

THE FLORA OF THE ISLAND OF RIVANJ AND THE VEGETATION OF THE MACCHIA AND FOREST OF RIVANJ AND THE SESTRICE ISLETS

FLORA OTOKA RIVNJA TE VEGETACIJA MAKIJE I DRVEĆA RIVNJA I OTOČIĆÂ SESTRICE

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SUMMARY

According to literature data and field research conducted in 2019 and 2020, there are 346 vascular native and non-native taxa with the ability to survive outside crops (309 species, 36 subspecies and varieties) on the island of Rivanj (3,615 km²). Including 84 taxa in cultivation, we state that the total flora of Rivanj numbers 430 taxa. Those in cultivation are not included in the flora analysis. During earlier research, 45 taxa were recorded, while 385 taxa are listed for the first time in this work. In addition to the flora inventory, a taxonomic, ecological and phytogeographical analysis was performed. The results are presented in Tables 1–4 and Figure 2. The composition of the flora is dominated by angiosperms, in which dicotyledons (73.99%) are significantly more common than monocotyledons (23.99%). The flora also includes two ferns and 5 gymnosperms. By the number of taxa, the most represented families are *Poaceae* (13.01%), *Asteraceae* s.l. (11.85%) and *Fabaceae* (8.96%). The spectrum of life forms is dominated by therophytes (43.93%) and hemicryptophytes (24.28%), while plants of the Mediterranean floral element (42.77%) dominate in the phytogeographical analysis, which indicates the climatic conditions and geographical position of the island of Rivanj. Four endemics and four endangered taxa (*Lathyrus ochrus* – critically endangered, *Carex extensa* – endangered and two vulnerable taxa: *Orchis tridentata* and *Parapholis incurva*) were recorded in the flora, as well as five orchid. Eleven invasive taxa were recorded in the weed and ruderal vegetation of the settlement (3.18% of the total flora of the island).

The investigation of the macchia and forest vegetation of the island of Rivanj and the islets of Sestrice was conducted in 2019 and 2020. The relevés were produced and analyzed according to the Braun-Blanquet method. Thirty relevés presenting the vegetation of the *Quercetea ilicis* and *Pinetea halepensis* classes were statistically analyzed and their dendrogram created. The results are shown in Tables 5–7 in accordance with the classic presentation regarding phytosociological relevés. Through the syntaxonomic analysis the *Erico arboreae-Arbutetum unedonis* Allier et Lacoste 1980 ex Foggi in Foggi et Grigioni 1999, *Myrto communis-Pistacietum lentisci* (Molinier 1954) Rivas-Martínez 1975, *Pistacio lentisci-Juniperetum turbinatae* Trinajstić 1987 ex Asensi, Díez-Garretas & Quézel 2007 and *Myrto communis-Quercetum ilicis* (Horvatić 1963) Trinajstić (1976) 1985 associations from the *Quercetea ilicis* class and the *Pistacio lentisci-Pinetum halepensis* De Marco, Veri & Caneva 1984 association. The autochthonous macchia and forest vegetation is mostly endangered by planted community of Aleppo pine on the islet of Mala Sestrica and on smaller areas on the island of Rivanj. North-west of the settlements on the Rivanj island a thick and impassable macchia grows. It is necessary to clear out the firefighting access paths and ban all activities that might cause fire.

KEY WORDS: phytosociology, the island of Rivanj and the islets of Sestrice, Northern Dalmatia, the Zadar archipelago, vascular flora

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INTRODUCTION

UVOD

Preliminary analyses show that the islands of the Adriatic archipelago stand out as one of the main centres of floristic diversity in Croatia (Nikolić *et al.* 2008, Nikolić 2014b). The islands of the Zadar archipelago are floristically the least explored. There are 23 islands, 177 islets and 65 rocks and reefs in the Zadar archipelago - a total of 265 (Anonymous 2007).

Although intensive floristic research on the islands of the Zadar archipelago has been carried out for the last 15 years, the flora of the larger islands: Premuda, Sestrunj, Zverinac, Škrda, Maun, Iž, Rivanj, Ugljan and Pašman, is still insufficiently researched or almost unknown. In the last 10 years, Perinčić *et al.* (2016) studied the horticultural flora of the islands of the Zadar archipelago, including Rivanj. They recorded 21 taxa for Rivanj.

The most extensive years-long phytosociological investigations of the littoral vegetation were conducted in the second half of 20th century by Horvatić (1961–1962, 1963). He investigated the vegetation of garrigues and rocky grassland on the islands of Kornati, Dugi otok, Korčula, Hvar, Brač, Šolta, Vis, the Zadar archipelago and others. On several occasions in 1958, 1959 and 1960, while investigating the vegetation of garrigue, Horvatić visited the islands of Ugljan, Pašman, Rivanj and Sestrunj of the Zadar archi-

pelago, as well as the eastern parts of the islands of Korčula and Badija. Horvatić presented the floristic composition of the investigated garrigue in Table 1 in 8 relevés. Relevés 1, 3 and 5 were produced on the island of Rivanj where Horvatić identified 24 taxa. At the time of Horvatić's investigations, 79 people lived on the island of Rivanj (Faričić 2012). The depopulation process reduced farming activities and vineyards and olive groves became overgrown by macchia. The absence of cutting, mowing, grazing and fires has contributed to the successional processes and development of forest vegetation. In recent past, there were three fires on the island of Rivanj. The last one happened on July 25, 2007 when a third of the island's vegetation was destroyed (Radulić 2010).

Floristic and vegetation investigations of the island of Rivanj and the islet of Sestrica Mala started in 2019 (Pandža *et al.* 2019). The aim of the investigations is to complete data regarding vegetation characteristics on the island of Rivanj and the Sestrice islets and to propose conservation measures for the endangered habitat types.

Research area – Područje istraživanja

The island of Rivanj (3,615 km²; Duplančić-Leder *et al.* 2004) is located in the Zadar archipelago and is located between the islands of Sestrunj and Ugljan (Fig. 1). It has a Dinaric northwest-southeast direction. It is 3.4 km long, and the greatest width is 1.4 km. Its coastline is 10.3 km

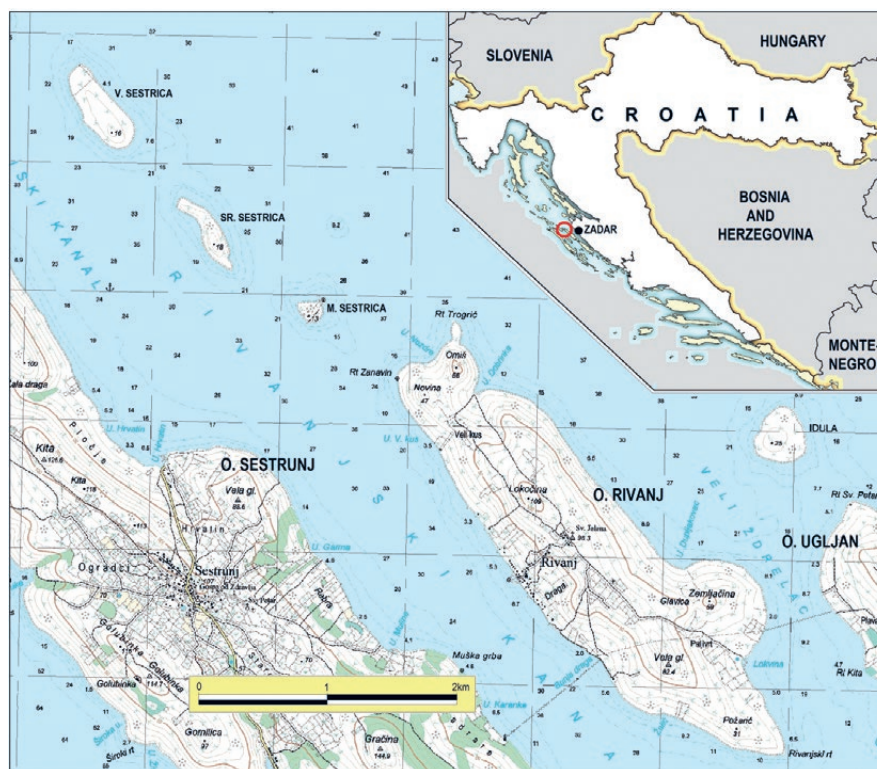


Figure 1 Geographic position of the island of Rivanj and the Sestrice islets.

Slika 1. Geografski položaj otoka Ravnja i otočića Sestrice.

(Radulić 2010). The highest point of the island is peak Lokočina, 112 m a.s.l. In terms of size, it belongs in the group of small inhabited Croatian islands. According to the 2021 census (Institute of Statistics of the Republic of Croatia), 23 inhabitants live on the island of Rivanj.

North-west of the Rivanj island and north of the Sestrinj island several islets stretch Sestrice (Fig. 1): Mala Sestrica (33 732 m²), Sridnja Sestrica (104 837 m²) and Vela Sestrica (187 520 m²) (Duplančić-Leder *et al.* 2004). These islets are uninhabited.

Rivanj, like the other islands of the Zadar archipelago, has a Mediterranean climate, which according to the Köppen classification is designated as a Csa climate type (Seletković *et al.* 2011). The average annual air temperature is 15.6 °C, and the average annual precipitation is 888.7 mm (data for the Zadar meteorological station, provided by the Croatian Meteorological and Hydrological Service for 1989 – 2018). The largest area of the island is made up of macchia. Phytogeographically, the island is in the Eu-Mediterranean vegetation (*Fraxino ornii-Quercion ilicis* alliance) while in the southern and protected positions it is in the Steno-Mediterranean vegetation (alliance *Oleo sylvestris-Ceratonion siliquae*).

The Rivanj channel, together with the islets of Sestrice, is included in the Ecological Network of Croatia Natura 2000 as an area important for species and habitats (site code HR 3000074). The related Natura codes are: 1120 and 1170. Natura code 1120 is a habitat type of interest for the European Union, which is an endangered and priority habitat of *Posidonia*. The other Natura code 1170 are reefs (Anonymous 2019).

MATERIAL AND METHODS

MATERIJAL I METODE

FLORA

The study was carried out in the period between April 2019 and August 2020 in all seasons. Floristic surveys were conducted using the standard method described by Nikolić *et al.* (1998) and Nikolić (2006). Taxa were determined using the standard keys, books and guides (Tutin *et al.* 1968-1980, Trinajstić 1975-1986, Pignatti 1982, Tutin *et al.* 1993, Domanac 1994, Delforge 2006). The nomenclature of plant taxa mainly follows *Flora Croatica Database* (Nikolić 2023), with the exception of some cultivated taxa, where *European Garden Flora* (Cullen & Knees 2011) was used. The nomenclature of taxa that are not according to Nikolić (2023) are marked with the symbol (*) in front of the taxa name. Their biological (*sensu* Raunkiaer 1934, Pignatti 1982) and chorological forms (geoelement) were determined according to Horvatić (1963) and Horvatić *et al.* (1967-1968). Life forms are marked with abbreviations: Ch (Chamaephyta), G (Ge-

ophyta), H (Hemicryptophyta), P (Phanerophyta), T (Therophyta) and Hy (Hydrophyta). The names of floral elements (geoelements) and the corresponding abbreviations used in the list of flora are shown in table 3. Family, life form and geoelement were attributed to each taxon, while other, more local characteristics (endemic, threatened, strictly protected, invasive) are given if they exist. Taxa that are considered endemic in the Croatian flora according to Nikolić *et al.* (2015), are marked with the abbreviation “end”

Strictly protected (“sp”) taxa in Croatia were defined according to Anonymous (2013b, 2016). Invasive plant taxa (IAS) have been defined according to Boršić *et al.* (2008) and Nikolić *et al.* (2014a). Categorization of endangered taxa was done according to the *Red Book of Vascular Flora of the Republic of Croatia* (Nikolić & Topić 2005). They are marked with international abbreviations that indicate the degree of endangerment: CR (*Critically endangered*), EN (*Endangered*), VU (*Vulnerable*) and NT (*Near Threatened*). The species noted by Horvatić (1961/1962) and Perinčić *et al.* 2016 are especially indicated in the list of flora (abbreviation: Ho = Horvatić, Pe = Perinčić *et al.*).

VEGETATION

The vegetation researches of the island of Rivanj and tree Sestrice islets were carried out in 2019 and 2020. The vegetation investigations were conducted according to the Zürich-Montpellier school method (Braun-Blanquet 1964). Thirty phytosociological relevés of the shrubs and forest vegetation were produced during personal investigations. In the phytosociological tables (Tables 5–7) the nomenclature of taxa follows Nikolić (2023). The phytosociological nomenclature follows the „International Code of Phytosociological Nomenclature“ (Theurillat *et al.* 2020). Habitat types and Natura code based on the *Regulation on the Ecological Network* and *List of Habitat Types* (Anonymous 2013a, 2014). Classification into particular syntaxonomical categories is based on Mucina *et al.* (2016) and Škvorc *et al.* (2017). The coordinates of the phytosociological relevés are next to the dates in Appendix 1, produced in accordance with Gauss-Krüger.

Classification of relevés was done using cluster analysis in the PC-ORD 5.0 (MjM Software Design, Gleneden Beach, OR, US). Square root transformation of percentage cover values of species, Beta flexible ($\beta = -0.25$) for group linkage with Relative Sørensen index as the distance measure was used (Van der Maarel 1979).

FLORA: RESULTS – REZULTATI

On the island of Rivanj, 346 taxa of vascular flora have been recorded that grow nativ on the island or spread spontaneously outside of cultivation. Also, 84 taxa were recorded

that grow on Rivanj only in cultivation and were not included in the flora analysis. The overall flora of Rivanj numbers 430 taxa. Of the total number of taxa, 45 taxa were previously recorded, while 385 taxa are listed for the first time in this paper. In addition to the flora inventory, a taxonomic, ecological and phytogeographical analysis was performed. Special attention is focused on analyses of endemic, endangered, strictly protected and invasive taxa. The results are presented in Tables 1-4 and Figures 1 and 2.

Floristic list – Popis flore

PTERIDOPHYTA

Aspleniaceae

- H *Asplenium ceterach* L.; 2
H *A. trichomanes* L.; 7

SPERMATOPHYTA – GYMNOSPERMAE

Cupressaceae

- P *Cupressus horizontalis* Mill.; 8
P *C. sempervirens* L.; 8
P *Juniperus oxycedrus* L. ssp. *oxycedrus* (Ho as *J. oxycedrus* L.); 1
P *J. phoenicea* L. (Ho); 1

Pinaceae

- P *Pinus halepensis* Mill.; 1

SPERMATOPHYTA

MAGNOLIOPSIDA

Aizoaceae

- Ch *Carpobrotus acinaciformis* (L.) L. Bolus; 8
Ch *Mesembryanthemum cordifolium* L. f.; 8

Amaranthaceae

- T *Amaranthus albus* L.; 7; IAS
T *A. deflexus* L.; 7; IAS
T *A. graecizans* L.; 7
T *A. retroflexus* L.; 7; IAS

Anacardiaceae

- P *Pistacia lentiscus* L. (Ho); 1

Apiaceae

- T *Bupleurum veronense* Turra; 1
H *Daucus carota* L. ssp. *major* (Vis.) Arcang.; 2
Ch *Crithmum maritimum* L.; 1
H *Eryngium campestre* L.; 2
H *Foeniculum vulgare* Mill. (Pe); 1
T *Tordylium apulum* L.; 1
T *Torilis arvensis* (Huds.) Link ssp. *purpurea* (Ten.) Hayek; 1

Apocynaceae

- Ch **Catharanthus roseus* (L.) G. Don; 8
Ch *Vinca major* L.; 8

Araliaceae

- P *Hedera helix* L.; 4

Asteraceae

- Ch *Artemisia caerulescens* L.; 1

- T *Aster squamatus* (Spreng.) Hieron.; 8; IAS
T *Bidens subalternans* DC.; 8; IAS
T *Calendula arvensis* (Vaill.) L.; 2
T *C. officinalis* L. (Pe); 8
H *Carduus micropterus* (Borbás) Teyber ssp. *micropterus*; 1, end, sp
H *C. pycnocephalus* L. ssp. *pycnocephalus*; 1
H *Carlina corymbosa* L.; 1
T *Conyza bonariensis* (L.) Cronquist; 8; IAS
T *C. sumatrensis* (Retz.) E. Walker; 8; IAS
H **Dimorphotheca jucunda* E. Phillips; 8
H *Dittrichia viscosa* (L.) Greuter; 1
T *Filago vulgaris* Lam.; 7
Ch *Helichrysum italicum* (Roth) G. Don; 1
Ch *Inula crithmoides* L.; 1
T *Pallenis spinosa* (L.) Cass.; 1
Ch *Senecio bicolor* (Willd.) Tod. ssp. *cineraria* (DC.) Chatter; 8
T *S. vulgaris* L.; 7
T *Zinnia elegans* Jacq.; 8

Bignoniaceae

- P *Campsis radicans* (L.) Seem.; 8

Boraginaceae

- T *Anchusella cretica* (Mill.) Bigazzi, E. Nardi; 1
T *Heliotropium europaeum* L.; 1

Brassicaceae

- Ch *Aethionema saxatile* (L.) W. T. Aiton; 2
T *Alyssum simplex* Rudolphi; 1
T *Cakile maritima* Scop.; 7
T *Capsella rubella* Reut.; 1
T *Cardamine hirsuta* L.; 7
H *Cardaria draba* (L.) Desv.; 7
H *Diplotaxis tenuifolia* (L.) DC.; 7
T *Eruca vesicaria* (L.) Cav. ssp. *sativa* (Mill.) Thell.; 8
H *Lobularia maritima* (L.) Desv.; 8
Ch *Matthiola incana* (L.) W. T. Aiton; 8
T *Raphanus sativus* L.; 8

Campanulaceae

- T *Campanula erinus* L.; 1

Caprifoliaceae

- P *Lonicera implexa* Aiton; 1
P *Viburnum tinus* L. (Ho); 1

Caryophyllaceae

- T *Arenaria leptoclados* (Rchb.) Guss.; 5
T *Cerastium glomeratum* Thuill.; 7
H *Herniaria incana* Lam.; 2
H *Petrorhagia saxifraga* (L.) Link; 2
T *Polycarpon tetraphyllum* (L.) L.; 2
H *Saponaria officinalis* L.; 8
T *Silene gallica* L.; 7
H *S. vulgaris* (Moench) Garcke ssp. *angustifolia* Hayek; 2
T *Stellaria media* (L.) Vill.; 7
T *S. pallida* (Dumort.) Piré; 5

Chenopodiaceae

- Ch *Arthrocnemum fruticosum* (L.) Moq.; 2
 Ch *A. macrostachyum* (Moric.) K. Koch; 2
 T *Atriplex prostrata* DC.; 7
 H *Beta vulgaris* L. ssp. *maritima* (L.) Arcang.; 1
 T *B. vulgaris* L. ssp. *vulgaris*; 8
 T *Chenopodium album* L.; 7
 T *Ch. murale* L.; 7
 T *Ch. strictum* Roth; 7
 T *Ch. vulvaria* L.; 2
 Ch *Halimione portulacoides* (L.) Aellen; 6

Cichoriaceae

- G *Aetheorhiza bulbosa* (L.) Cass.; 1
 H *Chondrilla juncea* L.; 5
 T *Cichorium endivia* L.; 8
 H *C. intybus* L.; 7
 T *Cirsium arvense* (L.) Scop.; 5
 H *C. vulgare* (Savi) Ten.; 5
 H *Crepis biennis* L.; 3
 T *C. foetida* L.; 2
 T *C. sancta* (L.) Bornm.; 1
 T *C. vesicaria* L. ssp. *vesicaria*; 1
 T *C. zacintha* (L.) Loisel.; 1
 T *Hedypnois cretica* (L.) Dum. Cours.; 1
 H *Hieracium praealtum* Vill. ex Gochnat ssp. *bauhinii* (Besser) Petunn.; 5
 H *Lactuca viminea* (L.) J. Presl et C. Presl; 2
 H *Leontodon tuberosus* L.; 1
 H *Picris hieracioides* L. ssp. *spinulosa* (Guss.) Arcang.; 5
 H *Reichardia picroides* (L.) Roth; 1
 T *Rhagadiolus stellatus* (L.) Gaertn.; 1
 T *Sonchus asper* (L.) Hill ssp. *glaucescens* (Jord.) Ball; 1
 T *S. tenerrimus* L.; 1
 H *Tragopogon porrifolius* L.; 1
 T *Urospermum picroides* (L.) F. W. Schmidt; 1

Cistaceae

- P *Cistus incanus* L. (Ho as *C. villosus* ssp. *villosus*); 1
 P *C. monspeliensis* L. (Ho); 1
 P *C. salviifolius* L. (Ho); 1
 Ch *Fumana ericifolia* Wallr.; 1
 Ch *F. thymifolia* (L.) Webb; 1

Clusiaceae

- H *Hypericum perforatum* L.; 2

Convolvulaceae

- H *Convolvulus althaeoides* L. ssp. *tenuissimus* (Sm.) Batt.; 1
 G *Convolvulus arvensis* L.; 7
 H *Convolvulus cantabrica* L.; 2

Crassulaceae

- Ch *Sedum sexangulare* L.; 2
 Ch *Sempervivum tectorum* L.; 8

Dipsacaceae

- H *Sixalix atropurpurea* (Forssk.) Greuter et Burdet ssp. *maritima* (L.) Greuter et Burdet; 1

Ericaceae

- P *Arbutus unedo* L. (Ho); 1
 P *Erica arborea* L. (Ho); 1

Euphorbiaceae

- T *Euphorbia chamaesyce* L.; 2
 Ch *E. characias* L. ssp. *wulfenii* (Hoppe ex W. D. J. Koch) Radcl.-Sm.; 1
 T *E. exigua* L.; 2
 T *E. falcata* L.; 2
 Ch *E. fragifera* Jan; 1
 T *E. helioscopia* L.; 7
 T *E. marginata* Pursh; 8
 T *E. pepus* L.; 7
 T *E. prostrata* Aiton, 8; IAS
 T *Mercurialis annua* L.; 7

Fabaceae

- H *Anthyllis vulneraria* L. ssp. *praepropera* (A. Kern.) Bornm.; 1
 P *Coronilla emerus* L. ssp. *emeroides* Boiss. et Spruner (Ho as *C. emeroides* Boiss. et Sprung.); 1
 T *C. scorpioides* (L.) W. D. J. Koch; 1
 Ch *Dorycnium hirsutum* (L.) Ser. (Ho as *D. hirsutum* (L.) Ser. var. *italicum* (Jord. et Fourr.) A. et G.); 1
 Ch *D. pentaphyllum* Scop.; 1
 T *Hippocrepis unisiliquosa* L.; 1
 T *Lathyrus aphaca* L.; 2
 T *L. cicera* L.; 1
 T *L. ochrus* (L.) DC.; 1, CR, sp
 H *Lotus corniculatus* L. ssp. *hirsutus* Rothm.; 2
 T *L. ornithopodioides* L.; 1
 T *Medicago arabica* (L.) Huds.; 7
 T *M. disciformis* DC.; 1
 H *M. falcata* L.; 4
 T *M. lupulina* L.; 7
 T *M. minima* (L.) Bartal.; 7
 T *M. orbicularis* (L.) Bartal.; 1
 T *M. polymorpha* L.; 2
 H *M. sativa* L. ssp. *sativa*; 7
 T *Scorpiurus muricatus* L.; 1
 P *Spartium junceum* L., 1
 T *Trifolium angustifolium* L., 1
 T *T. campestre* Schreb.; 7
 T *T. lappaceum* L.; 1
 T *T. scabrum* L.; 1
 T *T. stellatum* L.; 1
 T *T. tomentosum* L.; 1
 T *Trigonella esculenta* Willd.; 1
 T *Vicia angustifolia* L. ssp. *angustifolia*; 4
 T *V. hybrida* L.; 1
 T *V. parviflora* Cav.; 1

Fagaceae

- P *Quercus ilex* L. (Ho); 1

Fumariaceae

- T *Fumaria officinalis* L.; 7

T *F. parviflora* Lam.; 2

Gentianaceae

T *Blackstonia perfoliata* (L.) Huds.; 1

T *Centaureum erythraea* Rafn; 7

T *C. pulchellum* (Sw.) Druce; 5

Geraniaceae

T *Erodium malacoides* (L.) L. Hér.; 1

T *Geranium columbinum* L.; 5

T *G. purpureum* Vill.; 2

T *G. pusillum* Burm. f.; 4

T *G. rotundifolium* L.; 5

Lamiaceae

T *Ajuga chamaepitys* (L.) Schreb.; 1

H *A. genevensis* L.; 5

H *Calamintha glandulosa* (Req.) Benth.; 2

H *Mentha pulegium* L.; 5

H *M. spicata* L.; 8

Ch *Micromeria juliana* (L.) Benth. ex Rchb.; 1

Ch *Prasium majus* L.; 1

H *Prunella laciniata* (L.) L.; 2

P *Rosmarinus officinalis* L. (Ho); 1

H *Salvia pratensis* L. (incl. *S. bertolonii* Vis.); 5

H *S. verbenaca* L.; 1

T *Sideritis romana* L.; 1

H *Stachys cretica* L. ssp. *salviifolia* (Ten.) Rech. f.; 1

Ch *Teucrium chamaedrys* L. (Ho); 2

Ch *T. flavum* L.; 1

Ch *T. polium* L. ssp. *capitatum* (L.) Arcang.; 1

Ch *Thymus longicaulis* C. Presl; 1

Lauraceae

P *Laurus nobilis* L. (Pe); 1

Linaceae

H *Linum bienne* Mill.; 1

T *L. trigynum* L.; 1

Malvaceae

H *Alcea rosea* L.; 8

H *Lavatera arborea* L.; 1

T *Malva neglecta* Wallr.; 7

H *M. sylvestris* L.; 7

Meliaceae

P *Melia azedarach* L.; 8

Moraceae

P *Ficus carica* L. (Pe); 1

Myrtaceae

P *Myrtus communis* L. (Ho); 1

Nyctaginaceae

G *Mirabilis jalapa* L.; 8

Oleaceae

P *Olea europaea* L. (Pe); 8

P *O. europaea* L. var. *sylvestris* Brot.; 1

P *Phillyrea latifolia* L. (Ho); 1

P *Ph. media* L.; 1

Orobanchaceae

T *Orobanche gracilis* Sm.; 5

Oxalidaceae

G *Oxalis articulata* Savigny; 8

H *O. corniculata* L.; 7

Papaveraceae

T *Eschscholzia californica* Cham.; 8

T *Papaver rhoeas* L.; 7

Plantaginaceae

H *Plantago altissima* L.; 2

H *P. lanceolata* L.; 7

Plumbaginaceae

H *Limonium cancellatum* (Bernh. ex Bertol.) Kuntze; 1, end, sp

H *L. narbonense* Mill.; 1

H *L. virgatum* (Willd.) Fourr.; 1

Polygonaceae

T *Fallopia convolvulus* (L.) Á. Löve; 7

T *Polygonum arenastrum* Boreau; 7

T *P. aviculare* L.; 7

H *Rumex conglomeratus* Murray; 7

H *R. pulcher* L.; 2

Portulacaceae

T *Portulaca oleracea* L.; 7

Primulaceae

T *Anagallis arvensis* L.; 7

T *Asterolinon linum-stellatum* (L.) Duby; 1

G *Cyclamen repandum* Sibth. et Sm.; 1, NT

Ranunculaceae

G *Anemone hortensis* L.; 1

P *Clematis flammula* L. (Ho); 1

T *Nigella damascena* L.; 1

H *Ranunculus neapolitanus* Ten.; 2

Resedaceae

T *Reseda phyteuma* L.; 2

Rhamnaceae

P *Rhamnus alaternus* L.; 1

Rosaceae

H *Potentilla recta* L.; 5

P *Prunus cerasifera* Ehrh. (Pe); 8

P *P. dulcis* (Mill.) D. A. Webb; 8

P *P. spinosa* L.; 5

P *Rosa canina* L.; 7

P *Rubus ulmifolius* Schott; 1

H *Sanguisorba minor* Scop. ssp. *muricata* Briq.; 2

Rubiaceae

H *Asperula aristata* L. f. ssp. *scabra* (J. Presl et C. Presl) Nyman (Ho as *A. longiflora* W. et K.); 2

T *Crucianella latifolia* L.; 1

T *Galium aparine* L.; 7

H *G. corrudifolium* Vill.; 2

H *G. lucidum* All. (Ho); 2

- P *Rubia peregrina* L.; 1
 T *Sherardia arvensis* L.; 7
 T *Valantia muralis* L.; 1

Rutaceae

- Ch *Ruta chalepensis* L.; 2

Santalaceae

- P *Osyris alba* L.; 1

Scrophulariaceae

- H *Kickxia commutata* (Rchb.) R. M. Fritsch; 1
 T *K. spuria* (L.) Dumort.; 5
 T *Linaria simplex* (Willd.) DC.; 1
 H *Scrophularia canina* L. ssp. *bicolor* (Sibth. et Sm.) Greuter; 2
 T *Verbascum phoeniceum* L.; 2
 T *Veronica arvensis* L.; 5
 T *V. cymbalaria* Bodard; 2
 T *V. persica* Poir.; 7; IAS

Solanaceae

- T *Solanum lycopersicum* L. (Pe as *Lycopersicon esculentum* Mill.); 8
 T *S. nigrum* L. ssp. *nigrum*; 7
 T *S. tuberosum* L.; 8
 T *S. villosum* Mill.; 5

Tamaricaceae

- P *Tamarix dalmatina* B. R. Baum; 1

Theligonaceae

- T *Theligonum cynocrambe* L.; 2

Urticaceae

- H *Parietaria judaica* L.; 2
 T *Urtica urens* L.; 7

Verbenaceae

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

Violaceae

- T *Viola arvensis* Murray; 7

Vitaceae

- P *Parthenocissus quinquefolia* (L.) Planchon (Pe); 8; IAS
 P *Vitis vinifera* L. ssp. *vinifera* (Pe as *V. vinifera* L.); 8

Zygophyllaceae

- T *Tribulus terrestris* L.; 2

LILIOPSIDA**Agavaceae**

- P *Agave americana* L.; 8

Amaryllidaceae

- G *Allium ampeloprasum* L.; 1
 G *A. commutatum* Guss.; 1
 G *A. flavum* L.; 2
 G *A. paniculatum* L.; 2
 G *A. roseum* L.; 1
 G *A. sphaerocephalon* L.; 2
 G *A. subhirsutum* L.; 1

Araceae

- G *Arum italicum* Mill.; 1

Asparagaceae

- G *Asparagus acutifolius* L. (Ho); 1
 G *Muscari comosum* (L.) Mill.; 2
 G *Ruscus aculeatus* L.; 1

Cannaceae

- G *Canna indica* L.; 8

Cymodoceaceae

- Hy *Cymodocea nodosa* (Ucria) Asch., 1, sp

Cyperaceae

- H *Carex divulsa* Stokes; 7
 H *C. extensa* Gooden.; 1, EN, sp
 G *C. flacca* Schreb. ssp. *serrulata* (Spreng.) Greuter (Ho as *C. glauca* Murr. var. *cuspidata* (Host) A et G.); 1
 H *C. halleriana* Asso (Ho); 2
 H *C. otrubae* Podp.; 2
 G **Cyperus involucratus* Roottboell; 8
 G *Eleocharis palustris* (L.) R. Br.; 7
 H *Schoenus nigricans* L.; 7

Dioscoreaceae

- G *Tamus communis* L.; 2

Iridaceae

- G *Iris germanica* L.; 8
 G *Romulea bulbocodium* (L.) Sebast. et Mauri; 1

Juncaceae

- H *Juncus acutus* L., 1
 G *J. articulatus* L.; 6
 T *J. bufonius* L.; 7
 G *J. maritimus* Lam.; 7

Liliaceae

- G *Lilium candidum* L.; 8
 G **Alstroemeria ligtu* L.; 8

Orchidaceae

- G *Anacamptis pyramidalis* (L.) Rich.; 4, NT, sp
 G *Cephalanthera longifolia* (L.) R. M. Fritsch; 5, sp
 G *Ophrys sphegodes* Mill. ssp. *tommasinii* (Vis.) Soó; 1; end, sp
 G *Orchis tridentata* Scop.; 2, VU, sp
 G *Serapias parviflora* Parl.; 1, sp

Poaceae

- T *Aegilops neglecta* Bertol.; 1, NT
 T *Ae. triuncialis* L.; 1
 H *Agrostis castellana* Boiss. et Reut.; 1
 H *Anthoxanthum odoratum* L.; 5
 G *Arundo donax* L.; 1
 T *Avena barbata* Link; 2
 T *A. sterilis* L.; 2
 T *Brachypodium distachyon* (L.) P. Beauv.; 1
 H *B. pinnatum* (L.) P. Beauv. ssp. *pinnatum*; 7
 H *Brachypodium retusum* (Pers.) P. Beauv. (Ho as *B. ramosum*); 1
 T *Briza maxima* L.; 1
 H *Bromus erectus* Huds. ssp. *erectus*; 2

- T *B. hordeaceus* L. ssp. *molliformis* (Billot) Maire et Weiller; 2
 T *B. madritensis* L.; 1
 T *B. sterilis* L.; 7
 G *Cynodon dactylon* (L.) Pers.; 7
 T *Cynosurus echinatus* L.; 2
 H *Dactylis glomerata* L. ssp. *hispanica* (Roth) Nyman; 1
 T *Desmazeria pauciflora* Merino; 1
 T *D. rigida* (L.) Tutin; 1
 H *Dichanthium ischaemum* (L.) Roberty; 2
 T *Digitaria sanguinalis* (L.) Scop.; 7
 G *Elymus pycnanthus* (Godr.) Melderis; 1, NT
 T *Eragrostis cilianensis* (All.) Janch.; 7
 T *Gastridium ventricosum* (Gouan) Schinz et Thell.; 1
 H *Helictotrichon convolutum* (C. Presl) Henrard (Ho as *Avenastrum convolutum* (Presl) Fritsch); 1
 T *Hordeum murinum* L. ssp. *leporinum* (Link) Arcang.; 1
 T *Lagurus ovatus* L.; 1
 H *Lolium perenne* L.; 4
 T *L. subulatum* Vis.; 1, end, sp
 T *Lophochloa cristata* (L.) Hyl.; 1
 H *Melica ciliata* L.; 5
 T *Parapholis incurva* (L.) C. E. Hubb.; 1, VU, sp
 T *Phleum subulatum* (Savi) Asch. et Graebn.; 1
 H *Piptatherum miliaceum* (L.) Coss.; 1
 T *Poa annua* L.; 7
 H *P. bulbosa* L.; 5
 T *Psilurus incurvus* (Gouan) Schinz et Thell.; 1
 T *Setaria gussonei* Kerguelen; 7
 T *S. verticillata* (L.) P. Beauv.; 7
 T *S. viridis* (L.) P. Beauv.; 5
 G *Sorghum halepense* (L.) Pers.; 7; IAS
 H *Stipa bromoides* (L.) Dörfl.; 1
 T *Triticum aestivum* L.; 8
 T *Vulpia myuros* (L.) C. C. Gmel.; 7

Smilacaceae

- P *Smilax aspera* L.; 1

Zosteraceae

- Hy *Posidonia oceanica* (L.) Delile, 1, sp.

Cultivated taxa in the flora of Rivanj (84 taxa): *Actinidia chinensis* Planch., *Albizia julibrissin* Durazz., *Allium cepa* L. (Pe), *Allium sativum* L., *Antirrhinum majus* L., *Apium graveolens* L. (Pe), **Argyranthemum frutescens* (L.) Sch. Bip., **Asparagus densiflorus* (Kunth) Jessop, *Aspidistra elatior* Blume, *Atriplex halimus* L., *Bougainvillea spectabilis* Willd., *Brassica oleracea* L. ssp. *acephala* (DC.) O. Schwarz (Pe), *Brassica oleracea* L. ssp. *capitata* (L.) Duchesne, *Campanula portenschlagiana* Schult., *Capsicum annuum* L. (Pe), *Chrysanthemum coronarium* L., *Cicer arietinum* L., *Citrus deliciosa* Ten., *Citrus limon* (L.) Burm. f. (Pe), *Citrus sinensis* (L.) Osbeck, *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn., *Cucumis sativus* L., **Cycas revoluta* Thunb., *Cynara cardunculus* L. (Pe), *Cynara scolymus* L., *Dahlia variabilis* (Willd.) Desf., *Daucus carota* L. ssp. *sativus* (Hoffm.) Arcang., *Dianthus*

caryophyllus L., *Eriobotrya japonica* (Thunb.) Lindl., *Eunonymus japonica* L. f., **Fortunella margarita* (Lour.) Swingle, **Fragaria x ananassa* (Duchesne ex Weston) Duchesne ex Rozier, **Freesia refracta* (Jacq.) Klatt (Pe), **Gaillardia aristata* Pursh, **Gazania rigens* (L.) Gaertn., **Hedera canariensis* Willd., *Helianthus annuus* L., *Helianthus tuberosus* L., *Hydrangea macrophylla* (Thunb.) Ser. (Pe), *Iberis sempervirens* L., **Iris xiphium* L., *Jasminum nudiflorum* Lindl., *Koeleruteria paniculata* Laxm., *Lactuca sativa* L., *Lagenaria vulgaris* Ser., *Lavandula angustifolia* Mill. (Pe), *Lavandula x intermedia* Emeric ex Loisel., *Ligustrum lucidum* Aiton f., **Limonium sinuatum* (L.) Mill., **Lycianthes rantonnei* Carriere, *Malus pumila* Mill., *Morus alba* L., *Nerium oleander* L., *Pelargonium zonale* (L.) L'Hér., *Petroselinum crispum* (Mill.) (Pe), *Phaseolus vulgaris* L., *Phoenix canariensis* Chabaud, *Pisum sativum* L., *Pittosporum tobira* (Thunb.) W. T. Aiton, **Plumbago auriculata* Lam., *Prunus avium* (L.) L., *P. laurocerasus* L., *P. persica* (L.) Batsch, **Phyllostachys aurea* (André) Riviere et C. Riviere, *Punica granatum* L., *Pyrus communis* L., **Salvia farinacea* Benth., *S. officinalis* L., *Santolina chamaecyparissus* L., **Sedum palmeri* S. Watson, *Solanum melongena* L., *Sorbus domestica* L., *Spinacia oleracea* L., *Syringa vulgaris* L., *Tagetes patula* L., *Tetragonia tetragonoides* (Pall.) Kuntze, *Trachycarpus fortunei* (Hook.) H. Wendl., **Tradescantia virginiana* L., **Tulipa gesneriana* L., *Vicia faba* L., **Viola x witrockiana* Gams ex Kappert, *Yucca gloriosa* L. *Zantedeschia aethiopica* (L.) Spreng. and *Ziziphus jujuba* (L.) Mill.

DISCUSSION RASPRAVA

Analysis of the flora – Analiza flore

1. Taxonomic analysis of the flora – Taksonomska analiza flore

The flora analysis included 346 taxa from 231 genera and 78 families. Plants that come exclusively in cultivation (84) were not analysed. Two ferns (0.58%) and five gymnosperms (1.44%) and 339 angiosperms were recorded: (256 taxa, 73.99%) dicotyledons and 83 (23.99%) monocotyledons (tab. 1). The share of nativ and subspontaneous flora of the island of Rivanj is 6.71% of the total Croatian flora (346/ 5159; Nikolić 2023).

The families represented with the most species in the flora of Rivanj are *Poaceae* (45 taxa, 13.01%), *Fabaceae* (31, 8.96%) and jointly *Cichoriaceae* and *Asteraceae* (41, 11.85%). The mentioned families make up a third (33.82%) of the total flora of the island of Rivanj. The families *Poaceae*, *Fabaceae* and *Asteraceae* s.l. are adapted to the ecological conditions of the Mediterranean area, as shown by numerous studies of the islands of the eastern Adriatic coast: the island of Vir (Milović & Pandža 2016), the island of Olib (Milović *et al.*) 2016 and others. Genera with the highest number of

Table 1 Taxonomic analysis of flora on the Island of Rivanj.

Tablica 1. Taksonomska analiza flore na otoku Rivnju.

Taxa	Pteridophyta	Gymnospermae	Angiospermae		Total
			Dicotyledones	Monocotyledones	
Families	1	2	60	15	78
Genera	1	3	172	55	231
Species	2	4	227	76	309
Subspecies	0	1	28	7	36
Varieties	0	0	1	0	1
No. of species and infraspecific taxa	2	5	256	83	346
% of total flora	0.58	1.44	73.99	23.99	100.00

taxa were *Euphorbia* (9 taxa), *Medicago* (8), *Allium* (7) and *Trifolium* (6), followed by *Carex* and *Crepis* (five taxa in each genus).

2. Ecological analysis – Ekološka analiza

The analysis of plant life forms showed that the Rivanj flora is dominated by therophytes (152 taxa, 43.93 %) and hemicryptophytes (84, 24.28 %) (Fig. 2). The spectrum of life forms on the island of Rivanj coincides to the greatest extent with the spectrum of other Adriatic islands and the Mediterranean (see Tab. 2).

3. Phytogeographical analysis – Fitogeografska analiza

The flora of the island of Rivanj is dominated by plants of the Mediterranean (148 taxa, 42.77%) and South European floral elements (57, 16.47%), which is understandable given the Mediterranean climate and geographical location of the island. The dominance of plants of the Mediterranean flora element has also been established for the other Adriatic islands: Silba (Bogdanović *et al.* 2013), Rava (Pandža & Milović 2008), Vrgada (Piljac-Kosović & Pandža 2009). There is a large share of widespread plants (63, 18.21%), cultivated and adventitious plants (45, 13.01%) (Tab. 3). The share of cultivated and adventitious plants is the result of the author's approach that in addition to native and naturalised

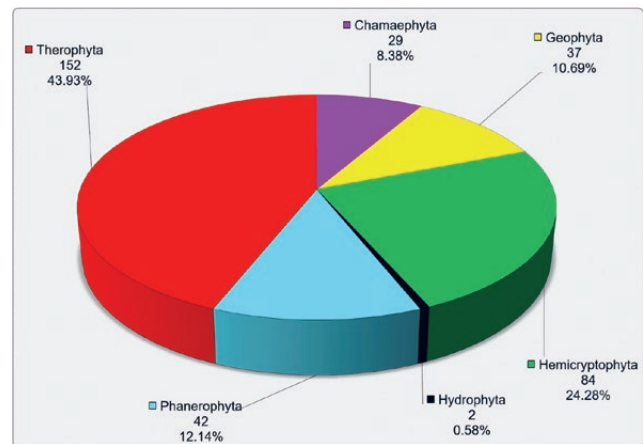


Figure 2 Life-form spectrum in the Island of Rivanj flora.

Slika 2. Spekter životnih oblika u flori otoka Rivnja.

taxa, the list of flora also includes taxa that spread spontaneously from cultivation.

4. Endemic, endangered, strictly protected and invasive taxa – Endemične, ugrožene, strogo zaštićene i invazivne svoje

There are four endemic taxa in the flora of Rivanj, and four taxa that are included in one of the IUCN categories (Nikolić & Topić 2005). Critically endangered (CR) is *Lathyrus ochrus*, endangered (EN) *Carex extensa*, and two taxa are in the vulnerable category: *Orchis tridentata* and *Parapholis incurva* (Tab. 4). Endangered taxa are mainly found in

Table 2 Comparative presentation of the spectrum of life forms on the island of Rivanj with several Adriatic islands and in the flora of the Mediterranean.

Tablica 2. Usporedni prikaz spektra životnih oblika na Rivnju s nekoliko jadranskih otoka te u flori Sredozemlja.

Island	T	Ch	H	G	P	Hy	References
	No. of taxa %	No. of taxa %	No. of taxa %	No. of taxa %	No. of taxa %	No. of taxa %	
Rava	47.02	9.00	23.14	10.28	10.28	0.26	Pandža & Milović 2008
Škarda	43.04	10.13	21.94	8.44	16.03	0.42	Milović & Pandža 2010
Silba	39.84	9.75	28.43	11.62	9.33	1.03	Bogdanović <i>et al.</i> 2013
Olib	37.63	7.10	33.33	9.89	11.40	0.65	Milović <i>et al.</i> 2016
Rivanj	43.93	8.38	24.28	10.69	12.14	0.58	This study
Vir	37.24	7.06	33.07	10.59	11.40	0.64	Milović & Pandža 2016
Vrgada	49.7	8.2	24.6	6.5	7.6	0.4	Piljac-Kosović & Pandža 2009
Sredozemlje	42	6	29	11	12	–	Horvat 1949

Table 3 Floral elements (geoelements) in the Island of Rivanj flora.**Tablica 3.** Florni elementi u flori otoka Rivnja.

Geoelements		No. of taxa	%
1.	MEDITERRANEAN (1)	148	42.77
2.	SOUTH EUROPEAN (2)	57	16.47
3.	CENTRAL EUROPEAN (3)	1	0.29
4.	EUROPEAN (4)	7	2.02
5.	EURASIAN (5)	23	6.65
6.	CIRCUM-HOLARCTIC PLANTS (6)	2	0.58
7.	WIDESPREAD PLANTS (7)	63	18.21
8.	CULTIVATED AND ADVENTIOUS PLANTS (8)	45	13.01
TOTAL		346	100.00

the vegetation of olive groves and stony pastures and in the halophilic vegetation along the sea coast. Due to the depopulation of the island's inhabitants, the grasslands and olive groves are overgrown with macchia, and the habitats along the sea coast are threatened by embankment of the coast, construction of beaches, pressure from swimmers in the summer and pollution. In the sea along and around the island of Rivanj, habitats with species of *Cymodocea nodosa* and *Posidonia oceanica* are threatened. In the Lokvina bay (Gauss-Krüger coordinates: x=5504660 y=4889220) a vegetation with the *Cymodocea nodosa* was recorded. They belong to an endangered and rare habitat type (Natura code 1110) that requires special conservation measures (Anonymous 2006). Another marine flowering plant with a larger number of sites and a larger area is *Posidonia*, which forms the vegetation of the alliance (*Posidonion oceanicae* Braun-Blanquet, Roussine & Nègre 1952) an endangered and priority habitat of EU interest. The authors of the paper note a priority habitat of EU interest for the island of Rivanj that is not registered in the lists (Anonymous 2013a, 2014, 2019). In the area of Lokvina (Gauss-Krüger coordinates: x=5504600 y=4889245, Natura code 3170) there are Mediterranean temporary ponds. Water is retained in the pond for most of the year. That pond is one of the rare habitats in the wider area with potable water for numerous organisms, which is not negligible.

Table 4 Representation of endemic, endangered, strictly protected and invasive species in the flora of the Rivanj Island.**Tablica 4.** Prikaz endemičnih, ugroženih, strogo zaštićenih i invazivnih vrsta u flori otoka Rivnja.

Category/ subcategory	No. of taxa	% of total flora (346)
Endemic (end)	4	1.16
Critically Endangered (CR)	1	0.29
Endangered (EN)	1	0.29
Vulnerable (VU)	2	0.58
End + CR + EN + VU	8	2.32
Strictly protected (sp)	13	3.76
Invasive species (IAS)	11	3.18

In the flora of Rivanj there are 13 (3.76% of the total flora) strictly protected taxa. Important species for the inhabitants of the island of Rivanj, in addition to the endangered and strictly protected species, are those that can cause them problems on arable land (by number of individuals, allergenicity, rapid growth, poisonous seeds and fruits...). When introducing alien species into cultivation (gardens, flower beds, homesteads, parks), species that spread independently without human influence should be avoided. Such species can have a negative impact on local flora and vegetation. Some of the cultivated species were found on the island of Rivanj in weed and ruderal vegetation as escapees from culture in gardens, flower beds, along the road, in cracks in the walls. These species are: *Eschscholzia californica*, *Dimorphotheca jucunda*, **Alstroemeria ligtu*, *Mesembryanthemum cordifolium*, **Catharanthus roseus*, *Melia azedarach*, *Mirabilis jalapa*, etc.

From the list of invasive taxa in Croatia (Nikolić *et al.* 2014a), 11 taxa were recorded in the flora of Rivanj. They occur in weed and ruderal vegetation around the settlement and none of them currently pose a threat to native species and habitats. It is important to pay attention to them because they spread quickly in new habitats, suppressing native species.

VEGETATION RESULTS AND DISCUSSION – REZULTATI I RASPRAVA

Through the syntaxonomic analysis, five clearly distinctive forest associations (see Tables 5–7 and Fig. 3).

Syntaxonomic review of the studied vegetation

QUERCETEA ILICIS Br.-Bl. ex A. & O. Bolos 1950

• *Pistacio lentisci-Rhamnetalia alaterni* Rivas-Martínez 1975

+ *Oleo sylvestris-Ceratonion siliquae* Br.-Bl. ex Guinochet et Drouineau 1994

Ass: *Erico arboreae-Arbutetum unedonis* Allier et La-coste 1980 ex Foggi in Foggi et Grigioni 1999

Ass: *Myrto communis-Pistacietum lentisci* (Molinier 1954) Rivas-Martínez 1975

Ass: *Pistacio lentisci-Juniperetum turbinatae* Trinajstić 1987 ex Asensi, Díez-Garretas & Quézel 2007 [NATURA 2000 habitat code 5210]

• *Quercetalia ilicis* Br.-Bl. ex Molinier 1934

+ *Fraxino orni-Quercion ilicis* Biondi, Casavecchia & Gigante in Biondi *et al.* 2013

Ass: *Myrto communis-Quercetum ilicis* (Horvatić 1963) Trinajstić (1976) 1985 [NATURA 2000 habitat code 9340]

Table 5 (Tablica 5.) *Erico arboreae-Arbutetum unedonis* Allier et Lacoste 1980 ex Foggi in Foggi et Grigioni 1999, *Myrto communis-Pistacietum lentisci* (Molinier 1954) Rivas-Martínez 1975 and *Pistacio lentisci-Juniperetum turbinatae* Trinajstić 1987 ex Asensi, Díez-Garretas & Quézel 2007

No. of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	1	2	3	4	5		
Surface (m ²)	400	100	100	100	100	100	100	100	100	100	100	100	100	100	200	100	100	100	100	100	100	100	100	100	100	100	
Total cover (%)	100	90	100	100	100	100	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Inclination (°)																						0	0	20	5-10	0	
No. of taxa	9	13	7	7	11	6	9	9	11	9	11	11	10	10	10	6	4	5	5	7		4	8	5	3	11	
	<i>Erico arboreae-Arbutetum unedonis</i>													<i>Myrto communis-Pistacietum lentisci</i>							<i>Pistacio lentisci-Juniperetum turbinatae</i>						
Char. Ass.																											
<i>Arbutus unedo</i> L.	3	2	3	3	3	3	2	3	2	3	2	1	3	+
<i>Erica arborea</i> L.	2	1	2	1	1	2	2	1	2	2	2	2	2	+
<i>Pistacia lentiscus</i> L.	+	1	+	+	1	.	.	.	.	+	.	.	.	2	3	3	4	4	4	4		3	2	2	2	3
<i>Myrtus communis</i> L.	.	+	.	.	.	+	1	.	.	+	.	.	+	3	3	2	2	1	1	1		+	.	+	+	.	
<i>Juniperus phoenicea</i> L.	.	+	.	.	.	.	.	+	+	.	1	1	+	.	.	+	+	.	+	.		3	4	4	4	4
Char. All., O., Cl. Oleo sylvestris-Ceratonton siliquae, Pistacio lentisci-Rhamnetalia alaterni; Quercetea ilicis																											
<i>Quercus ilex</i> L.	+	+	+	.	1	+	+	1	1	1	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Rhamnus alaternu</i> L.	.	.	.	.	.	.	.	+	+	.	+	+	+	.	.	1	.	1	1	.	.	.	+	1	.	+
<i>Phillyrea latifolia</i> L.	+	2	+	+	1	.	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+
<i>Smilax aspera</i> L.	.	.	.	.	.	.	.	1	2	2	+	.	.	.	.	+	1	.	.	.	.	1	.	.	.	.
<i>Asparagus acutifolius</i> L.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	.	+	.	+
<i>Viburnum tinus</i> L.	.	.	.	.	.	+	+	+	+	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Clematis flammula</i> L.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	+
<i>Lonicera implexa</i> Aiton	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.
<i>Juniperus oxycedrus</i> L. ssp. <i>oxycedrus</i>	.	+	.	.	.	+	+	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Rubia peregrina</i> L.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.
<i>Cyclamen repandum</i> Sibth et Sm.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
<i>Prasium majus</i> L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
<i>Ruscus aculeatus</i> L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
<i>Olea europaea</i> L. var. <i>sylvestris</i> Brot.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lygeo sparti-Stipetea tenacissimae																											
<i>Brachypodium retusum</i> (Pers.) P. Beauv	1	1	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Quercetea pubescentis																											
<i>Coronilla emerus</i> L. ssp. <i>emeroides</i> Boiss. et Spruner	+	.	.	.	+	.	.	.	.	+	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.
<i>Tamus communis</i> L.	+	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Ononido-Rosmarinetea																											
<i>Cistus monspeliensis</i> L.	+	+	1	1	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	+
<i>Cistus incanus</i> L.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cistus salvifolius</i> L.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Helictotrichon convolutum</i> (C. Presl) Henrad	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuco-Brometea																											
<i>Euphorbia fragifera</i> Jan	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.
<i>Teucrium chamaedrys</i> L.	+
Other																											
<i>Asphodelus aestivus</i> Brot.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	.	.	.	.	.	.
<i>Carex flacca</i> Schreb. ssp. <i>serrulata</i> (Biv.) Greuter
<i>Rubus ulmifolius</i> Schott
<i>Anagallis arvensis</i> L.	+

PINETEA HALEPENSIS Bonari et Chytrý 2020

• **Pinetalia halepensis Biondi, Blasi, Galdenzi, Pesaresi et Vagge in Biondi et al. 2014**

+ *Pistacio lentisci-Pinion halepensis* Biondi, Blasi, Galdenzi, Pesaresi et Vagge in Biondi et al. 2014

Ass: *Pistacio lentisci-Pinetum halepensis* De Marco, Veri & Caneva 1984 [NATURA 2000 habitat code 9540]

From the *Oleo sylvestris-Ceratonton siliquae* alliance related to the Steno-Mediterranean vegetation zone on the Rivanj

island and the Sestrice islets, tree associations developed (see Table 5).

The *Erico arboreae-Arbutetum unedonis* association is abundant on the island of Rivanj (Tab. 5; Fig. 3, Cluster A) and 13 phytosociological relevés were made. The vegetation spreads in the areas south-east from the settlement and along the macadam road towards the Lokvina cove in areas burnt by the fire in 2007. After the fire the garrigues dominated by the species of the *Cistus* genus grew. The *Erico arboreae-Arbutetum unedonis* vegetation developed from them. In the

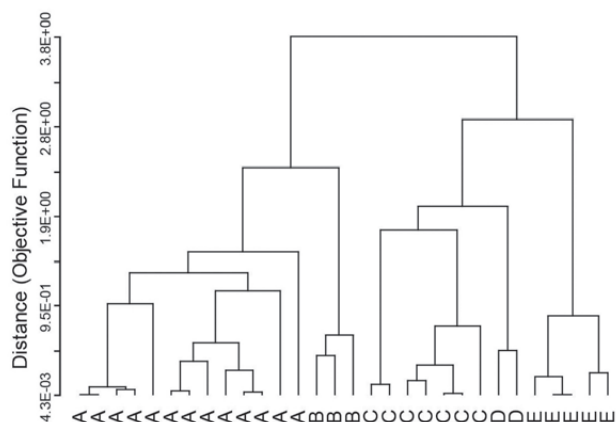


Figure 3 Dendrogram of the 30 relevés of forest vegetation and macchia.

Slika 3. Dendrogram s 30 fitocenoloških snimaka vegetacije šume i makije.

A – *Erica arborea*-*Arbutetum unedonis*; B – *Myrto communis*-*Quercetum ilicis*; C – *Myrto communis*-*Pistacietum lentisci*; D – *Pistacio lentisci*-*Pinetum halepensis*; E – *Pistacio lentisci*-*Juniperetum turbinatae*.

majority of the relevés the vegetation in thick and impassable and 1.5–2.5 m high. As shown in Table 5, 24 taxa were registered. The number of taxa ranges from 6 to 13 or in average 9.5 taxa per relevé. More than 50% of the relevés contain five species: *Arbutus unedo*, *Erica arborea*, *Quercus ilex*, *Phillyrea latifolia* and *Viburnum tinus*. *Arbutus unedo* (ornithochor species) is dominant in terms of coverage. The *Erica arborea* species dominated in several other relevés. The vegetation coverage ranges from 90 to 100%. Only a short period of time (13 years) has passed since the last fire so it is reasonable to expect the optimum growth of this vegetation in the near future as well as a natural progression in the direction of primary Holm Oak vegetation development.

The forest vegetation of Myrte and Lentisk Pistache (ass. *Myrto communis*-*Pistacietum lentisci*) was investigated for the first time on the islet of Supetar (Jasprica & Ruščić 2013) in the Župa cave north-west from Cavtat. Floristic composition of the *Myrto communis*-*Pistacietum lentisci* association is shown in Table 5 (Fig. 3, Cluster C). All the 7 phytosociological relevés were produced on the islets of Sestrice. In 7 phytosociological relevés there are 18 species, 4 to 10 species per relevé (6.71 in average). In most of the relevés, *Pistacia lentiscus* dominated with its coverage values, except in relevé 1 where the *Myrto communis* species prevails. The coverage in all the relevés is 100%. The Myrte and Lentisk Pistache vegetation grows on uninhabited islets exposed to strong winds. The investigations of this vegetation along the eastern Adriatic coast started approximately 10 years ago. The vegetation developed mostly in southern and south-western areas of the islets and is exposed to southern winds. The floristic composition includes a small number of species with large coverage. The halophytic zone exists on a very narrow strip by the sea and it turns into a thick, impervious macchia of Myrte and Lentisk Pistache 60–120 cm high that covers more

than 60% of the islet's surface. On the Sridnja Sestrica islet a thick and impervious 1–2 m high macchia grows on more than 80% of the islet's surface. On the islet of Vela Sestrica the *Myrto communis* and *Pistacia lentiscus* vegetation develops 1–10 m from the sea and together with the *Pistacio lentisci*-*Juniperetum turbinatae* vegetation covers 80–90% of the islet. The association has been described for some islets in the Zadar archipelago (Pandža & Milović 2017) and south Croatia (Jasprica *et al.* 2014, 2015).

According to Natura 2000 the *Pistacio lentisci*-*Juniperetum turbinatae* association of the *Oleosylvestris*-*Ceratonion siliquae* alliance is an endangered habitat (Tab. 5, Fig. 3, Cluster E). A total of 5 phytosociological relevés was produced (on the island of Rivanj and on the islet of Vela Sestrica). The vegetation is dominated by *Juniperus phoenicea* that form stand 2.5–3 m tall. Another species, namely *Pistacia lentiscus*, also stands out with its coverage. According to one of the phytosociological relevés, the number of species ranges from 3 to 11, 6.2 species per relevé in average. The coverage in all the relevés is 100%. A total of 16 species was recorded. The vegetation of Lentisk Pistache and Phoenician juniper was

Table 6 (Tablica 6.) *Myrto communis*-*Quercetum ilicis* (Horvatić 1963) Trinajstić (1976) 1985

No. of relevé	1	2	3
Surface (m ²)	100	100	100
Total covered (%)	100	100	100
Inclination (°)	30	30	10
No. of taxa	13	14	9
Char. Ass.			
<i>Quercus ilex</i> L.	4	3	3
<i>Myrto communis</i> L.	1	1	2
Char. Cl. <i>Quercetea ilicis</i>			
<i>Pistacia lentiscus</i> L.	1	2	+
<i>Smilax aspera</i> L.	1	1	1
<i>Viburnum tinus</i> L.	+	1	+
<i>Arbutus unedo</i> L.	.	1	1
<i>Rhamnus alaternus</i> L.	+	1	.
<i>Phillyrea latifolia</i> L.	+	+	+
<i>Asparagus acutifolius</i> L.	1	+	.
<i>Laurus nobilis</i> L.	1	.	.
<i>Erica arborea</i> L.	.	.	1
<i>Clematis flammula</i> L.	+	.	.
<i>Rubia peregrina</i> L.	+	.	.
<i>Rosmarinus officinalis</i> L.	.	+	.
<i>Lonicera implexa</i> Aiton	.	.	+
<i>Quercetea pubescentis</i>			
<i>Coronilla emeris</i> L. ssp. <i>emeroides</i> Boiss. et Spruner	+	1	.
<i>Festuco-Brometea</i>			
<i>Teucrium chamaedrys</i> L.	+	.	.
<i>Lygeo sparti-Stipetea tenacissimae</i>			
<i>Brachypodium retusum</i> (Pers.) P. Beauv.	.	+	.
<i>Ononido-Rosmarinetea</i>			
<i>Cistus salvifolius</i> L.	.	+	.
<i>Cistus incanus</i> L.	.	+	.

investigated for the first time in Croatia by Trinajstić (1987) on the island of Unije near Lošinj and on the islet of Veli Pržnjak near Korčula. The association has been described for some islets in the Zadar archipelago (Pandža & Milović 2017). Phoenician juniper macchia covers large surface areas throughout the entire southern coastal region of Croatia (Kovačić et al. 2001; Pandža 2004).

On the island of Rivanj 3 phytosociological relevés of the *Myrto communis-Quercetum ilicis* vegetation of the *Fraxino orni-Quercion ilicis* alliance were produced (Tab. 6, Fig. 3, Cluster B). As shown in Table 6, a total of 20 species were recorded (relevés present 9–14 species, in average 12 species per relevé). Similar results were obtained through the analysis of floristic relevés from the island of Rava (Pandža 2008): in 11 phytosociological relevés there are 13 species per phytosociological relevé in average. As for the three phytosociological relevés from the island of Brač, 22 species (13 species per phytosociological relevé) were recorded by Trinajstić (1990). Regarding coverage the woody elements of the *Quercetea ilicis* class prevail: *Pistacia lentiscus*, *Arbutus unedo*, *Viburnum tinus*, *Rhamnus alaternus*, *Phillyrea latifolia* and *Laurus nobilis* in relevé 1. The macchia is thick and impassable so the number of companion species is quite small and their coverage insignificant. This association is common in

Table 7 (Tablica 7.) *Pistacio lentisci-Pinetum halepensis* De Marco, Veri & Caneva 1984

No. of relevé	1	2
Surface (m ²)	100	100
Total covered (%)	100	100
No. of taxa	7	16
Char. Ass.		
<i>Pinus halepensis</i> Mill.	4	4
Char. Cl. <i>Quercetea ilicis</i>		
<i>Pistacia lentiscus</i> L.	3	3
<i>Myrto communis</i> L.	+	.
<i>Lonicera implexa</i> Aiton	+	+
<i>Smilax aspera</i> L.	1	1
<i>Rubia peregrina</i> L.	1	.
<i>Laurus nobilis</i> L.	.	1
<i>Quercus ilex</i> L.	.	+
<i>Viburnum tinus</i> L.	.	+
<i>Phillyrea latifolia</i> L.	.	+
<i>Juniperus phoenicea</i> L.	.	+
<i>Asparagus acutifolius</i> L.	.	+
<i>Cyclamen repandum</i> Sibth et Sm.	.	+
<i>Ruscus aculeatus</i> L.	.	+
<i>Clematis flammula</i> L.	.	+
<i>Quercetea pubescentis</i>		
<i>Tamus communis</i> L.	+	+
<i>Coronilla emerus</i> L. ssp. <i>emeroides</i> Boiss. et Spruner	.	+
<i>Lygeo sparti-Stipetea tenacissimae</i>		
<i>Brachypodium retusum</i> (Pers.) P. Beauv.	.	+

the warmer and drier areas along the eastern Adriatic coast and islands (Horvatić 1963).

The Aleppo pine forests belong to the *Pinetalia halepensis* order that used to belong to the *Quercetea ilicis* class (Škvorc et al. 2017), but the *Pinetalia halepensis* order has been singled out as a separate class termed *Pinetea halepensis* (Bonari et al. 2020). Two phytosociological relevés were made (Tab. 7, Fig. 3, Cluster D) one of the islet of Sestrica Mala and the other on the island of Rivanj. In both relevés the *Pinus halepensis* species dominates within the tree layer where as the *Pistacia lentiscus* species dominates within the shrub layer. In addition to the Lentisk Pistache, species of the *Quercetea ilicis* class were also identified in the shrub layer. The Aleppo pines species on the islet of Sestrica Mala have been planted by lighthouse keepers. The pine trees have been spontaneously spreading towards the dock in the southwest. On the island of Rivanj the Aleppo pine vegetation grows on small areas and for the time being there is no significant spontaneous expansion of the pine vegetation into the surrounding natural vegetation, except in the case of fire. The association is widespread along the Adriatic coasts (De Marco et al. 1984; Trinajstić & Kamenjarin 2001).

CONCLUSIONS ZAKLJUČCI

Rivanj Island has 346 vascular plant taxa. The total number of taxa represents about 6.71% of the Croatian vascular flora. There are 84 taxa under cultivation. The total flora of the island of Rivanj numbers 430 taxa. The flora has a Mediterranean character. It is dominated by plants with a Mediterranean floral element (42.77%) and the life forms are dominated by therophytes (43.93%). Four endemics and four endangered taxa were recorded in the vascular flora of Rivanj, of which *Lathyrus ochrus* is critically endangered. The flora includes five taxa from the orchid family (*Orchidaceae*). The above-mentioned taxa mostly occur in open habitats (grasslands and olive groves) that disappear due to the overgrowth of macchia. As succession processes advance, open habitats decrease, the number of species decreases, and thus decreases the total biodiversity of the island. In 2019 and 2020, the investigation of the shrubs and forest vegetation on the island of Rivanj and the Sestrice islets was conducted. A total of 30 phytosociological relevés were produced (tab. 5–7). Based on these relevés five associations (*Erico arboreae-Arbutetum unedonis*, *Myrto communis-Pistacietum lentisci*, *Pistacio lentisci-Juniperetum turbinatae*, *Myrto communis-Quercetum ilicis* and *Pistacio lentisci-Pinetum halepensis*). Since Horvatić's investigations (1961–1962) the island has been depopulated (cutting and grazing ended) resulting in a strong natural progression towards primary forest vegetation. There are evergreen holm-oak woods, which can be considered as the potential vegetation type (*Myrto-Quercetum ilicis*).

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SAŽETAK

Prema literaturnim podacima i provedenim terenskim istraživanjima tijekom 2019. i 2020. na otoku Rivnju (3,615 km²) se navodi 346 domaćih i stranih svojti koje imaju sposobnost održavanja izvan uzgoja (309 vrsta, 36 podvrsta i varijetet). Pribrojivši i 84 svojte u uzgoju navodimo da sveukupna flora Rivnja broji 430 svojti. Svojte u uzgoju nisu obuhvaćene analizom flore. Tijekom ranijih istraživanja zabilježeno je 45 svojti, a 385 svojti se po prvi puta navodi u ovome radu. Osim inventarizacije flore, obavljena je taksonomska, ekološka i fitogeografska analiza. Rezultati su predloženi u tablicama 1 – 4 i slikom 2. U sastavu flore dominiraju kritosjemenjače u kojima su dvosupnice (73,99%) znatno zastupljenije od jednosupnica (23,99%). Brojem svojti najzastupljenije su porodice *Poaceae* (13,01%), *Asteraceae* s.l. (11,85%) i *Fabaceae* (8,96%). U spektru životnih oblika dominiraju terofiti (43,93%) i hemikriptofiti (24,28%), a u fitogeografskoj analizi biljke mediteranskoga flornoga elementa (42,77%), što ukazuje na klimatske prilike i geografski položaj otoka Rivnja. U flori su zabilježena četiri endema i četiri ugrožene svojte (*Lathyrus ochrus*, *Carex extensa*, *Orchis tridentata* i *Parapholis incurva*) te pet svojti orhideja. Po naselju u korovnoj i ruderalnoj vegetaciji zabilježeno je 11 invazivnih svojti (3,18%

od ukupne samonikle i subspontane flore otoka). Predlažemo da se lokva koja nije registrirana za otok Rivanj u Popisu stanišnih tipova registrira. Mediteranske povremene lokve (Natura kod 3170) su prioritetna staništa od interesa EU. Vegetacijska istraživanja šuma i makija otoka Rivnja i otočića Sestrice obavljeno su tijekom 2019. i 2020. Ukupno je napravljeno 30 fitocenoloških snimaka. Snimke su rađene i analizirane po metodi Braun-Blanquet-a. Na fitocenološkim snimkama izvršena je statistička analiza i načinjen dendrogram. Rezultati su prikazani u tablicama 5-7 klasičnim prikazom fitocenoloških snimaka. Sintaksonomskom analizom iz razreda *Quercetea ilicis* utvrđene su asocijacije: *Erico arboreae-Arbutetum unedonis* Allier et Lacoste 1980 ex Foggi in Foggi et Grigioni 1999, *Myrto communis-Pistacietum lentisci* (Molinier 1954) Rivas-Martínez 1975, *Pistacio lentisci-Juniperetum turbinatae* Trinajstić 1987 ex Asensi, Díez-Garretas & Quézel 2007 i *Myrto communis-Quercetum ilicis* (Horvatić 1963) Trinajstić (1976) 1985, a iz razreda *Pinetea halepensis* asocijacija *Pistacio lentisci-Pinetum halepensis* De Marco, Veri & Caneva 1984. Najveća opasnost za autohtonu vegetaciju grmlja i drveća su sadene sastojine alepskog bora na Maloj Sestrici i male površine pod alepskim borom na otoku Rivnju. Na Rivnju sjeverozapadno od naselja je gusta i neprohodna makija. Potrebno je iskrčiti protupožarne putove i zabraniti sve aktivnosti koje bi mogle uzrokovati požar.

KLJUČNE RIJEČI: fitosociologija, otok Rivanj i otočići Sestrice, sjeverna Dalmacija, vaskularna flora, zadarski arhipelag

APPENDIX 1

Coordinates and dates of vegetation relevés within tables.

Table 5 Ass. *Erico arboreae-Arbutetum unedonis* (Figure 3, Cluster A)

(All the relevés were produced on the island of Rivanj, relevés 1. (April 17, 2019); 2-7 (April 18, 2019); 9-13 (April 19, 2019):

1. (x= 5503478 y= 4889918), 2. (x=5503380 y=4890015), 3. (x=5503427 y= 4889973), 4. (x= 5503481 y= 4889919), 5. (x= 5503865 y= 4889481), 6. (x= 5504539 y= 4889293), 7. (x= 5504552 y= 4889280), 8. (x= 5502188 y= 4890925), 9. (x= 5502258 y= 4890779), 10. (x= 5502277 y= 4890764), 11. (x= 5502304 y= 4890676), 12. (x= 5502527 y= 4890337), 13. (x= 5503180 y= 4889545).

Ass. *Myrto communis-Pistacietum lentisci* (Figure 3, Cluster C)

1. Islet of Mala Sestrica (x = 5501243 y = 4891910; 18/04/2019),
2. Islet of Mala Sestrica (x = 5501304 y= 4891883; 18/04/2019),
3. Islet of Vela Sestrica (x= 5499648 y= 4893463; 16/05/2020),
4. Islet of Vela Sestrica (x= 5499526 y= 4893596, 16/05/2020),
5. Islet of Sridnja Sestrica (x = 5500470 y= 4892528, 17/05/2020),
6. Islet of Sridnja Sestrica (x= 5500356 y= 4892633, 17/05/2020),
7. Islet of Sridnja Sestrica (x= 5501196 y= 4891802, 17/05/2020).

Ass. *Pistacio lentisci-Juniperetum turbinatae* (Figure 3, Cluster E)

1. Islet of Vela Sestrica (x= 5499315 y= 4893682, 16/05/2020),
2. Island of Rivanj (x= 5503327 y= 4890092, 18/04/2019),
3. Islet of Vela Sestrica (x= 5499709 y= 4893105, 16/05/2020),
4. Islet of Vela Sestrica (x= 5499807 y= 4893175, 16/05/2020),
5. Island of Rivanj (x= 5503366 y = 4890043, 19/07/2020).

Table 6 Ass. *Myrto communis-Quercetum ilicis* (Figure 3, Cluster B)

All the relevés were produced on the island of Rivanj.

- 1.(x =5503135 y= 4890153, 29/08/2019) 2. (x= 5503097 y= 4890172, 29/08/2019) 3. (x= 5502351 y= 4890591, 19/04/2019).

Table 7 Ass. *Pistacio lentisci-Pinetum halepensis* (Figure 3, Cluster D)

1. Islet of Mala Sestrica (x= 5501239 y= 4891864, 18/04/2019),
2. Island of Rivanj (x= 5503149 y= 4890135, 17/04/2019).

Syntaxa quoted in the tables (in alphabetical order).

Festuco-Brometea Br.-Bl. et Tx. ex Soó 1947

Lygeo sparti-Stipetea tenacissimae Rivas-Mart. 1978 nom. conserv. propos. (*Thero-Brachypodietea* Br.-Bl. in Br.-Bl. et al. 1947)

Ononido-Rosmarinetea Br.-Bl. in A. Bolòs y Vayreda 1950
Quercetea pubescentis Doing-Kraft ex Scamoni et Passarge 1959