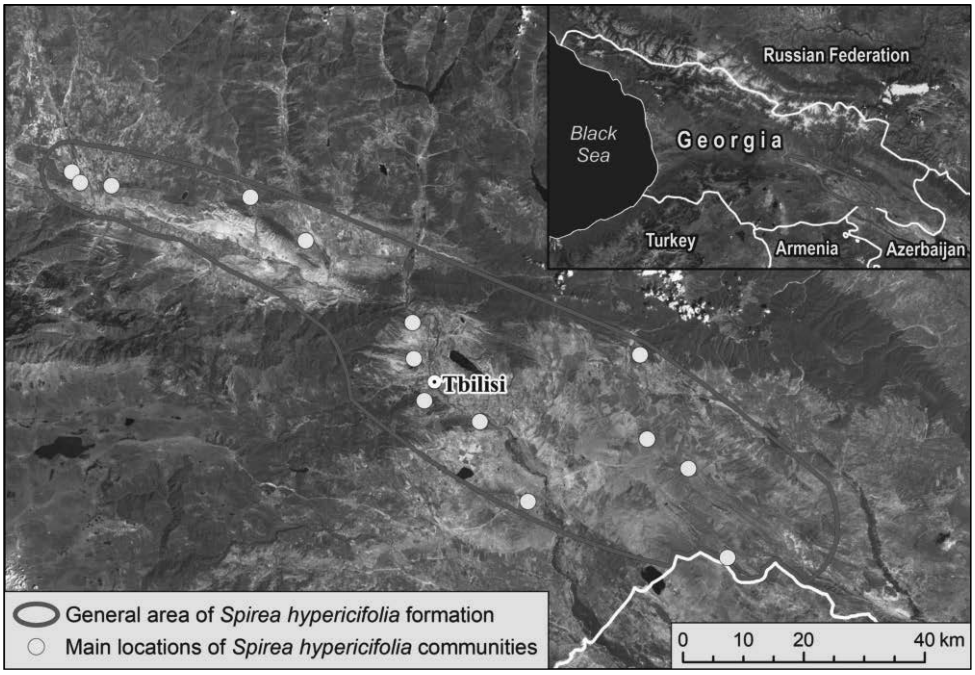

Fig. 1. Distribution area of *Spiraea hypericifolia* shrubberies in Georgia.

The central and western parts of the Iori Plateau are characterized by a transitional climate from a moderate warm steppe to a moderate humid with hot summer and two minimums of precipitation per year (BS-Cxa). The average annual temperature is in the range of 10.4°C-12°C, the average annual precipitation - (400) 450-550 (600) mm, evaporability – (800) 900-1000 mm, humidity ratio - (0.4) 0.5-0.6.

Area of different climatic zones (BS-Cxa, Cxa, Cxb, Dxbk') are intersected in the vicinity of Tbilisi. Most part of the Tbilisi area, as well as central and western parts of the Iori Plateau is within the transitional climate zone from a moderate warm steppe to a moderate humid (BS-Cxa). The eastern endings of the Trialeti Ridge entering in the Tbilisi environs are characterized by a moderate humide climate with moderately cold winter and prolonged warm summer and two minimums of precipitation per year (Cxb). Average annual temperature is within 8°C-10°C (11°C), the average annual precipitation is from (570) 600 to 800 (870) mm, evaporability - (700) 800-900 mm, humidity ratio - in the range of 0.6-1. Climatic data of the southwestern foothills of the Gombori Ridge (around the village of Khashmi) and northern foothills of the Saguramo Ridge is similar. Only a small part of the Trialeti Ridge entering in the Tbilisi area (Kojori and etc.) is located in a moderate humid climate zone with modereately cold winter and prolonged cool summer and two minimums of precipitation per year (Dxbk').

The Kvernaki Ridge and the hills of the Shida Kartli Plain are also characterized by a transitional climate from a moderate warm steppe to a moderate humid with hot summers and two minimums of precipitation per year (BS-Cxa). However, the degree of aridity, compared to the Iori plateau and the Tbilisi area, is slightly reduced. In particular, average annual temperature is in the range of 10°C-11°C, the average annual precipitation is from 550 to 650 mm, evaporability – 800-900 mm and humidity ratio - in range 0.6-1.

Hypsometric range of *Spiraea hypericifolia* communities in Georgia is within 600-1000 (1100) m a.s.l. and mostly covers the foothills. They are distributed on the slopes of different inclination (15°-20° to 30°-45°). The macro exposure of the slopes is mostly northern, although they are also found on the southern exposure. They are developed on the various modifications of gray-cinnamonic and cinnamonic soils. In most cases the soil is thin or medium deep. Soils are skeletal. In some cases, bares of the sandstone of marine origin is observed. The inclination of *Spiraea hypericifolia* plant communities in the Caucasus to northern exposure is also noted by other researchers (Kakulia 1942; Rubtsov 1956; Sakhokia 1961). But the distribution of Spirea communities in the southern part of the South Caucasus (in particularl in Armenia) is different. Here they are common in the subalpine belt mainly on slopes of southern exposure (Fayvush & Aleksanyan 2016).

General regularities of the distribution of Spiraea hypericifolia shrubberies in Georgia. – The area of Iberian Spirea formation in Georgia is included, on the one hand, in the area of steppes and, on the other hand, in the area of deciduous forests of the foothills and lower mountain belt.

S. hypericifolia communities are rare in the natural area of steppe (climate zone BS-Cxa). They are most widespread in the transitional climate zones (Cxa, Cxb, Dxbk'), particularly on the eastern endings of the Trialeti Ridge entering in the Tbilisi environs. Here they are in contact with the deciduous forests, various secondary shrubberies and secondary plant communities of steppes and meadows.

S. hypericifolia communities are mostly developed on the slopes of the northern macro-exposure and it is relatively rare on the slopes of the macro-southern exposure.

S. hypericifolia communities are of both primary and secondary origin. The secondary plant communities belong to one of the stages of the digressive succession of the foothill deciduous forests. At present, the structure of primary and secondary communities is, in most cases, identical and it is impossible to draw a line between them (Lachashvili & al. 2015, 2019).

Although the Spirea communities in different parts of the area are in direct contact with the deciduous forests of the foothills, as well as with the steppe vegetation, they do not form a connecting "bridge" between them.

Systematic Structure of Flora. – 256 species of vascular plants were recorded in *Spiraea hypericifolia* shrubberies of Georgia. They belong to 172 genera and 49 families (Table 1).

Leading families by contains of genera are represented in form of a table (Table 2).

Crassulaceae, *Orchidaceae* and *Ranunculaceae* are represented by 4 genera each. Three families (*Caprifoliaceae*, *Oleaceae* and *Rubiaceae*) contain 3 genera each. 10 families are represented by 2 genera each and 22 families – by one genus each. The data makes it clear, that genera are unequally distributed among families. In particular, most of the families (32 families) contain only 24.4% (42 genera) of the total number of genera.

Like genera, species are disproportionately distributed by to families. The spectrum of the top families is given in the form of a table (Table 3).

Boraginaceae and *Rubiaceae* contain 6 species each. 5 families (*Caprifoliaceae*, *Euphorbiaceae*, *Iridaceae, Orchidaceae* and *Ranunculaceae*) are represented by 5 species each and 3 families (*Amaryllidaceae*, *Crassulaceae*, *Geraniaceae*) by 4 species each. 9 families contain 3 species each and 5 families – 2 species each. Almost 1/3 of the families (16 families) are represented by only one species.

Leading genera by species content are *Alyssum* and *Euphorbia* (Table 4).

Composition of chorotypes (Geographical Range Types). – The flora of *Spiraea hypericifolia* shrubberies of Georgia is characterized by a rich composition of chorotypes.

Table 1. General spectrum of vascular flora of *Spirea hypericifolia* shrubberies of Georgia.

Large Taxa		**Families**		**Genera**		**Species**	
		Number	%	Number	%	Number	%
Gymnospermae		2	4.1	2	1.1	3	1.2
Angyospermae		47	95.9	170	98.9	253	98.8
	Dicotyledonae	39	79.6	136	79.1	198	77.3
	Monocotyledonae	8	16.3	34	19.8	55	21.5
Total		49	100	172	100	256	100

Table 2. Number of genera by the leading families in *Spiraea hypericifolia* shrubberies of Georgia.

Family	Number of genera	%
1. *Poaceae*	18	10.5
2. *Asteraceae*	17	9.9
3. *Fabaceae*	14	8.1
4. *Lamiaceae*	12	7.0
5. *Brassicaceae*	11	6.4
6. *Rosaceae*	10	5.8
7. *Apiaceae*	9	5.2
8. *Caryophyllaceae*	7	4.1
9. *Boraginaceae*	6	3.5
10. *Asparagaceae*	5	2.9
Total	109	63.4

Table 3. Number of species by the leading families in *Spiraea hypericifolia* shrubberies of Georgia.

Family	Number of species	%
1. *Poaceae*	28	10.9
2. *Asteraceae*	27	10.5
3. *Fabaceae*	20	7.8
4. *Rosaceae*	18	7.0
5. *Brassicaceae*	16	6.3
6. *Lamiaceae*	16	6.3
7. *Apiaceae*	11	4.3
8. *Caryophyllaceae*	11	4.3
9. *Asparagaceae*	7	2.7
Total	154	60.1

Table 4. Number of species in genera of the vascular flora of *Spirea hypericifolia* shrubberies of Georgia.

Genus	Number of species	Genus	Number of species
Euphorbia	5	*Helianthemum*	3
Allium	4	*Inula*	3
Alyssum	4	*Iris*	3
Astragalus	4	*Poa*	3
Cotoneaster	4	*Silene*	3
Galium	4	*Stipa*	3
Prunus	4	*Tragopogon*	3
Salvia	4	*Viola*	3
Bromus	3	In the rest:	
Convolvulus	3	37 genera	2-2
Geranium	3	116 genera	1-1

256 recorded vascular plants were grouped into 36 geographic range types. Proportion of chorotypes is given in the form of a table (Table 5).

Endemics. – 27 species, which is 10.5% of the total floristic composition, are endemics of Caucasus. All of them belong to the Caucasian chorotype. They are divided into two groups: Caucasus endemics, whose distribution area includes both the North and South Caucasus and endemics of the South Caucasus. The first group includes 17 species. They are: *Acer ibericum* M. Bieb., *Bromus biebersteinii* Roem. & Schult., *Astragalus bungeanus* Boiss., *Centaurea ovina* Willd., *C. reflexa* Lam., *Cephalaria media* Litv., *Cotoneaster meyeri* Pojark., *C. saxatilis* Pojark., *Dianthus subulosus* Conrath & Freyn, *Gagea commutata* K. Koch, *Jurinea blanda* (M. Bieb.) C. A. Mey., *Onobrychis cyri* Grossh., *Ophrys caucasica* Woronow, *Primula woronowii* Losinsk., *Teucrium chamaedrys* subsp. *nuchense* (K. Koch) Rech. F., *Tragopogon tuberosus* K. Koch, *Verbascum formosum* Schrank. The endemics of the South Caucasus are: *Bellevalia montana* (K. Koch) Boiss., *Euphorbia boissieriana* (Woronow) Prokh., *Gypsophila stevenii* Schrank, *Heracleum antasiaticum* Manden., *Polygala transcaucasica* Tamamsch., *Prunus georgica* (Desf.) Eisenman, *Psephellus carthalinicus* Sosn., *Salvia garedjii* Troitsky, *Seseli grandivittatum* (Sommier & Levier) Schischk., *Thymus coriifolius* Ronniger.

Composition of life forms. – Spectrum of life form (Raunkiaer 1934) is as follows: phanerophytes – 37 (14.4%), chamaephytes – 8 (3.1%), hemicryptophytes (with biennial plants) – 109 (42.6%), geophytes – 33 (12.9%), therophytes – 69 (27%).

Table 5. Proportion of chorotypes in the vascular flora of *Spirea hypericifolia* shrubberies of Georgia.

Chorotype	Number of species	%	Number of species	%
Boreal species				
Caucasian	36	14.0	60	**23.4**
European–Caucasian	6	2.3		
Eurasian steppe–Caucasian	12	4.7		
Eurasian steppe	1	0.4		
Caucasian–Euxinian	2	0.8		
Euxinian	2	0.8		
Euro-Siberian	1	0.4		
Ancient Mediterranean species				
Ancient Mediterranean	3	1.2		
Mediterranean	7	2.7	39	**15.2**
Mediterranean–South-West Asian	20	7.8		
Mediterranean–South-West Asian–Turanian	1	0.4		
Mediterranean–South-West Asian–Turanian–Central Asian	1	0.4		
South-West Asian	1	0.4		
South-West Asian–Turanian	3	1.2		
South-West Asian–Turanian–Central Asian	1	0.4		
Iran-Turanian	1	0.4		
Caspian	1	0.4		
"Conjunctive" species				
European–Ancient Mediterranean	4	1.6	109	**42.6**
European–Mediterranean	18	7.0		
European–Mediterranean–South-West Asian	17	6.6		
European–Mediterranean–South-West Asian–Turanian	1	0.4		
European–Caucasian–South-West Asian	2	0.8		
Mediterranean–Caucasian	3	1.2		
Mediterranean–Eurasian steppe	4	1.6		
Mediterranean–South-West Asian–Eurasian steppe	15	5.8		
Mediterranean–Eurasian steppe–Caucasian	4	1.6		
South-West Asian–Caucasian–Eurasian steppe	6	2.3		
Eurasian steppe–Caucasian–Anatolian	1	0.4		
Caucasian–South-West Asian	25	9.7		

Table 5. continued.

Caucasian–South-West Asian–Middle Asian	2	0. 8		
Caucasian–Middle Asian	1	0.4		
Caucasian–Turanian	1	0.4		
Caucasian–Hyrcanian	1	0.4		
Euxino–Hyrcanian	4	1.6		
Widespread species				
Palearctic	43	16.8	43	**18.8**
Holarctic	5	2.0	5	
All	256	100	256	100

Remark – "Middle Asian" means mountainous Middle Asia (Pamir-Alay, Tian Shan, etc.).

Discussion

Systematic structure of flora. – The spectrum of leading families by content of species does not fit into the standard of any floristic center (Mediterranean, South-West Asia, Iran-Turan, Europe, etc.). The influence of various floristic centers is reflected on it.

First of all, a very high position (fourth place) of the family *Rosaceae* is especially noteworthy. The position of this family in the Mediterranean floras is not clearly defined - it is rarely included in the top ten. Instead it is one of the leading families of submediterranean, nemoral and Boreal floras (Turrill 1929; Tolmachev 1986; Chasapis & al. 2020; Vladimirov & al. 2020, etc.). In addition, its position in the floristic spectrum rises from south to north. A similar situation is observed in the Iran-Turan region of the Ancient Mediterranean, where its place in the floristic spectrum increases from non-forest regions to forests (Turril 1929; Kamelin 1973; Karamysheva & Rachkovskaya 1973; Tolmachev 1986; Lachashvili & al. 2007; Lachashvili & al. 2020). Consequently, in the forest regions of South-West Asia, the family *Rosaceae* is always included in the top ten, although it is mostly in the second half of the top ten (6-10 places). Judging from the information above, one can conclude that such a high position of the *Rosaceae* in the *Spiraea hypericifolia* scrub of Georgia indicates both Boreal and South-West Asian connections.

If not for the very high position of the family *Rosaceae* in the spectrum, otherwise the main characteristic features of the Ancient Mediterranean floras are clearly visible. Families *Brassicaceae*, *Caryophyllaceae*, *Apiaceae* and *Lamiaceae* are almost always in the top ten of the floristic spectra of the Ancient Mediterranean regions (Turril 1929; Kamelin & al. 1989; Gagnidze 2000; Asaadi 2009; Aghaei & al. 2013; Dehshiri & Jozipoor 2014; Ghollasimood & al. 2014; Roshan & Heydari 2014: Jafari & al. 2016; Kargar Chigani & al. 2017, etc.). Mentioned families together with *Fabaceae*, *Asteraceae* and *Poaceae*, form the core of the leading families of the Ancient Mediterranean floras. In the context of Ancient Mediterranean connections, we should also consider the presence of *Boraginaceae* and *Rubiaceae* in the top of spectrum (10-11 places).

Separately should be noted the families of *Monocotyledonae* such as *Asparagaceae* (7 species), *Amaryllidaceae* (4), *Liliaceae* (3) and *Colchicaceae* (1). If we consider these families with the older, larger volume of *Liliaceae* (s.l.), then the total number of species included in them would be 15 species and *Lilaceae* (s.l.) would be in the 7th position. Currently the family *Asparagaceae* ranks 9th, and *Amaryllidaceae* is in the second echelon of leading families. All this once again underscores Ancient Mediterranean influence (Mediterranean and South-West Asia). The second dozen of the floristic spectrum (*Caprifoliaceae*, *Euphorbiaceae*, *Iridaceae*, *Orchidaceae*, *Ranunculaceae*, *Amaryllidaceae*, *Crassulaceae*, *Geraniaceae*) emphasize the transitional nature of the flora.

Composition of chorotypes (Geographical Range Types). – The composition of chorotypes is one of the most important characteristics of any flora and best reflects the main directions of florogenetic connections. The number of Boreal chorotypes is 1.5 times higher than the number of Ancient Mediterranean chorotypes. The so-called "conjunctive" chorotypes are represented by the largest number of species (Fig. 2).

In the spectrum of chorotypes first of all a very high share of Caucasian species (14%) are noteworthy. In addition, 27 out of 36 Caucasian species are endemic of Caucasus. All this emphasizes the originality of *Spiraea hypericifolia* shrubberies of Georgia. Not only the high share of Caucasian chorotype is noteworthy, but also its diverse composition. Plants of all life forms and different bioecology are presented. However, a significant part of them are hemixerophilous and xerophilous and with their bioecology and systematic connections they are associated rather more with the Ancient Mediterranean region than the Boreal. *Prunus georgica* (Desf.) Eisenman (*Amygdalus georgica* Desf.), which is considered as an independent species according to the IPNI (2022), POWO (2022) and WFO (2022), stands out in this respect. This species is closely related to *Prunus tenella* Batsch, which is widespread in the steppe area of Eurasia, and should be considered as its vicarious species.

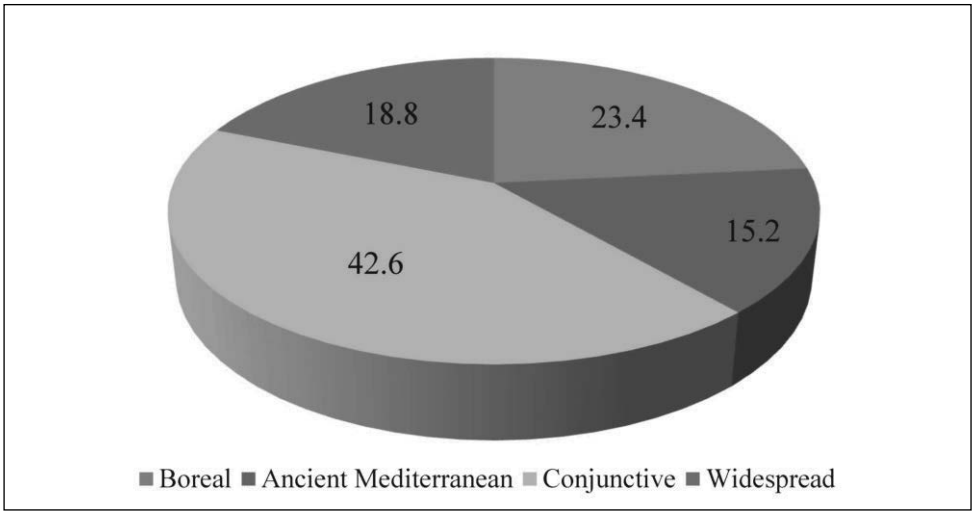

Fig. 2. Proportion (%) of Boreal, Ancient Mediterranean, "conjunctive" and widespread chorotypes.

As in our previous studies (Lachashvili & al. 2020; Lachashvili & al. 2021), we now note that the Caucasian chorotype by some researchers is considered within Ancient Mediterranean region, particularly in Submediterranean (Gagnidze 2004; Gagnidze & Davitadze 2000; Shetekauri & Gagnidze 2000). In such a case, the ratio of Boreal and Ancient Mediterranean chorotypes will change in the opposite direction.

Although European species have not been recorded, connections to Europe are expressed. These connections are mainly reflected in a wide range of "connecting" and European–Caucasian chorotypes. The total number of such species is 49 species (19.1%).

The links with the Eurasian steppes are also strong. The total number of species related to the Eurasian steppes in different ways is 43 (16.8%). It is obvious that in the floristic composition of the *Spiraea hypericifolia* formation of Georgia there is a kind of a circle of florogenetic connections between the Caucasus and the Eurasian steppes.

Ancient Mediterranean ties have two main directions - Mediterranean and South-West Asia. The main core of the Ancient Mediterranean chorotypes is Mediterranean–South-West Asian species – 20 species (7.8%). The number of directly South-West Asian–Turanian (–Central Asian) species is small – 6 species (2.4%). There are also few Mediterranean plants (7 species). The florogenetic connections with both the Mediterranea and South-West Asia are supported by a wide range of so-called "conjunctive" chorotypes. In this respect, the European–Mediterranean, European–Mediterranean–South-West Asian and Mediterranean–South-West Asian–Eurasian steppe chorotypes are important in relation to the Mediterranean, and the Caucasian–South-West Asian chorotype in relation to South-West Asia. The latter is the most numerous of the "conjunctive" chorotypes. Here we note that the Caucasus–South-West Asian (–Middle Asian) species form an important circle of florogenetic connections between the Caucasus and South-West Asia. In the direction of the Ancient Mediterranean, the weakest connection is with Turan and Central Asia. This is completely natural, because the hemixerophilous shrubberies of the Caucasus and Turanian deserts will not have a single "root" of origin.

The presented data show that both Boreal and Ancient Mediterranean connections of the most are revealed in a wide range of "connecting" chorotypes. The dominance of "conjunctive" chorotypes and their wide range, in our opinion, indicates the transitional nature of the floristic composition of Spirea shrubberies.

The very high share of widspread species in the spectrum of chorotypes attracts special attention. The most numerous are Palearctic species. They are divided into three groups: Palearctic – 25 species, West Palearctic – 12 and South Paleractic – 6. Palaearctic and Holarctic chorotypes are almost entirely represented by herbaceous plants (mainly with hemicryptophytes and therophytes). Nevertheless, among them so-called weed and ruderal plants are few.

The chorological analysis of the species compositions of the leading families turned out to be important and interesting. As mentioned, most of the top ten leading families are characteristics of the Ancient Mediterranean floras. In the chorological spectrum of all ten leading families mostly dominated are "conjunctive" chorotypes. Their wide range determines the florogenetic connections of different directions and no sharp influence of any floristic center is observed. However, certain tendencies are still evident. All the families of the top ten, except *Rubiaceae*, contain at least one Caucasian species. *Asteraceae* (6 species), *Fabaceae* (5) and *Lamiaceae* (4) are distinguished by the content of Caucasian

species. In the first ten leading families, compared to other connections, the strongest connection is expressed with South-West Asia, which is reflected in a wide range of "connecting" chorotypes. Species linked with South-West Asia dominate almost every family, including family *Rosaceae*. Compared to South-West Asia, the floristic connection of the European direction is significantly weakened, however, this is manifested to varying degrees in the floristic composition of all ten leading families. This connection is reflected in the " conjunctive" chorotypes. The species associated with the Eurasian steppes are disproportionately distributed. Their concentration is in three widely distributed families – *Asteraceae* (11 species), *Poaceae* (8) and *Fabaceae* (3). *Rosaceae* also includes three species. Most of the families characteristic of the Ancient Mediterranean floras (*Apiaceae*, *Brassicaceae*, *Caryophyllaceae*, *Rubiaceae*) do not contain species related to the Eurasian steppes. Only the family *Lamiaceae* is represented by two species of this group. Such a ratio of species associated with the Eurasian steppes, in our view, is perfectly natural. Almost all of the 10 leading families contain at least one widespread (Palearctic and Holarctic) species. Their highest concentration was observed in the families *Poaceae* (8 Palearctic and 1 Holarctic species) and *Brassicaceae* (7 Palearctic species). 5 Palearctic species include *Rosaceae*. At the same time, Palearctic and Holarctic species are negligibly present in the families *Asparagaceae*, *Apiaceae*, *Caryophyllaceae,* and *Fabaceae*, while *Asteraceae* does not contain such species at all.

The approximately similar situation is in the second echelon of leading families. "Conjunctive" chorotypes are mostly dominant in these families as well and no sharp influence of any floristic center is observed.

Based on the analysis of the systematic and chorological structure of the floristic composition, we can conclude that there is an influence of both Ancient Mediterranean and Boreal centers on the floristic composition of Iberian Spirea scrubs in Georgia and its formation was going through the "struggle" of these two floristic centers. If we do not take into account the local (Caucasian) species, which are considered differently by the researchers, then relatively strong florogenetic connections are expressed in the direction of the Ancient Mediterranean.

Composition of life forms. – The core of the flora consists of herbaceous plants (82.4%). Compared to them, the share of woody and semi-woody plants is much smaller (respectively, 13.7% and 3.9%).

One of the main characteristics of the life forms spectrum is the ratio of the share of hemicryptophytes and therophytes. In the life forms spectrum of Iberian Spirea shrubberies of Georgia the number of hemicryptophytes is almost 1.6 times higher than the number of therophytes.

The composition of hemicryptophytes is diverse. The main core is made up of plants characteristic of steppes, meadow-steppes and hemixerophilous shrubberies. Their composition is enriched, on the one hand, with forest components [*Aegonychon purpurocaeruleum* (L.) Holub, *Brachypodium sylvaticum* (Huds.) P. Beauv., *Poa nemoralis* L., *Primula veris* subsp. *macrocalyx* (Bunge) Lüdi, *P. woronowii*] and, on the other hand, with plants characteristic of stony ecotopes [*Gypsophila stevenii*, *Sempervivum transcaucasicum* Muirhead, *Euphorbia glareosa* Pall. ex M. Bieb., *Sedum pallidum* M. Bieb., *Phedimus spurius* (M. Bieb.) 't Hart, *Reseda lutea* L.].

It is noteworthy that in the composition of hemicryptophytes weed plants are very few [*Achillea arabica* Kotschy, *Convolvulus arvensis* L., *Eryngium caeruleum* M. Bieb., *Elymus repens* (L.) Gould], while the share of such plants among therophytes is much higher [*Aegilops tauschii* Coss., *Bromus japonicus* Thunb., *Camelina microcarpa* Andrz. ex DC., *Daucus carota* L., *Erodium cicutarium* (L.) L'Her, *Euphorbia helioscopia* L., *Filago eriocephala* Guss., *Hirschfeldia incana* (L.) Lagr.-Foss., *Geranium robertianum* L., *Lycopsis orientalis* L., *Trifolium arvense* L., *Carthamus lanatus* L., *Rapistrum rugosum* (L.) All., *Noccaea perfoliata* (L.) Al-Shehbaz, *Brachypodium distachyon* (L.) P. Beauv., *Filago pyramidata* L., etc.].

The share of phanerophytes is high (14.4%). The main core is made up of species characteristic of hemixerophilous shrubberies and arid open woodlands. Among them are also shrubs characteristic of stony, crumbling and rocky ecotopes. The composition of phanerophytes is enriched with the participation of the components of the deciduous forests of the foothills and the lower mountain belt [*Acer ibericum* M. Bieb., *Euonymus verrucosus* Scop., *Fraxinus excelsior* L., *Ligustrum vulgare* L., *Lonicera caprifolium* L., *Quercus petraea* subsp. *iberica* (Steven ex M. Bieb.) Krassiln., *Ulmus minor* Mill.], which are uncharacteristic and very rare plants for Iberian Spirea shrubberies.

With respect to life forms the ratio of characteristic (constant) plants is important. Study of Iberian Spirea shrubberies in the Tbilisi area revealed that the core of characteristic species consists of hemicryptophytes and phanerophytes (Lachahsvili & al. 2019). Some species of chamaephytes also belong to the constant species. Despite not that small number, there are no constant species in the composition of therophytes. They belong to the rare (uncharacteristic) plants. The data are also similar in the Iberian Spirea's communities common on the Iori plateau (Lachashvili & Kereselidze 2020).

An important picture is given by the mutual comparison of life forms and chorotypes. The main ties in the **phanerophytes** are to South-West Asia, Mediterranean and Europe. Caucasian–South-West Asian chorotype is represented by the largest number of species (9 species). Not that small number of local (Caucasian) species (6 species) deserves attention. The link with the Eurasian steppes is very weak - only *Spirea hypericifolia* belongs to Caucasian-Eurasian steppe chorotype. Local (Caucasian) species (4 species) predominate in **chamephytes**. The connections to Eurasian steppes and Mediterranean are weak.

The composition and florogenetic connections of **hemicryptophytes** are diverse. First of all, a large number of Palearctic (24 species) and Caucasian (20 species) species are striking. At the same time, strong connections with the South-West Asia and Mediterranean are pronounced, which is due to the wide range of chorotypes. Connections with Eurasian steppes are also strongly expressed – 28 species of hemicryptophytes are associated with the Eurasian steppe area. In relation to the Eurasian steppes the so-called 3 florogenetic circles are well-defined: Mediterranean – South-West Asia – Eurasian steppes, South-West Asia – Caucasus – Eurasian steppes and Caucasus – Eurasian steppes. In addition, in the "conjunctive" chorotypes not so weak ties to direction of Europe are reflected (15 species). It is clear that both Ancient Mediterranean and boreal connections are pronounced in the rich floristic composition of hemicryptophytes.

Both Ancient Mediterranean and Boreal connections are expressed in the composition of **geophytes**. The most evident is the florogenetic link with South-West Asia. In this direction, the Caucasian–South-West Asian chorotype stands out (8 species). Relatively weak

connections are to the direction of Mediterranean, Europe, Eurasian steppes and Euxine. It should be noted that florogenetic connections in geophytes are due to a wide range of "conjunctive" chorotypes. Compared to the life forms discussed above, the participation of local species is small (4 species) and the Caucasian "roots" are mostly reflected in the "connecting" chorotypes.

Unlike other life forms, the role of the Caucasian species in the composition of **therophytes** is insignificant (only one species). The most widely represented are Palearctic (17) and Mediterranean–Southwest Asian (16) species. The links with the Ancient Mediterranean are well expressed (both of Mediterranean and South-West Asia direction). Connections to Europe are relatively weak. The participation of species associated with Eurasian steppes is small.

Based on the reconciled of life forms and chorotypes, the following became evident:

Caucasian species are widely represented in all life forms except therophytes, which emphasizes the originality of the Iberian Spirea shrubberies of Georgia;

Ancient Mediterranean connections (mainly in the direction of the Mediterranean and South-West Asia) are clearly visible in the composition of all life forms;

Connections with Eurasian steppes are formed mainly through hemicryptophytes, although these connections are reinforced by plants of other life forms;

The florogenetic link with Europe is represented mainly by hemicryptophytes and therophytes; this connection is reinforced by the corresponding species of phanerophytes and geophytes;

The core of the Palaearctic and Holarctic species consist of hemicryptophytes and therophytes.

Bilateral (boreal and ancient Mediterranean) connections are most reflected in the composition of herbaceous plants.

General Conclusion

Based on the analysis of the systematic structure of the flora, compositions of chorotypes and life forms, we can conclude that the formation of the Iberian Spirea shrubberies in Georgia took place under the influence of both the Ancient Mediterranean and the Boreal centers. The florogenetic connection of four main directions is expressed: Mediterranea, South-West Asia, Europe and Eurasian steppe. Florogenic connections of the most are reflected in a wide range of "connecting" chorotypes. If we do not take into account the local (Caucasian) species, which are considered differently by the researchers, then relatively strong florogenetic connections are expressed in the Ancient Mediterranean direction. At the same time, the Mediterranean and South-West Asian connections are strongly reflected in the composition of all life forms, while the florogenetic connections in the direction of the Europe and especially Eurasian steppes are not equally expressed in all life forms. The high share of local (Caucasian) species emphasizes the originality of the Iberian Spirea shrubberies of the Georgia. It is also noteworthy that Caucasian species are present in all leading families, as well as in all life forms except therophytes.

Floristic composition indicating main synonyms, chorotypes and life forms for each species are given below.

List of floristic composition of *Spiraea hypericifolia* formation of Georgia

Abbreviations
Ann – Annual plant, Bien – Biennial plant, PH – Perennial herbaceus plant, Sh – Shrub, SSh – Semi-shrub, dwarf semi-shrub & undershrub, T – Tree.
Ch – Chamaephyte, G – Geophyte, H – Hemicryptophyte (including biennial plants), Ph – Phanerophyte; Th – Therophyte;
C. – Central, E. – East, M. – Middle, N. – North, S. – South, W. – West.
Anat. – Anatolian, Anc. – Ancient, As. – Asian, Cauc. – Caucasian, Eur. – European, Euras. step. – Eurasian steppe, Eux. – Euxinian, Hyrc. – Hyrcanian, Ir. – Iranian, Med. – Mediterranean, Pan. – Pannonian, Pon. – Pontian, Tur. – Turanian.

GYMNOSPERMAE
Cupressaceae
Juniperus communis var. *saxatilis* Pall. [*J. oblonga* M. Bieb.; *J. communis* L. subsp. *oblonga* (M. Bieb.) Galushko] – Ph, Sh; Holarctic.
Juniperus oxycedrus L. (*J. rufescens* Link) – Ph, Sh; Med.

Ephedraceae
Ephedra major subsp. *procera* (C.A. Mey.) Bornm. (*E. procera* C. A. Mey.) – Ph, Sh; Med.–S.W. As. (E. Med.–S.W. As.).

ANGIOSPERMAE
DICOTYLEDONEAE
Anacardiaceae
Cotinus coggygria Scop. – Ph, Sh; Palaearctic (S. Palaearctic).
Rhus coriaria L. – Ph, Sh; Med.–S.W. Asian

Apiaceae
Bupleurum marschallianum C. A. Mey. – Th, Ann; Eux.–Hyrc. (conditionally).
Bupleurum rotundifolium L. – Th, Ann; Eur.–Med.–S.W. As.
Daucus carota L. – Th, Ann; Eur.–Anc. Med.
Eryngium campestre L. – H, PH; Eur.–Med.
Eryngium caeruleum M. Bieb. (*E. caucasicum* Trautv.) – H, PH; Cauc.–S.W. As.–M. As..
Falcaria vulgaris Bernh. – H, PH; Palaearctic (W. Palaearctic).
Heracleum antasiaticum Manden. – H, PH; Cauc. (S. Cauc. endemic).
Malabaila dasyantha (K. Koch) Grossh. [*Leiotulus dasyanthus* (K. Koch) Pimenov & Ostr.] – H, PH; Cauc.–S.W. As. (S. Cauc.–S.W. As.).
Seseli grandivittatum (Sommier & Levier) Schischk. – H, PH; Cauc. (S. Cauc. endemic).
Trinia leiogona (C. A. Mey.) B. Fedtsch. – H, Bien; Cauc.–Hyrc.
Zosima absinthifolia (Vent.) Link (*Zosima orientalis* Hoffm.) – H, PH; S.W. As.–Tur.

Apocynaceae
Vinca herbacea Waldst. & Kit. – H, PH; Med.–Euras. step. (E. Med.–Pan.-Pon.).

Asteraceae
Achillea arabica Kotschy (*Achillea biebersteinii* Afan.) – H, PH; Med.–S.W. As.–Tur. (E. Med.–S.W. As.–Tur.).
Achillea nobilis L. – H, PH; Med.–Euras. step. (with Eur. irradiation).

Artemisia alpina Pall. ex Willd. (*Artemisia caucasica* Willd.) – Ch, SSh; Cauc.–Euras. step. (Cauc.–Pan.-Pon.).
Artemisia fragrans Willd. – Ch, SSh; Cauc.–Tur. (with irradiation)
Carduus hamulosus Ehrh. – H, Bien; Cauc.–Euras. step.
Carthamus lanatus L. – Med.–S.W. As.
Centaurea ovina Pall. ex Willd. – H, PH; Cauc. (endemic).
Centaurea reflexa Lam. – H, PH; Cauc. (endemic).
Crepis foetida subsp. *rhoeadifolia* (M. Bieb.) Čelak. (*Crepis rhoeadifolia* M. Bieb.) – H, Bien; Eur.–Med.–S.W. As. (Eur.–E. Med.–S.W. As.).
Crepis sancta (L.) Bornm. – Th, Ann; Med.–S.W. As.–Euras. step. (E. Med.–S.W. As.–Pon.)
Crupina vulgaris Pers. ex Cass. – Th, Ann; Med.–S.W. As.–Euras. step. (E. Med.–S.W. As.–Pon.).
Filago eriocephala Guss. – Th, Ann; Med.–S.W. As.
Filago pyramidata L. – Th, Ann; Med.–S.W. As.
Galatella linosyris (L.) Rchnb. f. [*Crinitaria linosyris* (L.) Less.] – H, PH; Eur.–Med.
Galatella villosa (L.) Rchb. f. [*Crinitaria villosa* (L.) Cass.] – H, PH; Cauc.–Euras. step.
Inula aspera Poir. [*Pentanema asperum* (Poir.) G.V.Boiko & Korniy.] – H, PH; Medit.–Euras. step.
Inula germanica L. [*Pentanema germanicum* (L.) D.Gut.Larr., Santos-Vicente, Anderb., E.Rico & M.M.Mart.Ort.] – H, PH; Med.–Euras. step.–Cauc. (E. Med.–Euras. step.–Cauc. with Eur. irradiation).
Inula oculus-christi L. [*Pentanema oculus-christi* (L.) D.Gut.Larr., Santos-Vicente, Anderb., E.Rico & M.M.Mart.Ort.] – H, PH; Med.–S.W. As.–Euras. step. (E. Med.–S.W. As.–Pan.-Pon.)
Jurinea blanda (M. Bieb.) C. A. Mey. – H, PH; Cauc. (endemic).
Klasea radiata (Waldst. & Kit.) Á. Löve & D. Löve [*Serratula radiata* (Waldst. & Kit.) M. Bieb.] – H, PH; Cauc.–Euras. step.
Pilosella procera (Fr.) F.W. Schultz & Sch.Bip. (*Hieracium procerum* Fr.) – H, PH; S.W. As.–Cauc.–Euras. step. (conditionally)
Psephellus carthalinicus Sosn. – H, PH; Cauc. (S. Cauc. endemic).
Tanacetum sericeum (Adams) Sch. Bip. [*Pyrethrum sericeum* (Adams) M. Bieb.] – H, PH; Cauc. with E. Anat. iraadiation (S. Cauc. with E. Anat. iraadiation).
Tragopogon graminifolius DC. – H, PH; Cauc.–S.W. As.
Tragopogon pusillus M. Bieb. – H, PH; Cauc.–S.W. As. (Cauc.–Ir.).
Tragopogon tuberosus K. Koch – G, PH; Cauc. (endemic).
Xeranthemum squarrosum Boiss. – Th, Ann; Cauc.–S.W. As.

Boraginaceae
Aegonychon purpurocaeruleum (L.) Holub. [*Lithospermum purpurocaeruleum* L.; *Buglossoides purpurocaerulea* (L.) I. M. Johnst.] – H, PH; Eur.–Med.
Lappula barbata (M. Bieb.) Gürke – H, Bienn; Med.–S.W. As.
Lycopsis orientalis L. [*Anchusa arvensis* subsp. *orientalis* (L.) Nordh.] – Th, Ann; Palaearctic (S. Palaearctic).
Myosotis arvensis (L.) Hill; Th, Ann; Euro–Siberian.
Nonea lutea (Desr.) DC. – Th, Ann; S.W. As.–Cauc.–Euras. step. (SW. As. –Cauc.–Pon.)
Pontechium maculatum (L.) Böhle & Hilger (*Echium maculatum* L.; *Echium rubrum* Jacq.; *Echium russicum* J. F. Gmel.) – H, PH; Cauc.–Euras. step. (with irradiations).

Brassicaceae
Alyssum alyssoides (L.) L. – Th, Ann; Eur.–Cauc.–S.W. As.
Alyssum desertorum Stapf – Th, Ann; Palaearctic (S. Palaearctic).
Alyssum hirsutum M. Bieb. – Th, Ann; Med.–S.W. As.–Pon. (E. Med.–S.W. As.–Pon.).

Alyssum murale Waldst. & Kit. [*Odontarrhena muralis* (Waldst. & Kit.) Endl.] – H, PH; Med.–S.W. As.–Euras. step. (E. Med.–S.W. As.–Pan.-Pon.).
Arabidopsis thaliana (L.) Heynh. – Th, Ann; Palaearctic.
Arabis nova Vill. (*Arabis auriculata* Lam.) – Th, Ann; Eur.–Med.–S.W. As.–Tur.
Camelina microcarpa Andrz. ex DC. – Th, Ann; Palaearctic.
Draba nemorosa L. – Th, Ann; Palaearctic.
Draba verna L. [*Erophila verna* (L.) DC.] –Th, Ann; Palaearctic (W. Palaearctic).
Erysimum leptophyllum (M. Bieb.) Andrz. ex DC. – H, PH; Cauc.–S.W. As. (S. Cauc.–Anat.).
Hirschfeldia incana (L.) Lagr.-Foss. – Th, Ann; Med.–S.W. As.
Meniocus linifolius (Stephan ex Willd.) DC. (*Alyssum linifolium* Stephan ex Willd.) – Th, Ann; Palaearctic (S. Palaearctic).
Noccaea orbiculata (Steven ex DC.) Al-Shehbaz (*Thlaspi orbiculatum* Steven ex DC.) – Th, Ann; Cauc. (with E. Anat. irradiation).
Noccaea perfoliata (L.) Al-Shehbaz (*Thlaspi perfoliatum* L.) – Th, Ann; Eur.–Anc. Med.
Rapistrum rugosum (L.) All. – Th, Ann; Anc. Med.
Turritis glabra L. – H, PH; Palaearctic.

Caprifoliaceae
Cephalaria media Litv. – H, PH; Cauc. (endemic).
Lonicera caprifolium L. – Ph, Sh; Eur.–Med. (C. Eur.–Med.).
Lonicera iberica M. Bieb. – Ph, Sh; Cauc.–S.W. As.
Scabiosa columbaria L. – H, PH; Eur.–Med.
Scabiosa micrantha Desf. [*Lomelosia micrantha* (Desf.) Greuter & Burdet] – Th, Ann; Med.–S.W. As. (E. Med.–S.W. As.).

Caryophyllaceae
Arenaria serpyllifolia L. – Th, Ann; Palaearctic.
Dianthus subulosus Conrath & Freyn – H, PH; Cauc. (endemic)
Gypsophila bicolor (Freyn & Sint.) Grossh. – H, PH; S.W. As.–Tur.
Gypsophila stevenii Fisch. ex Schrank – H, PH; Cauc. (S. Cauc. endemic).
Holosteum marginatum C.A.Mey. – Th, Ann; Cauc.– S.W. As. (conditionally)
Holosteum umbellatum subsp. *glutinosum* (M. Bieb.) Nyman [*H. glutinosum* (M. Bieb.) Fisch. & C. A. Mey.] – Th, Ann; Anc. Med. (conditionally).
Petrorhagia prolifera (L.) P. W. Ball. & Heywood [*Kohlrauschia prolifera* (L.) Kunth] – Th, Ann; Eur.–Med.
Silene latifolia Poir. [*Melandrium latifolium* (Poir.) Maire; *M. boissieri* Schishk.] – H, Bien; Eur.–Med.–S.W. As.
Silene italica (L.) Pers. – H, PH; Eur.–Med.–S.W. As.
Silene cyri Schischk. – H, Bien; Caspian
Stellaria media (L.) Vill. – Th, Ann / Bien; Holarctic.

Celastraceae
Euonymus verrucosus Scop. – Ph, Sh; Eur.–Cauc.

Cistaceae
Helianthemum ledifolium subsp. *lasiocarpum* (Janques & Herincq) Nyman (*H. lasiocarpum* Janques & Herincq) – Th, Ann; Med.–S.W. As.
Helianthemum nummularium (L.) Mill. – Ch, SSh; Eur.–Med.
Helianthemum salicifolium (L.) Mill. – Th, Ann; Med.–S.W. As.

Convolvulaceae
Convolvulus arvensis L. – H, PH; Palaearctic.
Convolvulus cantabrica L. – H, PH; Med.–S.W. As.–Euras. step. (Med.–S.W. As.–Pan.-Pon.).
Convolvulus lineatus L. – H, PH; Med.–S.W. As.–Euras. step. (with irradiations).

Crassulaceae
Hylotelephium maximum subsp. *ruprechtii* (Jalas) Dostál [*Sedum maximum* subsp. *ruprechtii* (Jalas) Soo; *S. caucasicum* (Grossh.) Boriss.] – G, PH; Eur.–Cauc. (E. Eur.–Cauc.).
Phedimus spurius (M. Bieb.) ‘t Hart (*Sedum spurium* M. Bieb.; *S. oppositifolium* Sims) – H, PH; Eux.–Hyrc. (conditionally).
Sedum pallidum M. Bieb. – H, PH; Eux.–Hyrc. (with irradiations).
Sempervivum transcaucasicum Muirhead – H, PH; Cauc. (with E. Anat. irradiation).

Euphorbiaceae
Euphorbia boissieriana (Woronow) Prokh. – H, PH; Cauc. (S. Cauc. endemic).
Euphorbia glareosa Pall. ex M. Bieb. – H, PH; Cauc.–Eux. (with Pon. irradiation).
Euphorbia helioscopia L. – Th, Ann; Palaearctic
Euphorbia iberica Boiss. – H, PH; Cauc.–S.W. As.
Euphorbia seguieriana Neck. – H, PH; Med.–Euras. step.

Fabaceae
Astragalus brachycarpus M. Bieb. – H, PH; Cauc. (with N.E. & E. Anat. irradiation).
Astragalus bungeanus Boiss. – H, PH; Caucasian (Cauc. endemic)
Astragalus cornutus Pall. – Ph; SSh; Euras. step.–Cauc. (conditionally).
Astragalus xiphidium Bunge – Ph, SSh; Cauc. (subendemic).
Caragana grandiflora DC. – Ph, Sh; Cauc.–S.W. As.
Colutea orientalis Mill. – Ph, Sh; Med. (E. Med. / Cauc.–Crymean).
Cytisus ruthenicus Wol. [*C. caucasicus* Grossh.; *Chamaecytisus ruthenicus* (Fisch. ex Wol.) Klásk.] – Ph, Sh; Eur.–Cauc. (E. Eur.–Cauc.).
Dorycnium pentaphyllum subsp. herbaceum (Vill.) Rouy (*D. herbaceum* Vill.) – H, PH; Med.–Cauc.
Halimodendron halodendron (Pall.) Voss [*Caragana halodendron* (Pall.) Dum.Cours.] – Ph, Sh; Ir.–Tur.
Lotus corniculatus L. – H, PH; Eur.–Med.–S.W. As. (with irradiations).
Medicago caerulea Less. ex Ledeb. [*Medicago sativa* subsp. *caerulea* (Ledeb.) Schmalh; *Medicago sativa* subsp. *microcarpa* Urb.; *Medicago lessingii* Fisch. & C.A. May. ex Kar.] – H, PH; Euras. step.–Cauc.
Medicago minima (L.) Bartal. – Th, Ann; Eur.–Anc. Med.
Melilotus neapolitanus Ten. – Th, Ann; Med.–S.W. As.
Onobrychis cyri Grossh. – H, PH; Cauc. (endemic).
Onobrychis radiata (Desf.) M. Bieb. – H, PH; Cauc. (with E. Anat. irradiation).
Securigera varia (L.) Lassen (*Coronilla varia* L.) – H, PH; Palearctic (W. Palearctic).
Sophora alopecuroides L. – H, PH; S.W. As.–Tur.–C. As. (with irradiations).
Trifolium arvense L. – Th, Ann; Palearctic (W. Palearctic).
Trifolium campestre Schreb. – Th, Ann; Eur.–Med.–S.W. As.
Vicia grandiflora Scop. – Th, Ann; Med.–Euras. step.–Cauc. (E. Med.–Pan.-Pon.–Cauc.).

Fagaceae
Quercus petraea subsp. *iberica* (Steven ex M. Bieb.) Krassiln. – Ph, T; Cauc.–S.W. As.

Geraniaceae
Erodium cicutarium (L.) L'Her – Th, Ann; Palearctic.
Geranium lucidum L. – Th, Ann; Eur.–Med.–S.W. As.
Geranium robertianum L. – Th, Ann; Eur.–Med.
Geranium sanguineum L. – H, PH; Palearctic.

Hypericaceae
Hypericum perforatum L. – H, PH; Palearctic.

Lamiaceae
Lamium amplexicaule L. – Th, Ann; Palearctic.
Nepeta racemosa Lam. (*Nepeta mussinii* Spreng. ex Henckel); H, PH; Cauc.–S.W. As.
Origanum vulgare L. – H, PH; Palearctic (W. Palearctic).
Phlomis herba-venti subsp. *pungens* (Willd.) Maire ex DeFilipps (*Phlomis pungens* Willd.) – H, PH; S.W. As.–Cauc.–Euras. step. (S.W. As.–Cauc.–Pon.).
Phlomoides tuberosa (L.) Moench (*Phlomis tuberosa* L.) – G, PH; Palearctic.
Salvia garedjii Troitsky – Ch, SSh; Cauc. (S. Cauc. endemic).
Salvia nemorosa L. – H, PH; Eur.–Med.–S.W. As. (Eur.–E. Med.–S.W. As.).
Salvia verticillata L. – H, PH; Eur.–Med.–S.W. As.
Salvia viridis L. – Th, Ann; Med.
Scutellaria orientalis L. – Ch, SSh; Cauc. (with Anat. irradiation).
Sideritis montana L. – Th, Ann; Eur.–Med.–S.W. As.
Stachys atherocalyx K. Koch – H, PH; Med. (E. Med.).
Teucrium chamaedrys subsp. *nuchense* (K. Koch) Rech. f. (*Teucrium nuchense* K. Koch) – Ch, SSh; Cauc. (endemic).
Teucrium polium L. – Ch, SSh; Med.–S.W. As.–Euras. step. (Med.–S.W. As.–Pon.).
Thymus coriifolius Ronniger – Ch, SSh; Cauc. (S. Cauc. endemic).
Ziziphora capitata L. – Th, Ann; Med.–S.W. As.

Linaceae
Linum austriacum L. – H, PH; Med.–S.W. As.–Euras. step.
Linum corymbulosum Rchb. – Th, Ann; Med.–S.W. As.

Oleaceae
Fraxinus excelsior L. – Ph, T; Eur.–Cauc.
Jasminum fruticans L. – Ph, Sh; Eur.–Med.–S.W. As.
Ligustrum vulgare L. – Ph, Sh; Eur.–Med.

Orobanchaceae
Melampyrum arvense L. – Th, Ann; Eur.–Cauc.

Papaveraceae
Glaucium corniculatum (L.) Rudolph – Th, Ann; Eur.–Med.–S.W. As.
Papaver arenarium M. Bieb. – Th, Ann; Cauc.–S.W. As.
Papaver dubium L. – Th, Ann; Eur.–Med.–S.W. As.

Plantaginaceae
Plantago lanceolata L. – H, PH; Palearctic (W. Palearctic).
Veronica multifida L. – H, PH; S.W. As.– Cauc.–Euras. step.

Polygalaceae
Polygala transcaucasica Tamamsch. – H, PH; Cauc. (S. Cauc. endemic).

Polygonaceae
Atraphaxis caucasica (Hoffm.) Pavlov – Ph, Sh; Cauc.–M. As.
Atraphaxis spinosa L. – Ph, Sh; Med.–S.W. As.–Tur.–C. As. (E. Med.–S.W. As.–Jungaro-Kashgarian)
Rumex tuberosus L. – G, PH; Med.–S.W. As.–Euras. step. (Med.–S.W. As.–Pon.).

Primulaceae
Cyclamen coum subsp. *caucasicum* (K. Koch) O. Schwarz (*Cyclamen vernum* Sweet) – G, PH; Cauc.–Eux. (with Med. irradiation).
Primula veris subsp. *macrocalyx* (Bunge) Lüdi (*Primula macrocalyx* Bunge) – H, PH; Palearctic (conditionally).
Primula woronowii Losinsk. – H, PH; Cauc. (endemic).

Ranunculaceae
Adonis flammea Jacq. – Th, Ann; Eur.–Med. (with W. Ir. irradiation).
Delphinium cyphoplectrum Boiss. – H, PH; Cauc.–S.W. As.
Delphinium ochroleucum Steven ex DC. – G, PH; Cauc. (with N.W. Ir. irradiation).
Ranunculus illyricus L. – G, PH; Med.–Euras. step.–Cauc. (E. Med.–Euras. step.–Cauc.) (with Eur. irradiation).
Thalictrum minus L. – H, PH; Holarctic.

Resedaceae
Reseda lutea L. – H, Bien; Eur.–Med.–S.W. As.

Rhamnaceae
Paliurus spina-christi Mill. – Ph, Sh; Med.–S.W. As.
Rhamnus pallasii Fisch. & C. A. Mey. – Ph, Sh; Cauc.–S.W. As.
Rhamnus spathulifolia Fisch. & C. A. Mey. – Ph, Sh; Cauc.

Rosaceae
Amelanchier ovalis Medik. – Ph, Sh; Eur.–Med. (C. Eur.–Med.).
Cotoneaster meyeri Pojark. – Ph, Sh; Cauc. (endemic).
Cotoneaster morulus Pojark. – Ph, Sh; Cauc.–S.W. As.
Cotoneaster racemiflorus (Desf.) K. Koch – Ph, Sh; Cauc.–S.W. As.–M. As.
Cotoneaster saxatilis Pojark. – Ph, Sh; Cauc. (endemic).
Filipendula vulgaris Moench – H, PH; Palearctic (W. Palearctic).
Fragaria vesca L. – H, PH; Palearctic.
Fragaria viridis Weston – H, PH; Palearctic (W. Palearctic).
Potentilla humifusa Willd. ex Schltdl. (*Potentilla adenophylla* Boiss. & Hohen.) – H, PH; Euras. step.–Cauc.–Anat.
Potentilla recta L. – H, PH; Palearctic (W. Palearctic).
Prunus georgica (Desf.) Eisenman (*Amygdalus georgica* Desf.) – Ph, Sh; Cauc. (S. Cauc. endemic).
Prunus incana (Pall.) Batsch [*Cerasus incana* (Pall.) Spach] – Ph, Sh; Cauc.–S.W. As.
Prunus microcarpa C. A. Mey. [*Cerasus microcarpa* (C. A. Mey.) Boiss.] – Ph, Sh; S.W. As.
Prunus spinosa L. – Ph, Sh; Eur.–Med.
Pyrus salicifolia Pall. – Ph, Sh; Cauc.–S.W. As.

Rosa spinosissima L. – Ph, Sh; Palearctic (W. Palearctic)
Sanguisorba minor subsp. *balearica* (Nyman) Muñoz Garm. & C. Navarro (*Poterium polygamum* Waldst. & Kit.) – H, PH; Med.–S.W. As.–Euras. step. (Med.–S.W. As.–Pan-Pon.) (with irradiations).
Spiraea hypericifolia L. – Ph, Sh; Euras. step.–Cauc. (with irradiations).

Rubiaceae
Asperula arvensis L. – Th, Ann; Eur.–Med.
Crucianella angustifolia L. – Th, Ann; Med.
Galium album Mill. – H, PH; Eur.–Med. (with W. Siberian irradiation).
Galium tenuissimum M. Bieb. – Th, Ann; Med.–S.W. As. (E. Med.–S.W. As.).
Galium spurium L. (*Galium vaillantii* DC.); Th, Ann; Holarctic.
Galium verum L. – H, PH; Palearctic.

Rutaceae
Dictamnus albus L. – H, PH; Palearctic (S. Palearctic).

Santalaceae
Thesium arvense Horv. (*T. ramosum* Hayne) – H, PH; Euras. step.–Cauc.

Sapindaceae
Acer ibericum M. Bieb. [*A. monspessulanum* subsp. *ibericum* (M. Bieb. ex Willd.) Yalt.] – Ph, T; Cauc. (endemic).

Scrophulariaceae
Verbascum formosum Fisch. ex Schrankl – H, Bien; Cauc. (endemic).

Thymeleaceae
Thymelaea passerina (L.) Coss. & Germ. – Th, Ann; Palearctic (W. Palearctic).

Ulmaceae
Ulmus minor Mill. – Ph, T; Eur.–Med.

Valerianaceae
Valeriana officinalis L. – H, PH; Palearctic.

Violaceae
Viola alba Besser – H, PH; Eur.–Med.
Viola arvensis Murray – Th, Ann; Palearctic.
Viola kitaibeliana Schult. – Th, Ann; Eur.–Med. (C. Eur.–Med.).

MONOCOTYLEDONEAE
Amaryllidaceae
Allium pseudoflavum Vved. – G, PH; Cauc.–S.W. As.
Allium rotundum L. – G, PH; Eur.–Med.–S.W. As.
Allium rupestre Steven – G, PH; Eux. (with Cauc. irradiation).
Allium saxatile M. Bieb. – G, PH; Euras. step.–Cauc. (with Sub. Med. & Med. irradiations).

Asparagaceae
Asparagus officinalis L. – G, PH; Palearctic (W. Palearctic).

Asparagus verticillatus L. – G, PH; Med.–S.W. As.–Euras. step. (E. Med.–S.W. As.–Pon.).
Bellevalia montana (K. Koch) Boiss. – G, PH; Cauc. (S. Cauc. endemic).
Muscari armeniacum Leichtlin ex Baker (*Muscari szovitsianum* Baker) – G, PH; Med.–Cauc. (E. Med.–Cauc.).
Ornithogalum navaschinii Agapova – G, PH; Med. (E. Med. / Cauc.–Crymean).
Ornithogalum ponticum Zahar. – G, PH; Med. (E. Med. / Cauc.–Crymean).
Scilla siberica Haw. – G, PH; Eur.–Cauc.–S.W. As. (E. Eur.–Cauc.–S.W. As.) (conditionally).

Colchicaceae
Colchicum trigynum (Steven ex Adams) Stearn [*Merendera trigyna* (Steven ex Adams) Stapf] – G, PH; Cauc.–S.W. As.

Cyperaceae
Carex liparocarpos subsp. *bordzilowskii* (V. I. Krecz.) T. V. Egorova – H, PH; Cauc.–S.W. As.
Carex humilis Leyss. – H, PH; Palearctic.

Iridaceae
Crocus biflorus subsp. *adamii* (J. Gay) K. Richt. (*Crocus adamii* J. Gay) – G, PH; Eux. (conditionally).
Crocus speciosus M. Bieb. – G, PH; Cauc.–S.W. As.
Iris caucasica Hoffm. – G, PH; Cauc.–S.W. As. (S. Cauc.–S.W. As.).
Iris pumila L. – G, PH; Med.–Euras. step.–Cauc. (E. Med.–Pan-Pon.–Cauc.).
Iris reticulata M. Bieb. – G, PH; Cauc.–S.W. As.

Lilaceae
Fritillaria caucasica Adams – G, PH; Eux.–Hyrc.
Gagea chlorantha (M. Bieb.) Schult. & Schult. f. – G, PH; Cauc.–S.W. As.
Gagea commutata K. Koch – G, PH; Cauc. (endemic).

Orchidaceae
Anacamptis morio (L.) R. M. Bateman, Pridgeon & M. W. Chase (*Orchis morio* L.) – G, PH; Eur.–Med. (with Ir. irradiation).
Anacamptis pyramidalis (L.) Rich. – G, PH; Eur.–Med. (with Ir. irradiation).
Dactylorhiza romana subsp. *georgica* (Klinge) Soó ex Renz & Taubenheim [*Orchis flavescens* K. Koch; *Dactylorhiza flavescens* (K. Koch) Holub] – G, PH; Cauc.–S.W. As.
Neotinea ustulata (L.) R. M. Bateman, Pridgeon & M. W. Chase (*Orchis ustulata* L.) – G, PH; Eur.–Cauc.
Ophrys caucasica Woronow ex Grossh. – G, PH; Cauc. (endemic).

Poaceae
Aegilops neglecta Req. ex Bertol. (*Aegilops ovata* L.) – Th, Ann; Med.–S.W. As.
Aegilops tauschii Coss. – Th, Ann; S.W. As.–Tur.
Agropyron cristatum subsp. *pectinatum* (M. Bieb.) Tzvelev – H, PH; Med.–S.W. As.–Euras. step.
Avena sterilis subsp. *ludoviciana* (Durieu) Gillet & Magne – Th, Ann; Med.–S.W. As. (with Eur. irradiation).
Bothriochloa ischaemum (L.) Keng – H, PH; Anc. Med.
Brachypodium distachyon (L.) P. Beauv. [*Trachynia distachya* (L.) Link.] – Th, Ann; Med.–S.W. As.
Brachypodium sylvaticum (Huds.) P. Beauv. – H, PH; Palearctic.
Bromus biebersteinii Roem. & Schult. [*Bromopsis biebersteinii* (Roem. & Schult.) Holub] – H, PH; Cauc. (endemic).
Bromus japonicus Thunb. – Th, Ann; Palearctic.

Bromus squarrosus L. – Th, Ann; Palearctic (S. Palearctic).
Cleistogenes serotina (L.) Keng; H, PH – Euras. step.–Cauc. (Pan.-Pon.–Cauc.) (with irradiations).
Cynosurus echinatus L. – Th, Ann; Med.–Cauc. (with irradiations).
Dactylis glomerata L. – H, PH; Palearctic.
Echinaria capitata (L.) Desf. – Th, Ann; Med.–S.W. As.
Elymus repens (L.) Gould [*Agropyron repens* (L.) P. Beauv.; *Elytrigia repens* (L.) Nevski] – H, PH; Palearctic.
Elymus hispidus (Opiz) Melderis [*Agropyron intermedium* (Host) P. Beauv.; *Elytrigia intermedia* (Host.) Nevski; *Thinopyrum intermedium* (Host) Barkworth & D.R.Dewey] – H, PH; Med.–S.W. As.–Euras. step. (Med.–S.W. As.–Pan.-Pon.) (with irradiations)
Festuca valesiaca Schleich. ex Gaudin – H, PH; S.W. As.–Cauc.–Euras. step.
Koeleria macrantha (Ledeb.) Schult. (*Aira cristata* L.) – H, PH; Holarctic.
Lolium rigidum Gaudin – Th, Ann; Med.–S.W. As.
Melica transsilvanica Schur – H, PH; Euras. step.–Cauc.
Phleum paniculatum Huds. – Th, Ann; Eur.–Med.–S.W. As. (C. Eur.–Med.–S.W. As.).
Phleum phleoides (L.) H. Karst. – H, PH; Palearctic.
Poa angustifolia L. – H, PH; Palearctic.
Poa bulbosa L. – G, PH; Eur.–Anc. Med.
Poa nemoralis L. – H, PH; Palearctic.
Stipa capillata L. – H, PH; Med.–S.W. As.–Euras. step.
Stipa lessingiana Trin. & Rupr. – H, PH; S.W. As.–Cauc.–Euras. step.
Stipa pennata L. – H, PH; Euras. step. (with irradiations).

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Article

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Studies on the halophytic *Sphaerophysa salsula* (*Fabaceae*) in Armenia

Abstract

Ghukasyan, A., Elbakyan, A., Martirosyan, L., Hovakimyan, Zh. & Akopian J.: Studies on the halophytic *Sphaerophysa salsula* (*Fabaceae*) in Armenia. — Fl. Medit. 33: 157-165. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

Morphological, karyological, palynological and ecological features of *Sphaerophysa salsula* halophytic vulnerable species of the Armenian flora are investigated based on the specimens collected from Ararat salt marshes of Armenia. The expanded morphological description and illustration of this species is given. The study shows that the somatic chromosome number is 2*n*=16, with basic chromosome number x=8.

Key words: morphology, karyology, palynology, eco-physiology, vulnerable species.

Introduction

The genus *Sphaerophysa* DC. is distributed in Middle and Central Asia, from South Siberia to North China, West Caucasia and Anatolia. The genus is represented by two species in the world – *Sphaerophysa salsula* (Pall.) DC. and *S. kotschyana* Boiss. (Polhill & Raven 1981). *S. salsula* grows in the south of European Russia, Middle Asia, Kazakhstan, Iran, Afghanistan, Altay, Tuva, Mongolia, China (Gorshkova 1945), while *S. kotschyana* is endemic to Central Anatolia (Duran & al. 2010). An isolated fragment of the range of *S. salsula* is also located in the Caucasus, where it grows in the coastal zone of Dagestan and in the valleys of the middle course of the Kura River and the Arax River (Grossheim 1952; Zakharyan & Fayvush 1991). In Armenia, *S. salsula* was found in 1990 within *Juncus acutum* community in the relict salt marshes of the Ararat valley, which is the extreme western point of the species range (Zakharyan & Fayvush 1991; Gabrielyan 2007; Avetisyan 2011). *S. salsula* meets in the Ararat and Armavir provinces of Armenia, in lower mountain belt, at the altitudes of 800–900 meters above sea level, in salt marshes, in slightly salted areas, on sands, along the banks of streams. The species is included in the Red Book of Plants of Armenia (2010) under the category VU (Vulnerable species). In Armenian flora at present two sub–populations of the target species are known from Yerevan floristic region.

The extent of occurrence and the area of occupancy are less than 500 km^2. It is not included in the Annexes of CITES and that of the Bern Convention. According the Bern Convention,

while *S. kotschyana* is in under absolute preservation plant list (CITES 2008). The species *S. kotschyana* is closely related to *S. salsula*. It mainly differs from *S. salsula* by stipules 2–9 mm long (not c. 2 mm), calyx 5–7 mm long (not 4–5 mm), corolla purplish-pink to violet (not red), ovary glabrous (not short appressed-hairy), seeds 3.5–4 mm long (not c. 1.5 mm) (Davis 1970).

In the Ararat valley of Armenia *S. salsula* blooms (Fig. 1a) from May to July (August), fructifies (Fig. 1b) in July-September. The plant is very ornamental in all phenological phases of its development. On the salt marshes of the Ararat valley the occurrence and abundance, as well as the status of the population are satisfactory (Akopian & al. 2018).

It is propagated by seeds and vegetatively through the rhizome. Fruits and seeds are often damaged by insects. It is eaten by cattle. It belongs to the ecological group of halo-xerophytic plants and can adapt to the increasing dryness of the habitat. The main threat to the population is grazing, ignition of vegetation, and territory reduction.

The purpose of this work is investigation of karyological and some palynological and eco-physiological features of the vulnerable halophilic species *Sphaerophysa salsula*, which is insufficiently studied in these aspects. The obtained data can contribute to the identification of the adaptation features of this species in the conditions of the Ararat valley and its protection.

Material and methods

Morphological, karyological, palynological and ecological features of the halophytic rare species *S. salsula* were investigated based on field observations and material collected from the Ararat valley of Armenia.

Fig. 1. *Sphaerophysa salsula*: a) in flowering, b) in fruiting.

S. salsula is perennial grayish plant 30–80 cm high, covered with short, adpressed, sparse hairs. Leaves odd-pinnate 4–10 cm long, with 6–10 pairs of elongated-elliptical, gray leaflets. Stipules acute, lanceolate, 2 mm long. Flowers numerous with short pedicels, collected in oblong, axillary raceme. Calyx 4–5×2–3 mm, campanulate, with 5 short, wide-triangular, sharp tooths. Corolla brick-red colored, vexillum rounded, slightly emarginate, 13–15×10 mm, wings oblong, curved, almost equal in length to the carina. Legumes 15–35×10–20 mm, inflated, oblong or almost rounded, membranous, glabrous or scattered-pubescent, indehiscent. Seeds 1.5 mm long, brownish, smooth. Rhizome long, cord-like (Akopian & al. 2018; pers. obs.).

The karyological investigations were made on the mitotic chromosome preparations in the stage of metaphases obtained from the meristematic cells of root tips. The seeds were germinated on wet filter paper in Petri dishes in the laboratory (19°−21°C). The root tips were pretreated in 0.4% colchicines solution for 2 hours and fixed in fluid of alcohol and glacial acetic acid at 3:1 ratio for at least 2 hours at room temperature. After hydrolysis in 1N HCl for 10−15 minutes at 60°C the root tips were stained in Schiff reagent for 1.5 hours. Then the root tips were squashed on a glass slide with 45% acetic acid. The preparations were placed in butyl alcohol for 5 minutes, then in xylene for 5 minutes, and were placed in Canadian balsam. For chromosome counts, a minimum of 10 plates of chromosome preparations were examined. The determination of the number of chromosomes and the description of the species karyotype were carried out by AmScope Photomicroscope using an oil immersion objective (×100). Photographs were taken with the same microscope.

Specimens karyologically examined: Ararat province of RA, near Armash village, at an altitude of 1000 m a.s.l., 39°45’38.5’’N 44°48’23.5’’E, 02.07.22. Leg. J. Akopian, A. Ghukasyan, L. Martirosyan, A. Elbakyan. Det. J. Akopian, A. Ghukasyan; Ararat province, “Salt marshes” in the vicinity of Ararat town, at an altitude of 900–1000 m a.s.l., 39°49’28.9’’N 44°43’53.2’’E. 02.07.22. Leg. J. Akopian, A. Ghukasyan, L. Martirosyan, A. Elbakyan. Det. J. Akopian, A. Ghukasyan.

Fertility, that is the ability of pollen to carry out complete fertilization was determined by staining with acetocarmine on temporary preparations under a light microscope at a magnification of 350 times (Pausheva 1980). The flower anthers of *S. salsula* were opened with a dissecting needle and tweezers, the pollen was removed and placed on a glass slide. For determine the pollen fertility was calculated 100 pollen grains in 5 repeats, totaling 500 pollen grains from each herbarium specimen. Pollen was taken from the ERE herbarium for different years to compare pollen fertility depending also on the year of collection. Statistical processing of experimental data was carried out according to Dospekhov (1973) and Wolf (1966). For income comparison, the arithmetic mean X=Sx was calculated. The size of pollen grains was also determined, because the morphological heterogeneity of pollen can be attributed to the failures in microsporogenesis, which can lead to unsuccessful seed formation.

Specimens examined: Armenia, Ararat region, in the vicinity vil. Ararat, salt marshes, 850 m a.s.l. 01.07.1997. Leg. *E. Gabrielyan, M. Hovhannisyan, K. Tamanyan, G. Faivush* ERE 147804; Armenia, Ararat province, in the vicinity vil. Armash, fish farm area, 830 m a.s.l. 06.09.2007. Leg. *G. Nikoghosyan* ERE 162900; Armenia. prov. Ararat, pr. Eraskh, 39°44’35’’N; 34°49’41’’E, 843 m. 28.06.2005, Cunneta de la carretera, *A. Quintanar &*

al., 1721 ERE 168083. Hortus Regius Matritensis (MA) Iter Armeniacum (VI.VII.2005) *Leguminosae-Papilionoideae*; Armenia, the shore of the reservoir near the Metsamor Museum. 11.07.2005. Leg. *Gabrielyan E.Ts., Barseghyan A.M., Aghababyan M., Gabrielyan I., Mkrtchyan A.* ERE 160162; Armenia. Ararat distr., near Ararat town, saline soil, 800 m a.s.l., N 39°49'581" E 44°43'401" 15.06.2011, in bloom. Leg. *E. Navasardyan, I. Gabrielyan* ERE 183096.

Eco-physiological studies of water regime, the intensity of transpiration and photosynthesis were conducted by Mezhunts, Navasardyan (2010) and Salnikov, Maslov (2014). We were the first to investigate the eco-physiological characteristics (water regime, water deficiency, transpiration, and photosynthesis intensity) of *S. salsula*. All the measurements were done in the period between 11:00 and 13:00. Each measurement was done with 3 repetitions and in 3 options (7-10 shoots were chosen for each sample). The presented data are the average results of the performed analysis which were subjected to statistical development. Water deficiency was determined based on the principle of water saturation of leaves. The water deficiency was calculated by the following formula:

$$WD = \frac{\text{the water content saturating the leaf (mg) - the initial water content (mg)}}{\text{the water content saturating the leaf (mg)}} \times 100$$

100 - is for expressing percentages

The fresh sample was promptly weighed and dried in a thermostat under 150 degrees of celsius for determining the total water content.

The total water content was calculated by the following formula:

$$X = \frac{P_1 - P_2}{P_1} \times 100$$

X - is the total water content, % from the wet weight, P_1 - is the wet weight of the leaf before drying, in grams, P_2 - is the dry weight of the leaf sample, in grams, 100 - is for expressing the total water content in the leaf from the wet weight in percentages.

The intensity of transpiration of the leaf was determined by rapid weighing with a torzon scale. Transpiration intensity was calculated by the following formula:

$$T = \frac{(B_1-B_2) \times 60 \times 1000}{B_1 \times t} \text{ mg/grams from wet weight, hour}$$

T_1 - is the intensity of transpiration, mg/g from wet weight, hour, B_1 - is the initial weight of the leaf, mg, B_2 – is the leaf weight after 3 minutes, 60 minutes - to express in hours,1000 mg - to express the wet weight in 1 gram, T - is the period between the initial and the final weighing in minutes.

The intensity of photosynthesis was determined by the change in the dry weight of the leaf sample. The amount of dry material synthesized during photosynthesis is determined by the difference between the initial and the final measurements of the dry weight. The intensity of photosynthesis in mg/dm2, per hour, is expressed by dividing the amount of

synthesized dry material by the time period between the measurements. The intensity of photosynthesis is measured by the following formula:

$$P = \frac{P_2 - P_1 \times 1 \times 100}{23.55} - \text{mg/dm}^2\text{, hour}$$

The content of photosynthetic pigments (chlorophylls a and b, carotenoids) was determined by a modified method based on the use of an organic solvent of dimethyl sulfoxide, which allows obtaining stable extracts necessary for performing extralaboratory studies (Mezhunts, Navasardyan 2010). The measurement was carried out on a spectrophotometer (SF-16), and the quantitative accounting of chlorophylls a, b and carotenoids was carried out according to the Mackini-Arnon and Wettstein formulas (Shlyk 1971); chlorophyll a=12.7E663-2.69E645; chlorophyll b = 22.9E645-4.68E663; sum of carotenoids = 4.695E440.5-0.268 (a + b), where E is the spectrophotometer reading.

Results and discussion

The studied samples of the species *S. salsula* were collected from the Yerevan floristic region. According to the literature data, only the diploid cytorace is characteristic for *S. salsula* with 2*n*=16 (Reveal & Spellenberg 1976; Nazarova 1997). The first report on chromosome count for the genus *Sphaerophysa* is believed for species *S. salsula*, that was introduced into the United States from central Asia about 50 years ago (Reveal & Spellenberg 1976).

Our material revealed a diploid cytorace for this species 2*n*=2x=16 (Fig. 1a), with basic chromosome number x=8. The karyotype of *S. salsula* is asymmetric, consisting of 5 pairs of submetacentric and 3 pairs of metacentric chromosomes (Fig. 1b). Karyotype formula is: 2*n*=16=10SM+6M.

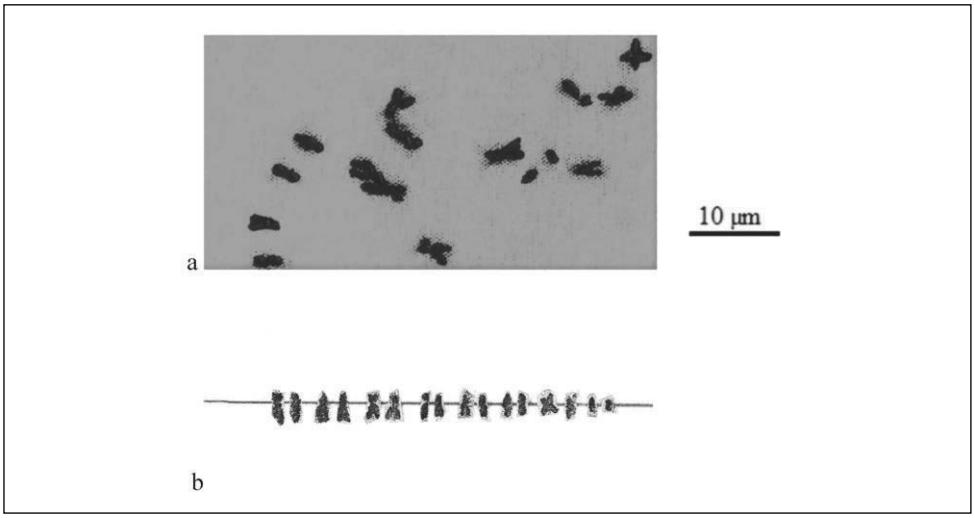

Fig. 2. a. Mitotic metaphase plate of *Sphaerophysa salsula*; b. Karyotype of *S. salsula.*

It is interesting to note that for species *S. kotschyana* from the vicinity of Tuz Lake (Turkey) a diploid cytorace with B-chromosomes was determined: 2*n*=14+0-2B, with basic chromosome number x=7 (Duran & al. 2010).

Fertility, that is, the ability of pollen to carry out complete fertilization, is a relatively constant value. The painted pollen grains were recorded as fertile and viable, and unpainted or very poorly colored pollen grains recorded as sterile or non-viable.

Pollen grain size measurements were carried out in order to identify morphological heterogeneity of pollen. If the size of pollen grains varied from 12.3 to 27.0 μm, the pollen fertility was high, almost unchanged, and ranged from 94.6 to 98.2, regardless of the year of collection from 1977 to 2011, which suggests that the difference in the pollen grains size will not affect the process of fertilization in the future (Tabl.1, Fig. 3).

Table 1.Pollen fertility of *Sphaerophysa salsula*.

***Sphaerophysa salsula*, ERE N°**	**Pollen grain size, μm**	**Pollen fertility percentage**	
		Range	**Average fertility, %**
147804	15.2–26.3	95–99	97.4±0.7
168083	14.8–22.3	98–99	98.2±0.2
160162	15.2–27.0	95–100	98.0±0.8
162900	17.6–25.4	96–100	97.8±0.9
183096	12.3–22.1	94– 96	94.6±0.5

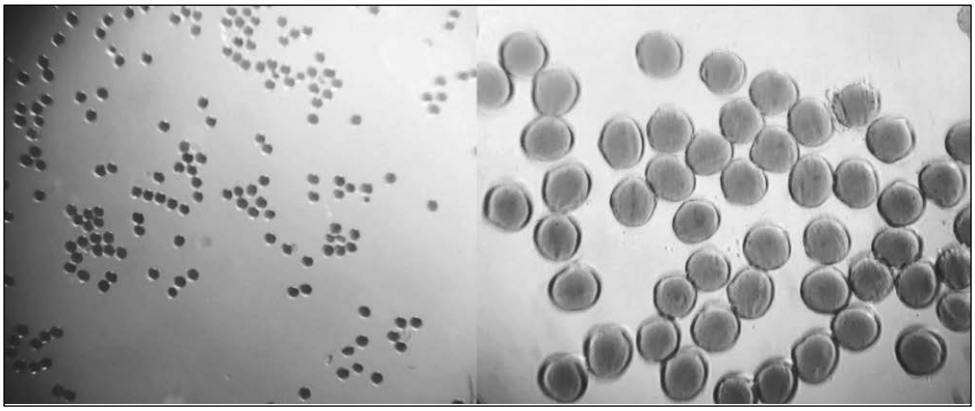

Fig. 3. *Sphaerophysa salsula* pollen fertility, ERE 147804.

To identify the adaptive features of *S. salsula* to the arid saline habitats of the Ararat valley, eco-physiological studies were carried out. It is obvious that the study of water regime is the most important at studying halophyte plants, since water is the environment where all the main biochemical reactions that determine the vital activity of plants take place. Most of the plants absorb highly mineralized water with difficulty because of the insufficient osmotic pressure in plant cells. Moreover, the degree of accumulation of salts by plants depends on both: the peculiarities of species and the amount of salts in the soil. Under the natural conditions of high salt content in soil and groundwater the water content in plant organs will be much lower than under conditions of normal moisture. The indicators of the water regime, the intensity of transpiration and photosynthesis of *S. salsula* are shown in Table 2.

Table 2. Indicators of the water regime, the intensity of transpiration and photosynthesis of *Sphaerophysa salsula.*

Indicators of water regime (raw weight)				**Transpiration and photosynthesis intensity**	
Total water %	**Free water, %**	**Bound water, %**	**Water deficit, %**	**Photosynthesis, mg/dm^2, per hour**	**Transpiration mg/wet weight, per hour**
52.33	23.71	28.62	16.85	2.15	200.0

In a complex change in the water regime caused by external factors, shifts in the intensity of transpiration are important, since it, together with the intensity of water inflow, determines the water balance of plants. Under conditions of soil salinity, the intensity of transpiration depends not only on the water content in the soil and the ability of plants to assimilate it by the root system, but also on the content of water-soluble salts in the leaves, which create an increased osmotic pressure, on the hydrophilicity of the plasma, etc. As for the change in the intensity of photosynthesis, it is obvious that the intensity of its physiological processes aimed at the fastest implementation of the reproductive cycle is determined (Rozentsvet & al. 2013).

The absorption and transformation of solar energy during photosynthesis is carried out by photosynthetic pigments of plants, in particular, chlorophyll “a” and “b” and carotenoids. To assess the state of the photosynthetic apparatus of *S. salsula*, the content of these pigments in them was studied, which is a very important internal factor in plant adaptation to unfavorable environmental conditions (Table 3).

The results of the study show that *S. salsula* plants are well adapted to conditions of Ararat valley habitats with a high content of mineral salts in soil and water, arid climate with high summer temperatures and water high evaporation from the soil surface, with changes in the groundwater level during the growing season. The content of pig-

Table 3. Chlorophyll and carotenoids content in *Sphaerophysa salsula.*

Chlorophyll "a", mg/g	Chlorophyll "b", mg/g	Chlorophyll "a+b", mg/g	Chlorophyll "a/b", mg/g	Carotenoids, mg/g
24.82±0.48	14.44±0.56	39.26	1.70	16.90±2.95

ments in *S. salsula* indicates the intensity of physiological processes associated with the life activity of this plant.

The results of our studies show that *S. salsula*, despite a different adaptation strategy, is well adapted to conditions with a high content of mineral salts in soil and water, an arid climate with high summer temperatures and high evaporation of water from the soil surface, with a change in groundwater levels during the growing season.

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Article

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Nora Sakhraoui

Nouveaux signalements de plantes exotiques échappées des cultures en Algérie

Abstract

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New records of alien plants escaped from cultivation in Algeria. — In this contribution are reported three vascular species new to the alien flora of Algeria and continental North Africa, reported outside the cultures in the Skikda region (northeastern Algeria). *Duranta erecta* and *Justicia adhatoda* are considered casual, *Tecomaria capensis* is considered naturalized. The latter is established in a relic of a maquis of *Quercus suber* and shows a significant potential for more spreading. Thus, *T. capensis* should be monitored to prevent a prompt potential invasiveness in Algeria.

Key words: non-native flora, ornamentals, *Asteridae*, new records, N-Africa.

Introduction

En période coloniale, des milliers de plantes exotiques ont été acclimatées en Algérie (Carra & Gueit 1952) dont plusieurs ont développé progressivement une capacité à se multiplier spontanément dans leurs milieux de culture augmentant ainsi considérablement leurs chances d'échapper à ces milieux pour coloniser les habitats adjacents et plus particulièrement certains milieux perturbés tels que les bords de routes. En effet, l'échappement de dizaines d'espèces exotiques a déjà été enregistré dans différentes régions du pays et beaucoup ont réussi à surmonter les barrières locales de dispersion et les barrières environnementales définies par Richardson & al. (2000), leur permettant de s'installer de façon définitive et d'être considérées comme complètement naturalisées. C'est ainsi que la flore exotique naturalisée en Algérie a été estimée à 143 espèces par Vila & al. (1999) et à seulement 108 espèces par Meddour & al. (2020); quoi qu'il en soit, la flore exotique en Algérie ne cesse d'augmenter avec les nouveaux signalements rapportés de temps à autre dans les différents travaux (voir e.g. Sakhraoui & al. 2022, 2023).

Cette contribution rejoint ce type d'investigations et permet de rapporter l'échappement de 3 espèces exotiques pour lesquelles il n'existe aucun statut d'indigénat en Algérie (APD 2023; Euro+Med PlantBase 2023). Ces espèces représentées par : *Duranta erecta* L., *Justicia adhatoda* L. et *Tecomaria capensis* (Thunb.) Spach, ont été observées exclusivement dans la région de Skikda où elles se sont installées et commencent à proliférer parmi la flore indigène locale.

Ici, un aperçu sur leurs caractéristiques biologiques et écologiques observées sur terrain est donné ainsi qu'une appréciation de leur future éventuelle propagation en Algérie.

Matériel et méthodes

Les différentes espèces ont été retrouvées, lors de la réalisation de prospections de terrain, dans la région de Skikda (NE Algérien). La détermination de certaines de leurs caractéristiques biologiques et écologiques (floraison, fructification, mode de reproduction, nature des milieux colonisés) a nécessité un suivi saisonnier *in situ* étendu sur trois années successives de 2021 à 2023. Cependant, la germination des graines a été suivie dans les jardins du Service Commun de Recherche 'Pôle de Vulgarisation Botanique'. L'appartenance taxonomique et l'origine biogéographique des espèces ont été établies à partir de la littérature scientifique (Flora of China 2023 ; Flora of Pakistan 2023 ; Missouri Botanical Garden 2023). Le statut d'indigénat, quant à lui, a été évalué selon Richardson & al. (2000). Leur distribution générale a été vérifiée à partir des différentes bases de données, notamment : African Plant Database (APD 2023), Euro+Med PlantBase (2023), Global Biodiversity Information Facility (GBIF 2023) et Plants Of the World Online (POWO 2023).

Résultats

Les 3 espèces (de la sous-classe des Asteridae) ont été trouvées dans la région de Stora (Municipalité de Skikda). La population de *Tecomaria capensis* est la plus importante car elle est représentée par des dizaines d'individus se répartissant sur plusieurs points de la zone d'observation. Les détails de ces enregistrements sont présentés ci-dessous.

Duranta erecta L. [= *D. repens* L.] (*Verbenaceae*).

Cette espèce originaire de la Floride jusqu'au Brésil et des Antilles (Missouri Botanical Garden 2023), très appréciée comme plante ornementale pour ses fleurs et son aspect décoratif, a été introduite dans différentes parties du monde où elle s'est échappée des cultures (POWO 2023). En Europe, *D. erecta* a été signalée à Malte (Mifsud 2022) comme espèce persistante (Occasionnelle ?) dans des sites abandonnés et en Turquie comme naturalisée (Uludağ & al. 2017). Cependant, l'espèce a été citée comme envahissante dans différentes régions du globe, notamment en Australie, en Chine et en Afrique du Sud (CABI 2023). En Afrique du Nord, il semblerait que, jusqu'ici, la plante n'a jamais été vue en dehors des cultures (POWO 2023). Cependant, une recherche accentuée au niveau des différentes bases de données mentionnées dans matériel et méthodes a révélé l'existence de trois occurrences de *D. erecta* en Algérie, dans la plateforme iNaturalist, reprises par GBIF (2023), dont deux seulement, enregistrés dans la même station à Misserghin (Oran, ouest Algérien) en Janvier 2020 (https://www.inaturalist.org/observations/37406656**;** https://www.inaturalist.org/observations/37406655), méritent une vérification sur terrain (la troisième représente sans aucun doute des individus cultivés dans les espaces verts de l'Université de Skikda). Malheureusement, les photos publiées sur la plateforme, ne donnent pas un aperçu sur l'habitat colonisé par la plante.

Cet enregistrement à Skikda, est donc le premier enregistrement confirmé de l'espèce en dehors des cultures en Algérie et probablement aussi en Afrique du Nord continentale.

À Skikda, *Duranta erecta* a été trouvée au bord de l'oued Griva, sur la route supérieure de Stora (Fig. 1a), où un seul individu d'environ 3 m de haut, et présentant des dizaines de rejets occupant environ 4 m^2, a été observé en fruits le 05.03.2021 et le 11.03.2023, en l'occurrence avec plusieurs plantes natives dont *Clematis cirrhosa* L. et *Smilax aspera* L.

Bien que la fructification a été enregistrée, la germination des graines, cependant, n'a pas été observée. L'espèce semble se reproduire via les fragments de tiges à partir desquels, elle a probablement pris place dans la station.

Bien qu'elle se maintienne dans la station d'observation, *Duranta erecta* ne peut être considérée que comme occasionnelle en Algérie, pour le moment.

Justicia adhatoda L. [= *Adhatoda zeylanica* Medik., *Dianthera latifolia* Salisb., *Ecbolium adhatoda* (L.) Kuntze] (*Acanthaceae*).

Cette espèce est originaire d'Asie (Inde, Indonésie, Malaisie, Népal, Pakistan, Sri Lanka) (Flora of China 2023). Introduite comme plante ornementale et probablement aussi comme plante médicinale dans différentes parties du monde où elle s'est échappée des cultures dans certains pays. Selon POWO (2023) son évasion a été signalée en Chine, en Ethiopie, à la Jamaïque, à Cuba et à Madagascar. En Europe, *Justicia adhatoda* a été signalée comme espèce introduite en Sicile (Euro+Med PlantBase 2023), comme occasionnelle en Grèce (Galanos 2015), comme manquant d'enregistrements récents en Italie **(**Celesti-Grapow & al. 2009; Galasso & al. 2018) et comme espèce persistante à Malte (Mifsud 2022). En Afrique du Nord, par contre, aucun enregistrement ne semble exister (ADP 2023). La consultation des différentes bases de données mentionnées plus haut a révélé l'existence d'une seule occurrence de ladite espèce en Algérie, sur la plateforme iNaturalist (https://www.inaturalist.org/observations/84143014) datant de Juin 2021, elle-même reprise par GBIF (2023). L'examen de la photo prise à Constantine (NE Algérien) et des informations mentionnées sur la plateforme, nous permet de dire qu'il s'agit plutôt d'un individu cultivé dans une station de transport. *J. adhatoda* est en effet très appréciée comme plante ornementale en Algérie, elle est d'ailleurs largement cultivée dans le milieu urbanisé, notamment dans les différents espaces verts.

Cet enregistrement dans la région de Skikda est donc le premier pour l'Algérie et probablement aussi pour l'Afrique du Nord continentale.

À Skikda, l'espèce a été observée en fleurs le 05.03.2021 puis ré-observée le 15.04.2022 et le 11.03.2023, à l'oued Griva sur la route supérieure de Stora (Fig. 1b), dans un ravin au bord de l'oued dans lequel se jettent plusieurs canaux d'évacuation des eaux usées. Quatre à cinq individus âgés faisant de 1,50 m à 2 m de haut ont été observés proliférant parmi les espèces indigènes arbustives notamment *Clematis cirrhosa* L., *Olea europaea* L., *Phillyrea* sp., *Pistacia lentiscus* L., *Rhamnus alaternus* L. et *Rubus ulmifolius* Schott. Des espèces exotiques naturalisées dans la région ont également été notées dans la station telles que *Acacia mearnsii* De Wild., *Ricinus communis* L., *Tropaeolum majus* L. et *Vachellia karroo* (Hayne) Banfi & Galasso.

Le suivi de la phénologie de l'espèce a révélé l'absence de la fructification. L'espèce se reproduit en Algérie via les fragments de tiges, ces derniers sont d'ailleurs probablement responsables de son apparition dans la station d'observation.

Malgré le maintien de la plante dans la station d'observation et la grande taille des individus enregistrés, indiquant leur ancienne installation, l'espèce ne peut être considérée que comme occasionnelle en Algérie, car elle ne se propage pas encore considérablement dans la station.

Tecomaria capensis (Thunb.) Spach [= *Bignonia capensis* Thunb., *Tecoma capensis* (Thunb.) Lindl.] (*Bignoniaceae*).

Cette espèce est originaire de l'Afrique du Sud (Flora of Pakistan 2023). Introduite comme plante d'ornement dans plusieurs régions du monde où elle a échappé des cultures. Selon POWO (2023), son échappement a été signalé en Amérique du sud, en Amérique du centre, en Australie et en Nouvelle Zélande où elle est considérée comme envahissante (GISD 2023). En Europe, l'espèce est considérée comme occasionnelle en Espagne (Aymerich & al. 2019), en Italie (Galasso & al. 2018), à Malte (Mifsud 2022) et en Turquie (Uludağ & al. 2017). En Afrique du Nord, l'espèce a été citée jusqu'ici, uniquement à Madère (ADP 2023) et aux Canaries (Flora de Canarias, http://www.floradecanarias.com/tecomaria_capensis.html). La consultation des différentes bases de données mentionnées dans matériel et méthodes a révélé l'existence de deux occurrences de *T. capensis* en Algérie, sur la plateforme iNaturalist reprises par GBIF (2023), dont une enregistrée en Janvier 2023 dans la même station où nos observations ont été faites, (https://www.inaturalist.org/observations/145967948) et une enregistrée en Mars 2022 dans la région de Ain Smara à Constantine (au Sud de Skikda) (https://www.inaturalist.org/observations/109833844). Au cours de nos prospections dans la zone de Stora, nous n'avons enregistré aucune population de ladite espèce qui parait échappée des cultures dans l'emplacement indiqué sur la carte de la plateforme, sachant que nos prospections ont été faites à pieds pour s'assurer de l'enregistrement de tous les cas d'éventuels échappements. L'examen des photos prises à Constantine, par contre, montre bien un cas d'évasion mais dans lequel un seul individu a été recensé. À travers ce travail, *Tecomaria capensis* est donc officiellement signalée en dehors des cultures pour la première fois en Algérie et en Afrique du Nord continentale.

À Skikda, l'espèce a été trouvée le 04.05.2021, le 24.05.2022 et le 11.03.2023 en fleurs au bord de la route supérieure de Stora où elle a probablement échappée des jardins pour se mêler à la flore indigène (Fig. 1c). Une population très importante constituée de dizaines de pieds adultes et de dizaines de pieds plus jeunes se répartie sur une longue distance tout au long de la route en se mêlant aux espèces autochtones arbustives représentant une relique de la subéraie d'origine. L'espèce végète bien en s'accrochant à *Clematis cirrhosa* L*., Olea europaea* L., *Phillyrea angustifolia* L., *Pistacia lentiscus* L., *Quercus suber* L., *Rhamnus alaternus* L., *Smilax aspera* L. et *Tamarix* sp. Des espèces exotiques ont également été observées, notamment *Acacia saligna* (Labill.) H. L. Wendl., *Eucalyptus camaldulensis* Dehnh*., Chasmanthe floribunda* (Salisb.) N. E. Br., *Opuntia ficus-indica* (L.) Mill. et *Tropaeolum majus* L.

D'autres individus ont été trouvés au bord de l'oued Griva à une centaine de mettre du premier point dans une zone ombragée. Les sujets en fleurs, observés le 12.03.2021 et le 11.03.2023, se mêlent à des espèces indigènes comme *Olea europaea* L. et *Acanthus mollis* L. ainsi qu'à des espèces exotiques comme *Eucalyptus* sp. et *Zantedeschia aethiopica* (L.) Spreng.

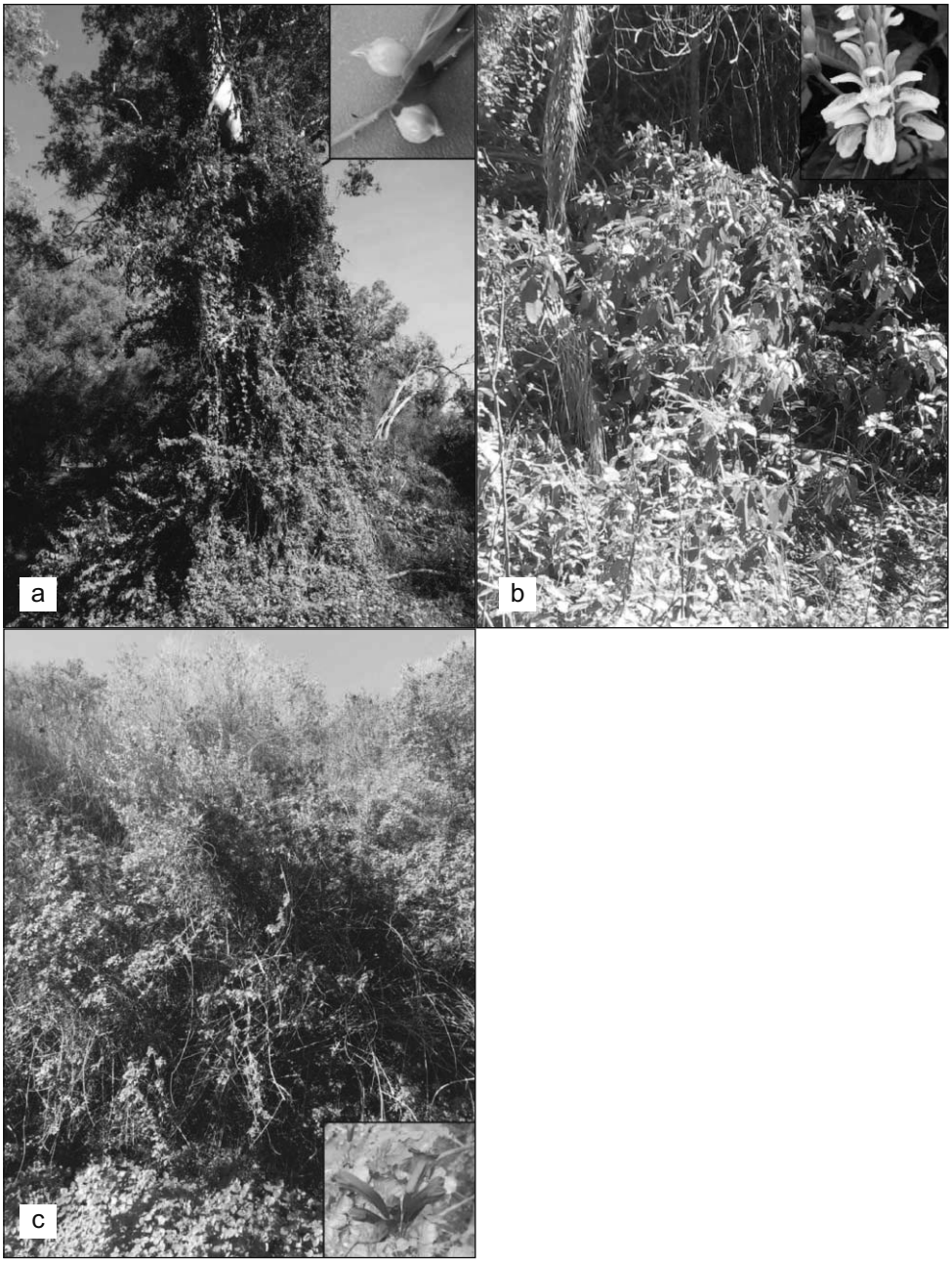

Fig. 1. a) *Duranta erecta* accrochée à *Eucalyptus camaldulensis* et mêlée à des lianes indigènes (Oued Griva, Stora, Skikda, NE Algérien). Photo par N. Sakhraoui (13.03.2023); b) Biotope de *Justicia adhatoda* à Stora (Skikda, NE Algérien). Photo par N. Sakhraoui (13.03.2023); c) Biotope de *Tecomaria capensis* observée dans un maquis arborescent à Stora (Skikda, NE Algérien). Photo par N. Sakhraoui (13.03.2023).

En Algérie, *Tecomaria capensis* arrive à produire des fruits (capsules); les graines ont été récoltées le 15.01.2023 à partir de quelques sujets, cependant, la germination des graines n'a pas été observée. L'espèce se reproduit vraisemblablement via les rejets, les fragments de tiges et les drageons ayant été observés en grands nombres sous les individus âgés.

Vu la taille de la population enregistrée et sa prolifération parmi la flore indigène, l'espèce peut être considérée comme naturalisée dans la station d'observation.

Discussion

Plusieurs villas datant de l'époque coloniale, possédant des jardins dans lesquels plusieurs espèces exotiques sont cultivées, sont situées au bord de l'oued Griva, nous pensons que les débris de tailles jetés par les habitants aux bords et/ou dans l'oued sont les principaux vecteurs de l'installation de ces plantes exotiques dans cette localité. Ces débris peuvent être entrainés par les courants de l'oued notamment en hiver pour échouer finalement dans des zones plus éloignées des plantes mères. C'est ce qui nous permet de soupçonner la présence de d'autres individus tout au long de l'oued qui reste à prospecter malgré l'accès difficile.

Ces enregistrements confirment nos conclusions précédentes relatives au rôle des oueds, des 'chaâbats' (petits cours d'eau qui se jettent le plus souvent dans les oueds) et des zones ombragées et humides dans la propagation des espèces exotiques en Algérie. Ces habitats fournissent l'humidité nécessaire à la subsistance des nouvelles plantules issues de la germination des graines ou de l'enracinement des fragments de tiges en période estivale qui connait en Algérie des pics de température très importants notamment en mois de juillet et d'août. Les enquêtes de terrain, précédemment menées dans différentes régions du NE Algérien, ont permis de reporter plusieurs espèces exotiques dans ces habitats, telles que *Acacia mearnsii* De Wild., *Ailanthus altissima* (Mill.) Swingle, *Anredera cordifolia* (Ten.) Steenis, *Bidens aurea* (Aiton) Sherff, *Canna indica* L., *Cardiospermum grandiflorum* Sw., *Chasmanthe floribunda* (Salisb.) N. E. Br., *Cyperus involucratus* Rottb., *Ipomoea indica* (Burm.) Merr., *Lycium ferocissimum* Miers, *Mirabilis jalapa* L., *Morus alba* L., *Nicotiana glauca* Graham, *Parthenocissus quinquefolia* (L.) Planch., *Ricinus communis* L., *Solanum lycopersicum* L., *Tipuana tipu* (Benth.) Kuntze, *Tradescantia fluminensis* Vell., *Tropaeolum majus* L. et *Zantedeschia aethiopica* (L.) Spreng (voir e.g., Sakhraoui & al. 2019a, 2019b, 2023; Sakhraoui 2021).

Parmi les trois espèces enregistrées dans ce travail, nous pensons que *Tecomaria capensis* est la plus susceptible d'élargir son aire de distribution en Algérie dans le futur, car d'un côté, elle montre déjà sur terrain un potentiel de propagation assez important, d'un autre côté, elle possède des antécédents d'envahissement dans des zones à climat méditerranéen, notamment dans le sud d'Australie (GISD 2023) où elle est considérée comme une mauvaise herbe (Weeds of Australia 2023).

D'autres *Bignoniaceae* lianescentes ont déjà été rapportées naturalisées ou presque en Algérie notamment *Dolichandra unguis-cati* (L.) L.G. Lohmann, *Podranea ricasoliana* (Tanfani) Sprague et *Campsis radicans* (L.) Bureau **(**Zeddam & Raus 2010 ; Zeddam 2011 ; Raus & Zeddam 2019), cette dernière ressemble beaucoup à *T. capensis* avec laquelle elle peut éventuellement être confondue, néanmoins, la distinction entre les deux espè-

ces peut largement être facilitée par l'examen des fleurs (*C. radicans*: corole cylindrique à 5 lobes arrondies, étamines et stigmate ne dépassant pas la corole ; *T. capensis*: corole cylindrique à 5 lobes allongés, étamines et stigmate dépassant nettement la corole (obs. pers.)). Le suivi des populations de *C. radicans* naturalisées dans la région de Skikda et celles cultivées dans les jardins du Service Commun de Recherche 'Pôle de Vulgarisation Botanique' a montré que cette espèce produit des graines fertiles qui germent sans aucune difficulté ce qui n'est pas le cas de sa congénère *T. capensis* (obs. pers.). Néanmoins, la reproduction végétative de cette dernière, est jusqu'ici efficace dans l'assurance de la propagation de l'espèce dans des habitats riches en espèces indigènes arbustives ne redoutant aucune compétition.

Nous pouvons dire vers la fin, que les évasions des plantes exotiques se poursuivent en Algérie nécessitant la continuation des prospections de terrain

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Article

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Additions to the vascular flora of Italy

Abstract

Conti, F., Cangelmi, G., Da Valle, J., De Santis, E., Giacanelli, V., Gubellini, L., Hofmann, N., Masin, R. R., Miglio, M., Palermo, D., Santucci, B. & Bartolucci, F.: Additions to the vascular flora of Italy. — Fl. Medit. 33: 177-191. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

In this paper new floristic records for 41 taxa (species and subspecies) are reported. In particular, 30 taxa are natives and 11 aliens. Among the natives 1 is new for Veneto, 7 are new or confirmed for Marche, 1 is new for Lazio, 9 are new or confirmed for Abruzzo, 2 are new or confirmed for Molise; 13 aliens taxa are new for Abruzzo, Lazio and Marche. Some findings are very interesting from a phytogeographic and/or conservation point of view, such as *Allium guttatum* subsp. *dalmaticum* new for Italy, Astragalus austriacus and *Myosotis minutiflora* subsp. *minutiflora* new for the Apennines, and, a species deserving urgent conservation actions, of which we report the second location at national scale. Furthermore, we report some new locations for very rare species.

Key words: native taxa, alien taxa, Apennines, biodiversity, floristics.

Introduction

In the last decades the study of the flora of Italy has seen important contributions, as the development of the Portal to the Flora of Italy (2023) with the associated database (Martellos & al. 2020), and the publication of two checklists relative to native and alien plant species (Bartolucci & al. 2018; Galasso & al. 2018). The checklists are updated twice a year concerning the systematics, taxonomy and distribution of plants based, mainly, on the "Notulae to the Italian native and alien vascular Flora" (Bartolucci & al. 2021, 2023). An important role in the study of plant's distribution and systematics is played by the Centro Ricerche Floristiche dell'Appennino (University of Camerino – Parco Nazionale del Gran Sasso e Monti della Laga) which represents a junction in the Italian floristic network and carries out abundant national and international investigations and collaborations (Conti & al. 2023a, 2023b).

The present paper contributes mainly to the knowledge of the flora of central Italy with unpublished floristic findings including different discoveries of phytogeographic interest,

as disjunct populations of northernmost or easternmost distributed species or new localities of restricted endemics (POWO 2023; Portal to the Flora of Italy 2023).

Materials and Methods

The investigated area located in the central and northern Italy comprises the territories of Marche, Lazio, Abruzzo, Molise and Veneto administrative regions. Floristic data were mainly collected through field investigations carried out during 2022 and 2023; some other specimens gathered in the past have been revised. Herbarium specimens are preserved in APP, FI, and PESA (code follows Index Herbariorum 2023+).

Nomenclature follows the checklists of the Italian native (Bartolucci & al. 2018) and alien (Galasso & al. 2018) vascular flora and subsequent updates summarized in the Portal to the Flora of Italy (2023; see also Martellos & al. 2020). Taxa are categorized in native and aliens and ordered alphabetically.

For each taxon, the following information is provided: current accepted name; family; reason(s) for its inclusion in the list; current invasiveness status (only for the alien units); examined herbarium materials, with details about the location (in Italian, according to the information reported on the herbarium label), UTM coordinates (datum WGS84) when available, altitude, habitat, collection date, collector(s), and herbarium storage code; any additional notes.

Results

Natives

Aira multiculmis Dumort. (*Poaceae*)
Species new for the flora of Lazio.
Anagni (Frosinone), loc. Radicine, UTM WGS84 33T 349995 E 4616927 N, fosso tra campi coltivati, 240 m, 29.04.2023, *E. De Santis s.n.* (APP No. 69573).

The species is distributed in Central-Western Europe, with disjunct populations in Greece (POWO 2023). In Italy, until now, was reported along the Thyrrenian regions with exception of Lazio (Portal to the Flora of Italy 2023).

Allium guttatum subsp. ***dalmaticum*** (A.Kern. ex Janch.) Stearn (*Alliaceae*)
Subspecies new for the flora of Italy and Veneto.
Battaglia Terme (Padova), M. Croce, UTM WGS84 32T 717334 E 5019369 N ± 100 m, prati e arbusteti termofili, 90 m, 06.06.2023, *R.R. Masin s.n.* (APP No. 69569); Battaglia Terme (Padova), loc. fra il M. Croce e Spinefrasse, UTM WGS84 32T 717153 E 5019680 N ± 100 m, prati e arbusteti termofili, 100 m, 26.06.2023, *R. Masin s.n.* (APP Nos. 69564, 69565. 69566, 69567, 69568).

The observation of some photos of *Allium guttatum* from the Colli Euganei population with pink to purple tepals, previously identified as *A. sardoum* Moris (Masin & Ghirelli 2003; Masin & Tietto 2005, 2006) gave rise to the suspicion that they belong to *A. gutta-*

tum subsp. *dalmaticum*. Field research undertaken in Colli Euganei in the last years and particularly in 2023 confirmed this character to the whole population. According to the relevant literature (Stearn 1978), we were able to identify the plants collected on M. Croce (housed in APP) as *A. guttatum* subsp. *dalmaticum*, which results as new to Italy. Thus, *A. sardoum* should be excluded from the flora of Veneto. *A. guttatum* subsp. *dalmaticum* was reported for Balkan Peninsula and Turkey (Stearn 1978; POWO 2023).

It is very common on sunny stony soils in clearings, meadows and thermophilous bushes. It has probably been confused for centuries with *A. sphaerocephalon* L. subsp. *sphaerocephalon*, a species with which it sometimes coexists. It grows up the summit of Mount Ceva at 250 m a.s.l. It is also common in the surrounding mountains: Croce, Spinefrasse and Nuovo, in the municipality of Battaglia Terme. It grows in the municipality of Montegrotto on the Ca' Vecchia hill and with a small population on Mount Trevisan. It thrives on both latitic and rhyolitic substrates.

The new finding appears to be very interesting from a phytogeographical point of view as it is the westernmost of its range, similarly to *Haplophyllum patavinum* (L.) G.Don, an illyric species considered a relic of a wider and continuous past distribution which become fragmented due to the alternate climate changes in the post glacial periods (Tietto 2022).

Allium permixtum Guss. (*Alliaceae*)
New finding for the flora of Abruzzo.
Ovindoli (L'Aquila), Piana di Ovindoli presso il rifugio degli Alpini, UTM WGS84 33T 378277 E 4667395 N, zona umida, prati, 1345 m, 06.06.2022, *F. Bartolucci, F. Conti & B. Santucci s.n.* (APP No. 66503).

Species described from Sicily, where it is extinct. In Italy it is confirmed only in Abruzzo, where it is recorded for the National Park of Abruzzo, Lazio e Molise (Cicerana, Valle Chiara, Passo Godi) (Conti 1995, 1998), Gran Sasso (Voltigno, Fossa di Paganica) (Conti 1998; Ballelli 1999), Mt. Ocre at Settacque (De Santis & Soldati 2019). The newly found population improve the knowledge about this rare species and helps to better plan the conservation efforts in its regards.

Anacamptis berica Doro (*Orchidaceae*)
Species new for the flora of Gran Sasso and Monti della Laga National Park.
Valle Castellana (Teramo), M. dei Fiori, San Giacomo, UTM WGS84 33T 383140 E 4739735 N ± 1 Km, pascoli, 1100 m, 28.05.2000, *G. Capecci s.n.* (APP No. 18201).

The species was recently recorded for the first time in Abruzzo (Pica & al. 2023).

Anacamptis papilionacea (L.) R.M.Bateman, Pridgeon & M.W.Chase (*Orchidaceae*)
Species new for the flora of National Park of Abruzzo, Lazio and Molise.
Cocullo (L'Aquila), Valico di Olmo di Bobbi, UTM WGS84 33T 395927 E 4656008 N, 1244 m, 19.05.2023 (observed by L. Vitale but not collected).

The species was not reported for National Park of Abruzzo, Lazio and Molise (Conti & Bartolucci 2015, 2022). It was observed, but not collected, at Passo Olmo di Bobbi by Luciano Vitale who took a picture.

Anisantha rigida (Roth) Hyl. (*Poaceae*)
Species new for the flora of Marche.

Pesaro (Pesaro e Urbino), dintorni di Pesaro, presso Muraglia, UTM WGS84 33T 333491 E 4861930 N, luoghi erbosi incolti, suolo argilloso-sabbioso, humus nullo, ca. 20 m, 12.05.1982, *A.J.B. Brilli-Cattarini s.n.* (PESA); Fano (Pesaro e Urbino), dintorni del paese, lungo il litorale di Torrette di Fano, UTM WGS84 33T 346989 E 4850924 N; campi coltivati e luoghi erbosi incolti, suolo prevalentemente argilloso-sabbioso, 3 m, 05.05.1973, *A.J.B. Brilli-Cattarini, E. Murch & R. Sialm s.n.* (PESA); Porto Recanati (Macerata), agli Scossicci, UTM WGS84 33T 389998 E 4813970 N; luoghi erbosi incolti, suolo prevalentemente argilloso-sabbioso, humus subnullo, 3 m, 07.05.1980, *A.J.B. Brilli-Cattarini s.n.* (PESA); S. Angelo in Pontano (Macerata), tra il Cimitero e il Fosso della Girola, UTM WGS84 33T 369349 E 4773356 N, luoghi erbosi incolti, suolo arenaceo, humus nullo o subnullo, 450-475 m, 20.05.1982, *A.J.B. Brilli-Cattarini & L. Gubellini s.n.* (PESA).

In Italy the species is already reported for all the Italian regions except for Valle d'Aosta, Marche, Basilicata and Sardegna, of doubtful presence in Trentino-Alto Adige (Portal to the Flora of Italy 2023). The mentioned herbarium specimens stored in PESA confirm its presence in Marche.

Astragalus austriacus Jacq. (*Fabaceae*)
Species new for the flora of the Apennines and Abruzzo.
San Pio delle Camere (L'Aquila), lungo la strada Prov. 8 (Peltuinate) verso Carapelle Calvisio, UTM WGS84 33T 389122 E 4684213 N, margine di rimboschimenti a *Pinus nigra* e *P. sylvestris* e querceti a roverella, 1006 m, 23.09.2023, *F. Conti, B. Santucci, V. Giacanelli & M. Miglio s.n.* (APP Nos. 69559, 69560, 69561, 69562, 69563).

In Italy the species is already known only for Piemonte (Portal to the Flora of Italy 2023), so the new finding represents the southernmost distribution limit of the species in our country, as well as a disjuncted population of a pontic, sud-siberian species generally associated with continental climate conditions. The Abruzzo region comprises continental internal basins that host the habitat "6240 Sub-pannonic steppic grasslands" (Filibeck & al. 2022) with a rich contingent of steppic plants of considerable scientific and phytogeographic interest, such as the disjunction with Eastern Europe, e.g., *Adonis vernalis* L., *Alyssum desertorum* Stapf, *Androsace maxima* L., *Astragalus exscapus* L. subsp. *exscapus*, *Festuca valesiaca* Schleich. ex Gaudin subsp. *valesiaca*, *Salvia aethiopis* L., *Spiraea hypericifolia* L. subsp. *hypericifolia* and *Stipa capillata* L. (Bartolucci & Conti 2016; Cancellieri & al. 2017; Filibeck & al. 2020; Conti & Bartolucci 2023). Moreover, some Italian endemics, living in the same areas, must be considered of steppic origin, such as *Goniolimon tataricum* (L.) Boiss. subsp. *italicum* (Tammaro, Pignatti & Frizzi) Buzurović, *Astragalus aquilanus* Anzal. (Morretti & al. 2015; Buzurović & al. 2020) and *Adonis fucensis* F.Conti & Bartolucci (Conti & al. 2023c).

Astragalus cicer L. (*Fabaceae*)
Species new for the flora of Abruzzo.
Cerchio (L'Aquila), località Vitellino, UTM WGS84 33T 384553 E 4653350 N, incolti, 671 m, 16.06.2023, *F. Conti & B. Santucci s.n.* (APP Nos. 68471, 68472, 68473).

In Italy it was reported only for the administrative regions northern to Toscana and doubtfully in Campania (Portal to the Flora of Italy 2023).

Barbarea sicula C.Presl (*Brassicaceae*)
Species new for the flora of Abruzzo.
Campotosto (L'Aquila), Lago di Campotosto, loc. Piano delle Macchie, UTM WGS84 33T 367084 E 4711753 N ± 500 m, incolti e ruderi in ambienti umidi, 1315-1350 m, 23.05.1999, *F. Conti & D. Tinti s.n.* (APP No. 3326); Rocca di Mezzo (L'Aquila), Piani di Pezza, UTM WGS84 33T 373568 E 4670899 N ± 200 m, zone umide, 1460 m, 05.06.2004, *F. Bartolucci s.n.* (APP No. 66734); Rocca di Mezzo (L'Aquila), Altopiano delle Rocche, loc. Prati della Madonna, UTM WGS84 33T 378708 E 4675514 N ± 200 m, 14.05.2013, *F. Bartolucci & F. Conti s.n.* (APP Nos. 68098, 68099).

The previous records as *Barbarea intermedia* Boreau for Campotosto (Conti & Tinti 2008) and Campo Felice (De Santis & Soldati 2011) should be referred here.

The species shows a very fragmented distribution, including Lebanon, Syria, Greece and Italy, where it was recorded only for Sicilia and Calabria administrative regions (POWO 2023; Portal to the Flora of Italy 2023). The new findings constitute new important localities for such fragmented species and the northernmost limit of its distribution.

Barbarea intermedia Boreau (*Brassicaceae*)
Species to be excluded from the flora of Abruzzo.

See the previous species.

Calamagrostis pseudophragmites (Haller f.) Koeler subsp. ***pseudophragmites*** (Poaceae)
Species confirmed for the flora of Abruzzo.
Celenza sul Trigno (Chieti), riva sinistra del Trigno, poco a valle di Madonna del Canneto, UTM WGS84 33T 466692 E 4635026 N, argille plioceniche, 175 m, 04.07.2010, *F. Conti & A. Manzi s.n.* (APP No. 67267).

In Abruzzo, a record by Tenore (1830) as *Arundo halleriana* Gaudin for "S. Nicola a Monte Corno", wrongly attributed to *Calamagrostis pseudophragmites* (Conti 1998), should have been referred to *Calamagrostis varia* (Schrad.) Host, so the presence of *C. pseudophragmites* in Abruzzo has been considered erroneous (Bartolucci & al. 2018).

Centaurea collina L. subsp. ***collina*** (*Asteraceae*)
Species new for the flora of Marche.
Fiastra (Macerata), lungo la strada da San Lorenzo di Fiastra a Bolognola presso Fiume di Fiastra, UTM WGS84 33T 350675 E 4766394 N, pendici erbose asciutte o subaride, suolo calcareo, humus scarso o subnullo, ca. 675 m, 16.07.1986, *A.J.B. Brilli-Cattarini & L. Gubellini s.n.* (PESA).

Centaurea collina is a southwestern-European species, widespread from Spain to Italy, where it is reported up to now exclusively for Liguria, Puglia and, as casual alien, for Trentino-Alto Adige (recorded by mistake also in Valle d'Aosta) (Portal to the Flora of Italy 2023). It is now reported for the first time also in Marche region on the basis of herbarium specimens preserved in (PESA).

Centaurea tommasinii A. Kern. (*Asteraceae*)
Species extinct for the flora of Abruzzo.

In Abruzzo this species was recorded for Roseto as *C. paniculata* L. (Zodda 1954 quotes Di Giuseppe) and Giulianova as *C. paniculta* var. *maculosa* (Lam.) Briq. (Chiosi 1975 from a specimen collected by Marchesetti in 1875 as *C. paniculata* L.). The revision of the specimen hosted in FI, allowed us to more correctly attribute it to *C. tommasinii* as doubtfully suggested by Pignatti (1982). Along the Abruzzo coasts it is no longer present and is to be considered extinct due to the almost complete anthropization.

Cyperus michelianus (L.) Delile (*Cyperaceae*)
Species extinct for the flora of Abruzzo.

In Abruzzo this species was recorded between the mouth of the Piomba and Francavilla in the loc. Pretara (Tammaro & Pirone 1979) where it is no longer present and is to be considered extinct due to the almost complete anthropization of the coast. Land use change in coastal environment is one of the main threats to the conservation of flora. This report in addition to the status of "no longer found" for Campania (Portal to the Flora of Italy 2023) highlights the ongoing fragmentation of the distribution area of this species in Italy.

Epilobium roseum Schreb. subsp. ***roseum*** (*Onagraceae*)
Species confirmed for the flora of Marche.
Montegallo (Ascoli Piceno), Gruppo del Monte Ceresa, versante NW del M. Ceresa lungo il Fosso del Fluvione, UTM WGS84 33T 364286 E 4741453 N, luoghi erbosi umidi, suolo arenaceo, humus scarso, ca. 1000 m, 26.07.1982, *A.J.B. Brilli-Cattarini* & *L. Gubellini s.n.* (PESA).

This eurasiatic species is widespread in central-northern Italy and Lazio, doubtful present in Marche, Abruzzo, Puglia and Sardegna (Portal to the Flora of Italy 2023). The specimens preserved in PESA confirm its presence in Marche.

Festuca bosniaca Kumm. & Sendtn. subsp. ***bosniaca*** (*Poaceae*)
Species new for the flora of National Park of Gran Sasso and Monti della Laga.

L'Aquila (L'Aquila), Gran Sasso, Vado di Corno, UTM WGS84 33T 384643 E 4701103 N ± 300 m, pascoli sassosi, 1933 m, 13.06.2003, F. *Conti & al. s.n.* (APP No. 6967).

Genista radiata (L.) Scop. (*Fabaceae*)
Species confirmed for the flora of Abruzzo.
Rocca di Mezzo (L'Aquila), crestina sopra Valle Ortica, tra Piani di Pezza e Cimata di Pezza, UTM WGS84 33T 371097 E 4672251 N, pendii rupestri, 1770 m, 18.06.2023, *F. Conti & V. Giacanelli s.n.* (APP No. 68389); *ibidem*, 06.07.2023, *F. Conti, F. Bartolucci, B. Santucci & J. Da Valle s.n.* (APP No. 67914); Villavallelonga (L'Aquila), Vallone Martino, UTM WGS84 33T 387806 E 4631258 N, arbusteti, 1764 m, 10.10.2023, *F. Conti, G. Cangelmi & L. Vitale s.n.* (APP No. 69646).

In Abruzzo it was recorded generically "sugli alti gioghi" (Tenore 1820) and for the Villavallelonga territory (Grande 1910) in the National Park of Abruzzo, Lazio and Molise. According to Grande (1910) Tenore's report comes from the Colonna (1606) report: "Aequiculorum montibus, Cornino", currently in Lazio region. On Mt. Nuria, on the eastern slopes over Cornino plateau we confirm its presence up to now.

Juncus atratus Krock. (*Juncaceae*)
Species new for the flora of Abruzzo
Rocca di Mezzo (L'Aquila), Prato della Madonna, UTM WGS84 33T 378708 E 4675514 N ± 300 m, molinieto, 10.07.2018, *F. Bartolucci, D. Angeloni & E. Proietti s.n.* (APP Nos. 60340, 60341).

It is a Central European – South Siberian species with an highly fragmented distribution range. In Italy it was previously recorded only in Veneto where it is extinct (Portal to the Flora of Italy 2023) and recently in Umbria (Bartolucci & al. 2019; Bonini & al. 2020). The newly discovered populations in central Italy represents an important disjunction at the western limit of the species distribution (see POWO 2023) and the second location at national scale.

Malva trimestris (L.) Salisb. (*Malvaceae*)
Cryptogenic species new for the flora of Marche.
Porto San Giorgio (Fermo), dintorni del paese, campi incolti nel litorale di Marina Palmense, UTM WGS84 33T 403249 E 4778715 N, suolo prevalentemente argilloso, humus nullo, 2 m, 06.06.1980, *A.J.B. Brilli-Cattarini & L. Gubellini s.n.* (PESA).

Malva trimestris is a stenomediterranean species recorded as native in Friuli Venezia Giulia, Lazio, Abruzzo, Molise, Campania, Calabria, Sardegna and Sicilia, as casual alien in Trentino-Alto Adige, Lombardia and Veneto and, as cryptogenic, in Toscana; moreover, historical records are reported for Liguria and Emilia-Romagna (Portal to the Flora of Italy 2023).

The presence in the region of a single small population (not confirmed recently) and the ornamental use of the species, suggest that *Malva trimestris* is probably to be considered cryptogenic in Marche.

Myosotis minutiflora Boiss. & Reut. subsp. ***minutiflora*** (*Boraginaceae*)
Species new for the flora of Apennines and Abruzzo
Gagliano Aterno (L'Aquila), M. Briccialone, UTM WGS84 33T 389681 E 4663500 N, sgrottamenti, 1637 m, 04.07.2012, *F. Conti, F. Bartolucci, P. Paris & S. Scivola s.n.* (APP No. 67171); *ibidem*, 12.06.2023, *F. Conti, F. Bartolucci & G. Cangelmi s.n.* (APP Nos. 67389, 67390, 67391); Lucoli (L'Aquila), M. Cefalone, UTM WGS84 33T 371586 E 4676951 N, sgrottamento, 1962 m, 19.07.2023, *F. Conti, F. Bartolucci & G. Cangelmi s.n.* (APP Nos. 67440, 67441).

It is an Irano-Turanian species, rare and fragmented in the Mediterranean basin (Spain, Greece Bulgaria, Cyprus and Turkey) (POWO 2023). In Italy it was recorded only in Trentino-Alto Adige and Veneto (Prosser 2006; Bertolli & Prosser 2013).

Oloptum miliaceum (L.) Röser & H.R. Hamasha (*Poaceae*)
Species new for the flora of Molise
San Giacomo degli Schiavoni (Campobasso), su argine Strada Provinciale 112 in esposizione S-SW, UTM WGS84 33T 495150 E 4646827 N, su costone roccioso incoerente di arenaria con *Pistacia lentiscus* L., *Colutea arborescens* L., *Asparagus acutifolius* L., *Cistus salvifolius* L., *Ampelodesmos mauritanicus* (Poir.) T.Durand & Schinz e la congenere *O. thomasii* (Duby) Banfi & Galasso, 150 m, 16.08 2023, *D. Palermo s.n.* (APP Nos. 69607, 69608, 69609, 69610).

Ononis alba Poir. subsp. ***alba*** (*Fabaceae*)
Species confirmed for the flora of Molise.
Termoli (Campobasso), loc. Fornace, UTM WGS84 33T: 497193 E 4647983 N, incolto sterile a ridosso di un piccolo torrente, substrato argilloso e spesso impaludato sino a fine primavera, le piante raggiungono il metro di altezza e formano popolamenti compatti, 50 m, 04.07.2023, *D. Palermo s.n.* (APP Nos. 69611, 69612, 69613, 69614, 69615, 69616).

This species is generically reported "ne' campi sterili" of the Molise region (Tenore 1820; Villani 1911 quoted Tenore), where it is not confirmed by Lucchese (1995) and doubtfully reported by the Portal to the Flora of Italy (2023). Contrary to what was stated by Pignatti (2019) who in a dichotomous key reported *O. alba* as glabrous and devoid of glands, the plants are densely hairy and glandular. In the protologue the plant is described as viscous.

The species is present in Morocco, Algeria, Tunisia and Italy, where it grows south of Lazio and Abruzzo. This record close the distribution gap with the Molise administrative region.

Orobanche amethystea Thuill. (*Orobanchaceae*)
Species confirmed for the flora of Marche.
Pesaro (Pesaro e Urbino), tra Candelara e Ginestreto, lungo la strada della Blilla, UTM WGS84 33T 325925 E 4857276 N, margini di siepi, su *Eryngium campestre* L., suolo argilloso, humus nullo, ca. 160 m, 15.05.2023, *L. Gubellini s.n.* (PESA, FI).
In Italy the species is present in all regions except in Valle d'Aosta, Friuli Venezia Giulia, Emilia-Romagna, Umbria, Molise and Calabria. Its presence is now confirmed also for Marche region, where it was already indicated as doubtful presence (Portal to the Flora of Italy 2023).

Orobanche ebuli Huter & Rigo (*Orobanchaceae*)
Species new for the flora of Marche
Montefortino (Fermo), versante E-NE del M. Priora, UTM WGS84 33T 359927 E 4756045 N, boschi mesofili, radure, suolo calcareo, humus abbondante, ca. 1100 m, 07.09.2009, *L. Gubellini* & *N. Hofmann s.n.* (PESA).

Orobanche ebuli is an Italian endemic exclusive to central Italy, known up to now only for Lazio and Abruzzo (Corazzi & al. 2003; Domina & al., 2018; Portal to the Flora of Italy 2023). It is now reported for the first time also in Marche, where it grows on the edge of beech woods, in clearings, on calcareous soil, with abundant humus, host of *Sambucus ebulus* L. The location of the discovery is the northernmost of the distribution area.

Pseudopodospermum hispanicum subsp. ***neapolitanum*** (Grande) Bartolucci, Galasso & F.Conti (*Asteraceae*)
Subspecies new for the flora of Abruzzo.
Roccascalegna (Chieti), Rio Secco, prati aridi, 21.02.1998, *A. Manzi s.n.* (APP Nos. 60043, 60044, 60045); Altino (Chieti), Rio Secco alla confluenza con l'Aventino, UTM WGS84 33T 445502 E 4663407 N ± 300 m, prati aridi, 07.03.1998, *F. Conti s.n.* (APP Nos. 60038, 60039, 60040, 60041, 60042); Furci (Chieti), Valle del Treste, UTM WGS84 33T 470621 E 4652184 N ± 300 m, calanchi su argille, 175 m, 30.04.2001, *F. Conti s.n.* (APP Nos. 60036, 60037); Lentella (Chieti), Valle del Treste sotto Lentella, UTM WGS84

33T 472523 E 4651432 N ± 300 m, 145 m, 30.04.2001, *F. Conti s.n.* (APP Nos. 60049, 60050); Casoli (Chieti), Grotta Rimposta, UTM WGS84 33T 440894 E 4659959 N ± 300 m, 11.06.2009, *A. Manzi s.n.* (APP Nos. 60046, 60047, 60048); Roccascalegna (Chieti), loc. Fontacciaro, UTM WGS84 33T 442863 E 4660340 N ± 300 m, argille oligoceniche, 03.05.2014, *A. Manzi s.n.* (APP Nos. 56232, 56233), *ibidem* 21.05.2014, *A. Manzi s.n.* (APP Nos. 56228, 56230).

This subspecies is endemic to southern and central Italy and until now it is known only for the Thyrrenian side of the peninsula up to Lazio region. The new findings are at the northern limit of the species distribution range in Italy.

Ranunculus lateriflorus DC. (*Ranunculaceae*)
New records for the flora of Abruzzo.
Santo Stefano di Sessanio (L'Aquila), il Prato, sotto Lago S. Pietro, UTM WGS84 33T 389926 E 4692447 N, rive, 1500-1510 m, 15.06.2022, *F. Conti & F. Bartolucci s.n.* (APP No. 67514); Rocca di Mezzo (L'Aquila), Campo di Rovere, UTM WGS84 33T 379242 E 4671109 N ± 100 m, fosso, 23.06.2022, *F. Conti & F. Bartolucci s.n.* (APP No. 67717).

In Italy it is recorded only in Abruzzo, Lazio, Sicilia and Sardegna (Portal to the Flora of Italy 2023). In Abruzzo it was previously recorded for Altopiano delle Cinquemiglia, Quarto di Santa Chiara, Quarto del Barone and Piano di S. Nicola (Conti & al. 2008, 2019).

Ranunculus polyanthemophyllus W. Koch & H.E. Hess (*Ranunculaceae*)
Species new for the flora of Abruzzo.
Pietracamela (Teramo), Prati di Tivo, UTM WGS84 33T 381547 E 4705990 N ± 300 m, pascoli, 1500 m, 13.06.2022, *F. Conti & F. Bartolucci s.n.* (APP Nos. 67971, 67972, 67973, 67974, 67975, 67976, 67977, 67978).

The new finding represents the southern limit of the species distribution range in Italy.

Salicornia perennis Mill. subsp. ***perennis*** (*Amaranthaceae*)
Species extinct for the flora of Abruzzo.

In Abruzzo, this species was recorded between the mouths of the rivers Piomba and Saline (Tammaro & Pirone 1979), where it is to be considered extinct due to anthropization.

This loss added to the status of "no longer found" for Campania (Portal to the Flora of Italy 2023), highlights the ongoing fragmentation of the distribution range of this species, mainly caused by the wide expansion of urban centers and by the alteration of coastal erosion balance.

Sempervivum riccii Iberite & Anzalone (*Crassulaceae*)
Species confirmed for the flora of Marche.
Matelica (Macerata), Gruppo del M. San Vicino, nel vers. SW del M. San Vicino, UTM WGS84 33T 342519 E 4799325 N, pendici erboso-pietrose, suolo calcareo, humus da scarso a +/- abbondante, 1300-1350 m, 26.07.1991, *A.J.B. Brilli-Cattarini, S. Di Massimo & L. Gubellini s.n.* (PESA).

In Italy this species is reported only for Abruzzo, Lazio, Molise and as doubtful record for Marche (Portal to the Flora of Italy 2023).

This record confirms the presence of the species in the Marche, where Mt. San Vicino represents the northernmost locality of its distribution range.

Soldanella minima subsp. ***samnitica*** Cristof. & Pignatti (*Primulaceae*)
Subspecies new to Gran Sasso, second finding for Italy
Pietracamela (Teramo), sentiero fra "La Madonnina" e il Rif. Franchetti, UTM WGS84 33T 382126 E 4704093 N, rupi calcaree, 2200-2250 m, 31.07.2023, *F. Conti, G. Cangelmi, R. Di Pietro & F. Di Pietro s.n.* (APP Nos. 67359, 67360).

The subspecies was considered endemic to the Maiella National Park (Cristofolini & Pignatti 1962) where it grows in few sites with specific microclimatic cold-wet conditions. The new population, located in comparable site conditions, in the National Park of Gran Sasso and Monti della Laga, represents a step forward towards its conservation.

Aliens

Achillea ligustica All. (*Asteraceae*)
Naturalized regional alien species new for the flora of Marche.
Camerino (Macerata), Via Leopardi 12, UTM WGS84 33T 343069 E 4777707 N, aiuola, 620 m, 22.07.1995, *F. Conti s.n.* (APP No. 62534); Camerino (Macerata), sulla strada per l'Orto Botanico sopra al gommista di Via Leopardi, UTM WGS84 33T 342972 E 4777600 N, siepe a *Ligustrum sinense* Lour., 630 m, 06.09.2023, *F. Conti s.n.* (APP No. 68898).

Aubrieta deltoidea (L.) DC. (*Brassicaceae*)
Naturalized alien species new for the flora of Marche.
Mercatello sul Metauro (Pesaro e Urbino), vecchie mura lungo Via IV Novembre, UTM WGS84 33T 285103 E 4836147 N, ca. 425 m, 16.04.2023, *L. Gubellini* (PESA, FI).

Aubrieta deltoidea is native to South-Est Europe and Caucasus and spread in central-western Europe, for ornamental purposes. In Italy it is reported as a casual alien species in Abruzzo, Emilia-Romagna, Lombardia, Piemonte and Trentino-Alto Adige, and as a naturalized alien in Toscana (Portal to the Flora of Italy 2023). According to Pignatti (2017), the detected species could refer to a cultivated form with intermediate characters between *A. columnae* Guss. and *A. deltoidea*, probably resulting from hybridization between Italian species and other of the Balkan Peninsula and Greece.

Capparis spinosa L. (*Capparaceae*)
Naturalized regional alien species to be excluded from the flora of Molise.

Capparis spinosa L. has been recorded for Termoli (Conti & al. 2023a) but it should be referred to *C. orientalis* Vell.

Cedrus deodara (Roxb.) G. Don (*Pinaceae*)
Casual alien species new for the flora of Marche.
Camerino (Macerata), presso S. Gregorio, UTM WGS84 33T 345758 E 4779501 N ± 200 m, castagneto, ca. 700 m, 13.06.2023, *F. Conti s.n. (*APP Nos. 68327, 68328).

Centaurea diluta Aiton (*Asteraceae*)
Naturalized alien species new for the flora of Lazio.
Anagni (Frosinone), Via S. Filippo, UTM WGS84 33T 343736 E 4625403 N, prato a pascolo, 230 m, 14.07.2023, *E. De Santis* (APP No. 69574).

Native to Spain, Morocco, Algeria and Tunisia, it is now spread across all central-northern Europe and in some states of the USA (POWO 2023).

Erigeron annuus subsp. ***strigosus*** (Muhl. ex Willd.) Wagenitz (*Asteraceae*)
Naturalized alien subspecies new for the flora of Abruzzo.
Tossicia (Teramo), Gran Sasso, fosso presso il paese, UTM WGS84 33T 389595 E 4711554 N ± 300 m, fosso, ca. 350 m, 20.08.1999, *F. Conti & A. Manzi s.n.* (APP Nos. 17963, 17964); Molina Aterno (L'Aquila), Lago Acquaviva, Fiume Aterno presso Molina, UTM WGS84 33T 394727 E 4667161 N ± 300 m, rive, 418 m, 19.07.2007, *F. Conti & K. Cianfaglione s.n.* (APP No. 27206); L'Aquila (L'Aquila), via Bazzanese 96, Palombara, UTM WGS 84 33T 370580 E 4688996 N ± 200 m, incolti, 700 m, 09.09.2016, *F. Bartolucci s.n.* (APP No. 66759).

Native from North America is now widespread across all Europe and Eastern Asia (POWO 2023). Already reported for northern regions of Italy (Piemonte, Lombardia and Veneto) the new findings are the first for Central Italy.

Erigeron lilacinus (Sennikov & Kurtto) Sennikov (*Asteraceae*)
Naturalized alien species new for Marche, Lazio and Abruzzo.
Montegallo (Ascoli Piceno), M. Ceresa: tra Abetito e Monte Pianamonte, UTM WGS84 33T 366325 E 4742410 N ± 500, margine del bosco, su arenaria, 1100 m, 02.08.2004, *D. Tinti, L. Gubellini & F. Ventrone s.n.* (APP No. 12128); Montegallo (Ascoli Piceno), sotto il paese verso Ascoli, 07.06.2011, *F. Conti s.n.* (APP No. 62255); Morino (L'Aquila), presso la cascata di Zompo lo Schioppo, UTM WGS84 33T 367471 E 4634400 N ± 300 m, radure, 700 m, 27.06.2002, *F. Conti s.n.* (APP No. 52159); Cittareale (Rieti), Colle Centoscudi, dall'abitato di S. Croce lungo pista forestale verso M. Verrico, UTM WGS84 33T 348137 E 4714223 N ± 500 m, radure, 771-1117 m, 16.06.2016, *F. Conti, F. Bartolucci & R. Pennesi s.n.* (APP No. 57579).

Ficus pumila L. (*Moraceae*)
Casual alien species new for the flora of Lazio.
Roma (Roma), Villa Ada, ponticello presso il Tempio di Flora, UTM WGS 84 33T 292869 E 4644337 N, muro a mattoni, 29.04.2023, *F. Conti, V. Giacanelli s.n.* (APP No. 68403).

Kalanchoë ×houghtonii D.B. Ward (*Crassulaceae*)
Casual alien species new for the flora of Abruzzo.
Ortona (Chieti), Passeggiata Orientale, UTM WGS84 33T 451085 E 4689648 N, 11.06.2023 (observed by F. Conti but not collected).

Senecio angulatus L.f. (*Asteraceae*)
Naturalized alien species new for the flora of Marche.
Potenza Picena (Macerata), presso Porto Potenza Picena, UTM WGS84 33T 393975 E 4803312 N, siepe, 4 m, 05.11.2019, *F. Conti, L. Bracchetti, L. Gubellini, N. Hofmann s.n.* (APP No. 69575).

Native from South Africa and recently spread in western Europe, Algeria and Australia (POWO 2023) for ornamental purposes. In Italy it is reported for all the southern regions

and all the Thyrrenian ones and considered as invasive in the northern (Liguria, Toscana and Sardegna) and naturalized in the south (Sicilia, Calabria, Basilicata, Puglia, Campania and Molise) (Portal to the Flora of Italy 2023).

Trifolium mutabile Port. (*Fabaceae*)
Casual regional alien species new for the flora of Abruzzo.
Lucoli (L'Aquila), Piana di Campo Felice, vicino recinto costruito per *Klasea lycopifolia* (Vill.) Á.Löve & D. Löve nell'ambito del Life Floranet, UTM WGS84 33T 369730 E 4676910 N, 1550 m, 19.07.2023, *F. Conti, F. Bartolucci & G. Cangelmi s.n.* (APP No. 67674).

Considered native from Balkan peninsula and Southern Italy even if "no longer found" in Campania and Basilicata (POWO 2023; Portal to the Flora of Italy 2023). Its presence in central Italy has been associated to volunteer or accidental dispersion by humans.

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Article

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B. Ali Tatar, L. Touati, T. Hamel, E. Mechentel, B. Badouna & M. Benslama

Phytoécologie, dynamique et reconstitution pollinique de deux mares tourbeuses (Aoural et Ain Salhat) de la petite Kabylie orientale: cas du bassin versant d'Oued Zhor (Nord-Est algérien)

Abstract

Ali Tatar, B., Touati, L., Hamel, T., Mechentel, E., Badouna, B. & Benslama, M.: Phytoécologie, dynamique et reconstitution pollinique de deux mares tourbeuses (Aoural et Ain Salhat) de la petite Kabylie orientale: cas du bassin versant d'Oued Zhor (Nord-Est algérien). — Fl. Medit. 33: 193-213. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

Phytoecology, dynamics and pollen reconstitution of two raised bogs (Aoural and Ain Salhat) of little eastern Kabylia: case of the Oued Zhor watershed (North-East Algeria). — Two raised bogs, Aoural and Ain Salhat, located in the region of the little Kabylia (North East of Algeria), were reviewed in both floristic inventories and pollen analyses during six years (2016-2022). The floristic study has revealed the existence of 174 taxa, 119 for the Aoural pond and 109 for the Ain Salhat one. Analysis of surface sediments pollen from the two ponds allowed us to identify 52 pollen taxa. In Ain Salhat pond, tree taxa dominate this assemblage, reaching a rate of 47.4%, followed by herbaceous ones with 24.5%, shrubby taxa with 24.4% and finally undetermined taxa with 3.7%, this is due to the position of the pond which is situated in a wooded forest environment. On the other hand, in Aoural's pond, herbaceous taxa dominate spectra with 37%, followed by trees ones which account for 36%, shrubs (23.4%) and finally undetermined taxa with at around 3.6%.
The contribution of pollen analysis to the knowledge of the current flora of the two studied ponds is of 58%. In total, 186 species have been identified using these two methods, of which 12 species have only been observed in the pollen spectrum. Floristic study and pollen analysis are therefore two complementary methods of study.

Key words: Eastern Kabylia (North-eastern Algeria), peaty ponds, surface pollen, indicator taxa.

Introduction

Les mares temporaires du pourtour méditerranéen, qui abritent un patrimoine naturel remarquable, représentent un élément majeur des "points chauds" de biodiversité de la région (Médail & Quézel 1997; Médail & al. 2004). En raison de leur caractère éphémère et de leur petite taille, ces milieux fragiles et vulnérables régressent rapidement sous l'influence des activités humaines (drainage, aménagement agricole, pâturage, pollution) (Rhazi & al. 2001; Grillas & al. 2004; Allem & al. 2017). C'est à leur niveau qu'a été rapporté le plus grand nombre de raréfactions voire de disparitions (Faurel 1959; Quézel & Zevaco 1964). Une des limites à l'implémentation de mesures conservatoires sur le long terme est le manque de connaissance sur les dynamiques passées et sur les capacités de

résilience de ces milieux (Froyd & Willis 2008; Daoud-Bouattour & al. 2011). Toutefois, les études paléoécologiques, généralement mises en œuvre pour révéler les phénomènes climatiques ou anthropiques impliqués dans l'évolution de la végétation, permettent également d'évaluer la paléo-richesse végétale qui peut être considérée comme une première approximation de la paléo-biodiversité (Odgaard 1999).

Le Nord-Est algérien recèle en son sein un important et vaste éco-complexe de zones humides. Il fait partie d'un point chaud de biodiversité, récemment reconnu au sein de l'ensemble méditerranéen (Véla & Benhouhou 2007). La petite Kabylie « K_2 » au sens de la subdivision biogéographique proposée par Quézel & Santa (1962) est riche en mares temporaires répondant aux critères Ramsar (Grillas & al. 2004). Sa flore hygrophile a fait l'objet de très peu de travaux et synthèses récents (de Bélair & Samraoui 2000; Bouldjedri & al. 2011; Benhassine-Gherzouli 2013) qui ont mis en évidence leur intérêt et leur originalité, tant biogéographique qu'écologique. En revanche, aucune étude ne révèle l'histoire paléobotanique dans cette région (cf. Benslama & al. 2010).

Les premiers résultats obtenus dans ce travail ont permis d'actualiser l'inventaire floristique du bassin versant d'Oued Zhor (Nord-Est algérien) dans deux mares tourbeuses (Aoural et Ain Salhat) et de reconstituer les dépôts polliniques représentatifs de la végétation actuelle dans ces deux mares.

Matériel et Méthodes

Région d'étude

Le bassin versant d'Oued Zhor est situé à l'Est de l'Algérie, dans la partie occidentale de la région de Skikda entre les latitudes 36°53' et 36°60'N et les longitudes 6°18' et 6°26'E (Fig. 1). Il est limité au Nord par la mer méditerranéenne, au Sud par les wilayas de Mila, Constantine et Guelma, par la wilaya d'Annaba à l'Est et par la wilaya de Jijel à l'Ouest (Bounouara 2018). La mare Oued Zhor est localisée dans une petite plaine sublittorale à proximité de l'Oued Zhor, d'une superficie variable (50–200 m^2), peu profonde (50 cm) et de basse altitude (2–3 m). La végétation est de type aulnaie-ormaie-saussaie à *Alnus glutinosa* (L.) Gaertn., *Ulmus minor* Mill. et *Salix pedicellata* Desf. (Bouldjedri & al. 2011). Tandis, la mare Ain Salhat est localisée à 610 m d'altitude dans la forêt de Laouinet dans le canton d'Ouled Atia, elle est d'une surface restreinte (20–40 m^2), d'à peine 5 m de diamètre. La végétation de cette mare est de type aulnaie-chênaie à *Alnus glutinosa* (L.) Gaertn., *Quercus suber* L. et *Q. canariensis* Willd (Bensettiti & Lacoste 1999).

La pluviométrie annuelle de la région est de l'ordre de 1002 mm par an à Collo, 1038 mm à Cap Bougaroun (incluant: la mare Aoural) et 1773 mm à Bessombourg (incluant: la mare Ain Salhat) (Seltzer & al. 1946). Les bioclimats sont essentiellement humides à perhumides, chauds et tempérés, et la période sèche n'excède pas 3-4 mois (Chaumont & Paquin 1971). Sur le plan géomorphologique, le bassin versant d'Oued Zhor est délimité par des chaines montagneuses essentiellement formées de terrains métamorphiques, recouvertes de lambeaux argilo-gréseux d'âge oligo-miocène et traversées par des roches éruptives d'âge miocène (Marre 1992). Le relief est marqué par des montagnes accidentées d'où le point culminant est le Djebel El Goufi (1181 m), entrecoupées par une plaine côtière d'Oued Zhor qui se caractérise par des dépôts alluviaux d'argiles, de limons et de sables du Quaternaire (Chouit 2015).

Méthodologie

Etude floristique

L'inventaire botanique des deux mares étudiées a été réalisé durant six années consécutives (2016-2022). L'ensemble de la zone d'étude a été parcouru autant que possible, avec une prospection de chaque habitat durant trois périodes par an (février-mars, avril-mai et juin-juillet), de chaque année de la période d'étude. Des quadras appliqués sur des transects varient en fonction de la surface de chacune des deux mares étudiées. Les espèces,

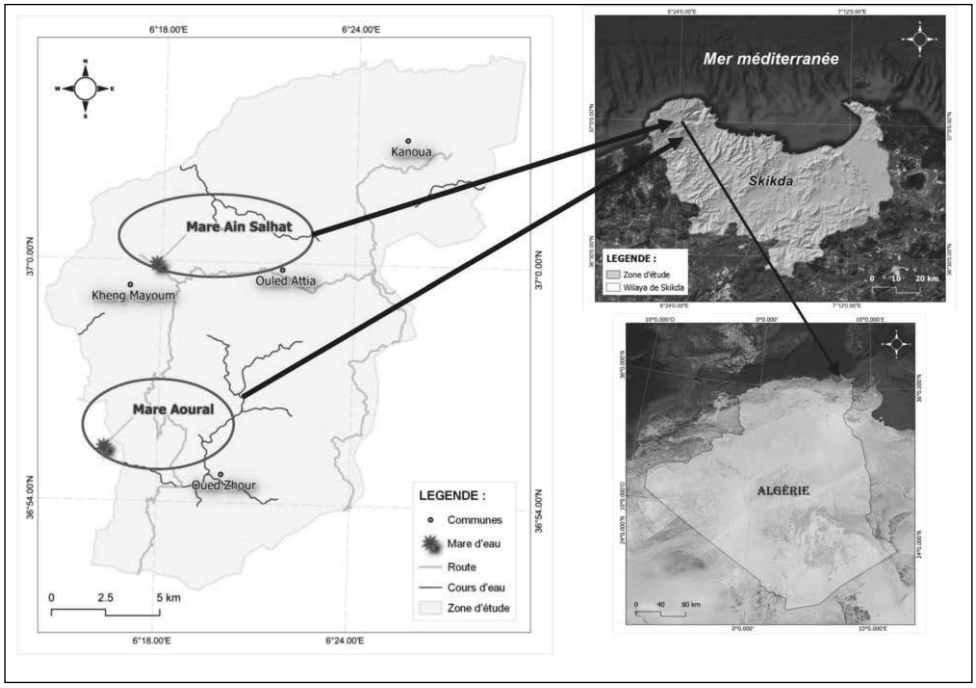

Fig.1. Localisation de la zone d'étude.

qu'elles soient en fleurs, en fruits ou en graines, sont photographiées et des échantillons sont récoltés de manière provisoire pour identification.

L'identification s'est faite en plusieurs étapes: tout d'abord en se référant à la flore d'Algérie de Quézel & Santa (1963-1963), complétée par la flore d'Afrique du Nord de Rêne Maire (1952-1987) pour les espèces qui sont parues; ensuite la plupart des identifications ont été vérifiées, complétées et actualisées en consultant la flore d'Italie (Pignatti 1982) et celle d'Andalousie orientale (Blanca & al. 2009).

La nomenclature est ajustée selon l'index synonymique de Dobignard & Chatelain (2010-2013) et sa version actualisée en ligne (APD 2023). Les espèces recensées ont

été renseignées par leur type biogéographique (Pignatti 1982; Blanca & al. 2009; Dobignard & Chatelain 2010-2013) et leur type biologique (Raunkier 1934; Pignatti 1982; Blanca & al. 2009; Tison & de Foucault 2014). La rareté des taxons est référée selon la flore de Quézel & Santa (1962-1963) et nos observations sur le terrain.

Analyse pollinique

L'étude pollinique a permis de prélever quatre échantillons de sédiment de surface le long d'un transect diagonal traversant d'Est en Ouest la mare d'Aoural. La distance séparant chaque échantillon est de 50 mètres. Tandis, un seul échantillon a été prélevé en milieu de la mare d'Ain Salhat en raison de sa petite surface. Le choix des mares d'échantillonnage a été effectué sur la base des caractéristiques stationnelles et régionales, particulièrement le degré de saturation de l'eau.

L'extraction pollinique a été réalisée sur des volumes de 1cm^3 pour tous les échantillons selon la méthode de Faegri & Iversen (1989). Elle est basée sur une série de traitements avec : NaOH (20%), HF (70%), HCl (10%), CH3COOH, acétolyse et enfin conservation du matériel pollinique dans la glycérine. Les comptages ont été effectués sous microscope optique OPTIKA (X 400) et l'identification a été réalisée par l'utilisation d'une clé d'identification de la collection de l'atlas de référence des pollens et spores (Reille 1992-1998; Beug 2004). Les données de l'analyse pollinique ont été présentées sous forme d'un diagramme pollinique qui a été construit à l'aide du logiciel C2 version 1.7.7.

Résultats

Diversité floristique

Un total de 174 espèces de plantes vasculaires appartenant à 143 genres et 73 familles ont été identifiées dans les deux mares étudiées, à savoir 119 pour la mare Aoural et 109 pour la mare Ain Salhat (Tab. 1). La famille des *Fabaceae* était la plus importante en termes de nombre d'espèces et a constitué 8,04% des plantes identifiées (14 espèces), suivie par les *Poaceae* avec 6,9% (12 espèces), les *Asteraceae* avec 6,3% (11 espèces) et les *Lamiaceae* avec 4,6 % soit 8 espèces. Ces quatre familles représentent à elles seules plus d'un quart de la flore étudiée. S'ajoutant à ces dernières, les *Cyperaceae* (7 espèces, soit 4%), les *Apiaceae* et les *Rubiaceae* (6 espèces, soit 3,5% pour chacun), les *Ranunculaceae,* les *Rosaceae* et les *Plantaginaceae* (5 espèces, soit 2,9% pour chacun) étaient moyennement représentées. Le reste des familles étaient le plus souvent monospécifique ou bien bispécifique.

Diversité biologique

Les thérophytes ont été nettement le type biologique le plus abondant, représenté par 57 espèces, ce qui constitue 32,75% de l'ensemble des taxons répertoriés, viennent ensuite les hémicryptophytes (47 taxons), les phanérophytes (34 taxons), les géophytes (21 taxons), les chamaephytes (9 taxons), les hydrophytes (5 taxons) et enfin les hélophytes (1 taxon).

Ce cortège est selon les systèmes, mêlé d'espèces transgressives de différents milieux plus ou moins ouverts et hydrophiles :

Tableau 1. Liste de la flore actuelle et pollinique de deux mares étudiées (mare Aoural et Ain Salhat) [Taxonomie selon APD (2023), protection nationale selon JORA (2012) /évaluation selon l'UICN (2023)].

Taxon	Famille	Type biogéo	Type biol	Mare Aroual	Mare Ain Salhat	Trace pollinique		Rareté en Algérie	JORA 2012	UICN 2023
						Mare Aoural	Mare Ain Salha			
Acacia karroo Hayne	*Fabaceae*	Intr	Ph	X		*Acacia*				
Acanthus mollis L.	*Acanthaceae*	Méd	Hém		X					
Achyranthes sicula (L.) All.	*Amaranthaceae*	Trop	Ch	X						
Alisma lanceolatum With.	*Alismataceae*	Paléotemp	Hém	X	X					
Allium triquetrum L.	*Alliaceae*	Méd- atl	Géo		X					
Alnus glutinosa (L.) Gaertn.	*Betulaceae*	Eury-méd	Ph	X	X	*A.*cf. *glutinosa*	*A.* cf. *glutinosa*			
Alternanthera sessilis (L.) R.Br. ex DC.	*Amaranthaceae*	Trop	Hyd		X			RR		
Ammi visnaga (L.) Lam	*Apiaceae*	Méd	Th	X						
Ampelodesmos mauritanicus (Poir.) T. Durand & Schinz	*Poaceae*	Eury-méd	Hém	X	X					
Anisantha rubens (L.) Nevski	*Poaceae*	Méd	Th	X						
Anogramma leptophylla (L.) Link	*Pteridaceae*	Subcosm	Th		X					
Arbutus unedo L.	*Ericaceae*	Méd-Atl	Ph		X	*A.* cf. *unedo*	*A.* cf. *unedo*			
Arisarum vulgare subsp. *hastatum* (Pomel) Dobignard	*Araceae*	Eury-méd	Géo	X	X					
Aristolochia paucinervis Pomel	*Aristolochiaceae*	Subend Tyrrhénien	Géo	X				R		
Arum italicum Mill.	*Araceae*	Méd	Géo	X	X					
Arundo donax L.	*Poaceae*	Subcosm	Géo	X						
Asperula laevigata L	*Rubiaceae*	Eury-méd	Hém	X	X					
Asphodelus ramosus L. subsp. *ramosus*	*Xanthorrhoeaceae*	Méd	Géo	X		*A.* cf. *ramosus*	*A.* cf. *ramosus*			
Asplenium onopteris L.	*Aspleniaceae*	Eury-méd	Hém		X	*Asplenium* sp.				
Athyrium filix-femina (L.) Roth	*Woodsiaceae*	Holar	Hém		X					
Bellis annua L. subsp. *annua*	*Asteraceae*	Méd	Th	X	X					
Bellis prostrata Pomel	*Asteraceae*	End Alg Tun Mar	Th		X			RR	P	NT
Bidens aurea (Aiton) Sherff	*Asteraceae*	Intr	Th	X						
Blackstonia perfoliata subsp. *grandiflora* (Viv.) Maire	*Gentianaceae*	Méd	Th		X					
Bolboschoenus glaucus (Lam.) S.G. Smith	*Cyperaceae*	Eurosibérien	Géo		X					
Borago officinalis L.	*Boraginaceae*	Méd	Th	X	X					
Brassica procumbens (Poir.) O.E. Schulz	*Brassicaceae*	End Alg-Tun	Hém	X		*Brassica* sp.	*Brassica* sp.			
Briza maxima L.	*Poaceae*	Méd	Th	X						

Tableau 1. continue.

Calicotome villosa (Poir.) Link	*Fabaceae*	Méd	Ph	X						
Callitriche obtusangula Le Gall	*Callitrichaceae*	Méd- atl	Hyd	X	X	*C. obtusangula*	*C. obtusangula*			
Campanula dichotoma L.	*Campanulaceae*	Méd	Th	X	X	Campanulaceae	Campanulaceae			
Cardamine hirsuta L.	*Brassicaceae*	Subcosm	Th	X						
Carex distachya Desf.	*Cyperaceae*	Euras	Hém	X						
Carex distans L.	*Cyperaceae*	Paléotemp	Hém	X						
Carex remota L.	*Cyperaceae*	Euras	Hém	X						
Castanea sativa Mill.	*Fagaceae*	Circum-méd	Ph		X	*C. sativa*	*C. sativa*	RR		
Catapodium rigidum (L.) C.E.Hubb.	*Poaceae*	Méd- atl	Th	X						
Celtis australis L.	*Ulmaceae*	Circum-méd	Ph		X		*C. australis*			
Cerastium glomeratum Thuill	*Caryophyllaceae*	Cosm	Th	X						
Chenopodium album L.	*Amaranthaceae*	Subcosm	Th	X		*Chenopodium* sp.	*Chenopodium* sp.			
Circaea lutetiana L.	*Onagraceae*	Circum-boréal	Géo	X						
Cistus monspeliensis L.	*Cistaceae*	Méd	Ph	X	X	*Cistus*-type	*Cistus*-type			
Cistus salviifolius L.	*Cistaceae*	Méd	Ph	X	X					
Clematis flammula L.	*Ranunculaceae*	Circum-méd	Ph		X					
Clinopodium vulgare subsp. *arundanum* (Boiss.) Nyman	*Lamiaceae*	Holar	Hém		X					
Cyclamen africanum Boiss. & Reut.	*Primulaceae*	End Alg-Tun-Mar	Géo		X				P	
Cynodon dactylon (L.) Pers.	*Poaceae*	Cosm	Géo	X	X					
Cynoglossum clandestinum Desf.	*Boraginaceae*	Méd	Th	X						
Cyperus rotundus L. subsp. *Rotundus*	*Cyperaceae*	Trop	Géo	X		*Cyperaceae*				
Cytisus villosus Pourr.	*Fabaceae*	Méd	Ph		X					
Daphne gnidium L.	*Thymelaeaceae*	Méd	Ph		X		*D. gnidium*			
Daucus carota subsp. *maximus* (Desf.) Ball	*Apiaceae*	Paléotemp	Hém	X						
Daucus virgatus (Poir.) Maire	*Apiaceae*	End Alg-Tun	Hém	X	X			R		
Drimia numidica (Jord. & Fourr.) J.C. Manning & Goldblatt	*Asparagaceae*	End Alg-Tun-Esp	Géo	X	X					
Echinops spinosus L.	*Asteraceae*	Méd	Hém	X						
Erica arborea L.	*Ericaceae*	Méd	Ph	X	X	*Erica*- type	*Erica*- type			
Erigeron canadensis L.	*Asteraceae*	Intr	Th	X	X					
Eryngium pusillum L.	*Apiaceae*	Méd	Hém	X				R		

Tableau 1. continue.

Euphorbia biumbellata Poir.	*Euphorbiaceae*	Méd	Hém	X				R		
Euphorbia cuneifolia Guss.	*Euphorbiaceae*	End Alg-Tun-Itl	Th	X				AR		
Euphorbia helioscopia L. subsp. *helioscopia*	*Euphorbiaceae*	Subcosm	Th	X						
Euphorbia terracina L.	*Euphorbiaceae*	Circum-méd	Ch	X						
Fedia graciliflora Fisch. & C.A. Mey.	*Valerianaceae*	Méd	Th	X	X					
Ficaria verna subsp. *grandiflora* (Robert) Hayek	*Ranunculaceae*	Euras	Hém		X					
Ficus carica L.	*Moraceae*	Circum-méd	Ph		X	*F. carica*				
Fraxinus angustifolia Vahl	*Oleaceae*	Méd	Ph	X	X	*F. angustifolia*	*F. angustifolia*			
Fumaria capreolata L.	*Papaveraceae*	Méd- atl	Th	X	X					
Galactites mutabilis Durieu	*Asteraceae*	End Alg-Tun	Th	X				AR		
Galium aparine L. subsp. *aparine*	*Rubiaceae*	Subcosm	Th	X						
Galium palustre subsp. *elongatum* (C. Presl) Lange	*Rubiaceae*	Circum-boréal	Hém	X	X					
Galium rotundifolium L.	*Rubiaceae*	Eury-méd	Hém		X					
Genista ferox (Poir.) Dum. Cour. subsp. *ferox*	*Fabaceae*	End Alg-Tun-Itl	Ph		X					
Geranium columbinum L.	*Geraniaceae*	Paléotemp	Th	X				R		
Geranium dissectum L.	*Geraniaceae*	Paléotemp	Th	X				R		
Geranium molle L. subsp. *molle*	*Geraniaceae*	Paléotemp	Th	X	X					
Geranium robertianum subsp. *purpureum* Vi.	*Geraniaceae*	Eury-méd	Th	X	X					
Glebionis segetum (L.) Fourr	*Asteraceae*	Eury-Circum-méd	Th	X						
Hedera algeriensis Hibberd	*Araliaceae*	End Alg-Tun	Ph		X					
Hordeum murinum subsp. *leporinum* (Link) Arcang.	*Poaceae*	Eury-méd	Th	X						
Hyoseris radiata L.	*Asteraceae*	Méd	Hém		X					
Hypericum androsaemum L.	*Hypericaceae*	Paléotemp	Ch		X			R		
Hypericum montanum L.	*Hypericaceae*	Eury-méd	Hém		X			R		
Illecebrum verticillatum L.	*Caryophyllaceae*	Eury-méd	Th		X			RR		
Iris pseudacorus L.	*Iridaceae*	Eury-méd	Hém	X						
Iris unguicularis Poir.	*Iridaceae*	End Alg-Tun	Géo	X	X					
Isoetes histrix Durieu ex Bory	*Isoetaceae*	Méd-Atl	Hém	X	X		*Isoetes* sp.			
Juncus bufonius L.	*Juncaceae*	Cosm	Th	X						
Juncus heterophyllus L. M. Dufour	*Juncaceae*	Méd	Hyd	X	X			R		NT

Tableau 1. continue.

Lamarckia aurea (L.) Moench	*Poaceae*	Méd	Th	X						
Lamium flexuosum Ten.	*Lamiaceae*	Méd	Hém		X	*Lamiaceae*	*Lamiaceae*			
Laurus nobilis L.	*Lauraceae*	Méd	Ph		X					
Lavandula stoechas L.	*Lamiaceae*	Méd	Ch	X	X					
Lemna minor L.	*Lemnaceae*	Méd	Hyd	X	X					
Leontodon tuberosus L.	*Asteraceae*	Méd	Hém		X					
Linaria pinifolia (Poir.) Thell.	*Plantaginaceae*	End Alg-Tun	Ch	X				R		
Linaria reflexa (L.) Chaz.	*Plantaginaceae*	Méd	Th		X					
Linum bienne Mill.	*Linaceae*	Méd-Atl	Th		X					
Lobularia maritima (L.) Desv.	*Brassicaceae*	Circum-méd	Ch	X						
Lotus corniculatus subsp. *preslii* (Ten.) P. Fourn.	*Fabaceae*	Méd	Hém	X	X					
Lysimachia arvensis (L.) B. Bock	*Primulaceae*	Subcosm	Th	X	X					
Lythrum junceum Banks & Sol.	*Lythraceae*	Méd	Géo	X						
Malva sylvestris L.	*Malvaceae*	Paléotemp	Hém	X		*Malvaceae*				
Medicago arabica (L.) Huds.	*Fabaceae*	Eury-méd	Th	X						
Medicago murex Willd.	*Fabaceae*	Méd	Th	X						
Mentha aquatica L.	*Lamiaceae*	Subcosm	Hém	X	.					
Mentha pulegium L. subsp. *pulegium*	*Lamiaceae*	Eury-méd	Hém	X	X					
Mentha suaveolens Ehrh subsp. *suaveolens*	*Lamiaceae*	Eury-méd	Hém	X	X	*Mentha*-type	*Mentha*-type			
Myosotis ramosissima Rochel subsp. *ramosissima*	*Boraginaceae*	Euras	Th	X						
Myriophyllum alternifolium DC.	*Haloragaceae*	Méd- atl	Hyd	X				R		
Myrtus communis L.	*Myrtaceae*	Méd	Ph	X	X	*M.*cf. *communis*	*M.* cf. *communis*			
Nerium oleander L.	*Apocynaceae*	Méd	Ph		X		*N.* cf. *oleander*			
Oenanthe virgata Poir.	*Apiaceae*	End Alg-Tun-Mar	Hém	X						
Opuntia ficus-indica (L.) Mill.	*Cactaceae*	Cult	Ph		X					
Osmunda regalis L.	*Osmundaceae*	Subcosm	Hém		X	*O. regalis*				
Oxalis corniculata L.	*Oxalidaceae*	Cosm	Géo		X					
Oxalis pes-caprae L.	*Oxalidaceae*	Intr	Géo	X	X					
Phalaris paradoxa L.	*Poaceae*	Méd	Th	X						
Phillyrea latifolia L.	*Oleaceae*	Méd	Ph	X	X	*P.* cf. *latifolia*	*P.* cf. *latifolia*			

Tableau 1. continue.

Phragmites australis (Cav.) Trin. ex Steud.	*Poaceae*	Subcosm	Hél	X						
Pistacia lentiscus L.	*Anacardiaceae*		Ph	X	X	*P. lentiscus*	*P. lentiscus*			
Plagius maghrebinus Vogt & Greuter	*Asteraceae*	End Alg-Tun-Mar	Ch		X					
Plantago lagopus L.	*Plantaginaceae*	Méd	Hém	X	X	*Plantago*-type	*Plantago*-type			
Plantago lanceolata L.	*Plantaginaceae*	Euras	Th	X						
Poa annua L. subsp. *annua*	*Poaceae*	Cosm	Th	X	X	*Poaceae*	*Poaceae*			
Poa trivialis L.	*Poaceae*	Euras	Hém	X	X					
Polygonum aviculare L.	*Polygonaceae*	Méd	Th	X	X	*Polygonum* sp.	*Polygonum* sp.			
Polypodium cambricum L. subsp. *cambricum*	*Polypodiaceae*	Méd- atl	Hém		X					
Polystichum setiferum (Forssk.) T. Moore ex Woyn.	*Dryopteridaceae*	Méd- atl	Hém		X					
Potentilla reptans L.	*Rosaceae*	Euras	Hém	X	X					
Prunus avium (L.) L.	*Rosaceae*	Eury-méd	Ph		X					
Pteridium aquilinum (L.) Kuhn	*Dennstaedtiaceae*	Subcosm	Géo		X	*P. aquilinum*				
Quercus canariensis Willd	*Fagaceae*	Méd	Ph		X	*Q.* cf. *canariensis*	*Q.* cf. *canariensis*			
Quercus suber L.	*Fagaceae*	Méd- atl	Ph		X	*Q. suber*	*Q. suber*			
Radiola linoides Roth.	*Linaceae*	Eury-méd	Th	X				R		
Ranunculus macrophyllus Desf.	*Ranunculaceae*	Méd	Géo	X	X	*Ranunculus*-type	*Ranunculus*-type			
Ranunculus muricatus L.	*Ranunculaceae*	Méd	Th	X						
Ranunculus parviflorus L.	*Ranunculaceae*	Méd	Th	X						
Retama raetam subsp. *bovei* (Spach) Talavera & Gibbs	*Fabaceae*	Méd	Ph		X		*Retama* sp.			
Rhamnus alaternus L.	*Rhamnaceae*	Méd	Ph		X					
Rosa sempervirens L.	*Rosaceae*	Méd- atl	Ph	X	X	*Rosaceae*	*Rosaceae*			
Rubia peregrina subsp. *longifolia* (Poir.) O. Bolòs	*Rubiaceae*	Méd- atl	Ch	X	X					
Rubus incanescens (DC.)	*Rosaceae*	Méd	Ph	X	X					
Rubus ulmifolius Schott	*Rosaceae*	Eury-méd	Ph	X	X					
Rumex conglomeratus Murray	*Polygonaceae*	Eury-méd	Hém	X		*Rumex*-type	*Rumex*-type			
Rumex pulcher L.	*Polygonaceae*	Eury-méd	Hém	X						
Salix pedicellata Desf.	*Salicaceae*	Méd	Ph	X	X	*S.* cf. *pedicellata*	*S.* cf. *pedicellata*			
Schoenoplectus supinus (L.) Palla	*Cyperaceae*	Cosm	Th		X					
Schoenus nigricans L.	*Cyperaceae*	Subcosm	Hém	X						

Tableau 1. continue.

Scolymus hispanicus L.	*Asteraceae*	Méd	Hém	X						
Sedum cepaea L.	*Crassulaceae*	Eury-méd	Th		X					
Selaginella denticulata (L.) Spring	*Selaginellaceae*	Méd	Ch		X					
Sherardia arvensis L.	*Rubiaceae*	Eury-méd	Th	X	X					
Silene gallica L.	*Caryophyllaceae*	Subcosm	Th	X	X	*Silene* sp.				
Silene laeta (Aiton) Godr.	*Caryophyllaceae*	Circum-méd	Géo	X						
Smilax aspera L.	*Smilacaceae*	Circum-méd	Ph		X					
Smyrnium olusatrum L.	*Apiaceae*	Méd- atl	Hém		X					
Sonchus oleraceus L.	*Asteraceae*	Cosm	Th	X	X					
Sparganium erectum L. subsp. *Erectum*	*Typhaceae*	Euras	Géo	X						
Stachys marrubiifolia Viv.	*Lamiaceae*	Subend Tyrrhénien	Th	X				R		
Stachys ocymastrum (L.) Briq.	*Lamiaceae*	Méd	Th	X						
Stellaria media (L.) Vill.	*Caryophyllaceae*	Subcosm	Th		X					
Tetragonolobus biflorus (Desr.) DC.	*Fabaceae*	Méd	Th	X						
Tolpis barbata (L.) Gaertn.	*Fabaceae*	Méd	Th	X						
Trifolium arvense L.	*Fabaceae*	Paléotemp	Th	X						
Trifolium campestre Schreb.	*Fabaceae*	Paléotemp	Th	X	X					
Trifolium pratense L.	*Fabaceae*	Paléotemp	Hém	X						
Typha domingensis Pers.	*Typhaceae*	Subcosm	Hém	X						
Ulmus minor Mill.	*Ulmaceae*	Eury-méd	Ph	X	X	*U.* cf. *minor*	*U.* cf. *minor*			
Umbilicus rupestris (Salisb.) Dandy	*Crassulaceae*	Méd- atl	Géo		X					
Verbascum sinuatum L.	*Scrophulariaceae*	Circum-méd	Hém		X					
Veronica cymbalaria Bodard	*Plantaginaceae*	Circum-méd	Th		X					
viburnum tinus L.	*Caprifoliaceae*	Méd	Ph		X					
Vicia altissima Desf.	*Fabaceae*	Méd	Hém	X	X					
Viola riviniana Rchb.	*Violaceae*	Eury-méd	Hém		X			R		
Taxons polliniques non enregistrés dans la flore actuelle										
Mare Aoural	*Apiaceae*, *Artemisia*, *Asteraceae, Cucurbitaceae*, *Ephedra*-type, *Hyacinthaceae*, *Olea*, *Pinus* sp., *Populus* sp., *Retama* sp., *Tamarix* cf. *gallica* L..									
Mare Ain Salhat	*Apiaceae*, *Asteraceae*, *Crataegus*-type, *Eucalyptus* sp., *Hyacinthaceae*, *Olea*, *Pinus* sp., *Solanaceae.*									

Biogéo: Biogéographique, Bio: Biologique, End: endémique, Alg: Algérie, Tun: Tunisie, Mar: Maroc, Itl: Italie, Esp: Espagne, Intr: introduit, Méd: méditerranéen, Atl: atlantique, Trop: tropical, Paléotemp: paléotempéré, Cosm: cosmopolite, Holar: holarctique, Euras : eurasien, Cult: cultivé, Th: thérophyte, Hém: hémicryptophyte, Ch: chaméphyte, Géo: géophyte, Ph: phanérophyte, Hél: hélophyte, Hyd: hydrophyte, X: présence, AR: assez rare, R: rare, RR: très rare, NT: Quasi menacée, P: protégé.

- des espèces forestières, comme *Quercus canariensis* Willd, *Quercus suber* L., *Ulmus minor* Mill., *Acanthus mollis* L., *Viburnum tinus* L., *Hypericum androsaemum* L., *Polystichum setiferum* (Forssk.) T. Moore ex Woyn. et *Viola riviniana* Rchb.

- des espèces hydrophytiques, comme *Lemna minor* L., *Myriophyllum alternifolium* DC. et *Callitriche obtusangula* Le Gall., ce dernier taxon présente un important recouvrement dans la mare Aoural.

- des espèces hygrophytiques, comme *Alisma lanceolatum* With., *Lythrum junceum* Banks & Sol., *Mentha suaveolens* Ehrh subsp. *suaveolens, Schoenus nigricans* L., *Sparganium erectum* L. subsp *erectum*, *Mentha pulegium* L. et *Bolboschoenus glaucus* (Lam.) S.G. Smith

- des espèces de pelouses, qui comprennent à la fois les espèces amphibies de mare temporaire (*Cyperus rotundus* L. subsp. *rotundus*, *Silene laeta* (Aiton) Godr., *Phragmites australis* (Cav.) Trin. ex Steud., *Typha domingensis* Pers. et *Iris pseudacorus* L.) et les espèces de pelouses thérophytiques (*Ranunculus muricatus* L., *Isoetes histrix* Durieu ex Bory, *Juncus bufonius* L., *Plantago lanceolata* L., *Polygonum aviculare* L., *Silene gallica* L. et *Geranium dissectum* L.).

Diversité biogéographique

Les espèces recensées appartiennent à plusieurs ensembles chorologiques :

- Ensemble méditerranéen : cet ensemble domine avec 105 espèces, soit 60,3 % de la flore répertoriée, dont 67 pour l'élément de liaison méditerranéen (*sensu stricto),* 23 pour l'élément de liaison eury-méditerranéen et 15 pour l'élément de liaison méditerranéen atlantique. Dans cet ensemble, les familles les plus riches sont celles qui sont les mieux représentées dans la flore étudiée. La famille des *Fabaceae* compte 9 espèces, celles des *Poaceae* (7 espèces), des *Asteraceae* et des *Lamiaceae* avec 6 espèces pour chacune. D'autres familles possèdent 4 voire 1 espèce.

- Ensemble à large répartition : cet ensemble regroupe 25 espèces, soit 14,4% de la flore étudiée. Il est représenté par 22 espèces cosmopolites (incluant les subcosmopolites) réparties en 16 familles et trois espèces d'origine tropicale (*Achyranthes sicula* (L.) All., *Alternanthera sessilis* (L.) R.Br. ex DC. et *Cyperus rotundus* L. subsp. *rotundus*).

- Ensemble nordique : ces espèces représentent 14,4 % de la flore étudiée (25 espèces). L'élément paléotempéré est représenté par 11 espèces, suivi par l'élément eurasien avec 9 espèces, l'élément boréal et l'élément holarctique par 2 espèces pour chacun, l'élément eurosibérien n'est représenté que par une seule espèce.

- Ensemble d'espèces introduites : cet ensemble est représenté par 5 espèces dont une espèce cultivée (*Opuntia ficus-indica* (L.) Mill.).

- Ensemble endémique : 15 espèces représentent cet ensemble soit 8,6 % de la flore inventoriée. Dix familles présentent des taxons endémiques dont la famille des *Asteraceae* est la plus diversifiée avec 3 espèces.

Taxons patrimoniaux

La flore rare de la région d'étude compte vingt espèces (*sensu* Quézel & Santa 1962-1963), parmi lesquelles, 2 se retrouvent sur la liste rouge de l'Union Internationale pour la Conservation de la Nature (UICN) avec différents statuts : Quasi menacée pour *Bellis prostrata* Pomel et *Juncus heterophyllus* L. M. Dufour (Tab. 1).

En ce qui concerne les catégories d'endémisme, les deux mares échantillonnées recèlent 15 endémiques ou subendémiques. Ce sont surtout des endémiques algéro–tunisiens (6 taxons) ou algéro–tuniso-marocains (4 taxons). Les espèces rares n'ont pas toujours la même valeur patrimoniale. Certaines d'entre elles sont à la fois endémiques et rares, comme (*Aristolochia paucinervis* Pomel, *Daucus virgatus* (Poir.) Maire, *Linaria pinifolia* (Poir.) Thell. et *Stachys marrubiifolia* Viv.). Cette relation entre la rareté et l'endémisme est remarquable dans la flore étudiée. Environ de la moitié des taxons endémiques au sens large, sont rares. Sept taxons endémiques largement distribuées sur le territoire national sont notés dans notre liste (ex. *Drimia numidica* (Jord. & Fourr.) J.C. Manning & Goldblatt, *Genista ferox* (Poir.) Dum. Cour. subsp. *ferox* et *Plagius maghrebinus* Vogt & Greuter).

En outre, deux espèces sont protégées selon la législation algérienne (Décret exécutif n°12/03 du 4 janvier 2012 fixant la liste des espèces végétales non cultivées protégées qui en comporte 449): *Bellis prostrata* Pomel et *Cyclamen africanum* Boiss. & Reut.

Typologie et diversité pollinique

Les données polliniques prélevées sur les cinq profils de surface dans la région d'Oued Zhor, nous ont permis de dégager trois principales communautés (Fig. 2) :

-La communauté des arbres méso-hygrophiles est organisée autour des fruticées ouvertes dominées par des phanérophytes comme *Quercus* cf. *canariensis*, *Castanea sativa*, *Celtis australis*, *Fraxinus, Salix* et *Ulmus* cf. *minor*.

-La communauté des arbustives méso-hygrophiles est organisée selon un gradient depuis des espèces hélophytiques comme (*Crataegus*-type, *Phillyrea* cf. *latifolia*, *Erica*-type, *Arbutus* cf. *unedo*, *Myrtus* cf. *communis* et *Pistacia lentiscus*) jusqu'à des arbustes hydrophiles comme (*Nerium* cf. *oleander* et *Tamarix* cf. *gallica*).

-La communauté des herbacées méso-hygrophiles qui comprennent à la fois les espèces amphibies de mare temporaire (*Callitriche obtusangula*, *Mentha*-type, *Juncus*-type et *Iris*-type) et des espèces de pelouses thérophytiques (*Asphodelus* cf. *ramosus*, *Plantago*-type, *Polygonum*-type, *Ranunculus*-type et *Rumex*-type).

Les spectres polliniques de surface des deux mares montrent une bonne conservation du signal et une flore pollinique diversifiée englobant 52 taxons appartenant à 38 familles et qui représente une somme pollinique de l'ordre de 3093 grains de pollen.

Un total de 36 taxons polliniques est enregistré dans la mare Ain Salhat avec une somme pollinique de l'ordre de 652 grains. Les pourcentages des taxons arborés dominent cet assemblage, atteignant un taux de 47,4 %, suivi par les herbacés 24,5%, arbustifs avec 24,4% et enfin les indéterminés avec 3,7% (Tab. 2). Dans ce spectre, le taxon *Alnus* cf. *glutinosa* est le plus dominant avec 22,5% suivi de *Quercus suber* 7,9% et *Pinus* 5,6%, le reste des taxons polliniques arborés (*Quercus* cf. *canariensis, Castanea sativa, Ulmus* cf. *minor, Populus* sp*., Salix* sp. et *Ficus* sp.) est représenté par 8,8% seulement. Dans la strate arbustive, le pollen d'*Erica-type* domine ce spectre avec un taux de 14,5%, suivi de *Phillyrea et Cistus*-type avec 4,3%, les autres taxons polliniques sont de l'ordre de <2%. Enfin, dans les herbacées, les *Poaceae, Asteraceae* et *Cyperaceae* ont un signal pollinique autour de 11,8%, suivi de *Rannunculus*-type*, Mentha*-type*, Brassicaceae, Chenopodium* sp., *Apiaceae* et *Artemisia* avec <2%. Les taxons polliniques *Asphodelus* cf. *ramosus, Daphne gnidium, Silene-type* ne sont pas présents dans ce spectre alors qu'ils sont très bien

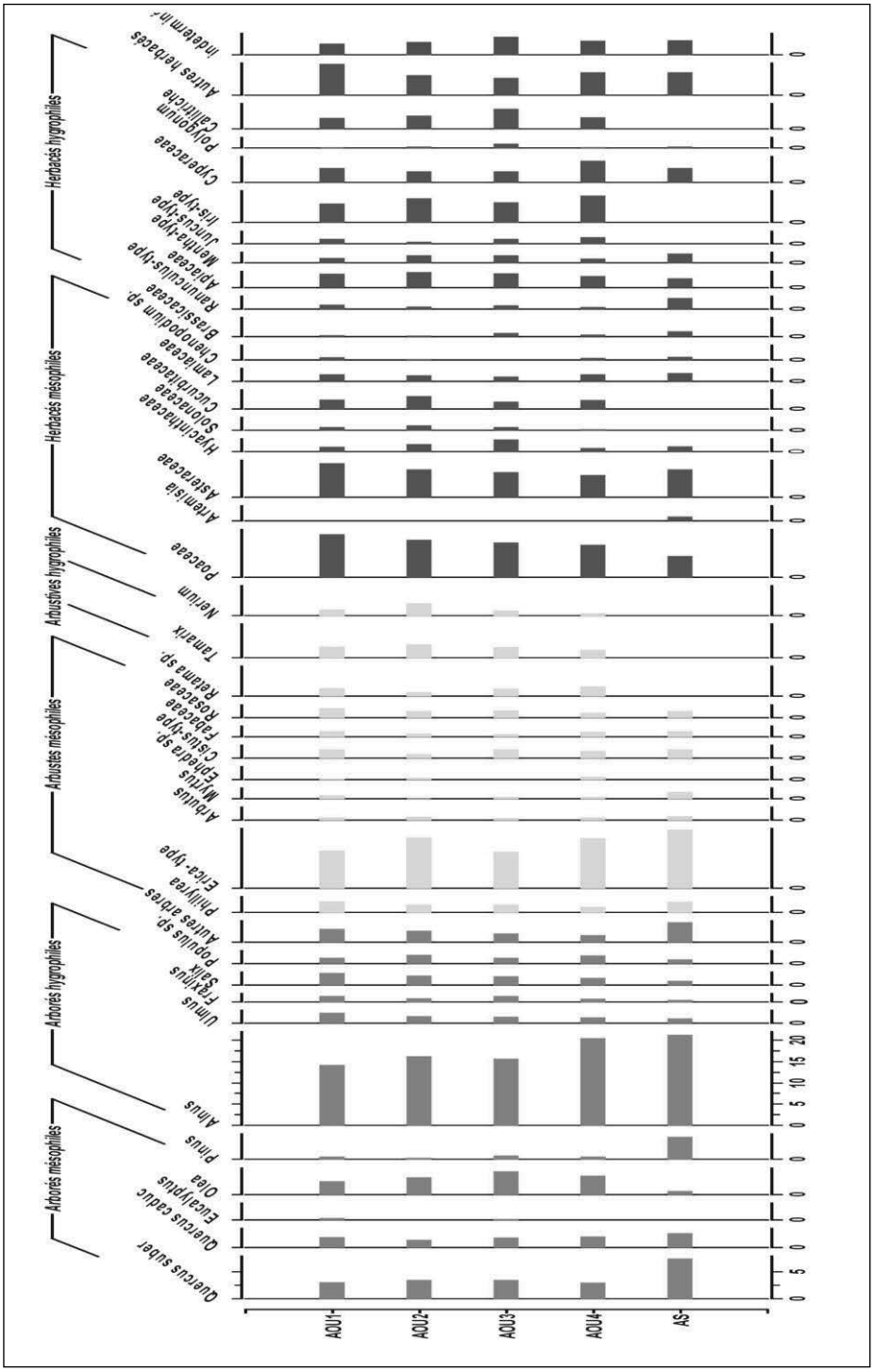

Fig. 2. Diagramme pollinique actuel en pourcentage des deux mares (Aoural et Ain Salhat) dans le bassin versant d'Oued Zhor.

Tableau 2. Les fréquences polliniques dans les cinq prélèvements de la surface des deux mares étudiées.

Pollen /Echantillon	Aoural 1 (Aou1)		Aoural 2 (Aou2)		Aoural 3 (Aou3)		Aoural 4 (Aou4)		Ain Salhat	
	Nbre	%	Nbre	%	Nbre	%	Nbre	%	Nbre	%
Acacia	1	0,1	-	-	-	-	-	-	-	-
Alnus	105	15,6	120	18,3	98	17,9	130	22,4	147	22,2
Apiaceae	19	2,8	21	3,2	17	3,1	14	2,4	12	1,8
Arbutus	3	0,4	4	0,6	2	0,4	3	0,5	4	0,6
Artemisia	1	0,1	-	-	-	-	-	-	2	0,3
Asphodelus	14	2,1	9	1,4	11	2,0	9	1,5	11	1,7
Asteraceae	34	5,1	28	4,3	21	3,8	19	3,3	26	3,9
Brassicaceae	2	0,3	1	0,2	4	0,7	2	0,3	6	0,9
Callitriche	10	1,5	12	1,8	15	2,7	9	1,5	-	-
Campanulaceae	1	0,1	2	0,3	-	-	1	0,2	2	0,3
Caryophyllaceae	12	1,8	9	1,4	7	1.3	5	0,9	9	1,4
Castanea sativa	-	-	-	-	-	-	-	-	13	2
Celtis australis	-	-	-	-	-	-	-	-	6	0,9
Chenopodium sp.	3	0,4	1	0,2	-	-	2	0,3	3	0,5
Cistus-type	15	2,2	7	1,1	13	2,4	11	1,9	14	2,1
Cratægus-type	3	0,4	4	0,6	1	0,2	2	0,3	-	-
Cucurbitaceae	11	1,6	15	2,3	7	1,3	9	1,5	-	-
Cyperaceae	25	3,7	19	2,9	16	2,9	32	5,5	23	3,5
Daphne	3	0,4	1	0,2	2	0,4	3	0,5	-	-
Ephedra sp.	1	0,1	2	0,3	-	-	3	0,5	-	-
Erica- type	65	9,7	87	13,2	53	9,7	74	12,7	95	14,3
Eucalyptus	2	0,3	-	-	1	0,2	-	-	-	-
Fabaceae	8	1,2	5	0,8	3	0,5	6	1	7	1,1
Ficus carica	-	-	-	-	-	-	-	-	9	1,4
Fraxinus	11	1,6	7	1,1	9	1,6	5	0,9	4	0,6
Indéterminés	19	2,8	22	3,3	26	4,7	21	3,6	24	3,6
Iris-type	22	3,3	28	4,3	20	3,6	27	4,6	-	-
Juncus-type	6	0,9	3	0,5	5	0,9	7	1,2	-	-
Lamiaceae	8	1,2	7	1,1	5	0,9	7	1,2	9	1,4
Hyacinthaceae	6	0,9	9	1,4	12	2,2	4	0,7	6	0,9
Malvaceae	5	0,7	2	0,3	1	0,2	3	0,5	-	-
Mentha-type	7	1	11	1,7	9	1,6	5	0,9	12	1,8
Myrtus	5	0,7	1	0,2	2	0,4	2	0,3	9	1,4
Nerium	3	0,4	6	0,9	2	0,4	1	0,2	-	-
Olea	19	2,8	24	3,7	28	5,1	23	4	5	0,8
Phillyrea	16	2,4	11	1,7	9	1,6	7	1,2	14	2,1
Pinus	5	0,7	3	0,5	6	1,1	4	0,7	37	5,6
Pistacia	19	2,8	16	2,4	12	2,2	9	1,5	5	0,8
Plantago-type	1	0,1	2	0,3	-	-	3	0,5	4	0,6
Poaceae	60	8,9	52	7,9	41	7,5	39	6,7	28	4,2
Polygonum	1	0,1	2	0,3	5	0,9	1	0,2	2	0,3
Populus sp.	7	1	10	1,5	6	1,1	8	1,4	5	0,8
Quercus caduc	12	1,8	9	1,4	10	1,8	11	1,9	16	2,4
Quercus suber	23	3,4	26	4	22	4	19	3,3	52	7,8

Tableau 2. continue.

Ranunculus-type	5	0,7	3	0,5	4	0,7	2	0,3	12	1,8
Retama sp.	4	0,6	2	0,3	3	0,5	4	0,7	-	-
Rosaceae	17	2,5	12	1,8	11	2	8	1,4	11	1,7
Rumex-type	1	0,1	-	-	-	-	2	0,3	4	0,6
Salix	21	3,1	16	2,4	13	2,4	11	1,9	7	1,1
Silene	4	0,6	2	0,3	-	-	1	0,2	-	-
Solanaceae	4	0,6	6	0,9	3	0,5	1	0,2	-	-
Tamarix	5	0,7	6	0,9	4	0,7	3	0,5	-	-
Ulmus	18	2,7	12	1,8	10	1,8	9	1,5	8	1,2

présents dans les relevés de végétation, contrairement au taxon *Artemisia* qui présente un spectre <1%.

Dans la mare Aoural, la somme pollinique est de l'ordre de 2441 grains. Elle est dominée par des herbacées avec 37%, en particulier avec des *Poaceae,* des *Asteraceae,* des *Cyperaceae, Apiaceae* et *Iris-type* de l'ordre de 15,1%. Les autres taxons polliniques enregistrés dans cette mare sont de l'ordre <2%. En revanche, les taxons polliniques de la strate arborée et arbustive sont de l'ordre de 36% et 23,4% respectivement, les indéterminés sont à 3,6%. Dans cet assemblage, le pollen d'*Alnus* est le plus dominant avec 18,6%, suivi d'*Erica-type* (11,4%), *Olea* (3,9%), *Quercus suber* (3,6%) et *Pinus* (0,7 %). Les autres essences arborées à savoir *Quercus caduc, Castanea sativa, Ulmus* cf. *minor, Populus* sp. et *Ficus carica* sont de l'ordre de <3%.

Approche écologique de la pluie pollinique actuelle

Les herbacées des prairies humides de la petite Kabylie orientale (*Asteraceae*, *Apiaceae*, *Poaceae*, *Cyperaceae* et *Ranunculaceae*) constituent l'essentiel des spectres de surface (0,7% à 6,4%). Les fréquences notables des *Malvaceae*, *Brassicaceae* et *Campanulaceae* reflètent les groupements xérophiles des bords des deux mares étudiées. Cependant, les taxons polliniques de la famille des *Asteraceae* peuvent aussi refléter en partie les essences xérophiles de la végétation hélophytique à l'exemple des genres *Echinops, Glebionis, Hyoseris, Scolymus* et *Sonchus*. Le niveau de détermination palynologique et l'analyse dans un contexte des mares sub-humide à humide permettent de séparer deux ensembles, hygrophile local et xérophile régional. Des essences forestières sont également enregistrées dans la mare Ain Salhat avec les taxons *Castanea sativa*, *Celtis australis, Quercus caduc* et *Quercus suber*.

Toutefois, les résultats obtenus ont également permis de distinguer un cortège diversifié de taxons polliniques terrestres traduisant les activités anthropiques locales, tels qu'*Asphodelus, Chenopodium*, *Malva* et *Plantago*. Ces marqueurs polliniques d'anthropisation sont le témoin d'une emprise humaine constante depuis plusieurs années et démontrent une fois de plus la grande valeur d'usage des deux mares pour la population locale.

Les taux de *Ranunculus* sont bien corrélés avec la présence de *Ranunculus macrophyllus*, *R. muricatus* et *R. parviflorus* qui connaissent leur maximum d'extension dans les tourbières d'altitude et de la plaine littorale. Toutefois, le spectre de la mare Ain Salhat est repré-

senté par des essences arborées. La présence de quelques grains de pollen allochtones de bioclimat humide (*Alnus*, *Erica*-type, *Quercus* sp. et *Ulmus minor*) dans les échantillons analysés de la mare Aoural illustre le transport du pollen par les différents agents de transport, notamment les vents qui assurent une dispersion hétérogène des grains de pollen.

Certaines espèces végétales ne figurent pas dans les relevés floristiques et sont bien présentes dans les spectres polliniques, le cas de *Pinus*, *Eucalyptus*, *Acacia*, *Tamarix*, *Artemisia*, *Solanaceae* et *Cucurbitaceae*.

On note l'absence de certains taxons de pollen dans les enregistrements polliniques, bien qu'ils soient signalés dans les inventaires floristiques, le cas des : *Lythraceae, Amaranthaceae*, *Araceae*, *Aristolochiaceae*, *Cactaceae*, *Crassulaceae*, *Euphorbiaceae*, *Gentianaceae* et *Hypericaceae*.

Discussion

Composante floristique, biologique et chorologique

La diversité floristique des deux mares étudiées, avec 174 espèces recensées, est la plus élevée pour des mares temporaires du secteur de la petite Kabylie (Benhassine-Gherzouli 2013). Ces espèces constituent un cortège floristique caractéristique des mares temporaires, relativement moyennent riche en comparaison avec le cortège de la Numidie (de Bélair 2005; Allem & al. 2017). Mis à part quelques particularités locales, la typologie de la végétation des mares d'Oued Zhor ne diffère pas du cadre général méditerranéen : communautés herbacées à développement décroissant de la zone inondée vers la zone exondée, sur des broussailles humides et enfin, formations méditerranéennes sclérophylles en fin de succession (Rhazi & al. 2001; Bonnet & al. 2005; Ferchichi-Ben Jamaa & al. 2010; Bouldjedri & al. 2011; Laribi & al. 2016; Fetnaci & al. 2019).

Les thérophytes (57 taxons) composent principalement le spectre biologique autour de la mare Aoural et Ain Salhat. La dominance des espèces annuelles traduit l'adaptation des communautés à l'imprévisibilité des conditions environnementales (Deil 2005; Williams 2006; Megharbi & al. 2016), en favorisant les espèces à cycle court qui investissent plus dans la reproduction sexuée que dans le développement végétatif (Allem & al. 2017; Fetnaci & al. 2019).

L'examen des principaux types chorologiques rencontrés dans les deux mares étudiées confirme la dominance de l'élément méditerranéen, souligné par Quézel (2002) pour l'ensemble des pays de l'Afrique du Nord.

Vingt-huit taxons remarquables (endémiques, rares, protégés ou menacés) d'angiospermes ont été signalés dans nos mares étudiées. Toutes ces espèces recensées présentent une grande valeur en terme de conservation, soit pour des raisons patrimoniales, ou pour leur risque d'extinction (Gaston & al. 1999; Véla & Benhouhou 2007; Hamel & al. 2013).

Relation pollen-végétation

Le couplage des données floristiques avec les données polliniques nous a permis de disposer d'un référentiel actuel pour l'interprétation des données fossiles (Ben Tiba 1982; Stambouli-Essassi & al. 2007; Benslama & al. 2010; Youbi & Benslama 2015; Kahit & al. 2017; Ghit & al. 2018) et de connaître la précision avec laquelle sont enregistrées la com-

position et la structuration de la végétation locale dans les assemblages polliniques de surface (Janssen 1979). Ainsi, les résultats obtenus montrent l'enregistrement de la végétation en ceintures. Cette zonation est liée à l'hydrologie qui est le principal facteur structurant la végétation des zones humides temporaires (Grillas & al. 2004; Deil, 2005; de Bélair 2005). Cela pourrait témoigner de l'absence de transport latéral du pollen au sein de nos mares.

Il ressort de l'inventaire de la végétation actuelle des deux mares étudiées que nombreuses espèces appartenant aux différentes communautés sont présentes sur le site, mais il n'y a pas de traces polliniques, cela peut être dû à trois possibilités : soit une faible production pollinique, soit une fragilité pollinique ou encore que la période de floraison coïncide avec la saison sèche qui expose le pollen au processus de décomposition (Djemai & al. 2017; Ghit & al. 2018). Toutefois, certains taxons étudiés sont régionaux et donc absents dans les relevés phytoécologiques de nos mares. C'est notamment le cas de *Olea*, *Populus* sp., *Tamarix* et de *Retama* sp. Ces taxons régionaux sont caractérisés par de bonnes dispersion (de Beaulieu & Pons 1979; Brugiapaglia & al. 1998; Baron & al. 2005; Cornet & Wales 2020) et production polliniques, en particulier le *Pinus* (de Beaulieu & Pons 1979). La dominance du pollen arboré dans le profil de surface de la mare Ain Salhat est logique, car la dynamique végétale régionale a été essentiellement forestière (Battandier & Trabut 1888-1890; Maire 1952-1987; Quézel & Santa 1962-1963). D'autre part, l'étude floristique permet d'identifier les taxons locaux, présents aujourd'hui sur nos tourbières. Certains de ces taxons sont retrouvés dans les enregistrements polliniques, mais parfois avec des abondances très différentes de leur abondance réelle. L'enregistrement des *Geraniaceae* est encore plus problématique bien qu'elles sont localement abondantes, le cas de *Geranium molle* L. subsp. *molle* et *Geranium robertianum* subsp. *purpureum* (Vill.) Nyman, tandis que le diagramme n'en indique aucune en surface. *Geraniaceae* ont un faible pouvoir de dispersion (Carrión & al. 2010), malgré que leur pollen a une exine très développée résistante aux conditions de dégradation mais, les conditions locales actuelles (sècheresse prolongée et incendies) peuvent être à l'origine de cette situation, car il a été bien enregistré dans les diagrammes polliniques de l'Algérie orientale (ex. Benslama & al. 2010; Djemai & al. 2017), en conditions normales.

Le pollen d'*Erica*-type est moyennement présent dans les enregistrements polliniques et les relevés floristiques aux abords de nos mares étudiées. Ceci indique la présence des maquis dégradés et déboisés, ce qui témoigne son abondance locale (Ghit & al. 2018). *Poaceae* et *Asteraceae* sont enregistrées à des fréquences > 6 % et > 3% respectivement. Ces taxons sont des indicateurs régionaux caractéristiques des milieux ouverts (Duplessy & Ramstein 2013).

Les deux mares étudiées abritent également des taxons patrimoniaux, rares et endémiques, comme *Bellis prostrata, Eryngium pusillum* et *Geranium dissectum* localement abondants, tandis qu'*Alternanthera sessilis, Aristolochia paucinervis* et *Linaria pinifolia* sont limités à de petites parcelles périphériques. Ces espèces sont typiques des mares temporaires et nécessitent des conditions hydrologiques particulières pour leur croissance et leur reproduction (de Bélair 2005; Allem & al. 2017). La représentation de la végétation par les assemblages polliniques est susceptible d'être affectée par plusieurs facteurs, notamment la taille du site, la structure de la végétation environnante, les capacités de production et de dispersion du pollen, la résistance des grains de pollen à la dégradation et la précision des identifications lors de l'analyse pollinique (Jacobson & Bradshaw 1981;

Muller & al. 2006). Ces facteurs sont susceptibles de limiter l'interprétation de données polliniques, notamment en termes de biodiversité (Odgaard 1999; Brun & al. 2007).

Conclusion

Notre étude a permis de mettre en lumière certains aspects notables de deux tourbières étudiées du bassin versant d'Oued Zhor. En se fondant sur les inventaires floristiques et leur interprétation écologique, l'étude de la végétation actuelle des deux mares étudiées (Aoural et Ain Salhat) nous a permis d'identifier, dans un environnement humide, plusieurs taxons caractéristiques indicateurs des zones humides dont certains sont patrimoniaux et qui nous permettront de guider les interprétations de nos séquences polliniques fossiles. L'identification morphopollinique, difficile aux niveaux spécifiques et générique, nous a poussés à constituer des groupements fonctionnels caractéristiques des différentes communautés basées sur le rang des familles. Ce rang de reconnaissance morphopollinique est le plus courant pour les herbacées. Toutefois, la caractérisation pollinique de toutes ces communautés et la construction d'un référentiel pollinique local par le biais de l'étude de la pluie pollinique actuelle et des analogues actuels est une étape indispensable pour l'interprétation des spectres fossiles. En fait, ces données floristiques et paléoécologiques peuvent maintenant être affinées pour fournir une perspective -à long terme- utile pour la conservation des zones humides et devraient aider les gestionnaires de l'environnement à concevoir des politiques de conservation appropriées.

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Article

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D. R. Agius, J. Čížková, J. P. Ebejer, L. Fresta, S. Lanfranco, J. Doležel & R. Farrugia

Genome size estimation of three endemic plant taxa from Malta

Abstract

Agius, D. R., Čížková, J., Ebejer, J. P., Fresta, L., Lanfranco, S., Doležel, J. & Farrugia, R.: Genome size estimation of three endemic plant taxa from Malta. — Fl. Medit. 33: 215-224. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

The Maltese archipelago has several endemic species adapted to an arid and hot climate. Due to its limited land area (316 km^2) and high human population density most of these endemics are endangered or critically so. Few genomic studies have been carried out on this flora to date. The purpose of the present study was to estimate genome sizes (1C-values) of three of these endemic taxa using flow cytometry. The genome size of *Cheirolophus crassifolius*, was found to be 0.98 pg. This is the highest recorded value in this genus and does not fit published values and trends. The genome size of the octoploid *Sedum album* subsp. *rupimelitense* was found to be 1.05 pg and that of *Anthyllis hermanniae* subsp. *melitensis* 0.52 pg.

Key words: endemism, island biodiversity, genome size, *Sedum*, *Cheirolophus*, *Anthyllis*.

Introduction

The Mediterranean basin is a hotspot of plant biodiversity (Myers & al. 2000). Sixty percent of the native plant species are endemics to the region with most being restricted to a single well-defined geographical area. It has also been observed that in the Mediterranean region, endemic species tend to occur on rocky habitats, on steeper slopes and in open vegetation rather than woodland (Thompson 2020). The Maltese archipelago, being central to this biodiversity hotspot, has a flora rich in rare endemic and relict species. This is also attributed to its geomorphology, edaphic factors, climatic fluctuations over the past eons and past geological activity amongst others (Cassar & al. 2008; Brullo & al. 2020).

Malta is one of the most densely populated countries. This creates strong pressures that are reshaping the distribution of the endemic taxa and changing the natural landscape. Conflicting land uses are resulting in loss of habitat for the endemics, with most of them becoming extremely rare and critically endangered. Many of these species are relevant to phylogenomic studies of the major taxa (Rokas & Abbot 2009; Brullo & al. 2020). A restricted and fragmented habitat is also resulting in loss of biodiversity within these taxa. This genetic diversity is currently of scientific interest since it confers adaptability to the

extreme climatic conditions found locally (Scheben & al. 2016). It can provide insight into these characteristics in view of the worldwide need of crops adapted to such climates, which are becoming more prevalent in wider geographical areas due to climate change (Rajpal & al. 2023). Genomic studies will address these issues including the conservation of this diversity (Theissinger & al. 2023). Of special interest are the three endemic and threatened taxa *Cheirolophus crassifolius* (Bertol.) Susanna, the Maltese rock-centaury, which is the islands' own national plant, *Sedum album* L. subsp. *rupimelitense* Mifsud, Stephenson & Thiede and *Anthyllis hermanniae* L. subsp. *melitensis* Brullo & Giusso del Galdo.

Cheirolophus crassifolius (*Asteraceae*: *Cardueae*: *Centaureinae*), a rupestral endemic of the Maltese islands, is considered a relict species of the preglacial circum-Mediterranean distribution of this genus (Susanna & al. 1999). Genome size has been recorded for twenty-four out of the twenty-seven species in this genus (Garnatje & al. 2007; Hidalgo & al. 2017). Garnatje & al. (2007) reported a statistically significant difference between mean 2C nuclear DNA contents of continental (1.58 pg) and insular (1.38 pg) *Cheirolophus* species. The smaller genome size of the insular species was attributed to selection pressures linked to speciation in restricted space or due to founder effects. The genome size of *C. crassifolius* was not reported in this study. Both chloroplast and nuclear DNA sequences have shown that *C. crassifolius* forms the most basal lineage in this genus (Hidalgo & al. 2017). This Maltese endemic is designated as critically endangered (Stevens & Lanfranco 2006).

Sedum album subsp. *rupimelitense* is a rupestral endemic, which is also critically endangered (Mifsud & al. 2015). *S. album* reverts to CAM photosynthesis under drought conditions, making it of prime interest in agricultural productivity research (Wai & al. 2019). Cytologically it is heterogenous with a base chromosome number of 17 from which a polyploid series is derived. The documented genome size for a diploid *S. album* is 0.15 pg ('t Hart 1991). Wai & al. (2019) reported genome size of 0.62 pg for a tetraploid individual. The Maltese subspecies, which reproduces asexually, has $2n = 8x = 136$ but undocumented genome size (Mifsud & al. 2015).

Anthyllis hermanniae L. species complex is divided in several disjunct and mostly isolated populations in Asian countries and the north-eastern Mediterranean. This complex was recently revised, to include several subspecies which are considered schizoendemics. *A. hermanniae* subsp. *melitensis*, has been consequently identified as a Maltese endemic. It is given the status of endangered in the IUCN Red List (Brullo & Giusso del Galdo 2006). The members of this genus are typically diploid with $2n = 2x = 12, 14$ (Goldblatt 2007). The genome size of *A. hermanniae* and its Maltese subspecies have not been estimated yet.

In the past fifty years, genome size estimation has enabled a multitude of investigations into biological patterns and processes (Kron & al. 2007). The genome size is the amount of DNA (C-value) in the haploid gametic nucleus (Doležel 2005), quantified in picograms (pg) or megabase pairs (Mbp), where 1 pg of nuclear DNA amounts to a length of 978 Mbp (Doležel & al. 2003). Genome size estimation by flow cytometry (FCM) is the gold standard of techniques for this metric (Al-Qurainy & al. 2021). FCM is not destructive which is critical when studying endangered species. Genome size estimation is one of the initial steps in genomic studies (Rhie & al. 2021). Its importance is evident in the fact that online databases documenting C-values have seen a steady input of data in the past decades.

Bioinformatics based methods for genome size estimation are becoming increasingly popular, although their level of accuracy, especially in highly repetitive plant genomes, is still to be investigated (Pellicer & Leitch 2020).

The main purpose of this work is to estimate the genome size of the three endemic, and threatened taxa from the islands of Malta, *C. crassifolius, S. album* subsp. *rupimelitense* and *A. hermanniae* subsp. *melitensis* using FCM.

Materials and Methods

Plant material collection. - Leaves from five different individuals of each taxon were used in this investigation. Table 1 lists the sites of specimen collection. In the case of *Anthyllis hermanniae* subsp. *melitensis* and *Cheirolophus crassifolius,* one sample was from a plant cultivated on the premises of the local Plant Protection Directorate at Lija, Malta. Collection and shipment of samples were done according to permit EP 1288/22 issued by the Environmental and Resource Authority of Malta. Photographic records were kept of the plants, together with their geographic coordinates. Each plant was tagged (with a reference number attached to the stem of the plant using a PVC wrap) for future reference.

Sample preparation and cytometric measurements. - The FCM was carried out at the Centre of Plant Structural and Functional Genomics (Institute of Experimental Botany, Czech Republic) using a Sysmex CyFlow® Space flow cytometer (Partec GmbH, Göttingen, Germany) installed with the software FloMax and equipped with a 532 nm green high-grade solid-state laser.

All leaves chosen for this analysis were young and visibly free from infection by parasites. The internal standard and isolation buffer were chosen so that the coefficient of variation (CV) was kept to a minimum (Loureiro & al. 2007). Mechanical isolation of the plants' nuclei was carried out according to Galbraith & al. (1983). This involved chopping the sandwiched leaf material from the studied plant and internal reference standard together, in isolation buffer, using sharp razor blades in glass Petri dishes. The homogenate was filtered through a double layer of 50 µm nylon mesh (Silk & Progress, CR) and stained with the fluorochrome propidium iodide (PI) at a concentration of 50 mg/mL and supplemented with 50 mg/mL RNase.

Table 1. Site of specimen collection for each species (N/A: not applicable).

Taxon	Sample No. (No. of technical replicates)	GPS coordinates		Locality Name
		Latitude	Longitude	
Cheirolophus crassifolius	C1 (6), C2 (6), C4 (3), C5 (3)	35°50'47.6"N	14°23'36.3"E	Dingli Cliffs
	C3 (6)	N/A	N/A	
Sedum album subsp. *rupimelitense*	S1 (5), S2 (4), S3 (6), S4 (3), S5 (3)	35°50'47.6"N	14°23'36.2"E	Dingli Cliffs
Anthyllis hermanniae subsp. *melitensis*	A1 (6), A2 (6), A4 (3), A5 (3)	35°50'47.6"N	14°23'36.3"E	Dingli Cliffs
	A3 (6)	N/A	N/A	

Woody plant buffer (Loureiro & al. 2007) was found to be the optimal buffer for *A. hermanniae* subsp. *melitensis*. In this case the internal standard used was *Solanum lycopersicum* L. cv. Stupické with a 2C DNA content of 1.96 pg (Doležel & al. 2007).

CyStain PI OxProtect Kit (Sysmex, United Kingdom), used according to manufacturer's instructions, was found to be the optimal system for the genome size estimation of *C. crassifolius* and *S. album* subsp. *rupimelitense*. The internal standards used were *Glycine max* Merr. cv. Polanka with a 2C DNA content of 2.50 pg and *Zea mays* L. cv. CE-777 with a 2C genome size of 5.43 pg respectively (Doležel & al. 2007). A minimum of five thousand events were analysed for each run. To improve accuracy and precision, the genome sizes were determined for each species as the mean of five individual specimens and several technical replicates (Table 1) to enable the standard error of the mean to be calculated. The technical replicates were spread out on different days.

The obtained histograms were visualised using FlowJo software (Version 10.8.2, Treestar, Ashland, OR, United States). The sample 2C DNA content was calculated according to the formula: $\text{2C DNA content of sample} = \frac{\text{MFI of sample G1 peak}}{\text{MFI of standard G1 peak}} \text{ x standard 2C DNA content}$

Where MFI is the mean fluorescence intensity, the standards used were as specified above for each sample plant and the 2C DNA content is given in picograms (pg).

A one-way Analysis of Variance (ANOVA) was performed to compare the effect of each individual replicate (per taxon) on estimated genome size measured using FCM. The ANOVA test was implemented in R (version 4.3.0).

Results and Discussion

The results obtained from flow cytometric analysis of PI-stained nuclei are summarised in Table 2. Figure 1 illustrates representative histograms of the genome size investigations. All three genomes in this study are on the smaller range in the plant kingdom (Pellicer & Leitch 2020). In our design we collected five individual plants for each of the three species: *C. crassifolius, S. album* subsp. *rupimelitense* and *A. hermanniae* subsp. *melitensis*. The number of technical replicates per individual specimen ranges from three to six (Table 1). The ANOVA test reported no statistically significant difference between the individual specimens for each species using an α-threshold of 0.05. F-values, P-values and degrees of freedom for each species are reported in Table 3.

We report that the 2C-value for *Cheirolophus crassifolius* is 1.95 pg, equivalent to a genome size of 0.98 pg (954 Mbp). This value is higher than a previously reported one of 0.9 pg, for the same species, by Hidalgo & al. (2017) which was estimated using a single specimen from the Orto Botanico of the Università degli Studi di Palermo in Italy. The value reported in the present study is the highest recorded for this genus in the Genome Size in *Asteraceae* Database (Release 3.0) (Garnatje & al. 2011). It also does not fall within the range of genome size variation documented for insular members of this genus by Garnatje & al. (2007). It is even higher than the mean value for continental members of this genus reported in the same work, hence it does not fit the hypothesis, based on statistically significant results, that insular members have a smaller genome size than continental members in this genus. It also implies that there is an incremental increase in genome

Table 2. Flow cytometry results for the three endemic taxa.

Taxon	2C-value (pg ± SD)	Ploidy level	1C-value (pg)	1C (pg)	Estimated Genome size (1C, Mbp)	Monoploid genome size (1C*x*, Mbp)
Cheirolophus crassifolius	1.95 ± 0.06	2*x*	0.98	0.98	954	954
Sedum album subsp. *rupimelitense*	2.11 ± 0.04	8*x*	1.05	0.26	1027	257
Anthyllis hermanniae subsp. *melitensis*	1.04 ± 0.03	2*x*	0.52	0.52	509	509

Table 3. Results of ANOVA tests between individual specimens for the three species.

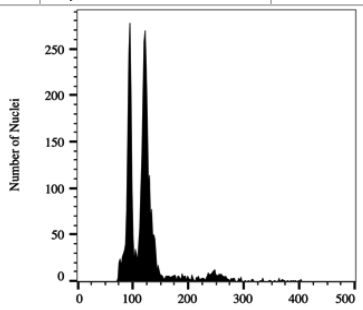
Species	F-value	P-value	Degrees of Freedom
Cheirolophus crassifolius	1.738	0.183	4
Sedum album subsp. *rupimelitense*	1.760	0.186	4
Anthyllis hermanniae subsp. *melitensis*	0.795	0.543	4

size in *C. crassifolius* when compared to the Mediterranean ancestral species *C. uliginosus*. This also does not fit the finding that there is a smaller genome size in the derived species within *Cheirolophus* (Garnatje & al. 2007). This might be interpreted as confirmation of basal position of this species within this genus which has a trend of genome size reduction in the derived species as showed by Hidalgo & al. (2017). Further genomic studies within this genus are required to shed light on the reasons for this larger genome size.

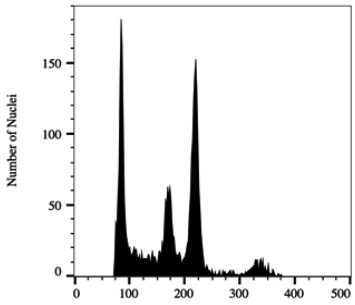
Sedum album subsp. *rupimelitense* was found to have an unreduced nucleus with a DNA content of 2.11 pg, amounting to a holoploid genome size of 1.05 pg (1,027 Mbp). The monoploid genome size (1C*x*) is 0.26 pg equivalent to 254 Mbp of DNA. The 1C*x* value, is a quantitative measure of the amount of DNA in the basic set of chromosomes. It is calculated by dividing the 2C-value by the ploidy level (Leitch & Bennett 2004). The value of 1C*x* for *S. album* documented here is higher than the 1C*x* value documented by ‘t Hart (1991) for a diploid *S. album*. This is counter to the literature finding that 1C*x* values tend to decrease with increased ploidy (Leitch & Bennett 2004). However, ‘t Hart (1991) does not specify the method by which genome size was estimated (van Prooijen-Knegt & al. 1980; Doležel & al. 1998). This general trend, showing a decrease in 1C*x* values with increasing ploidy is attributed to the predominance of deletion over insertion mutations, gene fractionation and unequal recombination which eliminates retrotransposon sequences (Bennetzen 2002). Wai & al (2019) reported a holoploid genome size of 0.62 pg and a monoploid genome size of 0.31 pg for a tetraploid *S. album* while k-mer analysis gave a monoploid genome size of 256 Mbp (equivalent to 0.26 pg of DNA) for the tetraploid. Our results are more concordant with the results published by Wai & al. (2019) for *S. album*. Further studies into the genome size of this taxon are required. The second minor peak in the histogram of *S. album* subsp. *rupimelitense* (Fig. 1B) represents the G2 nuclei of this species and as expected its position shows doubling in the DNA amount of the G1 nuclei.

Our investigations shows that the nuclear DNA content of *Anthyllis hermanniae* subsp. *melitensis* is 1.04 pg amounting to a genome size of 0.52 pg (509 Mbp). This is the third

	Peak	Position	CV (%)	2C DNA (pg)
A	*Cheirolophus crassifolius*	94.0	3.79	1.97
	Glycine max	119.0	3.61	2.50



	Peak	Position	CV (%)	2C DNA (pg)
B	*Sedum album* subsp. *rupimelitense*	86.6	4.43	2.14
	Zea mays	220.0	1.95	5.43



	Peak	Position	CV (%)	2C DNA (pg)
C	*Anthyllis hermanniae* subsp. *melitensis*	100.0	4.62	1.01
	Solanum lycopersicum	195.0	3.00	1.96

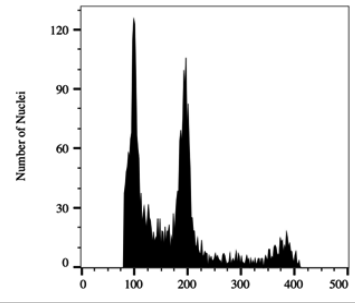


Fig. 1. Representative histograms of flow cytometry data showing 2C DNA content of 3 taxa endemic to Malta. The x-axis shows channel as a function of relative fluorescence intensity, while the y-axis represents the number of nuclei. (A) *C. crassifolius* (left peak) and *G. max* Merr. cv. Polanka (right peak); (B) *S. album* subsp. *rupimelitense* (left peak) and *Z. mays* L. 'CE-777' (right peak). The second minor peak in the histogram, at position 173, represents the G2 nuclei of this species. (C) *A. hermanniae* subsp. *melitensis* (left peak) *S. lycopersicum* L. cv. Stupické (right peak). (CV: coefficient of variation).

documented C-value within this genus of 23 species. It falls well within the range for this genus of 0.50 – 0.67 pg DNA (Pellicer & Leitch 2020). The chromosome number within the sporophytes of this genus varies from 12 to 14 chromosomes (Goldblatt 2007). This finding supports the indication that genome size within this genus is on the smaller side within the plant kingdom.

This is the first study of nuclear genome size of Maltese endemic plant taxa. Herein we report the genome size of *C. crassifolius,* the Maltese rock-centaury, and two recently described taxa *S. album* subsp. *rupimelitense* and *A. hermanniae* subsp. *melitensis.* We determined the genome size by means of FCM. All three species inhabit Special Areas of Conservation. The small geographical area they inhabit, and anthropogenic factors make these taxa endangered, some of them critically so.

The genera *Cheirolophus*, *Anthyllis* and *Sedum* have been studied extensively (’t Hart 1991; Susanna & al. 1999; Brullo & Giusso del Galdo 2006; Garnatje & al. 2007; Pellicer & Leitch 2020). However, most of these works do not include the Maltese endemics making the available knowledge incomplete. The results presented here shed some additional light into the evolutionary history of these genera and can also be used in further studies including studies into the characteristics that give them adaptability to the extreme local hot and dry environment, which is becoming more prevalent worldwide.

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Two new weeds in Morocco: *Ambrosia psilostachya* (*Asteraceae*) and *Datura ferox* (*Solanaceae*)

Abstract

Tanji, A.: Two new weeds in Morocco: *Ambrosia psilostachya* (*Asteraceae*) and *Datura ferox* (*Solanaceae*). — Fl. Medit. 33: 225-232. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

As a result of field surveys with special emphasis on weeds occurring in Moroccan farmlands, two recently introduced weed species (*Ambrosia psilostachya* and *Datura ferox*) have been found in several locations. *A. psilostachya* (*Asteraceae*) has been discovered in 2000 growing along roadsides. It is a perennial species that survives essentially through rhizomes and rootstocks, resulting in the establishment of clonal populations that form dense colonies on roadsides. It has been observed in March 2023 in 16 sites along national roads and highways. *Datura ferox* (*Solanaceae*) has been found in irrigated corn fields in 2022 and in a carrot field in 2023. Both species are unpalatable to livestock and will probably spread to other areas of Morocco. They are considered new naturalized weeds, which indicate that the country needs more botanical explorations. Herbariu specimens of both species were deposited at the national herbarium of the Institut Scientifique in Rabat.

Key words: xenophyte, weed survey, new record, flora, North Africa.

Introduction

There have been several contributions on the exotic alien plant species in Morocco (see e.g. Tanji & Taleb 1997; Fennane & al. 1999, 2007, 2014; Chambouleyron & Benrahmoune Idrissi 2017; Tanji 2020; Khamar & al. 2021; Pils 2022; Verloove & al. 2022; Sukhorukov & al. 2023; Tanji 2023). There are nearly 200 introduced weed taxa, involuntarily brought by humans or by other means such as rivers, winds, and birds (Fennane & al. 2023). Some of these exotics are becoming naturalized or even invasive. They threaten biodiversity and pose a huge global threat to sustainable agriculture, food security, and human livelihoods. Their spread and impact are growing due to climate change, globalisation, trade, and tourism (e. g. Lake & Leichman 2004; Lambdon & al. 2008; Early & al. 2016; Gervilla & al. 2019; Arianoutsou & al. 2021; Di Gristina & al. 2021; Cordero & al. 2023; Karrer & al. 2023).

I present here the distribution and status of two naturalized plant species in Morocco (*Ambrosia psilostachya* DC. and *Datura ferox* L.) that are expanding in the country. Photos, descriptions, and impacts of these newly introduced species are provided in the present note.

Ambrosia psilostachya DC.
= *Ambrosia coronopifolia* Torr. & A. Gray
English name: Western ragweed.
French names: Ambroisie vivace, ambroisie à épis grêles, ambroisie à épis lisses, ambroisie à épis glabres.

The author collected western ragweed plants for the first time in the country in 2000 in the roadside of Settat-Casablanca national road and Pr. Ibn Tattou confirmed the identification of *Ambrosia psilostachya* as a new exotic species in Morocco (Tanji 2005; Tanji & Taleb 2010). In March 2023, 16 clamps have been observed along roadsides and highways in Settat, Berrechid, Casablanca, Rabat, Salé, Kénitra, Sidi Yahya, and Sidi Slimane (Fig. 1, Table 1). However, *A. psilostachya* has not been cited yet in various floras of Morocco (Dobignard & Chatelain 2011; Fennane & al. 2014; Pils 2022; efloramaghreb 2023; floramaroccana 2023; Peltier 2023).

In Morocco, Western ragweed plants survive and expand primarily from horizontal and vertical rootstocks (Fig. 1). Since western ragweed is not palatable to livestock, some colonies prospered in sandy soils producing sometimes more than 100 stems m^{-2} and growing up to 1,40 m tall. Machines used for road construction and management certainly contributed a lot to rhizome dispersal.

From field observations, growth of new shoots occurs from November to April when minimal temperatures at night are 5 to 15 C, maximal temperatures in the day are 15 to 25 C, and the photoperiod is 10 to 12 hours. Stem growth and colony formation occur from January to May when minimal temperatures at night are 5 to 20 C, maximal temperatures in the day are 15 to 30 C, and the photoperiod is 10 to 13 hours. The flowering period is essentially from May to December. Panicles are predominantly formed with many male flowers at the top of the inflorescence, and only few female flowers at the base of the inflorescence. Seeds and seedlings have never been observed. Western ragweed is therefore considered, under local climatic conditions, a perennial weed in Morocco.

The dispersal strategy appears similar in all observed sites along roadsides and highways. In the first year, the individual plant does not appear to produce additional shoots from its root system. In the second year, new shoots emerge from the rootstocks, thus establishing a dense clone which can cover up to 1 or 2 m^2. Through its spreading rhizomes, a clamp can be formed or even an area can be colonized within few years. Dense colonies may rise questions about possible impact of western ragweed, through competition and allelopathy, on the local flora.

Chorology

Western ragweed is native of North and South America (Bassett & Crompton 1975; CABI 2023; POWO 2023). It is found in the 5 continents, and is usually distributed in roadsides, fields, and pastures (CABI 2023; POWO 2023; WFO 2023). In the Mediterranean region and surrounding areas, it was reported in Algeria, Italy, France, and Spain (Dobignard & Chatelain 2011; Tison & de Foucault 2014; Fried & al. 2015; Domina & al. 2018; APD 2023; CABI 2023; EPPO 2023; POWO 2023; efloramaghreb 2023).

Notes

Western ragweed is a perennial *Asteraceae* that survives primarily through rhizomes and rootstocks, resulting in the establishment of clonal populations that can cover rapidly

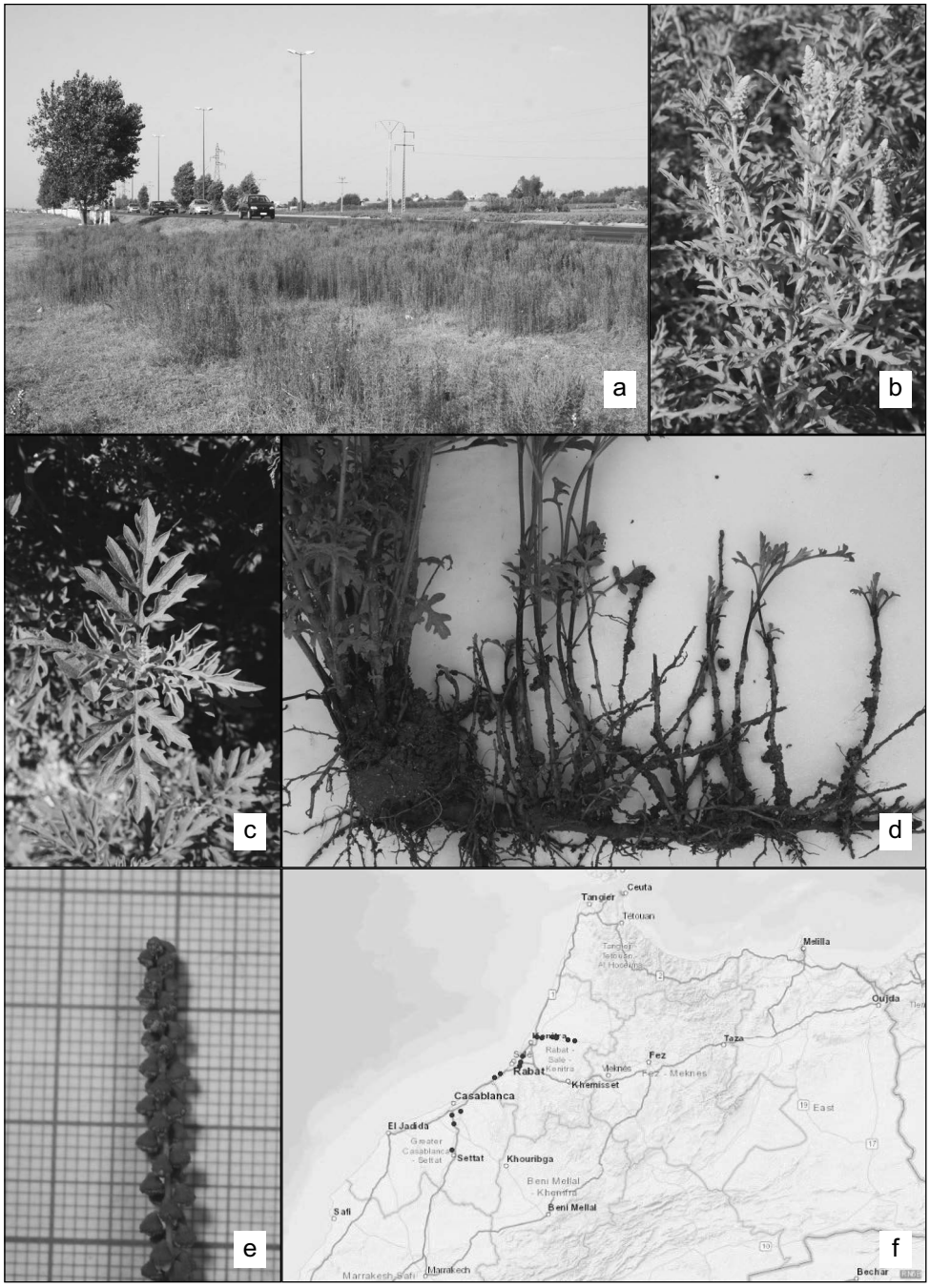

Fig. 1. *Ambrosia psilostachya*: a) dense colony on the roadside; b) general habit, c) leaves, d) horizontal rhizomes, e) inflorescence with male capitula; f) distribution in Morocco. Photos by the author.

Table 1. *Ambrosia psilostachya* in 16 sites along national roads and highways from Settat to Sidi Slimane in Morocco in March 2023.

Site no.	Locality	GPS latitude	GPS longitude	GPS altitude in m
1	Settat	33° 2′ 58” N	7° 37′ 32” W	300
2	Sidi El Aidi	33° 3′ 1” N	7° 37′ 33” W	280
3	Berrechid	33° 20′ 17” N	7° 36′ 40” W	200
4	Bouskoura	33° 26′ 6” N	7° 37′ 42” W	170
5	Médiouna	33° 28′ 58” N	7° 30′ 38” W	160
6	Skhirate	33° 51′ 10” N	7° 3′ 41” W	40
7	Rabat	33° 54′ 12” N	6° 59′ 26” W	20
8	Salé	33° 59′ 16” N	6° 43′ 42” W	140
9	Salé	34° 1′ 47” N	6° 42′ 42” W	120
10	kénitra	34° 5′ 28” N	6° 41′ 17” W	90
11	kénitra	34° 17′ 37” N	6° 25′ 46” W	10
12	Kénitra	34° 18′ 2” N	6° 29′ 32” W	10
13	Sidi Yahya	34° 18′ 7” N	6° 16′ 51” W	20
14	Sidi Yahya	34° 17′ 24” N	6° 14′ 4” W	30
15	Sidi Slimane	34° 16′ 27” N	6° 5′ 8” W	40
16	Sidi Slimane	34° 16′ 3” N	5° 59′ 23” W	30

large areas (Basset & Crompton 1975; Fried & al. 2015). It is an invasive weed in Australia (CABI 2023), in the USA (Vermeire & Gillen 2000), in France (Fried & al. 2015), in Iran (Saberi & al. 2022), and several other countries (GBIF 2023). It is considered one of the most common weeds in pastures and rangeland in the southern Great Plains region of the USA (Funderburg & al. 2014). It is an aggressive competitor with crops and is generally considered unpalatable to cattle (Vermeire & Gillen 2000). Leaf and rhizome extracts inhibited germination and early seedling growth in a range of *Poaceae* including wheat, oats and rye (Dalrymple & Rogers 1983).

Western ragweed is primarily anemophilous (wind-pollinated). It does shed large quantities of air-borne pollen that causes hay fever symptoms (Bassett & Crompton 1975). However, the pollen produced could potentially contribute to allergies by prolonging the presence of pollen in the air, and its effects on health might be aggravated by climate change (Wan & al. 2002; Fried & al. 2015).

Datura ferox L.

English names: fierce thornapple, long spined thorn apple, Angel’s-trumpets.

French names: La stramoine féroce, la stramoine épineuse.

Datura ferox belongs to the *Solanaceae* family that includes in Morocco 16 genera and 46 taxa, while the genus *Datura* contains 4 species: *Datura inoxia* Mill., *D. metel* L., *D. stramonium* L., and *D. wrightii* Regel (Fennane & al. 2007, Dobignard & Chatelain 2013, Pils 2022, efloramaghreb 2023, Peltier 2023). None of these references confirmed the presence of *D. ferox* in Morocco, and it is therefore considered an exotic weed species recently introduced into the country.

Fierce thornapple plants were found by the author in irrigated corn fields in Oualidia near the Atlantic Ocean (33° 2′ 23” N, 8° 41′ 30” W, altitude 10 m) and Khémis Mtouh (32° 51′ 4” N, 8° 8′ 55” W, altitude 160 m) in October 2020 (fall season) and in an irrigated carrot

field in Berrechid (33° 17′ 41” N, 7° 25′ 26” W, altitude 240 m) in May 2023 (early summer season). Pr. Ibn Tattou confirmed the identification of *Datura ferox* as a new exotic species in Morocco. Collected plants were at the flowering and fruiting stages (Fig. 2), and were growing in areas where daily temperatures in summer (June, July, August) usually exceed 30 C, nightly temperatures are around 20 C, and the photoperiod is 14 hours. *D. ferox* is therefore considered, under local climatic conditions, a summer annual weed in Morocco.

Chorology

Fierce thornapple is native to southern North America (CABI 2023; POWO 2023). It is located in roadsides, waste places, and cultivated lands. It is an annual plant that has become a significant weed of summer crops in many subtropical and warm temperate parts of the world. It is found in the 5 continents. In the Mediterranean region and surrounding areas, it was reported in the Canary Islands, Algeria, Israel, Greece, Italy, France, and

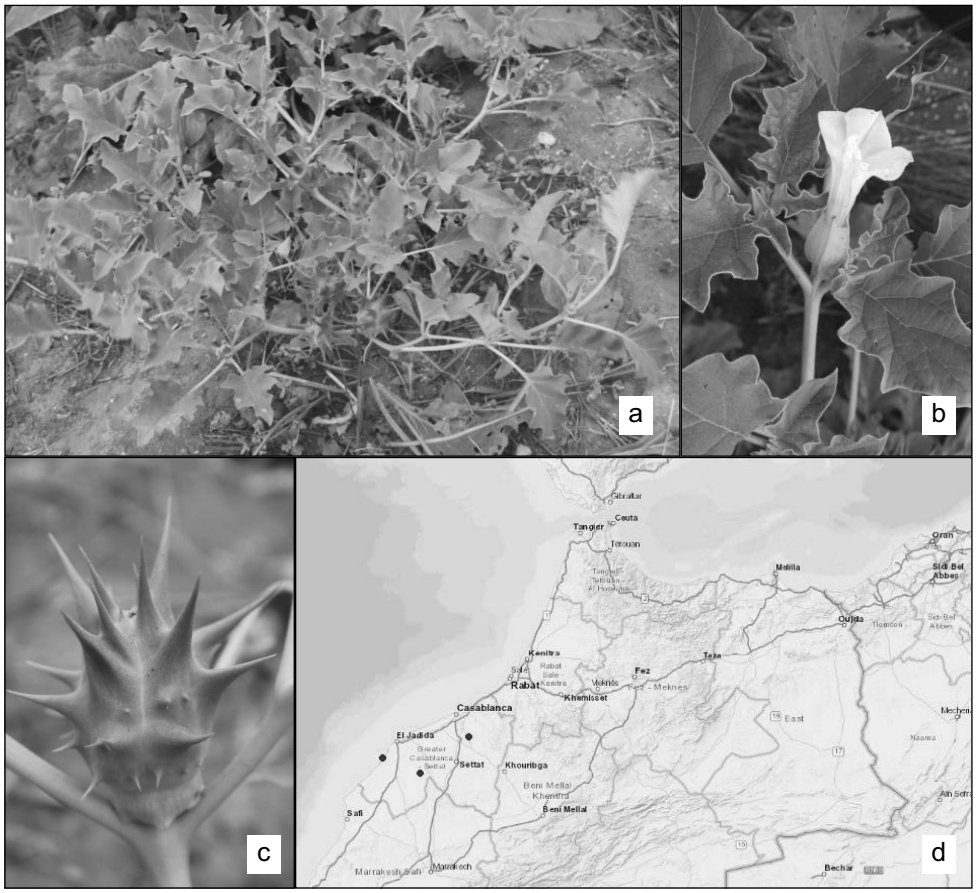

Fig. 2. *Datura ferox*: a) general habit, b) leaves and flower, c) capsule, d) distribution in the map of Morocco. Photos by the author.

Spain (Houmani & al. 1999; Dobignard & Chatelain 2013; Domina & al. 2018; Danin & Fragman-Sapir 2023; Sauerbier & al. 2023; CABI 2023; POWO 2023).

Notes

Datura ferox is a noxious weed in warm and hot regions of the world where its control could be problematic. It is a competitive weed in Spain (San Martın & al. 2015), in Australia (Charles & al. 1998), in Argentina (Torres & al. 2013), in the United Arab Emirates (Shahid & Rao 2014), and several other countries (GBIF 2023). It is toxic to animals and humans, because all plant parts and seeds contain toxic alkaloids. Cases of livestock poisoning do occur, especially if animal feed is contaminated with *D. ferox* seeds (CABI 2023; POWO 2023).

Conclusion

Ambrosia coronopifolia and *Datura ferox* are new exotic weeds naturalized in Morocco. They are unpalatable to livestock and can be invasive in agricultural systems and uncropped areas. Both plant species were introduced into Morocco with human activities, which indicate that the country needs more thorough botanical explorations.

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Article

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Update to the vascular flora of Mount Limbara: new records from Northern Sardinia

Abstract

Calvia, G. & Ruggero, A.: Update to the vascular flora of Mount Limbara: new records from Northern Sardinia. — Fl. Medit. 33: 233-241. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

Three years after the publication of the vascular flora of Mount Limbara, we present a revised floristic list with new records of 34 taxa in the study area. Specifically, 15 of these newly recorded taxa are native, while 19 are alien species. Additionally, we have removed 7 taxa from the previous list due to incorrect assignments. Furthermore, we have comprehensively revised the nomenclature, chorology, and distribution of additional 74 taxa within the study area. The inclusion of new alien taxa in our findings increases the already significant number of non-native taxa identified in this area. Following this revision, the vascular flora of Mount Limbara currently comprises 1,175 taxa, classified into 125 families and 500 genera. The endemic and subendemic taxa are 89, while the alien flora includes 134 taxa. In this report, we highlight the discovery of four casual aliens that are new to the Sardinian flora: *Hyacinthoides hispanica*, *Koelreuteria paniculata*, *Leucanthemum* ×*superbum*, *Ulex europaeus* subsp. *europaeus*. Additionally, we present the first report for the flora of Italy of *Eucalyptus* ×*trabutii* (casual alien). Moreover, we confirm the presence of *Hyacinthus orientalis* for the Sardinian flora, and we exclude *Cuscuta cesattiana* from the flora of the island. Finally, we remark the invasive status of *Abies cephalonica* and *Xanthium orientale* in the area.

Key words: alien taxa, endemic taxa, invasive taxa, native taxa, Sardinian flora.

Introduction

A flora, along with vegetation landscapes and ecosystems, is not a static entity, as is often demonstrated by updates in checklists at both local and broader levels (e.g., Fois & al. 2022; Bartolucci & al. 2018a; Galasso & al. 2018). Conversely, a flora constitutes a dynamic system that undergoes various, sometimes gradual or rapid, changes resulting from external and internal factors. These factors encompass both natural events (as climatic phenomena, genetic drift, successional evolution, colonization, migrations), and, most significantly, anthropogenic pressures and alterations (Iamonico & al. 2012; Gianguzzi & al. 2013; Carta & al. 2018; Cambria & al. 2023). Furthermore, new scientific discoveries and updates can supply additional information to bridge gaps in previous knowledge,

thereby enhancing what initially appeared to be a comprehensive and well-rounded effort (Bedini & al. 2016).

In 2020, we published the vascular flora of Mount Limbara (northern Sardinia, Italy), highlighting its species richness and the precarious situation arising from a high abundance of non-native species (Calvia & Ruggero 2020). Three years later, recent field findings, the analysis of new herbarium samples, in conjunction with the re-evaluation of some previously collected specimens, along with nomenclatural and chorological changes occurred for various taxa, prompted us to revise our original list.

Materials and methods

We updated the floristic list published by Calvia & Ruggero (2020), after the collection of new floristic data during the years 2021-2023. Also, some specimens already collected in the past have been revised. Herbarium specimens are preserved at our personal herbaria (Roma-Marzio & al. 2018). Nomenclature generally follows the checklists of the Italian native (Bartolucci & al. 2018a) and alien (Galasso & al. 2018) vascular flora, except in few cases specified in the notes. Taxa are categorized in native and alien, and ordered per families and genera, as in the previous version. For each taxon, the following information is provided: family, current accepted name, biological type, chorology, abundance (expressed as in Calvia & Ruggero 2020), habitat, elevation range. For all the updated and added taxa we also reported additional notes. For some taxa we also added the citation of the first report in the area. For the alien taxa we reported the current invasiveness status (A = adventitious; P = planted; CAS = Casual; NAT = naturalised; INV = invasive; OP = only planted). Regarding the decision to include only planted taxa, our rationale is rooted in the acknowledgment that comprehending taxa with the potential to spread in the near future, under favourable environmental conditions, is crucial for monitoring the vascular flora of an area (Celesti-Grapow & al. 2010). While we have opted to create a distinct list exclusively for planted taxa, we recognize and consider them as integral components of the active vascular flora of Mount Limbara.

In the current list (Electronic Supplementary File 1, ESF1), scientific names of native taxa are presented in both bold and italics, whereas those classified as alien taxa are displayed in italics only. We have marked all newly reported taxa with the symbol (+), taxa that have been removed from the previous list are indicated with (–), distributional updates of previously documented taxa are highlighted with (*), and denoted chorological and nomenclatural changes are marked with (§). An ecological analysis based on the four altitudinal belts proposed by Canu & al. (2015) is here presented.

Results

After the recent findings of the last three years, the new floristic list consists of 1,175 taxa, which are divided as follows: 1,021 native (86.9%), and 134 (11.4%) alien taxa (details in Appendix 1). An additional 20 taxa are OP (1.7%). The flora includes 125 families (17 of which are represented by alien/OP taxa only) and 500 genera (72 of which are

alien/OP taxa only). The taxa at the species level are 874, while 285 are subspecies, 12 are hybrids and 4 are varieties. Pteridophytes consist of 14 families, 18 genera, 33 taxa. Gymnosperms are divided in 3 families, 12 genera and 23 taxa (19 of them introduced). Angiosperms are 108 families, 471 genera and 1,129 taxa: 16 families, 118 genera and 282 taxa are Monocots (24 non-native); 92 families, 353 genera and 847 taxa are Dicots (111 non-native). The most represented families are *Asteraceae* (139 taxa), *Poaceae* (126), *Fabaceae* (110), *Caryophyllaceae* (38), *Rosaceae* (37), *Apiaceae* and *Lamiaceae* (36).

The endemic contingent of Mount Limbara currently amounts to 89 taxa. All the vascular endemics found are Angiosperms, with 67 Dicots and 22 Monocots.

Sardo-Corsican endemics are the most frequent (32 taxa, 35.9%), followed by Sardinian endemics (25, 28.1%), Sardinian, Corsican and Tuscan Archipelago (14, 15.7%) and Sardinian, Corsican and Italian endemics (11, 12.4%), while the other endemic and subendemic taxa are 7 (7.9%). Currently, 4 taxa are exclusive to Limbara (*Genista salzmannii* subsp. *limbarae* Bacch., Brullo & Giusso, *Hieracium mattirolianum* subsp. *martellianum* (Zahn) Greuter, *H. racemosum* subsp. *limbarae* (Arrigoni) Greuter, *Rubus limbarae* Camarda) representing 3.5% of the entire endemic flora. Furthermore, 8 endemic taxa (9.3% of the total) have their *locus classicus* in the area: *Barbarea rupicola* Moris, *Festuca sardoa* (Hack.) K. Richt., *Genista salzmannii* subsp. *limbarae* (Bacchetta & al. 2020), *Hieracium bernardii* subsp. *gallurense* (Arrigoni) Greuter, *H. mattirolianum* subsp. *martellianum*, *H. racemosum* subsp. *limbarae*, *Romulea* × *limbarae* Bég., *Rubus limbarae*, *Viola corsica* subsp. *limbarae* Merxm. & W. Lippert.

Alien plant taxa on Mount Limbara are documented at 154 in total, comprising 51 classified as CAS, 75 as NAT, 8 as INV, and 20 as OP. American taxa dominate with 42 (including 6 OP), followed by Mediterranean taxa (19, including 2 OP), and Asian taxa with 15 (including 3 OP).

The updated biological spectrum of the current floristic list demonstrates a richness in therophytes (464) and hemicryptophytes (341), followed by phanerophytes/nanophanerophytes (158) and geophytes (152). Chamaephytes, hydrophytes, and helophytes are represented by 38, 22, and 2 taxa, respectively.

The biological spectrum of alien taxa highlights a predominance of phanerophytes, totalling 70 (including OP). Therophytes are the next most abundant, with 33 taxa. Hemicryptophytes follow with 21 taxa, geophytes with 18, chamaephytes with 10, and hydrophytes with 2.

Among the most noteworthy updates since the previous list, we present 6 new taxa for the flora of Sardinia. Notably, one of these findings also marks the first-ever occurrence in the Italian flora (see also the new list in ESF1):

Eucalyptus × *trabutii* H. Vilm. (a hybrid between *E. camaldulensis* Labill. and *E. botryoides* Sm.): several young trees and saplings now thrive in the vicinity of an ancient shepherd's settlement, where an old tree of this taxon also grows. This marks the first recorded occurrence of this taxon as an adventitious species in Italy.

Hyacinthoides hispanica (Mill.) Rothm.: in spring 2023, a few plants were discovered along a country road on the northern side of the mountain. This is the first report of the taxon as a casual alien in the flora of Sardinia.

Hyacinthus orientalis L.: several plants were observed starting in April 2021 on a former military base that was decommissioned in 1993. This confirms the presence of

the taxon as a casual alien in Sardinia, dispelling earlier doubts raised by Bartolucci & al. (2018a).

Koelreuteria paniculata Laxm.: several young trees and saplings now thrive along the northern border of the study area. This is the first documented occurrence of this species as an alien in the flora of Sardinia.

Leucanthemum ×*superbum* (Bergmans ex J. W. Ingram) D. H. Kent: this is the correct binomial name for the taxon previously reported as *Leucanthemum* sp. and is the first recorded occurrence of this taxon as an alien in Sardinia.

Ulex europaeus L.: in September 2023, we found a small shrub and two seedlings of this species along a forestry road. This marks the first recorded occurrence of this taxon as a casual alien in Sardinia.

Additionally, we confirm the presence of *Cuscuta campestris* Yunck. as a naturalised species in Sardinia, while we exclude the presence of *Cuscuta cesattiana* Bertol., *Scrophularia umbrosa* Dumort., and *Sedum villosum* L. from both the study area and Sardinia as a whole.

The lowermost area of the mountain, covering approximately 102.11 km² and influenced by the Oceanic Pluviseasonal Mediterranean bioclimate (data exerted from Canu & al. 2015), from an elevation of roughly 160 m to 500 m, is the most taxonomically rich, housing 950 taxa, which corresponds to 80.9% of the entire flora.

The second belt, which marks the transition between hillside and low mountain areas (500-800 m a.s.l.) and is influenced by a transitional bioclimate shifting from the upper meso-Mediterranean to the supra-Mediterranean thermotype, particularly evident on northern slopes, remains diverse with 908 taxa (constituting 77.2% of the total flora). The lower number of taxa in this portion of the study area, despite its slightly larger size (110.75 km²), can be attributed to a more uniform presence of woodlands, reforestations, and dense *Arbutus unedo* L. and *Erica arborea* L. high shrublands. These habitats limit diversity, and consequently, species richness (Bacchetta & al. 2009).

The lower mountain belt (800-1,200 m a.s.l., covering 47 km²), characterized by the supra-Mediterranean thermotype within the sub-Mediterranean variant, is less rich in comparison to the previous belts but still boasts 766 taxa, accounting for 65.1% of the total flora.

Lastly, the uppermost zone, spanning from 1,200 m to 1,359 m a.s.l. and covering the smallest area (2.6 km²), which is influenced by the oceanic temperate bioclimate, currently houses 455 taxa (representing 38.7% of the total flora and increased from the previous count of 440, as documented in Calvia & Ruggero 2020).

Discussion and conclusions

The updated vascular flora of the Limbara massif now comprises 1,175 taxa, which accounts for approximately 40% of the entire Sardinian flora, as indicated by Galasso & al. (2018). Of these, the 1,021 native taxa represent approximately 42% of the native flora of the island, as reported by Bartolucci & al. (2018a). Unfortunately, the already high number of non-native taxa (119, excluding OP, as detailed in Calvia & Ruggero 2020) has further increased to 134 taxa, constituting around 23% of the alien flora found in Sardinia, according to Galasso & al. (2018).

When considering the four belts as if they were distinct floras, categorized by elevation, it becomes evident, from both a biological and a chorological perspective, how the highest region of the mountain differs from the Mediterranean context that surrounds it (see also Tables S1, S2). This observation aligns with previous findings by Farris & al. (2018) for Anela.

The H/T ratio, which serves as an indicator of the Mediterranean (H/T < 1) or continental (H/T > 1) nature of the flora (Sabato & Valenzano 1975; Cannucci & al. 2017), reaffirms the low continentality of the uppermost region of the mountain and a consistent increase in the index from the base (0.61) to the summit: the belt between 500 and 800 m a.s.l. records an index of 0.78, while the lower mountain area, ranging from 800 to 1,200 m, reaches 0.82. Notably, the newly discovered data reveals a slight uptick in the value at the highest peaks, now at 1.06 (compared to 1.04 in Calvia & Ruggero 2020), further confirming the low continentality at the mountain' summits. Nonetheless, this value remains lower than that of the Gennargentu massif (1.25, as reported by Arrigoni & Camarda 2015), whose peaks are almost 500 m higher than those of Limbara.

Specifically, when examining the chorological data, including alien, endemic, paleotemperate, Circum-Mediterranean, and Euro-Mediterranean taxa (refer to Table S2), it becomes evident that the floral composition undergoes significant changes along the gradient. Sardinian and Sardinian-Corsican endemics consistently increase from a minimum of 0.4% and 1.4% in the basal zones to 2.2% and 5.5% at the mountain' summits. Conversely, American and Asian taxa decline from 3.5% and 1.4% to 0.4% each.

At a broader scale, Circum-Mediterranean taxa dominate the entire flora, particularly in the basal belt, closely followed by Euro-Mediterranean taxa. However, the percentage of Circum-Mediterranean taxa decreases from 19.4% in the lowest belt to 12.3% at the highest elevation. Conversely, although the presence of Euro-Mediterranean taxa remains relatively constant along the gradient (as indicated in Table S2), their peak is observed in the uppermost region, at 19.1%. In this area, Euro-Mediterranean taxa predominate.

Furthermore, the reduced influence of the Mediterranean bioclimate at the highest elevation is evident through the increasing percentages of Circumboreal, Euro-Caucasian, and Paleo-temperate taxa. In these cases, their percentage consistently rises along the gradient, transitioning from 1.8%, 1.7%, and 6.3% to 3.3%, 3.1%, and 7.5%, respectively. It is worth noting that several species belonging to these chorological types are often found at lower elevations due to the cooler conditions created by gallery forests (Sanz & al. 2009; Calvia & al. 2023). Otherwise, we could speculate that this gap in distribution might have been even more pronounced.

As mentioned previously, the plant diversity on Mount Limbara is influenced by climatic and environmental factors. However, in the overall composition of the flora, human influence emerges as a significant factor that underscores the impact of human activities on the presence of non-native and endemic taxa within each belt and along the elevation gradient (Angiolini & al. 2013; Fois & al. 2020).

On one hand, in the basal belt (160-500 m) there are 99 alien taxa, accounting for 10.4% of the entire flora in this zone, while endemic taxa make up only 5% (48). This particular area is characterized by the presence of human settlements and various activities that exert a notable influence on the landscape and, consequently, on the floristic diversity. This influence stems from the introduction of cultivated plant species, which serve agricultural, crop, and

ornamental purposes, contributing to the observed changes in the flora. In addition to these, there are random introductions resulting from activities such as earthworks, road construction, building sites, and artisanal and industrial areas (Dimitrakopoulos & al. 2020).

On the other hand, at the mountain summits (1,200-1,359 m), the number of non-native taxa decreases significantly to just 24, comprising just 5.3% of the flora. This data marks a slight increase from the 4.7% reported in Calvia & Ruggero (2020). Meanwhile, the presence of endemic taxa rises to 57, accounting for 12.5% of the total. However, it is worth noting that the species richness in the highest area of Mount Limbara is still influenced by human activities. This is evident through the presence of synanthropic and invasive alien taxa along roads, within military bases, radio-television communication centres, and parking areas. Additionally, a number of taxa are spreading from extensive reforestations in neighbouring areas and lower elevations (as documented in Calvia & Ruggero 2020).

Nevertheless, the endemic taxa in this same area are more closely associated with less disturbed habitats, such as mountain meadows, garrigues, wet sites, rocks, and crevices, as one might expect. Future efforts to monitor the environmental stability of the mountain will primarily focus on the conservation of these habitats, which have acted as "islands" fostering the differentiation and speciation of endemic taxa (Esposito 2015; Steinbauer 2016; Itescu 2019; Flantua & al. 2020). However, they are currently facing concerning invasions. In fact, among the previously reported alien taxa, it is worth highlighting that *Abies cephalonica* Loudon has now become invasive in the central parts of the mountain. This raises new concerns regarding future colonization in the uppermost areas of the massif, as it coincides with the simultaneous invasion of taxa like *Pinus nigra* subsp. *laricio* Palib. ex Maire and *Cytisus scoparius* (L.) Link (as documented by Bartolucci & al. 2018b and Galasso & al. 2019).

At the lower extreme of the study area, we report the presence of another invasive species: *Xanthium orientale* L., which is colonising the shores of lake Coghinas and the neighbouring sandy areas.

Furthermore, with this update, we provide valuable information on 74 taxa for which we now have a clearer distributional overview, updated nomenclature, and well-documented chorological changes (e.g., Bacchetta & al. 2020; El Mokni & Pasta 2021; Miguez & al. 2021; Bartolucci & al. 2022; Fois & al. 2022; Jiménez-López & al. 2022; Marchenko & Kuzovkina 2022).

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Article

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First report of a well-established *Ambrosia* (*Asteraceae*) to the non-native African flora

Abstract

El Mokni A-A., El Mokni Ra. & El Mokni Ri.: First report of a well-established *Ambrosia* (*Asteraceae*) to the non-native African flora. — Fl. Medit. 33: 243-250. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

Ambrosia confertiflora a perennial herb native to North America and Caribbean has been recorded as a new alien to the vascular flora of African continent, second report to the Mediterranean area. In Tunisia, *A. confertiflora* is reported naturalized from few localities in the centre of the country where the species has established small and extended populations in surrounding ruderal disturbed habitats. A short morphological description as well as its distribution and habitat in Tunisia with color photos are presented. Moreover, a key to the *Ambrosia* species in the African continent is here firstly provided.

Key words: *Asterales*, alien plants, *Compositae*, floristic data, new record, Tunisia.

Introduction

Since few decades a tendency for invasion of foreign plant species into the southern Mediterranean flora becomes ever more prominent (see e.g. Véla & al. 2013; Meddour & El Mokni 2016; Sukhorukov & al. 2018, 2019; El Mokni & Iamonico 2019; El Mokni & Verloove 2019; El Mokni & Domina 2020; El Mokni & al. 2020; Verloove & al. 2020) where the *Asteraceae* remains one of the largest families of flowering plants and contains major globally naturalized flora (see e.g. El Mokni & El Aouni 2011; Hamel & Azzouz 2018; El Mokni & Iamonico 2018a, 2018b; El Mokni & Domina 2018a, 2018b; El Mokni & Véla 2018; Miara & al. 2018; Verloove & al. 2020; Sakhraoui 2021; El Mokni & al. 2022). *Ambrosiinae* Less is a subtribe of the *Heliantheae* Cassini tribe (*Asterales*, *Asteraceae*), including almost eight genera among which *Ambrosia* L. and *Xanthium* L. are widely spreading in Africa. The genus *Ambrosia* counts more than 50 species, with ragweed or bursage as the commonly known member. *Ambrosia* is naturally occurring in the new world, mainly in North America (Leon de la Luz & Rebman 2019; WFO 2023). It is distributed mostly in the southwestern United States and the nearby North Mexico with an apparent centre of origin and diversity in the Sonoran Desert, but a few species can be

found in Central America and South America (Payne 1966). In Africa, the genus includes almost five casual to naturalized species (APD 2023).

During field work at the centre of Tunisia (N-Africa), an extended population of one *Ambrosia* that looks new to the African continent, has been found. Details about the identity of this new established *Ambrosia* in continental Africa and its habitats are presented. Moreover, a key to the *Ambrosia* species in Africa is here proposed.

Material and methods

Several botanical expeditions were carried through different regions of centre of Tunisia since 2015 to make updates about its wild/non-native flora, especially the undocumented ones. Data on the plant populations and the habitats of the recoded taxa were also collected. For the identification of the species, relevant literature (see e.g. Keil 2012; Flora of North America 2017; EPPO 2019) and examination of specimens preserved at some accessible herbaria were used (MPU, NYBG and P, acronyms follow Thiers 2023 [continuously update]). Collected specimens are deposited at the personal herbarium of the author (Herb. R. El Mokni) housed in the Herbarium of Monastir University (not listed in *Index Herbariorum*).

Results

As stated in the introduction, the unknown species proved to be *Ambrosia confertiflora* DC., a species with native range restricted to the North America (mainly Mexico, Villaseñor Ríos 2016) and Caribbean (Puerto Rico, EPPO 2019 :50), not known yet in the African continent and second report for the Mediterranean area (CABI 2023). All discovered population and subpopulations from different sites of centre Tunisia seem to be well established, suggesting that the species is naturalized and could be more widespread within surroundings if not in other parts of Tunisia and N-Africa. The given morphological description is based in part from material collected in this study.

Ambrosia confertiflora DC., Prodromus Systematis Naturalis Regni Vegetabilis 5: 526. 1836.
≡ *Franseria confertiflora* (DC.) Rydb., N. Amer. Fl. 33: 28. 1922.

Morphological description – (Fig 1). Perennial herb (hemicryptophyte), rhizome-like roots, monoecious; *stems* 60–80(–250) cm erect reddish at the base; *leaves* aromatic, 40–85(–150) mm long and 20–35(–55) mm wide, opposite at the base, mostly alternating higher up, petioles 10–35 mm, blades lanceolate to ovate, 40–85(–150) × 20–35(–55) mm overall, laciniately 2–4-pinnately lobed (lobes more or less lanceolate), bases cuneate to truncate, ultimate margins entire, abaxial and adaxial faces strigillose to sericeous (often grayish) and gland-dotted; *inflorescence* with *pistillate* (female) *florets* lacking petals clustered in distal leaf axils, proximal to staminates, 1(–2)-flowered, style branches long and linear, exserted from involucre and numerous small *staminate* (male) *florets* born on erect

Fig. 1. *Ambrosia confertiflora* in Tunisia : a) habit of the plant and ruderal habitat within roadsides; b) detail of the inflorescence. Photographs by R. El Mokni.

clusters with peduncles 0.5–2.0 mm, involucres cup-shaped, ca. 1.5–3.0 mm in diameter, strigillose, 5–9(–20)-flowered; *fruits* in spiny burs, 1.0–2.0(–5) mm long, 1.5–5.0 mm in diameter, ovoid, more or less tapered at base, pyramidal to pyriform, strigillose to pilosulous, bearing hooked spines, and each one includes a single seed, tips uncinate; *spines* (1–)5–12(–20), mostly distal, stoutly conic to subulate, 0.5–1.0 mm, puberulent and minutely gland-dotted; *seeds* are brown with a diameter of 3.0–4.0 mm.

Phenology in Tunisia – Flowering and fruiting times October to December (sometimes up to January).

Geographical distribution and rate of invasiveness (Fig. 2) – Native to northern Mexico and south-western USA, *Ambrosia confertiflora* has been reported as introduced and naturalized in Australia (New South Wales, South Australia and Queensland) by Watt (1987) and Council of Heads of Australasian Herbaria (2019) and also Palestinian occupied territory including the West Bank (Yair & al. 2017) where it can form very dense stands and outcompetes other plants. Among several other *Ambrosia* species that have proved to be invasive after being introduced to areas outside of their native ranges (*A. artemisiifolia* L., *A. psilostachya* DC., and *A. trifida* L.), *A. confertiflora* spreads very fast, reproducing from seeds and through vegetative propagation, and is considered to have the fastest rate of spread among land invasive alien plants in the Palestinian occupied territory where low winter temperatures in the Mediterranean basin do not seem to affect survival. The numerous spiny burrs stick to the fur of mammals but also spread in flowing water, particularly during floods (EPPO 2019).

Distribution and habitat in Tunisia – *Ambrosia confertiflora* grows mainly in moist localities along the roadsides, in waste places and edges of cultivated fields, more rarely in human-made habitats on loamy and sandy substrates within ruderal vegetation (mainly *Opuntia ficus-indica* (L.) Mill.) and abandoned rocky soils from 85 to 165 m a.s.l. At the

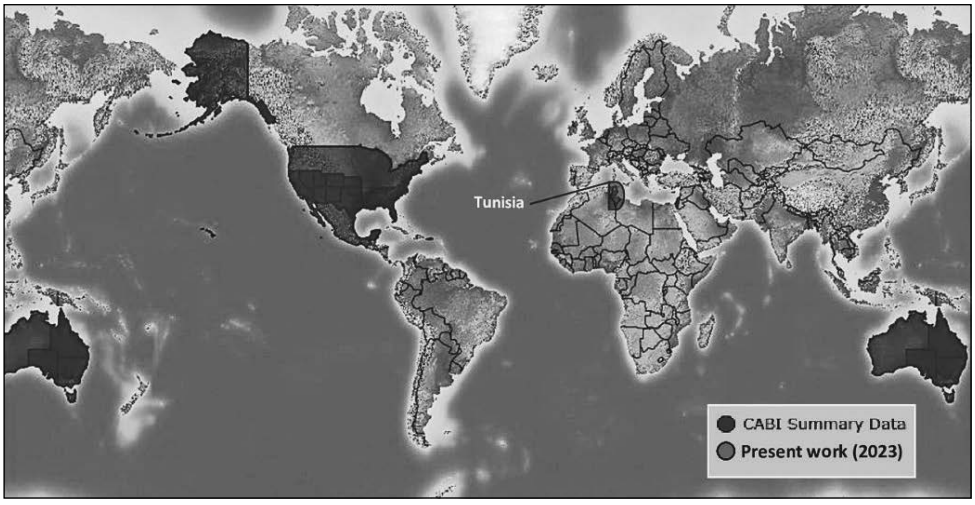

Fig. 2. Actual worldwide distribution area of *Ambrosia confertiflora* red color for CABI summary data and purple color (Tunisia, African continent) for the present work.

sites where it was discovered (Limaya, Menzel chaker, Sfax, CE of Tunisia), it continued growing through winter, spring, and summer but flowering occurred only from October and no benefits were attributed to the plant for the Limaya's habitants.

Selected specimens examined (new records) – Tunisia. Sidi Bouzid towards Sfax, Limaya, Menzel chaker, Sfax (CE of Tunisia), along roadsides, 10 September 2022, *El Mokni s.n.* (Herb. R. El Mokni), ibidem, 07 November 2022, *El Mokni s.n.* (Herb. R. El Mokni).

Diagnostic key to species of *Ambrosia* in Africa

The key below, based on published literature (see e.g. Strother 2006; Karrer & al. 2021; Jepson Flora Project 2023), can be used to distinguish the six species of *Ambrosia* known from the African continent, so far:

1a. Taproots……...……...……...……..……..……2
1b. Bud-bearing creeping roots (stolon-like)…….……...……3
2a. Shrub…….....…….…… *A. arborescens* Mill.
2b. Annual, biennial, perennial herbs ……..……..……....4
3a. Leaf blade lanceolate to ovate, laciniately 2–4-pinnately lobed (lobes ± lanceolate); involucres of staminate heads ca. 1.5–3 mm in diameter; bur spines many (up to 13+), subulate, tips usually uncinate …….……..……*A. confertiflora* DC.
3b. Leaf blade different (pinnatifid to bipinnate with rounded to broadened and separated or linear and connected leaf segments); involucres of staminate heads ca. 2–4(–5) mm in diameter; bur spines 0 to few (1 to 6), conic or straight, tips straight …..……..……5
4a. Annual, leaves sparsely hairy (subglabrous), green, spicy smell ..... *A. artemisiifolia* L.
4b. Annual to perennial, leaves dark green and pubescent above, grey-green and hairy below, aromatic with a strong smell of thyme ……..…….……. *A. maritima* L.
5a. Leaves 2(3)–pinnate compound (only the uppermost ones 1-pinnate), with long and wingless petioles; ultimate segments linear, ca. 1 mm wide; pistillate capitula solitary or few in the axils of the upper leaves; lateral teeth of the fruiting involucre 4–6, conical……...…….. *A. tenuifolia* Spreng.
5b. Leaves 1-pinnate compound or pinnatipartite, subsessile or occasionally on short-winged petioles; ultimate segments wider 2–3 mm; pistillate capitula clustered in the axils of the upper leaves; lateral teeth of the fruiting involucre 1-6, sometimes lacking, blunt ..... *A. psilostachya* DC. (syn. *A. coronopifolia* Torr. & A. Gray.).

Discussion

Ambrosia confertiflora is one more reported taxon for the non-native flora of Africa, second report to the alien *Asteraceae* for the Mediterranean area. Two major established populations/subpopulations were here firstly found in centre Tunisia. The plant produces a large amount of pollen (as with the other *Ambrosia* species) which is considered to be severely allergenic (Yair 2017), causing hay fever and contact dermatitis in susceptible people and classified as noxious (Parsons & Cuthbertson 2001). In the nearer future, all sites of the new alien plant have to be under continuous monitoring to limit its spreading at least via disper-

sal seeds by traffic over very long distances and storm water run-off might along roadsides over short or mid-distances and as a second urgent step and due to its almost not very extended populations, actions for manual eradication (pulling out) must be taken before the flowering period. We strongly discourage the application of herbicides as some of these chemical products have the capacity to move in the environment away from the target area, and to cause damage to non-target plants and animals, besides the ability to cause a loss of vegetation cover and, consequently, an increase in erosion problems.

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Article

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A. Cuena-Lombraña, M. Fois, G. Calvia & G. Bacchetta

An updated checklist of the vascular flora of Montarbu massif (CE Sardinia, Italy)

Abstract

Cuena-Lombraña, A., Fois, M., Calvia, G. & Bacchetta, G.: An updated checklist of the vascular flora of Montarbu massif (CE Sardinia, Italy). — Fl. Medit. 33: 251-268. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

The Montarbu (CE Sardinia) is the second highest carbonate massif of Sardinia. This area mainly consists of a group of limestone mountain outcrops named "tonneri" or "tacchi", with a great variety of micro-environmental and topographic conditions that host a high floristic richness. The main aim of this work is to present an updated checklist of the vascular flora of Montarbu to assess its conservation priorities. Based on several field surveys carried out from 2012 to 2023 and integrated by bibliographic and herbaria analyses, the updated checklist of the vascular flora is presented here. The flora amounts to 874 taxa, belonging to 94 families and 425 genera. Regarding the endemic component, we found 126 taxa, of which 44 are exclusive to Sardinia and 40 are shared with Corsica. The alien taxa are 33, but it appears worrying that 20 are recorded for the first time during the last two decades. The analysis of biologic and chorologic data highlighted the peculiarities of this territory and its biogeographic autonomy. Due to the relatively high number of endemics exclusive to Montarbu and its geological and geomorphological peculiarities, despite the already implemented initiatives, we suggest further activities supporting the conservation of this area.

Key words: alien plants, biodiversity hotspot, conservation, endemism, geographical island, Mediterranean flora, native plants.

Introduction

Mountains worldwide represent important areas for biodiversity and endemism (Steinbauer & al. 2016; Hoorn & al. 2018). The high presence of endemic taxa in mountain environments was sometimes explained within the theory of "mountain islands"; in other words, mountains can act as ecological and/or edaphic and climatic islands (Flantua & al. 2020; Lopez-Alvarado & Farris 2022). The concept of islands within islands has also been developed in phylogeny, biogeography, and ecology (Itescu 2019). These island-like systems, though not as considerable as actual islands, can represent essential places for differentiation and speciation for many taxa (Esposito & al. 2015; Steinbauer & al. 2016). Accordingly, many mountains have been

identified as centers of endemism or "micro-hotspots" within the Mediterranean islands (Cañadas & al. 2014; Kougioumoutzis & al. 2021).

Sardinia is the second-largest island in the Mediterranean Sea, with 24,090 km^2. The prolonged isolation and its high geological diversity created a wide range of habitats rich in endemic species, particularly on its mountain massifs, where the insularity is strengthened by the elevation and edaphic diversity (Médail & Quézel 1997). The Sardinian vascular flora consists of 2,922 total taxa of which are 2,441 natives (Galasso & al. 2018). Recently, 341 taxa have been reported as endemic to the island and neighbouring islands or small portions of other phylogeographically affine regions, amounting to 12% of the entire native floristic contingent (Fois & al. 2022). Among them, 199 are exclusive endemics, corresponding to about 8% of the native Sardinian flora (Fois & al. 2022). According to the biogeographic classification of the Mediterranean region proposed by Rivas-Martínez & al. (2011), the Italo-Tyrrhenian province includes three subprovinces: the Sardinian, the Corsican and the Tuscano-Calabrian. Later on, the complex of Sardinia, Corsica and the Tuscan Archipelago was proposed as an independent biogeographical province within an Italo-Tyrrhenian superprovince, which extends over the entire western coast of the Italian Peninsula (Bacchetta & al. 2012; Bacchetta & Pontecorvo 2005). Basing their studies on the endemic vascular flora, the Sardinian subprovince was furtherly divided into six sectors and 22 biogeographic subsectors (Fenu & al. 2014).

The present study focused on the updating previous floristic research on the Montarbu massif (Loi & Lai 2001; Loi & al. 2004). This mountain range includes some of the highest carbonate peaks, such as Pizzu Margiani Pubusa and Perda 'e Liana, located in the historical region of Ogliastra, in the central-eastern Sardinia, that constitute an independent biogeographic subsector within the "Barbaricino" sector (Fenu & al. 2014). The geographical position, elevation, isolation, and complex geology of this area contributed to the exceptional plant and animal species richness and to the local variety of unique ecosystems and landscapes. According to the regional law L.R.31/89, about 70% of the Montarbu massif area has been included in the "Golfo di Orosei e del Gennargentu" National Park, established in 1998 but never entered into force. Within this area, the same law L.R.31/89 recognised the calcareous outcrop of Perda 'e Liana as a Regional Natural Monument. These mountains are also included within the Special Areas of Conservation (SAC) "Monti del Gennargentu" (ITB021103; European Commission Habitats Directive 92/43/EEC).

In this paper, we summarised and critically revised both published and unpublished data about the vascular flora of Montarbu and its conservation status. Even though the area has been the focus of numerous botanical studies (e. g., Loi & Lai 2001; Loi & al. 2004; Bacchetta & al. 2004, 2009, 2010, 2014, 2020; Farris & al. 2012; Calvo & Aedo 2015; Brullo & al. 2023) due to its high floristic importance, and considering the recently described and reported species, there is an evident need for further research in the area. Therefore, an update of the Montarbu vascular flora was of critical importance for planning and performing a more effective conservation and management. This checklist, coupled with the analysis of its more relevant components, supports the evaluation of local phytodiversity, highlights its relevance, and sheds light on the conservation status in this area.

Materials and methods

Study area

Montarbu (Fig. 1) consists of a group of limestone mountains and small tablelands, which are commonly called "tonneri" or "tacchi" (Loi & Lai 2001). The study area has a total surface of 42 km^2 and is located in central-eastern Sardinia, in the municipalities of Seui and Gairo (Nuoro). The highest mountain peaks, some of which with elevations higher than 1,200 m a.s.l., are in the northern part of the investigated territory: Pizzu Margiani Pubusa (1,324 m a.s.l.), Perda 'e Liana (1,293 m a.s.l.), Pizzu Andriottu (1,232 m a.s.l.), Accu Linnaru (1,193 m a.s.l.), Bruncu Arrascialei (1,178 m a.s.l.), and Pizzu Is Abis (1,102 m a.s.l.). The peaks of the southern sector reach lower altitudes, rarely exceeding 1,000 m

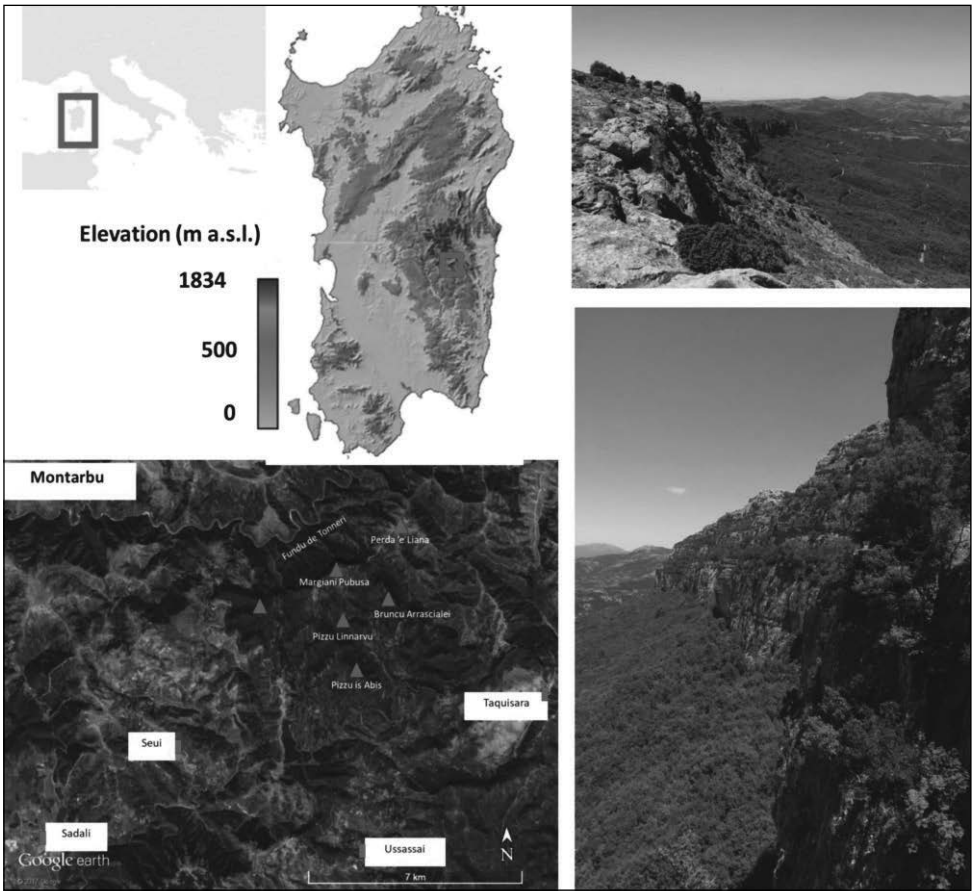


Fig. 1. The study area of Montarbu massif (central-eastern Sardinia) with some typical landscapes: "Pizzu Margiani Pubusa", photo taken from the upper, westwards (top right) and "Fundu de Tonneri", taken from the West to the East (bottom right).

a.s.l. Different environments, such as steep cliffs and gorges (even more than 100 m deep), small wetlands, vast scrublands and woodlands constitute other relevant landmarks scattered over the whole area. Moreover, there are restricted vegetation types of high biogeographic and conservation interests, such as the relict formations with temperate trees like the woods with *Taxus baccata* L., *Ilex aquifolium* L., *Acer monspessulanum* L. and *Ostrya carpinifolia* Scop. (Bacchetta & al. 2004, 2009; Farris & al. 2012).

Apart from some specific studies (e.g., Arrigoni 1965, 1973), the flora of part of this area was published in a relatively recent past (Loi & Lai 2001; Loi & al. 2004). Due to its difficult accessibility, especially to the high cliffs, new endemic plant species were only been described or found in recent years, such as *Senecio morisii* J.Calvo & Bacch., *Pinguicula sehuensis* Bacch., Cannas & Peruzzi, *Hypericum scruglii* Bacch., Brullo & Salmeri, *Genista nuragica* Bacch., Brullo & Giusso, *Solenopsis bacchettae* Brullo, C.Brullo, Tavilla, Siracusa & Cambria and *Siler montanum* subsp. *ogliastrinum* Bacch., F.Conti & Bartolucci (Bacchetta & al. 2010, 2014, 2020; Calvo & Aedo 2015; Conti & al. 2021; Brullo & al. 2023). Moreover, it should be noted that the flora of some marginal crystalline environments, which include part of the Flumendosa valley bordering the study area with the Gennargentu massif and home to some species of particular conservation interest, such as the endemic *Rhamnus persicifolia* Moris, were not included in any previous flora. According to its high endemicity rate, this area has also been identified as a "micro-hotspot" of biodiversity (Fois & al. 2018a). Moreover, part of its peculiar flora has recently been the object of studies concerning several aspects, such as ethnobotany (Sanna & al. 2020), spatial ecology (Fois & al. 2018b) or seed ecophysiology of threatened taxa (Mattana & al. 2012; Cuena-Lombraña & al. 2020; Porceddu & al. 2020).

Geology and geomorphology

From a geological point of view, the studied area comprehends metamorphic, volcanic, and sedimentary outcrops of the Palaeozoic and the Mesozoic. Chronologically, Palaeozoic phyllitic schists and micaschists, which were intensely corrugated and metamorphosed during the Hercynian orogeny (Silurian, approximately 443–419 Ma ago, extending from the close of the Ordovician to the beginning of the Devonian), constitute the basement. Therefore, surface erosion agents swiftly disassembled the mountain range that had risen during the Hercynian orogeny. The detritus from higher elevations was then deposited into depressions, frequently occupied by lacustrine basins. This sedimentation process persisted until the conclusion of the Permian period (298–252 million years ago), spanning from the end of the Carboniferous to the beginning of the Triassic. It was during this time that post-orogenic volcanic activity commenced, leading to the formation of effusive eruptive rock covers (Carmignani & al. 2016). In the Mesozoic, other events affected the geologic formation of this area. Currently, the calcareous succession is characterised by the "Dorgali formation" of the middle-late Jurassic Period (c.a. 170-150 Ma), which here reaches a thickness of about two hundred meters and has a slightly southward-inclined pattern, comprising grey or yellowish limestones, sometimes oolithic, dolomites and dolomitic limestones (Agnesi & al. 1990; Carmignani & al. 2016). The predominant soils in the study area are lithosols (lithic and typic xerorthents) supporting vegetation represented by a very sparse maquis, red soil (lithic and typic rhodexeralfs) with a clayey horizon more than 15 cm in thickness, with a very scarce cover represented by forms of degra-

dation of maquis and garrigue, and the inceptisols (lithic and typic xerochrepts) with forest vegetation or evolved maquis (Loi & Lai 2001).

The hydrography of the area is mainly characterised by the course of the Flumendosa River, which is the most extensive hydrographic system of Sardinia and defines the entire northern border of Montarbu, flowing mostly westwards along this stretch. A system of smaller tributaries flows northwards from the highest peaks, feeding the main watercourse through the northern sector. The streams that flow mostly southwards are larger than those flowing in the northern part and are rich in interesting habitats and plant communities (e.g., Rio Ermolinus) and often host rare or endemic taxa.

From a bioclimatic point of view, these territories have a Mediterranean Pluviseasonal Oceanic bioclimate. The observed thermotype and ombrotype indices are comprised between the Euoceanic lower Mesomediterranean and lower subhumid in the basal areas and Semicontinental lower Supramediterranean and lower humid among the peaks (Bacchetta & al. 2009; Canu & al. 2015).

Data collection and analysis

The floristic list presented here issues from field surveys carried out from 2012 to 2023 and extensive analysis of relevant literature, implemented with the data from CAG, SASSA, and SS herbaria.

Collected specimens had been identified using the most relevant and updated floras: Tutin & al. (1964-1980, 1993), Castroviejo & al. (1986-2019), Arrigoni (2006-2015), Jeanmonod & Gamisans (2013), and Pignatti & al. (2017-2019).

The nomenclature follows the most recent checklists of the Italian native (Bartolucci & al. 2018) and alien (Galasso & al. 2018) vascular flora, updated taking into account some floristic and taxonomic novelties (e.g., Bartolucci & al. 2019; Bacchetta & al. 2020). Family names follow PPG I (2016) for Pteridophytes, Pignatti & al. (2017-2019) for Gymnosperms, and APG IV (2016) for Angiosperms.

Life forms had been determined in the field following the classification of Raunkiaer (1934). Chorology follows the abbreviations proposed by Pignatti & al. (2017-2019). Doubtful taxa previously recorded were considered in the checklist as *taxa inquirenda* or *taxa excludenda* and enlisted in different tables (see Electronic Supplementary File 1, ESF1 - Table S2 and S3, respectively).

Details and characteristics regarding the alien flora were based on the national standardised system presented in the study of Galasso & al. (2018). Alien: plants occurring in a specific area, whose presence in Sardinia can be attributed either to intentional or unintentional human activities, or that naturally spread from a non-native region. Casual: alien plants that may flourish and occasionally produce offspring beyond cultivation or unintentional dissemination. However, they usually fade away as they are unable to establish self-sustaining populations. Their persistence is contingent on recurrent introductions. Naturalized: alien plants that occur with self-maintaining populations without direct human intervention. Invasive: alien plants that occur with self-maintaining populations without direct human intervention, produce fertile offspring at considerable distances from the parent individuals, thus being able to spread over a large area. Furthermore, in our classification, archaeophyte taxa pertain to alien plants introduced to Sardinia before 1492, while neophytes refer to those introduced after this date. The term ‘cultivated’ is used to

differentiate taxa exclusively found under cultivation (based on visual data from the authors) from those that have become more or less established within the local ecosystems.

Results

The floristic checklist consists of 874 taxa, belonging to 94 families and 425 genera (see ESF1 - Table S1 for further details). The taxa at species level are 678, and 196 are considered at the subspecies level. Pteridophytes are 17, which represent 1.97% of the total flora; Gymnosperms consist of 10 taxa, representing 1.14%, of which only the genera *Juniperus* and *Taxus* are native; Angiosperms are 846 taxa, with a percentage equal to 96.90%. The *taxa inquirenda* are 26 (ESF1 - Table S2) and *taxa excludenda* are 18 (ESF1 - Table S3).

Considering families (Fig. 2), the most represented are *Asteraceae* (97 taxa, 11.11%), *Fabaceae* (95, 10.88%), *Poaceae* (83, 9.50%), and *Orchidaceae* (38, 4.35%). The richest genera are *Trifolium* (19 taxa), *Ranunculus* (17 taxa), *Carex* (14 taxa), and *Medicago* (13 taxa).

Biological life forms highlight a substantial richness in therophytes (T = 35.62%), followed by hemicryptophytes (H = 31.73%), geophytes (G = 13.52%), trees and shrubs (P = 7.90% and NP = 2.98%, respectively) and hydrophytes (I = 1.49%) (Fig. 3).

Chorological data (Fig. 4) show a prevalence of Mediterranean (*s.l.*) taxa (30%), followed by European (*s.l.*) ones (28%) and by a further 14% of endemic elements (Fig. 4). The endemic contingent consists of 126 taxa, belonging to 36 families and 96 genera. The

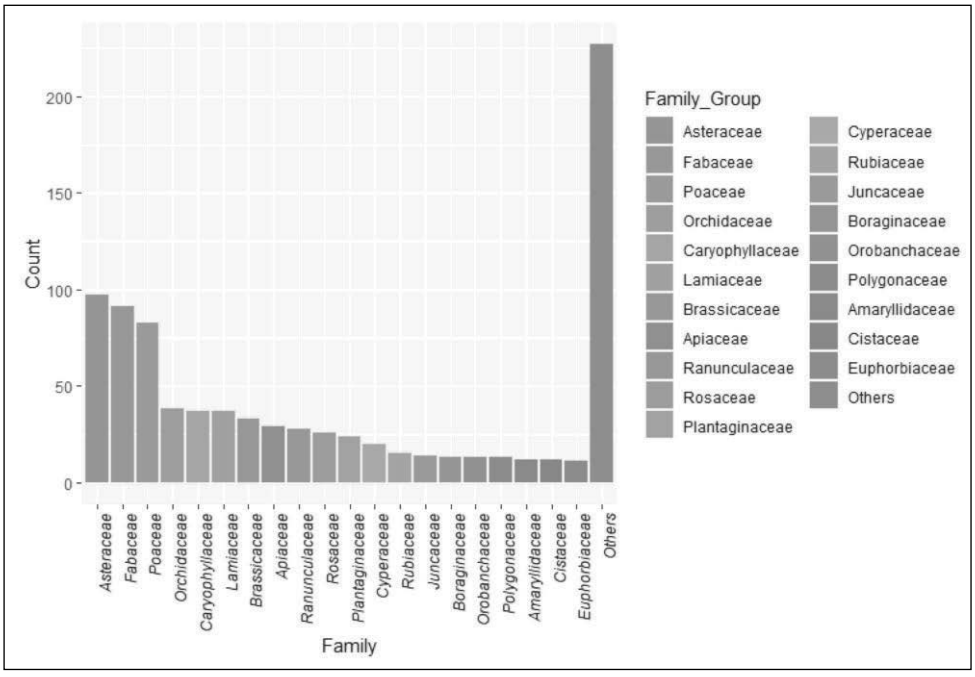


Fig. 2. Number of taxa of the flora of Montarbu by family. Here only the top 20 families are reported.

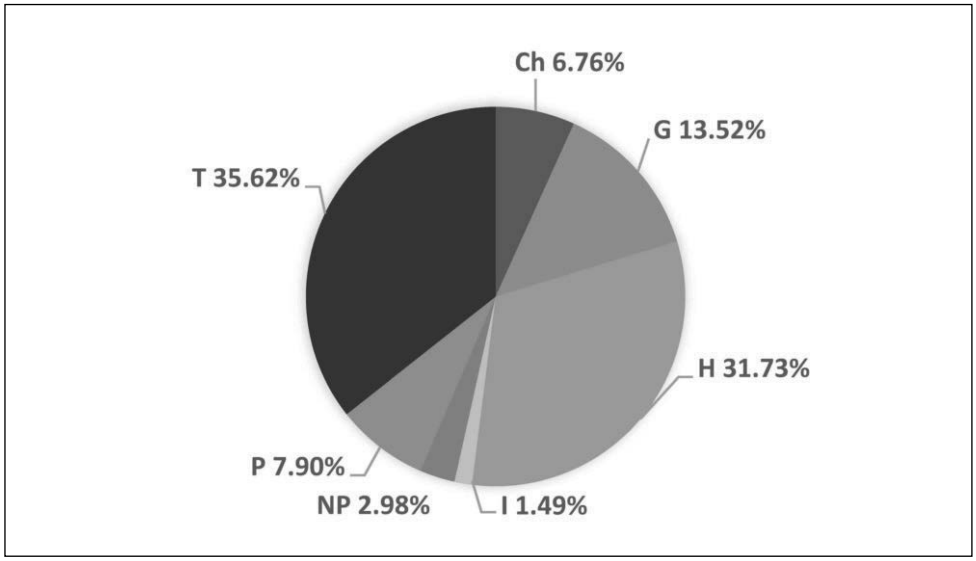


Fig. 3. Biological spectrum of the vascular flora of Montarbu. Life forms: H = hemicryptophytes; Ch = chamaephytes; G = geophytes; NP = nanophanerophytes; P = phanerophytes; T = therophytes and I = hydrophytes.

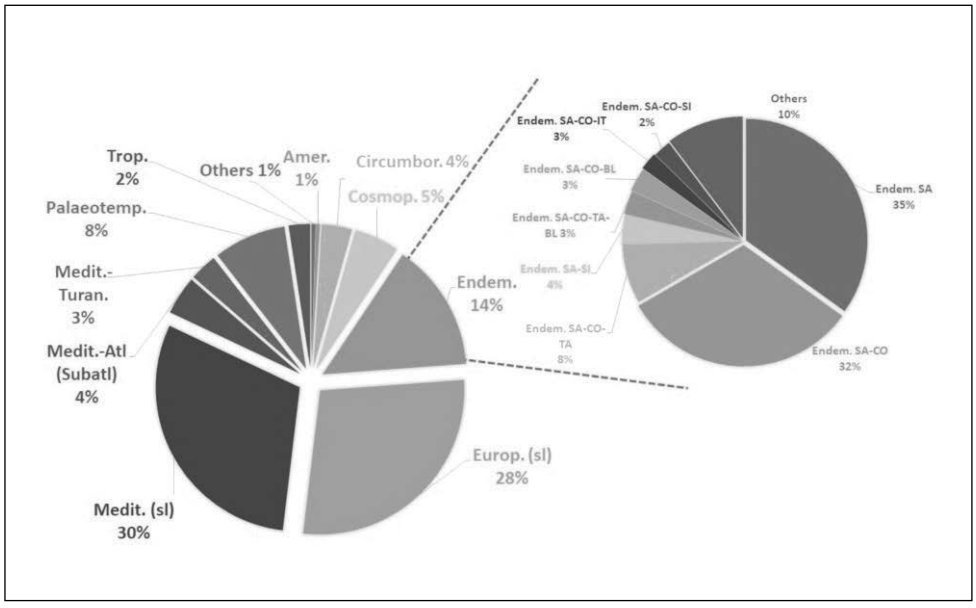


Fig. 4 Chorological spectrum and details regarding the endemic contingent of the flora of Montarbu. SA = Sardinia; CO = Corsica; BL = Balearic Islands; IT = Italian peninsula; SI = Sicily; and TA = Tuscan Archipelago.

families with the highest numbers of endemic taxa were *Asteraceae* (16), *Lamiaceae* (11) *Caryophyllaceae* (10), and *Orchidaceae* (9). The chorology of endemics showed the prevalence of Sardinian (35%) and Sardo-Corsican taxa (32%), that together reach 67% of the total, followed by taxa endemic to Sardinia, Corsica and Tuscan Archipelago (8%), and by the Sardinian and Sicilian endemics (4%). Among the endemic taxa, four only occur in the study area (*Genista nuragica*, *Pinguicula sehuensis*, *Siler montanum* subsp. *ogliastrinum* and *Solenopsis bacchettae*).

We found 33 alien taxa (3.78% of the total flora) (Fig. 5), of which nine are considered invasive, 13 are naturalised and one is a casual alien. Another component of the alien taxa regards the cultivated (8) or cryptogenic (2) taxa. The biological spectrum of the alien flora showed a prevalence of phanerophytes (19 taxa), followed by therophytes (9 taxa), hemicryptophytes and chamaephytes (two taxa both) and one geophyte. From a chorological perspective, the alien taxa were primarily of European or Euro-Mediterranean origin, with a notable prevalence attributed to the cultivated component (e.g. *Corylus avellana* L., *Castanea sativa* Mill., *Juglans regia* L. *Olea europaea* L.). Regarding the invasive taxa, they were primarily of American and Tropical origin, each represented by four taxa. Additionally, there was one taxon each from New Zealand, Macaronesia, and Africa.

Over the taxa included in the most recent Italian Red List (Rossi & al. 2020; Fois & al. 2022), we found 15 Endangered (EN), six Vulnerable (VU), 23 Near Threatened (NT), five Data Deficient (DD) and 67 Least Concern (LC) taxa (Fig. 6).

A total of 325 taxa are here reported for the first time. Twenty of them are alien taxa, accounting for 60.6% of all alien taxa found in the study area, and 40 are endemic, representing 31.7% of the 126 endemic taxa (ESF1 - Table S1).

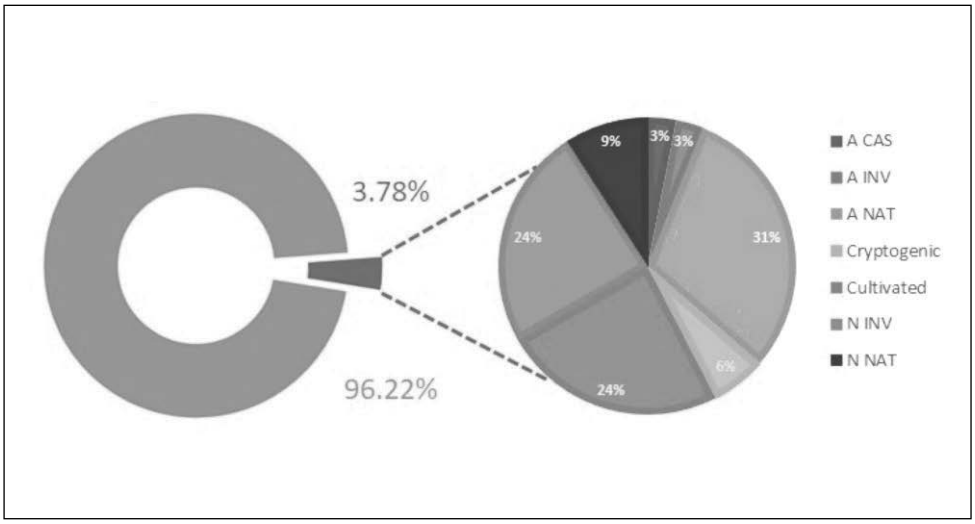
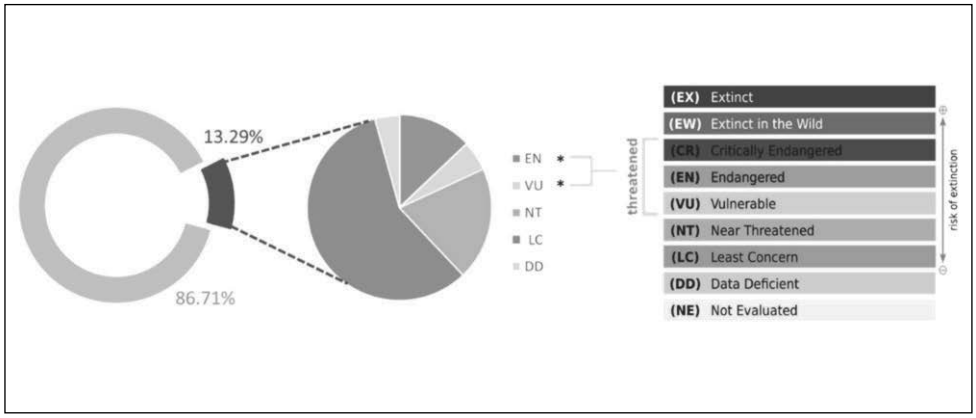


Fig. 5 Native and alien flora details of the flora of Montarbu: A = archaeophytes; N = neophytes; CAS = casual; INV = invasive; NAT = naturalised.

Fig. 6 Vascular plants of Montarbu subject to IUCN assessment and details on their risk categories.



Discussion

The vascular flora of Montarbu includes 841 native taxa, equal to 36.5% (Table 1) of the total flora of Sardinia in less than 0.2% of the whole island surface. These values of species richness appear remarkably high if compared, among others, even with the plant-rich Gennargentu and Limbara massifs, which host more than 30% and 41% of the regional flora, respectively, both in an area near to 1% of the island (Bacchetta & al. 2013; Calvia & Ruggero 2020, 2023).

When evaluating the native taxa richness(n)-to-area ratios (Table 1), Montarbu stood out with a notably high ratio (20.02 n/km^2), followed by the other calcareous chain of Monte Albo (9.51 n/km^2). This suggests a significant influence of lithology in shaping the phytodiversity of Sardinia. This is also confirmed by the lower ratio found for the metamorphic and igneous Gennargentu (1.82 n/km^2) and Limbara (3.85 n/km^2) massifs. Base-rich substrates, and especially limestones, have been observed to be richer than other substrates in various contexts, such as in Sicily or Crete (Sciandrello & al. 2020; Kougioumoutzis & al. 2021). A hypothesis of such higher species richness on calcareous soils in Sardinia and, more generally in Europe, is that carbonate substrates were widely distributed during the Quaternary period and that this influenced the evolution of many plant species on high pH soils (Djordjević & Tsiftsis 2019).

All the aforementioned mountainous areas show a higher density of plant taxa than Sardinia as a whole, which suffers from higher levels of unsustainable land use, habitat degradation and a higher frequency of exotic flora and fauna. In other words, the phytodiversity in mountain areas, apart from the phylogeographical reasons, mainly related to isolation and habitat specificity, is favoured by a lower accessibility and pressure from humans compared to coastal areas and inland plains, which are more impacted, mainly by extensive and long-standing agriculture and urbanization.

Among the most recent floristic novelties for this area, those taxa recently described for the Sardinian flora, such as *Pinguicula sehuensis*, exclusive to the North-Western part of

Table 1. Some information on the vascular floras of other mountain massifs in Sardinia and the whole flora of the island.

Characteristics	Montarbu	Gennargentu	Limbara	Monte Albo	Sardinia
Total taxa	874	948	1,147	659	2,922*
Native taxa	841 (96.22%)	910 (95.99%)	1,010 (88.10%)	647 (98.17%)	2,441 (83.54%)*
Alien taxa	33 (3.70%)	38 (4.01%)	137 (11.90%)	12 (1.83%)	481 (16.46%)*
No. families	94	97	120	82	152*
No. genera	425	427	486	393	730*
No. endemic taxa	126	141	86	49	341**
Area (km^2)	42	500	262	68	24,090
Native taxa/total island native taxa	36.5%	30.0%	41.0%	28.1%	-
Ratio native taxa richness/area	20.02	1.82	3.85	9.51	0.10
References	This work	Bacchetta & al. (2013)	Calvia & Ruggero (2020)	Camarda (1984)	*Galasso & al. (2018) **Fois & al. (2022)

Montarbu, are worthy of attention. Currently, only one population is known, with seven subpopulations occurring in vertical cliffs (chasmophytic habitat), and one linked to small terraces among cliffs (Bacchetta & al. 2014). Another species recently described is *Senecio morisii* (Calvo & Aedo 2015), previously reported as *S. doria* L. (Arrigoni 2006-2015). This species grows only in CE Sardinia, on saturated calcareous soils along the banks of streams and springs, under woods of *Ostrya carpinifolia,* often accompanied by *Taxus baccata* and *Ilex aquifolium*, at elevations between 700–1,200 m a.s.l. (Calvo & Aedo 2015). Another taxon with a similar distribution and ecology is *Hypericum scruglii*, an endemism recently described (Bacchetta & al. 2010) and previously reported as *H. tomentosum* L. (Loi & Lai 2001). More recently, the new species *Genista nuragica* within the *G. salzmannii* group has been described (Bacchetta & al. 2020). It is a dwarf shrub exclusively growing on the windy ridges of Montarbu di Seui, at an elevation of 1,250–1,310 m a.s.l. Recent studies on the *Siler montanum* group (Conti & al. 2022) have also allowed to describe *S. montanum* subsp. *ogliastrinum*, a subspecies endemic to the limestone cliffs of Ogliastra. Finally, the most recent taxon described for this area is *Solenopsis bacchettae*, an exclusive species of CE Sardinia, typical of calcareous substrates in wet habitats such as springs and small streams (Brullo & al. 2023).

The remaining newly reported taxa mainly concerned alien introductions or colonisations, such as *Ailanthus altissima* (Mill.) Swingle or *Erigeron canadensis* L., or neglected, cryptic and rare taxa, such as *Bivonaea lutea* (Biv.) DC., *Monotropa hypopitys* L., or *Hypericum aegypticum* subsp. *webbii* (Spach) N.Robson. For the reasons mentioned above, it is essential to highlight the need to keep on updating the floras to incorporate new records/taxa, their nomenclature, and their conservation status.

Overall, *Asteraceae*, *Fabaceae* and *Poaceae* are usually the most represented families of the vascular flora (e.g., Bacchetta & al. 2013; Cannucci & al. 2019; Calvia & Ruggero 2020; Nikolić & al. 2020). However, the flora of Montarbu di Seui also shows a high presence of *Orchidaceae*, including several taxa exclusive to Mesozoic limestones (Lussu & al. 2020). This apparently surprising result is not an uncommon feature; in fact, numerous studies have highlighted that - especially in the European countries under Mediterranean bioclimatic conditions - calcareous substrates (limestone-dolomite, in particular) are the most favourable for the growth and survival of orchids (Landi & al. 2009; Pierce & al. 2014; Djordjević & Tsiftsis 2019; Tsiftsis & al. 2019).

Data relating to the biological spectrum underline the Mediterranean character of the area, a pattern that is confirmed by the H/T index = 0.88 (T = 35.62%; H = 31.52%). According to Cannucci & al. (2019), typical Mediterranean conditions occur if H/T = <1, while under continental bioclimatic conditions H/T > 1. Compared to the flora of Gennargentu (H/T index = 1.05: Bacchetta & al. 2013), Montarbu hosts a higher number of Mediterranean vascular plants. The rate of woody taxa (P/NP = 10.8%) is similar to Monte Albo (P = 9.7%: Camarda 1984) and Genneragentu Massif (ca. P/NP = 11.6%: Bacchetta & al. 2013), but lower than the one recorded for Mount Limbara (P/NP = 12.7%: Calvia & Ruggero 2020). The high percentage of hemicryptophytes and chamaephytes (31.52% and 6.75%, respectively) can be correlated to the abundance of natural rocky crevices and Mediterranean climatic conditions. The percentage of geophytes (G = 13.52%) results higher than that of Gennargentu (12.13%: Bacchetta & al. 2013) and Limbara (12.90%: Calvia & Ruggero 2020) massifs and seems to be more related to the high presence of *Orchidaceae*. This richness can also be related to land use, especially in relation to the practice of setting fires and other sylvo-pastoral activities shared with other Sardinian mountain systems, which favoured the formation of different environmental types, thus allowing better conditions for geophytes and orchids as well. The percentage of hydrophytes, mainly located along watercourses and around springs, is significant (I = 1.49%), due to the geological nature of the territory that facilitates infiltration and percolation processes. These are mainly located in the lower parts, where the Hercynian basement is in contact with the overlying limestone outcrops and where the waters of the upper parts flow out, giving rise to numerous springs, rivulets and streams, which are also of high faunistic interest due to the presence, among others, of the Mediterranean brown trout *Salmo cettii* and the endemic Sardinian newt *Euproctus platycephalus* (Lecis & Norris 2003; Sabatini & al. 2018). The percentage of hydrophytes is more similar to that of the Limbara Massif (1.9%: Calvia & Ruggero 2020) than the closer mountains of the Gennargentu Massif (0.53%: Bacchetta & al. 2013).

Chorological data show a dominance of Mediterranean and endemic taxa; their total amounts correspond to 51% of the entire local vascular flora. Nonetheless, the remarkable importance of this area is increased by those chorological elements, such as Palaeotemperate (8%) and Circumboreal (4%) taxa, testifying past different climatic conditions, that can still be observed in the relic *Taxus baccata* and *Ostrya carpinifolia* communities, confirming the complex geological history and prolonged insularity leading to the inclusion of Montarbu massif as a putative Mediterranean refugium and micro hotspot (Fenu & al. 2014).

The richness of endemic taxa is among the most relevant elements highlighted in this study, although in line with the general proportion of endemics in Sardinia (approx. 14% of its total native flora, Fois & al. 2022). The presence of endemics in the study area is facilitated by its high biological and ecological diversity. Simultaneously, this underscores the robust association between limestone mountain environments, especially cliffs, and endemism. This connection has been previously highlighted by Fenu & al. (2010) for the Supramontes area and by Bacchetta & al. (2013) for the Gennargentu in Sardinia. Similar patterns have been observed in various locations throughout the Mediterranean, as highlighted by Thompson (2020) and references therein.

Alien taxa correspond to a low percentage (3.7%, Table 1), which is a further confirmation of the high ecological value of this area. This component was mainly originated by reforestations during the 1970s and 1980s, which have partly modified the original landscape. Only seven of the alien taxa are considered invasive, albeit their impact in the studied territory is still not particularly high. However, more than half of the alien taxa (20 over 33 taxa) were recorded for the first time during the last decades, highlighting the need to pay attention on this potential threat, which is particularly common, especially in islands (Fois & al. 2020). Similarly, another important part of newly reported taxa is consisting of ruderal and synanthropic ones, such as *Dittrichia graveolens* (L.) Greuter or *Hyoscyamus albus* L.

From a conservation point of view, only 13.29% of the flora of Montarbu di Seui has been assessed following the IUCN criteria. In particular, 15 taxa are Endangered (EN), and six are Vulnerable (VU). Five taxa were already assessed as Data Deficient (DD), while other recent discoveries, such as *Genista nuragica*, are not yet assessed, confirming, once again, the need to enhance the current knowledge about conservation statuses. It should be noted that many endangered taxa, such as *Solenopsis bacchettae, Hypericum scruglii, Borago pygmaea* (EN, IUCN category) or *Senecio morisii* (VU, IUCN category) are closely linked to wetlands, and their survival is threatened by anthropogenic alterations of the water regime, such as withdrawals of water from the springs, possible reclamation works or climate change (Bacchetta & al. 2010; Cuena-Lombraña & al. 2021). Moreover, a considerable number of orchid taxa clearly show a preference for moderately humid to wet habitats (Djordjević & Tsiftsis 2019). Given their conservation significance, their recognition is particularly emphasised in multilateral environmental agreements, including the Water Framework Directive (WFD 2000/60/EC). Other endangered (EN) taxa, such as *Centaurea filiformis* Viv. subsp. *filiformis* or *Sesleria insularis* subsp. *barbaricina* Arrigoni, are more closely associated with xeric cliffs and screes. They may be particularly susceptible to stochastic episodes induced by the growing frequency of extreme meteorological events or by tourism, especially the rise in climbers opening new routes. Similar threats may affect chasmo-hygrophilous species living in wet crevices and cliffs, such as the endangered (EN) *Aquilegia nugorensis* Arrigoni & E.Nardi and the vulnerable (VU) *Pinguicula sehuensis*.

These results indicate that Montarbu is one of the most interesting massifs of Sardinia from a botanical point of view. Consistent with the findings of Bacchetta & al. (2013), where regions in Sardinia dominated by limestone and carbonate rocks were examined, the count of exclusive Sardinian endemics appeared to be greater in the limestone reliefs than in the Limbara and Gennargentu massifs, which are considered a putative floristic refuge

according to the criteria of Médail & Diadema (2009). Similarly, cliffs – especially limestone cliffs have acted as refuges for many plants which were able to survive there safe from anthropogenic and environmental stress and disturbance factors, resulting in unique habitats with many rare and endemic species that are particularly sensitive to interspecific competition and/or environmental changes (Lorite & al 2017). These habitats have proven to be very useful in addressing a significant number of ecophysiological and evolutionary issues, thereby constituting a priority for biodiversity conservation (Bacchetta & al 2013; Cañadas & al. 2014). Wet habitats, together with cliff habitats, can be considered ecologically or topographically controlled "islands". Due to the high number of endemics, exclusive endemics and peculiarities related to geology and geomorphology, and according to the recent conservation policies at local level (Fenu & al. 2010), Montarbu is a reservoir for plant diversity and already defined as a "micro-hotspot" of biodiversity within the Mediterranean "mega-hotspot", and its protection is of pivotal importance (Bacchetta & al. 2013; Cañadas & al. 2014).

Conclusions

Despite its relatively small extent, Montarbu massif presents a high diversity in vascular plants, being their flora made up of 874 specific and subspecific taxa. Even if comparison with previous floras is difficult, mainly because of the different extent of the examined area, several plant species are reported for the first time in a checklist concerning this area. These new reports contribute to the already extensive list of endemic and exclusive taxa found in this area. An increasing number of non-native vascular taxa has been recorded. Although less representative, European, temperate and circumboreal taxa play a relevant role, and the plant communities where they belong are important from both the ecological and conservation point of view. These taxa and communities are often represented by peripheral and isolated plant populations at the edge of their distribution range, thus particularly sensitive to climate change and global warming. Overall, considering the high endemicity rate, the increasing number of alien taxa and the endangered ones, along with those potentially endangered, we confirm the importance of conserving and pursuing floristic investigations in this area.

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Article

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Ignazio Camarda & Francesco M. Raimondo

Daphne oleoides subsp. *sardoa* (*Thymelaeaceae*), a new subspecies from Sardinia (Italy)

Abstract

Camarda I. & Raimondo F. M.: *Daphne oleoides* subsp. *sardoa* (*Thymelaeaceae*), a new subspecies from Sardinia (Italy). — Fl. Medit. 33: 269-277. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

Daphne oleoides subsp. *sardoa* is a chamaephyte scrub described as a new subspecies occurring in the siliceous and limestone mountains of central Sardinia, characterised by cleistogamous flowers, purplish-purple hypanthium with generally erect short triangular segments.

Key words: vascular flora, taxonomy, endemism, Mediterranean islands.

Introduction

Daphne oleoides Schreber is a chamaephyte described "*in Crete montosis"*. Its range is widespread in the Mediterranean mountains area including the Balcanic peninsula, Albania, Bulgaria, Greece, Kriti, Turkey, Syria, Lebanon, Italy, Sicily, Sardinia, Corse, Algeria, Morocco, and Spain (Greuter & al. 1984). Consequently, to the large distribution range some synonyms, subspecies or varieties are described (WFO 2023): *Daphne buxifolia* Vahl,, *D. euboica* Rech.f.*, D. caucasica* M.Bieb.*, D. glandulosa* Bertol., *D. oleoides* var. *glandulosa* (Bertol.) Keissl., *D. glandulosa* Spreng.*, D. gnidioides* Szov. ex Meisn.*, D. hispanica* Pau in Bol., *D. hispanica* var. *granatensis* Pau, *D. oleoides* var. *hispanica* (Pau) Cuatrec., *Daphne oleoides* subsp. *hispanica* (Pau) Rivas Mart.*, Daphne jasminea* Sm.*, Daphne lucida* Loisel., *Daphne sericea* Noë ex Meisn.*, Daphne kurdica* Bornm.*, Daphne oleoides* var. *brachyloba* Meisn.

Daphne oleoides is currently divided in four subspecies (Halda 2001): *D. oleoides* subsp. *oleoides*, *D. oleoides* subsp. *baksanica* (Pobed.) Halda, *D. oleoides* subsp. *transcaucasica* (Pobed.) Halda, and *D. oleoides* subsp. *kurdica* (Pobed.) Halda.

In Sardinia the species of *Thymeleaceae* are: *Thymelaea hirsuta* (L.) Hendl.*,* coasts and hills, *Thymelaea tartonraira* (L.) All., rather widespread from sea level to 1000 m hight, *Daphne gnidium* L., very common in the siliceous macchia, *D. laureola* L., only at the top at the Limbara mountain. *D. oleoides* s. l. is rather rare and exclusive on the garrigues of the siliceous soils of Gennargentu and central-eastern limestone mountains (Moris 1827;

Camarda & Valsecchi 1990; Arrigoni 2010; Arrigoni & Camarda 2014; Pignatti 2017). Recent observations by the authors in the Sardinian population of Gennergentu (Camarda & Raimondo 2020) have highlighted unusual characters recurring in all plants hitherto referred to *D. oleoides* subsp. *oleoides*. The extension of observations in nature and the subsequent study of herbarium materials led the authors to distinguish the Sardinian populations of *D. oleoides*, recognizing it as a new subspecies.

Materials and methods

The study was conducted through observations in nature, analysis of the literature and herbarium materials reported below.

Specimens examined – Creste da Bruncu Spina a Punta La Marmora, 18.6.1996, I. *Camarda* (SS); Desulo. Da Rifugio CAI ad Arcu Gennargentu, 13.6.2006, *I. Camarda* (SS); Desulo. Gennargentu, da Ortu is Aragnos a Rifugio Lamarmora, is Miriagus, 7.5.2006, *I. Camarda*, (SS); Tuones, limestone slopes, at the bend before the end of the path to Scala Pradu, 28.7.2022, *I. Camarda & D. Ruju* (SS); Perda Liana on a limestone rock along path to the top, 28.7.2023, *I. Camarda* & *U. Nieddu* (SS).

Specimens examined through images from Arrigoni's Sardinian Herbarium in Firenze – Sardegna: Gennargentu, 7 agosto 1960. Legit *P.V. Arrigoni* (FI); Sardegna: Orgosolo, Supramonte di Orgosolo, 1964, Legit *P. Barba* det. P.V. Arrigoni (FI); Gennargentu, 17.7.1966, Legit *P.V. Arrigoni* (FI); Sardegna: M.te Gennargentu, da B. Furau a P. Lamarmora, 17.7.1966, Legit *P.V. Arrigoni*. Sardegna: M.te Gennargentu, Parte alta del fianco sinistro di Riu Aratu a m 1350-1500, 23/7/ 1968, Legit. *P.V. Arrigoni* (FI); Sardegna: M.te Gennargentu, Pascoli da Bruncu Spina a Punta Paolina e dintorni del rifugio Lamarmora, 6.7.1969, Legit P.V. Arrigoni (FI); Sardegna: M.ti del Gennargentu. Versante Nord di Bruncu Allasi, m 1600-1699, 12.7.1970, Legit *P.V.Arrigoni* (FI); Sardegna: Baunei. Rupi calcaree, quota 815 m, a SE della regione di Scoroddine, 30.4.1971, Legit *P.V. Arrigoni et E. Nardi* (FI); Sardegna: M.te Gennargentu, dal Rio Paulinu, presso il Rifugio ad Arcu Gennargentu, Esp. S.O., m 1600-1650 ca., scisti paleozoici, 24.6.1971, Legit *P. V. Arrigoni et C. Ricceri* (FI); Sardegna: M.te Gennargentu, da Arcu Gennargentu a Bruncu Spina per la via di cresta che passa per Punta Paolina, m 1600-1800 ca., 24.6.1971, Legit *P. V. Arrigoni et C. Ricceri* (FI); Sardegna: M.te Gennargentu, da Arcu Gennargentu a Punta Lamarmora passando da su Sciusciu, 5.7.1972, Legit *P.V. Arrigoni et E. Nardi* (FI); Sardegna: Orgosolo, Rocce calcaree, Nord e Nord-Ovest di Mt. Fumai, 7.7.1972, Legit *P.V. Arrigoni et E. Nardi* (FI); Sardegna: Orgosolo, Rupi e falesie calcaree lungo la cresta P. Sa Pruna, Punta Lolloine, Sos Cuzzos, 7.7.1973, Legit *P.V. Arrigoni*, *E. Sartoni et P.L. Di Tommaso* (FI); Sardegna: Desulo, M.te Gennargentu tra Perda Grispa e Ortu is Aragnos, m 1660, Substr. porfidi, 5.7.1985, Legit *P.V. Arrigoni, P.L. Di Tommaso, A. Mazzanti et C. Ricceri* (FI); Sardegna: Oliena, Iscala de Pradu, una sola pianta, 7.1997, Legit *A. Congiu* (FI).

Results

The study of materials relating to the Sardinian population of *Daphne oleoides* together with the observation in nature of the populations of Sicily and that of Albania (Fig. 1) resulted in the establishment of a different taxonomic treatment for Sardinian populations. In fact, despite having a similar ecology, it differs from the nominal subspecies and from the other three mentioned subspecies, for some morphological characters and mainly for the shape and color of the corolla. So that we are inclined to treat this as subspecies of

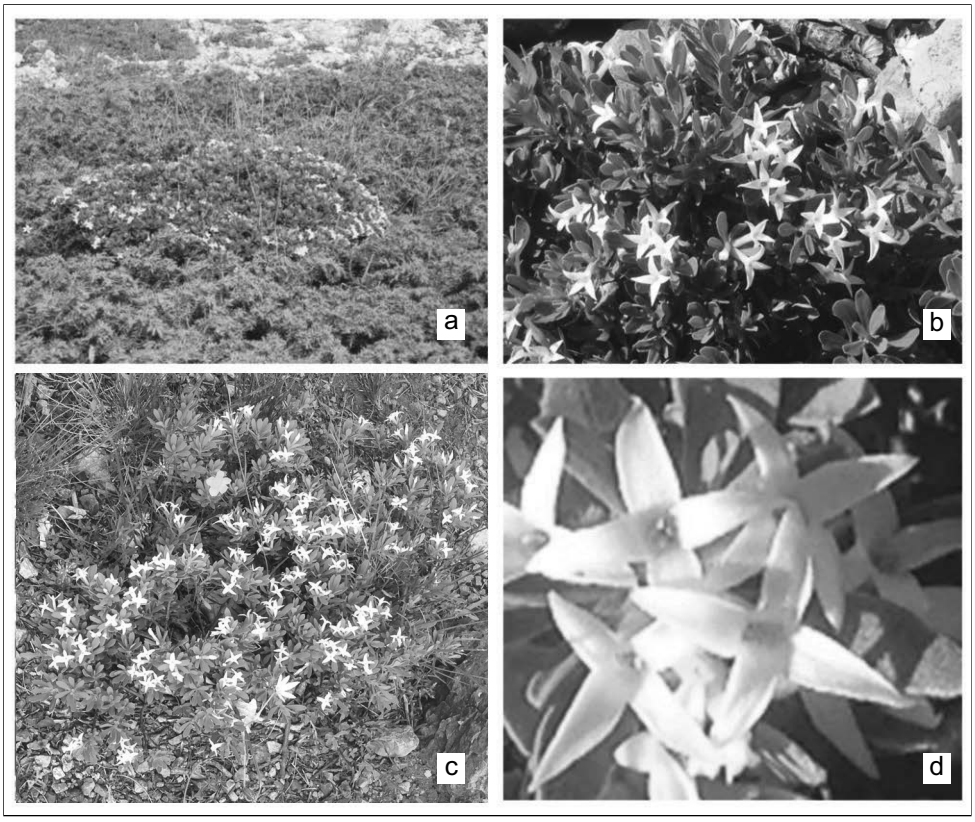

Fig. 1. *Daphne oleoides:* a, b) in Sicily, on the Madonie Mountains; c, d) in Albania on the Qark Elbasan.

D. oleoides in addition to the nominal and the other three subspecies, because actually diverges for some characters that are lost in the dried material and the most obvious are the plant's habit, the color and shape of the flowers, that therefore escape the descriptions based on herbarium materials. So, we called it as *Daphne oleoides* subsp. *sardoa*.

Daphne oleoides subsp. ***sardoa*** Camarda & Raimondo **subsp. nova**

Diagnosis – Differt a Daphne oleoides subsp. oleoides foliis adultis subspatolatis glabris, 4–15 mm longis, 3–5 mm largis (recurved triangular segments in subsp. oleoides of Sicilian specimens); floribus plerum cleistogamis ipanthio tubuloso 10–12 mm longo, rubente-purpurascentebus, dentibus 4–5 longis, 3–4 mm largis, erectis, extus purpurescetnibus, vel atro-violaceis.

Typus – Bruncu Spina, Genargenti montibus, 1.589 m (a.s.l.), Coord. 40,017387 N 9°25'30.91"E, 13.6.2015, *Camarda et Raimondo* (SS) (*Holotypus*). *Isotypes* in FI and SS.

Description – Small evergreen shrub with numerous flexible branches 20–60 cm long, creeping or suberect to form a cushion up to 1 m wide and no more than 50–60 cm high. Leaves persistent and new apical twigs arising immediately after flowering, glabrous, linear-lanceolate, sub-spatulate, 6–20 mm long, 3–6 mm wide, closely spaced. Flowers cleistogamous with tubular hypanthium 10–12 mm long, narrowed at the insertion of the teeth, erect and rarely open, usually purplish with dense, minute hairs; teeth triangular sub-equal two by two, 4–5 mm long and 2–3 mm wide, erect or rarely open, purplish-red to purplish-dark outside; stamens 8 subsessile, arranged in two planes; ovary 2–3 mm long with sessile stigma; drupe 5-6 mm yellowish-orange, with pyriform seed 4×2.3 mm.

Etymology **–** *Sardoa*, from the island of Sardinia.

Phenology – Flowering May-July, fruiting July-August.

Iconography (Fig. 2) – by Camarda & Valsecchi (from Camarda & Valsecchi 1990).

Biological type **-** Chamaephyte, evergreen with prostrate branches (Fig. 3).

Range (Fig.4) – Gennargentu Mountain, siliceous substrate over 1500 m (a.s.l.) and very rare limestone mountain from Corrasi to Punta sa Pruna, at Perda Liana (Gairo), Scoroddine (Urzulei), Montarbu at Margiani Pubusa pick and nearby Nuraghe Ardasai (Ierzu) (*fide* G. Mereu, *in litteris*). Specimens are indicated at Sos Thuthurrelis near the Corrasi Mountain (Congiu 2006) and on the rocks along the path from Chelle to Palumbrosa sites (Putzu 2020). Doubtful at Monte Scova, Aritzo (Martinoli 1951).

Ecology (Fig.3) – Heliophilous and orophylous species of siliceous montane garrigues in the *Juniperetum (nanae)-sibiricae* and other associations of phytoclimatic stage of prostrate dwarf shrubs of the Gennargentu mountain (Carta & al. 2014). It commonly lives with *Astragalus genargenteus* Moris, *Thymus catharinae* Camarda, *Rosa seraphini* Viv., *Cerastium boissierianum* Greuter et Burdet, *Trisetum gracile* (Moris) Boiss. *Festuca morisiana* Parl. and other endemic species (Arrigoni & Camarda 2014). It is very rare on limestone rocks and always with only few isolated specimens.

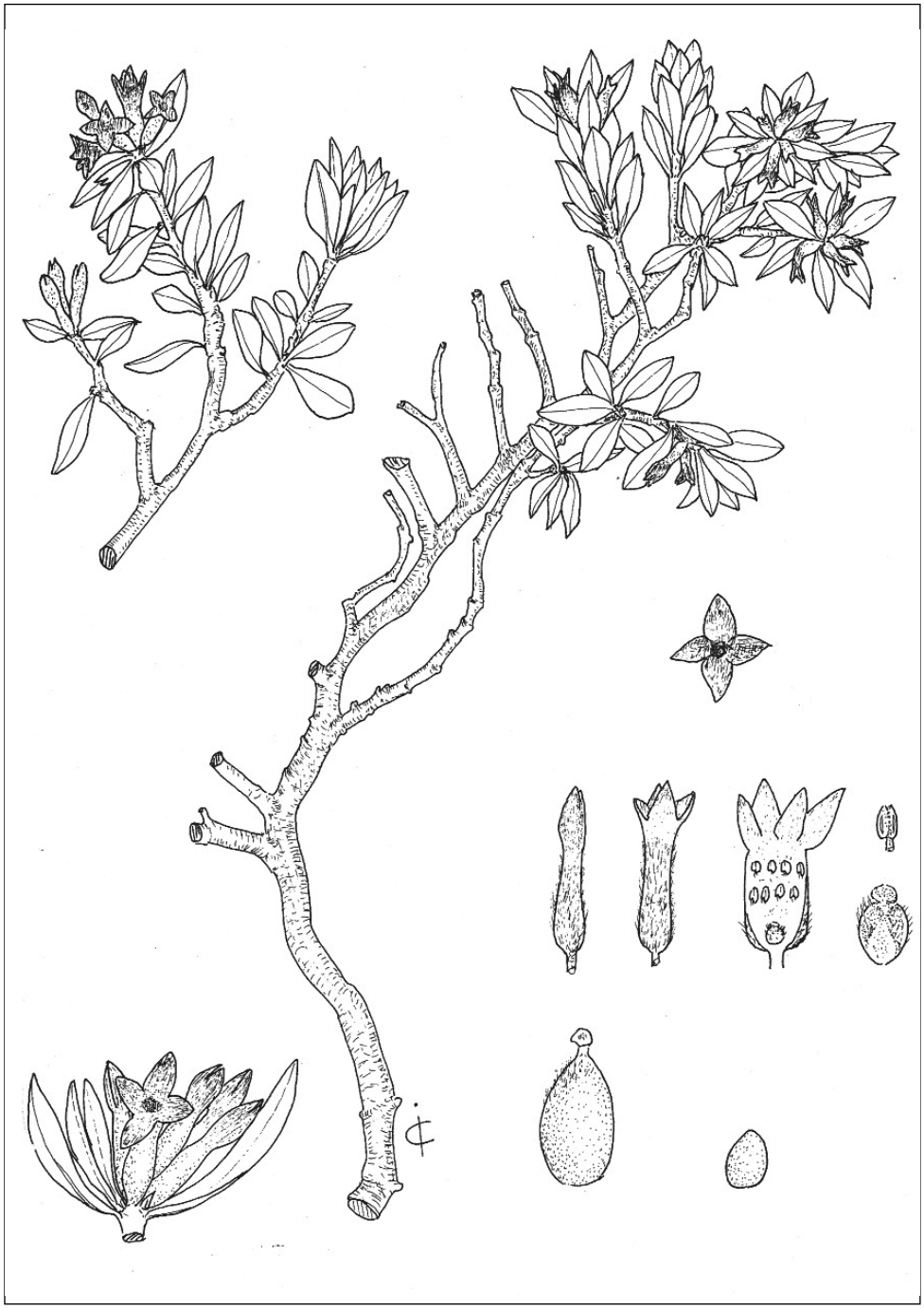

Fig. 2. Iconographia of *Daphne oleoides* subsp. *sardoa* (from Camarda & Valsecchi 2004, sub *D. oleoides* s.l.).

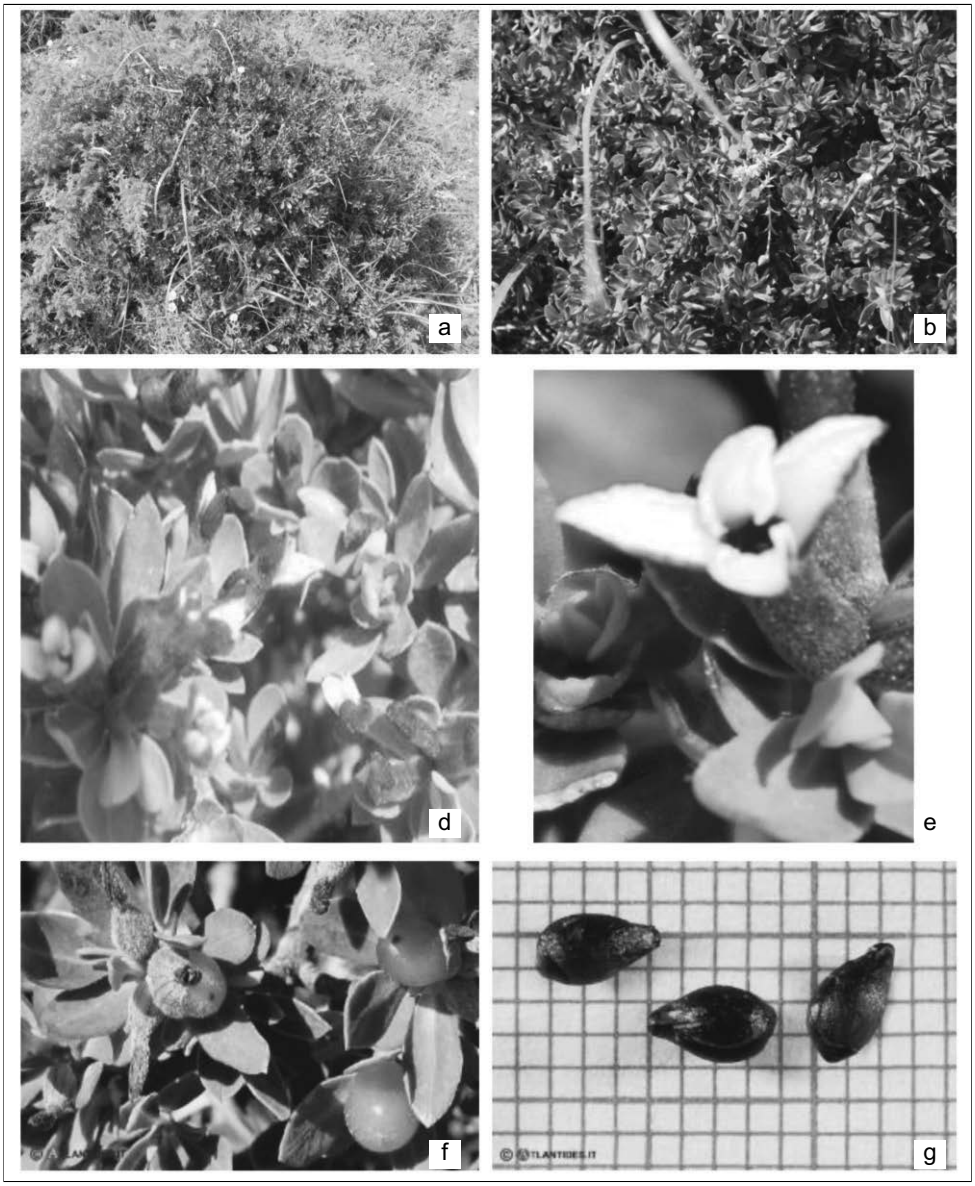

Fig. 3. *Daphne oleoides* subsp. *sardoa* (Gennargentu, Punta Orisa): a-d) flowering plant, e) detail of flower, f) fruits, g) seeds.

Discussion and Conclusions

Daphe oleoides Schreber, In Sardinia, was collect first by Moris (1827; 1858-59) sub *D. glandulosa* Bertol. and after by many Authors (Arrigoni & Camarda 2014). Our recent

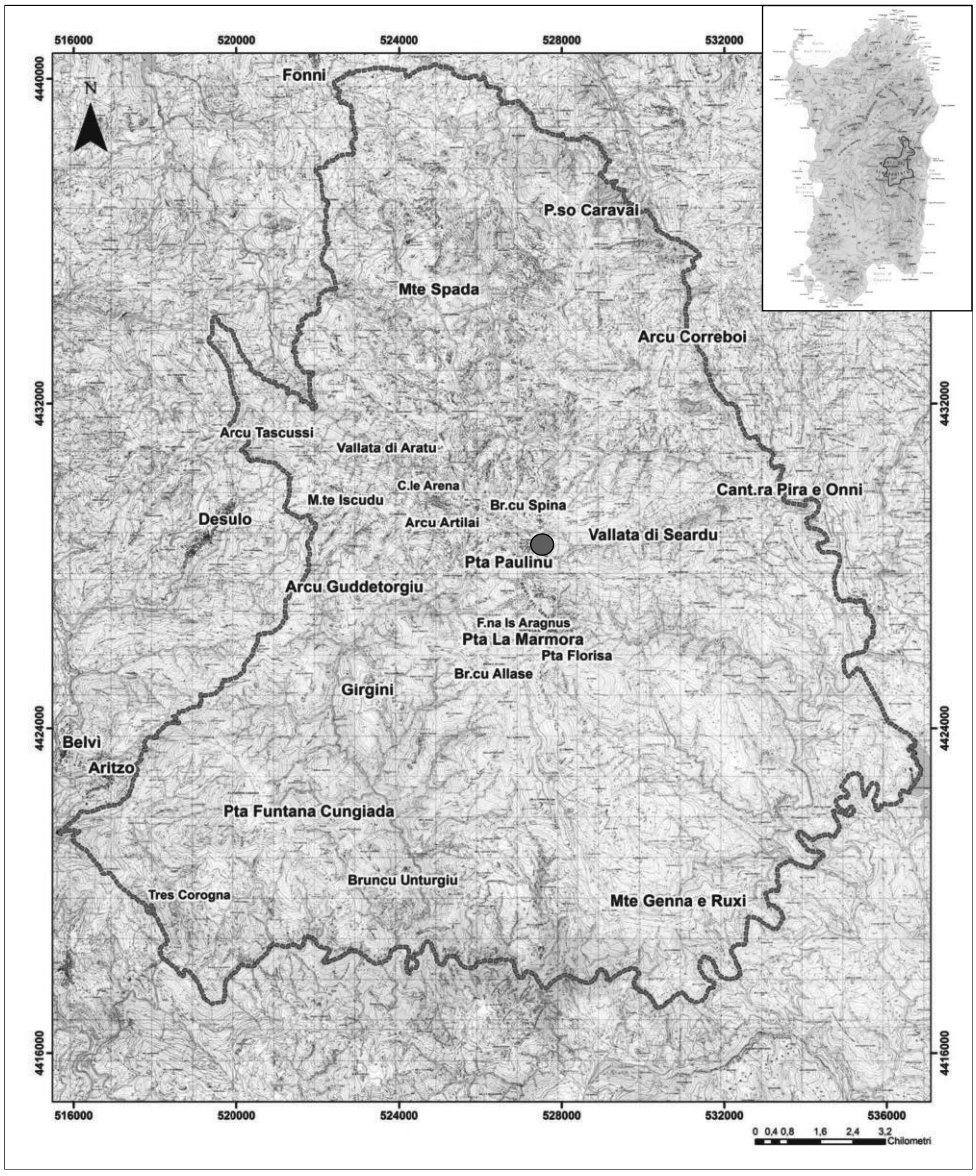

Fig. 4. Map of Gennanrgentu Mountain, locus classicus of *Daphne oleoides* subsp. *sardoa* and map of Sardinia indicating its range.

investigations of the natural populations of *D. oleoides* from Albania and Sicily and confrontation with plants of Criti Mountains, with typical yellow whitish flowers and long triangular white teeth, have allowed to appreciate any diagnostic characters of the Sardinian plants in the Gennargentu siliceous mountain and the population of Monte Corrasi,

Supramonte and Monte Perda Liana, living on limestone substrate. The populations are well distinguished, according to the images of this taxon also reported in the illustrated floras of these countries.

White flowers and recurved triangular segments are confirmed by original description of Criti specimens, and by the direct observation of the populations living in Sicily and Albania. The white color also results from the images of this species reported in the most recent illustrated floras of other countries such as Lebanon and references to even purple flowers are not rare. All this led the authors to critically examine the population so far attributed to the taxon described by Schreber (1776).

Leaves of Sardinian plants are lanceolate to obovate shaped of 4–15 mm long and 3–4 mm large, and clearly hairless. Flowers are covered by minute silky hairs, color of hypanthium is markedly dark-violet or red-purple outside, even more accentuated on the teeth of calyx, while they are white inside; teeth are shorter and erect. Flowers soon appears cleistogamous and mostly infertile. Segments are triangular-shaped much shorter compared to that of the populations of Crete, Sicily and Albania. The length and indumentum of leaves are very important characters to discriminate the subspecies.

On the morphometric investigations we have been undertaken which have meanwhile allowed us to establish that these are characters uniformly distributed in the same population in order to establish whether the observed variation could lead to a different taxonomic treatment. On this basis, morphometric investigations have been undertaken which have meanwhile allowed us to establish that these are characters uniformly distributed in the same population which has suggested to establish a different taxonomic treatment.

So that we are inclined to treat the Sardinian population as subspecies of *D. oleoides* in addition to the nominal, because actually diverges for some characters that are lost in the dried material and the most obvious are the plant's habit, the color and shape of the flowers, that therefore escape the descriptions based on herbarium materials.

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Article

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C. Salmeri (ed.), G. Bacchetta, G. Barone, G. Calvia, M. Deplano, E. Di Gristina, E. Estrelles, E. García-Martínez, L. Martínez-Oliver, G. Mirabile, M. Porceddu, J. Prieto-Mossi, F. Scafidi, E. I. Villaluenga & S. Magrini (ed.)

Mediterranean plant germination reports – 5

Abstract

Salmeri, C. (ed.), Bacchetta, G., Barone, G., Calvia, G., Deplano, M., Di Gristina, E., Estrelles, E., García-Martínez, E., Martínez-Oliver, Mirabile, G., L., Porceddu, M., Prieto-Mossi, J., Scafidi, F., Villaluenga, E. I. & Magrini, S. (ed.): Mediterranean plant germination reports – 5. — Fl. Medit. 33: 279-297. 2023. — ISSN: 1120-4052 printed, 2240-4538 online.

This is the fifth issue of the series of germination reports from Mediterranean areas (sensu Med-Checklist). It comprises germination protocols for 18 taxa: *Hieracium* and *Pilosella* from South Italy by Di Gristina & al. (Nos. 103-106); *Genista* from Sardinia by Deplano & al. (No. 107); *Antirrhinum*, *Anthyllis*, *Digitalis*, *Echium*, *Jasione*, *Nothoscordum*, *Silene* and *Verbascum* by Martínez-Oliver & al. (Nos. 108-116); *Dianthus*, *Helichrysum* and *Silene* from Sicily by Scafidi & Salmeri (Nos. 117-120).

Key words: endemic species, *ex-situ* conservation, monumental populations, protocols, Sardinia, seeds, Sicily, Valencia.

Introduction

This fifth issue of the series of germination reports from Mediterranean areas (sensu Med-Checklist) examines the germination protocols of 18 taxa belonging to seven dicot and one monocot plant families, namely *Asteraceae* (5), *Caryophyllaceae* (4), *Fabaceae* (3), *Plantaginaceae* (2), *Boraginaceae* (1), *Campanulaceae* (1), *Scrophulariaceae* (1) and *Amaryllidaceae* (1). Seven out of 18 taxa are endemic to Italy, five of which are strictly endemic to NW Sicily, other five taxa are endemic to Spain, and one subendemic (SE Spain and NW Africa), while the remaining three taxa have a wider distribution in the Mediterranean. Overall, these reports contribute to improving the knowledge on the germination behaviour of the Mediterranean plants pivotal to both *in situ* and *ex situ* conservation actions and further implement the checklist of the Mediterranean germination reports available in the RIBES website (https://www.reteribes.it).

103. *Hieracium lucidum* subsp. ***cophanense*** (Lojac.) Greuter (*Asteraceae*)

Accession data:

Si: Trapani, Cornino, Mt Cofano (WGS84: 38.108889°N, 12.659722°E), limestone rocks, 185 m a.s.l., 9 Nov 2021, *E. Di Gristina* (SAF 100112).

Germination data

Pre-treatments: No treatment. Only manual removal of pappus.
Germination medium: Petri dishes with 2 sheets of sterilized Whatman 40 filter papers, imbibed in sterilized distilled water or 10^{-3} M gibberellic acid (GA_3) water solution(1).
Sample size: 80 seeds for each test (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
92%(1)	constant 20°C	0/24h	5.0	10.1	16.0	12.0
90%	constant 20°C	0/24h	6.0	10.6	16.0	12.0

Observations

Hieracium lucidum subsp. *cophanense* is a chasmophytic hawkweed endemic to Sicily, recorded only for Mt Cofano (Natural reserve of Monte Cofano, NW-Sicily) and Mt Passo del Lupo (Natural Reserve of Zingaro, NW-Sicily). It is closely related to *H. lucidum* subsp. *lucidum*, an endemic Sicilian taxon, which, according to Pignatti (2018), ascribes to Sicily the interesting role of the likely differentiation center of the genus. Although *H. lucidum* subsp. *cophanense* grows on rocks and vertical cliffs, the recurrent presence of fire is progressively reducing the number of individuals and, according to the recent conservation status assessment of the endemic *Hieracium* s. str. occurring in Sicily (Di Gristina & al. 2022), the taxon can be classified as Critically Endangered (CR): C2a(i). *H. lucidum* subsp. *cophanense* matures and disperses its seeds from November to early December.

Germination tests were carried out 3 months after seed harvesting, using the constant temperatures of 15°C, 20°C, and 25°C in continuous darkness, and alternating temperature of 30/15°C (16h/8h, light/dark). The obtained results showed that *H. lucidum* subsp. *cophanense* produces non-dormant seeds, with a high percentage of germination at all tested thermoperiods. This can be due to a strategy aimed at allowing populations living in unfavourable ecological conditions, such as chasmophytic environments, to increase the probability of dispersion and affirmation of the progeny (Di Gristina & al. 2020). The optimal germination temperature was 20°C (90%). Germination tests carried out in 10^{-3} M gibberellic acid (GA_3) provided slightly higher germination percentages (92%). No germination data are present in the literature for this taxon.

E. Di Gristina, G. Mirabile & G. Barone

104. *Hieracium racemosum* subsp. ***lucanum*** Di Grist., Domina, Gottschl. & Scafidi (*Asteraceae*)

Accession data:

It: Basilicata, Potenza, Lauria, Timpa Rossa (WGS84: 40.107361°N, 15.934836°E), quartzarenitic stony slopes, 846 m a.s.l., 18 Aug 2021, *E. Di Gristina* (SAF 100113).

Germination data

Pre-treatments: No treatment. Only manual removal of pappus.
Germination medium: Petri dishes with 2 sheets of sterilized Whatman 40 filter papers, imbibed in sterilized distilled water or 10^{-3} M gibberellic acid (GA_3) water solution(1).
Sample size: 80 seeds for each test (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
90%(1)	constant 20°C	0/24h	6.0	13.4	19.0	14.0
85%	constant 20°C	0/24h	7.0	14.1	20.0	15.0

Observations

Hieracium racemosum subsp. *lucanum* is a pseudorosulate hemicryptophytic hawkweed endemic to Basilicata (S Italy) (Di Gristina & al. 2019). This taxon belongs to the collective species *H. racemosum* Willd. which is one of the most polymorphic aggregates in the genus *Hieracium* L. s. str. Indeed, it includes 40 infraspecific taxa with the center of their distribution in Italy and the Balkan Peninsula (Di Gristina & al. 2019). *H. racemosum* subsp. *lucanum* matures and disperses the seeds from August to early September (Di Gristina & al. 2019).

Germination tests were carried out 3 months after seed harvesting, using the constant temperatures of 15°C, 20°C, and 25°C in continuous darkness, and the alternating temperature of 30/15°C (16h/8h, light/dark). In water, a high percentage of germination was obtained at all tested thermoperiods, the highest (85%) and with high germination speed (T_{50}: 14.1, MTG: 15.0) at the constant temperature of 20°C. Germination tests carried out in 10^{-3} M gibberellic acid (GA_3) provided a bit higher germination percentage (90%). Here we report the first germination data for this taxon and the *H. racemosum* aggregate.

E. Di Gristina, G. Mirabile & G. Barone

105. *Hieracium umbrosum* subsp. ***abietinum*** (Boiss. & Heldr.) Greuter (*Asteraceae*)

Accession data:

It: Basilicata, Potenza, Terranova di Pollino, Passo delle Ciavole (Pollino National Park) (WGS84: 39.907222°N, 16.214167°E), calcareous stony slopes, 1,722 m a.s.l., 14 Aug 2021, *E. Di Gristina* (SAF 100114).

Germination data

Pre-treatments: No treatment. Only manual removal of pappus.

Germination medium: Petri dishes with 2 sheets of sterilized Whatman 40 filter papers, imbibed in sterilized distilled water or 10^{-3} M gibberellic acid (GA_3) water solution(1).
Sample size: 80 seeds for each test (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
90%	constant 15°C	0/24h	7.0	14.8	19.0	15.0
90%(1)	constant 15°C	0/24h	6.0	13.3	19.0	14.0

Observations

Hieracium umbrosum subsp. *abietinum* is a pseudorosulate hemicryptophytic hawkweed, first considered endemic to Greece, recently noted in the Pollino National Park (S Italy) (Gottschlich & al. 2017a). The presence in Southern Italy is an important extension of its distribution range and it represents a highly interesting case of an amphi-Adriatic disjunction, known also from other plant groups or zoological investigations (Di Gristina & al. 2014, 2015a, 2015b, 2016a, 2016c; Gottschlich & al. 2017a, 2017b). *H. umbrosum* subsp. *abietinum* matures and disperses its seeds in August (Gottschlich & al. 2017a).

Germination tests were carried out 3 months after seed harvesting, using the constant temperatures of 15°C, 20°C, and 25°C in continuous darkness, and the alternating temperature of 30/15°C (16h/8h, light/dark). The seeds of *H. umbrosum* subsp. *abietinum* showed no dormancy and the highest germination (90%) at the temperature of 15°C in continuous darkness. High germination was also obtained at 20°C reaching a value of 82%, while the alternating temperature of 30/15°C only reached 64%. These results suggest that the seeds of *H. umbrosum* subsp. *abietinum* prefer constant, cool or medium temperatures, for germination. Tests carried out in 10^{-3} M gibberellic acid (GA_3) provided similar germination percentages. Here we report the first germination data for this taxon and the *H. umbrosum* aggregate.

E. Di Gristina, G. Mirabile & G. Barone

106. *Pilosella hoppeana* subsp. ***macrantha*** (Ten.) S.Bräut. & Greuter (*Asteraceae*)

Accession data:

Si: Palermo, Polizzi Generosa, Monte Quacella (Madonie Regional Park) (WGS84: 37.849167°N, 14.016389°E), carbonate rocky slopes, 1,350 m a.s.l., 20 Jun 2021, *E. Di Gristina* (SAF 100115).

Germination data

Pre-treatments: No treatment. Only manual removal of pappus.
Germination medium: Petri dishes with 2 sheets of sterilized Whatman 40 filter papers, imbibed in sterilized distilled water or 10^{-3} M gibberellic acid (GA_3) water solution(1).
Sample size: 80 seeds for each test (20 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
90%[(1)]	constant 15°C	0/24h	6.0	10.9	19.0	12.3
88%	constant 15°C	0/24h	7.0	11.6	20.0	13.1

Observations

Pilosella hoppeana subsp. *macrantha* is a rosulate hemicryptophytic hawkweed distributed from central and southern Europe to the Caucasus (Di Gristina & al. 2013). In Italy, the taxon is recorded only for Umbria, Lazio, Abruzzo, and Sicily (Bartolucci & al. 2018). The *P. hoppeana* (Schult.) F.W. Schultz & Sch. Bip. aggregate includes widespread taxa and also very localized ones (Di Gristina & al. 2013). The latter case includes *P. hoppeana* subsp. *sicula* Di Grist., Gottschl. & Raimondo, an endemic taxon of Sicily (Di Gristina & al. 2016b), recently described based on an integrated morphological, karyological and isoenzymatic study (Di Gristina & al. 2013). *Pilosella hoppeana* subsp. *macrantha* matures and disperses the seeds from June to early July.

Germination tests were carried out 3 months after seed harvesting, using the constant temperatures of 15°C, 20°C, and 25°C in continuous darkness, and the alternating temperature of 30/15°C (16h/8h, light/dark). The results showed no seed dormancy and 15°C as the optimal germination temperature. Tests carried out in 10^{-3} M gibberellic acid (GA_3) provided slightly higher germination percentages (90%). These are the first germination tests for this taxon. The results obtained are similar to those found for *P. hoppeana* subsp. *sicula* (Di Gristina & al. 2020), but not exactly coincident. In fact, in the case of *P. hoppeana* subsp. *sicula* the highest percentage of germination was obtained at the constant temperature of 20°C (Di Gristina & al. 2020).

E. Di Gristina, G. Mirabile & G. Barone

107. *Genista etnensis* (Raf.) DC. (*Fabaceae*)

Accession data

Sa: Berchidda (North-East Sardinia), Riu Mannu loc. Sas Rujas (WGS84: 40.755278°N, 9.146111°E), isolated in pastures, sandy shores and sparse shrublands, 170 m a.s.l., 11 Sept 2022, *G. Calvia*, (BG-SAR 138/22, Sardinian Germplasm Bank).

Sa: Berchidda (North-East Sardinia), Riu Badu Pedrosu between Osseddu and Corrosolis (WGS84: 40.755000°N, 9.191944°E), isolated in pastures, sandy shores and sparse shrublands, 190 m a.s.l., 11 Sept 2022, *G. Calvia*, (BG-SAR 139/22, Sardinian Germplasm Bank).

Germination data

Pre-treatments: scarification with a scalpel.
Germination medium: 1% agar.
Sample size: 60 seeds (20 × 3 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]	Accession code
98.2%	constant 15°C	12/12h	3.4	5.0	7.9	5.9	138/22
92.3%	constant 20°C	12/12h	3.1	3.6	4.5	4.2	138/22
90.3%	constant 10°C	12/12h	7.5	10.7	23.5	13.3	138/22
98.3%	constant 10°C	12/12h	7.0	10.5	12.7	10.8	139/22
95.7%	constant 20°C	12/12h	3.1	3.6	4.2	4.1	139/22
90.6%	constant 15°C	12/12h	3.4	4.3	5.8	5.0	139/22

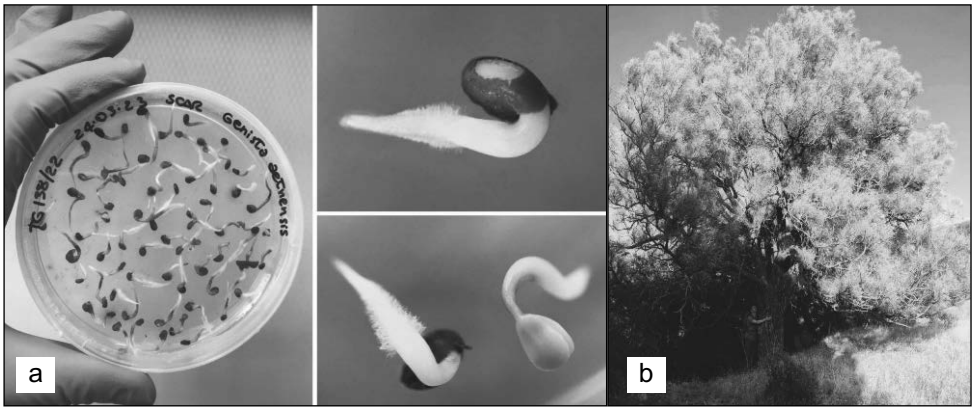

Fig. 1. a) Details of germination tests of *Genista etnensis* after scarification pre-treatment; b) Monumental tree of *Genista etnensis.*

Observations

Different experiments were carried out to find an efficient germination protocol, such as imbibition and germination tests. Due to the presence of impermeable seed coat in seeds of *G. etnensis*, non-scarified seeds showed a very low water imbibition capacity with a poor and slow mass gain, compared to scarified ones (data not shown). The germination test of non-scarified seeds showed weak results as well (accession BG-SAR 138/22: 8.5% at 10°C, 5.6% at 15°C, 1.7% at 20°C; accession BG-SAR 139/22: 3.7% at 10°C, 0.0% at 15°C, 1.7% at 20°C), while the scarified seeds of *G. etnensis* germinated with high percentages and high rates at all tested temperatures (see germination tables and Fig. 1a). This result is comparable with what reported in the SER's Seed Information Database, that indicates a 96% of germination capability obtained in 43 days after scarification treatment with a scalpel (SER, INSR, RBGK, Seed Information Database (SID), 2023). The results obtained with the imbibition and germination tests on non-scarified and scarified seeds confirm that *G. etnensis* has Physical Dormancy (PY), as detected in other *Genista* spp. (see Baskin & Baskin, 2014 and references therein).

In Sardinia, *G. etnensis* does not appear to have particular conservation problems and it is categorized as Least Concern (LC) at the regional level, sensu IUCN, being Not

Evaluated (NE) at the global level (Orsenigo & al. 2018). However, *in-situ* and *ex-situ* conservation actions are needed to preserve Berchidda's monumental population of *G. etnensis* (see Fig. 1b), in agreement with Camarda & Brundu (2021) who pointed out that the system of monumental trees and old-growth forests of Sardinia is a fundamental asset for the study and conservation of Mediterranean biodiversity, history and culture.

M. Deplano, G. Bacchetta, G. Calvia & M. Porceddu

108. ***Antirrhinum valentinum*** Font Quer (*Plantaginaceae*)

Accession data

Hs: Valencia, Quatretonda, Microrreserva de Flora "l'Ombría del Buixcarró" (WGS84: 39.005916ºN, -0.365960ºW), 450 m a.s.l., 12 Jun 1996, *J. Riera* (UVEG-JBVAL-BG 78B1996).

Germination data

Pre-treatments: no treatment.
Germination medium: Agar 0.6%.
Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
90.9%	constant 25°C	12/12h	3.8	8.4	15.0	8.8
87.9%	constant 20°C	12/12h	7.0	9.3	14.3	9.9
80.9%	constant 15°C	12/12h	11.0	12.2	21.0	13.7

Observations

Antirrhinum valentinum inhabits shaded crevices and ledges on limestone rock walls. It is a narrow endemic from the province of Valencia. This species is considered vulnerable, according to IUCN (VU B1ab(v)+2ab(v)). At higher temperatures, the germination percentage is lower than 50%. Specifically, we have obtained 32.0% at 30°C.

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

109. ***Anthyllis cytisoides*** L. (*Fabaceae*)

Accession data

Hs: Valencia, Montserrat, Microrreserva de Flora "El Castellet" (WGS84: 39.363764ºN, -0.600214ºW), 235 m a.s.l., 16 Jul 2020, *P. Soriano & E. Estrelles* (UVEG-JBVAL-BG 15B2020).

Germination data

Pre-treatments: mechanical scarification with sandpaper.

Germination medium: Agar 0.6%.
Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
96.9%	constant 20°C	12/12h	1.3	1.7	4.3	2.4

Observations

This plant is characteristic of thermophilic open scrublands from the west Mediterranean. The seeds, as is common within the family *Fabaceae*, show physical dormancy, thus a previous scarification is needed to reach high germination percentages. Only 14% of seed germination has been obtained from the control.

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

110. *Anthyllis lagascana* Benedí (*Fabaceae*)

Accession data

Hs: Valencia, Paterna, La Cañada (WGS84: 39.537234ºN, -0.496698ºW), 108 m a.s.l., 06 Jun 1996, *F. Marco, J. Riera & E. Estrelles* (UVEG-JBVAL-BG 109B1996).

Germination data

Pre-treatments: mechanical scarification with sandpaper.
Germination medium: Agar 0.6%.
Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
92.5%	constant 20°C	12/12h	3.0	2.9	8.3	4.4

Observations

This species is an endemism from the SE of the Iberian Peninsula and NW Africa (Algeria) that inhabits Mediterranean open scrublands. The seeds, as is common within the family *Fabaceae*, show physical dormancy thus a previous scarification is needed to reach high germination percentages. The seeds without any pretreatment only germinate up to 19%.

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

111. *Digitalis obscura* L. subsp. ***obscura*** (*Plantaginaceae*)

Accession data

Hs: Valencia, Aras de los Olmos, Losilla (WGS84: 39.969119ºN, -1.093832ºW), 1060 m a.s.l., 03 Aug 2007, *E. Estrelles & A.M. Ibars* (UVEG-JBVAL-BG 114B2007).

Germination data

Pre-treatments: no treatment.

Germination medium: Agar 0.6%.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
91.9%	constant 15°C	12/12h	5.0	7.9	17.5	9.3
90.6%	constant 20°C	12/12h	4.5	5.6	17.3	7.1

Observations

This Mediterranean woody *Digitalis*, endemic to the west Mediterranean, does not show seed dormancy, although staggered germination of the seeds is observed, lasting more than three weeks.

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

112. *Echium flavum* subsp. ***saetabense*** (Peris, Figuerola & G. Stübing) Mateo & M.B. Crespo (*Boraginaceae*)

Accession data

Hs: Valencia, Teresa de Cofrentes, El Caroch, prope fuente del Collado (WGS84: 39.093160ºN, -0.919929ºW), wet grasslands, 1000 m a.s.l., 03 Jun 1997, *F. Marco & J. Riera* (UVEG-JBVAL-BG 43B1997).

Germination data

Pre-treatments: no treatment.

Germination medium: Agar 0.6%.

Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
95.0%	constant 20°C	12/12h	3.0	3.7	5.5	4.2

Observations

This Ibero-Levantine endemic plant does not exhibit seed dormancy after a long period of dry conservation in the seed bank. Due to the successful results obtained, and the small number of seeds preserved in this accession, no other conditions have been tested at the moment.

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

113. *Jasione mansanetiana* Roselló & Peris (*Campanulaceae*)

Accession data

Hs: Castellón, Llucena, loc. el Salt del Cavall (WGS84: 40.089490ºN, -0.278650ºW), 450 m a.s.l., limestone rock walls, 28 Oct 1997, *J. Riera & E. Estrelles*, (UVEG-JBVAL-BG 112B1997).

Germination data

Pre-treatments: no treatment.
Germination medium: Agar 0.6%.
Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
88.0%	constant 20°C	12/12h	3.3	4.8	10.8	5.7

Observations

This species is a localized endemism to the Castellón province in the East of the Iberian Peninsula. The viability of preserved seeds was tested. No dormancy was detected. This protocol provided the best germination performances.

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

114. *Nothoscordum borbonicum* Kunth (*Amaryllidaceae*)

Accession data

Hs: Valencia, Paterna, La Canyada, Lloma Redona (WGS84: 39.528098ºN, -0.479038ºW), 82 m a.s.l., 27 Oct 2019, *E. Estrelles* (UVEG-JBVAL-BG 99B2019).

Germination data

Pre-treatments: no treatment.
Germination medium: Agar 0.6%.
Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
85.0%	constant 7°C	12/12h	51.0	56.9	58.5	56.5

Observations

This species is considered a naturalized plant. The study of seed response is mainly focused on knowing its competitiveness with respect to the native species. Due to the low velocity, the test of this accession was maintained at 5ºC for 60 days. Germination at higher temperatures

was also tested, but poor results were obtained, specifically, 32% at 15ºC (MGT = 24.5 days and T_{50} = 18.5 days) and 0% at 20ºC, all under light/dark conditions (12h photoperiod).

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

115. *Silene diclinis* (Lag.) M. Laínz (*Caryophyllaceae*)

Accession data

Hs: Valencia, Xàtiva, Microrreserva Serra del Castell (WGS84: 38.984063ºN, -0.516493ºW), 200 m a.s.l., 27 May 1997, *J. Riera & F. Marco* (UVEG-JBVAL-BG 6B1997).

Germination data

Pre-treatments: no treatment.
Germination medium: Agar 0.6%.
Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
97.5%	constant 20°C	12/12h	2.0	1.9	4.5	2.6

Observations

This plant, belonging to the pink family, is a narrow endemic with a highly restricted distribution in the East of Spain, and it is distributed only in the Valencia province (Comunitat Valenciana). Natural habitats are, mainly, grasslands, crop fields and roadsides. It has a preference for disturbed soils, whether calcareous or siliceous.

Silene diclinis is categorized as an endangered species, nationally and globally, according to IUCN criteria (EN, B1ab(iii,v)+2ab(iii,v); C1).

Seeds of this species show dormancy immediately after collecting but germination increased over time with an after-ripening period of several months at ambient conditions (Mira & al. 2011). Therefore, it is advisable to extend the cleaning and preparation time of the seeds to at least four months before freezing them for long-term conservation.

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

116. *Verbascum fontqueri* Benedí & J.M. Monts. (*Scrophulariaceae*)

Accession data

Hs: Valencia, Real, Alt de les Canyes (WGS84: 39.292294ºN, -0.667832ºW), 410 m a.s.l., 28 Jun 1996, *J. Riera & E. Estrelles* (UVEG-JBVAL-BG 141B1996).

Germination data
Pre-treatments: no treatment.
Germination medium: Agar 0.6%.
Sample size: 100 seeds (25 × 4 replicates).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MGT [d]
80.4%	constant 20°C	12/12h	3.5	4.7	13.0	5.9

Observations
This plant inhabits cleared and sunny shrubs, preferably on calcareous soils. It is an Ibero-Levantine endemic, distributed in some mountainous regions from the province of Valencia. *Verbascum fontqueri* is a vulnerable species at the national and global levels, according to IUCN categories (VU B1ac(iii,iv)+2ac(iii,iv); D2). Seeds of this accession do not show dormancy.

L. Martínez-Oliver, E. García-Martínez, E. I. Villaluenga, J. Prieto-Mossi & E. Estrelles

117. *Dianthus borbonicus* Brullo, C.Brullo, Colombo, Giusso, Ilardi & R.Perrone (*Caryophyllaceae*)

Accession data
Si: Palermo, Mezzojuso, Pizzo Morabito, (WGS84: 37.840833°N, 13.448055°E), limestone rocky walls, ca. 1130 m a.s.l., 18 Jul 2023, *F. Scafid*i (096_SF/23; SPGR/PA Sicilian Plant Germplasm Repository, University of Palermo)

Germination data
Pre-treatments: sterilization with a 1% sodium hypochlorite water solution for 2 minutes followed by 2 rinses in sterile distilled water.
Germination medium: 3 sheets of sterilized filter paper (Whatmann No. 1), imbibed with 5 ml of sterilized distilled water.
Sample size: 60 seeds for each test (20 × 3 replicates) (Fig. 2A, 3B).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
91.7%	constant 15°C	12/12h	3	7.2	30	7.8
86.7%	constant 15°C	0/24h	4	4.7	23	5.8
81.7%	alternating 25/15°C	0/24h	2	7.2	29	12.4

Observations
Dianthus borbonicus is a rare chasmophyte restricted to north-facing Mesozoic limestone outcrops of Pizzo Morabito in the Ficuzza-Rocca Busambra Natural Reserve (NW Sicily),

where it grows together with other endemic plants, such as *Anthemis cupaniana* Tod. ex Nyman, *Centaurea busambarensis* Guss., *Helichrysum pendulum* (C.Presl) C.Presl (Brullo & al. 2015). No previous germination data occurred for this species. Seeds incubated at a constant temperature of 15°C showed the highest germination percentage (ca. 92 %) under a 12/12h light/dark photoperiod, while under full darkness conditions seed germination was a little lower (ca. 87%) but faster. Alternating daily temperature of 25°/15°C with a 16/8h light/dark photoperiod did not favour seed germination (31.7%, with many imbibed seeds), which conversely increased to 85% under total darkness at the same alternating thermoperiod. Apparently, high temperatures enhance the seed photosensitivity in this species.

F. Scafidi & C. Salmeri

118. ***Helichrysum panormitanum*** subsp. ***latifolium*** (Guss.) Maggio, Bruno, Guarino, Senatore & Ilardi (*Asteraceae*)

Accession data

Si: Palermo, Santa Flavia, Capo Zafferano (WGS84: 38.109444°N, 13.538889°E), maritime limestone cliffs, ca. 30 m a.s.l., 16 Jun 2023, *F. Scafidi* (041_SF/23; SPGR/PA Sicilian Plant Germplasm Repository, University of Palermo).

Germination data

Pre-treatments: no treatments.
Germination medium: 3 sheets of sterilized filter paper (Whatmann No. 1), imbibed with 5 ml of sterilized distilled water.
Sample size: 60 seeds for each test (20 × 3 replicates) (Fig. 3A).

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
91.7%	constant 15°C	0/24h	8	11.4	26	12.5

Observations

This taxon shows controversial taxonomic treatments, as it is considered a synonym of *H. pendulum* C.Presl by Peruzzi & al. (2018), together with many other Sicilian endemic taxa of the genus, while other authors (Iamonico & al. 2016; Maggio & al. 2016; Pignatti & al. 2018) treat it as valid taxon within the *H. panormitanum* complex, also based on its phytochemical compounds (Maggio & al. 2016). *H. panormitanum* subsp. *latifolium* is endemic to the coastal capes of north-western Sicily, from Mt. Catalfano to Termini Imerese. This is the first germination report for this taxon. The best germination rate was obtained from seeds incubated in the dark at a constant temperature of 15°C, while 80% of germination was reached under 12/12h light/dark photoperiod at the same constant temperature. Conversely, the alternating regimes of both thermo- (25/15° C) and photoperiod provided poor germination responses, with a percentage ranging from 35%, under full darkness, and 28.3 % under 12/12h light/dark conditions.

F. Scafidi & C. Salmeri

119. *Silene kemoniana* C. Brullo, Brullo, Giusso, Ilardi & Sciandr. (*Caryophyllaceae*)

Accession data

Si: Palermo, Monreale, Portella Sant'Anna, (WGS84: 38.100833°N, 13.242222°E), clearings among limestone rocks, ca. 800 m a.s.l., 04 Jun 2023, *F. Scafid*i (018_SF/23; SPGR/PA Sicilian Plant Germplasm Repository, University of Palermo).

Germination data

Pre-treatments: sterilization with a 1% sodium hypochlorite water solution for 2 minutes followed by 2 rinses in sterile distilled water.
Germination medium: 3 sheets of sterilized filter paper (Whatmann No. 1), imbibed with 5 ml of sterilized distilled water.
Sample size: 60 seeds for each test (20 × 3 replicates) (Fig. 2B)

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
95.0%	constant 15°C	0/24h	2	4.1	14	5.1
95.0%	constant 15°C	12/12h	2	5.1	23	7.3
85.0%	alternating 25/15°C	16/8h	2	10.0	28	12.9

Observations

Silene kemoniana is a strict Sicilian endemic, only known from two close localities in the Mounts of Palermo (NW Sicily), where it grows in xerophilous garrigues on Mesozoic limestones (Brullo & al. 2012; Cambria & al. 2013). The species is reported as near threatened (NT) in the Red List of the Italian flora (Rossi & al. 2020). This is the first germination report for this species. The best germination protocol provided 95% of seed germination at the constant temperature of 15°C, in both 12/12h photoperiod and full darkness, revealing no seed photosensitivity though seed germination was faster without light exposure. Tests carried out at alternating thermos- and photoperiod (25/15°C, 16/8h light/dark) gave lower germination rates, with 85% of germinated seeds in the light but just 73.3% in total darkness, thus revealing negative effects of high temperature on seed vigour and responses to light.

F. Scafidi & C. Salmeri

120. *Silene nefelites* C. Brullo, Brullo, Giusso & Ilardi (*Caryophyllaceae*)

Accession data

Si: Trapani, Erice, Monte Erice (WGS84: 38.035277°N, 12.589722°E), ephemeral meadows, ca. 750 m a.s.l., 07 Jun 2023, *F. Scafid*i (023_SF/23; SPGR/PA Sicilian Plant Germplasm Repository, University of Palermo).

Germination data

Pre-treatments: sterilization with a 1% sodium hypochlorite water solution for 2 minutes followed by 2 rinses in sterile distilled water.

Germination medium: 3 sheets of sterilized filter paper (Whatmann No. 1), imbibed with 5 ml of sterilized distilled water.

Sample size: 60 seeds for each test (20 × 3 replicates)

Germination	Thermoperiod	Photoperiod [light/dark]	T_1 [d]	T_{50} [d]	T_{max} [d]	MTG [d]
93.3%	constant 15°C	0/24h	2	3.2	9	3.8
91.7%	constant 15°C	12/12h	2	4.6	13	5.6
90.0%	alternating 25/15°C	0/24h	2	2.3	30	4.8
81.7%	alternating 25/15°C	12/12h	2	4.2	23	5.0

Observations

Silene nefelites is another strict Sicilian endemic, confined to the top of Mt. Erice, near Trapani. It is a therophyte growing among the ephemeral meadows in calcareous rocky stands (Brullo & al. 2014). The species is reported as Vulnerable (VU) in the Red List of the Italian flora (Rossi & al. 2020). This is the first germination report for this species. Likewise other Sicilian populations of *Silene* species (Brullo & Salmeri 2022), the highest and faster germination rate occurred at the constant temperature of 15°C, with 93.3% of germinated seeds under total darkness conditions. The application of alternating thermo- and photoperiod also provided successful seed germination, reaching 90% in full darkness. Seeds exhibit a slight photosensitivity, which increases at higher temperatures.

F. Scafidi & C. Salmeri

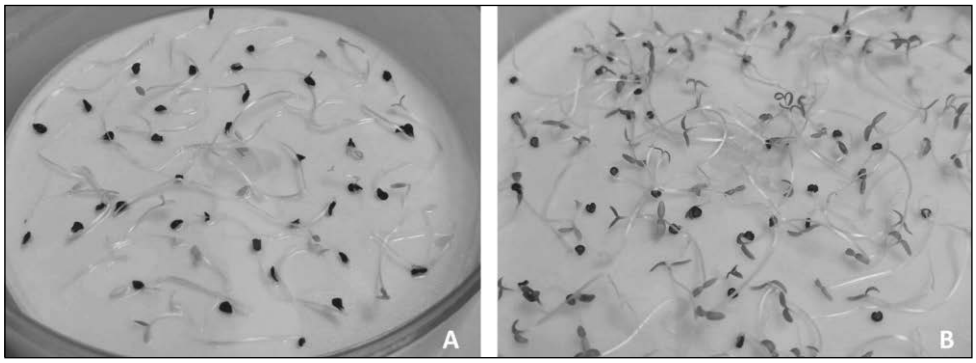

Fig. 2. Seedlings of *Dianthus borbonicus* (A) and *Silene kemoniana* (B).

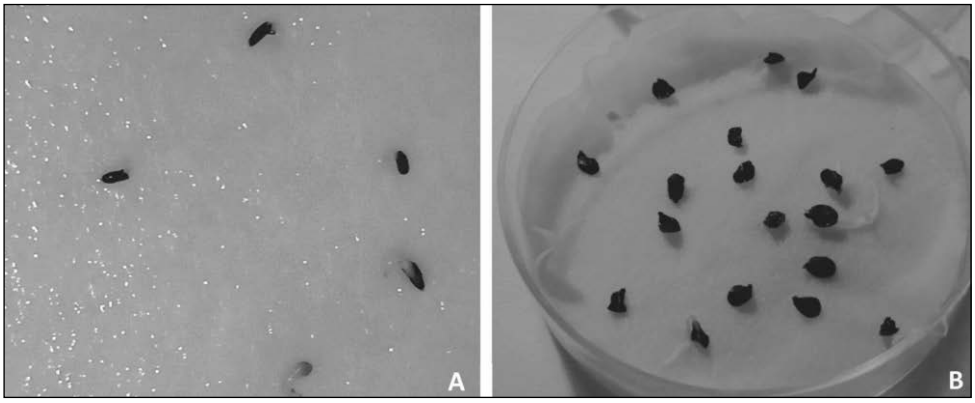

Fig. 3. Germinated seeds of *Helichrysum panormitanum* subsp. *latifolium* (A) and *Dianthus borbonicus* (B). Green light comes from an inactinic lamp for the control of tests under full-dark conditions.

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Mediterranean plant karyological data – 33

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Mediterranean plant karyological data – 33/1

Karyological data on wild pears (*Pyrus*, *Rosaceae*) of Armenia

Anahit Ghukasyan & Janna Akopian

Abstract

For the first time, the chromosome number was determined for 5 species of the genus *Pyrus* L. (*Rosaceae*) from Armenia, viz. *P. daralaghezii*, *P. hyrcana* var. *yeghegisi*, *P. medvedevii*, *P. oxiprion*, *P. takhtadzhianii*, and the previous count of chromosome number for *P. caucasica* was confirmed. All the explored species have a diploid chromosome number $2n = 34$ with the basic chromosome number x = 17.

Keywords: *Pyrus*, Armenian flora, chromosome number, karyology.

Introduction

Pyrus belongs to subtribe *Pyrinae* (formerly subfamily *Maloideae*) of family *Rosaceae* (Campbell & al. 2007). The area of the genus *Pyrus* occupies the territories from the Atlas Mountains in Northern Africa and South of France and through the whole Eurasian continent, including the Japanese seashore, and in the north from the Baltic to India in the south (Fedorov 1954; Browicz 1993). According to paleontological evidence, *Pyrus* probably originated in Tertiary in the mountainous regions of China (Rubtsov 1944). Centers of *Pyrus* diversity are in the mountain regions of East and South-West Asia, the Mediterranean and the Caucasus (Fedorov 1954; Browicz 1993). The number of the genus *Pyrus* species differs from 20-40 (Browicz 1993) to 80 (Phipps & al. 1990). Currently, the genus is subdivided into four sections: *Pyrus*, *Xeropyrenia* Fed., *Argyromalon* Fed., *Pashia* Koehne (Koehne 1890; Fedorov 1954).

The Caucasus is an important diversity center for the genus *Pyrus* (Fedorov 1954; Gladkova 1990; Korotkova & al. 2018). Some *Pyrus* regional taxonomic studies for the Caucasus (Medvedev 1919; Gladkova 1990) and for Armenia have been done (Fedorov 1958; Akopian 2007, 2022).

The territory of Armenia is a center of high diversity and local narrow endemism of the genus *Pyrus*. About 32-34 species of *Pyrus* grow in Armenia, 18 of which are endemics to Southern Transcaucasia and Armenia (Akopian 2007, 2021, 2022). In all of the pear habitats, especially in arid woodlands of the southern and south-eastern regions of the country, rich diversity of species and intraspecific hybrid forms of pears are observed (Akopian 2022).

Until now, the Armenian species of the genus *Pyrus* remain insufficiently studied in cytologenetical terms. According to the literature, only one publication is known in which was determined chromosome number ($2n = 34$) for 7 pear species of the Armenian flora, viz. *P. caucasica* Fed., *P. communis* L., *P. complexa* Rubtzov, *P. fedorovii* Kuth., *P. nutans* Rubtzov, *P. salicifolia* Pall. (including var. *angustifolia* Kuth. and var. *serratula* Browicz),

P. pseudosyriaca Gladkova and for hybrid forms *P. pseudosyriaca* × *P. salicifolia* and *P. pseudosyriaca* × *P. caucasica* (Gladkova & Sveshnikova 1990). Since pear polymorphism is determined not only by natural variability, but also by species hybridization and naturalization of cultivars, the study of chromosome number and karyotype in *Pyrus* species is of particular interest. Native population-based karyological studies of *Pyrus* species will provide new data on chromosome number and ploidy level of Armenian *Pyrus* species and hybrid forms.

Materials and methods

The research was based on the *Pyrus* seed material, collected in nature and from the wild pears living collection of the Yerevan Botanical Garden NAS RA (Akopian 2010). Karyological investigations were made on the mitotic metaphases of the meristematic cells from root tips of germinated seeds. The root tips were pretreated in 0.4% colchicine solution and fixed in Carnoy (3:1 alcohol and glacial acetic acid). After hydrolysis in HCl for 12 minutes, the root tips were stained in Schiff reagent and were squashed on a glass slide in 45% acetic acid. For all chromosome counts, a minimum of 10 plates were examined for each taxon. The slides were examined under light microscope AmScope Photomicroscope using an oil immersion objective (100×). Determination of chromosome number was carried out by light microscope AmScope (×40, ×100) with photo camera for photomicrography.

Results and discussion

Chromosome number was determined for 6 species of the genus *Pyrus* from sections *Pyrus*, *Xeropyrenia* and *Argyromalon* native to Armenia.

Pyrus Sect. *Pyrus*

2014. *Pyrus hyrcana* var. ***yeghegisi*** Akopian **—** $2n = 34$ (Fig. 1A).

Ar: Vayots Dzor province, Yeghegis river gorge, in the vicinity of village Vardahovit, pear open woodland, 1970 m a.s.l., 39° 53’ N, 45° 27’ E, 11 Oct 2019, leg. *J. Akopian, A. Ghukasyan & M. Oganesian* (ERE 199486).

Tree up to 7–8 m in height with spherical crown; branches without thorns. Bark greyish-brown, perennial and one-year-old branches dotted with small whitish lenticels. Leaves 6.5×3.4 cm, lustrous green, elliptic, long acuminate or attenuate at apex, cuneate at base. Fruits 2×1.8 to 2.5×2.5 cm, globose, single or by 2–3, light or bright brown with lenticels, juicy and sweet. Sepals persistent in fruit, erect, crown-like, not deciduous. In Armenia it grows in pear open woodlands, 1950-2000 m a.s.l. Local endemic to Vayots Dzor province of Armenia.

In the studied specimens of *P. hyrcana* var. *yeghegisi* from its *locus classicus* (vicinity

of village Vardahovit, Vayots Dzor province) a characteristic diploid cytotype $2n = 34$ was identified, the chromosome number is given for the first time.

2015. ***Pyrus caucasica*** Fed. **—** $2n = 34$ (Fig. 1B).

Ar: Ararat province, hills in the vicinity of village Getazat, 930 m, 40° 02’ 18’’ N, 44° 33’ 49’’ E, 03 Jul 2022, leg. *J. Akopian, G. Gabrielyan, A. Rudov & G. Zaroyan* (ERE 291412).

Tree 10–20 m in height, thorny. Leaves arachnoid-hairy along the edges and below, sometimes almost glabrous, broadly elliptical or ovate, 3–6×2–4 cm, pointed or obtuse at the apex, entire, blackening in drying. Fruits are round or slightly oblate, 2.5–3 cm in diameter, have a varied taste.

It is highly polymorphic species considered to be the ancestor of several native pear cultivars. In Armenia it grows in broad-leaved forests, by river valleys, from 600 to 2200 m a.s.l. The species was described from Armenia. General distribution: Caucasus, Northern and South-Western Anatolia.

In the karyologically studied samples of *P. caucasica*, a characteristic diploid cytotype $2n = 34$, with a base number x = 17, was revealed. Previously, a diploid cytotype was also reported for this species from Armenia (near Dilijan, Tavush province) and from Dagestan (Gladkova & Sveshnikova 1990).

Pyrus **Sect.** ***Xeropyrenia***

2016. ***Pyrus daralaghezi*** Mulk. **—** $2n = 34$ (Fig. 1C & Fig. 2A).

Ar: Vayots Dzor province, in the vicinity of village Kechut, in the forest along the road, 2072 m a.s.l., 39° 49’ 21’’ N, 45° 40’ 38’’ E, 23 May 2019, leg. *J. Akopian, A. Ghukasyan, M. Oganesian & Zh. Hovakimyan* (ERE 201408).

Tree 5 m in height with a pyramidal crown. Leaves at the base broadly cuneate-shaped, at the apex shortly acuminated, elliptical, 8–10×3–5 cm, equally narrowed to both ends, finely sharp-dentate, ciliated, above glabrous, from beneath with scattered hairs, dry in blackening. Fruits are pear-form, fruit-stalk thick, up to 3–4 cm long. It grows in broad-leaved forests, 1700–2200 m a.s.l. Endemic to Armenia.

In karyologically studied specimens of this species from its *locus classicus* (Kechut forest, Vayots Dzor province) a characteristic diploid cytotype $2n = 34$ was revealed (Fig. 2). The chromosome number is given for the first time.

2017. *Pyrus oxyprion* Woronow **—** 2*n* = 34 (Fig. 1D).

Ar: Ararat province, in the vicinity of village Narek, 1030 m a.s.l., 39° 59’ 57’’ N, 44° 39’ 58’’ E, 18 Jun 2017, leg. *J. Akopian, Zh. Hovakimyan & Z. Paravyan* (ERE 201411).

Tree up to 5 m in height, with dense canopy, thorny. Leaves bright green, lustrous, usually glabrous, on the margins unequally acute-serrate, narrow-oblanceolate, with the utmost width higher the middle, 3.0–7.0×1.0–1.5 cm. Fruits pear-shaped, green, very hard, ripen late. It is very ornamental with glossy green leaves, and numerous whitish-rose flowers. In Armenia it grows in arid light forests, from 1.400 up to 1.900 m a.s.l.

The species was described from North-Eastern Anatolia. General distribution: Southern Transcaucasia, North-Eastern Anatolia, Northern Iran.

In karyologically studied specimens of this species the characteristic diploid cytotype 2*n* = 34 was revealed. The chromosome number is given for the first time.

Pyrus* Sect. *Argyromalon

2018. *Pyrus medvedevii* Rubtzov **—** 2*n* = 34 (Fig. 1E).

Ar: Vayots Dzor province, right bank of the river Yeghegis, in the vicinity of village Vardahovit, 2000 m a.s.l. 39° 53’ 52’’ N, 45° 28’ 12’’ E, 11 Oct 2019, leg. *J. Akopian, A. Ghukasyan & M. Oganesian* (ERE 201409).

Tree 10-12 m in height, usually thorny. The leaves are entire-edged, wavy, oblanceolate, 9–11×3–4 cm, more pointed at the base than at the top, asymmetrical, above green, glabrous, whitish from beneath, petioles 2.5–3 cm long. Fruits are small, 2.5–3 cm in diameter, green-yellow, pear-shaped or globular, soft, sour-sweet, stalk 4–5 cm long. In Armenia *P. medvedevii* grows in arid woodlands, from 1.400 up to 2.200 m a.s.l. It was described from Nakhichevan. Endemic to Southern Transcaucasia.

In karyologically studied specimens of this species, collected from the Vayots Dzor province of Armenia, a characteristic diploid cytotype 2*n* = 34 was revealed. The chromosome number was given for the first time.

2019. *Pyrus. takhtadzhianii* Fed. **—** 2*n* = 34 (Fig. 1F & Fig. 2B).

Ar: Vayots Dzor province, Noravank gorge, 1480 m a.s.l., 39° 41’ 07’’ N, 45° 13’ 50’’ E, 26 Aug 2018, leg. *J. Akopian, N. Korotkova, G. Parolly & Z. Asanidze* (ERE 201410).

Thornless tree 5–7 m in height. The leaves are serrate or small-toothed, sometimes entire, obovate, ovate, rhombic, or narrowly elliptical, on one branch of various shapes, 4–7×2–4 cm. It has large, pear-shaped, brown, juicy fruits. According to Fedorov (1954) the

Fig. 1. *Pyrus* species studied: A) *P. hyrcana* var. *yeghegisi*; B) *P. caucasica*; C) *P.daralaghezi*; D) *P. oxyprion*; E) *P. medvedevii*; F) *P. takhtadzhianii* (Photos by Janna Akopian).

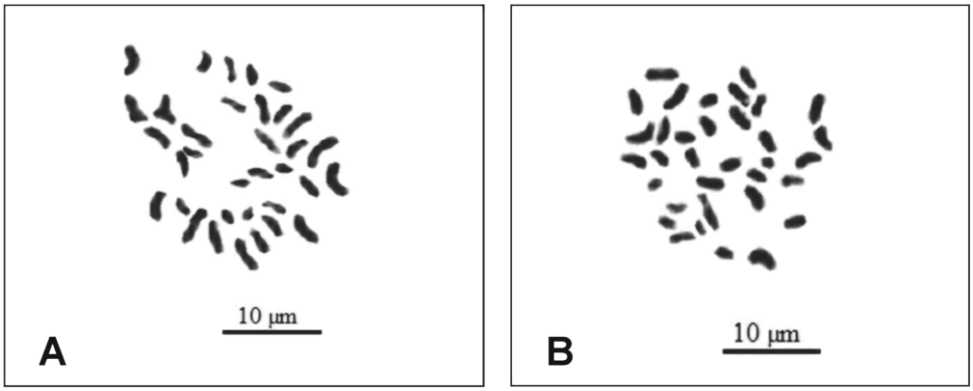

Fig. 2. Metaphase chromosome plate of: A) *Pyrus daralaghezi*, 2*n* = 34; B) *P. takhtadzhiani*, 2*n* = 34.

species may have originated from ancient local pear cultivars. *P. takhtadzhianii* is ornamental with a crown of grayish leaves of various shapes. In Armenia it grows in broad-leaved and arid light forests, among mountainous xerophytic vegetation, from 800 up to 2.200 m a.s.l. The species was described from Armenia. Endemic to Transcaucasia.

In karyologically studied specimens of *Pyrus takhtadzhianii* from Vayots Dzor province of Armenia we revealed a characteristic diploid cytotype 2*n* = 34 (Fig. 3). The chromosome number was given for the first time.

It is interesting to note that the morphological variability and hybridization processes characteristic of pear species are not accompanied by the process of polyploidization. According to Gladkova & Sveshnikova (1990) polyploidy in the genus *Pyrus* is found mainly in cultivated species. As noted by Zelinski & Thompson (1967), speciation within the genus *Pyrus* occurred without changing the chromosome number, apparently the Pomoideae group arose as an allopolyploid between two primary forms having basic numbers of 8 and 9.

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Mediterranean plant karyological data – 33/2

New karyological data for *Hieracium* and *Pilosella* (*Asteraceae*) from Southern Italy

E. Di Gristina, V. Gianguzzi & E. Bajona

Abstract
The chromosome numbers of three *Hieracium* and one *Pilosella* taxa from Southern Italy are given. The chromosome number of *Hieracium grovesianum* subsp. *rigoanum*, *H. grovesianum* subsp. *luteobarbatum* and *H. hypochoeroides* subsp. *serinense* is resulted triploid (2*n* = 3x = 27). The tetraploid chromosome set (2*n* = 4x = 36) found in the population of *Pilosella testimonialis* from Mt. Alpi (Basilicata region) differs from the previous counts (2*n* = 2x = 18) reported for this taxon in literature.

Keywords: Apomixis, Basilicata and Calabria regions, chromosome number, collective species, endemism, *Hieracium* sect. *Grovesiana.*

2020. *Hieracium hypochoeroides* subsp. *serinense* (Zahn) Greuter — 2*n* = 3x = 27 (Fig. 1a).

It: Potenza, Monte Sirino (Lagonegro), 40° 08’ 13” N, 15° 50’ 17” E, rocky stony slopes, 1.715 m a.s.l., 22 Jul 2022, *E. Di Gristina & E. Bajona 100110* (*SAF*).

Hieracium hypochoeroides subsp. *serinense* (Zahn) Greuter is a chasmophytic hawkweed endemic to Mt. Sirino (Basilicata) (Di Gristina & al. 2016a). The collective species *H. hypochoeroides* s. l. includes many apomictic microtaxa which have evolved probably during the postglacial period (Di Gristina & al. 2015a). In southern Europe, many of the taxa described seem to be relict (Gottschlich & al. 2017) and they are punctual endemics (Di Gristina & al. 2015b).

The chromosome number 2*n* = 3x = 27 (Fig. 1a), found here for the first time on material from the *locus classicus* (Mt. Sirino, Basilicata region) of this subspecies, is included in the variability (2*n* = 27, 2*n* = 36) reported for the *H. hypochoeroides* aggregate by Sell and West (1976) and Di Gristina & al. (2021).

2021. *Hieracium grovesianum* subsp. *luteobarbatum* Gottschl. **—** 2*n* = 3x = 27 (Fig. 1b).

It: Cosenza, Parco Nazionale della Sila, Monte Scuro (Camigliatello Silano), 39° 17’ 20.95” N, 16° 26’ 10.01” E, 1,670 m a.s.l., rocky stony slopes, 23 Jul 2022, *E. Di Gristina & E. Bajona* (SAF 100109).

Hieracium grovesianum subsp. *luteobarbatum* Gottschl. is a pseudorosulate hemicryp-

tophytic Italian endemic hawkweed described for the first time from Abruzzo (Gottschlich 2009) and subsequently found also in the Marche (Bartolucci & al. 2018). Recently its range has also been extended to Calabria (Di Gristina & Gottschlich 2023). It belongs to the *H.* sect. *Grovesiana* although *H. grovesianum* subsp. *luteobarbatum* is also similar to *H. murorum* due to the characteristics of the inflorescence (Gottschlich 2009).

The chromosome number $2n = 3x = 27$ (Fig. 1b), found here for the first time on material from Mt. Scuro (Calabria region), is included in the variability ($2n = 27$, $2n = 36$) reported for the other taxa belonging to the *H.* sect. *Grovesiana* (Brullo & al. 2005; Di Gristina & al. 2021).

2022. *Hieracium grovesianum* subsp. ***rigoanum*** (Zahn) Zahn — $2n = 3x = 27$ (Fig. 1c).

It: Reggio Calabria, Parco Nazionale dell'Aspromonte, Gambarie (Santo Stefano in Aspromonte), 38° 10' 16.01" N 15° 51' 40.84" E, quartzarenitic rocky slopes, 1,450 m a.s.l., 23 Jul 2022, *E. Di Gristina & E. Bajona* (SAF 100108).

Hieracium grovesianum subsp. *rigoanum* (Zahn) Zahn is a pseudorosulate hemicryptophytic Italian endemic hawkweed currently known only from Calabria, where it was described for the first time, Basilicata and Abruzzo (Di Gristina & Bajona 2023). It belongs to the *H.* sect. *Grovesiana* which comprehends a complex of similar morphotypes resulting from hybridisation processes of *H. grovesianum* Belli and *H. racemosum* Willd. (Gottschlich & al. 2013; Di Gristina & al. 2014, 2016b).

The chromosome number $2n = 3x = 27$ (Fig. 1c), found here for the first time on material from the *locus classicus* (Aspromonte, Calabria region) of this subspecies, is included in the variability ($2n = 27$, $2n = 36$) reported for the other taxa belonging to the *H.* sect. *Grovesiana* (Brullo & al. 2005; Di Gristina & al. 2021).

2023. *Pilosella testimonialis* (Nägeli ex J.Hofm.) Gottschl. — $2n = 4x = 36$ (Fig. 1d).

It: Potenza, Parco Nazionale del Pollino, Monte Alpi (Latronico), 40° 06' 20.59" N, 15° 58' 45" E, 1,570 m a.s.l., rocky stony slopes, 22 Jul 2022, *E. Di Gristina & E. Bajona* (SAF 100111).

Pilosella testimonialis (Nägeli ex J. Hofm.) Gottschl. is a very polymorphic hawkweed, widespread in central and south-east Europe (Sell & West 1976). In Italy, it is distributed along the southern periphery of the eastern Alps, in Campania, Basilicata and Calabria (Di Gristina & al. 2013).

The chromosome number $2n = 4x = 36$ (Fig. 1d), found here for the first time on material from Mt. Alpi (Basilicata region) differs from the other counts ($2n = 2x = 18$) reported for this taxon (Grau & Erben 1988; Suda & al. 2007; Di Gristina & al. 2013). This suggest that the *P. testimonialis* population of Mt. Alpi needs critical treatment.

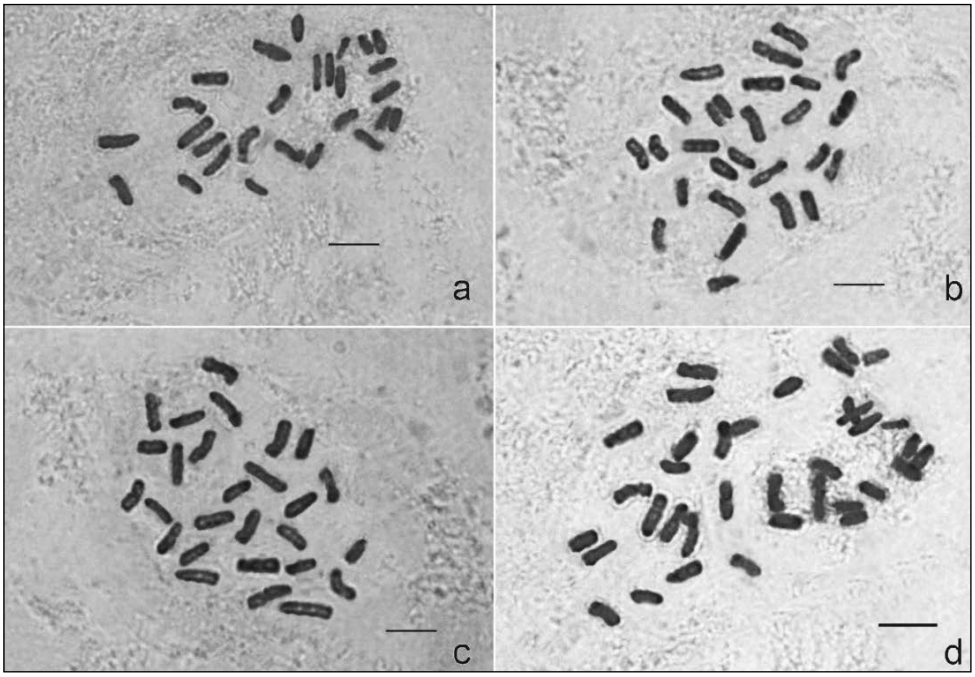

Fig. 1. Microphotographs of mitotic metaphase plates of: **a**, *Hieracium hypochoeroides* subsp. *serinense*, 2*n* = 27; **b**, *H. grovesianum* subsp. *luteobarbatum*, 2*n* = 27; **c**, *H. grovesianum* subsp. *rigoanum*, 2*n* = 27; **d**, *Pilosella testimonialis*, 2*n* = 36. – Scale bars = 10 μm.

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Mediterranean plant karyological data – 33/3

Karyological investigation of some Greek taxa with special reference to cases of polyploidy

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Abstract
Chromosome numbers and karyotypes are given for 8 taxa occurring in Greece. Microphotographs and karyotype morphology are provided, and polyploidy in some of them is discussed. Specifically, a polypoid karyotype is recorded in the species *Centaurea spruneri* s.l. (2*n* = 10x and 2*n* = 11x) *Muscari spreitzenhoferi* (2*n* = 4x) and *Allium neapolitanum* (2*n* = 3x).

Keywords: Chromosome number, distribution, Greece, karyomorphology, polyploidy.

Introduction

In the context of updating the PhytoKaryon database (Kamari & al. 2017-onwards), which aims to record the chromosomal diversity of the plants of Greece, populations of eight native taxa were studied. Chromosome numbers and karyotypes are provided along with microphotographs of metaphase plates and karyotype morphology, while polyploidy in some of them is discussed.

2024. ***Allium neapolitanum*** Cirillo — 2*n* = 3x = 21 (Fig. 1A).

Gr: East Aegean Islands (EAe), Chios Island, Prov. Ionia, near provincial road Tholopotami-Kalamotis, locality named Plakouria, 38° 17’ 53” N, 26° 04’ 54” E, alt. 223 m, 04 Apr 2022, leg. *E. Kriemadi E28* (AUA).

Allium neapolitanum is a Mediterranean element with a wide distribution in Greece in almost all phytogeographical areas, except North Pindos (NPi) and North Central (NC).

Several polyploid and aneuploid chromosome numbers have been reported for the species, with the basic chromosome number x = 7 (2*n* = 14, 21, 28, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40), originated from several countries (see Christou & al. 2008 for references). In Greece, triploid, tetraploid and pentaploid populations have been found by Tzanoudakis (1986) from Sterea Hellas (2*n* = 21, 35), Peloponnisos (2*n* = 21), and East Aegean Islands (2*n* = 21, 28), while the tetraploid chromosome number of 2*n* = 28 was given by Karavokyrou & Tzanoudakis (1991) in material from the Aegean islands of Leros, Kos, Rhodos and Lesvos.

The triploid chromosome number found here has already been given from another population of Chios island (Tzanoudakis 1986). The karyotype is symmetrical, consisting of metacentric and submetacentric chromosomes, ranging in size from 13.27 to 8.00 μm. The karyotype formula is given as: $2n = 4x = 12m + 9sm = 21$ chromosomes.

2025. ***Allium subhirsutum*** L. — $2n = 2x = 14$ (Fig. 1B).

Gr: Kriti (KK), Nomos Hanion, Prov. Kissamos, Falassarna village, 35° 30' 02" N, 23° 35' 04" E, alt. 56 m, 18 Apr 2022, leg. *E. Kriemadi E33* (AUA).

Allium subhirsutum is a widely distributed Mediterranean species. In Greece it grows all over the country except North Pindos (NPi).

The diploid chromosome number as well as karyotype morphology have been given by several authors in material originated from numerous countries (Cela Renzoni & Garbari 1971; Garbari & Tornadore 1972; Ruiz Rejón & Sañudo 1976; Badr & Elkington 1977; Jacobsen & Ownbey 1977; Capineri & al. 1978; Bartolo & al. 1981; Strid & Franzén 1981; Johnson 1982; Wittman 1984; Montmollin 1986; Tzanoudakis & Vosa 1988; Karavokirou & Tzanoudakis 1991; Lovka 1995; Brullo & al. 1997; De Sarker & al. 1997; Ohri & Pistrick 2001; Badr & El-Shazly 2022).

The karyotype of the population originated from Falassarna (Kriti) is symmetrical consisting of $2n = 2x = 10m + 4sm = 14$ chromosomes. The size of the chromosome varies between 13.73 and 8.33 μm.

2026. ***Bellevalia cilliata*** (Cirillo) Nees — $2n = 2x = 8$ (Fig. 1C).

Gr: Sterea Hellas (StE), Nomos Viotias, Viotias, Mt. Sagmata, at summit Ypato, near Church of Transfiguration of Jesus, 38° 23' 58" N, 23° 24' 44" E, alt.734 m, 16 May 2021, leg. *E. Kriemadi E25* (AUA).

Bellevalia ciliata is distributed in the Mediterranean area, while in Greece it is found in Macedonia, Thessalia, Sterea Hellas and Peloponnisos, as well as Evvia and Scopelos islands (WAe). Its habitat includes open ground, fields and cultivated places (Bareka & al. 2008).

The diploid chromosome number of $2n = 2x = 8$ reported here has been previously reported by several authors (Feinbrun, 1938-1940; Constantinidis & al. 1997; Bareka & al. 2008, 2012). Moreover, a tetraploid karyotype with $2n = 4x = 16$ chromosomes from material originated from NE Peloponnisos on serpentine substrate has been reported (Bareka & al. 2008, 2012). In the population studied here 2-4 satellited chromosomes are observed, while up to 6 satellited chromosomes have been reported for the species (Bareka 2008). It should be noted that satellites in the genus species are small, spherical and not always visible. The karyotype of the population studied here consists of $2n = 2x = 2m\text{-SAT} + 2st + 2sm\text{-SAT} + 2sm = 8$ chromosomes ranging in size from 12.00 to 6.13 μm.

2027. ***Bellevalia trifoliata*** (Ten.) Kunth — 2*n* = 2x = 8 (Figs 1D, 1E).

Gr: East Aegean Islands (EAe), Chios Island, Prov. Ionia, near provincial road Tholopotami-Kalamotis, locality named Plakouria, 38° 17’ 53” N, 26° 04’ 54” E, alt. 223 m, 04 Apr 2022, leg. *E. Kriemadi E27* (AUA). – Fig. 1D.

— East Aegean Islands (EAe), Lesvos Island, NE of the village Larisos, 50 m from provincial road Panagiouda-Larisos, alt. 65 m, 39° 07’ 43” N, 26° 28’ 28” E, 3 Apr 2022, leg. *E. Kriemadi E26* (AUA). – Fig. 1E.

Bellevalia trifoliata is a Mediterranean element, distributed in Greece at the East and West Aegean Islands, Kriti and Karpathos islands, Kithira, Ionian Islands (Kerkira) and South Pindos, where it is found in open stony places, olive groves, meadows and cultivated fields.

The diploid chromosome number (2*n* = 2x = 8) and the karyotype morphology found here from Lesvos and Chios islands, are previously given from Greece and other countries (see Bareka & al. 2008, 2012 for references). All populations studied have a diploid chromosome number with a karyotype formula consisting of two long metacentric chromosomes with small spherical satellites on their shorter arm, two acrocentric and four submetacentric chromosomes, where one pair of them bears satellites on their long arm (2*n* = 2x = 2m-SAT + 2st + 2sm-SAT + 2sm = 8). Chromosome size varies from 12.33 to 6.00 μm.

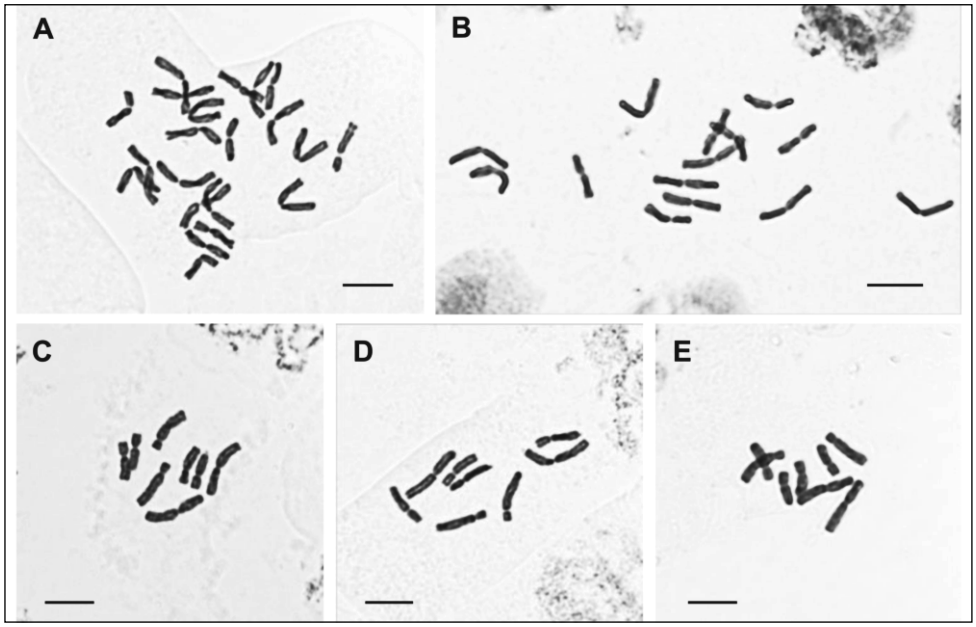

Fig. 1. Microphotographs of mitotic metaphase plates of: **A)** *Allium neapolitanum*, 2*n* = 3x = 21; **B)** *A. subhirsutum*, 2*n* = 2x = 14; **C)** *Bellevalia ciliata*, 2*n* = 2x = 8; **D)** *B. trifoliata*, 2*n* = 2x = 8 (*E27*); **E)** *B. trifoliata*, 2*n* = 2x = 8 (*E26*). – Scale bars = 10 μm.

2028. ***Centaurea spruneri*** Boiss. & Heldr. subsp. ***spruneri*** — 2*n* = 2x = 110 (Fig. 2A).

Gr: Sterea Hellas (StE), Nomos Attikis, Marathon, locality named Ramnouda, Limiko, next to a rural road, 30 Aug 2021, leg. *E. Kriemadi E24* (AUA).

Centaurea spruneri s.l. (sect. *Acrocentron*) is a Balkan endemic distributed in Albania and Greece. According to Rechinger (1943) is divided into three subspecies; subsp. *spruneri*, endemic to Attiki; subsp. *guicciardii* with a wider distribution in S Albania, Ionian Islands, CW continental Greece and N Peloponnisos and subsp. *minoa* (Heldr.) Rech fil., which is a Cretan endemic. However, according to POWO (2023) the Cretan plants belong to subsp. *guicciardii*.

Polyploid karyotypes of 2*n* = 10x = 100 and 2*n* = 11x = 110 have been already given for the typical subspecies (Phitos 1970; Phitos & Kamari 1973). In the population studied here a microphotograph of a symmetrical karyotype with 2*n* = 11x = 110 chromosomes is given. The above karyotype comprises of mostly metacentric and submetacentric chromosomes varying in size from 4.08 and 1.38 μm.

2029. ***Centaurea spruneri*** subsp. ***guicciardii*** **(**Boiss.) Hayek — 2*n* = 10x = 100 (Fig. 2B).

Gr: Ionian Islands (IoI), Lefkada Island, low peak Pirgos, SW slopes, alt. 112 m., near Ammousa beach, 38° 36’ 36.6’ N, 20° 38’ 00.2’ E, 15 Aug 2021, leg. *E. Kriemadi E23* (AUA).

Centaurea spruneri subsp. *guicciardii* has (as mentioned above) a wide distribution in the SW of the Balkan peninsula. The polyploid chromosome numbers of 2*n* = 10x = 100 and 2*n* = 11x = 110 are already reported for subsp. *guicciardii* (Phitos 1970; Phitos & Kamari 1973; Routsi 1993). Additionally, a dekaploid karyotype (2*n* = 10x = 100) is reported from Kriti (under subsp. *minoa*) by Kamari & al. (1993).

The population studied here from Lefkada Island is also decaploid with a symmetric karyotype of 2*n* = 10x = 100 metacentric and submetacentric chromosomes. The chromosome size ranges from 3.10 to 0.85 μm.

2030. ***Muscari comosum*** (L.) Mill. — 2*n* = 2x = 18 (Figs 2C, D).

Gr: Kriti (KK), Nomos Hanion, Prov. Selinou, N part of Omalos plain, near Omalos village, fallow field, 35° 20’ 26.8” N, 23° 54’ 06.4” E, alt. 1055 m, 18 Apr 2022, leg. *E. Kriemadi E40* (AUA). – Fig. 2C.

— Peloponnisos (Pe), Nomos Messinias, close to the village Skliros, next to provincial road Andritsenas-Epikouriou Apollona, at the foothills of Mt. Likeon, 37° 27’16” N, 21° 55’ 30” E, alt. 1110 m, 9 Apr 2022, leg. *E. Kriemadi E31* (AUA). – Fig. 2D.

Muscari comosum occurs from Middle East Asia to the Iberian Peninsula and Canary Islands and from central Germany and S Russia to N Africa (Bentzer 1973).

There are numerous studies on the karyotypic variation of the species, the majority of which gives the chromosome number 2*n* = 18. Material from several countries e.g. Turkey, Italy, Spain, Portugal, France, and Switzerland has been studied revealing a diploid karyotype (Garbari 1966, 1969; Ruiz Rejon 1976; Ruiz Rejon & Oliver 1981; Valdés & al. 1978; Natarajan 1979; Löve & Löve 1982; Lozano & al. 1990; Ruiz Rejón & al. 1990; Dalgiç 1991; Steck-Blaser 1992; Johnson & al. 1996; Özhatay & Johnson 1996; Johnson & Brandham 1997; Garrido-Ramos & al. 1998; Demirci Kayiran & Özhatay 2017; Kiran & al. 2020).

There are also references reporting the same somatic number 2*n* = 18 from Balkan Peninsula (Dalgiç 1991; Lovka 1995), Algeria (Azizi & al. 2016), North Africa (Corsi & al. 1996) and Cyprus (Christou & al. 2008). Several Greek populations are studied (Bentzer 1972, Bentzer & Ellmer 1975, Bentzer & Landström 1975, Montmollin 1986, Kapasa & al. 2001), while cases of trisomic karyotype with 2*n* = 18 + 1 = 19 chromosomes, triploidy (2*n* = 3x = 27), tetraploidy (2*n* = 4x = 36) and diploid karyotypes with 1-2 B chromosomes are reported (Bentzer 1972; Ruiz Rejón & al. 1981, 1986).

Additionally, a heterozygosity at the second in size chromosome pair, caused by a pericentric inversion has been reported in several studied (Garbari 1969, 1973; Bentzer 1972; Bentzer & Ellmer 1975; Bentzer & Landström 1975; Ruiz Rejón & Oliver 1981; Ruiz Rejón & al. 1990; Lozano & al. 1990; Garrido-Ramos & al. 1998; Kapasa & al. 2001; Christou & al. 2008; Azizi & al. 2016).

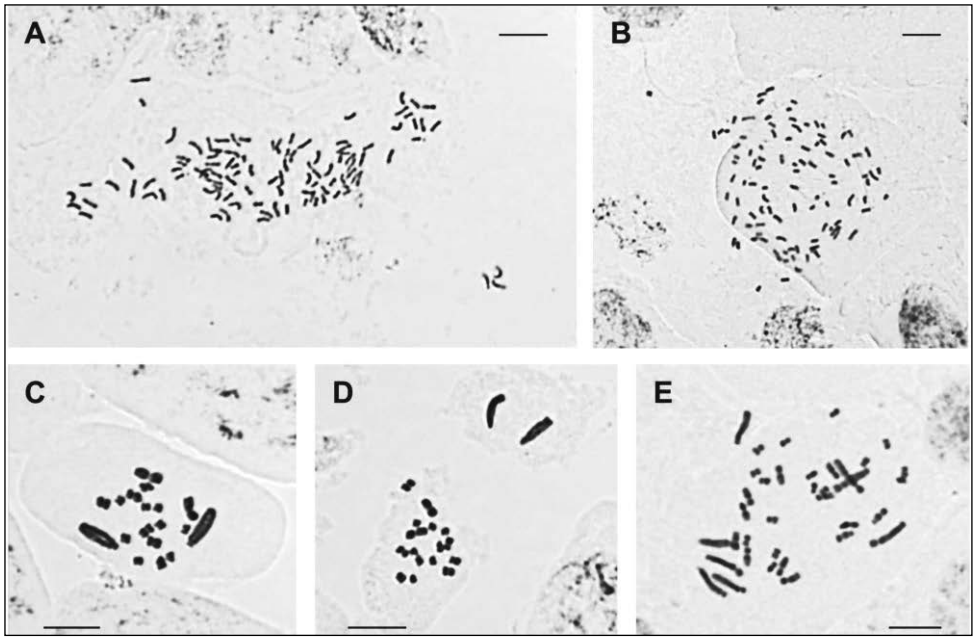

Fig. 2. Microphotographs of mitotic metaphase plates of: **A)** *Centaurea spruneri* subsp. *spruneri*, 2*n* = 11x = 110; **B)** *C. spruneri* subsp. *guicciardii* 2*n* = 10x = 100; **C)** *Muscari comosum*, 2*n* = 2x = 18 (*E40*); **D)** *M. comosum*, 2*n* = 2x = 18 (*E31*); **E)** *M. spreitzenhoferi*, 2*n* = 4x = 36. – Scale bars = 10 μm.

The karyotype formula of the populations studied here is in accordance with previous reports and consists of $2n = 2x = 2t + 2sm + 4m/sm + 10m = 18$ chromosomes, ranging in size between 8.00 and 1.11 μm.

2031. ***Muscari spreitzenhoferi*** (Heldr.) H.R. Wehrh. — $2n = 4x = 36$ (Fig. 2E).

Gr: Kriti (KK), Nomos Hanion, Prov. Kissamos, Falasarna village, 35° 30' 00" N, 23° 34' 46" E, alt. 15 m, 18 Apr 2022, leg. *E. Kriemadi E34* (AUA).

A Greek endemic species, with a wide distribution on Kriti island and Gavdopoula islet, found in sandy and rocky places, scrub and mountain dolines, mainly on limestone at an altitude of 0-2200 m.

The tetraploid chromosome number of $2n = 4x = 36$ found in the population studied here, has already been given by Montmollin (1986) from different localities. A microphotograph is given revealing an asymmetrical karyotype consisting of 8 long acrocentric chromosomes, 4 submetacentric and 28 small metacentric to submetacentric chromosomes. The karyotype formula is given as $2n = 8t + 4sm + 24m = 36$, while chromosome size varies from 8.01 to 1.81 μm.

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Mediterranean plant karyological data – 33/4

Contribution to the karyological knowledge of some representatives of the family *Asteraceae* in the Pyrenean flora

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Abstract
Chromosome numbers, ploidy level, distribution, localities, and selected prior chromosome counts are detailed for eight taxa belonging to the *Asteraceae* family including the first count in *Hieracium hastile*. All of these species grow in the Pyrenees.

Keywords: Chromosome number, *Cirsium, Hieracium, Hypochaeris, Jacobea*, *Lactuca*, *Pilosella*, *Taraxacum*, *Tragopogon*, distribution, ploidy level.

Introduction

Within the context of various ongoing projects in alpine systems' plants, with a particular focus on the Pyrenees, acquiring information about chromosome numbers and ploidy levels is crucial. These data are indispensable for comprehending the processes that impact the species constituting the flora in these regions.

The objective of this study is to augment existing cytogenetic datasets by providing additional information about chromosome numbers and ploidy levels of these species, in one of them (*Hieracium hastile*) for the first time. All plants studied have been collected in the Catalan Pyrenees (Iberian Peninsula). The information provided about their general distribution area has been obtained in all cases from Plants of the World Online (POWO, https://powo.science.kew.org, accessed November 24, 2023).

2032. *Cirsium vulgare* (Savi) Ten. — 2*n* = 4x = 68 (Fig. 1A).

Hs: Catalonia, Setcases, La Serra, edges of the pine forest, alt. 1837 m, 42° 23' 11" N, 2° 18' 59" E, 18 Aug 2023, leg. *T. Garnatje (GR-900)*, *O. Hidalgo*, *J. de Montaigne de Poncins* & *I. Pérez-Lorenzo* (BC).

This species is native to Europe, Siberia, Arabian Peninsula and NW of Africa, and introduced into Australia, America and South of Africa.

It is a ruderal species that grows on the edges of forests in the Pyrenees (Bolòs & al. 2005).

The chromosome number established in this study agrees with most previous counts (e.g. Tonian 1982), and confirms the tetraploid status of this species, but a diploid 2*n* = 34 report exists from Bulgaria (Kuzmanov & al. 1991). This is the first count from the Pyrenean area studied (https://sites.google.com/view/cromocat/home, accessed November 25, 2023).

2033. *Hieracium hastile* Arv.-Touv. & Gaut. (syn.: *Hieracium phlomoides* subsp. *hastile* (Arv.-Touv. & Gaut.) Zahn) — $2n = 3x = 27$ (Fig. 1B).

Hs: Catalonia, Setcases, Camí de la Serra, meadows, alt. 1261 m, 42° 22' 33" N, 2° 18' 12" E. 11 Aug 2023, leg. *T. Garnatje (GR-862)* & *J. Luque* (BC).

This species is a perennial plant native to NE Pyrenees & E. Central Spain (POWO).

To our knowledge, the chromosome number established in this study is the first count for this species. It agrees with counts in other triploid species of the *Hieracium* gr. *laniferum* according to *Flora iberica* (Mateo & al. 2017), such as *H. spatulathum* Scheele (Castro & al. 2007).

2034. *Jacobaea leucophylla* (DC.) Pelser (syn.: *Senecio leucophyllus* DC.) — $2n = 4x = 40$ (Fig. 1C).

Hs: Catalonia, Setcases, Coma Ombriaga, open habitats of the screes, alt. 2315 m, 42° 25' 48" N, 2° 15' 33" E, 22 Aug 2023, leg. *T. Garnatje (GR-908)* & *J. Luque* (BC).

This species is native to Southern and Central France and Eastern Pyrenees. It thrives amidst the pebbles and screes within the alpine region.

The tetraploid chromosome number established in this study agrees with previous counts: Favarger & Küpfer (1968) indicated $n = 20$ for a Pyrenean population geographically very close to the one here reported.

2035. *Lactuca serriola* L. — $2n = 2x = 18$ (Fig. 1D).

Hs: Catalonia, Puigcerdà, near the railway track, 1-2 km from the urban nucleus, ruderal, alt. 1200 m. Coord.: 42º 41' 48" N, 1º 91' 99" E, 12 Aug 2023, leg. *J. Vallès* (BC).

Native to Europe to SW Siberia and Xinjiang and N Africa to Somalia, and introduced into Australia, America and South of Africa. It grows often in ruderal locations.

The chromosome number established in this study agrees with $n = 9$ and $2n = 18$ counts reported by Mejías (1993) from a low-altitude population located at ca. 150 km from the one here studied, and from $2n = 18$ recorded from an also non-far Southern French population (Garcia & al. 2013). The same $2n = 18$ number is recorded from many other provenances (Index to plant chromosome numbers, http://legacy.tropicos.org/NameSearch.aspx?projectid=9, accessed November 25, 2023).

2036. *Pilosella lactucella* (Wallr.) P.D.Sell & C.West (syn.: *Hieracium lactucella* Wallr.) — $2n = 2x = 18$ (Fig. 1E).

Hs: Catalonia, Setcases, La Serra, meadows, alt. 1781 m, 42° 23' 11" N, 2° 18' 58" E, 18

Aug 2023, leg. *T. Garnatje (GR-897)*, *O. Hidalgo*, *J. de Montaigne de Poncins & I. Pérez-Lorenzo* (BC).

This species is native to Europe and introduced into very restricted areas of America (New York, Nova Scotia).

The chromosome number established in this study agrees with the previous counts (e.g. Rotreklová & al. 2005). This is the first count in the Pyrenean area studied (https://sites.google.com/view/cromocat/home, accessed November 25, 2023).

2037. *Hypochaeris radicata* L. — 2*n* = 2x = 8 (Fig. 1F).

Hs: Catalonia, Setcases, camí de la Serra, meadows, alt. 1521 m, 42° 22' 52" N, 2° 18' 29" E, 12 Aug 2023, leg. *T. Garnatje (GR-870)* & J. *Luque* (BC).

This species is native to Europe and Northern Africa. In the Pyrenees, it grows in meadows, grazing lands and mountain trail edges.

The chromosome number established in this study agrees with the previous counts of *n* = 4 (Luque & al. 1984) and 2*n* = 8 (Izusquiza 1989) in low-altitude areas not far from the studied one, as well as in other places (e.g. in Morocco, Serra & al. 2001; in Italy, Barghi & al. 1988).

2038. *Taraxacum pyrenaicum* Reut. — 2*n* = 2x = 16 (Fig. 1G).

Hs: Catalonia, Setcases, on the trail to the Ulldeter refuge, alt. 2139 m, 42° 25' 14" N, 2° 15' 42" E, 18 Aug 2023, leg. *T. Garnatje (GR-887)*, *O. Hidalgo*, *J. de Montaigne de Poncins* & *I. Pérez-Lorenzo* (BC).

This species is native to Bulgaria, France and Spain. It grows in alpine meadows. Bolòs & al. (2005) included this taxon in *Taraxacum dissectum* (Ledeb.) Ledeb., whereas Galán de Mera (2017) disagrees with this structuration and considers both taxa separated, with only *T. pyrenaicum* present in the Iberian Peninsula.

The chromosome number here reported confirms the count published (under the name of *T. dissectum*) of a population extremely close to the present one (Garcia & al. 2013). It is also consistent with the number *n* = 8 observed by Küpfer (1969a, b) in a population under the name of *T.* aff. *pyrenaicum* (Col du Puymorens), not far from the present one, and with the number reported by Macháčková & al. (2022) for the Encamp population in Andorra, also in the same area. The report of a triploid lineage, with 2*n* = 3x = 24, in the Ordesa valley (Záveský & al. 2005) is remarkable, with the taxon recorded as *Taraxacum pyrenaicum* group. These chromosome numbers in Eastern Pyrenees' populations differ from 2*n* = 32 reported for *T. dissectum* from China (Zhai & al. 1997).

2039. *Tragopogon lamottei* Rouy (syn.: *Tragopogon pratensis* subsp. *lamottei* (Rouy) O.Bolòs & Vigo). — 2*n* = 2x = 12 (Fig. 1H).

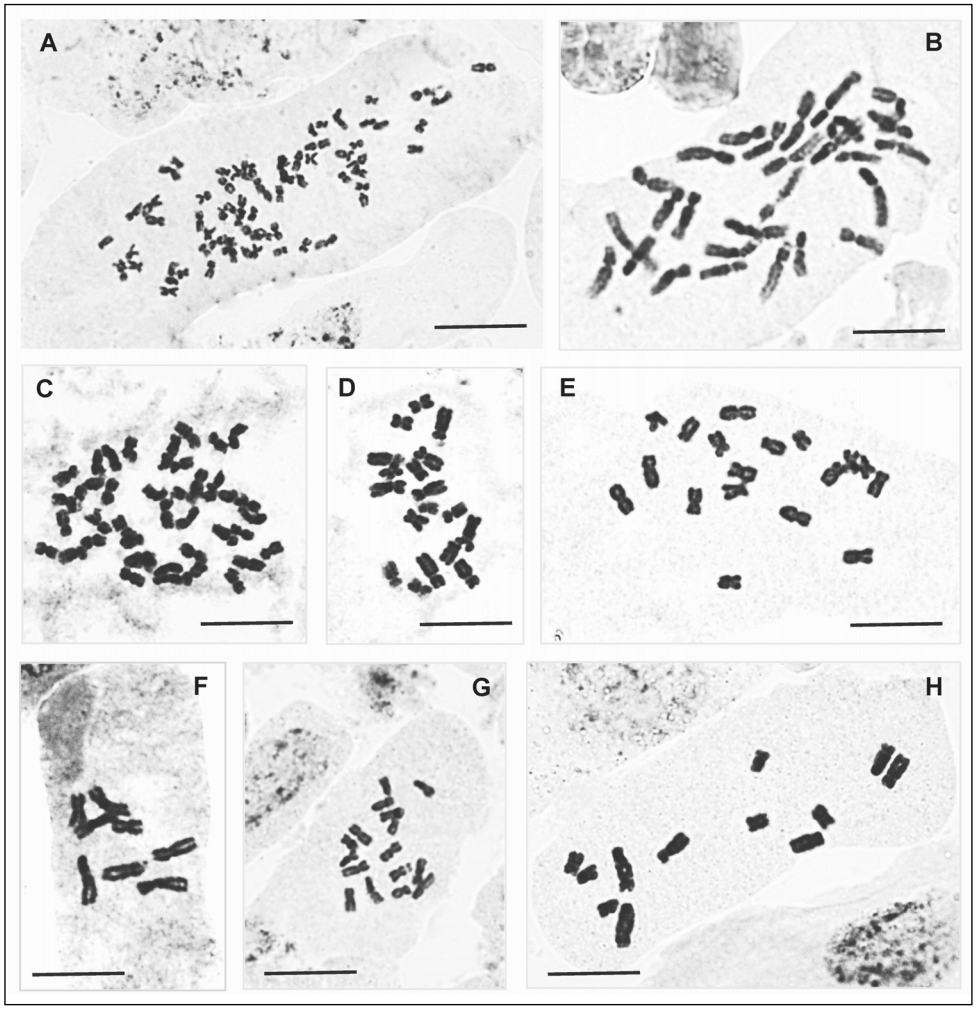

Fig. 1. Metaphase chromosome plates: A) *Cirsium vulgare*, 2*n* = 68; B) *Hieracium hastile*, 2*n* = 27; C) *Jacobaea leucophylla*, 2*n* = 40; D) *Lactuca serriola*, 2*n* = 18; E) *Pilosella lactucella*, 2*n* = 18; F) *Hypochaeris radicata*, 2*n* = 8; G) *Taraxacum pyrenaicum*, 2*n* = 16; H) *Tragopogon lamottei*, 2*n* = 12. – Scale bars = 10 μm.

Hs: Catalonia, Setcases, camí de la Serra, alt. 1365 m, 42° 22' 40" N, 2° 18' 25" E, 12 Aug 2023, leg. *T. Garnatje (GR-865)* & *J. Luque* (BC).

The native range of this species is limited to France and Spain. This species grows in the Pyrenean meadows.

The chromosome number here reported is coincidental with the one published by Díaz de la Guardia & Blanca (1988) for a Southern Iberian population. Garcia & al. (2013)

reported the same chromosome number for a *T. pratensis* -without subspecific assignation- population located not far from and at a similar altitude than the one studied in the present paper. In any case, $2n = 12$ is constant as chromosome number for all *T. pratensis* subspecies with such data available (Index to plant chromosome numbers, http://legacy.tropicos.org/NameSearch.aspx?projectid=9, accessed November 25, 2023).

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