The flora and vegetation of Gyali island, SE Aegean, Greece

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Abstract

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Gyali is a small volcanic island with a surface of 4.63 km^2 in the SE Aegean Sea. Flora and vegetation of its main natural ecosystems and their ecological conditions are examined. The main vegetation units on Gyali are: *Pinus brutia* forest, scrubs and phrygana, psammophilous and halophytic communities. A total of 241 native taxa (species and subspecies) are reported, including 149 new records for the island. Analysis of the flora based on ecological indicator values shows that 29 % of the taxa are indicators of extreme warmth and 72 % of very dry or dry habitats. 43 % are acidophilous or calcifuge taxa and 45.2 % halotolerant taxa, or facultative or obligatory halophytes.

Introduction

Gyali is a small volcanic island situated in the SE Aegean. The island is covered with forest, scrubs and phrygana, and lacks agricultural cultivation and permanent inhabitants, except workers of the pumice quarries. Traces of previous agriculture (old terraces) as well as few ancient ruins can be discerned in parts of the island and goats grazed on the island until the end of 1998. Presently, the only human activity affecting the environment is the open-pit exploitation of pumice stone on the SW hill.

Gyali belongs to the group of small SE Aegean islands whose flora is not well known and has, in many cases, floristic peculiarities. The knowledge of these peculiarities aids the comprehension of the distribution patterns of species in the Aegean area. The variety of vegetation types observed from one island to another could help comparative studies to estimate the influence of environmental and ecological factors on the present vegetation composition and physiognomy.

Papatsou (1975) has studied the flora of the island, mentioning all previously known floristic data including the references to Gyali in "Flora aegaea" (Rechinger 1943). All available references to the island were also incorporated in Davis (1965-88).

In this paper, the island's flora is listed and its vegetation briefly discussed. The *Pinus brutia* forest, which is continuously receding from the Mediterranean region in general, covers roughly half the island and is of particular interest. It represents a natural, isolated population and is the only known forest of this species to grow on perlite and pumice substrates and on such a small island.

Study area

Gyali is situated between the islands Nisyros and Kos in the SE Aegean Sea. The island is characterized by two hills of 180 m altitude in the NE and 175 m in the SW, which are connected by a low, narrow ridge (Fig. 1). The island is orientated SW-NE, approximately 5.4 km in length and has a surface of 4.63 km^2.

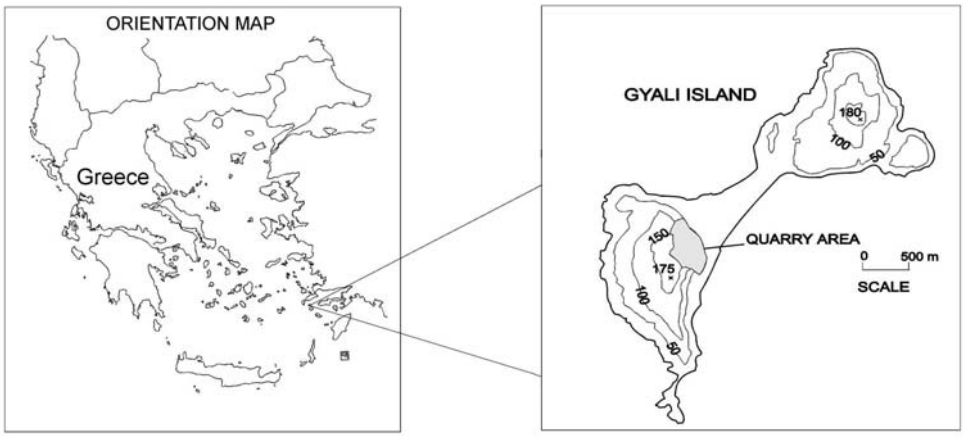

Fig. 1. Geographical position and detail map of Gyali island.

Gyali is located on the eastern edge of the Aegean volcanic arc and composed of volcanic rocks (Pentarakis & Markoulis 1974). The NE hill consists of volcanic rocks and rhyolites (perlite) with small, scattered concentrations of glass (obsidian); on its southern slope is a small patch of pumice. It is to the obsidian that the island owes its present name (in Greek, gyali means glass). The SW hill consists of aeolian, intermediate and basic pumice rocks, suggesting a sedimentary pyroclastic geological sequence. Under the pumice are clay, calcarenite and fragments of various volcanic rocks (mainly pumice) cohesed with calcium carbonate. The northern half of the east slope has a narrow coastal strip of loose sedimentary material (sand and pebbles), and the ridge connecting the two hills is of the same material.

Three soil groups are found on the island, according to the parent material:

1) Soil on perlite. These soils are generally shallow (less than 30 cm deep), but reach 30-60 cm on some gentle slopes or sites covered with vegetation. They have a sandy or sandy-loamy texture and the pH (1:1 soil-H_2O ratio, determined by glass electrode) ranges between 6.14 and 7.2.

2) Soils on pumice. These soils are usually medium deep (30-60 cm) or deep, except those on the steep hill slopes which are shallow. Their texture is sandy to sandy-loamy and the pH values range from 7.5 to 8.3, increasing with depth.

3) Soils on coastal deposits. These are not real soils but consist of medium to coarse-grained sand, with very little loam and clay, and small quantities of calcium carbonate. They are very poor in organic matter and have a slightly basic pH.

There is no meteorological station on Gyali. The meteorological data of Kos (National Meteorological Service) are presented in Table 1 and are considered representative of the climate on Gyali. The mean annual precipitation is about 754 mm, of which 463 mm are received in winter, while the summer is almost dry (5 mm). The drought period is rather extensive and lasts from mid-April to September (Fig. 2). The dominant winds in the area blow from the north and severely affect the whole island due to its small size.

Table 1. Meteorological data of Kos station (1948-75).

Month	J	F	M	A	M	J	J	A	S	O	N	D
Mean temperature [°C]	12.0	12.2	13.3	16.5	20.3	24.0	25.6	25.9	23.7	20.1	16.7	13.6
Precipitation [mm]	183.3	161.9	67.9	31.9	18.1	3.7	0.9	0.2	12.1	67.0	89.0	178.3
Relative humidity [%]	71	68	66	66	67	64	64	64	66	69	72	71

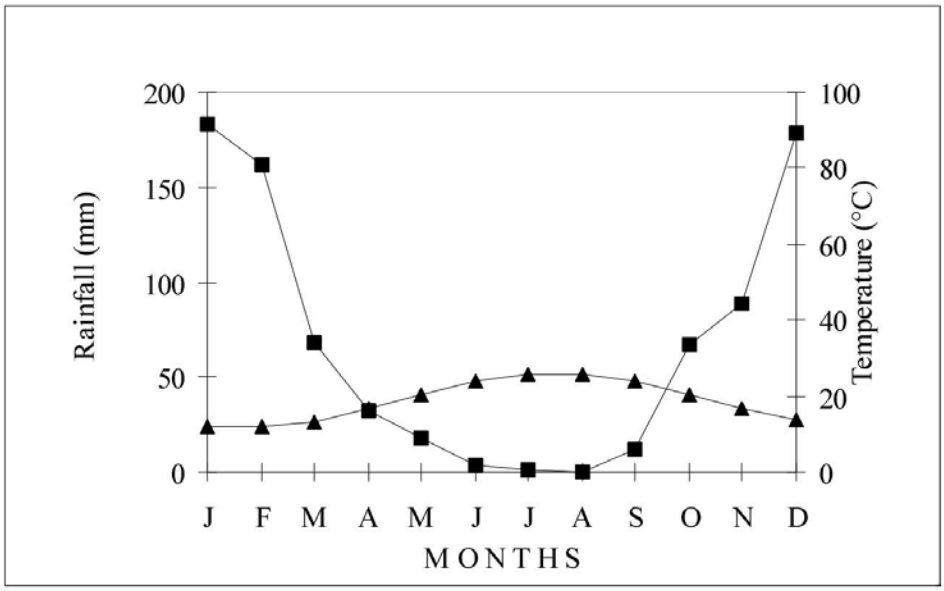

Fig. 2. Ombrothermic diagram of Kos meteorological station.

The bioclimate of Gyali was determined using the xerothermic index (Mavrommatis 1980) and the Emberger coefficient (Emberger 1955, 1959). According to the xerothermic index (x), the island belongs to an intense thermo-mediterranean type (125<x<150 biologically dry days), whereas the Emberger-coefficient assigns it to the wet zone with warm winter.

Material and methods

This paper is based on fieldwork of the authors carried out in spring and autumn between 1994 and 1999. After surveying the island and studying aerial photographs, we distinguished the main vegetation formations and made several plant sampling collections. Vouchers of the authors' collection are deposited in the herbarium of the Institute of Mediterranean Forest Ecosystems and Forest Products Technology, in Athens.

Species were identified using "Flora europaea" (Tutin & al. 1968-93) and "Flora of Turkey" (Davis 1965-88). Nomenclature follows "Flora europaea" and "Med-Checklist" (Greuter & al. 1984, 1986, 1989). The definition of the chorological types follows Pignatti (1982), and Raunkiaer's system (Raunkiaer 1934) was used to produce life-form spectra and rank taxa into life form categories.

The ecological preferences of the taxa were taken from Böhling (1995), so far available, since 213 (88.8 %) of the taxa found on Gyali occur also on Naxos.

Results

1. Plant list

Symbols and abbreviations used in the plant list

Life forms	=	see Table 4
Chorology	=	see Table 5
*	=	taxa already reported by Papatsou (1975)
!	=	taxa observed
W, F, R, S	=	indicator values for warmth (W), moisture (F), soil reaction (R) and salt stress tolerance (S), see Table 6
"Kar." + number	=	collection number of the plant samples gathered by the authors.

PTERIDOPHYTA

Polypodiaceae

Anogramma leptophylla (L.) Link – Tcaesp, Cosmop.-subtrop., W 2, F 4, R 1-, S 1; *Kar. 6000*
Asplenium ceterach L. – Hros, Euras.-temp., Wx, F 2w, R 4, S 1; *Kar. 5950*
* *Cheilanthes maderensis* Lowe – Hros, W-Medit.-Macarones., W 3, F 3w, R 1, S 1; *Kar. 5853*
* *Polypodium cambricum* L. – Grhiz, Eurymedit., W 3, F 4, Rx, S 1

GYMNOSPERMAE

Cupressaceae

* *Juniperus oxycedrus* subsp. *macrocarpa* (Sibth. & Sm.) Ball – Pcaesp, Eurymedit., W 4, F 3, R 5, S 2; !

Ephedraceae

Ephedra foeminea Forssk. – Pcaesp, E-Medit., W 3, F 2, Rx, S 2; *Kar. 6146*

Pinaceae

* *Pinus brutia* Ten. – Pscap, E-Medit., W 3, F 3, Rx, S 2; *Kar. 5482, 5493*

ANGIOSPERMAE

DICOTYLEDONES

Anacardiaceae

* *Pistacia lentiscus* L. – Pcaesp, S-Stenomedit.-Makarones., Wx, Fx, R 4, S 2; *Kar. 5450, 5468*

Boraginaceae

Alkanna orientalis (L.) Boiss. – Hscap., E-Medit.-Turan., W 2, F 3, R 3, S 1; *Kar. 5686, 5856*
**Anchusa hybrida* Ten. – Hscap, Stenomedit., W 3, F 4, R 3, S 1; *Kar. 6084*
* *Echium arenarium* Guss. – Tscap, Stenomedit., W 4, Fx, R 4, S 1; *Kar. 5685, 6163*
* *Heliotropium dolosum* De Not. – Tscap, Centromedit.-Turan., W 4, F 3, R 3, S 1; *Kar. 6138*
Myosotis ramosissima Rochels subsp. *ramosissima* – Tscap, Paleotemp., W 2-, F 3, R-, S 1, *Kar. 5952, 6004*

Campanulaceae

* *Campanula erinus* L. – Tscap, Stenomedit., Wx, F 3, R 5, S 1

Capparidaceae

* *Capparis orientalis* Veill. – NP, Eurymedit., W 3, F 3, R 5, S 2; *Kar. 6139*

Caryophyllaceae

* *Herniaria hirsuta* L. – Tscap, Paleotemp., Wx, F 2, R 5-, S 2

Polycarpon tetraphyllum (L.) L. subsp. *tetraphyllum* – Tscap, Subcosmop., W 4, F 3, R 3-, S 1; *Kar. 5615*
* *P. tetraphyllum* subsp. *diphyllum* (Cav.) O. Bolòs & Font Quer – Tscap, Stenomedit., W 4, F 2, Rx, S 1; *Kar. 6126*
* *Silene sedoides* Poir. subsp. *sedoides* – Tscap, Stenomedit., W 4, F 2, R 3-, S 3; *Kar. 5583*
Stellaria media (L.) Vill. subsp. *media* – Trept, Cosmop., Wx, F 5, R 3-, S 1; *Kar. 5953*

Chenopodiaceae
**Atriplex halimus* L. – NP, Medit.-Atl., W 3, F 5, R 5, S 4; !
Chenopodium murale L. – Tscap, Subcosmop., W 4, F 4, R 3-, S 2; *Kar. 6035*
* *Salsola kali* L. subsp. *kali* – Tscap, Paleotemp., W 4, F 2, Rx, S 3; *Kar. 5584*

Cistaceae
Cistus creticus L. subsp. *creticus* – Cfrut, E-Stenomedit., Wx, F 3, Rx, S 2; *Kar. 5451*
* *C. parviflorus* Lam. – Cfrut, E-Medit., W 4, F 2-, R 5, S 2; *Kar. 5452, 5470*
* *C. salviifolius* L. – Cfrut, Eurymedit., W 3, F 3, R 2, S 1; *Kar. 5453*
Fumana arabica (L.) Spach – Csuffr, S-Medit.-Turan., W 4, F 2, Rx, S 1; *Kar. 5807*
F. thymifolia (L.) Webb – Csuffr, Eurymedit., Wx, F 2, R 5, S 2; *Kar. 5530, 6165*
Helianthemum salicifolium (L.) Mill. – Tscap, Eurymedit., Wx, F 2, R 5, S 1; *Kar. 5471*
H. syriacum (Jacq.) Dum.-Cours. subsp. *syriacum* – Csuffr, Stenomedit., Wx, F 3, R 3, S 1; *Kar. 6028*
Tuberaria guttata (L.) Fourr. – Tscap, Eurymedit., Wx, F 2, R 2, S 1; *Kar. 5768, 5783*

Compositae
Aetheorhiza bulbosa subsp. *microcephala* Rech. f. – Gbulb, E-Stenomedit., Wx, F 4, Rx, S 2, *Kar. 5723*
Andryala integrifolia L. – Tscap, Stenomedit., W 4, F 3, R 3, S 1; *Kar. 5484*
**Anthemis pseudocotula* Boiss. – Tscap, E-Medit., W 3, F 3, R 3, S 1
A. tomentosa L. subsp. *tomentosa* – Tscap, Stenomedit., Wx-, F 3-, R 4-, S 2-; *Kar. 5620*
* *Bellium minutum* L. – Tscap, E-Medit., W 4, F 2-, R 4-, S 2; !
Carlina graeca Heldr. & Sart. – Hscap, NE-Stenomedit., Wx, F 3, R 4, S 2; *Kar. 6088*
Chrysanthemum coronarium L. – Tscap, Eurymedit., W 3, F 3, R 3, S 2; *Kar. 5690*
* *Cichorium endivia* subsp. *divaricatum* (Schousb.) P. D. Sell – Tscap, Stenomedit., W 4, F 4w, Rx, S 2
* *C. pumilum* Jacq. – Tscap, Stenomedit., W 4, F 4, Rx, S 2
* *C. spinosum* L. – Csuffr, Stenomedit., W 4, F 2, R 2, S 4
* *Conyza bonariensis* (L.) Cronquist – Tscap, Trop.-Americ., W 4, F 2, R 3, S 1
Crepis micrantha Czerep. – Tscap, E-Medit., Wx, F 3, Rx, S 2; *Kar. 5508*
* *C. multiflora* Sm. – Tscap, E-Medit., Wx, F 3, Rx, S 2; *Kar. 5454*
C. neglecta L. subsp. *neglecta* – Tscap, Eurymedit.-N-Orient., Wx, F 2, Rx, S 2; *Kar. 5485, 5724*
Dittrichia graveolens (L.) Greuter – Tscap, Medit.-Turan., W 4, F 3, R 3, S 1; *Kar. 6142*
* *D. viscosa* (L.) Greuter – Tscap, Medit.-Turan., W 3, F 4, R 4-, S 1; *Kar. 5646*
Echinops spinosissimus subsp. *bithynicus* (Boiss.) Kozuharov – Hscap, E-Medit., W 4-, F 3-, R 3, S 2, *Kar. 6145*
Filago cretensis subsp. *cycladum* Wagenitz – Tscap, Aegean, W 2, F 2, R 3-, S 1; *Kar. 5917*
F. eriocephala Guss. – Tscap, E-Stenomedit., W 3, F 2, R 2, S 1; *Kar. 6089*
Geropogon hybridus (L.) Sch. Bip. – Tscap, Stenomedit., W 4, F 2, R 5, S 1; *Kar. 6170*
Hedypnois cretica (L.) Dum-Cours. – Tscap, Stenomedit., Wx, Fx, Rx, S 2; *Kar. 5593*
* *Helianthus annuus* L. – Tscap, Cosmop., W 3, F 4, R 3, S 2
Helichrysum conglobatum (Viv.) Steud. – Csuffr, E-Stenomedit., Wx, F 3, R 4, S 2; *Kar. 5532*
Hypochaeris achyrophorus L. – Tscap, Stenomedit., Wx, F 2, Rx, S 2; *Kar. 5957*
H. glabra L. – Tscap, Eurymedit., W 1, F 3, R 2-, S 1; *Kar. 5507*
Logfia gallica L. – Tscap, Eurymedit., Wx, F 2, R 2, S 2; *Kar. 5771,5786*

* *Otanthus maritimus* (L.) Hoffmanns. & Link – Csuffr, Medit.-Atl., W 4, F 2, R 5, S 2; *Kar. 5642*
Phagnalon graecum Boiss. – Csuffr, NE-Medit., Wx, F 3, Rx, S 2; *Kar. 5552*
P. rupestre (L.) DC. – Csuffr, SW-Medit., W 3, F 3, R 2-, S 1; *Kar. 5531*
Picnomon acarna (L.) Cass. – Tscap, Eurymedit., Wx, F 3, Rx, S 1; *Kar. 6140*
Scolymus hispanicus L. – Hscap, Eurymedit., Wx, F 3, Rx, S 1; *Kar. 6143*
Senecio bicolor (Willd.) Tod. subsp. *bicolor* – Csuffr, Stenomedit., Wx-, F 3-, R 5-, Sx-; *Kar. 5689*
* *S. vulgaris* L. – Tscap, Cosmop., Wx, F 2, Rx, S 1
Sonchus asper subsp. *glaucescens* (Jordan) Ball – Hscap, Eurasiat., Wx, F 5, R 3, S 1; *Kar. 5688, 6167*
Sonchus oleraceus L. – Tscap, Subcosmop., Wx, F 3, R 3, S 1-; *Kar. 5486, 5509*
* *S. tenerrimus* L. – Tscap, Eurymedit., W 4, F 3, Rx, S 2; *Kar. 5597*
Tyrimnus leucographus (L.) Cass. – Tscap, Stenomedit., W 2, F 4, R 1, S 1; *Kar. 5691*
* *Urospermum picroides* (L.) Scop. ex F. W. Schmidt – Tscap, Eurymedit., Wx, F 3, R 4, S 2; *Kar. 5510, 5553*

Convolvulaceae
* *Calystegia soldanella* (L.) R. Br. – Grhiz, Cosmop., W 3, F 2, R 5, S 3; !
* *Convolvulus altheoides* L. subsp. *altheoides* – Hscand, Stenomedit., Wx, F 3, Rx, S 1; *Kar. 5694*
Cuscuta palaestina Boiss. subsp. *palaestina* – Tpar, SE-Medit., Wx, F 2, R 4-, S 1; *Kar. 5960*

Crassulaceae
Sedum pallidum M. Bieb. – Tscap, SE-Europ., Wx, F 1, Rx, S 2 ; *Kar. 5962*
Umbilicus horizontalis (Guss.) DC. – Gbulb, Eurymedit., W 3-, F 2, Rx, S 1; *Kar. 5961*

Cruciferae
Arabidopsis thaliana (L.) Meynh. – Tscap, Cosmop., W 2, F 3, R 2, S 1; *Kar. 5964*
Biscutella didyma L. – Tscap, S-Medit.-Turan., Wx, F 2, Rx, S 2; *Kar. 5555*
Brassica tournefortii Gouan – Tscap, Eurymedit., W 4, F 3, R 5, S 2; *Kar.6171*
* *Cakile maritima* Scop. subsp. *maritima* – Tscap, Medit.-Atl., W 3-, F 2, R 5, S 3; *Kar. 5586*
Cardamine hirsuta L. – Tscap, Cosmop., W 2-, F 3, R 3-, S 1; *Kar. 5963*
Diplotaxis muralis (L.) DC. – Tscap, N-Medit.-Atl., W 4, F 3, R 5, S 1; *Kar. 5696*
* *Matthiola tricuspidata* (L.) R. Br. – Tscap, Stenomedit., W 4, F 3, R 5, S 2; *Kar. 5587*
* *Raphanus raphanistrum* L. subsp. *raphanistrum* – Tscap/Hscap, Paleotemp., W 4, F 3, R 2, S 1; !
Sinapis arvensis L. – Tscap, Stenomedit., W 4, F 4, R 4-, S 1; *Kar. 6094*
Sisymbrium orientale L. – Tscap, Eurymedit., W 3, F 3, R 3-, S 1; *Kar. 6096*

Cucurbitaceae
* *Bryonia dioica* Jacq. – Grhiz/Hscand, Eurymedit., W 3-, F 4, R 3, S 1; *Kar. 5965*

Ericaceae
* *Arbutus unedo* L. – Pcaesp, Stenomedit., W 3, F 5, R 1, S 1; *Kar. 5499*
* *Erica manipuliflora* Salisb. – Cfrut, E-Medit., Wx, F 3, Rx, S 2; *Kar. 5456*

Euphorbiaceae
* *Chrozophora obliqua* (Vahl) A. Juss. ex Spreng. – Tscap, S-Medit.-Turan., W 4, F 3, R 3, S 1; *Kar. 6147*
Euphorbia dendroides L. – Crept, E-Stenomedit.-Makarones., W 3, F 3, R 5, S 2; *Kar. 6012*
E. myrsinites L. – Crept, E-Stenomedit., W 3, F 3, R 4, S 2; *Kar. 5674*
* *E. paralias* L. – Cfrut, Eurymedit.-Atl., W 4, F 2, R 4, S 3; *Kar. 5588*
* *E. peplis* L. – Trept, Eurymedit., W 3, F 5, R 5, S 4; *Kar. 6148*

* *E. peplus* L. – Tscap, Cosmop., Wx, Fx, Rx, S 1; *Kar. 5487*
* *Mercurialis annua* L. – Tscap, Paleotemp., Wx, F 3, R 4, S 1; *Kar. 5698*

Fagaceae
* *Quercus coccifera* L. – Tscap, Stenomedit., Wx, F 4, R 5, S 1; *Kar. 5967*

Frankeniaceae
* *Frankenia hirsuta* L. – Csuffr, Medit.-Turan., W 4, F 2, Rx, S 4; *Kar. 5580, 6172*

Gentianaceae
Centaurium erythraea Rafn subsp. *erythraea* – Hbienn, Paleotemp., W 4-, Fx, R 4-, S 2; *Kar. 6064*
C. tenuiflorum subsp. *acutiflorum* (Schott) Zeltner – Tscap, Eurymedit., W 4-, Fx, R 4, S 2; *Kar. 5835*

Geraniaceae
Erodium cicutarium (L.) L'Her. – Hros, Subcosmop., Wx, F 2, Rx, S 1; *Kar. 6098*
Geranium robertianum subsp. *purpureum* (Vill.) Nyman – Tscap, Eurymedit., Wx, F 2, Rx, S 1; *Kar. 5513*
G. robertianum L. subsp. *robertianum* – Tscap, Eurymedit., W 1, F 3, Rx-, S 2; *Kar. 5757, 5920*
G. rotuntifolium L. – Tscap, Paleotemp., W 4-, F 5w, R 3, S 1; *Kar. 6149*

Guttiferae
Hypericum empetrifolium Willd. subsp. *empetrifolium* – Cfrut, E-Medit., Wx, F 2, R 5, S 1; *Kar. 5462*

Labiatae
* *Ajuca chamaepitys* subsp. *chia* (Schreb.) Arcang. – Hscap, Eurymedit., Wx-, F 3-, Rx-, S 1
A. iva (L.) Schreb. – Csuffr, Stenomedit., Wx, F 4, R 4-, S 1; *Kar. 6153*
Coridothymus capitatus (L.) Reichenb.f. – Cfrut, E-Stenomedit., Wx, F 3, R 5, S 2; !
Lavandula stoechas L. subsp. *stoechas* – Cfrut, Stenomedit., W 3, F 3, R 2, S 1; *Kar. 5479*
Satureja nervosa Desf. – Cfrut, Stenomedit., Wx, F 2, R 4, S 1; *Kar. 5515*
S. thymbra L. – Cfrut, E-Medit., Wx, F 3, Rx, S 2 ; *Kar. 5464*
* *Sideritis lanata* L. – Tscap, E-Medit. (Aegean region & S Balkan peninsula), W 4, F 1, R 5, S 1
* *Teucrium capitatum* L. – Csuffr, Stenomedit., Wx, F 2, Rx, S 2; *Kar. 5463*

Leguminosae
* *Anthyllis hermanniae* L. – Cfrut, NE-Stenomedit., Wx, F 3, Rx, S 2; *Kar. 5466*
Astragalus pelecinus (L.) Barneby – Tscap, Eurymedit., W 4, F 2, R 2-, S 1; *Kar. 5575*
* *Calicotome villosa* (Poir.) Link – Pcaesp, Stenomedit., Wx, F 3, Rx, S 2; *Kar. 5682*
Ceratonia siliqua L. – Pcaesp, S-Medit., W 4, F 3, R 4, S 1; *Kar. 5741*
* *Genista acanthoclada* DC. – Cfrut, Stenomedit., Wx, F 4, Rx, S 2; !
Hippocrepis ciliata Willd. – Tscap, Stenomedit., W 3, F 2, R 4, S 1; *Kar. 5568*
* *Hymenocarpos circinnatus* (L.) Savi – Tscap, Eurymedit., Wx, F 2, R 4, S 1; *Kar. 5569*
Lotus corniculatus L. – Hscap, Cosmop., W 4, F 2, R 2-, S 1; *Kar. 5707*
* *L. cytisoides* L. – Csuffr, Stenomedit., W 4, F 3, R 4, S 2; !
L. edulis L. – Tscap, Stenomedit., W 4, F 3, Rx, S 1; *Kar. 6156*
L. halophilus Boiss. & Spruner – Tscap, S-Medit., W 4, F 2, R 5, S 2; *Kar. 5606*
L. peregrinus L. – Tscap, E-Stenomedit., W 4, F 2, R 5, S 1; *Kar. 5576*
Lupinus angustifolius L. – Tscap, Stenomedit., W 4, F 3, R 2, S 1; *Kar. 6154*
L. pilosus L. – Tscap, Paleotemp., W 3, F 4, R 4, S 1; *Kar. 6015*
Medicago littoralis Rohde ex Lois. – Tscap, Eurymedit., Wx, F 2, Rx, S 2; *Kar. 5607*
* *M. marina* L. – Crept, Eurymedit., W 4, F 2, R 5-, S 2; *Kar. 5608, 5631*
M. polymorpha L. – Tscap, Subcosmop., Wx, Fx, Rx, S 2; *Kar. 5577*
M. tuberculata (Retz.) Willd. – Tscap, Stenomedit., W 3, F 3, R 4, S 1; *Kar. 6157*

Melilotus indicus (L.) All. – Tscap, Eurymedit., W 4, F 3, R 4, S 2; *Kar. 5574, 5660*
Onobrychis caput-galli (L.) Lam. – Tscap, Eurymedit., Wx, F 2, Rx, S 2; *Kar. 5567, 6109*
* *Ononis diffusa* Ten. – Tscap, S-Medit., W 4, F 3, R 4-, S 2; *Kar. 5545, 5571*
Ornithopus pinnatus (Mill.) Druce – Tscap, Medit.-Atl., W 3-, F 5w, R 2-, S 1; *Kar. 6132*
Trifolium angustifolium L. – Tscap, Eurymedit., Wx, F 2, Rx, S 1; *Kar. 5543, 5564*
T. arvense L. – Tscap, Paleotemp., Wx, F 2, R 1-, S 1; *Kar. 5543*
T. campestre Schreb. – Tscap, Paleotemp., Wx, F 2, Rx, S 1; *Kar. 5566*
T. glomeratum L. – Tscap, Eurymedit., W 3, F 5w, R 1-, S 1; *Kar. 5779*
T. hirtum All. – Tscap, Eurymedit., W 4-, F 2, R 1-, S 1; *Kar. 5573*
T. lappaceum L. – Tscap, Eurymedit., W 3, F 3, R 4, S 2; *Kar. 6114*
T. scabrum L. – Tscap, Eurymedit., Wx, F 2, Rx, S 1; *Kar. 5578, 5632*
T. tomentosum L. – Trept, Eurymedit., Wx, F 2, R 2, S 1; *Kar. 6118*
Vicia cretica Boiss. & Heldr. – Tscap, NE-Medit., Wx, Fx, R 4, S 1-; *Kar. 5492, 5516*
V. lathyroides L. – Tscap, Eurymedit., W 2, F 3, R 3-, S 1; *Kar. 5945*
V. villosa subsp. *eriocarpa* (Hausskn.) P.W. Ball – Tscap, Stenomedit.-Orient., Wx, F 3, R 3, S 2; *Kar. 6078*

Malvaceae
* *Malva nicaeensis* All. – Tscap, Stenomedit., W 4, F 3, R 3, S 1
* *M. parviflora* L. – Tscap, Eurymedit., W 4-, F 2, Rx, S 1; *Kar. 6159*

Moraceae
Ficus carica L. – Pcaesp, Medit.-Turan., W 3-, F 3, Rx, S 1; !

Myrtaceae
* *Myrtus communis* L. subsp. *communis* – Pcaesp, Stenomedit., W 3, F 6w, R 2, S 1; *Kar. 5519*

Oleaceae
* *Olea europaea* subsp. *oleaster* (Hoffmanns. & Link) Negodi – Pcaesp, Eurymedit., Wx, F 2, Rx, S 2; *Kar. 5743*

Orobanchaceae
Orobanche oxyloba (Reut.) G. Beck – Tpar, Eurymedit., Wx, F 2, R 5, S 1; *Kar. 5764*
O. ramosa L. subsp. *ramosa* – Tpar, Paleotemp., W 3, F 5, R 3-, S 1; *Kar. 6161*

Papaveraceae
* *Fumaria officinalis* L. subsp. *officinalis* – Tscap, Subcosmop., Wx, F 3, R 3-, S 1; *Kar. 5521*
* *Glaucium flavum* Crantz – Hscap, Eurymedit., W 4, F 3, R 3, S 2; *Kar. 5710*
Papaver dubium L. subsp. *dubium* – Tscap, Medit.-Turan., W 2, F 2, R 4-, S 1; *Kar. 6119*

Plantaginaceae
Plantago afra L. – Tscap, Eurymedit., Wx, F 2, Rx, S 1; *Kar. 6121*
* *P. albicans* L. – Csuffr, Stenomedit., Wx, F 1, Rx, S 2; !
P. coronopus L. subsp. *coronopus* – Tscap/Hros, Eurymedit., Wx, F 2, Rx, S 2; *Kar. 6122, 6135*

Plumbaginaceae
Limonium echioides (L.) Mill. – Tros, S-Medit., W 4, F 2, R 5, S 2; *Kar. 5844*
L. graecum (Poir.) Rech. f. subsp. *graecum* – Csuffr, E-Medit., W 4, F 2, R 5, S 4 ; *Kar. 5610, 5634*
L. graecum subsp. *ammophilon* Papatsou & Phitos – Csuffr, E-Aeg., W 4, F 2, R 5, S 4; *Kar. 5611, 5635*

Polygonaceae
* *Polygonum maritimum* L. – Trept, Subcosmop., W 3, F 5, R 5, S 4; *Kar. 5590*
Rumex bucephalophorus subsp. *gallicus* (Steinh.) Rech. f. – Tscap, Stenomedit., Wx, F 2, R 2, S 2; *Kar. 5664*

Primulaceae
* *Anagallis arvensis* (L.) L. – Trept, Subcosmop., Wx, Fx, Rx, S 2; *Kar. 5823, 5845*
Asterolinon linum-stellatum (L.) Duby – Tscap, Eurymedit., Wx, F 2, Rx, S 2; *Kar. 5523*
* *Cyclamen hederifolium* Aiton – Gbulb, Eurymedit., Wx, Fx, R 5, S 1; !

Rafflesiaceae
* *Cytinus hypocistis* (L.) L. subsp. *hypocistis* – Grad, Medit.-Macarones., W 3-, F 3-, Rx-, S 1; *Kar. 5988*

Ranunculaceae
Anemone coronaria L. – Gbulb, Eurymedit., W 3, F 3, R 5, S 1; *Kar. 5989*
* *Clematis cirrhosa* L. – Plian, Stenomedit.-Turan., Wx, F 4, R 4, S 1; !

Rosaceae
Sarcopoterium spinosum (L.) Spach – Cfrut, E-Medit., Wx, Fx, Rx, S 1; *Kar. 5580*

Rubiaceae
Galium aparine L. – Tscap. Paleotemp., Wx, F 3, Rx, S 2; *Kar. 5714*
G. murale (L.) All. – Tscap, Eurymedit., Wx, F 2, Rx-, S 1; *Kar. 5992*
G. recurvum Req. – Tscap, E-Medit., Wx, F 2, R 2, S 1; *Kar. 6162*
Rubia tenuifolia D'Urv. – Pcaesp, E-Medit., Wx, F 3, R 5, S 1; *Kar. 5847*
* *Valantia hispida* L. – Tscap, Eurymedit., Wx, F 2, Rx, S 2; *Kar. 5467*
V. muralis L. – Tscap, Stenomedit., Wx, F 2, R 5-, S 1; *Kar. 6021*

Santalaceae
Thesium bergeri Zucc. – Csuffr, E-Medit., Wx-, F 3-, Rx-, S 1; *Kar. 5876*

Scrophulariaceae
Misopates orontium (L.) Raf. – Tscap, Eurymedit., Wx, F 2, Rx, S 1; *Kar. 5794*
* *Scrophularia heterophylla* Willd. – Csuffr, S-Balkan-Aeg., W 4, F 2, R 4, S 1; *Kar. 6023*
S. peregrina L. – Tscap, Eurymedit., W 4, F 4, R 4, S 1; *Kar. 5994*
* *Veronica cymbalaria* Bodard – Trept, Eurymedit., Wx, F 2, Rx, S 1; *Kar. 5993*

Solanaceae
* *Solanum nigrum* L. – Tscap, Cosmop., Wx, F 3, R 3, S 1; *Kar. 5766*

Theligonaceae
Theligonum cynocrambe L. – Tscap, Stenomedit., W 2, F 3, R 4, S 1; *Kar. 5525*

Thymelaeaceae
* *Daphne gnidioides* Jaub. & Spach – NP, E-Medit., Wx, F 3, Rx, S 2-; *Kar. 5878, 5995*
* *Thymelaea tartonraira* subsp. *argentea* (Sm.) Holmboe – Cfrut, E-Medit., Wx, F 3, Rx, S 2; *Kar. 5548*

Umbelliferae
* *Crithmum maritimum* L. – Csuffr, Medit.-Atl., W 4, F 2, Rx-, S 3; !
Daucus involucratus Sm. – Tscap, E-Stenomedit., W 4, F 1, R 4-, S 2; *Kar. 5549, 5825*
* *Eryngium maritimum* L. – Grhiz, Medit.-Atl., W 4, F 2, R 5, S 3; *Kar. 5591*
Orlaya daucorlaya Murb. – Tscap, E-Medit., W 2, F 4, R 3, S 1; *Kar. 5883*

Urticaceae
* *Parietaria cretica* L. – Hscap, E-Stenomedit., W 3, F 3, R 4, S 1; *Kar. 5636*
P. lusitanica L. – Trept, Eurymedit., Wx, F 2, R 4-, S 1; *Kar. 5947*
Urtica pilulifera L. – Tscap, Eurymedit., Wx, F 4, R 3, S 1; *Kar. 5998*

Valerianaceae

Centranthus calcitrapae (L.) Dufr. subsp. *calcitrapa* – Tscap, Stenomedit., Wx, F 2, R 4, S 1; *Kar. 5936, 5999*

MONOCOTYLEDONES

Amaryllidaceae

**Pancratium maritimum* L. – Gbulb, Stenomedit., W 4, F 2, R 5, S 2; *Kar. 5609*

Araceae

Arisarum vulgare Targ.-Tozz. subsp. *vulgare* – Grhiz, Eurymedit., Wx, F 3, R 4, S 1; *Kar. 5502*

Cyperaceae

Carex distans L. – Hcaesp, Eurymedit., Wx, F 6, R 3, S 1; *Kar. 5534*

Cyperus capitatus Vand. – Grhiz, Stenomedit., W 4, F 3, R 4, S 2; *Kar. 5599*

Gramineae

Aegilops neglecta Req. ex Bertol. – Tcaesp, Medit.-Turan., W 4, F 2, R 5, S 2; *Kar. 6102*

Aira caryophyllea L. – Tscap, Paleosubtrop., Wx, Fx, R 2, S 2; *Kar. 5923*

** A. elegantissima* Schur subsp. *elegantissima* – Tcaesp, Eurymedit., Wx, Fx, R 2, S 2; *Kar. 5775, 5789*

Avellinia michelli (Savi) Parl. – Tscap, Stenomedit., W 3-, F 2, R 2-, S 1; *Kar. 5927*

Avena barbata subsp. *atherantha* (C. Koch) Rocha Afonso – Tcaesp, Eurymedit., Wx, Fx, Rx, S2; *Kar. 5457, 5536*

A. barbata Pott ex Link subsp. *barbata* – Tcaesp, Eurymedit.-Turan., Wx, Fx, Rx, S 2; *Kar. 5969*

Briza maxima L. – Tcaesp, Paleosubtrop., Wx, F 2, Rx, S 1; *Kar. 5972*

Bromus diandrus Roth – Tcaesp, Eurymedit., W 3, F 5, R 3, S 1; *Kar. 5702, 5970*

B. fasciculatus C. Presl – Tcaesp, S-Medit., Wx, F 2, Rx, S 2; *Kar. 5459, 5488*

B. intermedius Guss. – Tcaesp, Eurymedit., Wx, F 2, Rx, S 1; *Kar. 6151*

B. rubens L. – Tcaesp. – S-Medit.-Turan., W 4, F 1, R 5, S 2; *Kar. 5706*

** B. tectorum* L. – Tcaesp, Paleotemp., Wx, F 2, Rx, S 2; *Kar. 5461*

Catapodium rigidum (L.) C. A. Hubb. subsp. *rigidum* – Tcaesp, Eurymedit., Wx, F 2, Rx, S 2; *Kar. 6070, 6104*

** Corynephorus divaricatus* (Pourr.) Breistr. – Tscap, Stenomedit., W 3, F 2, R 4, S 2; *Kar. 6129*

Cynodon dactylon (L.) Pers. – Grhiz, Cosmop., W 4, F 3, R 3, S 1; *Kar. 6150*

Dactylis glomerata subsp. *hispanica* (Roth.) Nyman – Hcaesp, Eurymedit., Wx, F 2, Rx, S 2; *Kar. 5559*

Elymus farctus subsp. *rechingeri* – Grhiz, E-Medit., W 4, F 3, R 5, S 3; *Kar. 5601,5625*

** Gastridium ventricosum* (Gouan) Schinz & Thell. – Tcaesp, Medit.-Atl., W 3-, F 2-, R 5-, S 1; *Kar. 5975, 6072*

Hordeum murinum L. subsp. *murinum* – Tscap, Circumbor., Wx, F 3, Rx, S 2; *Kar. 5604*

** Hordeum vulgare* L. – Tscap, Cosmop., Wx, F 3, Rx, S 1; !

Hyparrhenia hirta (L.) Stapf – Hcaesp, Paleotrop., W 4, F 3, R 3-, S 1; *Kar. 5560, 5816*

** Lagurus ovatus* L. – Tcaesp, Eurymedit., W 3, F 2, Rx, S 2; *Kar. 5476*

Lolium perenne L. – Hcaesp, Circumbor., Wx, Fx, Rx, S 2; *Kar. 6152*

L. rigidum Gaudin subsp. *rigidum* – Tcaesp, Paleosubtrop., W 4, F 4, R 5, S 3; *Kar. 5974, 6071*

Parapholis marginata Runemark – Tscap, E-Medit., W 4, F 3, Rx, S 4; *Kar. 5589*

Phleum crypsoides (d'Urv.) Hackel – Tscap, E-Medit., W 4, F 2, R 5, S 2; *Kar. 5600*

** Piptatherum miliaceum* (L.) Cosson – Hcaesp, Eurymedit.-Turan., Wx, F 4, R 3-, S 2; *Kar. 5561*

Poa bulbosa L. – Hcaesp, Paleotemp., Wx, F 3, Rx, S 1; *Kar. 5894*

Psilurus incurvus (Gouan) Schinz & Thell. – Tcaesp, Eurymedit., Wx, F 2, R 2, S 1; *Kar. 5460, 5474*

Rostaria cristata (L.) Tzvel. – Tcaesp, Subcosmop., Wx, F 2, Rx, S 2; *Kar. 5537,5556*
Stipa capensis Thunb. – Tcaesp, Stenomedit., W 4, F 1, R 4, S 2; *Kar. 5864, 6040*
Trachynia distachya (L.) Link – Tcaesp, Stenomedit.-Turan., W 3, F 5, R 4, S 1; *Kar. 5458, 5538*
Triplachne nitens (Guss.) Link – Tscap, Stenomedit., W 4, F 2, R 5, S 2; *Kar. 5475, 5626*
Vulpia fasciculata (Forssk.) Fritsch – Tcaesp, Medit.-Atl., W 4, F 1, R 5, S 2; *Kar. 5602*
V. myuros (L.) C. C. Gmel. – Tcaesp, Subcosmop., Wx, F 3, Rx, S 1; *Kar. 5900*

Liliaceae
Allium staticiforme Sm. – Gbulb, E-Medit., W 4, F 2, R 5, S 2; *Kar. 5547, 5933*
Gagea graeca (L.) Teracc. – Gbulb, Eurymedit., Wx, F 3, Rx, S 1; *Kar. 5518*
Muscari commutatum Guss. – Gbulb, Eurymedit., Wx, F 2, R 4, S 1 ; *Kar. 5517*
* *M. comosum* (L.) Mill. – Gbulb, Eurymedit., Wx, F 4, R 5, S 1; !
M. neglectum Guss. – Gbulb, Eurymedit., W 2, F 4, R 5, S 1; *Kar. 5803*
Urginea maritima (L.) Baker – Gbulb, Eurymedit.-Makarones., Wx, F 1, R 4, S 2; *Kar. 5905*

Orchidaceae
* *Limodorum abortivum* (L.) Swartz – Grhiz, Eurymedit., W 2-, F 4-, R 4-, S 1; !
Neotinea maculata (Desf.) Stearn – Gbulb, Eurymedit., W 2, F 4, R 4, S 1; *Kar. 5520*
Orchis coriophora subsp. *fragrans* (Pollini) Surde – Gbulb, Eurymedit., W 3, F 3, R 5, S 1; *Kar. 6173*
Orchis sancta L. – Gbulb, E-Medit., W 3, F 3, R 5, S 1; *Kar. 5579, 5872*

2. Flora

The vascular flora of the island Gyali comprises 241 native taxa of vascular plants belonging to 55 families, 178 genera, 196 species and 45 subspecies. Four of the taxa are pteridophytes and 237 are spermatophytes (Table 2). 149 taxa are new records for the island, compared to Papatsou (1975) and Davis (1965-88) who reported 92 taxa. Our floristic inventory does not include species introduced by the mining company for land reclamation and landscaping, such as *Eucalyptus camaldulensis, Cupressus sempervirens, Robinia pseudoacacia, Acacia cyanophylla, Nerium oleander, Medicago arborea, Tamarix* sp. and *Spartium junceum*.

Of the 55 vascular plant families present on Gyali, seven dicotyledonous and two monocotyledonous families, thus 16.3 % of the families recorded, are represented by more than five species or subspecies. Together these nine families comprise 150 taxa (Table 3) or 62.2 % of the island's vascular plant flora. *Leguminosae, Compositae* and *Graminae* and the other families of Table 3 are among those best adapted to the ecological conditions of the Mediterranean region. Indeed, many other floristic studies of insular and continental Greece (Brofas & Karetsos 1992, Carlström 1987, Christodoulakis 1986, Georgiadis 1983, Georgiadis & al. 1986, Panitsa 1997, Panitsa & al. 1994, etc.) have confirmed that these families are the richest in taxa in the Greek flora.

The life-form spectrum of the island's flora is presented in Table 4. Therophytes predominate and make up 58.9 % of the flora; chamaephytes follow with 14.9 % and hemicryptophytes with 10.4 %.

For the chorological analysis, all taxa were classified into three chorological units. The widespread unit includes mainly cosmopolitan-subcosmopolitan, paleotemperate, paleotropical-paleosubtropical and Mediterranean-Turanian taxa. The Mediterranean unit consists mainly of eury-Mediterranean, steno-Mediterranean and E Mediterranean taxa, and the endemic unit consists of taxa endemic to the Aegean islands. The results of the floristic analysis are presented in Table 5 and show that the Mediterranean unit dominates with 70.1 %. Widespread taxa account for 29.1 % of the flora. The endemic unit has only 0.8 % and is represented by *Limonium graecum* subsp. *ammophilon* (E Aegean endemic) and *Filago cretensis* subsp. *cycladum* (Aegean endemic).

Table 2. Numbers of vascular plant taxa in the flora of Gyali.

Systematic unit	Families	Genera	Species	Subspecies	Total	%
Pteridophyta	3	4	4	–	4	1.7
Gymnospermae	3	3	1	2	3	1.2
Dicotyledones	43	144	147	38	185	76.8
Monocotyledones	6	37	44	5	49	20.3
Total	55	178	196	45	241	100

Table 3. The nine largest families in the flora of Gyali.

	Families	Number of taxa
1	*Compositae*	38
2	*Gramineae*	35
3	*Leguminosae*	32
4	*Cruciferae*	10
5	*Cistaceae*	8
6	*Labiatae*	8
7	*Euphorbiaceae*	7
8	*Rubiaceae*	6
9	*Liliaceae*	6

Table 4. Life form spectrum of the flora of Gyali.

Life forms	Species and subspecies	%
Therophytes (T)		
Tscap: scapose t.	110	
Tcaesp: caespitose t.	21	
Tros: rosulate t.	1	58.9
Trept: reptant t.	7	
Tpar: parasite t.	3	
Hemicryptophytes (H)		
Hscap: scapose h.	9	
Hcaesp: caespitose h.	6	
Hros: rosulate h.	4	10.4
Hrept: reptant h.	3	
Hscand: scandent h.	2	
Hbienn: biennial h.	1	
Chamaephytes (C)		
Cfrut: fruticose c.	14	
Csuffr: suffruticose c.	19	14.9
Chrept: reptant c.	3	
Geophytes (G)		
Gbulb: bulbose g.	13	
Grhiz: rhizomatose g.	9	9.6
Gpar: parasite g.	1	
Phanerophytes (P)		
NP: Nano-p.	4	
Pscap: scapose p.	1	6.2
Pcaesp: caespitose p.	10	
Total	241	100.0

An additional analysis was made with respect to the indicator values proposed by Böhling (1995) for Naxos. These values seem to be transferable to the Gyali flora. The vascular flora of Gyali was accordingly assigned to ecological groups on the basis of warmth (W), moisture (F), soil reaction (R) and salt stress tolerance (S), as presented in Table 6. Our results show that 29 % of the taxa are indicators of extreme warmth and 72 % indicators of very dry or dry habitats. Acidophilous or calcifuge taxa account for 43 % of the taxa, and 45.2 % are halotolerant, facultative or obligatory halophytes.

3. Vegetation

Four different vegetation formations, which are distinguished by vegetation structure and dominant species, characterize the island (Fig. 3): a) *Pinus brutia* forests, b) scrubs and phrygana, c) psammophilous, and d) halophytic formations covering very restricted areas.

Each formation and its main characteristics are briefly described below.

a. *Pinus brutia* forest

The *Pinus brutia* forest represents the only natural arboreal vegetation on Gyali. It occurs in broken stands and scattered trees on the NE hill, mainly on the eastern and northeastern slopes, while it covers the entire SW hill except the pumice stone quarry and a narrow coastal strip where bushes prevail.

The forest is generally of uneven age with various degrees of canopy cover, although small, evenly aged stands may be found. Maximum measured tree age (by increment borer) is one hundred years. The forest grows from sea level to the hill tops and trees are (3-)6-7(-9) m tall with tabular crowns. In deep soils of ravines on the NE slope and the wind protected plateau of the SW hill, some trees reach 12 meters in height and have conical crowns. In contrast, on lower, northern slopes, which are exposed to strong winds, the trees have a bushy form and a height of less than three meters. Their canopies are flag-shaped and branches reach the ground. Based on the physiognomy of the understorey shrub layer and dominant species, the following vegetation types were distinguished:

a1. Type with *Pistacia lentiscus:* It is found in restricted, non-degraded areas on the northwestern slope of the SW hill and is characterized by the dominance of *P. lentiscus*. Several other species participate in this formation, with lower frequency and coverage degree, such as *Olea europaea* subsp. *oleaster, Ceratonia siliqua, Quercus coccifera, Arbutus unedo, Myrtus communis* and *Erica manipuliflora.*

a2. Type with *Erica manipuliflora:* This type is found on the eastern slopes of the NE hill and the western slope of the SW hill, on shallow soils, and occupies roughly half the *Pinus brutia* forest. This understorey vegetation is thick and consists almost exclusively of *E. manipuliflora*. In some small openings, dispersed herbaceous species such as *Psilurus incurvus* and *Aira elegantissima* grow.

a3. Type with phryganic species: It occurs on the eastern and northeastern slopes of the NE hill and constitutes the open *Pinus brutia* formations (broken stands, scattered trees). It is characterized by the dominant phryganic species *Cistus salviifolius, C. parviflorus, C. incanus* subsp. *creticus, Hypericum empetrifolium* and *Lavandula stoechas. Erica manipuliflora* also grows in this type and is sometimes associated with species such as *Olea europaea* subsp. *oleaster, Ceratonia siliqua, Quercus coccifera, Satureja thymbra, Anthyllis hermanniae* and *Thymelaea tartonraira*.

According to their floristic composition, as referred above, the *Pinus brutia* forests belong to the association Ceratonio-Pistacietum lentisci Zohary & Orshan 1959 of the alliance Ceratonio-Rhamnion Barbero-Quézel 1979 and the order Pistacio-Rhamnetalia Rivas-Martinez 1974. Open *Pinus brutia* stands participating in a vegetation complex with phrygana communities could be assigned to the alliance Cistion orientale (Cisto-Micromerietea (-etalia) Oberdorfer 1954). *Pinus halepensis* forests with similar floristics have been reported from the island of Euboea (Krause & al. 1963).

Table 5. Chorological spectrum of the flora of the island Gyali.

Chorological unit	Chorological group (abbreviation)	Number of taxa	%
1. Widespread	Cosmopolitan-Subcosmopolitan (Cosmop., Subcosmop., Cosmop.-subtrop.	25	10.4
	Paleotropical-Paleosubtropical (Paleotrop., Paleosubtrop.)	4	1.7
	Paleotemperate (Paleotemp.)	15	6.2
	Eurasian, Eurasian-temperate (Eurasiat., Euras.-temp.)	2	0.8
	Circumboreal (Circumbor.)	1	0.4
	Southeast-European (SE-Europ.)	1	0.4
	Tropical-American (Trop.-Americ.)	1	0.4
	Mediterranean-Atlantic (Medit.-Atl.)	2	0.8
	Mediterranean-Turanian (Medit.-Turan.)	4	1.7
	Stenomediterranea-Turanian (Stenomedit.-Turan.)	2	0.8
	South Mediterranean-Turanian (S-Medit.-Turan.)	3	1.3
	Eurymedit.-Atlant., Centromedit.-Turan., E-Medit.-Turan., E-Stenomedit.-Makarones., Eurymedit.-Makarones., Eurymedit.-N-Orient., Medit.-Macarones., N-Medit.-Atl., S-Stenomedit.-Makarones., Stenomedit.-Orient., W-Medit.-Macarones.	10	4.2
2. Mediterranean	East Mediterranean (E-Medit.)	26	10.8
	Eurymediterranean (Eurymedit.)	57	23.6
	Stenomediterranean (Stenomedit.)	58	24.1
	East Stenomediterranean (E-Stenomedit.)	11	4.6
	South Mediterranean (S-Medit.)	9	3.7
	South Balkan-Aegean (S-Balkan-Aeg.)	2	0.8
	NE-Medit., NE-Stenomedit., SW-Medit., SE-Medit.	6	2.5
3. Endemic	Aegean (Aeg.)	1	0.4
	East Aegean (E-Aeg.)	1	0.4
Total		241	100

Table 6. Percentages of indicator values after Böhling (1995) for warmth (W), moisture (F), soil reaction (R) and salt stress (S) in the flora of Gyali.

The indicator value scales comprise eight units for moisture (F), five units for soil reaction (R) and four units for warmth (W) and salt tolerance (S). Value 1 reflects the lowest expression of a site factor, 4, 5 or 8 the highest. – Abbreviations: W 1: indicators of moderate cold, W 2: moderate warmth, W 3: warmth, W 4: extreme warmth; F 1: indicators of extremely dry habitats, F 2: very dry habitats, F 3: dry habitats, F 4: moderately dry habitats, F 5: medium moist (fresh) habitats; R 1: basiphilous species, R 2: calcicolous, R 3: slightly acid-slightly alkaline, R 4: acidophilous, R 5: calcifuge; S 1: halophobe species, S 2: halotolerant, S 3: facultative halophytes, S 4: obligatory halophytes; x = indifferent (no indicator properties).

	W (%)	F (%)	R (%)	S (%)
1	0.9	3.2	2.7	54.8
2	5.0	37.6	8.1	38.0
3	17.1	34.4	13.6	2.7
4	29.0	11.7	20.4	4.5
5	–	5.0	22.6	–
6	–	0.9	–	–
x	48.0	7.2	32.6	–

Fig. 4. *Pinus brutia* forest on Gyali island, NE hill, SE aspect. – Photograph by G. Brofas, 1995.

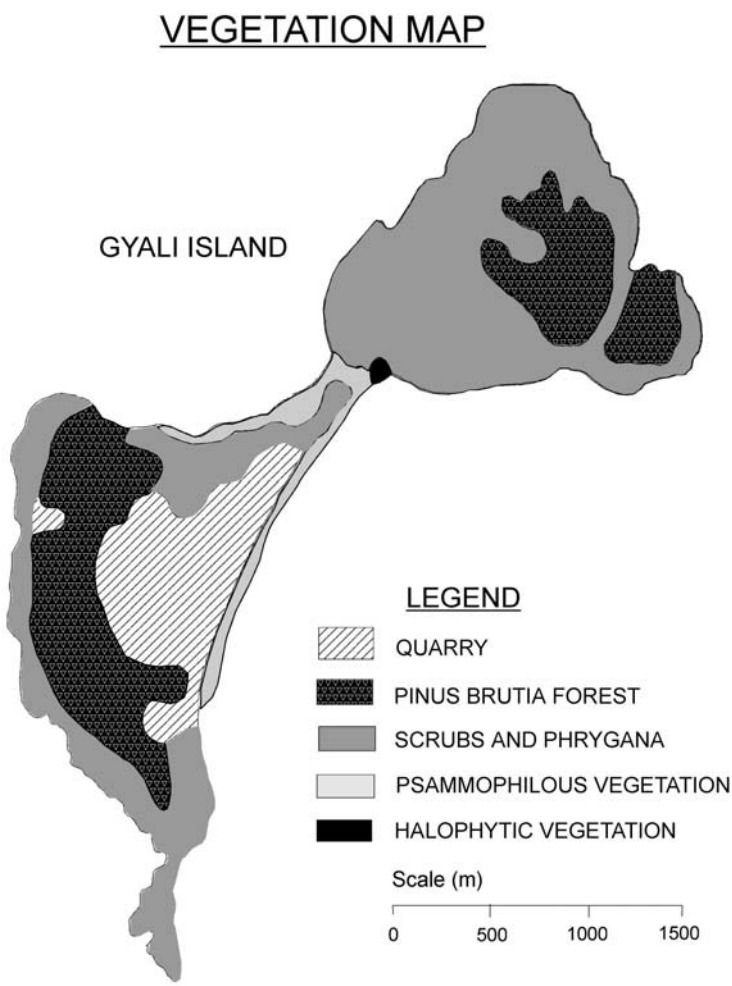

Fig. 3. Vegetation map of Gyali island.

b. Scrubs and phrygana

Scrub and phrygana vegetation is mostly mixed in varying degrees. Pure bush formations are restricted; they are dominated by *Pistacia lentiscus,* while *Erica manipuliflora, Ceratonia siliqua, Olea europaea* subsp. *oleaster, Myrtus communis, Quercus coccifera, Arbutus unedo,* etc. occur with lower frequencies. *Juniperus oxycedrus* subsp. *macrocarpa* grows near the coast and in some sites it is the dominant species. Small, relic stands of *Juniperus* are also found in the interior of the island. In some areas on the northwestern slope of the perlite hill, *Daphne gnidioides* and *Euphorbia dendroides* dominate the vegetation, and on the rocky outcrops of the northeastern hill scattered *Ephedra foeminea* and *Capparis orientalis* plants are found.

Degradation of scrub formations in large areas has led to the decline of shrubs and the dominance of phryganic species such as *Erica manipuliflora, Cistus creticus* subsp. *creticus, C. parviflorus, Cistus salviifolius, Lavandula stoechas* subsp. *stoechas, Hypericum empetrifolium, Phagnalon graecum, Anthyllis hermanniae, Thymelaea tartonraira* subsp. *argentea* and *Teucrium*

capitatum. The dominant species depends on the site; for example, *Anthyllis hermanniae* dominates the isthmus, *Cistus creticus* subsp. *creticus* and *C. parviflorus* dominate the northwestern slopes of the perlite hill, *Lavandula stoechas* subsp. *stoechas* prevails on the old terraces, and in some areas *Erica manipuliflora* grows in pure formations. *Coridothymus capitatus* is generally absent from the island except for the vegetation on the southeast coast.

c. Psammophilous formations

Psammophilous vegetation is found on the northern and southern coasts of the isthmus and the narrow coastal strip to the east of the SW hill. It is found on coastal sands between high tide drift line and the inland shrubs and composed of mainly psammophilous and nitrophilous species such as: *Otanthus maritimus, Elymus farctus* subsp. *rechingeri, Cyperus capitatus, Parapholis marginata, Pancratium maritimum, Medicago marina, Eryngium maritimum, Euphorbia paralias, Limonium graecum* subsp. *ammophilum, Cakile maritima, Matthiola tricuspidata, Polygonum maritimum, Medicago littoralis, Lotus halophilus, Salsola kali* subsp. *kali, Silene sedoides, Lagurus ovatus, Anthemis tomentosa* subsp. *tomentosa, Urospermum picroides, Crepis micrantha, Hordeum murinum* subsp. *murinum, Phleum crypsoides, Hedypnois cretica* and *Vulpia fasciculata.*

The Ammophiletum arundinaceae (class Ammophiletea) seems to be absent on Gyali, while the Eryngio-Elymetum farcti Gehu 1986 (Agropyretum mediterraneum Br.-Bl. 1933) is well represented. Species of the Cakiletea are also present but do not form their typical plant communities.

d. Halophytic formations

Halophytic vegetation is found only in very restricted areas. The only saline soils on Gyali cover an area of about 0.1 ha on the eastern edge of the SW hill, near the isthmus. This area is flooded periodically and dry during the summer.

Halophytic vegetation does not cover all the saline soil but grows in scattered patches. The vegetation of the inner area consists only of *Limonium graecum* subsp. *graecum* and subsp. *ammophilon,* while around the edges and on steep slopes *Frankenia hirsuta* and *Parapholis marginata* occur. Halophytic vegetation it also present on some low coastal areas covered periodically by waves.

Discussion and conclusions

Compared to other islands of the same size, the vegetation of Gyali is considerably diverse and this is mainly due to the *Pinus brutia* forest, which is the only one known to grow on perlite and pumice substrates and on such a small island. Small islands are covered usually with degraded bushes and phrygana only. The preservation of this forest is probably associated to the lack of permanent human inhabitants and the easily weathering substrate, which aids the creation of topsoil and easy root penetration and regeneration.

The Gyali *Pinus brutia* forest represents an isolated natural population. It is among the lowest forests of the species and falls into the lowest site-quality class of *P. brutia* in Greece (Tziovaras & Apatsidis, unpublished data). The forest is dominated by trees with tabular crowns, while in few parts of the island with deep soils some trees reach 12 meters in height and have conical crowns. According to Nahal (1983), the tabular crown form appears in old age but it is also associated with site fertility. In sites with low fertility, height growth stops early (50-60 years) and tree crowns become tabular in shape. In fertile sites height growth continues further (80-90 years) and the crown remains conical.

The understorey vegetation differs from that of other *Pinus brutia* forests known presently in Greece. It shows some affinity with degraded *P. brutia* forests on Crete (Barbero & Quezel 1980) but is very similar to the understorey of Ceratonio-Pinetum brutiae on the Aegean coastal region of Anatolia (Zohary 1973).

Pure scrub formations have a very limited distribution on Gyali and consist of typical species of the Ceratonio-Pistacietum association. They are usually mixed, in various degrees, with phrygana communities that cover much larger areas. The restricted bush formations and significant presence of phrygana have resulted from the combination of harsh ecological conditions and human activities, lasting from the Neolithic period up to present (Samson 1988). This combination has greatly affected the physiognomy and composition of the vegetation. The island's phrygana is secondary and represents degraded stages of the *Pinus brutia* forest and scrub communities. Their presence in abandoned fields shows the progressive re-establishment of the natural vegetation. On Gyali, abandoned fields are dominated by *Lavandula stoechas* and other phrygana species, but not by *Sarcopoterium spinosum* (Rechinger 1951, Panitsa & al. 1994). It is possible that *L. stoechas* communities constitute a successive stage of a previous plant community, since the fields have been abandoned for many years. *L. stoechas* is a characteristic species of acidic soils but grows on Gyali on soils with a pH >7.

The absence of *Juniperus phoenicea* from Gyali is rather surprising, as this species is very common in the East Aegean islands. However, *J. phoenicea* is also absent from the neighbouring island of Nisyros, which has a similar geology (Papatsou 1975). Its absence is either due to the soil conditions or the destruction of a previous community and its subsequent inability to re-establish from elsewhere, due to its hardly dispersable diaspores. The absence of *Quercus macrolepis*, which grows on Nisyros and Kos, can be explained in the same way. Whereas the extinction of a species on the mainland may be temporary, on an island it may rather turn out to be permanent due to the lesser probability of its re-establishing.

On Gyali, vegetation of the sandy beaches is represented mainly by the Eryngio-Elymetum farcti association. The absence of the Ammophiletum arundinaceae association is due to the lack of well-developed dune formations. Halophytic formations are very restricted and with low species diversity. The dominant taxon is the local endemic *Limonium graecum* subsp. *ammophilon,* and low species diversity is probably due to the lack of more extended halophytic habitats.

The high proportions of the Mediterranean species and therophytes in the flora of Gyali indicate the Mediterranean character of the island. High numbers of therophytes are also attributed to human activities, especially grazing pressure (Barbero & al. 1990), which can cause important changes in floristic composition and vegetation structure (Pettit & al. 1995).

The very low percentage of endemic taxa and the absence of chorological elements with distributions restricted to the East Aegean and the neighbouring coasts of Asia minor was rather expected. This can be attributed to the recent geographical isolation of the area. The low altitude (180 m maximum) and rather uniform geomorphology and climate of the island minimize the role of isolation as a floral differentiation factor even further.

Classification of the flora of Gyali based on the ecological factors of warmth, moisture, soil reaction and salt stress shows that about one third of the taxa are indicators of extreme warmth and more than two thirds of the taxa are indicators of extremely, very dry or dry habitats. These results reinforce the argument of harsh ecological and climatic conditions of the island.

Future studies on Gyali should include vegetation monitoring to help comprehending the ecological succession process in the harsh conditions affecting, particularly, small islands. For this reason, inventories of the flora and of taxa with special demands for warmth, moisture, soil reaction and salt stress, should be extended. This would provide the necessary data for an ecological evaluation of the Aegean islands, which is indispendable for the future conservation and management of this very sensitive insular region.

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