

VASCULAR FLORA OF THE VRGADA ISLETS (ZADAR ARCHIPELAGO, EASTERN ADRIATIC)

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Floristic researches of the 14 islets and reefs near Vrgada Island (Zadar archipelago, eastern Adriatic) were conducted in the period from 2009 and the spring of 2010.

For the 13 islets and reefs, 264 vascular plant taxa were recorded and classified in 184 genera and 63 families. No taxa were recorded for one reef. The domination of therophytes (42.42 %) and plants of the Mediterranean floral element (49.62 %) confirmed the Mediterranean character of the islets' flora.

Key words: vascular flora, Vrgada Islets, eastern Adriatic, North Dalmatia, Croatia.

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Tijekom 2009. i u proljeće 2010. g. obavljena su floristička istraživanja 14 malih otočića i hridi uz otok Vrgadu (zadarski arhipelag, istočni Jadran). Za 13 otočića i hridi zabilježene su 264 svojite vaskularnih biljaka koje su svrstane u 184 roda i 63 porodice, dok na hridi Lončarić bilje ne raste. Dominacija terofita (42.42 %) i biljaka mediteranskoga flornog elementa (49.62 %) ukazuje na izraziti mediteranski karakter flore tih otočića.

Ključne riječi: vaskularna flora, vrgadski otočići, istočni Jadran, sjeverna Dalmacija, Hrvatska.

INTRODUCTION

Vrgada Island with its surface of 2.3 km² belongs to a group of small islands (DUPLANČIĆ-LEDERET *et al.*, 2004). It is surrounded by 14 islets and reefs:

Murvenjak or Murvenik (0.609 km²), Šipnata (0.085 km²), Oblik (0.074 km²), Kozina (0.063 km²), Gira (0.056 km²), Obrovanj (0.04 km²), Artina (0.033 km²), Veliki Školjić (0.03 km²), Mali Školjić (0.013 km²) and the Rakita, Vrtlić, Lončarić, Kamičić reefs (north of Vrgada) and Kamičić (south of Vrgada). The Vrgada islets and reefs are located in north Dalmatia and belong to the Zadar archipelago (Fig. 1). The islets lie in the Dinaric direction (northwest – southeast). The geological structure of the islets varies from limestone to dolomite (MAMUŽIĆ *et al.*, 1975).

The highest point of the islets is 64 meters above sea level and is situated on the island of Murvenjak. All the islets are uninhabited except Veliki Školjić where guards of the nearby mariculture cages have lived since 1999. Near the house there is a small garden with flowers and a corral for the goats that have until recently been living on the island. Mali Školjić is inhabited with goats, and the coastal part of the islets of Gira, Murvenjak and Kozina as well as the Vrtlić and Kamičić reefs north of Vrgada are the nesting sites of a large colony of seagulls.

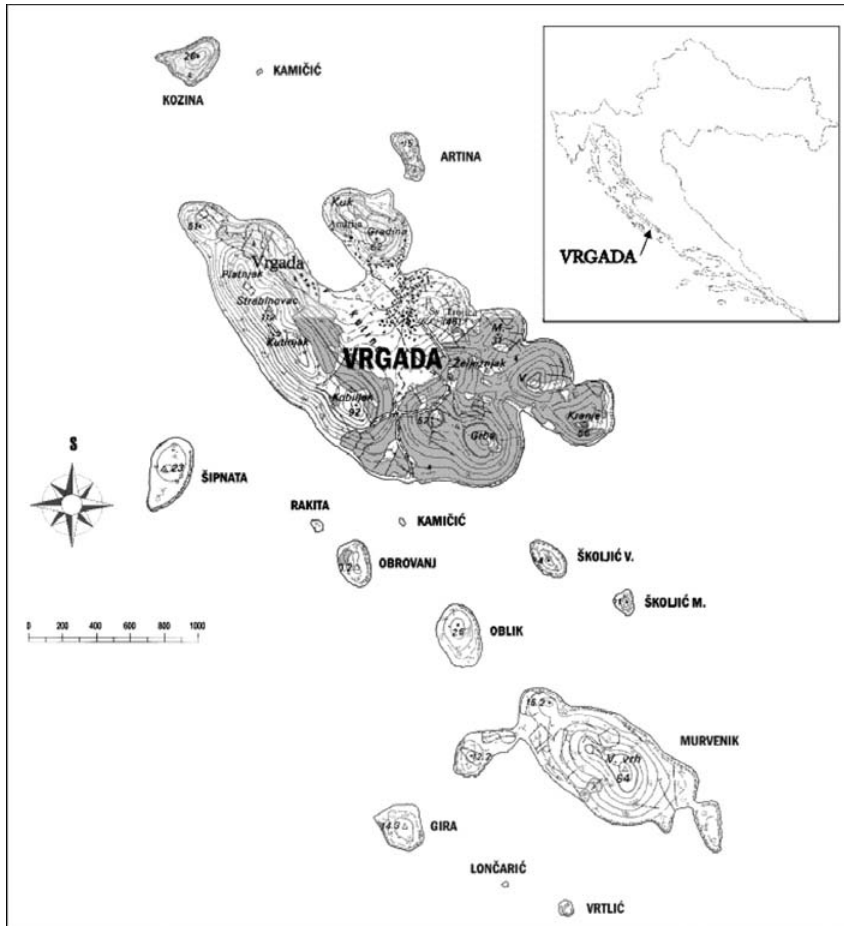


Fig. 1. Geographical position of the islets and the reefs of Vrgada

There are no climatic data for Vrgada Island and surrounding islets. Therefore, climatic data for the nearest meteorological station, Biograd, was used in this study. According to the data of the Croatian Meteorological and Hydrological Service for the period of 1981–2000 the average annual temperature was 15 °C. The annual precipitation was 814.2 mm. The precipitation was highest in October (106.3 mm on average) and lowest in July (24 mm on average).

Phytogeographically, the Vrgada islets and reefs belong to the Eu-Mediterranean vegetation zone. On the reefs and rocks along the coast there is halophytic vegetation (ass. *Plantagini-Limonietum cancellati* H-ić (1934) 1939), while ass. *Puccinellio festucaefor-mi-Sarcocornietum fruticosae* (Br.-Bl. 1928) Géhu 1967 appears on the muddy soils on Murvenjak islet. Forrest vegetation on the islets consists of Phoenician juniper macchia (ass. *Pistacio lentisci-Juniperetum phoeniceae* Trinajstić 1987), and on higher grounds of Murvenjak and on Rakita there is holm oak macchia with myrtle (ass. *Myrto communis-Quercetum ilicis* (H-ić 1963) Trinajstić 1985). The halophytic zone of Murvenjak is followed by the myrtle and lentisk vegetation (*Myrto communis-Pistacietum lentisci* (Molinier (1936) 1954) Rivas Martinez 1975). Forest vegetation of the island of Vrgada and its islets are well documented in a paper by PANDŽA & KRPINA (2010).

Research into the vascular flora of Vrgada Island and of the surrounding islets and reefs has started only recently. According to the previously published results (PILJAC-KOSOVIC & PANDŽA, 2009), the vascular flora of the Vrgada Island is considerably well explored (462 of taxa in the wild with addition of 108 cultivated taxa), whereas research into the surrounding islets were only partial. PILJAC-KOSOVIC & PANDŽA (2009) list the data only for Artina (88 taxa), Rakita (31) and Obrovanj (17) islets, and for Kaminčić reef north of Vrgada (nine taxa) and for Kaminčić reef south of Vrgada (seven taxa). The flora of the remaining Vrgada islets was previously unexplored.

New results of the vascular flora of all 14 islets and reefs around Vrgada are presented in this paper.

METHODS

The floristic research into the vascular flora of the Vrgada islets and reefs was conducted during 2009 and in spring of 2010.

The taxa were determined by standard determination keys (HORVATIC & TRINAJSTIĆ, 1967–1981; TUTIN *et. al.* 1968–1980, 1993; TRINAJSTIĆ, 1975–1986; PIGNATTI, 1982; DOMAC, 1994). The nomenclature of the taxa has been adjusted according to Nikolić (1994–2000, 2010) except for *Cyperus alternifolius*, which has been adjusted by the GRIN Taxonomy for Plants (2010).

Families, genera, species and subspecies in the list of flora are listed in alphabetical order within the higher systematic taxa.

In the flora list, the life form marks are placed in front of the taxa names and the habitat marks after the names. Floral elements follow the habitat names.

Life forms are interpreted according to HORVAT (1949) and PIGNATTI (1982) and the following abbreviations are given in the front of the name of each species and subspecies: **T** – *Therophyta*, **G** – *Geophyta*, **H** – *Hemicryptophyta*, **Ch** – *Chamaephyta*, **P** – *Phanerophyta* and **Hy** – *Hydrophyta*.

The habitats are marked by small letters as follows:

- | | |
|--|---|
| a – macchia and garrigue | b – rocky grasslands |
| c – rocky sea shore | d – nitrophylic habitats with the nesting sites of seagulls |
| e – muddy, sandy and pebbled sea shore | f – ruderal habitats |
| h – in culture | g – muddy and sandy sea bottom |

The analysis of floral elements has been made according to HORVATIĆ (1963) and HORVATIĆ *et al.* (1967–1968).

The floral elements are numerated in the list of flora as follows:

MEDITERRANEAN

- Circum-Mediterranean plants – 1
- West Mediterranean plants – 2
- East Mediterranean plants – 3
- Illyrian Mediterranean plants:
 - Illyrian South European plants – 4
 - Illyrian Adriatic plants:
 - Illyrian Adriatic Endemic plants – 5
 - Illyrian Apennine plants – 6
- Mediterranean Atlantic plants – 7
- European Mediterranean plants – 8
- Mediterranean Pontic plants – 9

SOUTH EUROPEAN

- South European Mediterranean plants – 10
- South European Pontic plants – 11

SOUTHEAST EUROPEAN –12

EUROPEAN – 13

EUROASIATIC– 14

WIDESPREAD PLANTS – 15

CULTIVATED AND ADVENTITIOUS PLANTS – 16

An analysis of endemic species was made according to ŠILIC (1984) and TRINAJSTIĆ (1991, 1992).

The islets and the reefs where the taxa were found are marked with the following abbreviations:

- A** the reef of Vrtlić (x = 5541690, y = 4853348; **2159–331**)
- B** the islet of Veliki Školjić (x = 5541590, y = 4855385 and x = 5541678, y = 4855332; **2159–311**)
- C** the islet of Mali Školjić (x = 5542043, y = 4855142 and x = 5541998, y = 4855192; **2159–314**)
- G** the islet of Gira (x = 5540659, y = 4853938; **2159–331**)
- HJ** Kamičić reef south of Vrgada (x = 5540722, y = 4855625; **2159–311**)
- HS** Kamičić reef north of Vrgada (x = 5539887, y = 4858273; **2158–242**)
- K** the islet of Kozina (x = 5539360, y = 4858370; **2158–242**)

- M** the islet of Murvenjak (x = 5541423, y = 4854366; **2159–313** and x = 5542562; y = 4853897; **2159–332**)
O the islet of Obrovanj (x = 5540424, y = 4855433 and x = 5540518, y = 4855309; **2159–311**)
R the islet of Rakita (x = 5540228, y = 4855609; **2159–311**)
S the islet of Šipnata (x = 5539369, y = 4855974 and x = 5539407, y = 4856019; **2158–422**)
Z the islet of Oblik (x = 5540974, y = 4855032; 2159; **2159–313**)
Y the islet of Artina (**2159–131**)

In the parentheses with the above mentioned islets and reefs the coordinates of the localities explored are listed according to Gauß-Krüger and the codes of their associated MTB 1/64 units.

Previously recorded taxa (PILJAC-KOSOVIC & PANDŽA 2009) are marked in the list of flora with an asterisk placed with the indication of the islet and reef where they were found. The name under which the taxa was recorded by PILJAC-KOSOVIC & PANDŽA (2009), if it differs from the one in the list of flora according to NIKOLIĆ (1994–2000, 2010), is also written in parentheses.

RESULTS

FLORISTIC LIST

PTERIDOPHYTA

Aspleniaceae

H *Asplenium ceterach* L.; b; 10; O

SPERMATOPHYTA-CONIFEROPHYTINA

Cupressaceae

P *Juniperus oxycedrus* L. ssp. *oxycedrus*; a; 1; O*, Y*; B, G, S, Z

P *J. phoenicea* L.; a; 1; O*, R*, Y*, B, C, G, K, M, S, Z

Pinaceae

P *Pinus halepensis* Mill.; a; 1; O*, R*, Y*, B, G, K, M, S, Z

P *P. pinea* L.; a; 1; R, S

CYCADOPHYTINA

Ephedraceae

Ch *Ephedra fragilis* Desf. ssp. *campylopoda* (C. A. Meyer) Asch. et Graeb.; a; 3; Y*
 (as *Ephedra fragilis* Desf.), M

SPERMATOPHYTA-MAGNOLIOPHYTINA

MAGNOLIATAE

Anacardiaceae

P *Pistacia lentiscus* L.; a, b; 1; O*, R*, HS*, Y*, B, C, G, K, M, S, Z

P *P. terebinthus* L.; a; 1; C

Apocynaceae

P *Nerium oleander* L.; h; **16**; B

Apiaceae

T *Bupleurum veronense* Turra; b; **4**; G

Ch *Crithmum maritimum* L.; c; **7**; HJ*, HS*, O*, R*, Y*, A, B, C, G, K, M, S, Z

H *Daucus carota* L. ssp. *hispanicus* (Gouan) Thell.; c; **7**; Y* (as *D. gingidium* L. ssp. *gingidium*), A, B, C, G, R

H *D. carota* L. ssp. *maritimus* (Lam.) Batt.; **2**; Y*

H *Eryngium amethystinum* L.; b; **4**; Y*; B, C, G, S, Z

H *Petroselinum crispum* (Mill.) A. W. Hill; h; **16**; B

H *Seseli tomentosum* Vis.; b; **5**; G, B, R, S

Araliaceae

P *Hedera helix* L.; **13**; Y*

Asclepiadaceae

H *Vincetoxicum hirundinaria* Medik. ssp. *adriaticum* (Beck) Markgr.; b, c; **5**; R*, Y*, B, C, G, K, M, O, S, Z

Asteraceae

T *Ambrosia artemisiifolia* L.; d; **16**; K

H *Aster linosyris* (L.) Bernh.; b; **11**; B, G

T *Bombycilaena erecta* (L.) Smoljan.; b; **11**; Z

H *Carduus micropterus* (Borbás) Teyber; c, d; **5**; G, S, Z

H *C. pycnocephalus* L.; d; **1**; K, M, S

H *Carlina corymbosa* L.; b; **1**; Y*, B, C, G, O, S, Z

H *Centaurea solstitialis* L.; d; **11**; K

T *Chamomilla recutita* (L.) Rauschert; d; **16**; M

T *Conyza canadensis* (L.) Cronquist; d; **16**; K

T *Dittrichia graveolens* (L.) Greuter.(= *Inula graveolens* (L.); d; **10**; M

H *D. viscosa* (L.) Greuter.; c, d; **1**; HJ*, Y* (as *Inula viscosa* (L.) Aiton), K, M, R

T *Filago pyramidata* L.; b; **10**; S

T *F. vulgaris* Lam.; b; **15**; S

Ch *Helichrysum italicum* (Roth) G. Don; b; **1**; O*, R*, Y*, B, C, G, K, M, S, Z

Ch *Inula crithmoides* L.; c, e; **7**; Y*, G, K, R

H *I. spiraeifolia* L.; b; **10**; C

Ch *Santolina chamaecyparissus* L.; h; **16**; B

Ch *Senecio bicolor* (Willd.) Tod. ssp. *cineraria* (DC.) Chater; b, c; **2**; G

T *S. vulgaris* L.; d; **15**; K, O

Boraginaceae

T *Heliotropium europaeum* L.; c; d; **9**; G, K, M

T *Myosotis ramosissima* Rochel; b; **14**; B, O, S

Brassicaceae

Ch *Aethionema saxatile* (L.) R. Br.; a; **10**; R*; Y*, B, C, G, K, O, S, Z

H *Arabis hirsuta* (L.) Scop.; b; **15**; S

- Ch *Aurinia sinuata* (L.) Griseb.; b; 5; B, C
 T *Cakile maritima* Scop.; e; 15; R*, A, G, K
 H *Capsella bursa-pastoris* (L.) Medik.; d; 15; K
 T *C. rubella* Reuter; d; 1; C, K, O, S
 T *Diplotaxis muralis* (L.) DC.; d; 15; G
 T *D. tenuifolia* (L.) DC.; d; f; 15; B, G, K
 T *Hornungia petraea* (L.) Rchb.; c, d; 15; K
 Ch *Matthiola incana* (L.) R. Br.; h; 16; B
 T *Sisymbrium officinale* (L.) Scop.; f; 15; G, K

Campanulaceae

- H *Campanula pyramidalis* L.; b; 5; B, C, Z

Caprifoliaceae

- P *Lonicera implexa* Aiton; a; 1; R*, Y*, C, G
 P *Viburnum tinus* L.; 1; Y*

Caryophyllaceae

- T *Arenaria leptoclados* (Reichenb.) Guss.; c; d; 14; C, K, S
 T *A. serpyllifolia* L.; b; 15; B, C, K, O, S, Z
 T *Cerastium glomeratum* Thuil.; b; 15; C, G, O, S
 T *C. pumilum* Curtis ssp. *glutinatum* (Fries) Jalas; b; 15; B, C, G, R, S
 H *Dianthus ciliatus* Guss.; b; 5; A, B, C, G
 T *Herniaria glabra* L.; b, c; 14; Y*, C, G, K, O, Z
 T *H. hirsuta* L.; b; 13; K
 H *Petrorhagia saxifraga* (L.) Link; b; 10; Y*, B, G, K, R, S, Z
 T *Polycarpon tetraphyllum* (L.) L.; c, d; 10; K
 T *Sagina maritima* G. Don; e; 7; O, Z
 H *Silene vulgaris* (Moench) Garcke ssp. *angustifolia* Hayek; c; 10; HJ*, O*, R*, Y*
 (as *S. angustifolia* (Miller) Guss. ssp. *reiseri* (K. Maly) Trinajstić), A, B, C, G,
 K, S, Z
 T *Stellaria media* (L.) Vill.; d, f; 15; C, K
 T *S. pallida* (Dumort.) Pire; c; 14; S

Chenopodiaceae

- Ch *Arthrocnemum fruticosum* (L.) Moq. (= *Salicornia fruticosa* L.); e; 10; M
 Ch *A. macrostachyum* (Moric.) C. Koch; c; 10; R*, Y* (as *A. glaucum* (Delile)
 Ung.- Stbg.), A, G, K, M, O, S, Z
 T *Atriplex littoralis* L.; c; 14; K
 T *A. prostrata* Boucher ex DC. in Lam. et DC.; c, d; 15; HS* (as *A. latifolia*
 Wohlenb.), A, G, K
 H *Beta vulgaris* L. ssp. *maritima* (L.) Arcang.; c, d; 7; K
 T *Chenopodium album* L.; d; 15; A, B, G; HS, K
 T *Ch. murale* L.; d; 15; G
 T *Ch. vulvaria* L.; d; 10; K
 Ch *Halimione portulacoides* (L.) Aellen; e; 15; M
 T *Salsola kali* L.; e; 15; K, M

T *S. soda* L.; e; **11**; M

T *Suaeda maritima* (L.) Dumort.; e; **15**; M

Cichoriaceae

G *Aetheorrhiza bulbosa* (L.) Cass.; a, b; **1**; G, O, R, S

H *Cichorium intybus* L.; c; **15**; Y*, B, G, M, Z

T *Crepis foetida* L.; b; **10**; K, S

T *C. pulchra* L.; b; **10**; K

T *C. rubra* L.; b; **3**; C, K

H *Hieracium praealtum* Vill. ex Gochnat ssp. *bauhinii* (Besser) Petunn.; b; **14**; K

H *Lactuca serriola* L.; f; **15**; B, K, O

H *Leontodon crispus* Vill.; b; **10**; G, O, Z

T *Picris echioides* L. (= *Helminthia echioides* (L.) Gaertn.); d; **1**; K

H *P. hieracioides* L.; f; **14**; K

H *Reichardia picroides* (L.) Roth; c; **1**; O*, R*, Y*, A, B, C, G, K, S, Z

H *Scorzonera villosa* Scop. ssp. *villosa*; b; **4**; A, B, C, G, R

T *Sonchus asper* (L.) Hill ssp. *glaucescens* (Jord.) Ball; c, d; **1**; HS*, Y* (as *S. glaucescens* Jordan), B, K, O

T *S. oleraceus* L.; c, d; **15**; B, K, O

T *S. tenerrimus* L.; c; **1**; B, C, G

H *Urospermum delechampii* (L.) Scop. ex F. W. Schmidt; b; **1**; G

T *U. picroides* (L.) Scop. ex F. W. Schmidt; d, f; **1**; B, G, K, S

Cistaceae

P *Cistus incanus* L.; a; **1**; R*, G, M,

P *C. monspeliensis* L.; a; **1**; M

Ch *Fumana ericoides* (Cav.) Gand.; a; **1**; Y*, B, S

Convolvulaceae

H *Convolvulus althaeoides* L. ssp. *tenuissimus* (Sibth. et Sm.) Stace; **3**; Y* (as *C. elegantissimus* Miller)

G *C. arvensis* L.; f; **15**; B, K

H *C. cantabrica* L.; b; **10**; A, G

Crassulaceae

Ch *Sedum acre* L.; b; **15**; Y*, C, G, K, O, S, Z

T *S. rubens* L.; d; **10**; K, S

Ch *S. sexangulare* L.; b; **13**; G

Ch *Sempervivum tectorum* L.; h; **16**; B

Ericaceae

P *Erica arborea* L.; a; **1**; K

Euphorbiaceae

T *Euphorbia exigua* L.; b; **10**; Z

Ch *E. fragifera* Jan; b; **5**; Y*, B, C, G, O, S, Z

Ch *E. pinea* L.; c; **1**; O*, R*, A, C, G, HS, K, M, S, Z

Fabaceae

- H *Anthyllis vulneraria* L. subsp. *praepropera* (A. Kern) Bornm; b; 5; B, C, G
 P *Colutea arborescens* L.; a; 1; B, C, G
 P *Coronilla emerus* L. ssp. *emeroides* Boiss. et Spruner; a; 3; R*, Y*, B, C, G, M, O, S, Z
 Ch *Dorycnium hirsutum* (L.) Sér; b, c; 1; Y*, C, G, K, S, Z
 T *Hippocrepis ciliata* Willd.; 1; Y*
 T *H. unisiliquosa* L.; 1; Y*
 T *Lathyrus aphaca* L.; b; 10; C
 H *Lotus cytisoides* L.; c; 1; HS*, Y*, A, B, C, G, K, M, R, S, Z
 T *L. edulis* L.; b; 1; B, G
 T *L. ornithopodioides* L.; b; 1; G
 T *Medicago lupulina* L.; b; 15; Y*, K
 T *M. minima* (L.) Bartl.; b; 15; Y*, B, C, G, O, R, S
 T *M. orbicularis* (L.) Bartal.; b; 1; G
 H *Ononis pusilla* L.; b; 10; M
 T *O. reclinata* L.; b; 1; Y*, B, C, G, K, S
 T *Scorpiurus muricatus* L.; b; 1; Y*, G
 P *Spartium junceum* L.; h; 16; B
 T *Trifolium campestre* Schreber; b; 15; Y*, B, C, G, K, O, R, S, Z
 T *T. lappaceum* L.; 1; Y*
 T *T. scabrum* L.; b; 1; Y*, B, C, G, K, O, R, S, Z
 T *T. stellatum* L.; b; 1; C
 T *Trigonella esculenta* Willd.; b; 1; G, K
 T *T. monspeliaca* L.; b; 9; Y*, B
 T *Vicia angustifolia* L. ssp. *angustifolia*; b; 13; G
 T *V. tenuissima* (M. Bieb.) Schinz et Thell (= *V. gracilis* Loisel.); b; 10; O

Fagaceae

- P *Quercus ilex* L.; a; 1; R*, Y*, G, M, O, S

Fumariaceae

- T *Fumaria capreolata* L.; b, c; 7; C, M, S

Gentianaceae

- T *Blackstonia perfoliata* (L.) Huds. ssp. *perfoliata*; b; 7; Y* (as *B. perfoliata* (L.) Huds.), M, O, S, Z
 T *Centaurium erythraea* Rafn; b; 15; Y*, B, C, G, K, M, O, S, Z
 T *C. pulchellum* (Sw.) Druce; e; 14; C, K, M, O, S, Z, Y
 T *C. spicatum* (L.) Fritsch; c; 1; Y*, O

Geraniaceae

- T *Erodium cicutarium* (L.) L'Her.; f; 15; K
 T *E. malacoides* (L.) L'Her.; f; 1; B
 T *Geranium columbinum* L.; b; 14; G, O
 T *G. molle* L. ssp. *brutium* (Gasparr.) Graebn.; b; 3; K, S
 T *G. purpureum* Vill.; a, b; 10; Y*, B, C, G, K, M, O, S, Z
 T *G. rotundifolium* L.; b, f; 14; G, K

Hypericaceae

- H *Hypericum perforatum* L. ssp. *veronense* (Schrank) H. Lindb.; b; 10; Y*, B, G, K, M, O, S, Z

Lamiaceae

- T *Ajuga chamaepytis* (L.) Schreb.; d; 1; K, M, O
 H *Calamintha nepetoides* Jord.; d, f; 11; B
 Ch *Prasium majus* L.; a; 1; R*, Y*, B, C, G, K, O, S, Z
 P *Rosmarinus officinalis* L.; h; 16; B
 Ch *Salvia officinalis* L.; b; 8; Y*, B, G, M, S
 Ch *Satureja montana* L. ssp. *variegata* (Host) P. W. Ball; b; 9; G, O, S, Z
 H *Stachys cretica* L. ssp. *salviifolia* (Ten.) Rech.; h; 16; B
 T *Sideritis romana* L.; b, f; 1; B, C, G, O, Z
 Ch *Teucrium chamaedrys* L.; a; 11; Y*, B, C, G, M, O, R, S, Z
 Ch *T. flavum* L.; a; 1; R*, G, M
 Ch *T. polium* L.; a, b; 9; R*, Y*, B, C, G; M, O, S, Z

Linaceae

- H *Linum bienne* Mill.; b; 7; S
 T *L. strictum* L. ssp. *strictum*; b; 1; Y*, G
 T *L. strictum* L. ssp. *corymbulosum* (Rchb.) Riony; 9; Y*

Malvaceae

- H *Lavatera arborea* L.; d; 1; HS

Moraceae

- P *Ficus carica* L.; b; 1; Y*, G, M, O, S

Myrtaceae

- P *Myrtus communis* L.; a; 1; O*, R*, Y*, G, K, M, Z

Oleaceae

- P *Olea europaea* L.; h; 16; O*, B, G, M
 P *O. europaea* L. var. *syloestris* Brot.; a, b; 1; B, C, G, M, S, Z
 P *Phillyrea latifolia* L.; a; 1; O*, R*, Y*, B, C, G, K, M, S, Z

Orobanchaceae

- T *Orobanche minor* L.; b; 10; G, K, O, S

Papaveraceae

- H *Glaucium flavum* Crantz; e; 7; M
 T *Papaver rhoeas* L.; f; 15; B, C, G

Plantaginaceae

- H *Plantago coronopus* L. ssp. *commutata* (Guss.) Pilg.; 9; Y*
 H *P. holosteam* Scop. (incl. *P. holosteam* ssp. *scopulorum* (Degen) H-ić; c; 10; Y*, B, C
 H *P. lanceolata* L.; d, f; 15; A, G
 H *P. major* L. ssp. *intermedia* (Gilib.) Lange; b; 15; K

Plumbaginaceae

- H *Limonium cancellatum* (Bernh. ex Bertol.) O. Kuntze; c; 6; O*, R*, Y*, A, B, C, G, HS, K, M, S, Z
 H *L. narbonense* Mill.; e; 1; HS* (as *L. serotinum* (Rchb.) Pign.), B, HS, M
 Ch *Plumbago europaea* L.; b, d; 1; A

Polygonaceae

- T *Polygonum aviculare* L.; d; 15; A, K

Portulacaceae

- T *Portulaca oleracea* L.; c, d; 15; B, G, HS, K

Primulaceae

- T *Anagallis arvensis* L.; b, c, d; 15; C, G, K, M, O, S, Z
 G *Cyclamen repandum* Sibth. et Sm.; a; 8; M, O

Ranunculaceae

- P *Clematis flammula* L.; a; 1; R*, Y*, B, C, G, O, S, Z

Rhamnaceae

- P *Rhamnus alaternus* L.; a; 1; Y*, G, S
 P *R. intermedius* Steud. et Hochst.; 5; Y*

Rosaceae

- P *Prunus mahaleb* L.; a; 11; G, M
 P *Rubus ulmifolius* Schott; 7; Y*

Rubiaceae

- H *Asperula aristata* L. ssp. *scabra* (J. Presl et C. Presl) Nyman; b; 10; G
 H *Galium corrudifolium* Vill.; a, b; 10; R*, Y*, B, C, G, K, O, S, Z
 T *G. murale* (L.) All.; b; 1; O, S
 P *Rubia peregrina* L.; a; 1; R*, Y*, B, G, K, O, Z
 T *Valantia muralis* L.; b, c; 1; Y*, B, C, G, K, M, O, R, S, Z

Santalaceae

- P *Osyris alba* L.; a, b; 1; Y*, B, M

Saxifragaceae

- T *Saxifraga tridactylites* L.; b; 15; O, S

Scrophulariaceae

- T *Chaenorhinum minus* (L.) Lange ssp. *litorale* (Willd.) Hayek; c; 6; G, K, M, O, Z
 H *Kickxia commutata* (Bernh. ex Rchb.) Fritsch; d; 8; K
 T *Veronica arvensis* L.; b; 14; B, G, K, O
 T *V. persica* Poir.; f; 16; K

Solanaceae

- T *Solanum lycopersicum* L.; f; 16; K
 T *S. nigrum* L.; c, d; 15; HS, K
 G *S. tuberosum* L.; h; 16; B

Urticaceae

- H *Parietaria judaica* L.; b, c; 10; HS* (as *P. diffusa* M. et K.), B, C, K, O, S, Z

Verbenaceae

T *Verbena officinalis* L.; f; 15; K

P *Vitex agnus-castus* L.; c; 1; K

Violaceae

T *Viola arvensis* Murray; a, b; 15; O, Z

Vitaceae

P *Vitis vinifera* L.; h; 16; B

LILIATAE**Agavaceae**

P *Agave americana* L.; h; 16; B

P *Yucca gloriosa* L.; h; 16; B

Araceae

G *Arum italicum* Mill.; f; 7; C, B, M, O, S

Cyperaceae

H *Carex distachya* Desf.; b; 1; Z

G *C. divisa* Huds.; e; 10; R

G *C. flacca* Schreb.; b; 15; Y*, G, K, R

H *C. hallerana* Asso; a, b; 10; C, O, R, S

G *Cyperus alternifolius* L.*; h; 16; B

Dioscoreaceae

G *Tamus communis* L.; a; 10; B, C, O

Iridaceae

G *Iris adriatica* Trinajstić ex Mitić; b; 5; S

G *I. germanica* L.; f; 16; B

G *Romulea bulbocodium* (L.) Sebast. et Mauri; b; 1; A, G

Juncaceae

H *Juncus acutus* L.; e; 7; M

Liliaceae

G *Allium commutatum* Guss.; c; 1; HJ*, HS*, R*, Y*, A, B, C, G, M, O, S

G *A. flavum* L.; b; 10; G

G *Allium dentiferum* Webb et Berthel; f; 1; G

G *A. sphaerocephalon* L.; b; 10; Y*, A, B, C, G, O, R, S

G *A. subhirsutum* L.; a, b; 1; Y*, B, C, G, S, Z

G *Asphodeline liburnica* (Scop.) Rchb.; b; 4; G, O, S

G *Asphodelus aestivus* Brot.; b; 1; O* (as *A. microcarpus* Viv.), C, G, S

G *Asparagus acutifolius* L.; a; 1; HJ*, O*, R*, Y*, A, B, C, G, HS, K, M, S, Z

G *Muscari comosum* (L.) Mill.; b; 10; C, G

G *M. neglectum* Guss. ex Ten.; b; 1; A, B, C, K

G *Ornithogalum comosum* L.; b; 12; G

- G *Ruscus aculeatus* L.; a; 9; Y*, C, G, O
 P *Smilax aspera* L.; a; 1; HJ*, O*, R*, Y*, A, B, C, G, K, M, S, Z

Orchidaceae

- G *Anacamptis pyramidalis* (L.) Rich.; b; 13; R
 G *Serapias parviflora* Parl.; b; 1; R

Poaceae

- G *Arundo donax* L.; e; 1; Y*, M
 T *Avena barbata* Pott ex Link; b, d, f; 15; A, B, G
 T *A. sterilis* L.; f; 11; B
 T *Brachypodium distachyon* (L.) P. Beauv.; 1; Y*
 H *B. retusum* (Pers.) P. Beauv.; a, b, c; 1; O*, R*, Y* (as *B. ramosum* (L.) R. et S.),
 B, C, G, K, M, S, Z
 H *Bromus erectus* Huds. ssp. *condensatus* (Hack.) Asch. et Graebn.; b; 10; Y*
 (as *B. condensatus* Hackel), A, B, C, G, R, S
 T *B. madritensis* L.; f; 7; C, G
 T *B. sterilis* L.; f; 15; B, G, K, R
 H *Cynodon dactylon* (L.) Pers.; c; 15; Y*, A, G, K, O, S, Z
 T *Cynosurus echinatus* L.; b; 10; B
 H *Dactylis glomerata* L. ssp. *glomerata*; f; 14; A, B, G, O, R
 H *D. glomerata* L. ssp. *hispanica* (Roth) Nyman; b; 1; R*, Y* (as *D. hispanica*
 Roth), B, C, G, K, O, S, Z
 T *Dasyphyrum villosum* (L.) P. Candargy; f; 11; B
 T *Desmazeria marina* (L.) Druce; c, e; 7; Y* (as *Catapodium marinum* (L.)
 Hubbard), C, G, HS, K, O, S, Z
 T *D. rigida* (L.) Tutin; b; 7; Y* (as *Catapodium rigidum* (L.) Hubbard), B, C, G, K,
 O, S, Z
 T *Digitaria sanguinalis* (L.) Scop.; f; 15; K
 G *Elymus pycnanthus* (Godr.) Melderis; c; 1; HJ*, HS*, R*, Y*, A, B, C, G, K, O, S, Z
 H *Helictotrichon convolutum* (C. Presl) Henrard.; b; 2; B, G, O, R, S
 T *Hordeum murinum* L. ssp. *leporinum* (Link) Arcang.; f; 1; B, C, G, K
 T *Gastridium ventricosum* (Gouan) Schinz et Thell.; b; 7; Y*, B, O, S, Z
 H *Koeleria splendens* C. Presl; b; 10; G, K, S
 T *Lagurus ovatus* L.; 1; Y*
 H *Lolium perenne* L.; f; 13; B, C
 T *L. rigidum* Gaudin ssp. *rigidum* (= *L. strictum* C. Presl); b; 10; G
 T *Lophochloa cristata* (L.) Hyl.; b; 15; C, S
 H *Melica ciliata* L.; b; 14; Y*, B, C, G, M, O, S
 T *Parapholis incurva* (L.) C. E. Hubb.; e, d; 7; Y*, B, K, O, Z
 T *Poa annua* L.; b; 15; C, S
 T *Setaria viridis* (L.) P. Beauv.; c, d; 15; C, K, S
 T *Triticum aestivum* L.; d; 16; K

Potamogetonaceae

- Hy *Posidonia oceanica* (L.) Delile; g; 1; Y*, meadows of *Posidonia* are spread
 around the islands.

ANALYSIS OF THE FLORA

1. Taxonomic analysis

In total, 264 vascular plant taxa (Tab. 1) were recorded on the 14 Vrgada islets and reefs. Among them, 231 were species, 32 subspecies and one variety classified within 184 genera and 63 families

Tab. 1. Taxonomic analysis

TAXON	Pterido- phyta	Gymnospermae		Angiospermae		TOTAL
		Conifero- phytina	Cycado- phytina	Magnoliatae	Liliatae	
Family	1	2	1	49	10	63
Genus	1	2	1	137	43	184
Species	1	3	-	173	54	231
Subspecies	-	1	1	25	5	32
Variety	-	-	-	1	-	1
Total of species, subspecies and variety	1	4	1	199	59	264
% of total flora	0.38	1.51	0.38	75.38	22.35	100

Most taxa were recorded for the Islet of Gira (126), Veliki Školjić (108) and Kozina (105), whereas no vascular plant taxa were found on Lončarić reef (Tab. 2).

Tab. 2. Number of taxa on the islets and reefs

Islets and reefs	No. of previously registered taxa (PILJAC-KOSOVIC & PANDŽA, 2009)	No. of taxa (this study)	Total
Vrtlić (A)	-	28	28
Obrovanj (O)	17	68	85
Rakita (R)	31	25	56
Veliki Školjić (B)	-	108	108
Mali Školjić (C)	-	84	84
Gira (G)	-	126	126
Kozina (K)	-	105	105
Murvenjak (M)	-	59	59
Šipnata (S)	-	95	95
Oblik (Z)	-	65	65
Kamičić – reef north of Vrgada (HS)	9	8	17
Kamičić – reef south of Vrgada (HJ)	7	-	7
Artina (Y)	88	1	89
Lončarić	-	-	-

2. Life forms

Therophytes prevailed with 42.42 % followed by hemicryptophytes (23.48 %, Fig. 2).

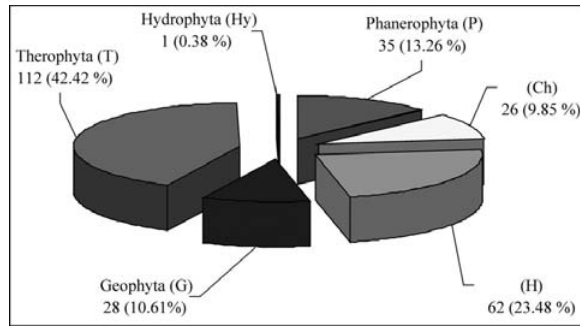


Fig. 2. Spectrum of life forms

3. Floral elements

The Mediterranean floral element dominated (49.62 %) followed by widespread plants (17.80 %), and the plants of the South European element (17.05 %, Tab. 3).

Tab. 3. Analysis of the floral elements in the flora of the islets and reefs of Vrgada

FLORAL ELEMENT		No. of taxa	%
1.	MEDITERRANEAN	131	49.62
	A Circum-Mediterranean plants	79	29.93
	B West Mediterranean plants	3	1.14
	C East Mediterranean plants	5	1.89
	D Illyrian Mediterranean plants	18	6.81
	1) Illyrian South European plants	4	1.51
	2) Illyrian Adriatic plants	14	5.30
	a) Illyrian Adriatic Endemic plants	10	3.79
	b) Illyrian Apennine plants	4	1.51
	E Mediterranean Atlantic plants	15	5.68
	F European Mediterranean plants	3	1.14
	G Mediterranean Pontic plants	8	3.03
2.	SOUTH EUROPEAN	45	17.05
	A South European Mediterranean plants	36	13.64
	B South European Pontic plants	9	3.41
3.	SOUTHEAST EUROPEAN	1	0.38
4.	EUROPEAN	6	2.27
5.	EUROASIATIC	13	4.92
6.	WIDESPREAD PLANTS	47	17.80
7.	CULTIVATED AND ADVENTITIOUS PLANTS	21	7.96
TOTAL		264	100,00

DISCUSSION AND CONCLUSION

The flora of the 14 Vrgada islets and reefs comprises 264 taxa (231 species, 32 subspecies and one variety) within 184 genera and 63 families. All previously recorded taxa on the islets of Obrovanj and Rakita (PILJAC-KOSOVIC & PANDŽA, 2009) as well as all the taxa from the Kamičić reef (north and south of Vrgada) have been confirmed with this study. No vascular flora were recorded on Lončarić reef (less than 1ha in surface).

Despite the fact that the islets are uninhabited and the anthropogenic influence is slight, 21 taxa of cultivated and adventitious plants were recorded. Out of these, nine species occur only in crops (*Agave americana*, *Cyperus alternifolius*, *Nerium oleander*, *Petroselinum crispum*, *Rosmarinus officinalis*, *Santolina chamaecyparissus*, *Sempervivum tectorum*, *Solanum tuberosum* and *Yucca gloriosa*), and three species demonstrate the ability to spread spontaneously (*Matthiola incana*, *Iris germanica* and *Vitis vinifera*).

We have listed the taxa *Spartium junceum* and *Stachys cretica* ssp. *salviifolia*, which were found only on the Veliki Školjić islet and only in crops, in the group of cultivated and adventitious plants in this paper. Normally, these taxa are common in the natural vegetation in the Zadar area as well as in the wider area of Dalmatia.

The adventitious taxa *Chamomilla recutita*, *Solanum lycopersicum* and *Triticum aestivum* were recorded in the nitrophylic vegetation alongside nesting sites of seagulls. These species were probably brought into the area from the surrounding inhabited islands and reefs by the seagulls.

The largest islet in the Vrgada archipelago – Murvenjak (0.609 km²) has the least taxa (59) in comparison with its surface. Myrtle and lentisk vegetation (ass. *Myrto communis-Pistacietum lentisci*) continues on the halophytic zone of Murvenjak, and on higher grounds we find a small area with the myrtle and holm oak vegetation (ass. *Myrto communis-Quercetum ilicis*). Within the halophytic and forest vegetation, a certain amount of ruderal species are present, brought by the seagulls. It is important to stress that on the narrow parts of the island in the west and southeast there are muddy surface areas of the association *Puccinellio festucaeformis-Sarcocornietum fruticosae*, which belongs among the protected and endangered habitats in Croatia. The number of taxa depends on degree of habitat diversity.

The islets Gira (0.056 km²) and Veliki Školjić (0.03 km²) are richest in taxa found with 126 and 108 taxa, respectively (Tab. 2.). We found nesting sites of a large colony of seagulls next to the halophytic vegetation and macchia on Gira. A lot of ruderal and cultivated taxa are present on Veliki Školjić.

The number of taxa of the Vrgada islets (59–126 taxa) does not differ significantly from the number of taxa in the flora of other uninhabited Adriatic islets whose surface is smaller than one km² (Tab. 4).

On the islets that have been anthropogenically influenced (e.g. the islet of Prišnjak, near the island of Murter, where the lighthouse keeper's family dwelled for a long time) the number of species is significantly larger than the number of taxa of islets that have the same surface but without anthropogenic influence (compare with Kozina), (see Tab. 4).

The families *Fabaceae* (30 taxa, 11.36 %), *Poaceae* (25 taxa, 9.47 %) and *Asteraceae* and *Cichoriaceae* (both together 36 taxa, 13.64 %) had the highest number of taxa. These families prevail in the flora of other Adriatic islands and islets, e.g. on Obo-

Tab. 4. A comparison of the number of taxa and the surface area among selected uninhabited Dalmatian islets with surface area less than one km².

Islets	Surface area (km ²)	No. of taxa	References
Obonjan	0.70	230	MILOVIĆ 2004.
Daksa	0.59	225	HEĆIMOVIĆ, M. & S. 1989.
Mrkan	0.28	179	HEĆIMOVIĆ, S. 1982.
Palagruža	0.286	220	PAVLETIĆ, ZI. 1978a.
Vela Kluda	0.12	137	VLADOVIĆ <i>et al.</i> 2001.
Bobara	0.075	86	HEĆIMOVIĆ, S. 1982.
Prišnjak (Murter)	0.065	175	PANDŽA, M. 2002
Kozina	0.063	105	This study
Sv. Andrija	0.053	160	JASPRICA <i>et al.</i> 2006.
Brusnik	0.05	41	PAVLETIĆ, ZI. 1983.
Hrbošnjak (Murter)	0.05	84	PANDŽA, 2002.
Samograd	0.043	71	PANDŽA, 2003.
Hrbošnjak (Žirje)	0.019	44	PANDŽA, 2003.

njan (MILOVIĆ, 2004), Vela Kluda (VLADOVIĆ *et al.*, 2001), Rava (MILOVIĆ & PANDŽA, 2008), etc.

Therophytes dominated with 112 taxa (42.42 %), followed by hemicryptophytes (23.48 %), phanerophytes (13.26 %), geophytes (10.61 %), and chamaephytes (9.85%). The representation of the therophytes indicates a dry and warm climate. However, the number of therophytes is significantly higher on Vrgada Island (49.7 %), (Tab. 5.), which is permanently inhabited, than on the researched uninhabited islets and reefs (42.42 %). The increased number of therophytes in the Mediterranean area is the result of a dry and warm climate, and a consequence of anthropogenic influence. In addition, therophytes are a reliable indicator of the degree of anthropogenic influence, that is, they considerably increase in areas with stronger anthropogenic influences (HRUSKA, 1989, 1993/94).

Tab. 5. Life forms in the flora of Vrgada island and its islets, and selected Dalmatian islets and in the Mediterranean (%).

Islet	Life forms (%)						References
	P	Ch	H	G	T	Hy	
Obonjan	11.74	11.74	19.13	10.43	46.96	–	MILOVIĆ 2004.
Vela Kluda	13.11	8.8	21.2	11.6	45.3	–	VLADOVIĆ <i>et al.</i> , 2001.
Sv. Andrija	18.18	12.98	25.31	6.49	36.4	0.64	JASPRICA <i>et al.</i> , 2006.
Daksa	17.33	11.56	19.11	10.67	41.33	–	HEĆIMOVIĆ, M. & S., 1989.
Vrgada	7.6	8.2	24.6	9.5	49.7	0.4	PILJAC-KOSOVIC & PANDŽA, 2009.
Islets of Vrgada	13.2	9.8	23.8	10.5	42.3	0.4	
Mediterranean	12	6	29	11	42	–	HORVAT, I. 1949

Out of 264 taxa, 131 (49.62 %) belong to the Mediterranean floral element, among which the most numerous are Circum-Mediterranean plants (79 taxa, 29.93 %). The

domination of Mediterranean plants has been determined for other Adriatic islands as well: Svetac (PAVLETIĆ, 1978b), Daksa (HEĆIMOVIĆ, M. & S., 1989), Obonjan (MILOVIĆ, 2004), Rava (MILOVIĆ & PANDŽA, 2008). The domination of Mediterranean plants indicates the Mediterranean character of the climate, typical for the area of East Adriatic littoral.

In total, 10 taxa (3.79 %) are endemic plants found on Vrgada islets: *Anthyllis vulneraria* ssp. *praepropera*, *Aurinia sinuata*, *Campanula pyramidalis*, *Carduus micropterus*, *Dianthus ciliatus*, *Euphorbia fragifera*, *Iris adriatica*, *Rhamnus intermedius*, *Seseli tomentosum* and *Vincetoxicum hirundinaria* ssp. *Adriaticum*.

Seven taxa from the Red Book of Vascular Flora of Croatia (NIKOLIĆ & TOPIĆ, 2005, were recorded; two endangered (*Carex divisa* and *Glaucium flavum*) and five vulnerable taxa (*Desmazeria marina*, *Pharapholis incurva*, *Salsola kali*, *S. soda* and *Suaeda maritima*). All these plants grow within the halophytic vegetation... Development of the tourist industry in settlements, as well as a great increase in the traffic of nautical tourism are threats to these plants. Out of the nearly threatened taxa were: *Anacamptis pyramidalis*, *Cyclamen repandum*, *Elymus pycnanthus*, *Ephedra fragilis* ssp. *campylopoda*, *Iris adriatica* and *Seseli tomentosum*.

Eight orchids were recorded on Vrgada island (PANDŽA & PILJAC-KOSKOVIĆ, 2007), but only two species (*Anacamptis pyramidalis* and *Serapias parviflora*) were noted on the islets. About one hundred specimens of both species were found on the islet of Rakita. This may be because of the preservation of habitats by the grazing of the grass and the cutting of the surrounding macchia.

Although these islets are uninhabited there are a significant number of ruderal species that were brought to these islets by the seagulls that nest there.

There is an abundance of species on these islets, both protected and endemic. They are endangered by the spreading of forest vegetation caused by the decrease in the area of pasture land and by increasing tourist activities.

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SAŽETAK

Vaskularna flora vrgadskih otočića

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Flora vrgadskih otočića istraživana je tijekom vegetacijske 2009. i u proljeće 2010. Otok Vrgadu okružuje 14 otočića i hridi: Murvenjak ili Murvenik, Šipnata, Oblik, Kozina, Gira, Obrovanj, Artina, Veliki Školjić, Mali Školjić te hridi Rakita, Vrtlić,

Lončarić, Kamičić sjeverno i južno od Vrgade. Na hridi Lončarić nije zabilježena niti jedna vrsta. Na 13 otočića i hridi zabilježene su ukupno 264 svoje vaskularnih biljaka svrstanih u 184 roda i 63 porodice. Najzastupljenije porodice su *Fabaceae* (30 taksona, 11.36 %), *Poaceae* (25 taksona, 9.47 %) te *Asteraceae* i *Cichoriaceae* zajedno (36 taksona, 13.64 %).

Analiza životnih oblika ukazuje na dominaciju terofita sa 112 vrsta (42.42 %), zatim slijede hemikriptofiti (23.48 %), fanerofiti (13.26 %), geofiti (10.61 %) i kamefiti (9.85 %) dok su hidrofiti zastupljeni samo jednom vrstom (0.38 %).

Fitogeografska analiza flore pokazuje visoki udio biljaka mediteranskog flornog elementa (49.62 %), među kojima su najbrojnije općemediteranske biljke (79 taksona, 29.93 % od ukupnog broja taksona). Brojno su zastupljene biljke široke rasprostranjenosti (47 taksona, 17.8 %) i biljke južnoeuropskog flornog elementa (45 taksona, 17.05 %).

Dominacija terofita (42.42 %) i biljaka mediteranskoga flornog elementa (49.62 %) ukazuje na mediteranski karakter flore ovih otočića.