Emanuele Farris & Rossella Filigheddu

Floristic traits of effusive substrata in North-Western Sardinia

Abstract

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The trachyte-basalt biogeographic sub-district of the north-western Sardinian district, included in the coastal and hill sub-sector of the Sardinian sector, is characterised by two large effusive complexes: Rhyolites, Andesites and Dikes of the Oligo-Miocenic limestone/alkaline cycle (14-32 Myrs), and alkaline Basalts, Rhyolites, Rhyodacites and Dikes of the volcanic cycle with alkaline, transitional and sub-alkaline affinity of Pliocene-Pleistocene (0.14-5.3 Myrs). Between 2000 and 2002, 508 floristic/vegetation surveys were carried out on plant communities in order to improve the botanical knowledge and characterise this area biogeographycally. Floristic analysis, still in progress, led to detect 476 subgeneric taxa, as many as 23% of Sardinian flora. Among them, 44 endemics were found, as many as 20.5% of the Sardinian endemic flora. In the light of these results, the trachyte-basalt sub-region is characterised, with respect to the Sardinian flora, by significantly higher percentages of hemicryptophytes and lower percentages of therophytes; an increase in Eurimediterranean taxa is highlighted, whereas orophylous taxa are lower than the regional average; among the Mediterranean ones, the occurrence of a large number of western taxa stands out and is higher than the regional average, whereas eastern taxa are totally lacking.

Introduction

Areas characterised by effusive substrata in north-western Sardinia are among the least investigated in the island, from both a floristic and vegetational point of view.

This in spite of several endemics such as *Limonium bosanum* Arrigoni & Diana and *L. cornusianum* Arrigoni & Diana, which are exclusive to the study area (Arrigoni & Diana 1985, 1986), *Verbascum conocarpum* Moris (Diana 1981), *Genista desoleana* Valsecchi (Valsecchi 1986) and *Castellia tuberculosa* (Moris) Bor (Brullo & al. 2003) also occur here.

Thus far, no comprehensive floristic studies but only rare information on single taxa in wide-ranging contributions (Moris 1837-1859) or specific contributuion on endemic or phytogeographically interesting entities (Arrigoni 1970; Arrigoni & Diana 1999; Atzei 1996; Béguinot 1922; Camarda 1979; Chiappini 1960; Desole 1947, 1948, 1949, 1950, 1966; Martinoli 1950; Nardi 1979; Picci 1966; Valsecchi 1976, 1993, 1995) is available. In addition specific information about the endemic component is provided by Arrigoni & al. (1976-1991), who report 38 endemics. Distribution data on trees, shrubby and came-

phytic species are found in Camarda & Valsecchi (1983, 1990) and other data on endangered, vulnerable or rare species are reported by Corrias & Diana-Corrias (1977) and Conti & al. (1992, 1997).

According to Arrigoni (1983), this area is the trachyte-basalt sub-district of the north-western district, which is in turn included in the coastal and hill sub-sector of the Sardinian sector.

Floristic and vegetational studies were so carried out in order to improve the botanical knowledge and characterise this area biogeographycally. Phytosociological surveys, were made on natural and sub-natural plant communities, and floristic samples were studied in order to define the human use.

The study area

The study area (Fig. 1) lies between 40°40'N and 40°00'N and between 4°00'E and 3°40'E. Cartographic references, on I.G.M. Italy Map 1:100,000, are found on plates 192 (Alghero), 193 (Bonorva) and 205-206 (Capo Mannu-Macomer). From an administrative point of view, it falls within the provinces of Sassari, Nuoro and Oristano.

It borders Nurra to the north, Mar di Sardegna to the west and Campidano di Milis to the south, while the eastern border is marked by sedimentary substrata of the Sea Succession of Middle Lower Miocene, which form the geomorphologic landscape of the province of Sassari and extend uninterruptedly from Porto Torres to Bonorva with NNW-SSE direction. These substrata are below the effusive coverings and often crop out in the area, especially in Planargia and Mejlogu. Thus, the surface really covered by effusive substrata is about 1500 Km^2.

The investigated substrata investigated can be ascribed to two large effusive complexes: Rhyolites, Andesites and Dikes of the Oligo-Miocenic limestone/alkaline cycle (14-32 Myrs), and alkaline Basalts, Rhyolites, Rhyodacites and Dikes of the volcanic cycle with alkaline, transitional and sub-alkaline affinity of Pliocene-Pleistocene (0.14-5.3 Myrs) (Carmignani & al. 2001).

Tabular forms dominate the Oligo-Miocenic effusive system as a result of erosive differential phenomena (Brandis 1978).

In the landscape system of Plio-Pleistocenic volcanic rocks, the formation of Montiferru stands out. It consists of trachytes and phonolites with trachyte/basalt, alkaline/basalt and hawaiitic dikes, and flows of alkaline and transitional basalts from the tablelands of Campeda and Abbasanta. In the former case, formations are sharp and higher than 1.000 m a.s.l.

The watershed of the Temo River, extending 837 Km^2, dominates the hydrography of the Oligo-Miocenic system, whereas Montiferru hydrography shows a radial symmetry, the head of valleys developing from the highest area.

Phytoclimate refers to thermopluviometric data from the stations of Alghero and Macomer (1924-1965 & 1961-1990), Cuglieri and Villanova Monteleone (1924-1965) (Anonimous 1924-1990). Annual series analysis allowed processing the main phytoclimatic indices, according to Rivas-Martìnez & al. (2002), which are reported in the Table 1. This allows classifying the stations phytoclimatically (Table 2).

Despite the lack of climatic detection stations above 600 m a.s.l., two different macroclimate regions can be distinguished according to Blasi & Michetti (2002): Mediterranean

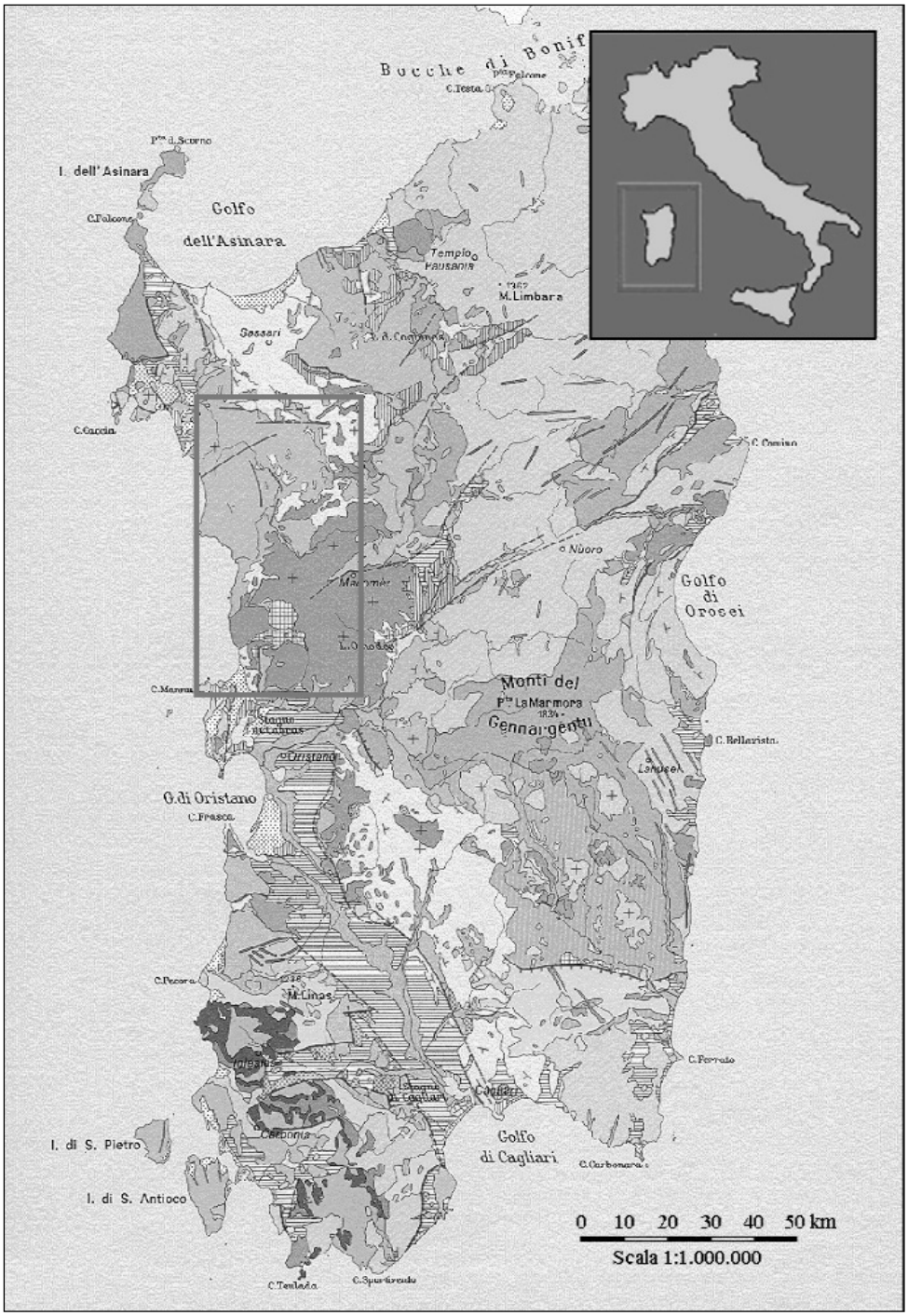

Fig. 1. The study area.

Table 1. Bioclimatic indices of thermopluviometric stations (T = mean annual temperature; M = mean of maximum temperatures of the coldest month; m = mean of minimum temperatures of the coldest month; P = mean annual precipitation; Tp = annual positive temperature; Ic = continentality index; It = termicity index; Io = ombrothermic index).

	Altitude (m asl)	Period	T (°C)	M (°C)	m (°C)	P (mm)	Tp	Ic	It	Io
Alghero	7	1924-65	16.2	12.8	6.1	688	1940	14.0	351	3.5
Alghero	28	1961-90	16.0	13.9	6.3	591	1917	13.3	362	3.1
Cuglieri	479	1924-65	14.5	9.8	4.9	791	1744	15.3	292	4.5
Macomer	572	1924-65	15.0	10.6	3.8	901	1804	16.9	294	5.0
Macomer	572	1961-90	15.2	8.9	3.4	946	1825	17.3	299	5.2
Villanova Monteleone	567	1924-65	14.3	9.3	3.9	1010	1713	16.5	275	5.9

and Temperate. The former, clearly dominant, is present in both geo-lithologic systems with three phytoclimatic belts (coastal upper thermomediterranean, lower mesomediterranean up to 500 m a.s.l. and upper mesomediterranean above 500 m a.s.l.). The latter is not found in the Oligo-Miocenic system, found in the Plio-Pleistocenic one between 700 and 1050 m a.s.l. in Montiferru, with the upper mesotemperate, low humid phytoclimatic belt.

Table 2. Bioclimatic classification of thermo-pluviometric stations.

	Altitude (m asl)	Period	Bioclimate	Phytoclimatic belt
Alghero	7	1924-65	Medit. pluviseasonal-Oc.	Upper thermomedit. low sub-humid
Alghero	28	1961-90	Medit. pluviseasonal-Oc.	Upper thermomedit. low sub-humid
Cuglieri	479	1924-65	Medit. pluviseasonal-Oc.	Lower mesomedit. upper sub-humid
Macomer	572	1924-65	Medit. pluviseasonal-Oc.	Lower mesomedit. upper sub-humid
Macomer	572	1951-90	Medit. pluviseasonal-Oc.	Lower mesomedit. upper sub-humid
Villanova Monteleone	567	1924-65	Medit. pluviseasonal-Oc.	Upper mesomedit. low humid

Methods

Between 2000 and 2002, 508 floristic/vegetation surveys were carried out on plant communities established on effusive substrata, except for coastal sectors and urban and suburban areas. 321 surveys were carried out in the Oligo-Miocenic system, 187 in the Plio-Pleistocenic system. Due to the extension of the study area (1500 Km^2), this survey aims to get a significant floristic sample, although its ultimate end is to perform the flora of the area.

A floristic list was prepared for each survey and the relevant specimens are kept at the Herbarium of the Dipartimento di Botanica ed Ecologia vegetale of the University of Sassari (SS). In the lists systematic order and nomenclature were performed according to Pignatti (1982), excepting some cases whose references were Arrigoni & al. (1976-1991), Greuter & al., (1984-1989), Tutin & al. (1964-1980, 1993), Valdés & al. (1987) and Valsecchi (1993, 1995).

Pignatti (1982) mostly developed biological forms, according to Raunkiaer (1934). Chorologic types, developed again by Pignatti (1982), were classified in larger classes (Pignatti 1994).

Biological and chorologic spectra of the flora in the study area were carried out by using the floristic list processed from floristic-vegetational surveys in the field. The analysis of the biological spectrum of the flora in the study area compared to that of Sardinia (Pignatti 1994), shows some peculiar aspects.

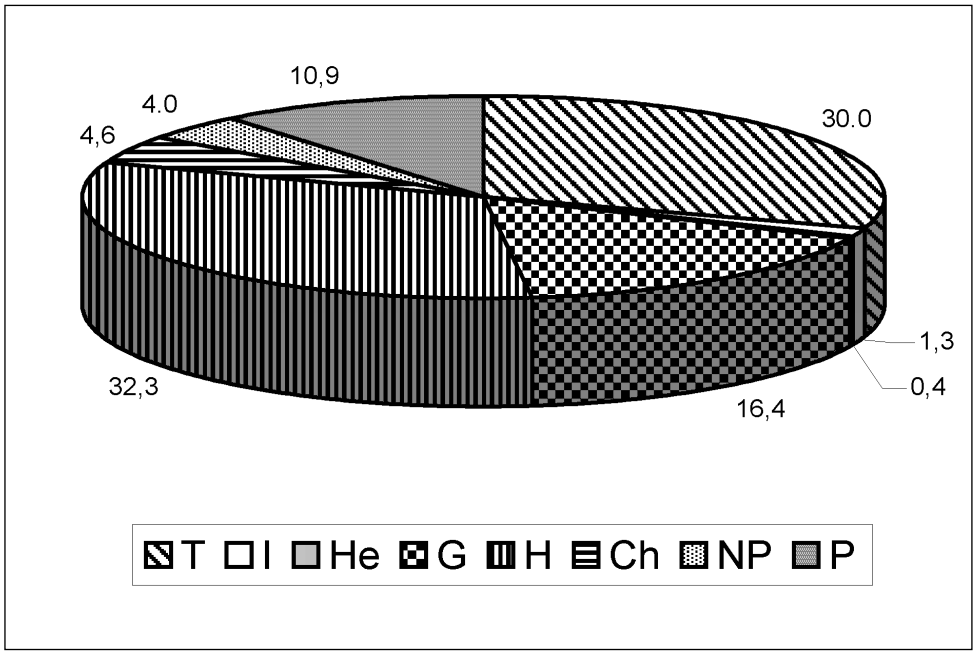

Fig. 2. Biological spectrum (%) of the flora in the study area.

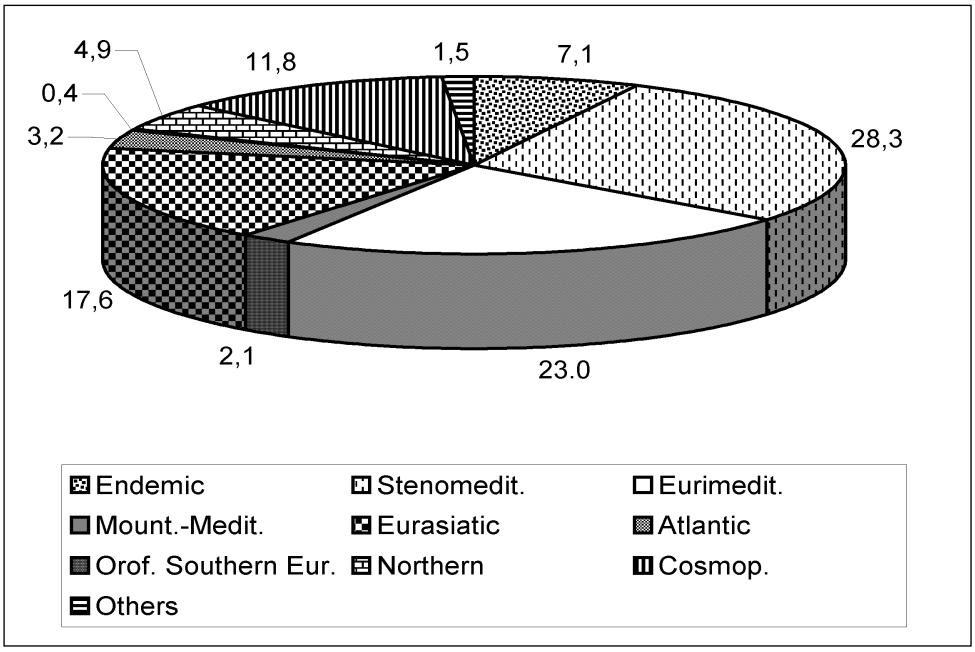

Fig. 3. Chorologic spectrum (%) of the flora in the study area.

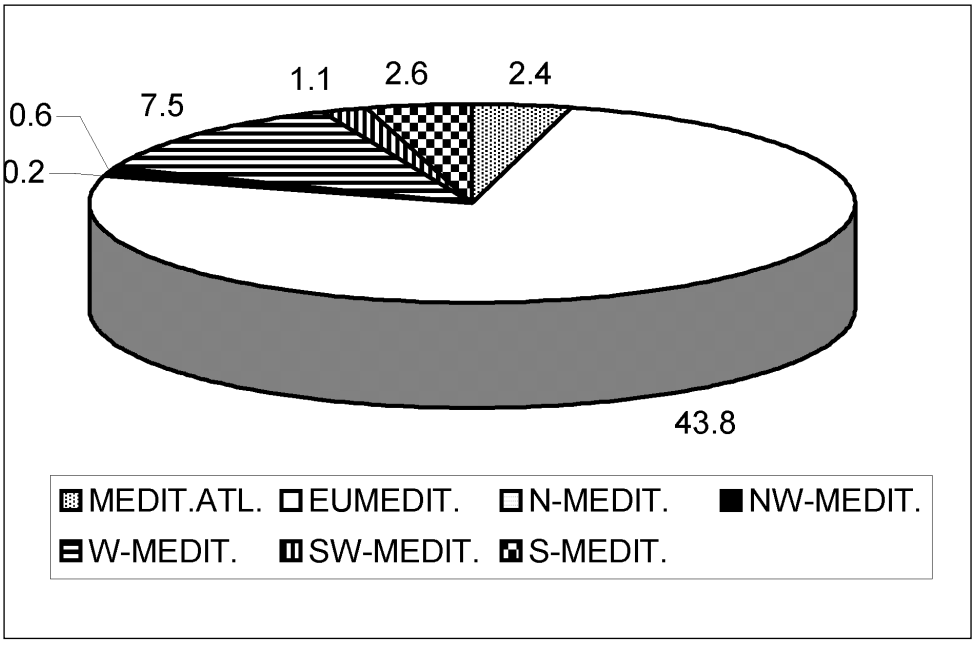

Fig. 4. Analysis of the Mediterranean component (%) of the flora in the study area.

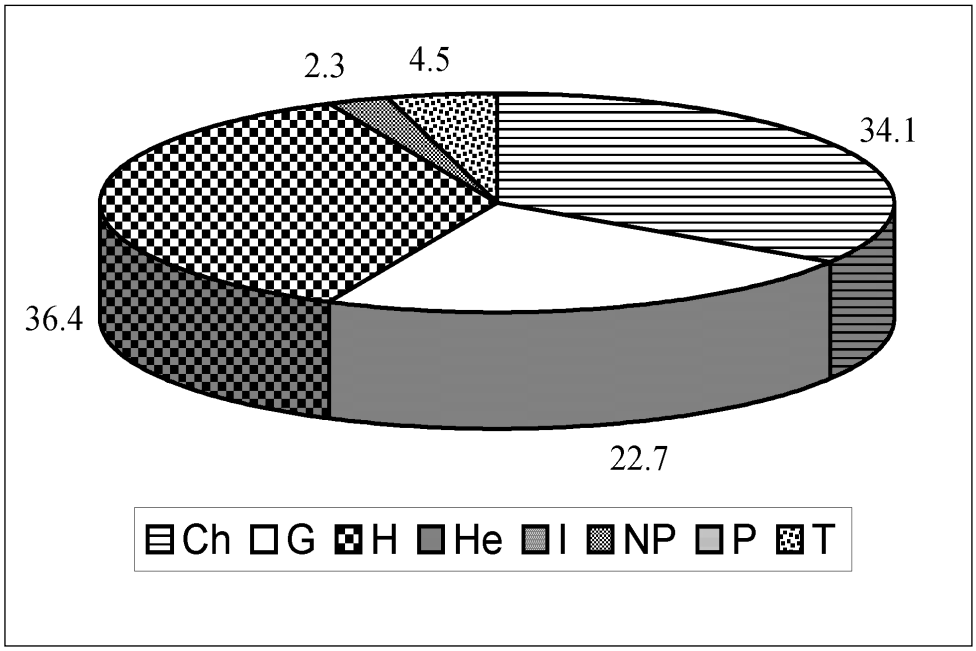

Fig. 5. Biological spectrum (%) of endemics.

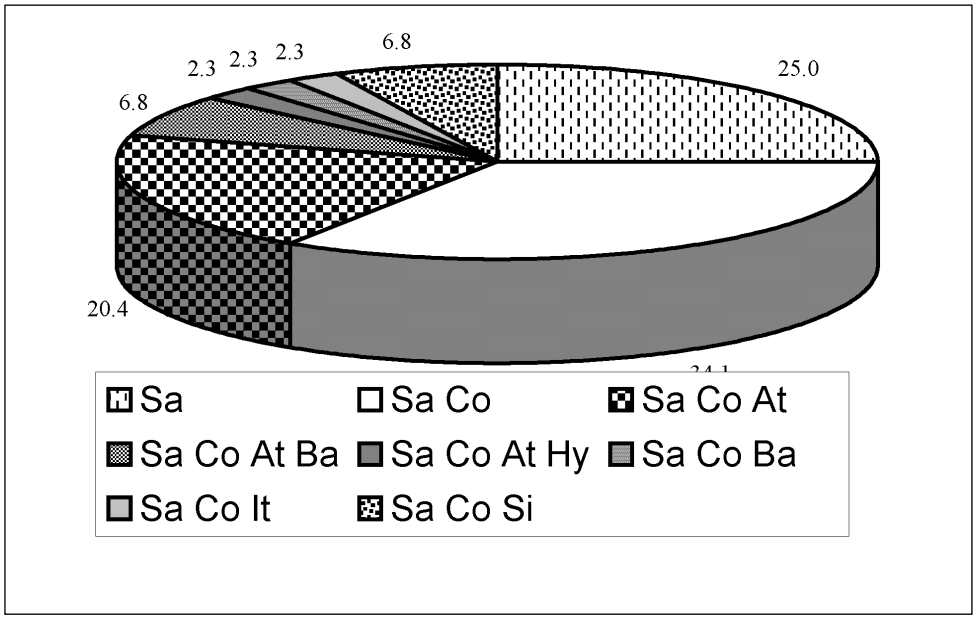

Fig. 6. Chorologic spectrum (%) of endemics (Sa = Sardinia; Co = Corsica; At = Tuscany Archipelago; Ba = Balearic Islands; Hy = Hyeres Islands; It = peninsular Italy; Si = Sicily).

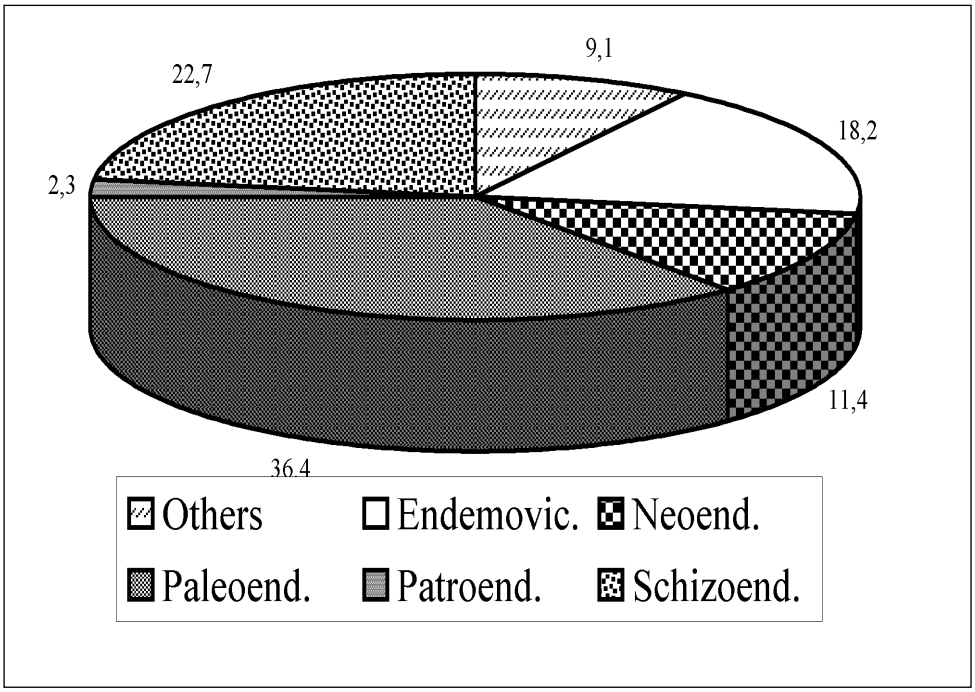

Fig. 7. Classes (%) of endemic flora in the study area.

The Mediterranean component was analysed separately, by using once again the floristic list only. The results were compared to the ones gathered by Schmid (1933).

On the contrary, the endemic component was analysed considering both our field data and the bibliographic ones reported by (Arrigoni & al. 1976-1991) and subsequent updating concerning the genera *Limonium* Miller (Arrigoni & Diana 1999; Erben 2001), *Genista* L. (Valsecchi 1993), *Paeonia* L. (Cesca & al. 2001) and *Helichrysum* Miller (Bacchetta & al. 2003) and the endemics *Stachys corsica* Pers. (Soldano 1993), *Arum pictum* L. fil. (Rossellò & Sàez 1998) and *Thymus herba-barona* s. l. (Camarda 2003).

Results

In the floristic survey, still in progress, 476 taxa, ascribed to 466 species, as many as 23% of Sardinian flora (estimated as 2028 species by Pignatti 1994) have been recorded. These taxa are included in 280 genera of 92 families. The most represented genera are *Trifolium* L. with 16 infrageneric taxa, *Ranunculus* L. with 11, *Asplenium* L., *Euphorbia* L., *Medicago* L. and *Vicia* L. with 8. The most represented families are the *Gramineae* with 58 species and lower taxa, the *Leguminosae* with 56 and the *Compositae* with 45 which amount to 33.4% of the flora recorded in this area up to now.

Biological spectrum - The biological spectrum of the flora in the study area (Fig. 2) shows the dominance of herbaceous perennial taxa, contrary to the regional average indicating the annual ones as dominant. With respect to the regional average, a higher proportion of geophytes and phanerophytes and a lower proportion of camephytes are highlighted.

Chorological spectrum - The chorological spectrum (Fig. 3) shows the dominance of Stenomediterranean species, followed by the Eurimediterranean and Eurasian ones. In comparison with the regional average, the higher rate of Eurimediterranean entities and the lower rate of cosmopolitan, mountain-Mediterranean, south-European orophytes and Mediterranean-Atlantic are stressed. The percentage of endemics is identical to the regional one.

Analysis of the Mediterranean component - Mediterranean entities of the study area were grouped into larger categories for a comparative analysis (Fig. 4). Stenomediterranean, Eurimediterranean, mountain-Mediterranean, Turanic-Mediterranean and Macaronesic-Mediterranean entities were considered as Eumediterranean *sensu* Schmid (1933) or as Circumediterranean *sensu* Contandriopoulos (1962). Other entities were ascribed to chorologic groups having a northern, north-western, western, south-western, southern and Mediterranean-Atlantic barycentre.

Overall, the Mediterranean component reaches 58.1% of the total in the study area.

The peculiar aspect of the area is represented by a large portion of entities with western barycentre and by the lack of entities with eastern barycentre (which form 1.4% of the Sardinian flora). Western, north-western and south-western Mediterranean species reach as a whole 9.2% of the total, which is a value higher than the regional one (about 8.7%, calculated by Schmid on 1950 entities).

Southern entities are 2.6% of the total and this value is lower than the regional one (about 3.1%) reported by Schmid (1933).

Analysis of the endemic component - Endemic entities represent origin and evolution of a flora (Arrigoni 1976; Contandriopoulos 1962) and therefore have a great importance for the phytogeographic classification of a region (Contandriopoulos 1981). 44 endemic entities for the study area (Annex 1), as many as 20.5% of the Sardinian endemic flora, calculated on 210 entities, were inventored by both our field data and litterature.

On 38 endemic entities already known in literature, this study allowed adding for the study area the following ones: *Arum pictum* L. f. subsp. *pictum*, *Crocus minimus* DC., *Euphorbia semiperfoliata* Viv., *Hypericum hircinum* L. subsp. *hircinum*, *Paeonia morisii* Cesca, Bernardo & Passalacqua and *Viola corsica* Nyman subsp. *limbarae* Merxm. & Lippert.

The biological spectrum of the endemics (Fig. 5) considerably diverges from the general one of the flora (Fig. 2), since hemicryptophytes and camephytes, followed by geophytes, are prevalent. Therophytes are represented by only two entities, and nanophanerophytes by only one.

The chorologic spectrum (Fig. 6) clearly shows that the most representative group consists of Sardinian-Corsican entities, followed by entities exclusive to Sardinia and the ones shared among Sardinia, Corsica and Tuscan Archipelago. Overall, 33 entities (75.0%) are shared with Corsica, 13 with the Tuscan Archipelago (29.5%), 4 with the Balearic Islands (9.1%), 3 with the Sicily, 1 with the Italian Peninsula and the Hyeres Islands in Provence, respectively.

The analysis of the endemic classes (Fig. 7) shows that the paleo-endemics are prevalent, followed by schizo-endemics, endemic-vicarious and neo-endemics. Only two entities exclusive to Sardinia are represented among the paleoendemics [*Bituminaria morisiana* (Pignatti & Metlesics) Greuter and *Thymus catharinae* Camarda], whereas the most important group consists of the Tyrrhenian elements (being evidence of past relations between the Sardinian-Corsican block and the Catalan-Provence and Balearic provinces), followed by the Sardinian-Corsican ones. On the contrary, the Sardinian elements are mostly represented by the neo-endemic and endemic-vicarious component. The Sardinian-Corsican entities represent the most conspicuous group in the schizo-endemic component. Overall, paleoendemic and patroendemic elements form 38.7% of the endemic component, whereas the endemic-vicarious, neo-endemic and schizo-endemic elements form 52.3%.

Discussion and conclusions

This analysis on flora of effusive substrata in North-Western Sardinia, still in progress, allows a first phytogeographic characterisation of the area, little investigated up to now.

In the light of the above results, the trachyte-basalt sub-region is characterised, with respect to the Sardinian flora, by significantly higher percentage of hemicryptophytes and lower percentage of therophytes, in connection with rainfall higher than the average of the Region, as observed for the flora of Monte Limbara (Veri & Bruno 1974). In the chorologic spectrum, an increase in Eurimediterranean entities is highlighted, whereas the percentage of the orophylous (both Mediterranean and south-European) entities is lower than the regional because of the low altitude of the effusive system. Among the Mediterranean ones, the presence of a large quantity of western entities stands out and it is higher than taxa the proportion of eastern entities are quite lacking. On the contrary, in the regional flora amount to 1.4% (Schmid 1933) and in smaller areas, such as the Massiccio del Marganai, reach 5.9% (Ballero & Angiolino 1991).

The analysis of the endemic component highlighted that the Sardinian-Corsican prevail (75.0% of endemic entities are shared with Corsica and at least 34.1% are exclusive), followed by the Sardinian exclusive entities (25.0%). Relations with the Italian Peninsula and Sicily are weakly represented. In particular, the amount of the Sardinian-Corsican exclusive entities, corresponding to more than one third of total endemics, agree with the classification by Arrigoni (1983), which included the Sardinian Sector in the Sardinian-Corsican Dominion where, contrary to Rivas-Martìnez & al. (2001) which include the Sardinian Sub-Province in the Italian-Thyrrenian Province. Thus, within the western Mediterranean Sub-Region, a Sardinian-Corsican Province (= Dominion *sensu* Arrigoni 1983) is believed to be present with the Sardinian and Corsican Sub- Provinces (=Sector *sensu* Arrigoni 1983).

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Address of the authors:
Emanuele Farris & Rossella Filigheddu,
Dipartimento di Botanica ed Ecologia vegetale e Centro Conservazione e Valorizzazione Biodiversità Vegetale, Università di Sassari, Via Muroni 25 – 07100 Sassari (Italy) E-mail: emfa@uniss.it.

Annex 1. Endemics occurring in the study area.

Entity	Biologic form	Distribution	Type
Allium parciflorum Viv.	G bulb	Sa Co	Paleoend.
Arenaria balearica L.	Ch suffr	Sa Co At Ba	Paleoend.
Armeria sardoa Sprengel subsp. *sardoa*	Ch suffr	Sa	Schizoend.
Arum pictum L. f. subsp. *pictum*	G rhiz	Sa Co At	Paleoend.
Barbarea rupicola Moris	Ch suffr	Sa Co	Paleoend.
Bellium bellidioides L.	H ros	Sa Co Ba	Schizoend.
Bituminaria morisiana (Pignatti & Metlesics) Greuter	Ch frut	Sa	Paleoend.
Borago pygmaea (DC.) Chater & Greuter	H scap	Sa Co At	Paleoend.
Bryonia marmorata Petit	G rhiz	Sa Co	Apoend.
Carex caryophyllea subsp. *insularis* (Barbey) Arrigoni	H scap	Sa Co	Neoend.
Cerastium palustre Moris	T scap	Sa	Endemovic.
Crocus minimus DC.	G bulb	Sa Co At	Neoend.
Cymbalaria aequitriloba (Viv.) A. Chevalier	Ch rept	Sa Co At Ba	End. Progr.
Euphorbia cupanii Guss. ex Bertol.	G rhiz	Sa Si Co	Paleoend.
Euphorbia semiperfoliata Viv.	Ch	Sa Co	Schizoend.
Galium corsicum Sprengel	H scap	Sa Co	Patroend.
Genista corsica (Loisel.) DC.	NP	Sa Co	Paleoend.
Glechoma sardoa Bég.	H rept	Sa	Neoend.
Helleborus lividus subsp. *corsicus* (Briq.) P. Fourn.	G rhiz	Sa Co	Schizoend.
Hypericum hircinum L. subsp. *hircinum*	Ch frut	Sa Co At	Endemovic.
Limonium bosanum Arrigoni & Diana	Ch suffr	Sa	Neoend.
Limonium cornusianum Arrigoni & Diana	Ch suffr	Sa	Neoend.
Limonium dubium (Andr. ex Guss.) R. Lit.	H ros	Sa Si Co	Paleoend.
Mentha insularis Requien	H scap	Sa Co At Ba	Endemovic.
Morisia monantha (Viv.) Ascherson ex Barbey	H ros	Sa Co	Paleoend.
Oenanthe lisae Moris	H scap	Sa	End. Mesog.
Ornithogalum corsicum Jord. & Fourr.	G bulb	Sa Co	Schizoend.
Paeonia morisii Cesca, Bernardo & Passalacqua	G rhiz.	Sa Co Si	Not Det.
Pancratium illyricum L.	G bulb	Sa Co At	Paleoend.
Plagius flosculosus (L.) Alavi & Heywood	Ch suffr	Sa Co	Paleoend.
Polygonum scoparium Req. ex Loisel.	Ch suffr	Sa Co	Schizoend.
Ptilostemon casabonae (L.) Greuter	H scap	Sa Co At Hy	Paleoend.
Ranunculus cordiger subsp. *diffusus* (Moris) Arrigoni	H scap	Sa Co	Endemovic.
Romulea requienii Parl.	G bulb	Sa Co It	Schizoend.
Saxifraga cervicornis Viv.	Ch pulv	Sa Co	Schizoend.
Scrophularia trifoliata L.	H caesp	Sa Co At	Schizoend.
Silene morisiana Bég. & Rav.	T scap	Sa	Endemovic.
Silene nodulosa Viv.	H caesp	Sa Co	Schizoend.
Stachys corsica Pers.	H rept	Sa Co At	Paleoend.
Stachys glutinosa L.	Ch frut	Sa Co At	Paleoend.
Thymus catharinae Camarda	Ch suffr	Sa	Paleoend.
Verbascum conocarpum Moris	H bienn	Sa Co At	Endemovic.
Vinca sardoa (Stearn) Pign.	Ch rept	Sa	Endemovic.
Viola corsica subsp. *limbarae* Merxm. & Lippert	H scap	Sa	Endemovic.