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Floristic, phenologic and chorological differences in the therophytic vegetation-types of Sardinia

Abstract

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The therophytic flora of Sardinia has been split into four main groups, basing on the ecologic requirements of species. The following groups have been recognized: flora of dry entisoils, flora of periodically swampy or submerged entisoils, flora of coastal sites, flora of fields, road edges and human settlements. Either, most frequent or exclusive species were ascribed to each group. A species was considered "exclusive" when its relative frequency outside a given group was estimated ?10%. Differences have been highlighted within the groups, dealing with chorology, growth form, flowering time, colour of flowers, pollination and seed dispersal strategies.

Introduction

The abundance of therophytes largely contributes to the naturalistic value of Sardinia. Moreover, most of the annual species belonging to the Sardinian flora also have an historical and cultural value, as in most cases their occurrence reflects different ways of traditional land management and exploitation of natural resources, that are still performed on the island. Indeed, the development of human technology increased number and frequency of the annual plants of Sardinia over 10 thousand years of civilisation.

At present, therophytes count about 40% of the Sardinian flora (Camarda 1984a; Bocchieri 1995): they occur in several habitats of the island, where they play a keystone role, both as biomass producers and protecting the soil from rill erosion during the rainy season, at least where the environmental factors do not let a thick layer of perennial plants.

In the frame of a research about the ephemeral flora and vegetation of Sardinia, an updated checklist of the therophytes occurring on the island has been recently edited by Mossa & Guarino (in press). The list, counting 862 ascertained species, was based on over 250 bibliographic references, integrated with data concerning collections in the field. For each record of the check-list, information was provided about chorology, growth form, flowering time, colour of the flowers, pollination, seed dispersal strategies, habitat requirements and rarity. Aim of this paper is to distinguish, within the check-list, groups of species having a similar ecologic specialisation and to characterize them by means of the above-

mentioned parameters. This will be done by referring to the phytosociological classes to which the ephemeral vegetation of Sardinia can be ascribed.

Data set and metodology

The floristic study, that led to the editing of the previously mentioned check-list, has been carried out within a still in progress phytosociological survey about the annual vegetation of Sardinia. Thus, the frequency of species in a given ecologic context has also been recorded. The species of the check-list were then split into different groups, depending on their frequencies in different habitats. In Tab. 1, the numerical entity of such groups is reported, with reference to the phytosociological classes, to which the therophytic vegetation of Sardinia can be ascribed. Phytosociological classes are actually a good tool to point out in a synthetic way the traits of different habitats (Mossa & al. 2000). It must be noted that each group includes not only the exclusive species, but also those having an high frequency within the group. Species like *Avena barbata*, *Briza maxima*, *Lagurus ovatus, Rumex bucephalophorus*, being extremely common in many different habitats of Sardinia, have been included in several groups. In Tab. 1, the percentage of exclusive species is reported as well: a species was considered "exclusive" when its relative frequency outside the group was estimated ≤ 10%.

In order to verify possible adaptive differences within the groups, synthetic diagrams have been performed, with reference to the following parameters:

Chorology

Based on *Flora d'Italia* (Pignatti 1982), with some integrations from Bocchieri (1981, 1988), Bocchieri & Mulas (1988), Bocchieri & al. (1982), Brullo & al. (2003), Chiappini

Table 1. Numerical entity of the different phytosociological classes to which the annual vegetation of Sardinia can be ascribed: in the first column, the number of frequent and/or exclusive species is reported (F & E); in the second column, the percentage of exclusive species (% E).

Class	F & E	% E
Tuberarietea guttatae	300	42,1
Stipo-Trachynietea distachyae	183	45,3
Stellarietea mediae	417	37,1
Papaveretea rhoeadis	68	14,7
Polygono-Poetea annuae	22	41,0
Isoëto-nanojuncetea	107	63,1
Lemnetea minoris	4	100
Saginetea maritimae	25	60,0
Cakiletea maritimae	8	62,5
Thero-Suaedetea	13	76,9

(1963), Greuter & al. (1984-1989), Marchioni Ortu (1984, 1986), Marchioni & De Martis (1982), Ricceri & Lanza (1982), Sardara (1982), Valsecchi (1983, 1995).

Growth form

The following growth forms have been recognized: "scapose" (scap), "caespitose" (caesp), "rosulate" (ros), "creeping" (rept), "climbing" (scand). Growth forms have been identified on fresh material and on herbarium specimens collected in Sardinia. As well, the mean length of the subaerial part of the Sardinian therophytes has been screened on herbarium specimens or on plants collected in the field. The length has been reported in each case as the mean value ± 95% confidence interval.

Reproductive ecology

Data about phenology and dispersal strategies have been collected according to Pacini (1987) and Menzel & al. (2001), but the most time-consuming procedures (such as those to assess the autocompatibility of species or the specificity of pollinator) have been disregarded.

While defining the pollination strategy, it was just tried to ascertain which of the following main types was prevailing: anemogamy, entomogamy, autogamy, hydrogamy.

The colour of flowers has been classified by focussing on the dominant hues. It has been recorded more than one colour per species only in case of clear codominance of different colours (for instance: *Bellis annua*, white and yellow; *Bellardia trixago*, pink and yellow). Sixteen chromatic types have been considered, among which "greenish" and "greyish" have been used even in case of rudimental or very reduced flowers.

The flowering time of species has been recorded during the years 2002-2003 and integrated with data from literature (Nicotra 1897; Béguinot 1923; Aru & al. 1982; Camarda 1984b; Bagella 1985; Chiappini 1985; Camarda & al. 1986). Field-data were mainly collected in central and southern Sardinia, so the records might not be reliable for the northern part of the island.

While defining the seed dispersal strategy, it was tried to ascertain which of the following main types was prevailing: anemochory, balistochory, ectozoochory, barochory, and hydrochory. In case of diplo- or polichory, all possible types have been indicated. Among the post-fall dispersal strategies, only myrmecochory and hygronastochory have been considered, even if ornito- and/or endozoochory might be important for some species (such as *Solanum nigrum*), especially in the colonisation of the small islands surrounding Sardinia. Myrmecochory was assessed by feeding-trials (Guarino & Mossa 2003), without distinguishing between myrmecochory and dismyrmecochory (Wolff & Debussche 1999). Such distinction would have been rather difficult, nor yet possible, as several studies demonstrated that harvesting ants can feed on the elaiosomes or on the whole seeds depending on the food availability and on the environmental drought (reviews in Hölldobler & Wilson 1990; Huxley & Cutler 1991). Further information on the seed dispersal strategies and on the assessment methods is reported in Mossa & Guarino (in press).

Results

The screening of the above-mentioned parameters highlighted the occurrence of four main groups, to which the considered phytosociological classes can be ascribed. The species forming the four main groups find their optimal ecological requirements, either, on dry entisoils (*Tuberarietea guttatae*, *Stipo-Trachynietea distachyae*) on periodically swampy or submerged entisoils (*Isoëto-Nanojuncetea*, *Lemnetea minoris*), in coastal sites (*Saginetea maritimae*, *Cakiletea maritimae*, *Thero-Suaedetea*), in fields, road edges and human settlements (*Stellarietea mediae*, *Polygono arenastri-Poetea annuae*, *Papaveretea rhoeadis*). With reference to these main groups, it is interesting to note that the higher is the ecological specialisation of the included phytosociological classes, the higher is the percentage of exclusive species (Tab. 1).

It is interesting to note that the class *Stellarietea mediae*, grouping most of the synanthropic annual vegetation, turns out to have the highest species richness. This is due to the apophytism, i.e. species coming from the neighbouring natural vegetation settle down wherever the human impact becomes more influent, as an environmental factor, than the interspecific competition. Perhaps the most frequent floristic contamination occurs between elements of the annual dry grasslands, either, on acid (*Tuberarietea guttatae*) and neutral-basic (*Stipo-Trachynietea distachyae*) entisoils, often growing together on the road-edges and in abandoned fields. As well, the vegetation of cereal fields is mainly formed by apophytes, being the Sardinian pool of species characterising the class *Papaveretea rhoeadis* just 14% of the species which are frequent in this context.

In the following part, the above-mentioned main groups will be compared in terms of chorology, growth forms, dispersal strategies, blooming period and colours of flowers.

Flora of dry entisoils

The following phytosociological classes are here included: *Tuberarietea guttatae* and *Stipo-Trachynietea distachyae*. These classes group therophytes dwelling entisoils deriving from, either, acid rocks, the former, and neutral-basic ones, the latter. Typically, the plants belonging to this group colonize sands, eroded soils and thin mixtures of organic matter and crumbles accumulating on the bedrock. With reference to the Grime's adaptive strategies (Grime 1988), according to Madon & Médail (1997) most of the plants belonging to this group can be considered stress-tolerant.

The group at issue gathers 384 frequent and/or exclusive species, belonging to 140 genera of 30 families. The floristic fidelity, i.e. the percentage of species exclusively occurring within the group, is equal to 54%. The most represented families within the group are *Poaceae*, *Asteraceae* and *Fabaceae*, counting 94, 54 and 33 species, respectively (Tab. 2).

The chorologic spectrum shows a clear dominance of Mediterranean species, among which a relevant percentage has a W-Mediterranean distribution range (Fig. 1).

The scapose growth form is largely prevalent (Fig. 2) and the average size of the species belonging to this group is 18 cm (max_{av}: 50±20 cm, *Lathyrus articulatus*; min_{av}: 3±cm, *Evax rotundata* and *Phleum sardoum*).

The flowering period has a strictly unimodal trend, with the peak of blossom in March-April. The dominant colour of flowers is always yellow (Fig. 3). Concerning the pollination strategy, about 81% of the species is enthomogamic, 15% is anemogamic, 4% might

Table 2. Top-ten of families, genera and species of the therophytes occurring on dry entisoils.

Families vs. genera		Families vs. species		Genera vs. species	
Poceae	27	*Fabaceae*	94	*Trifolium*	20
Asteraceae	22	*Poceae*	54	*Vicia*	17
Fabaceae	18	*Asteraceae*	33	*Medicago*	16
Caryophyllaceae	13	*Caryophyllaceae*	26	*Sedum*	9
Brassicaceae	8	*Scrophulariaceae*	15	*Ononis*	8
Scrophulariaceae	7	*Brassicaceae*	11	*Silene*	7
Boraginaceae	6	*Apiaceae*	10	*Vulpia*	6
Apiaceae	6	*Crassulaceae*	10	*Erodium*	5
Labiatae	4	*Boraginaceae*	9	*Aira caryophyllea*	5
Rubiaceae	3	*Geraniaceae*	8	*Bromus*	5

be prevalently autogamic. We estimated that 34% of the species belonging to this group exhibit more than three of the characters listed by Hickman (1974) for ant-pollinated plants: dry-hot habitat; nectaries small, quantity of nectar too small to interest larger visitors; blossoms exposed near the ground, sessile, small, with minimal visual attraction; few blossoms in anthesis at the same time; gregarious occurrence of several individuals; small quantities of sticky pollen; number of ovules per flower small.

Balistochory is the prevailing seed dispersal strategy, but ants are likely to play a relevant role in the post-fall diaspore (Fig. 4).

Flora of periodically swampy or submerged entisoils

The following phytosociological classes are here included: *Isoëto-Nanojuncetea* and *Lemnetea minoris*, the former grouping the ephemeral amphibious vegetation of temporary ponds, the latter including the microphytic vegetation floating on the surface of eutro- and mesotrophyc waters. The class *Lemnetea* is represented in Sardinia just by four, extremely specialised species: *Spirodela polyrrhiza*, *Lemna gibba*, *L. minor* and *L. paucocistata*.

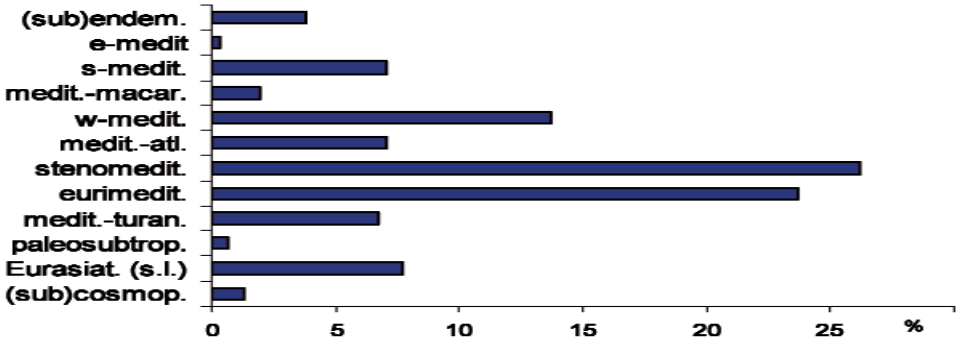

Fig. 1. Chorologic spectrum of the therophytes occurring on dry entisoils.

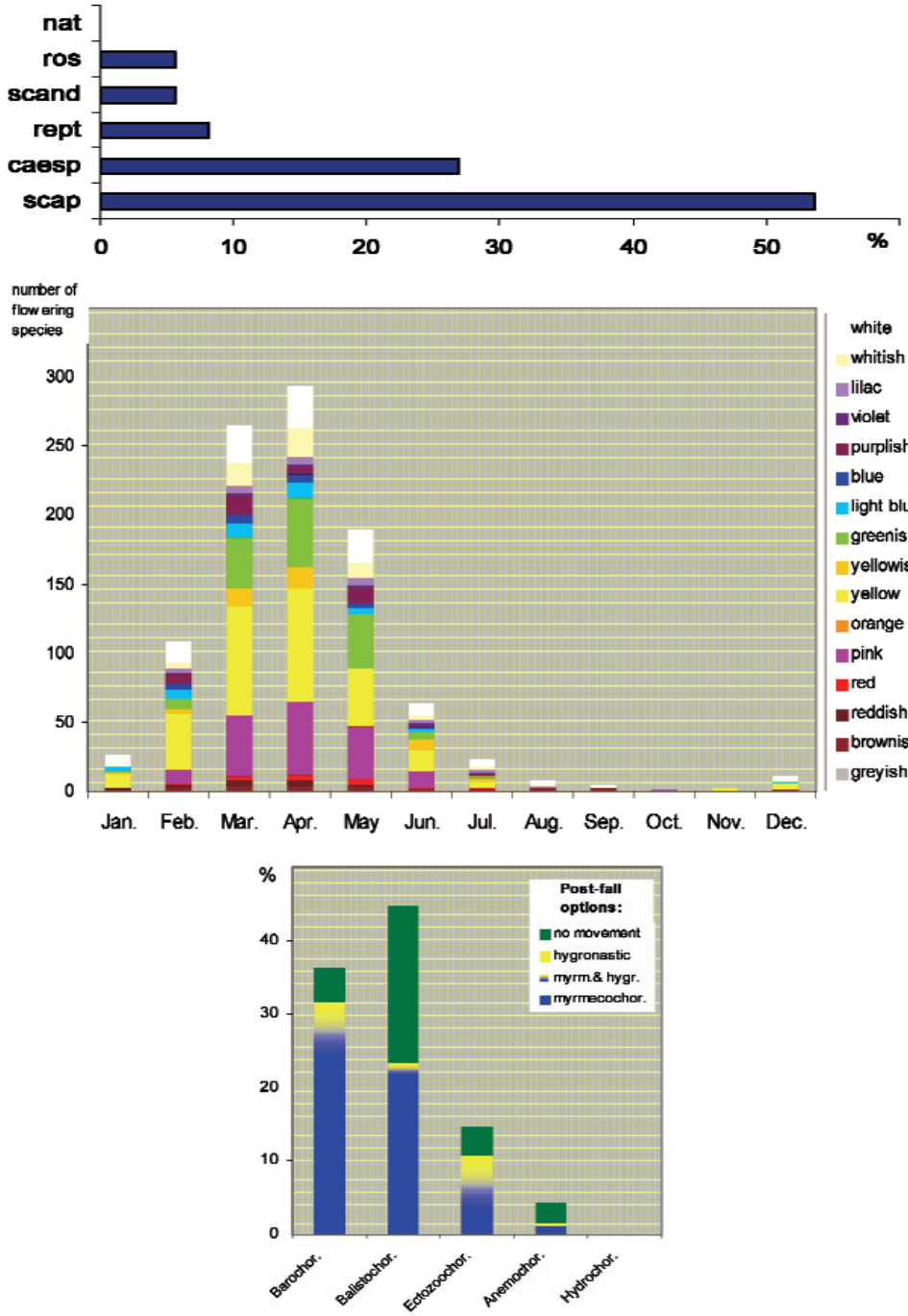

Fig. 2-4. Therophytes occurring on dry entisoils: **2.** Anabainic spectrum; **3.** Anthesic diagram; **4.** Diasporic diagram.

All of them have an almost worldwide distribution range and such a peculiar ecology, that it was decided to exclude these species from the current analysis. A thorough commentary on the *Lemnetea*-vegetation of central Italy, holding true for the Sardinian populations as well, is reported by Scoppola (1982).

With reference to the Sardinian flora, the class *Isoëto-Nanojuncetea* includes 107 frequent and/or exclusive species, belonging to 47 genera of 21 families. The floristic fidelity, i.e. the percentage of species exclusively occurring within the group, is equal to 63,1 %. The most represented families within the group are *Poaceae*, *Fabaceae* and *Asteraceae*, counting 15, 14 and 12 species, respectively (Tab. 3).

The chorologic spectrum shows a clear dominance of Mediterranean species, but those having Mediterranean-Atlantic or paleotemperate distribution range also are significant (Fig. 5).

The caespitose growth form is prevailing (Fig. 6) and the average size of the species belonging to this group is 16 cm (max_{av}: 40±20 cm, *Pulicaria sicula*; min_{av}: 5±4 cm, *Exaculum pusillum*).

The flowering period has a wide unimodal trend, with the peak of blossom in April-May. A relevant percentage of species keeps on flowering up to the end of summer. The dominant colour of flowers is yellow in winter and early spring, then it becomes greenish at the blossom of *Cyperaceae*, *Juncaceae* and *Poaceae* (Fig. 3). Concerning the pollination strategy, about 64% of the species is enthomogamic, 29% is anemogamic, 5% might be prevalently autogamic, 2% might be prevalently hydrogamic. We estimated that just 5 *Trifolium* species exhibit more than three of the characters listed by Hickman (*l.c.*) for ant-pollinated plants.

Balistochory is the prevailing seed dispersal strategy, and more than 50% of the species probably do not have any post-fall diaspore (Fig. 8).

Flora of coastal sites

The following phytosociological classes are here included: *Saginetea maritimae*, *Cakiletea maritimae* and *Thero-Suaedetea*. The first one refers to the ephemeral vegetation occurring on initial soils and detritus accumulating in hollowed sites next to the sea; the

Table 3. Top-ten of families, genera and species of the therophytes occurring on periodically swampy or submerged entisoils.

Families vs. genera		**Families vs. species**		**Genera vs. species**	
Poceae	10	*Poceae*	15	*Trifolium*	12
Caryophyllaceae	7	*Fabaceae*	14	*Ranunculus*	9
Asteraceae	6	*Asteraceae*	12	*Juncus*	8
Fabaceae	5	*Ranunculaceae*	9	*Lythrum*	5
Apiaceae	4	*Juncaceae*	8	*Veronica*	5
Gentianaceae	3	*Apiaceae*	7	*Myosotis*	4
Cyperaceae	2	*Caryophyllaceae*	6	*Anthemis*	3
Primulaceae	2	*Cyperaceae*	5	*Cyperus*	3
		Gentianaceae	5	*Lotus*	3
		Lythraceae	5	*Silene*	3

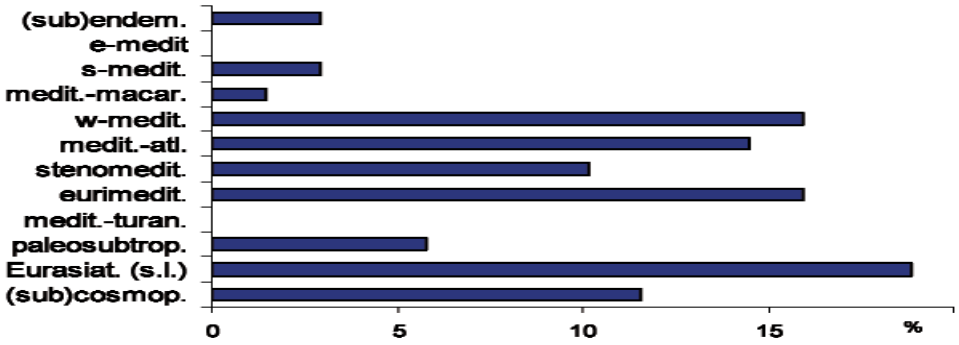

Fig. 5. Chorologic spectrum of the therophytes occurring on periodically swampy or submerged entisoils.

second one groups the annual vegetation colonizing the deposits of organic matter along the shoreline of sandy coasts; the third one groups the annual vegetation dominated by succulent *Chenopodiaceae* blooming on halomorphic soils of temporary ponds at the end of the rainy season.

The group at issue includes 46 frequent or exclusive species, belonging to 30 genera and 14 families. The floristic fidelity, i.e. the percentage of species exclusively occurring within the group, is equal to 72,3 %. The most represented families within the group are *Poaceae*, *Caryophyllaceae* and *Fabaceae*, counting 11, 9 and 9 species, respectively (Tab. 4).

From the chorologic spectrum, a clear dominance of steno-Mediterranean and Mediterranean-Atlantic species can be observed, although, among the considered groups, the present one bears the highest percentage of East-Mediterranean species (Fig. 9).

The caespitose growth form tends to prevail in all the classes (Fig. 10) while the average size ranges from the 18 cm of *Cakiletea maritimae* and *Thero-Suaedetea* and the 12 cm of *Saginetea maritimae* (max_{av}: 20±15 cm, *Cakile maritima*; min_{av}: 3±2 cm, *Nananthea perpusilla*).

The flowering period has a strictly unimodal trend, with the peak of blossom in March-April (Fig. 11). The dominant colour of flowers is yellow in winter and early spring, then it becomes greenish at the blossom of *Chenopodiaceae* and *Poaceae*. Concerning the pollination strategy, about 52% of the species is enthomogamic, 43% is anemogamic, 5% might be prevalently autogamic. No one of the species belonging to this group exhibit more than three of the characters listed by Hickman (*l.c.*) for ant-pollinated plants.

Barochory is the prevailing seed dispersal strategy (Fig. 12), and the eventual post-fall diaspore by ants is not relevant. Since the ecological niches occupied by the species belonging to this group occur in quite a narrow ecotone, the long-distance seed dispersal, i.e. anemochory, could represent a selective disadvantage, as most of the seeds would be blown away.

Flora of fields, road edges and human settlements

The following phytosociological classes are here included: *Stellarietea mediae*, *Papaveretea rhoeadis* and *Polygono arenastri-Poetea annuae*. The class *Stellarietea medi-*

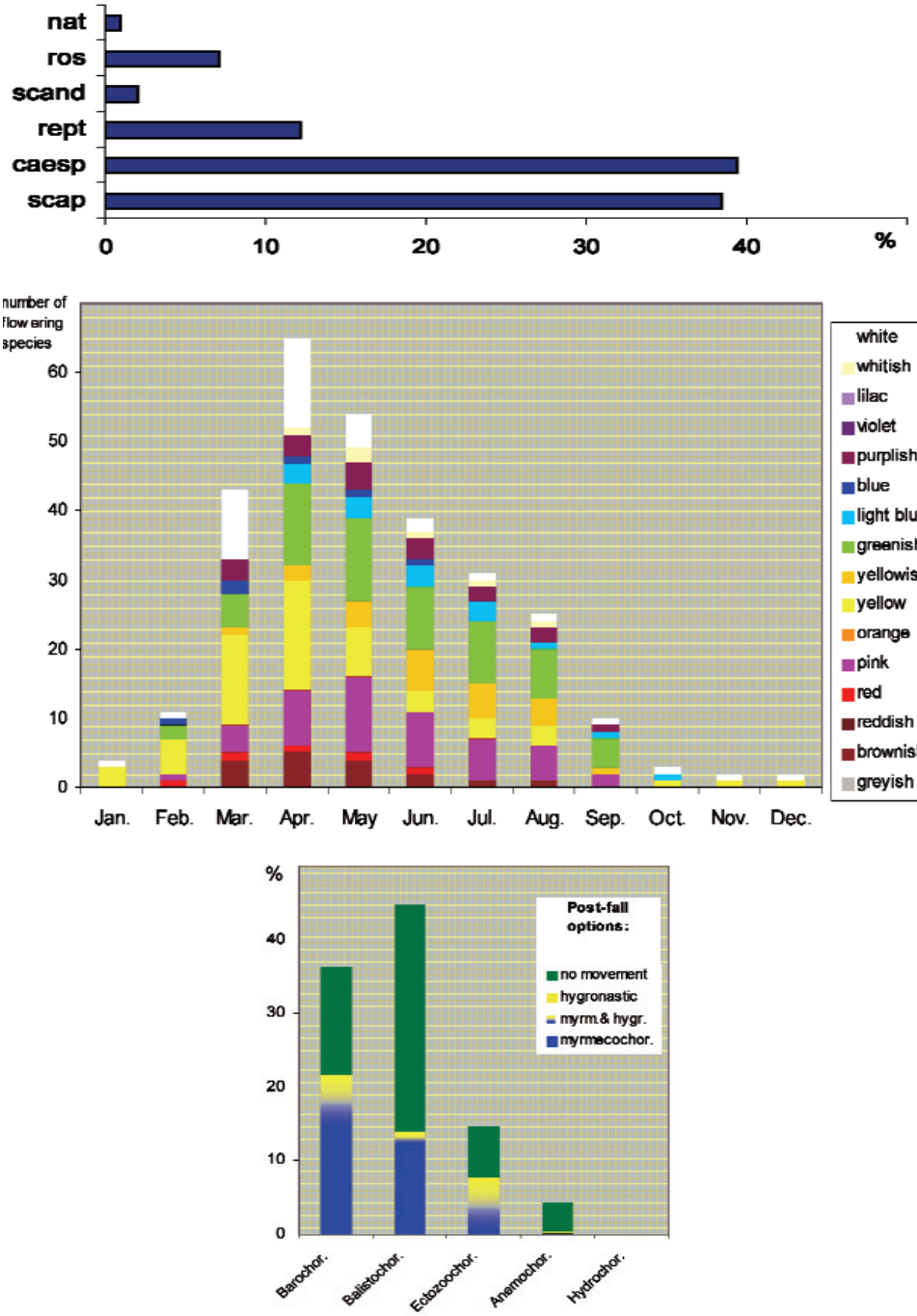

Fig. 6-8. Therophytes occurring on periodically swampy or submerged entisols: **6.** Anabainic spectrum; **7.** Anthesic diagram; **8.** Diasporic diagram.

Table 4. Top-ten of families, genera and species of the therophytes occurring in coastal sites.

Families vs. genera		Families vs. species		Genera vs. species	
Poceae	7	*Poaceae*	11	*Plantago*	3
Caryophyllaceae	5	*Caryophyllaceae*	9	*Medicago*	3
Asteraceae	5	*Fabaceae*	9	*Trifolium*	3
Chenopodiaceae	5	*Chenopodiaceae*	8	*Centaurium*	3
Fabaceae	4	*Asteraceae*	6	*Silene*	3
Gentianaceae	2	*Gentianaceae*	4	*Spergularia*	3
Juncaceae	2	*Plantaginaceae*	3		
		Juncaceae	3		

ae, actually quite an heterogeneous syntaxon, includes any kind of synanthropic therophytic vegetation occurring on the island, but the weed-communities of cereal fields (*Papaveretea rhoeadis*) and the pioneer plant communities occurring on heavily trampled soils and paved roadways (*Polygono arenastri-Poetea annuae*).

The group at issue gathers 436 frequent and/or exclusive species, belonging to 190 genera and 38 families. The floristic fidelity, i.e. the percentage of species exclusively occurring within the group, is equal to 38 %. The most represented families within the group are *Fabaceae*, *Asteraceae* and *Poaceae*, counting 65, 62 and 56 species, respectively (Tab. 5).

The chorologic spectrum shows a clear dominance of Mediterranean elements, with a relevant percentage of Mediterranean-Turanian species, grouping almost all the archeophytes occurring on the island. The widely distributed species also play a relevant role (Fig. 13).

The scapose growth form is largely prevalent (Fig. 14) and the average size of the species belonging to this group is 30 cm (max_{av}: 100±50 cm, *Datura innoxia*; min_{av}: 6±4 cm, *Buglossoides minima* and *Filago congesta*).

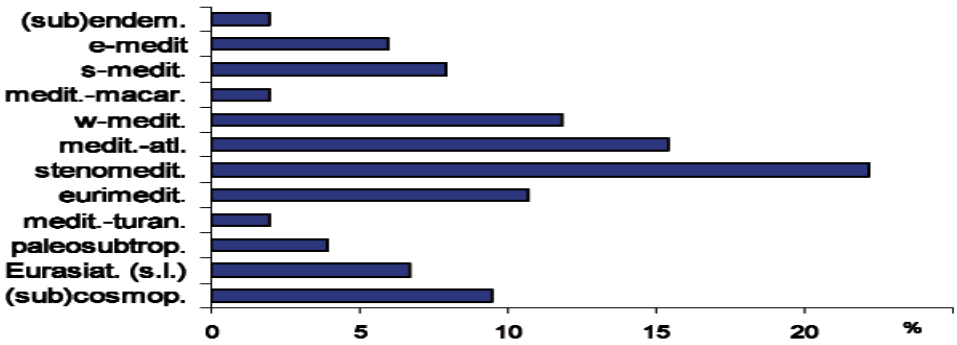

Fig. 9. Chorologic spectrum of the therophytes occurring in coastal sites.

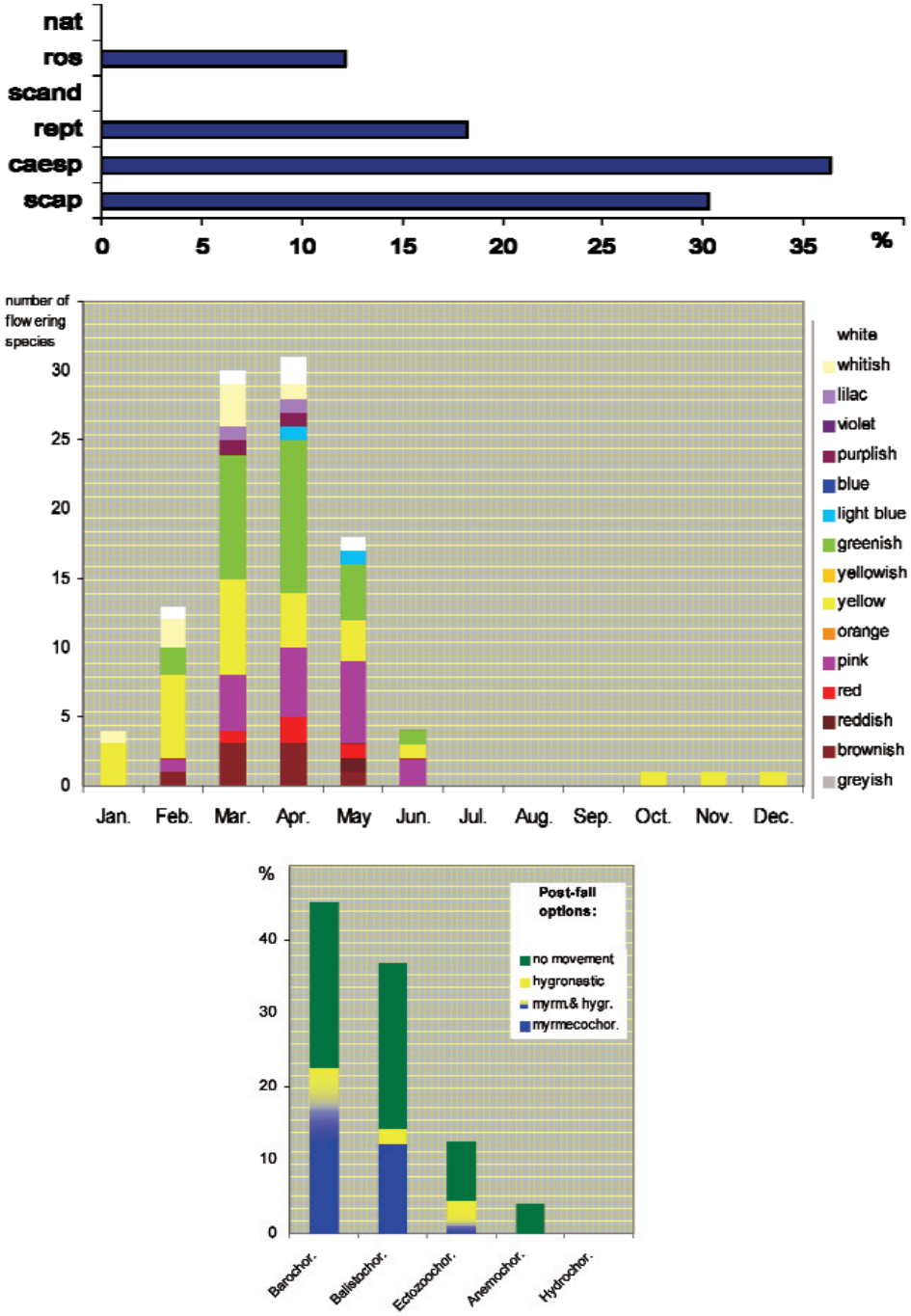

Fig. 10-12. Therophytes occurring in coastal sites:**10.** Anabainic spectrum; **11.** Anthesic diagram; **12.** Diasporic diagram.

Table 5.Top-ten of families, genera and species of the therophytes occurring in fields, road edges and human settlements.

Families vs. genera		Families vs. species		Genera vs. species	
Asteraceae	32	*Fabaceae*	65	*Vicia*	19
Brassicaceae	25	*Asteraceae*	61	*Fumaria*	13
Poceae	20	*Poceae*	56	*Euphorbia*	13
Fabaceae	14	*Brassicaceae*	39	*Medicago*	12
Caryophyllaceae	13	*Caryophyllaceae*	20	*Trifolium*	11
Apiaceae	12	*Apiaceae*	18	*Bromus*	11
Scrophulariaceae	8	*Scrophulariaceae*	16	*Chenopodium*	9
Boraginaceae	7	*Euphorbiaceae*	16	*Geranium*	8
Malv., Polygon., Solan.	4	*Geraniaceae*	15	*Valerianella*	8
Ranunc., Rubiac.	4	*Fumariaceae*	13	*Erodium*	7

The flowering period has a wide unimodal trend, with the peak of blossom in March-April-May. A relevant percentage of species keeps on flowering all year long (Fig. 15). The dominant colour of flowers is almost always yellow. It is interesting to note that greenish flowers have a bimodal trend, with a maximum in spring, due to the blossom of the *Poaceae* and another one in the late summer, due to the blossom of some *Poaceae* together with that of *Amaranthaceae* and *Chenopodiaceae*. Concerning the pollination strategy, about 79% of the species is enthomogamic, 18% is anemogamic, 3% might be prevalently autogamic. We estimated that 12 % of the species belonging to this group (nearly all those occurring within the class *Polygono-Poetea annuae*) exhibit more than three of the characters listed by Hickman (l.c.) for ant-pollinated plants.

Barochory is the prevailing seed dispersal strategy, but ants are likely to play a relevant role in the post-fall diaspore (Fig. 16).

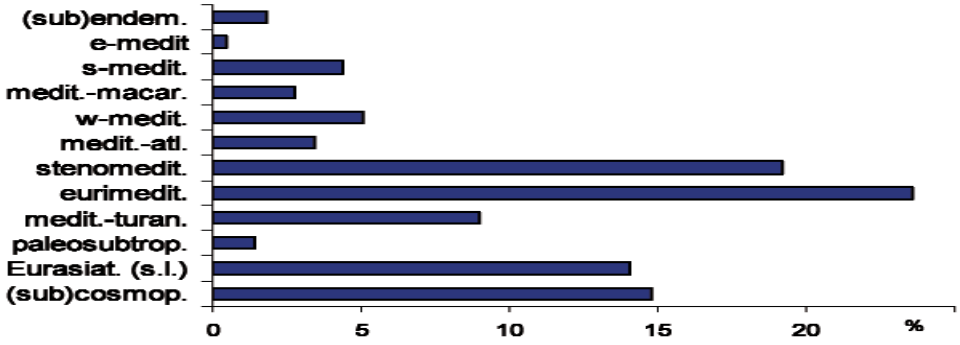

Fig. 13. Chorologic spectrum of the therophytes occurring in fields, road edges and human settlements.

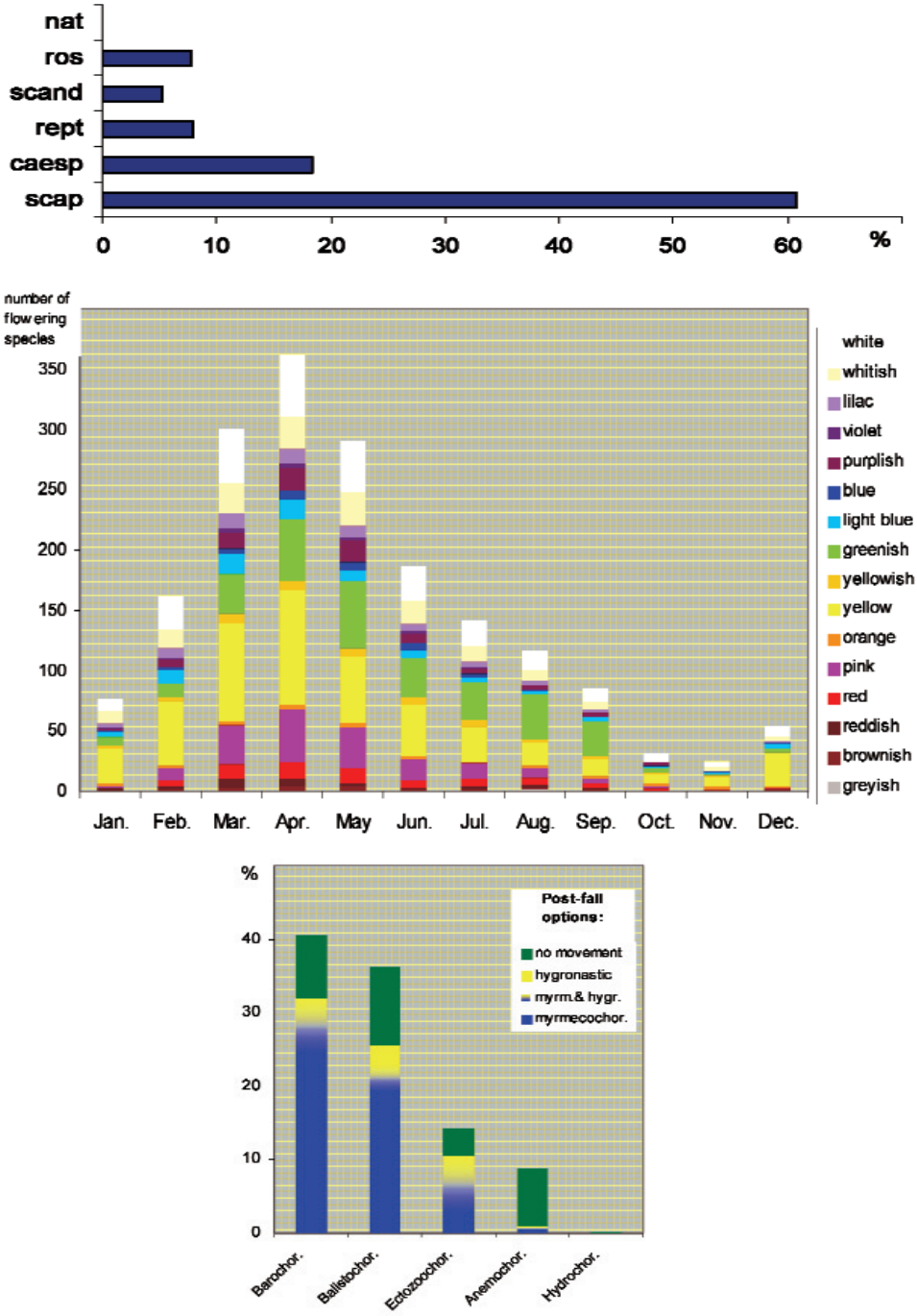

Fig. 14-16. Therophytes occurring in fields, road edges and human settlements: **14.** Anabainic spectrum; **15.** Anthesic diagram; **16.** Diasporic diagram.

Discussion

The considered groups bear significant differences concerning floristic richness and fidelity, chorology, phenology, pollination and seed-dispersal strategies. Diasporic diagrams of each group (Fig. 4, 8, 12, 16) show that myrmecochory is likely to be an important post-fall strategy, especially when the seed dispersal is performed through barochory or balistochory. Ants can influence the spatial heterogeneity of annual vegetation (Guarino & Mossa, 2003) by reducing the density of the most abundant seeds and therefore increasing the probability to succeed for less competitive species; by rearranging the distribution of seeds on the ground, and therefore contrasting the natural tendency of vegetation to form patches (Dhillion-Shivcharn 1999); by carrying seeds beyond the distance normally covered by the non-anemochorous annual plants, and therefore contributing to the spread of species.

In spite of the high number of species, the annual flora of Sardinia counts just 28 endemic o subendemic *taxa*: quite a low number in comparison to the high rate of endemism characterising the whole vascular flora of the island. Moreover, with the few exceptions of *Evax rotundata*, *Nananthea perpusilla* and *Odontites corsica* (Arrigoni 1979a; Corrias 1978, 1981) all the endemic therophytes of Sardinia are relatively recent poliploid apoendemics or schizoendemics (Arrigoni 1979b 1980; Bocchieri 1988; Bocchieri & Mulas 1988; Camarda 1978, 1982a, 1978b; Diana Corrias 1983; Valsecchi 1983, 1995). A similar low rate of endemism also characterizes the therophytic flora on the whole Mediterranean basin, bearing the highest number of therophytes among the other Mediterranean-type ecosystems of the world (Meusel 1969; Raven 1973). Many people think that the exceptional richness in therophytes of the Eu-Mediterranean flora is the result of a long-lasting human history. Twelve thousand years of land exploitation greatly contributed to the spreading of annual plants throughout the Mediterranean region, but, being the time-scale of the natural evolution not comparable to the time-scale of the cultural evolution, only in few cases (such as the allopoliploids *Poa annua, Veronica persica* and *V. hederifolia*) the human activity might have favoured the appearance of new species.

The richness in therophytes of the Mediterranean flora could be more probably an effect of the Messinian salinity crisis: in that time (from 5.8 to 5.4 millions yrs b.p.), the cyclic sea regressions opened new ecological niches and set free broad extensions of land suitable for plant colonisation (Bocquet & al. 1978; Contandriopoulos 1981). In the struggle to achieve the evolutionary success, the true winners have been those genera who managed to increase as much as possible the seed production and to shorten as much as possible their generation time, in order to increase the probability that a given combination of genes would result particularly fit for a given habitat. This hypothesis gives a possible explanation both to the above-average richness in annual species of the Mediterranean flora and to the wide ranging of such species: the prevailing polichory, the frequent gene flows and the ecological plasticity make less probable the segregation of endemic populations.

Moreover, many groups of Mediterranean therophytes still have quite an unsatisfactory taxonomy: with reference to the Sardinian flora, for example, it is likely that a peer investigation would highlight the occurrence of several taxa within the groups "*Senecio leucanthemifolius*", "*Senecio lividus*", "*Astragalus hamosus*", as it happened in the last ten years to the *Silene* sect. *scorpioideae* and sect. *coloratae* (Valsecchi 1983, 1995; Bocchieri 1988).

Still much information is needed even concerning the ecology of therophytes of

Sardinia and, in general, of the Mediterranean region: the seed productivity of most species is still unknown, as well as the seed durability and fertility. Data about the productivity of therophytes are also missing: it is likely that, at least in the Eu-Mediterranean region, therophytes introduce a relevant percentage of energy in the bio-geochemical cycles. Such energy, if not sequestrated by therophytes, would increase the erosion and the overheating of the soil surface, therefore increasing the hydric stress suffered by the perennial plants.

Nomenclature of the syntaxa mentioned in the text

Cakiletea maritimae R. Tx. & Preising in Tx. 1950
Isoëto-nanojuncetea Br.-Bl. & R. Tx. ex Westhoff & al. 1946
Lemnetea minoris R. Tx. ex O. Bolòs & Masclans 1955
Papaveretea rhoeadis Brullo, Scelsi & Spampinato 2001
Polygono-Poetea annuae Rivas-Martínez 1975
Saginetea maritimae Westhoff, Van Leeuwen & Adriani 1962
Stellarietea mediae R. Tx., Lohmeyer & Preising ex von Rochow 1951
Stipo-Trachynietea distachyae Brullo ex Brullo, Scelsi & Spampinato 2001
Thero-Suaedetea Rivas-Martínez 1972
Tuberarietea guttatae Br.-Bl. (1940) 1964

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