

## FLORA OF THE ISLETS NEAR PAKOŠTANE (DALMATIA, CROATIA)

MARIJA PANDŽA<sup>1</sup> & MILENKO MILOVIĆ<sup>2</sup>

<sup>1</sup>Primary School Murterski škoji, Put škole 8, HR-22243 Murter, Croatia  
(E-mail: marija.pandza@si.t-com.hr)

<sup>2</sup>Medical and Chemical School, Ante Šupuk Street, HR-22000 Šibenik, Croatia  
(E-mail: milenko.milovic@si.t-com.hr)

**Pandža, M. & Milović, M.: Flora of the islets near Pakoštane (Dalmatia, Croatia). Nat. Croat., Vol. 24, No. 1, 19–35, 2015, Zagreb.**

During 2004 and 2012 field research into the flora of the five uninhabited islets near Pakoštane, Dalmatia, South Croatia was carried out: Babuljaš, Veliki Školj, St Justina, Mali and Veliki Žavinac. Altogether, 257 vascular flora taxa were recorded. The flora of the islet Veliki Školj had 159 taxa, that of St Justina 118, Veliki Žavinac 115, Mali Žavinac 105 and Babuljaš 95.

The largest number of taxa were found in the families *Fabaceae* (40 taxa; 15.56%), *Poaceae* (36 taxa; 14.00%) and *Asteraceae* s.l. (31 taxa; 12.06%). Regarding life forms, therophytes prevailed (49.42%). The chorological spectrum highlights a clear dominance of Mediterranean taxa (50.19%). Their percentage contribution did not significantly differ among the islets (47.62–53.04%).

There were four endemic, eight endangered and eight strictly protected plant taxa. No neophytes were found except *Conyza sumatrensis* which was observed on the islet of St Justina.

**Key words:** diversity, vascular flora, small islets, Adriatic Sea, Dalmatia, Croatia

**Pandža, M. & Milović, M.: Flora otočića ispred Pakoššana (Dalmacija, Hrvatska). Nat. Croat., Vol. 24, No. 1, 19–35, 2015, Zagreb.**

Tijekom 2004. i 2012. provedena su terenska istraživanja flore na pet nenaseljenih otočića ispred Pakoššana: Babuljaš, Veliki Školj, Sveta Justina, Mali i Veliki Žavinac. Utvrđeno je ukupno 257 svojiti vaskularne flore. Flora Velikog Školja ima 159 svojiti, Sv. Justine 118, Velikog Žavinca 115, Malog Žavinca 105 i Babuljaša 95 svojiti.

Porodice s najvećim brojem svojiti su *Fabaceae* (40 svojiti; 15,56 %), *Poaceae* (36 svojiti; 14,00%) i *Asteraceae* s.l. (31 svojita; 12,06%). Terofiti su najzastupljeniji životni oblik (49,42%), a među flornim elementima najzastupljenije su mediteranske biljke (50,19%). Biljke mediteranskog rasprostranjenja približno su jednako (47,62–53,04%) zastupljene na svim otočićima. Zabilježena su četiri endema, osam ugroženih te osam strogo zaštićenih biljaka. Od neofita, na Sv. Justini je zabilježena samo vrsta *Conyza sumatrensis* dok na ostalim otočićima neofita nije bilo.

**Ključne riječi:** raznolikost, vaskularna flora, otočići, Jadransko more, Dalmacija, Hrvatska

### INTRODUCTION

According to DUPLANČIĆ LEDER *et al.* (2004) in the Croatian part of the Adriatic Sea there are 79 islands (area >1 km<sup>2</sup>), 525 islets (0,01 – 1 km<sup>2</sup>) and 642 rocks and rocks awash (< 0,01 km<sup>2</sup>). In general, the larger and inhabited islands of the Adriatic archipelago are botanically well explored and recognized as one of the major centers of plant diversity in Croatia (NIKOLIĆ *et al.*, 2008, 2014). But there is still a significant number of uninhabi-

ted islets and reefs where the vascular flora, apart from a few exceptions (HEĆIMOVIĆ, 1982; PANDŽA, 2002; PAVLETIĆ, 1983; JASPRICA & RUŠČIĆ, 2013; SKELIN *et al.*, 2014), is practically unexplored. There are five islets off the village of Pakoštane (Zadar archipelago, north Dalmatia): Babuljaš, Veliki Školj, St Justina, Mali Žavinac and Veliki Žavinac (Fig. 1) whose flora has never been investigated before. The aim of this study is to investigate the vascular flora of these five islets and to compare it with other small uninhabited islets of the Adriatic archipelago.

## STUDY AREA

The islets which are the subject of this study are part of the Zadar archipelago, which belongs to the group of North Dalmatian islands (STRAŽIČIĆ, 1987), Fig. 1. They are situated off the village of Pakoštane at distances from 260 m (St Justina) to 570 m (Veli Skoj) from the nearest shore (Fig. 1). Four of them are considerably smaller than 1 km<sup>2</sup> which puts them into the islets category: Veliki Školj (0.0549 km<sup>2</sup>), St Justina (0.0125 km<sup>2</sup>), Žavinac Mali (0.0115 km<sup>2</sup>) and Žavinac Veliki (0.0277 km<sup>2</sup>). Babuljaš (0.0078 km<sup>2</sup>) is included

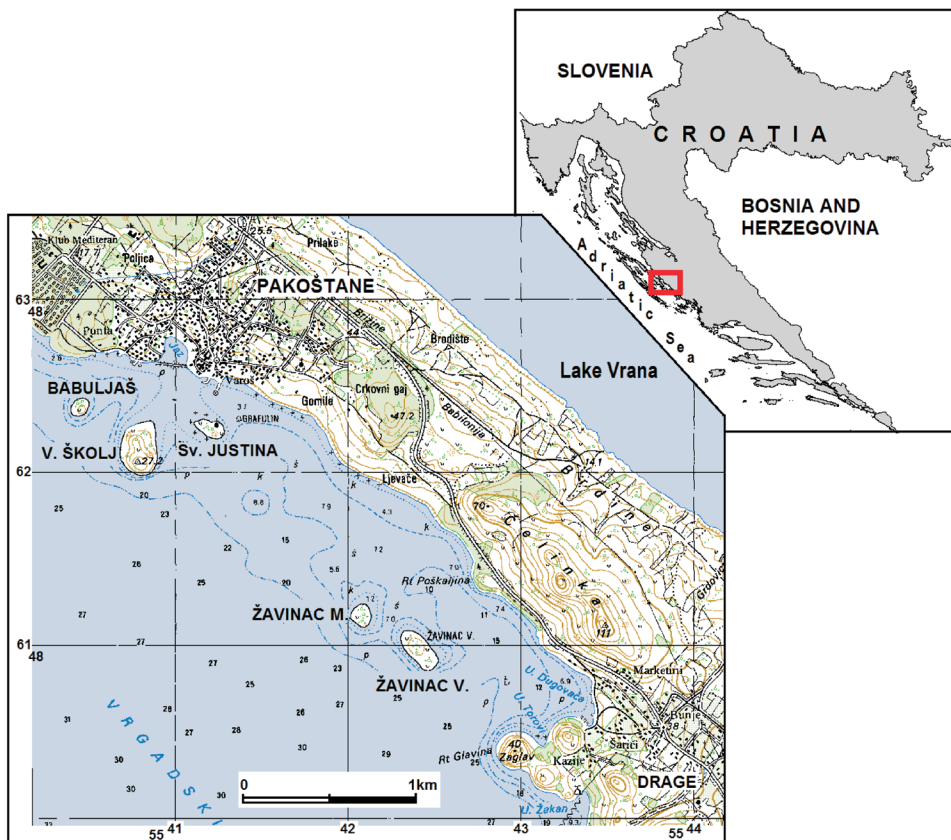


Fig. 1. Geographical position of the studied islets.

into the reefs category (DUPLANČIĆ LEDER *et al.*, 2004). All of them are uninhabited and are included into the group of small, occasionally inhabited or uninhabited islands and islets – MPNNOo, the Area of Special State Concern (ANONYMOUS, 2007). *The National Programme for Protection and use of MPNNOo* was adopted in order to protect them from inappropriate and unplanned management.

Although they are located very close to the mainland, there is little human impact on the investigated islands. On St Justina people occasionally pay visits to the small church and tend the small olive grove that has been recently planted and the islet of Veliki Školj is used for goat grazing.

According to Köppen classification, they are within the C<sub>sa</sub> climate zone (BERTOVIĆ, 1975; ŠEGOTA & FILIPČIĆ, 2003) characterized by hot summers with the average monthly temperature of  $\geq 22$  °C. The nearest weather station in Biograd reported the average annual precipitation of 815.4 mm and the average annual air temperature was 15 °C for the period from 1981–2010. The lowest precipitation values were recorded in July, 23.5 mm average and the highest in the period from October to March. These are typical maritime precipitation regime characteristics (PENZAR & PENZAR, 1979/80; 1981). During summer, vegetation practically stops growing due to harsh droughts.

These islets are situated within the Eu-Mediterranean belt of evergreen vegetation of the *Fraxino orni-Quercion ilicis* Biondi, Casavecchia & Gigante 2013 alliance while the coastal area belongs to the *Plantagini-Limonietum cancellati* Horvatić (1934) 1939) association. The muddy soil in the north-west of the St. Justina islet is covered by the *Puccinellio festuciformis-Salicornietum fruticosae* (Br.–Bl. 1928) Géhu 1967 association (Croatian National Classification of Habitats, NCH – F.1.1.3.1 – endangered and protected habitat, TOPIĆ & VUKELIĆ, 2009) which is mentioned in Directive 92/43 EEC (ANONYMOUS, 1992). Mosaics of low bushes and clearings with dry grassland vegetation can be seen on every islet.

## METHODS

Field work on flora inventory was performed in 2004 and 2012. Identification of plant taxa was carried out using the standard floristic literature: BONNIER (1911–1935), FIORI (1923–1929), HAYEK (1924–1933), HEGI (1936–1987), TUTIN *et al.* (1968–1980, 1993), HORVATIĆ & TRINAJSTIĆ (1967–1981), TRINAJSTIĆ (1975–1986), JAVORKA & CSAPODY (1975), PIGNATTI (1982) and ĐOMAC (1994). The nomenclature of plant taxa follows NIKOLIĆ (2014a).

The list of families, genera, species and subspecies is given in alphabetical order and is organised within higher system units. Designations for islets, life forms, chorological type (geoelement), threatened and protected status were provided for taxa in the flora list.

Based on the life form classification of RAUNKIAER (1934), biological form was verified in the field and denoted according to categories reported in HORVAT (1949) and PIGNATTI (1982): **T** – *Therophytes*, **G** – *Geophytes*, **H** – *Hemicryptophytes*, **Ch** – *Chamaephytes* and **P** – *Phanerophytes*.

The division of the plants into floral elements and lower categories was made according to HORVATIĆ (1963) and HORVATIĆ *et al.* (1967–1968). In the list of flora, each species name is followed by the floral element and marked as follows:

1. MEDITERRANEAN (MED)
  - 1.1. Circum-Mediterranean (CM)
  - 1.2. West Mediterranean (ZM)
  - 1.3. East Mediterranean (IM)
  - 1.4. Illyrian Mediterranean plants
    - A) Illyrian South European (ILJEU)
    - B) Illyrian Adriatic plants
      - a) Illyrian Adriatic Endemic plants (ILJAE)
      - b) Illyrian Apennine plants (ILAP)
  - 1.5. Mediterranean Atlantic (MA)
  - 1.6. European Mediterranean (EUM)
  - 1.7. Mediterranean Pontic (MP)
2. SOUTH EUROPEAN (SEU)
  - 2.1. South European Mediterranean plants (JEUM)
  - 2.2. South European Pontic (JEUP)
  - 2.3. South European-Atlantic (JT)
3. ATLANTIC PLANTS (AN)
4. EAST EUROPEAN-PONTIC (IEP)
5. EUROPEAN (EF)
6. EUROASIATIC (EAF)
7. CIRCUM-HOLARCTIC (CIRC)
8. WIDESPREAD PLANTS (ŠR)
9. CULTURAL AND ADVENTIVE PLANTS (N)

In the list of flora the islets are marked by numbers given after the floral element: 1 – Babuljaš, 2 – Veliki Školj, 3 – St. Justina, 4 – Žavinac Mali and 5 – Žavinac Veliki. Abbreviation “**end**” in the list of flora stands for endemic taxa, as classified by Nikolić (2014a).

Species from the Red Book List of the Vascular Flora of Croatia (Nikolić & Topić, 2005; Nikolić 2014b) are marked by proper abbreviations showing the degree of each species endangerment: Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) and Data Deficient (DD).

Taxa protected by the Nature Protection Act (Anonymous, 2013a) and listed in the Ordinance on Designating Wild Taxa Protected (Anonymous, 2013b) are denoted as “**spr**”-strictly protected.

In the floristic list, habitats are given after the phytogeographical element and marked by letters as follows: a – macchia and garrigue, b – Aleppo pine forests; c – dry grasslands; d – ruderal habitats; e – muddy and salty soils; f – rocky sea shores; g – rocks and cracks in the walls; h – parasites on the plants.

## RESULTS

## Floristic list

**PTERIDOPHYTA****Aspleniaceae**

H *Asplenium trichomanes* L.; ŠR; 2; g

**SPERMATOPHYTA-CONIFEROPHYTINA****Cupressaceae**

P *Cupressus sempervirens* L.; IM; 1, 2, 3; b

P *Juniperus oxycedrus* L. ssp. *macrocarpa* (Sibth. et Sm.) Ball; CM; 1, 5; a

P *J. oxycedrus* L. ssp. *oxycedrus*; CM; 1, 2, 4; a

P *J. phoenicea* L.; CM; 1; a

**Pinaceae**

P *Pinus halepensis* Mill.; CM; 2, 3, 5; b

**SPERMATOPHYTA-MAGNOLIOPHYTINA****MAGNOLIATAE****Anacardiaceae**

P *Pistacia lentiscus* L.; CM; 1, 2, 3, 5; a, b

P *P. terebinthus* L.; CM; 4; a, b

**Apiaceae**

Ch *Crithmum maritimum* L.; MA; 1, 2, 3, 4, 5; f

H *Eryngium amethystinum* L.; ILJEU; 5; c

T *Torilis arvensis* (Huds.) Link; JEUM; 4, 5; c, d

T *T. nodosa* (L.) Gaertn.; MA; 1, 2, 3, 5; c, d

**Asclepiadaceae**

H *Vincetoxicum hirsutiflorum* Medik ssp. *adriaticum* (Beck) Markgr.; ILJAE; 4, 5; c;  
end; spr; LC

**Asteraceae**

Ch *Artemisia caerulea* L.; ILAP; 3; e

T *Bombycilaena erecta* (L.) Smoljan.; JEUP; 2; c, d

H *Carduus micropterus* (Borbás) Teyber ssp. *micropterus*; ILJAE; 1, 2, 3; c; end; spr

H *C. pycnocephalus* L. ssp. *pycnocephalus*; CM; 1, 2, 3, 4; d; DD

H *Carlina corymbosa* L.; CM; 2, 3, 4, 5; c

H *Cirsium vulgare* (Savi) Ten.; EAF; 3; c, d

T *Conyza sumatrensis* (Retz.) E. Walker; N; 3; d

H *Dittrichia viscosa* (L.) Greuter; CM; 5; f

Ch *Helichrysum italicum* (Roth) G. Don; CM; 2, 5; a, c, d, f

Ch *Inula crithmoides* L.; MA; 3, 4, 5; e, f

H *Onopordum illyricum* L.; CM; 1, 2, 3; c, d

H *Picnomon acarua* (L.) Cass.; CM; 2; c

T *Senecio vulgaris* L.; ŠR; 5; d

**Boraginaceae**

T *Myosotis arvensis* (L.) Hill; EAF; 2, 3, 4, 5; c, d

**Brassicaceae**

- Ch *Aethionema saxatile* (L.) R.Br.; **JEUM**; 5; a, b  
 H *Arabis hirsuta* (L.) Scop.; **ŠR**; 4, 5; c, d  
 Ch *Aurinina sinuata* (L.) Griseb.; **ILAP**; 1, 2; c, d, g; **end**; **spr**  
 T *Biscutella cichoriifolia* Loisel.; **JEUM**; 1; g  
 T *Capsella rubella* Reut. ; **CM**; 1, 2, 3, 5; d  
 T *Cardamine hirsuta* L.; **ŠR**; 2; c, d  
 T *Clypeola jonthlaspi* L.; **CM**; 2; c  
 H *Diplotaxis tenuifolia* (L.) DC.; **ŠR**; 3; d  
 H *Lepidium graminifolium* L. ssp. *suffruticosum* (L.) P.Monts.; **JEUP**; 1, 3, 4; d  
 T *Sinapis arvensis* L.; **ŠR**; 2; d  
 T *Sisymbrium officinale* (L.) Scop.; **ŠR**; 1, 2, 3, 4, 5; d

**Campanulaceae**

- H *Campanula rapunculus* L.; **EAF**; 5; c

**Caprifoliaceae**

- P *Lonicera implexa* Aiton; **CM**; 4, 5; a

**Caryophyllaceae**

- T *Arenaria leptoclados* (Reichenb.) Guss.; **EAF**; 1, 2, 3, 4, 5; b, c  
 T *A. serpillifolia* L.; **ŠR**; 1, 2, 4, 5; c  
 T *Cerastium brachypetalum* Pers. ssp. *roeseri* (Boiss. et Heldr.) Nyman; **JT**; 5; c  
 T *C. pumilum* Curtis ssp. *glutinosum* (Fries) Jalas; **ŠR**; 2, 3, 4, 5; c  
 T *C. semidecandrum* L.; **JEUP**; 2, 5; c  
 T *Herniaria glabra* L.; **EAF**; 2; f  
 H *H. incana* Lam.; **JEUM**; 5; c, d  
 T *Minuartia hybrida* (Vill.) Schischkin; **EAF**; 2; c  
 H *Petrorhagia saxifraga* (L.) Link; **JEUM**; 2, 4, 5; c  
 T *Polycarpon tetraphyllum* (L.) L.; **ŠR**; 1, 2, 4; c, d, f  
 T *Sagina maritima* G.Don; **ŠR**; 1, 2, 5; f  
 H *Silene latifolia* Poir. ssp. *alba* (Mill.) Greuter et Bourdet; **EAF**; 1, 2, 3, 4; d  
 H *S. vulgaris* (Moench) Garcke ssp. *angustifolia* Hayek; **JEUM**; 1, 2, 3, 4, 5; a, c, f  
 T *Spergularia salina* J.Presl et C.Presl; **ŠR**; 3; f  
 T *Stellaria media* (L.) Vill.; **ŠR**; 1, 2, 5; d

**Chenopodiaceae**

- Ch *Arthrocnemum fruticosum* (L.) Moq.; **JEUM**; 3; e  
 Ch *A. macrostachyum* (Morici) C. Koch; **JEUM**; 1, 3, 4, 5; e, f  
 T *Atriplex prostrata* Boucher ex DC in Lam. et DC.; **ŠR**; 1, 2, 3, 4; f  
 H *Beta vulgaris* L. ssp. *maritima* (L.) Arcang.; **MA**; 3, 4; f  
 Ch *Camphorosma monspeliaca* L.; **CM**; 1, 3; c  
 T *Chenopodium album* L.; **ŠR**; 1, 2, 5; d  
 T *Ch. strictum* Roth; **ŠR**; 1; d  
 Ch *Halimione portulacoides* (L.) Aellen; **CIRC**; 3; e

**Cichoriaceae**

- G *Aetheorhiza bulbosa* (L.) Cass.; **CM**; 1, 2, 4, 5; a, b, c, f  
 T *Crepis neglecta* L.; **EUM**; 3, 4, 5; c  
 T *C. rubra* L.; **IM**; 1, 3; c  
 T *C. sancta* (L.) Babc.; **IM**; 1, 2; c, d  
 T *C. zacintha* (L.) Babc.; **CM**; 2; c

- T *Hedypnois cretica* (L.) Dum.Cours.; **CM**; 1, 2, 4; c  
 H *Hieracium piloselloides* Vill. **ILJEU**; 3; c  
 H *Lactuca serriola* L.; **ŠR**; 3; d  
 H *Leontodon tuberosus* L.; **CM**; 2; a, c  
 H *Reichardia picroides* (L.) Roth.; **CM**; 1, 2, 3, 4, 5; a, c, f  
 T *Rhagadiolus stellatus* (L.) Gaertn.; **CM**; 2, 3; b, c, d  
 H *Scolymus hispanicus* L.; **CM**; 2, 3; d  
 H *Scorzonera villosa* Scop.; **ILJEU**; 2; c  
 T *Sonchus asper* (L.) Hill ssp. *glaucescens* (Jord.) Ball; **CM**; 2, 3, 5; d, f  
 T *S. tenerrimus* L.; **CM**; 1, 3, 5; d  
 H *Tragopogon dubius* Scop.; **JEUP**; 3; c  
 H *T. porrifolius* L.; **CM**; 3; c  
 T *Urospermum picroides* (L.) Scop. ex F.W. Schmidt; **CM**; 2, 3, 4, 5; a, c

#### **Clusiaceae**

- H *Hypericum perforatum* L. ssp. *veronense* (Schrank) H. Lindb.; **JEUM**; 1, 3, 4, 5; c

#### **Convolvulaceae**

- G *Convolvulus arvensis* L.; **ŠR**; 3, 4; c, d

#### **Crassulaceae**

- Ch *Sedum acre* L.; **ŠR**; 2, 3, 4, 5; c, g  
 T *S. rubens* L.; **JEUM**; 2, 5; c

#### **Cuscutaceae**

- T *Cuscuta epithymum* (L.) L.; **ŠR**; 2, 4, 5; h

#### **Euphorbiaceae**

- T *Euphorbia helioscopia* L.; **ŠR**; 1, 2, 3; d  
 T *E. peplus* L.; **ŠR**; 2, 3; d  
 Ch *E. pinea* L.; **CM**; 1, 4; f  
 Ch *E. spinosa* L.; **CM**; 2; c, g  
 T *Mercurialis annua* L.; **ŠR**; 1, 2, 3; b, d, g

#### **Fabaceae**

- T *Astragalus hamosus* L.; **CM**; 2, 3; c  
 P *Colutea arborescens* L.; **CM**; 4, 5; a  
 P *Coronilla emerus* L. ssp. *emeroides* Boiss. et Spruner; **IM**; 2, 4, 5; a, c  
 T *C. scorpioides* (L.) Koch; **CM**; 2, 5; a, c  
 Ch *Dorycnium hirsutum* (L.) Ser.; **CM**; 2; a, c, f  
 T *Lathyrus aphaca* L.; **JEUM**; 2, 4, 5; a, c  
 T *L. sphaericus* Retz.; **JEUM**; 3; a, c  
 T *L. cicera* L.; **CM**; 2; c  
 T *Lens nigricans* (M. Bieb.) Godr.; **CM**; 2; c  
 Ch *Lotus cytisoides* L.; **CM**; 1, 2, 3, 4, 5; f  
 T *Medicago arabica* (L.) Huds.; **ŠR**; 1, 3; c  
 T *M. coronata* (L.) Bartal.; **CM**; 1, 2; c  
 H *M. falcata* L.; **EAF**; 3; c  
 T *M. littoralis* Rohde ex Loisel.; **CM**; 1, 2, 3, 4, 5; c  
 T *M. lupulina* L.; **ŠR**; 2, 4, 5; c  
 T *M. minima* (L.) Bartal.; **ŠR**; 1, 2, 3, 4, 5; a, b, c  
 T *M. orbicularis* (L.) Bartal.; **CM**; 1, 2, 3; c, d  
 H *M. sativa* L. ssp. *sativa*; **ŠR**; 3; c

- T *Melilotus indica* (L.) All.; **CM**; 3, 4, 5; c  
 H *M. officinalis* (L.) Lam.; **IM**; 3, 5; c, d  
 T *Ononis ornithopodioides* L.; **CM**; 2; c  
 H *O. pusilla* L.; **JEUM**; 2, 5; a, c  
 T *O. reclinata* L.; **CM**; 2; c  
 T *Pisum sativum* L. ssp. *elatius* (M. Bieb.) Asch. et Graebn.; **JEUM**; 4, 5; c  
 T *Securigera cretica* (L.) Lassen (= *Coronilla cretica* L.); **IM**; 2, 3; c  
 T *Trifolium angustifolium* L.; **CM**; 5; a, c  
 T *T. arvense* L.; **EAF**; 2, 5; c  
 T *T. campestre* Schreber; **ŠR**; 1, 2, 3, 4, 5; a, c  
 T *T. scabrum* L.; **CM**; 1, 2, 3, 4, 5; a, b, c, d, f  
 T *T. stellatum* L.; **CM**; 1; c  
 T *T. striatum* L.; **EAF**; 2, 3, 4; c, d  
 T *T. subterraneum* L.; **MA**; 2; d  
 T *T. suffocatum* L.; **CM**; 1; f  
 T *T. tomentosum* L.; **CM**; 2; c  
 T *Trigonella esculenta* Will; **MA**; 1, 2, 4; c, d  
 T *T. monspeliaca* L.; **CM**; 2; c  
 T *Vicia angustifolia* L. ssp. *angustifolia*; **EF**; 2, 3, 4, 5; c  
 T *V. parviflora* Cav.; **CM**; 2; c  
 T *V. tenuissima* (M. Bieb.) Schinz et Thell. (= *V. gracilis* Loisel.); **JEUM**; 2; c  
 T *V. villosa* Roth. ssp. *varia* (Host) Corb.; **IEP**; 4; c

#### Fagaceae

- P *Quercus ilex* L.; **CM**; 3, 4, 5; a, b  
 P *Q. pubescens* Willd.; **JEUP**; 3; c

#### Fumariaceae

- T *Fumaria capreolata* L.; **MA**; 2, 4, 5; a, d  
 T *F. officinalis* L.; **ŠR**; 1, 3, 4, 5; d

#### Gentianaceae

- T *Centaurium erythraea* Rafn; **ŠR**; 5; c

#### Geraniaceae

- T *Erodium cicutarium* (L.) L'Hér.; **ŠR**; 1, 2; d  
 T *E. malacoides* (L.) L'Hér.; **CM**; 1, 3; d  
 T *Geranium columbinum* L.; **EAF**; 1, 2; c  
 T *G. lucidum* L.; **MA**; 2; c  
 T *G. molle* L. ssp. *molle*; **ŠR**; 4; c  
 T *G. molle* L. ssp. *brutium* (Gasparr.) Graebn.; **IM**; 3; c  
 T *G. purpureum* Vill.; **JEUM**; 1, 2, 4, 5; a, b, g  
 T *G. rotundifolium* L.; **EAF**; 1, 2, 3, 4; c

#### Lamiaceae

- T *Acinos arvensis* (Lam.) Dandy; **EF**; 2; c  
 T *Ajuga chamaepitys* (L.) Schreb.; **CM**; 2; c  
 H *Calamintha nepetoides* Jord.; **JEUP**; 1, 3, 4; d  
 T *Lamium amlexicaule* L.; **EAF**; 1, 2; d, g  
 H *Marrubium incanum* Desr.; **ILAP**; 1; d  
 Ch *Prasium majus* L.; **CM**; 2, 4, 5; a  
 H *Salvia bertolonii* Vis.; **ILJAE**; 1, 2, 3, 5; c



- T *Sideritis romana* L.; **CM**; 1, 2, 5; c  
 Ch *Teucrium chamaedrys* L.; **JEUP**; 2, 5; a, b, c  
 Ch *T. polium* L. ssp. *capitatum* (L.) Arcang; **MP**; 2, 5; a, b, c

**Linaceae**

- H *Linum bienne* Mill.; **MA**; 4; c  
 T *L. strictum* L. ssp. *corymbulosum* (Rchb.) Riony; **MP**; 5; c

**Malvaceae**

- H *Malva sylvestris* L.; **ŠR**; 1, 2, 3, 4; d

**Moraceae**

- P *Ficus carica* L.; **CM**; 4; g

**Oleaceae**

- P *Olea europaea* L. (incl. *O. europaea* L. var. *oleaster* (Hoffm. et Link) Fiori); **N**; 3, 5; a, c  
 P *Phillyrea latifolia* L.; **CM**; 2, 4, 5; a, b

**Orobanchaceae**

- T *Orobanche nana* Noë; **JEUP**; 1, 3; c

**Papaveraceae**

- T *Papaver rhoeas* L.; **ŠR**; 2; d

**Plantaginaceae**

- H *Plantago altissima* L.; **JEUM**; 1, 2, 3; c, d  
 T *P. coronopus* L. ssp. *commutata* (Guss.) Pilger; **MP**; 1, 2; e  
 H *P. lanceolata* L.; **ŠR**; 1, 2, 3, 4; b, d

**Plumbaginaceae**

- H *Limonium cancellatum* (Bernh. ex Bertol.) O. Kuntze; **ILAP**; 2, 3, 4, 5; f; **end**; **spr**  
 H *L. narbonense* Mill.; **CM**; 1, 3, 4, 5; e

**Polygonaceae**

- T *Fallopia convolvulus* (L.) Á. Löve; **CIRC**; 2; d  
 T *Polygonum aviculare* L.; **ŠR**; 5; d  
 H *Rumex pulcher* L.; **JEUP**; 2, 3; d

**Primulaceae**

- T *Anagallis arvensis* L.; **ŠR**; 1, 2, 3, 4, 5; b, c, d  
 T *A. coerulea* Schreb.; **ŠR**; 2, 5; c  
 T *Asterolinon linum-stellatum* (L.) Duby; **CM**; 2, 5; c  
 G *Cyclamen repandum* Sibth. et Sm.; **EUM**; 2; a, b

**Ranunculaceae**

- P *Clematis flammula* L.; **CM**; 2, 3, 4, 5; a

**Rhamnaceae**

- P *Paliurus spina-christi* Mill.; **ILJEU**; 1; a

**Rosaceae**

- T *Aphanes arvensis* L.; **EF**; 1, 2; c  
 P *Prunus mahaleb* L.; **JEUP**; 2; c  
 P *Rubus ulmifolius* Schott; **MA**; 2, 3; c, d

**Rubiaceae**

- T *Galium aparine* L.; **ŠR**; 1, 2, 3, 4, 5; b, d  
 H *G. corrudifolium* Vill.; **JEUM**; 2, 5; a, c

- T *G. murale* (L.) All.; **CM**; 2; c  
 P *Rubia peregrina* L.; **CM**; 2, 4, 5; a, b, c  
 T *Sherardia arvensis* L.; **ŠR**; 1, 2, 3, 4, 5; c  
 T *Valantia muralis* L.; **CM**; 1, 2, 4, 5; f

#### **Santalaceae**

- P *Osyris alba* L.; **CM**; 3, 4, 5; a

#### **Scrophulariaceae**

- T *Linaria simplex* (Willd.) DC.; **CM**; 5; c  
 H *Verbascum pulverulentum* Vill.; **JT**; 3; c  
 T *Veronica arvensis* L.; **EAF**; 1, 2, 3, 5; c  
 T *V. cymbalaria* Bodard; **JEUM**; 4; g  
 T *V. persica* Poir.; **ŠR**; 1, 2; d  
 T *V. polita* Fr.; **EAF**; 1, 4; c, d  
 T *V. praecox* All.; **EUM**; 1; c

#### **Tamaricaceae**

- P *Tamarix dalmatica* Baum; **ZM**; 3; f

#### **Ulmaceae**

- P *Celtis australis* L.; **JEUM**; 3; c

#### **Urticaceae**

- H *Parietaria judaica* L.; **JEUM**; 1, 2, 3, 4, 5; b, d  
 T *Urtica urens* L.; **ŠR**; 1, 2, 3; d

#### **Valerianaceae**

- T *Valerianella muricata* (Stiven ex M.Bieb.) J.W. Loudon; **CM**; 2; c

#### **Verbenaceae**

- P *Vitex agnus-castus* L.; **CM**; 2; f

#### **Violaceae**

- T *Viola kitaibeliana* Schultes; **CM**; 2; c

### **LILIATAE**

#### **Araceae**

- G *Arum italicum* Mill.; **CM**; 1, 2, 3, 4, 5; a, b, d

#### **Cyperaceae**

- H *Carex distachya* Desf.; **CM**; 4; c  
 G *C. divisa* Huds.; **MA**; 3; c; **spr**; **EN**  
 H *C. divulsa* Stokes; **ŠR**; 4; c  
 H *C. extensa* Gooden.; **ŠR**; 2, 3; e; **spr**; **EN**  
 G *C. flacca* Schreb. ssp. *serrulata* (Biv.) Greuter; **ŠR**; 5; a, c  
 H *C. hallerana* Asso; **JEUM**; 2; c  
 H *Schoenus nigricans* L.; **ŠR**; 4, 5; f

#### **Dioscoreaceae**

- G *Tamus communis* L.; **JEUM**; 2, 4, 5; a, b

#### **Iridaceae**

- G *Romulea bulbocodium* (L.) Seb. et Mauri; **CM**; 2, 4; c

#### **Juncaceae**

- H *Juncus acutus* L.; **MA**; 3; f  
 G *J. maritimus* Lam.; **ŠR**; 3, 4; e, f

**Liliaceae**

- G *Allium commutatum* Guss.; **CM**; 3, 4, 5; f  
 G *A. roseum* L.; **CM**; 3; c  
 G *A. subhirsutum* L.; **CM**; 2, 3, 4, 5; a, b  
 G *Asparagus acutifolius* L.; **CM**; 1, 2, 3, 4, 5; a, b, c  
 G *Asphodelus aestivus* Brot.; **CM**; 1, 2, 4, 5; c  
 G *Muscari comosum* (L.) Mill.; **JEUM**; 2, 3, 4, 5; c  
 G *M. neglectum* Guss. ex Ten.; **JEUM**; 2; c  
 G *Ornithogalum pyramidale* L.; **JEUM**; 5; c  
 P *Smilax aspera* L.; **CM**; 2, 4, 5; a, b, c

**Poaceae**

- H *Anthoxanthum odoratum* L.; **EAF**; 2; c  
 T *Avena barbata* Pott ex Link; **JEUP**; 1, 2, 3, 4, 5; d  
 T *A. sterilis* L.; **JEUP**; 4; d  
 T *Brachypodium distachyon* (L.) P.Beauv.; **CM**; 2; c  
 H *B. pinnatum* (L.) P. Beauv. ssp. *rupestre* (Host) Schubl. et M. Martens; **AN**; 4; b, c  
 H *B. retusum* (Pers.) P. Beauv.; **CM**; 2, 5; a, b, c, d, f  
 T *Briza maxima* L.; **CM**; 2; c  
 H *Bromus erectus* Huds. ssp. *condensatus* (Hack.) Asch. et Graebn.; **JEUM**; 2, 3, 4, 5; c  
 T *B. hordaceus* L. ssp. *molliformis* (Lloyd) Maire et Weiller; **JEUM**; 1, 2, 4; c  
 T *B. madritensis* L.; **MA**; 3, 5; d  
 T *B. sterilis* L.; **ŠR**; 1, 2, 3, 4; d  
 H *Chrysopogon gryllus* (L.) Trin.; **MP**; 5; c  
 G *Cynodon dactylon* (L.) Pers.; **ŠR**; 1, 2, 4, 5; d, f  
 T *Cynosurus echinatus* L.; **JEUM**; 2; c  
 H *Dactylis glomerata* L. ssp. *glomerata*; **EAF**; 5; c  
 H *D. glomerata* L. ssp. *hispanica* (Roth) Nyman; **CM**; 1, 2, 3, 4; c  
 T *Desmazeria marina* (L.) Druce; **MA**; 1, 2, 4, 5; f; **spr**; **VU**  
 T *D. rigida* (L.) Tutin; **MA**; 1, 2, 3, 4, 5; c  
 H *Dichanthium ischaemum* (L.) Roberty; **JEUM**; 4; c  
 G *Elymus pycnanthus* (Godr.) Melderis; **CM**; 1, 2, 3, 4, 5; f; **NT**  
 G *E. repens* (L.) Gould; **ŠR**; 3; c, d  
 H *Festuca pratensis* Huds.; **ŠR**; 3, 4; c  
 H *F. pseudovina* Hack. ex Wiesb.; **IEP**; 2; c  
 H *Helictotrichon convolutum* (C. Presl) Henrard; **ZM**; 2, 4, 5; c  
 T *Hordeum murinum* L. ssp. *leporinum* (Link) Arcang.; **CM**; 1, 2, 3, 5; d  
 T *Lagurus ovatus* L.; **CM**; 1, 2, 3, 4; b, d  
 H *Lolium perenne* L.; **EF**; 1; d  
 T *L. rigidum* Gaudin ssp. *lepturoides* (Boiss.) Sennen et Mauricio; **IM**; 3, 4, 5; d, e  
 T *L. strictum* L. ssp. *strictum*; **JEUM**; 1, 3, 4; c  
 T *Lophochloa cristata* (L.) Hyl.; **MA**; 1, 2, 5; c  
 H *Melica ciliata* L.; **EAF**; 2, 3, 4; c, g; **LC**  
 T *Parapholis incurva* (L.) C.E.Hubb.; **MA**; 1, 2, 3, 4, 5; e, f; **spr**; **VU**  
 H *Poa bulbosa* L.; **EAF**; 1, 2, 5; c  
 H *P. pratensis* L.; **ŠR**; 3; c  
 H *Puccinellia festuciformis* (Host) Parl.; **MP**; 3; e  
 T *Vulpia ciliata* Dumort.; **JEUM**; 2; c

## ANALYSIS OF THE FLORA

### Taxonomical analysis

On the five uninhabited islets situated in the vicinity of village of Pakoštane, there were 257 vascular flora taxa (225 species and 32 subspecies), which were classified into 169 genera and 54 families (Tab.1). This is the first recording of the taxa for these islets.

The largest number of taxa was found on Veliki Školj (159), followed by St. Justina (118), Žavinac Veliki (115), Žavinac Mali (105) and Babuljaš (95) (Tab. 2).

As expected, the largest number of taxa is recorded for V. Školj (159). It has the largest area (0,055 km<sup>2</sup>), the highest point above the sea level (27 m) and it is moderately exposed to anthropogenic influence (goat grazing). The other four islets are smaller (0.008 – 0.028 km<sup>2</sup>), and are lower lying, which makes their vegetation completely exposed to salinization. St. Justina (0,013 km<sup>2</sup>) is one-half the size of Žavinac Veliki (0,028 km<sup>2</sup>) but has the largest number of taxa (118 vs. 115). This is due to the greater human influence: a small olive grove has been recently planted on St Justina creating a new type of habitat and resulting in an increase in the richness of the flora.

The results indicate that the richness of the vascular flora of these five islands is influenced more by the diversity of habitats and anthropogenic elements than by the areas of islets.

Families with the highest number of taxa were: *Fabaceae* (15.56 % of the total flora), *Poaceae* (14.00 %) and *Asteraceae* s.l. (12.06 %). Their contribution to the total number of taxa was 42% of the total flora (Tab. 3). These families are also predominant on other Dalmatian islands and islets: Lokrum, Bobara and Mrkan (HEĆIMOVIĆ, 1982), Žirje (PANDŽA, 2003), Ist and Škarda (MILOVIĆ & PANDŽA, 2010), Obonjan (MILOVIĆ, 2004a), Supetar (JASPRICA & RUŠČIĆ, 2013) etc.

### Analysis of the life forms

As expected, the proportion of therophytes in the flora of the investigated islets was high (49.42%) (Fig. 2). This was also shown for each particular islet (Tab. 4).

The proportion of therophytes ranges from 41.53 % on St. Justina to as much as 61.04% on Babuljaš. Therophytes are also the predominant life form in other Dalmatian islets'

**Tab. 1.** Taxonomical analysis

Taxa	Pterydophyta	Gymnospermae	Angiospermae		Total
			Dicotyledones	Monocotyledones	
Families	1	2	44	7	54
Genera	1	3	130	35	169
Species	1	3	173	48	225
Subspecies	-	2	21	9	32
Species and subspecies	1	5	194	57	257
%	0.39	1.95	75.48	22.18	100

**Tab. 2.** Number of taxa compared with numbers on other uninhabited Dalmatian islets (with surface areas less than one km<sup>2</sup>).

Island/Islet	Area (km <sup>2</sup> )*	No. of taxa	References
Obonjan	0.550	230	MILOVIĆ (2004a)
Palagruža	0.286	220	PAVLETIĆ (1983)
Mrkan	0.197	179	HEĆIMOVIĆ (1982)
Zečevo (Hvar)	0.11	216	SKELIN <i>et al.</i> (2014)
Kozina	0.063	105	PANDŽA <i>et al.</i> (2011)
Veliki Školj	0.055	159	this study
Hrbošnjak (Murter)	0.050	84	PANDŽA (2002)
Samograd	0.043	71	PANDŽA (2003)
Supetar (Cavtat)	0.039	173	JASPRICA & RUŠČIĆ (2013)
St Andrija	0.036	160	JASPRICA <i>et al.</i> (2006)
Veliki Žavinac	0.028	115	this study
Dražemanski Mali	0.027	81	PANDŽA (2002)
Sustipanac	0.0125	123	PANDŽA (2002)
St Justina	0.0125	118	this study
Kamenjak (Ist)	0.0119	34	MILOVIĆ & PANDŽA (2010)
Tužbina	0.0119	62	PANDŽA (2002)
Mali Žavinac	0.0115	105	this study
Benušić (Ist)	0.006	33	MILOVIĆ & PANDŽA (2010)
Babuljaš	<0.001	95	this study

\* According to DUPLANČIĆ LEDER *et al.* (2004)

**Tab. 3.** List of families with  $\geq 10$  taxa.

Family	No. of taxa	% of total flora
<i>Fabaceae</i>	40	15.56
<i>Poaceae</i>	36	14.00
<i>Asteraceae</i> s.l.	31	12.06
<i>Asteraceae</i> s.s.	(13)	(5.06)
<i>Cichoriaceae</i>	(18)	(7.00)
<i>Caryophyllaceae</i>	15	5.84
<i>Brassicaceae</i>	11	4.28
<i>Lamiaceae</i>	10	3.89
<i>Other families</i> (47)	114	44.37
Total	257	100.00

flora (PANDŽA, 2002; JASPRICA & RUŠČIĆ, 2013; SKELIN *et al.*, 2014), indicative of the dry Mediterranean climate. Life form spectra in the flora of the investigated islets do not significantly differ from those recorded for other Dalmatian uninhabited islets (MILOVIĆ, 2004a; BOGDANOVIĆ&MITIĆ, 2003; JASPRICA *et al.*, 2006; PANDŽA *et al.*, 2011; SKELIN *et al.*, 2014).

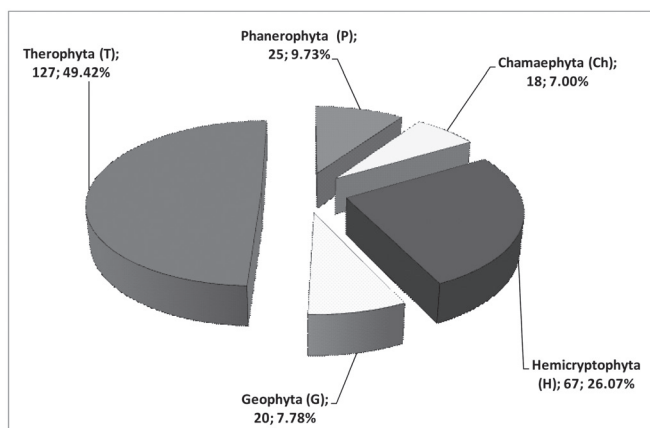
**Tab. 4.** Life forms in the floras of the islets researched.

Islets	Therophyta	Hemicrypto- phyta	Geophyta	Chamaephyta	Phanerophyta	Total flora (%)
	No. of taxa (%)	No. of taxa (%)	No. of taxa (%)	No. of taxa (%)	No. of taxa (%)	
Babuljaš	58 (61.04)	19 (20.00)	6 (6.32)	6 (6.32)	6 (6.32)	95 (100)
V. Školj	92 (57.86)	32 (20.13)	12 (7.55)	10 (6.29)	13 (8.17)	159 (100)
St. Justina	49 (41.53)	38 (32.20)	11 (9.32)	9 (7.63)	11 (9.32)	118 (100)
Žavinac M.	45 (42.86)	28 (26.67)	13 (12.38)	7 (6.67)	12 (11.42)	105 (100)
Žavinac V.	55 (47.83)	25 (21.74)	12 (10.43)	10 (8.70)	13 (11.30)	115 (100)

### Phytogeographical analysis

As the region of this research belongs to the typical Mediterranean climate, the phytogeographical analysis results (Tab. 6) were as expected: plants of the Mediterranean floral element are the most common (50.19%). They are followed by widespread (20.23%) and South European plants (17.90%). Such a predominance of Mediterranean plants was also recorded in some other Dalmatian islands' flora (e.g. MILOVIĆ, 2004a, PANDŽA *et al.*, 2011).

Although they are situated only a small distance (less than 0.6 km) from the mainland (Fig. 1), anthropogenic influence on the investigated islets is insignificant, with the exception of Veli Školj (grazing goats) and St. Justina (a small olive grove). Therefore, the poor representation of alien plants (0.78% of the total flora) was expected. Low representation of suitable anthropogenic habitats and the exposure of the islets to salinization are the main limiting factors for the immigration of adventive plants. Only two of them were found, both on islet of St. Justina. Olive trees (*Olea europaea*) have recently been brought into cultivation. The neophyte taxon *Conyza sumatrensis* has been accidentally brought. This taxon is currently spreading invasively throughout Dalmatia, south Croatia (MILOVIĆ, 2004b).

**Fig. 2.** Spectrum of life forms in the flora on the all investigated islets.

**Tab. 6.** Floral elements analysis of the flora of the islets near Pakoštane.

Geoelements	No. of taxa	%
MEDITERRANEAN – <b>MED</b>	129	50.19
SOUTH EUROPEAN – <b>SEU</b>	46	17.90
ATLANTIC PLANTS – <b>AN</b>	1	0.39
EAST EUROPEAN-PONTIC – <b>IEP</b>	2	0.78
EUROPEAN – <b>EF</b>	4	1.56
EUROASIATIC – <b>EAF</b>	19	7.39
CIRCUM-HOLARCTIC – <b>CIRC</b>	2	0.78
WIDESPREAD PLANTS – <b>ŠR</b>	52	20.23
CULTURAL & ADVENTIVE – <b>N</b>	2	0.78
<b>TOTAL</b>	<b>257</b>	<b>100.00</b>

In the flora of the investigated region, four endemic, eight endangered and eight strictly protected taxa were found. Three endemic taxa were found on dry rocky grasslands (*Vincetoxicum hirundinaria* ssp. *adriaticum*, *Carduus micropterus* ssp. *micropterus* and *Aurinia sinuata*) while *Limonium cancellatum* grows on rocks in the halophytic zone. There were two endangered (*Carex divisa* and *C. extensa*) and two vulnerable (*Desmazeria marina* and *Parapholis incurva*) taxa, and they are also found in the coastal zone which is exposed to salinization.

## CONCLUSION

In this study, 257 plant taxa (species and subspecies) are recorded for the first time for the five uninhabited islets near Pakoštane, North Dalmatia. Due to the small surface areas and some particular ecological conditions, the flora of islets showed characteristics similar to those of some other Dalmatian islands. These results contribute to the broadening of our knowledge on the vascular plant diversity of the uninhabited Adriatic islands.

## ACKNOWLEDGEMENTS

We would like to thank the two anonymous reviewers for their constructive comments on an earlier version of this manuscript.

Received May 11, 2014

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## SAŽETAK

### Flora otočića ispred Pakoštana (Dalmacija, Hrvatska)

M. Pandža & M. Milović

Vaskularna flora nenaseljenih i slabo naseljenih otočića i hridi hrvatskog otočnog arhipelaga je slabo istražena. Tijekom 2004. i 2012. provedena su terenska istraživanja flore na pet nenaseljenih otočića ispred Pakoštana (zadarski arhipelag, sjeverna Dalmacija): Babuljaš, Veliki Školj, Sveta Justina, Mali i Veliki Žavinac. Zbog male površine i male nadmorske visine, vegetacija istraživanih otočića gotovo je u cijelosti izložena zaslanjivanju. Značajnijem antropogenom utjecaju izloženi su samo Sv. Justina (maslinik i crkvice) i Veliki Školj (ispaša koza). Za pet istraživanih otočića utvrđeno je ukupno 257 svojiti vaskularne flore. Flora Velikog Školja ima 159 svojiti, Sv. Justine 118, Velikog Žavinca 115, Malog Žavinca 105 i Babuljaša 95 svojiti. Zabilježeni broj svojiti ne odstupa značajno u odnosu na broj svojiti koji je zabilježen za druge nenaseljene otočiće u Dalmaciji.

Rezultati taksonomske, fitogeografske i ekološke analize flore su očekivani s obzirom na fitogeografski položaj i tipičnu mediteransku klimu i u skladu su s rezultatima utvrđenim za floru drugih dalmatinskih otočića. Porodice s najvećim brojem svojiti su *Fabaceae* (15,56%), *Poaceae* (14,00%) i *Asteraceae* s.l. (12,06%). Terofiti su najzastupljeniji životni oblik (49,42%), a među flornim elementima najzastupljenije su mediteranske biljke (50,19%), koje su približno jednako zastupljene u flori svih pet otočića (47,62–53,04%). U flori istraživanih otočića su značajno zastupljene svojite od posebnog interesa: zabilježena su četiri endema, osam ugroženih te osam strogo zaštićenih svojiti. Od neofita, na Sv. Justini je zabilježena samo vrsta *Conyza sumatrensis* dok na ostalim otočićima neofita nije bilo. Izostanak većeg broja stranih vrsta posljedica je slabo izraženog antropogenog utjecaja i izostanka odgovarajućih staništa pogodnih za njihovo useljavanje.