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Analysis of the floristic diversity of the Tuscan Archipelago for conservation purposes

Abstract

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The Tuscan Archipelago, with its seven main islands, is one of the most interesting areas in the northern Tyrrhenian Sea from the naturalistic point of view. Botanical studies of this area began in the XIX century; in particular, the intensive floristic work of Sommier pointed out the high floristic diversity of the Archipelago. The level of insularity varies from island to island, especially in relation to the paleogeographic history of the region as a whole. The past and present role played by human activity in this area of study has influenced floristic and vegetational dynamics, so this aspect is one of the most important fields of interest. A revision of the flora of each island proved necessary for the purpose of conservation, especially after the constitution of the National Park of the Tuscan Archipelago in 1996. Our floristic researches are based on field investigations and on the revision of original collections housed in FI, plus all the available bibliography. The floristic diversity for each island is reported in relation to morphological, ecological and chorological aspects. In particular, the floristic relationships with the Corso-Sardinian sector and the Tuscan mainland area are examined, together with the role of endemics. This study is only the first part of a study on botanical aspects of the Tuscan Archipelago, currently in progress at the University of Florence.

Introduction

Insular floras are a favourite topic for phytogeographical studies because of their geographical isolation, infact they are subjected to selection factors that determine distinct and original floristic compositions compared with those that can develop in a continental habitat. Thus they represent extremely particular aspects of floristic diversity.

The processes of selection and diversification affecting insular flora are greater the smaller the area of the islands and smaller the size of the specific populations. In a small territorial area, populations with a low number of individuals become extinct more easily and frequently, thus contributing to the establishment of "turnover" processes. Comparing insular floras compiled at different times, together with direct experience in the field, has confirmed a degree of "volatility" of the taxonomic units recorded in the past (Baldini

1998, 2000; Foggi & al. 2001) and the poorer floristic abundance of the islands compared with the continental flora of a similarly sized area.

A phytogeographical study of archipelagos is often difficult because of the unavailability of recent, or at least fairly contemporary, and sufficiently complete inventories. The Tuscan Archipelago is an exception to this rule as it has often been explored over the last centuries, in particular by Sommier between the XIX and XX centuries and more recently by several other researchers. Sommier (1903) and Arrigoni (1975) carried out phytogeographical analyses of the whole archipelago. After recent revisions of the flora of the main islands, it was possible to compile an updated floristic inventory of the Archipelago and perform a survey on the most significant phytogeographical characters of the area. This is particularly useful for conservation purposes, especially after the constitution in 1996 of the National Park of the Tuscan Archipelago.

Methods

Compilation of the floristic inventory for the Archipelago was based on the following surveys and contributions:

Gorgona - Gori (1989, PhD thesis), Moggi & al. (1991);
Capraia - Foggi & al. (2001);
Elba - Fossi Innamorati (1983-1994);
Pianosa - Baldini (2000);
Montecristo - Paoli & Romagnoli (1976) and Sartori (1980);
Giglio - Baldini (1998);
Giannutri - Baldini (2001);
Formica di Grosseto - Baldini (1990);
Cerboli - Unpublished data, Foggi & al.;
Palmaiola - Unpublished data, Foggi & al.

The inventories were collected on a "data-base". The same nomenclature was employed throughout to guarantee homogeneity. During the process we also considered partial floristic contributions and recent taxonomic revisions, as well as unpublished data the authors had collected in the field or from herbarium material. Our compilation only includes spontaneous, indigenous species and permanently naturalised exotic species. With regard to the Isle of Elba, many species which appear in the Fossi Innamorati catalogue have been excluded if they had not been confirmed by documented findings.

Geographical and environmental descriptions of the Archipelago's islands have been omitted because these can be found in the above mentioned monographs. Floristic affinity coefficients between the various islands were calculated using the Kulczinski (1928) test, which, on account of its formula, is more suitable than the others for comparing numerically highly different floras.

Diversity factors of insular flora

As Arrigoni & Bocchieri (1996) report, several factors influence the floristic diversity of islands. In short, these are as follows:

The Historical Factor

There is no doubt that the succession of events that determined the formation of islands and the development of the plant population plays a major role in the origin and composition of insular floras. Unfortunately, it is often difficult to reconstruct historical events and we often have to be content with a limited number of verifications and clues rather than real paleontological proofs. It would be particularly important to know the origin era of the island, its past links with the mainland and the previous distances from terrestrial sources as means of dispersal.

Bio-ecological factors

Bio-ecological factors can be divided into two main categories:

I - those related to the dispersal potential of the various species, particularly their disseminules (seeds, spores, propagules), but also the efficiency of the vectors on which they rely for dispersal;

II - those depending on the ecological-geographical characteristics of insular locations, in particular:

1. surface area, considered to be a limiting factor in the number of individuals and thus the stability of the species, as well as a limit to site diversity;
2. altitude, that is one of the factors determining the greater or lesser occurrence of ecologically different sites;
3. geological composition, a factor governing the diversification of the stational conditions and soil;
4. geomorphological diversity, a further factor affecting site differentiation; this especially affects the so-called azonal components of the flora, related to well defined habitats (slopes, water bodies, littoral sand, brackish areas etc.);
5. distance from other lands, considered as potential sources of external dissemination;
6. characteristics of the fauna, particularly the types of herbivores, the herbivore/carnivore ratio, occurrence of parasites, ornithic component.

The Human Factor

Man's intervention can equally influence the conditions of the bio-ecological equilibrium of the natural populations and stations.

Human activity means the following factors must also be considered:

A. extent of human intervention on natural ecosystems, which can be expressed by indices of the levels of degradation for the vegetation types;

B. introduction of exotic species;

C. size of cultivated or grazed areas;

D. length of time man has been present.

On the basis of studies performed on different insular and continental floras (e.g. Arrigoni & Bocchieri 1996), we can summarise that above all it is environmental and vegetation diversity that determine floristic richness.

Results

The islands of the Archipelago under study exhibit numerically highly diversified land surfaces and floras (Fig. 1): there is one large island (Elba), 6 medium (Capraia, Montecristo, Giglio) or small-to medium sized islands (Gorgona, Pianosa, Giannutri) and 3 small islands (Palmaiola, Cerboli, Formica grande). The floras of the smallest islets are included in those of the nearest islands.

The Flora of the whole Tuscan Archipelago consists of 1300 taxa, divided among the different islands as shown in table 1.

The influence of land surface area on floristic diversity of the islands is evident from figure 2. It is clear that the species/area ratio is expressed by a typically logarithmic curve, with a lower increase in floristic diversity as an area increases in size. It is also evident that no island alone has the same floristic wealth as a continental area of the same size, not even

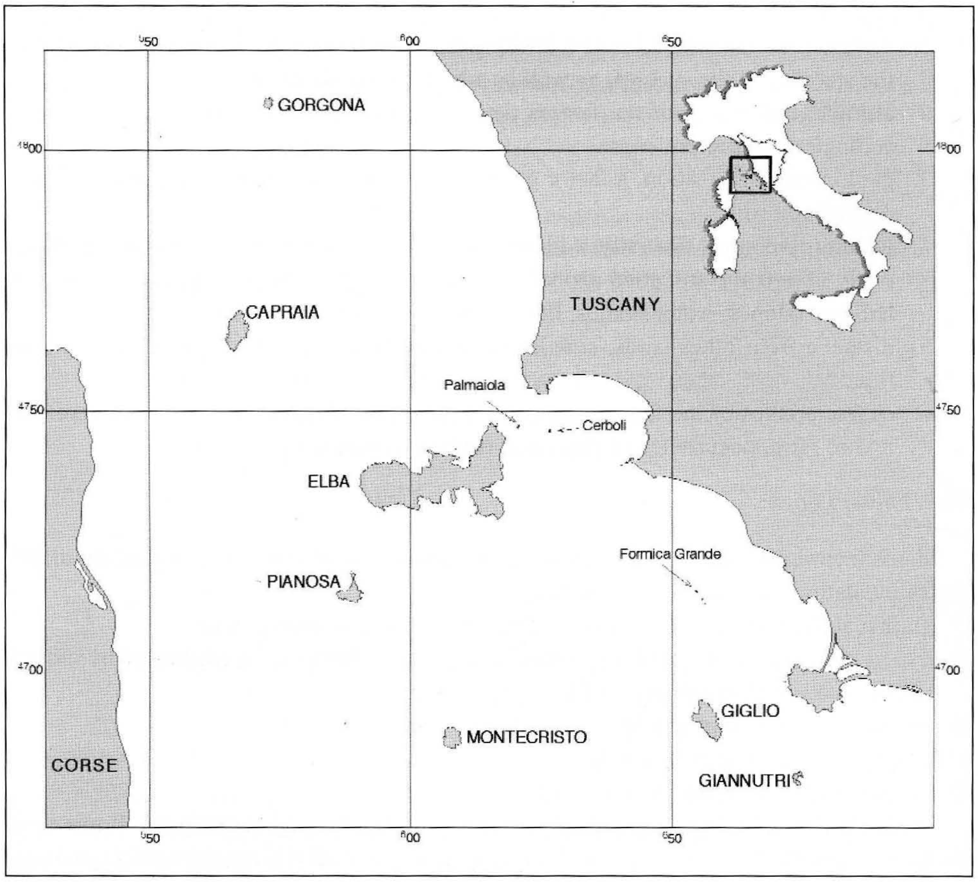

Fig. 1. The Tuscan Archipelago.

when compared with Monte Argentario, a fossil island with a high level of topographical-edaphic and anthropological diversity.

Capraia and Giglio, which are more or less of the same surface area and share similar topographical-edaphic characters, have almost identical floras numerically speaking, but their floristic affinity (Table 2) is not particularly relevant because of their different geographical settings and of the epiontology of their respective flora.

The affinity indices for Elba are only partially indicative because the size and consequently the flora of this island differ too much from the others. In fact Elba can boast

Table. 1. Physiographical and floristic characters of the islands of the Tuscan Archipelago.

	area (Ha)	perimeter (m)	max. alt. (m)	min. dist. from Corsica (Km)	min. dist. from Tuscany (Km)	min. dist. from Elba (Km)	substrate	taxa
Elba	22409,33	154641	1018	50	9	-	Several	1043
Giglio	2154,32	33874	498	108	15	52	Granite/Limestone	708
Capraia	1931,53	27993	447	27	52	33	Trachyte	669
Montecristo	1043,41	19040	645	60	66	40	Granite	465
Pianosa	1028,02	26034	27	42	57	13	Limestone	532
Giannutri	239,39	13589	93	127	11	75	Limestone	337
Gorgona	225,96	7615	255	59	34	72	Granite	528
Formica Grande	10,28	2148	11	111	14	38	Limestone	37
Cerboli	8,57	1688	71	-	7	8	Limestone	97
Palmaiola	8,39	1894	85	-	7	3	Sandstone	135

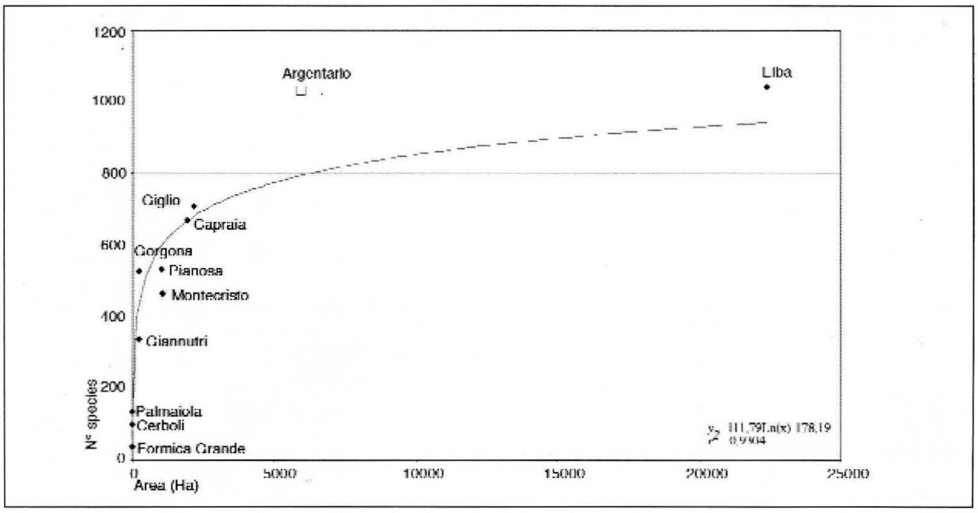

Fig. 2. Number of species/area ratio in the islands of the Tuscan Archipelago.

80.23% of the entire flora of the Archipelago. Floristic affinity levels between Pianosa and Giannutri (both limestone) and the prevalently siliceous islands are low, but also between each other on account of the different ways that species arrived there (mostly from Elba and the Argentario respectively).

The poorest of the island floristically speaking, in relation to surface area, is Montecristo. However, this is mainly due to the degraded state of the vegetation resulting from the uncontrolled and massive presence of introduced populations of domestic goats.

The distribution of the growth forms and developmental periodicity of the flora of the Archipelago (Table 3) reflect the Mediterranean setting of the area and the prevalence of anthropogenic, secondary forms of vegetation. In fact the prevalent form is herbaceous with late-winter vegetative development that has become established especially in the open, sunny areas derived from the degradation of woodland vegetation. There is also a marked presence of perennials, represented by several geophytes. The scarcity or absence of some forms on the different islands (Table 4) reflects a modest richness of different habitats.

From a chorological point of view (Table 5), there is a prevalence of Mediterranean and Tethydic elements. Nevertheless, the large presence of Euro-Mediterranean and Euro-Tethydic species reveals a more northern Mediterranean floristic combination (Euro-Mediterranean).

Human influence caused the almost total vanishing of the original forest vegetation and the development of cultivated and urbanised areas on the islands. Another indication of the level of human settlement is the high percentage (3.92%) of adventitious species in the Archipelago.

The spectrum of ecological elements (Table 6) expresses the environmental diversity of the different insular situations. The extent of degradation and development of cultivated

Table 2. Floristic affinity between the largest islands of the Tuscan Archipelago.

	EL	GI	CA	MO	PI	GN	GO
Elba (EL)	-	74	71	63	66	58	68
Giglio (GI)	74	-	72	64	67	62	66
Capraia (CA)	71	72	-	65	63	57	67
Montecristo (MO)	63	64	65	-	55	53	60
Pianosa (PI)	66	67	63	55	-	64	64
Giannutri (GN)	58	62	57	53	64	-	59
Gorgona (GO)	68	66	67	60	64	59	-

Table 3. Distribution of growth forms in the flora of the Tuscan Archipelago (1300 species).

Growth Forms		n°	%
Hydrophytes (HY)		**13**	**1,00**
Pteridophytes (PT)		**34**	**2,62**
Parasitic (Ø)	(herbaceous)	**18**	**1,38**
Woody		**170**	**13,08**
Trees	(W)	28	2,15
Saplings	(WA)	12	0,92
Shrubs	(WB)	26	2,00
Lianas	(WL)	7	0,54
Frutexes	(WF)	30	2,31
Suffrutexes	(WS)	67	5,15
Herbs		**1065**	**81,92**
Annual	(HA)	537	41,31
Biennial and perennial	(HB, HP)	528	40,62

Table 4. Distribution of growth forms in the Archipelago and in principal islands.

Island	Total number of taxa	HY	PT	Ø	Woody						Herbaceous	
					W	WA	WB	WL	WF	WS	Graminoids	others
Archipelago	**1300**	**1,00**	**2,62**	**1,38**	**2,15**	**0,92**	**2,00**	**0,54**	**2,31**	**5,15**	**11,62**	**70,31**
Elba	1043	0,67	2,78	1,44	2,40	1,15	1,82	0,67	2,01	4,51	11,98	70,57
Giglio	708	0,71	2,54	0,99	2,54	1,13	2,54	0,99	2,12	4,94	12,43	69,07
Capraia	669	0,90	2,54	0,75	2,69	0,75	2,24	1,05	2,39	3,89	12,86	69,96
Pianosa	532	0,19	1,50	0,75	1,88	0,75	1,88	0,94	1,69	5,45	13,72	71,24
Gorgona	528	0,19	2,27	1,14	3,22	1,14	1,14	0,95	2,08	4,92	13,26	69,70
Montecristo	465	0,86	4,09	1,08	2,80	1,51	2,80	0,65	2,58	3,23	12,47	67,96
Giannutri	337	-	1,48	0,59	1,19	1,48	2,97	0,89	1,19	4,15	10,39	75,67
Palmaiola	135	-	-	0,74	2,22	0,74	2,96	2,22	2,96	9,63	14,07	64,44
Cerboli	97	-	-	1,03	1,03	2,06	6,19	2,06	3,09	9,28	11,34	63,92
Formica Grande	37	-	-	2,70	-	2,70	-	-	2,70	13,51	18,92	59,46

areas and wasteland is reflected in the considerable occurrence of marginal and meadowy elements. Wet stations are hardly represented at all in the Archipelago and only the larger islands have a substantial hygrophytic element. Chasmophytes are widespread along the high coasts.

Only 132 species occur on all the islands. These are mostly erect annual herbs and

Table 5. Distribution of major chorological groups in the flora of the Tuscan Archipelago.

Chorological type	**Archipelago**	**GOR**	**CAP**	**ELB**	**GIA**	**GIG**	**PIA**	**MON**	**FOR**	**PAL**	**CER**
Taxa	**1300**	**528**	**669**	**1043**	**337**	**708**	**532**	**465**	**37**	**135**	**97**
Endemics of the Archipelago	1,23	0,38	0,90	0,77	0,30	0,28	0,38	0,65	2,70	1,48	1,03
Endemics of the Cyrno-Sardian dominion	1,31	0,57	1,79	0,38	-	0,28	0,19	1,08	-	-	-
Endemics of the Thyrrhenian dominion	0,31	0,38	0,30	0,38	0,30	0,14	0,19	0,22	-	0,74	1,03
Mediterranean	26,85	27,65	24,51	25,41	29,08	27,54	30,26	24,30	35,14	31,11	35,05
Mediterranean and Tethydic	9,77	11,17	11,66	9,97	17,80	11,72	13,72	10,32	13,51	14,81	17,53
European-Mediterranean and European-Tethyd	32,38	31,82	32,29	33,84	32,05	31,21	30,64	33,55	32,43	33,33	26,80
European	4,00	1,89	2,24	3,64	-	2,54	0,94	1,51	-	0,74	-
Eurosiberian, Olartic and Boreal	14,46	14,96	13,90	15,24	11,87	13,98	11,84	14,84	5,41	10,37	10,31
Subcosmopolite and Cosmopolite	5,77	7,01	8,52	6,42	5,93	8,19	7,33	9,68	10,81	4,44	6,19
Adventitious	3,92	4,17	3,89	3,93	2,67	4,10	4,51	3,87	-	2,96	2,06

Table 6. Distribution of ecological elements in the flora of the Archipelago.

Ecological element	**ELB**	**GIG**	**CAP**	**PIA**	**GOR**	**MON**	**GIA**	**PAL**	**CER**	**FOR**
Halophytic	2,13	1,56	1,05	2,08	1,14	0,86	2,69	3,70	3,09	13,89
Casmophytic	3,58	4,13	5,71	3,97	5,50	6,25	4,18	9,63	11,34	8,33
Commensal	0,97	1,14	1,05	1,51	1,90	1,94	1,19	2,96	-	-
Helophytic	1,64	1,42	2,10	0,76	0,95	2,37	0,30	-	-	-
Hydrophytic	0,68	0,85	1,05	0,19	-	0,86	-	-	-	-
Hygrophytic	13,15	10,67	13,06	5,86	7,78	11,42	3,58	1,48	4,12	-
Lithophytic	2,51	2,42	3,15	2,84	2,66	3,23	3,28	3,70	6,19	5,56
Ruderal	5,90	6,54	6,61	7,56	6,26	6,25	8,06	7,41	12,37	19,44
Marginal	33,37	39,12	35,89	40,83	43,26	34,27	45,97	34,81	27,84	36,11
Nemorose	10,15	8,11	7,81	4,73	7,97	8,62	5,07	6,67	13,40	5,56
Orophytic	0,68	0,14	-	-	-	-	-	-	-	-
Meadowy	12,57	12,94	15,32	15,88	15,18	14,87	16,42	19,26	10,31	8,33
Psammophytic	3,00	1,99	1,05	2,84	0,57	0,86	0,90	-	1,03	-
Ubiquitous	0,48	0,57	0,60	0,95	0,76	0,65	0,90	1,48	2,06	-
Xerophytic	9,19	8,39	5,56	10,02	6,07	7,54	7,46	8,89	8,25	2,78

grasses, of Mediterranean, Euro-Mediterranean and Euro-Tethydic chorology and mostly belong to marginal habitats and more or less xerophytic meadows.

Each of the islands followed a distinct epiontology, on account of the different distances they lie from the ancient west Corso-Sardinian insular complex and the Italian peninsula. During the last ice-age, thus in relatively recent times, some of the islands (Elba, Pianosa, Giglio, Giannutri) were an integral part of the peninsula and can in this respect be defined as "chersogenic". Any possible pleistocene links that Gorgona and especially Capraia and Montecristo had with Corso-Sardinia are dubious and in any case more ancient.

To evaluate the extent that the Corso-Sardinian lands and Tuscany may have contributed to populating the islands of the Archipelago, we compared their respective floras and obtained the data given in figure 3. The figure shows a greater penetration of Tuscan species: between 93 and 97% of the flora of the Archipelago occurs in Tuscany. On the other hand, the percentage of taxa in common with the Corso-Sardinian flora is lower, with the exception of Capraia. Similar results were also obtained when considering the percentages of those species of the Archipelago that occur in only one of the two floras (Corso-Sardinian or Tuscan). This suggests that the Italian peninsula contributed more to the floristic populations of the Archipelago than the Corso-Sardinian block.

By creating conditions of reproductive isolation of the populations, insularity favoured differentiation or conservation of species exclusive to the Archipelago, so that they became endemic (Table 7). As can been seen, the greatest concentration of local endemics occurs on Elba and Capraia. However, they are rather weak endemics, so that it is usually easy to distinguish the corresponding vicarious species (Table 8).

There is also a significant occurrence of Corso-Sardinian endemics (Table 9), especially on Capraia and Montecristo.

This kind of endemism is composed by well-characterised entities, and is certainly due to the closeness of the two islands to the Corso-Sardinian block.

On the other hand, endemics belonging to the Tyrrhenian dominion are rare on the Archipelago (Table 10). The presence of Corso-Sardinian endemics suggests that western

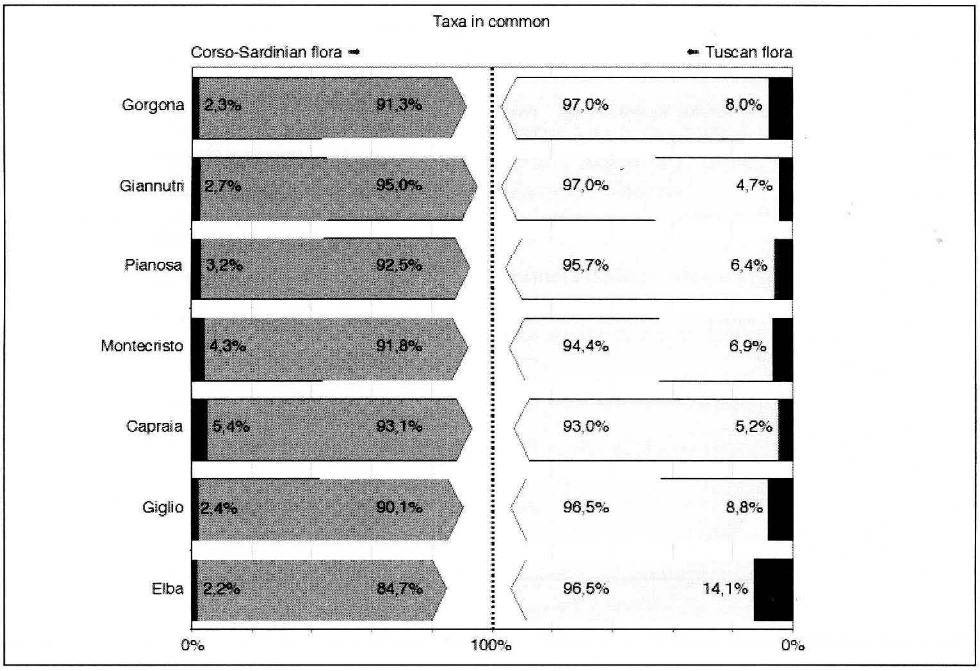

Fig. 3. Percentage of taxa in common between the flora of the largest islands of the Archipelago and the Corso-Sardinian and Tuscan floras. Black bars correspond to the percentage of taxa in common with only one of the two floras.

Table 7. Exclusive endemics of the Tuscan Archipelago.

	GOR	CAP	ELB	GIA	GIG	PIA	MON	FOR	PAL	CER
Linaria capraria Moris et De Not.	•	•	•		•	•	•		•	
Mentha requienii Benth. subsp. *bistaminata* Mannocci et Falconcini		•					•			
Silene capraria Sommier		•								
Saxifraga granulata var. *brevicaulis* Sommier		•								
Centaurea gymnocarpa Moris et De Not.		•								
Romulea insularis Somm.		•	•							
Viola corsica Nyman subsp. *ilvensis* (W.Becker) Merxm.			•							
Biscutella pichiana Raffaelli subsp. *ilvensis* Raffaelli			•							
Centaurea aethaliae (Sommier) Bég.			•							
Centaurea dissecta Ten. var. *ilvensis* Sommier			•							
Festuca gamisansii Kerguélen subsp. *aethaliae* Signorini et Foggi			•							
Limonium ilvae Pign.			•						•	•
Limonium doriae (Somm.) Pign.								•		
Limonium sommierianum (Fiori) Arrigoni				•	•		•			
Limonium gorgonae Pign.	•									
Limonium planesiae Pign.						•				

Table 8. Exclusive endemics of the Tuscan Archipelago: growth forms, ecological elements and corresponding vicarious.

Biscutella pichiana Raffaelli subsp. *ilvensis* Raffaelli	Perennial herb	Lithophytic	*Biscutella pichiana* Raffaelli subsp. *pichiana*
Centaurea aethaliae (Sommier) Bég.	Perennial herb	Lithophytic	*Centaurea dissecta* var. *ilvensis* e C. *paniculata* L. var. *litigiosa* (Fiori) Sommier
Centaurea dissecta Ten. var. *ilvensis* Sommier	Perennial herb	Lithophytic	*Centaurea aethaliae* e *C. paniculata* L. var. *litigiosa* (Fiori) Sommier
Centaurea gymnocarpa Moris et De Not.	Perennial herb	Casmophytic	*Centaurea cineraria* gr.
Festuca gamisansii Kerguélen subsp. *aethaliae* Signorini et Foggi	Perennial graminoid	Orophytic	*Festuca gamisansii* Kerguélen subsp. *gamisansii*
Limonium doriae (Somm.) Pign.	Suffrutex	Casmophytic	*Limonium multiforme* gr.
Limonium gorgonae Pign.	Suffrutex	Casmophytic	*Limonium multiforme* gr.
Limonium ilvae Pign.	Suffrutex	Casmophytic	*Limonium multiforme* gr.
Limonium planesiae Pign.	Suffrutex	Casmophytic	*Limonium multiforme* gr.
Limonium sommierianum (Fiori) Arrigoni	Suffrutex	Casmophytic	*Limonium multiforme* gr.
Linaria capraria Moris et De Not.	Perennial herb	Casmophytic	*Linaria arcusangeli* Atzei et Camarda
Mentha requienii Benth. subsp. *bistaminata* Mannocci et Falconcini	Perennial herb	Casmophytic	*Mentha requienii* Benth. subsp. requienii
Romulea insularis Somm.	Perennial herb with underground stem	Hygrophytic	*Romulea revelieri* Jord. et Fourr.
Silene capraria Sommier	Annual herb	Meadowy	*Silene apetala* Willd.
Viola corsica Nyman subsp. *ilvensis* (W.Becker) Merxm.	Perennial herb	Orophytic	*Viola corsica* Nyman subsp. *corsica*

floristic penetration was greater than that from the continent, but this could also depend on the greater antiquity and relevance of Corso-Sardinian endemisms (over 300 species) compared to Tuscan ones (little over 70 species).

Table 9. Endemics belonging to the Corso-Sardinian Dominion.

	GOR	CAP	ELB	GIA	GIG	PIA	MON
Urtica atrovirens Req. ex Loisel.	•	•	•		•	•	
Soleirolia soleirolii (Req.) Dandy		•					
Limonium contortirameum (Mabille) Erben		•					
Hypericum hircinum L.			•				•
Borago pygmaea (DC.) Chater et W. Greuter		•					
Stachys corsica Pers.		•					
Stachys glutinosa L.		•					
Mentha suaveolens Ehrh. subsp. *insularis* (Req.) Greuter		•					
Scrophularia trifoliata L.	•						•
Verbascum conocarpum Moris							•
Galium caprarium Natali	•	•					
Carduus fasciculiflorus Viv.							•
Pancratium illyricum L.		•	•				
Arum pictum L. fil.							•
Carex microcarpa Bertol. ex Moris		•	•		•		
Festuca arundinacea Schreber subsp. *corsica* (Hack.) Kerguélen		•					
Trisetaria burnoufii (Req. ex Parl.) Banfi et Soldano		•					

Table 10. Endemics belonging to the Thyrrhenian Dominion.

	GOR	CAP	ELB	GIA	GIG	PIA	MON	PAL	CER
Silene badaroi Breistr.	•	•	•						
Helichrysum litoreum Guss.	•	•	•	•	•	•	•	•	•
Ophrys exaltata Ten. subsp. *tyrrhena* (Gölz et Reinh.) Del Prete			•						
Crocus etruscus Parl.			•						

Conserving phytodiversity

On completion of the phytogeographical analysis it was clear that in spite of its insular fragmentation, the Tuscan Archipelago represents a bridge as well as a biological filter between the floristic Corso-Sardinian dominion and the Italian peninsula. The influence of the Corso-Sardinian flora is more evident in the western islands, whilst the eastern islands appear to have been invaded more by peninsular flora.

Phytogeographical evaluation of these islands is obscured by the profound changes that human settlement brought to the various territories over the past centuries. In fact, it must be mentioned that the original woodland vegetation has almost totally been removed to give place to agriculture and grazing, leading to drastic changes in the environmental pattern.

The nemorose, mesophilic and sciaphilous elements all suffered; they were practically eliminated and replaced by chorologically Mediterranean heliophilous, shrubby and herbaceous, mostly annual, species. At the same time, a lot of exotic species, introduced voluntarily or involuntarily by man were added to the insular flora.

The main factors disturbing flora and vegetation are as follows:
- fire, as a means of transforming land use in the territory, especially for grazing;
- intensive grazing by farm animals;
- change in land use: cultivation of degraded areas, reforestation, urbanisation;
- excessive numbers of wild herbivores, especially ungulates;
- elevated human activity in some parts of the territory and the development of a road network;
- introduction of aggressive, exotic plants (e.g.: *Ailanthus altissima*).

Also reforestation is a highly disturbing factor, because it quantitatively and qualitatively alters the composition of the local ecosystems. Conifer reforestation, in particular, drastically alters the ecology of the sites. The practice of conifer plantation must always be carefully evaluated in relation to the geobotanical exigencies of an area.

Grazing by domestic animals must be controlled, especially the number and choice of species, to avoid unsustainable damage of the spontaneous vegetation. In particular, goat grazing must be forbidden or controlled, as this can be extremely damaging to efforts aimed at conserving and reconstructing woodland ecosystems.

Even more dangerous, as the experience of the Tuscan Regional Parks has warned, can be grazing by ungulates. In the absence of carnivores, there are often far too many and their numbers go unchecked, so jeopardising the stability of the ecosystems. The reproduction rate of ungulates is so high that their numbers can lead to true and proper disasters, threatening the renewal of woodland species and completely eliminating a large part of the geophytes (e.g. *Orchidaceae*) and other herbaceous plants they find appetible. This problem is particularly serious in insular territories, where it is difficult to reconstruct the original composition of the ecosystem, because there is no territorial contiguity as a possible source of dissemination.

Today, the economy of the territory relies less on agricultural and grazing resources, degradation phenomena are declining, but there is still the threat of fire and arson.

Tourist and recreational development, which some of the islands have achieved, should, among other things, promote greater attention towards naturalistic and landscape aspects, favouring the reconstruction of the most evolved woodland vegetation.

In general, insular floras are subject to "turnover", i.e. the disappearance/replacement of species, which is higher the smaller the island, lower the number of relative populations and higher the level of human settlement and the nearer terrestrial sources of repopulation. Comparison between recent and older censuses of the floras of the Archipelago (see Baldini and other previously mentioned authors) testify the existence of "turnover" phenomena, the disappearance of already recorded species and the influx of new species, often favoured by man. Locally rare species are in potential danger of disappearing, especially on the smaller islands, as they are often easily involved in the "turnover" processes.

Conservation of the present floristic diversity depends essentially on maintaining vegetation diversity. As it is known that the main part of the flora of the Tuscan Archipelago is in common with those of the Corso-Sardinian and/or of the Italian peninsula, attention must principally be directed towards endemic and locally rare species which are in danger of extinction.

Chorological analysis (Fig. 4) reveals a non-homogeneous distribution of these species with high concentrations in certain areas.

The number of rare species was established after a chorological investigation performed for the Region of Tuscany. For this purpose, we defined taxonomic entities as rare if they

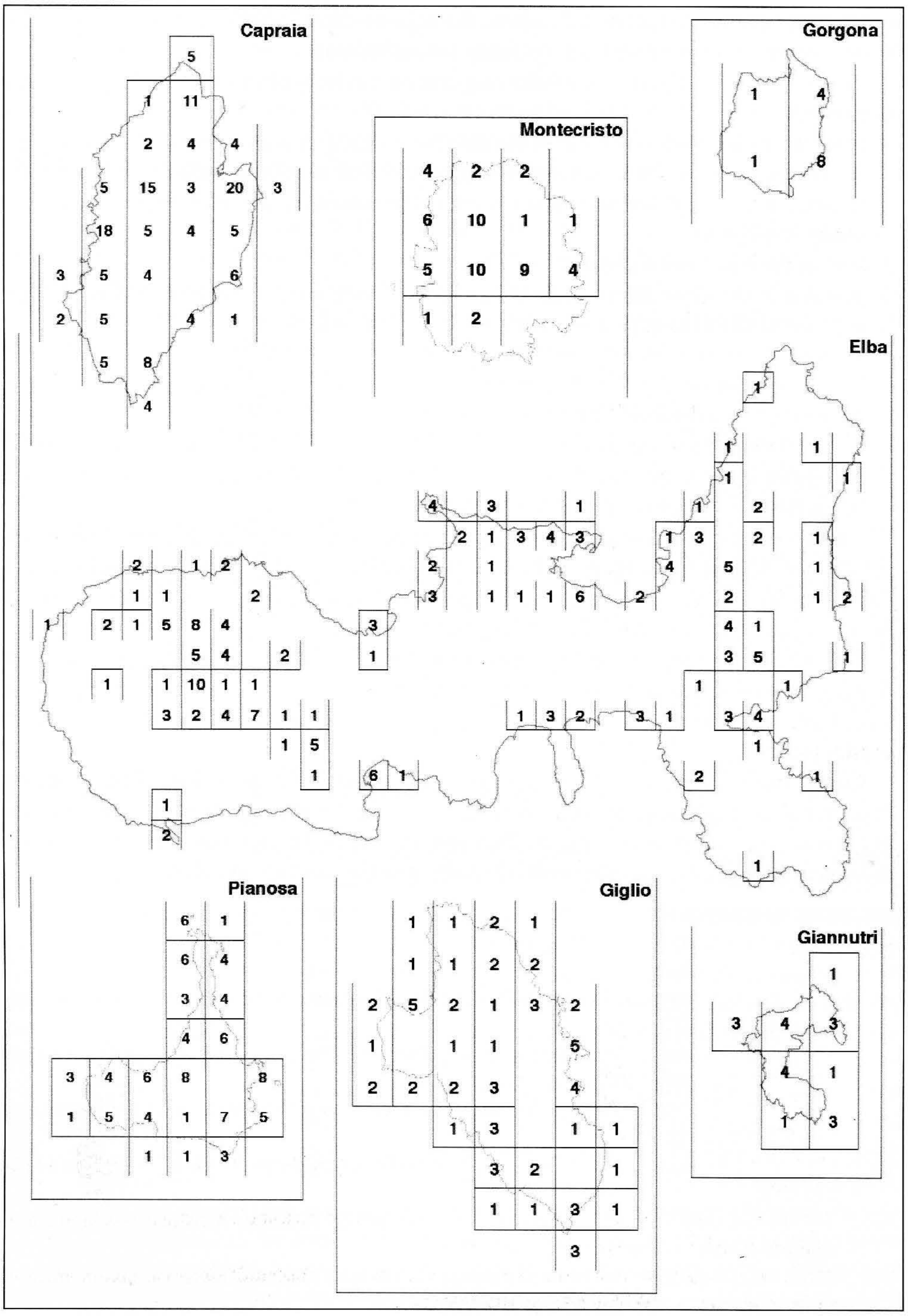

Fig. 4. Distribution and concentration of endemic and rare species on the Tuscan Archipelago.

occur in fewer than 4 stations throughout the regional territory; this number was raised to 6 for species growing in wetlands or sandy littoral habitats.

For each entity in figure 4, the following criteria can be applied for evaluating the threat of extinction:

1. confirmed reduction in the size of the distribution area; species that especially fall within this category are those that are ecologically linked to natural habitats that have been transformed through human activity or are in the process of alteration (e.g. wetlands and sandy coastlines);
2. low number of known stations;
3. changes in the vegetation surrounding a station, both natural (vegetation dynamism in act) and artificial (e.g. frequent fires, reforestation, grazing etc.);
4. vicinity of urban areas (e.g. less than 10 km, 10-50 km, over 50 km) and size of their human population (e.g. less than 10,000; 10-100,000; over 100,000 inhabitants);
5. accessibility and practicability of the distribution area by car;
6. practicability of the station through man's intervention (e.g. meadows, beaches, etc.);
7. imbalance in the ecosystem (e.g. imbalance in the food chains due to excessive number of herbivores, erosion or possible landslides).

Conservation of floristic phytodiversity requires a sort of management that respects the natural diversity of the territory, but that also maintains forms of traditional land use (cultural diversity). At the same time, as far as possible it should prevent any tendency towards homogenisation in the exploitation of vegetation resources.

Ecological diversity (regarding vegetation and landscape), which highly conditions floristic diversity, demands the contemporary presence of different vegetation dynamic stages over the territory, since the sum of vegetation diversity depends on total phytodiversity (see Arrigoni 1989).

Conservation of phytodiversity obviously also calls for a definition of the so-called "vocations" in exploiting territorial units and a project for the maintenance of all the serial types of vegetation, depending on their specific needs. In each case any trend towards homogenisation of the environmental diversity must be actively avoided.

References

Arrigoni, P. V. 1975: Rapporti floristici tra l'Arcipelago Toscano e le terre vicine. — Lav. Soc. Ital. Biogeogr. **5** (1974): 55-65.

— 1989: Parco Naturale della Maremma. Caratteri della Vegetazione. In: Natura e storia del Parco Naturale della Maremma. — Marsilio ed.

— & Bocchieri, E. 1996: Caratteri fitogeografici della flora delle piccole isole circumsarde. — Biogeographica **18**: 63-90.

Baldini, R. M. 1990: Florula delle "Formiche di Grosseto" (Arcipelago Toscano). — Webbia **44** (2): 271-278.

— 1998: Flora vascolare dell'Isola del Giglio (Arcipelago Toscano): revisione tassonomica ed aggiornamento. — Webbia **52** (2): 307-404.

— 2000: Flora vascolare dell'Isola di Pianosa (Arcipelago Toscano): revisione tassonomica ed aggiornamento. — Webbia **55** (1): 107-189.

— 2001: Flora vascolare dell'isola di Giannutri (Arcipelago toscano). — Webbia **56** (1): 69-125.

Foggi, B., Grigioni, A. & Luzzi, P. 2000: La flora vascolare dell'Isola di Capraia (Arcipelago Toscano). — Parlatorea **5**: 5-53.

Fossi Innamorati, T. 1983: La flora vascolare dell'Isola d'Elba (Arcipelago Toscano). — Webbia **36**: 273-411; 1989 — Webbia **43** (2): 201-267; 1991 — Webbia **45** (1): 137-185; 1994 — Webbia **49** (1): 93-123; 1997 — Webbia **51** (2): 385-389.

Gori, C. 1993: Inventario floristico ed analisi fitogeografica delle isole dell'Arcipelago Toscano. — Tesi Dottorato "Sistematica ed Ecologia Vegetale". Univ. Firenze.

Kulczynski, S. 1928: Die Pflanzenassoziationen der Pieninen. — Bull. Int. Acad. Pol. Sci. Lett., Cl. Sci. Math. Nat., ser. B, **1927** (suppl. 2): 57-203.

Moggi, G., Rizzotto, M., & Gori, C. 1991: Aspetti significativi della flora dell'isola di Gorgona (Arcipelago Toscano), ai fini della sua protezione. — Atti Soc. Tosc. Sci. Nat., Mem. ser. B, **97** (1990): 103-120.

Paoli, P. & Romagnoli, G. 1976: La flora vascolare dell'isola di Montecristo (Arcipelago Toscano). — Webbia **30**: 303-456.

Sartori, F. 1980: Aggiunte alla Flora Vascolare dell'Isola di Montecristo (Arcipelago Toscano). — Atti Ist. Bot. Univ. Lab. Critt. Pavia, ser. 6, **13**:171-180.

Sommier, S. 1902: La Flora dell'Arcipelgo Toscano. — Nuovo Giorn. Bot. Ital., n.s., **9**: 319-354.

— 1903: La Flora dell'Arcipelgo Toscano. — Nuovo Giorn. Bot. Ital., n.s., **10**: 133-200.

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