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FLORISTIC COMPOSITION OF THE RUDERAL HABITATS ALONG THE NEWLY BUILT ACCESS ROADS TO PELJEŠAC BRIDGE: PRELIMINARY RESULTS

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We investigated the floristic richness of ruderal sites along the newly built access roads to Pelješac Bridge after several years of construction and three months of traffic on the roads (in autumn 2022). A clear dominance of steno-Mediterranean plants was observed, with a considerable proportion of cosmopolitans, accompanied by a high proportion of therophytes. Taxa from the vegetation classes *Artemisietea vulgaris* and *Chenopodietea* predominated. This study analyzes preliminary data and can be used as a basis for a further examination of how plant colonization processes are influenced by human activities. This report can also support comprehensive phytosociological studies of ruderal communities in this area, as well as in other regions with a Mediterranean climate.

Keywords: eastern Adriatic, floristic survey, man-made habitats, Mediterranean climate, roadsides

Jasprica, N., Pandža, M. & Milović, M.: Floristički sastav ruderalnih staništa uz novoizgrađene pristupne ceste Pelješkog mosta: preliminarni rezultati. Nat. Croat., Vol. 32, No. 1., 213-231, 2023, Zagreb.

Istraživali smo floristički sastav ruderalnih staništa uz novoizgrađene pristupne ceste Pelješkog mosta nakon višegodišnjeg razdoblja njihove gradnje i tri mjeseca prometa na cestama (u jesen 2022.). Utvrđena je prevlast terofita, mediteranskih svojti sa značajnim udjelom kozmopolita te svojti iz vegetacijskih razreda *Artemisietea vulgaris* i *Chenopodietea*. Studija daje analizu preliminarnih podataka i može se smatrati temeljem za daljnju analizu procesa naseljavanja biljaka uvjetovanih ljudskim djelovanjem. Ovaj rad, također, može poduprijeti sveobuhvatna fitocenološka istraživanja ruderalnih zajednica na tom području, kao i u drugim područjima sa sredozemnom klimom.

Ključne riječi: antropogena staništa, istočni Jadran, mediteranska klima, pregled flore, rubovi cesta

INTRODUCTION

Land use changes are widespread at global, national, and local scales, resulting in greatly altered environmental conditions. Abiotic conditions (such as disturbances in physical conditions and climate) determine which plant species are capable of persisting in a habitat (Stachowicz, 2001). In addition, these conditions are best explained by

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a combination of land use, soil characteristics, and socioeconomic factors that filter species based on their adaptations and functional traits (Diaz *et al.*, 1998). In general, populations of some nitrophilous and ruderal species spread in areas of intense human activity. However, ruderal plants are also considere a type of spontaneous vegetation, and their occurrence can be significantly accelerated by the impact of human activities (e.g., Biondi *et al.*, 2012; Guo *et al.*, 2018). On the other hand, they have a survival strategy that can adapt to local habitats and withstand intensive human intervention (Ohsawa *et al.*, 1988).

Roads are built to spur economic development or alleviate poverty. However, such engineering undertakings can affect biodiversity and conservation values (Bennett, 2017). The negative impacts of road construction include fragmentation of complex natural ecosystems (Forman & Alexander, 1998; Vanneste *et al.*, 2020) and the creation of edge effects along roadsides that promote colonization by ruderal species (Mullerova *et al.*, 2011; Hughes, 2018) to the detriment of native species that depend on specialized local habitats (Lembrechts *et al.*, 2017). Many studies have found that roadsides favour non-native species and significantly alter community composition (Lazaro-Lobo & Ervin, 2019; Li *et al.*, 2022).

In July 2022, the construction of Pelješac Bridge with its access roads was almost completed after six years of construction. The main goal of the construction of the bridge is to improve connections of the south of Croatia and the rest of the country. A total of 32.5 km of roads with associated facilities (viaducts, bridges, tunnels, underpasses, rest areas, reservoirs, etc.) were built. The construction of the access roads has changed the appearance of the landscape due to increased ground obstructions, the presence of embankments in the abutments, etc. Also, the temporary increase of human population (workers) in the container settlements and the machinery maneuvers in the area during the construction works are not to be neglected.

In this study we would like to show the floristic richness of the ruderal areas along the access road verges to Pelješac Bridge after several years of construction and three months of traffic on the roads. This study provides an analysis of preliminary data and can serve as a basis for further analysis of plant colonization processes as a result of human activity. In addition, the study can support comprehensive phytosociological studies of ruderal communities in this area as well as in other regions with a Mediterranean climate.

MATERIAL AND METHODS

Study area

During the construction of the Pelješac Bridge (2.4 km long), an extensive network of access roads was built (Fig. 1). The works were completed on July 26, 2022 on a section of 22.14 km in length. The section between Prapratno Bay and the village of Zaton Doli (7.9 km in length) is still under construction and has not been included here (completion expected in May 2023).

The study area is located in the Mediterranean region, the Eastern Mediterranean subregion, the Adriatic province and the Epiro-Dalmatian sector (Rivas-Martínez *et al.*, 2004).

Fig. 1. Map of the study area showing the locations where the relevés were collected on the southern Croatian mainland and the Pelješac Peninsula in autumn 2022.

The climate is Mediterranean: the average annual air temperature is 15.8 °C, and the average annual rainfall is 1081.2 mm (data for the Ploče meteorological station, provided by the Croatian Meteorological and Hydrological Service for 1988 – 2019). The average monthly air temperature (25.7 °C) is highest in July, and lowest (7.0 °C) in January. The lowest air temperature (-7.2 °C) was recorded on February 15, 2012, while the highest (38.8 °C) was recorded twice: on July 24, 2007 and August 2, 2017. The amount of rainfall is highest in November (154.6 mm average) and December (143.6 mm). The total rainfall from June to August is 121.0 mm. North winds are the most frequent winds in this area. The sums of relative frequencies (in ‰) are the following: tramontana (N) – 49.5, burin (NNE) – 148.6 and bora (NE) – 84.7. The wind speed (average 2.4 m s^{-1}) is highest in March. The area has 2668.9 hours of sunshine per year. On average, the relative humidity is 68% (Jasprica *et al.*, 2015). According to the bioclimatic classification of Europe (Rivas-Martínez *et al.*, 2011), the area in question belongs to the Mediterranean pluviseason-oceanic bioclimate and is located in the lower meso-Mediterranean belt.

The bedrock consists mainly of carbonate rocks (Raić *et al.*, 1982). The Lower Cretaceous carbonate deposits can be recognized in different types of vertically alternating lithotypes. In the lower horizon dolomites and dolomitic limestones have developed, and in the upper part there are limestones with dolomitic intercalations and interbeds. The soils are automorphic and of shallow to medium depth (Bašić, 2013). They include limestone dolomite dark soil, rendzina, brown soil on limestone and dolomite, red soil (*terra rossa*) and regosol soil (cultivated soil on red and brown soil developed on limestone and dolomite in the field). Brown soil on limestone and dolomite (calcaric cambisol), developed on pure limestone and dolomite, is the most common type of soil.

The Pelješac Peninsula is one of the Important Plant Areas (IPAs) in Croatia (Jasprica & Kovačić, 2010) and includes sites rich in endemic flora (Nikolić *et al*., 2015). The study area is located within the NATURA 2000 network of protected areas in Croatia (site code HR1000036 – Central Dalmatian Islands and Pelješac; HR2001364 – SE part of the Pelješac Peninsula; HR4000015 – the Bay of Mali Ston; HR5000031 – the Neretva Delta) (Anonymous, 2019). Only a small part of the roads, both on the mainland and on the Pelješac Peninsula, is located within the protected area of the Mali Ston Special Nature Reserve (Jasprica & Batistić, 2021). In accordance with legislation, the environmental impact assessment for the project Bridge: Mainland - Pelješac with access roads, including the area of the Mali Ston Special Nature Reserve, was carried out, as well as the acceptance assessment for the network NATURA 2000. In addition, the main impact assessment for the ecological network was prepared in accordance with the Law on Environmental Protection (Anonymous, 2013a).

Phytogeographically, the area of interest belongs to the meso-Mediterranean vegetation belt of the *Fraxino orni-Quercion ilicis* Biondi et al. ex Biondi, Casavecchia et Gigante 2013, with orographic exclaves (e.g., the village of Brijesta, the Prapratno Bay) of the thermo-Mediterranean *Oleo-Ceratonion siliquae* Br.-Bl. ex Guinochet et Drouineau 1944 (Jasprica & Dolina, 2009; *sensu* Mucina *et al*., 2016; Škvorc *et al*., 2017).

Sampling and analysis

Field data were collected from 24 vegetation sample plots (relevés) from October 22 to November 5, 2022. Relevés were collected according to the principles of the Braun-Blanquet approach (Braun-Blanquet, 1964; Westhoff & van der Maarel, 1980). The sites where relevés are sampled were randomly chosen along different sections of access roads (in a belt no wider than 10 m from the road) on the mainland and on the Pelješac Peninsula. The total length of the roads is 22.14 km. The geographical coordinates of the relevés are given in Appendix 1.

Taxa were determined using the standard determination keys, books and guides listed in Jasprica & Milović (2016), Milović *et al.* (2016), etc. Their biological (*sensu* Raunkiaer, 1934; Pignatti, 1982) and chorological forms (see Tab. 1) were determined according to Jasprica *et al*. (2017). Species whose geographical range is restricted (endemism), IUCN status of taxa (IUCN, 2022) and invasive plant taxa were defined according to Nikolić (2023). Strictly protected taxa in Croatia were defined according to Anonymous (2013b, 2016).

The nomenclature of plant taxa follows the *Euro+Med PlantBase* (Euro+Med, 2006+), except for *Silene vulgaris* (Moench) Garcke subsp. *angustifolia* Hayek and *Cistus incanus* L., for which the *Flora Croatica Database* was used (Nikolić, 2023). Taxa are assigned to vegetation units (classes) using the system of characterizing species reported by Mucina *et al*. (2016) (i.e., for those plants that are considered 'characteristic species' of the classes, see Electronic Appendix S6). The nomenclature of the high-rank vegetation units also follows the syntaxonomic system proposed by Mucina *et al*. (2016), and followed by Škvorc *et al.* (2017) (the EuroVegChecklist).

RESULTS

In autumn 2022, we found 128 taxa (113 species and 11 subspecies; four taxa were defined at genus rank only) over 24 phytosociological relevés collected alongside the road verges (Tab. 1). Road sections built in the last phase (early summer 2022) were covered with gravel (e.g., Sparagovići rest area) and vegetation had not yet developed during this survey (autumn 2022).

The number of taxa per relevé varied from 6 to 22 (an average of 16.1). The vegetation cover ranged from 5 to 90% (an average of 41%). There were a high number of taxa found in only one single relevé (51, i.e. 40%).

The flora was dominated by therophytes (50 taxa, i.e. 40%) and hemicryptophytes (41. 34%) followed by phanerophytes (16.13%), chamaephytes (10.8%) and geophytes (7.5%).

Mediterranean plants (52 taxa, i.e. 41%) followed by a considerable proportion of cosmopolitans (27.22%) dominated the flora (Tab. 1). South-European plants contributed 18%, while Euroasian, cultivated and adventive plants were equally represented (11 taxa in each, i.e. 9%). The occurrence of European taxa was negligible (1%).

The most frequent taxa, found in 42-58% of the relevés, were *Diplotaxis tenuifolia* (L.) DC., *Euphorbia prostrata* Aiton, *Sonchus asper* (L.) Hill subsp. *glaucescens* (Jord.) Ball, *Solanum nigrum* L. and *Bituminaria bituminosa* (L.) Stirton (Tab. 1).

Four taxa (*Carduus nutans* L. subsp. *micropterus* (Borbás) Hayek, *Aurinia sinuata* (L.) Griseb., *Chaerophyllum coloratum* L. and *Galium firmum* Tausch) were considered endemic to Croatia. In addition, three taxa strictly protected by Croatian law (*C. nutans* subsp. *micropterus*, *Ch. coloratum* L. and *G. firmum* Tausch) were also recorded. Two taxa were listed in the Red Book of Vascular Flora of Croatia (*Ch. coloratum* as Near Threatened, NT) and *Euphorbia prostrata* (Least Concern, LC). The status of *E. prostrata* needs to be revised in the Red Book of Vascular Flora of Croatia due to its invasive character.

Eleven neophytes were recorded, most of them originating in the Americas. All were classified as invasive species in Croatia. *Euphorbia prostrata*, *Sorghum halepense* (L.) Pers. and *Conyza bonariensis* (L.) Cronquist were detected most frequently (in 33-58% of the relevés) (Tab. 1).

In the phytosociological spectrum, taxa of *Artemisietea vulgaris* and *Chenopodietea* (16 taxa each, i.e. 14%) formed the largest proportion, followed by taxa of *Festuco-Brometea* (15, 13%), *Papaveretea rhoeadis* (13, 11%), and *Digitario sanguinalis-Eragrostietea minoris* (12, 10%). Taxa from the class *Sisymbrietea* contributed 8%. The proportion of the other classes was less than 8%.

DISCUSSION

After the construction of the access roads to Pelješac Bridge, previously well-developed woody (*Quercetea ilicis*) and garrigue (*Ononido-Rosmarinetea*) plant communities (Jasprica & Dolina, 2009) were replaced by ruderal communities as early as autumn 2022. Road construction directly fragmented forest habitats. The newly disturbed zones create a new microclimate and a change in other physical conditions at different distances from the roadside. On the road verges, species of woody and garrigue vegetation were replaced to a considerable extent by taxa of the *Artemisietea vulgaris* and *Chenopodietea* classes, cosmopolitans and therophytes.

In landscapes fragmented by roads, where spontaneous colonization depends almost entirely on vegetation in the immediate vicinity of the roads, newly constructed roads provide habitats for "edge species" (Spellerberg, 1998). In our study, almost 93%

Tab. 1. Phytosociological relevés of ruderal stands collected three months after completion of road construction on the Pelje©ac Peninsula and mainland in southern Croatia. Geographical coordinates of relevés are listed in Appendix 1. Abbreviations: Life forms (LF): Ch – chamaephytes, G – geophytes, H – hemicryptophytes, P – phanerophytes, T – therophytes. Chorotypes (CHOR), and origin of invasive taxa (neophytes, displayed on a brownish background): AF – Africa, AM – Americas, Co – Cosmopolitan (widespread), CuAd – Cultivate and adventive plants, EU – European, EA – Euroasian, Med – Mediterranean, N – neotropics, SEU – South European. Threatened taxa: LC – Least Concern, NT – Near Threatened. SP – Strictly protected taxa in Croatia. The column "Classes" shows (some) phytosociological classes taxa, as reported on the website https://www.synbiosys.alterra.nl/evc/, on the basis of the EuroVegChecklist (Mucina *et al.*, 2016). Diagnostic species are defined on the class level only:

Relevé number					1	2	3	4	5	6
Localities (M=mainland, PP=Pelješac Peninsula)					PP	PP	PP	PP	PP	PP
Altitude (m a.s.l.)					70	55	75	65	135	135
Aspect					.	.	E	E	.	.
Slope (°)					.	.	5	40	.	.
Plot size (mq)					25	25	20	25	25	25
Vegetation cover (%)					30	40	40	60	50	20
Number of taxa					11	15	18	21	14	14
	LF	CHOR	Status	Classes						
Diplotaxis tenuifolia (L.) DC.	H	Co		DIG	+	+	+	.	+	+
Euphorbia prostrata Aiton	T	CuAd	invasive, LC, AM	DIG	.	2	+	.	2	+
Sonchus asper (L.) Hill subsp. *glaucescens* (Jord.) Ball	H	Med		CHE	.	.	+	.	.	+
Solanum nigrum L.	T	Co		PAR, SIS	.	.	+	.	.	+
Bituminaria bituminosa (L.) Stirton	H	Med		DRY, LYG	2	.	+	+	.	.
Picris hieracioides L.	H	EA		ART	+	+	+	+	.	.
Sorghum halepense (L.) Pers.	G	Co	invasive, EU(Med)	DIG	+	.	2	.	+	.
Chenopodium strictum Roth	T	Co		SIS	.	3	3	.	.	.
Conyza bonariensis (L.) Cronquist	T	CuAd	invasive, AM	CHE, DIG	.	.	+	+	+	.
Erodium malacoides (L.) L'Hér.	T	Med		CHE	+	.	.	.	.	.
Setaria viridis (L.) P.Beauv.	T	EA		DIG	.	2	1	.	+	.
Heliotropium europaeum L.	T	Med		DIG	.	1	.	.	.	.
Bidens subalternans DC.	T	CuAd	invasive, AM	SIS	.	+	+	.	+	.
Sonchus oleraceus L.	T	Co		PAR, SIS	.	.	.	+	.	+
Conyza canadensis (L.) Cronquist	T	CuAd	invasive, AM		.	.	.	.	.	.
Asphodelus fistulosus L.	H	Med		CHE	+	.	.	.	.	+
Cynodon dactylon (L.) Pers.	G	Co		DIG	.	+	.	+	.	.
Dittrichia viscosa (L.) Greuter	H	Med		ART, LYG	.	.	+	+	.	.
Cistus incanus L.	P	Med		ROS	.	.	.	.	.	.
Lactuca serriola L.	H	Co		SIS	.	.	.	.	.	.
Phillyrea latifolia L.	P	Med		QUI	.	.	.	.	.	.
Tribulus terrestris L.	T	SEU		DIG	+	+	.	.	.	.

ART – *Artemisietea vulgaris*, ASP – *Asplenietea trichomanis*, BUL – *Poetea bulbosae*, CAK – *Cakiletea maritimae*, CHE – *Chenopodietea*, COR – *Koelerio-Corynephoretea canescentis*, CRU – *Helichryso-Crucianelletea maritimae*, CYM – *Cymbalario-Parietarietea diffusae*, DIG – *Digitario sanguinalis-Eragrostietea minoris*, DRY – *Drypidetea spinosae*, EPI – *Epilobietea angustifolii*, FES – *Festuco-Brometea*, GER – *Trifolio-Geranietea sanguinei*, LAU – *Pruno lusitanicae-Lauretea azoricae*, LAV – *Cisto-Lavanduletea stoechadis*, LYG – *Lygeo sparti-Stipetea tenacissimae*, MOL – *Molinio-Arrhenatheretea*, ONO – *Festuco hystricis-Ononidetea striatae*, PAR – *Papaveretea rhoeadis*, PUB – *Quercetea pubescentis*, QUI – *Quercetea ilicis*, RHA – *Crataego-Prunetea*, ROS – *Ononido-Rosmarinetea*, SED – *Sedo-Scleranthetea*, SIS – *Sisymbrietea*, THL – *Thlaspietea rotundifolii*, TRA – *Stipo-Trachynietea distachyae*, TUB – *Helianthemetea guttati*.

7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
PP	PP	PP	PP	PP	PP	PP	PP	PP	PP	M	M	M	M	M	M	M	M		
160	200	200	175	180	185	205	220	75	30	60	60	75	7	11	157	155	155		
N	S	.	N	.	.	.	.	S	S	.	.	SW	SE	NE	.	SE	.		
20	90	.	10	.	.	.	.	10	10	.	.	40	20	10	.	5	.		
25	20	5	25	20	20	25	25	25	50	5	25	20	20	15	25	10	20		
40	5	60	40	30	20	40	15	20	10	65	50	90	30	35	80	50	70		
20	6	12	15	11	6	15	15	20	23	19	18	15	24	25	15	13	22	fN	f%
+	.	1	+	.	.	.	.	.	.	2	+	.	1	+	.	+	1	14	58
.	.	+	.	.	.	+	.	.	+	+	3	.	+	2	.	1	+	13	54
.	+	.	+	+	+	.	1	2	+	+	+	.	.	.	.	.	+	12	50
.	+	2	3	.	.	.	+	+	+	.	+	+	+	.	.	.	.	11	46
2	.	.	.	.	.	+	.	+	+	.	1	.	+	2	.	.	.	10	42
.	.	+	1	.	.	.	+	.	.	.	.	.	.	.	+	.	+	9	38
.	.	.	.	.	.	.	.	+	.	1	+	.	.	.	+	.	1	8	33
.	.	.	.	.	.	2	.	+	+	+	2	.	.	.	.	+	.	8	33
+	+	.	.	.	.	.	+	.	.	.	2	.	.	.	1	.	.	8	33
+	.	.	.	.	.	+	.	.	.	2	.	.	1	.	.	1	+	7	29
.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	1	7	29
.	.	.	.	.	.	.	.	+	.	+	.	+	.	+	+	.	3	7	29
+	.	.	.	.	.	.	.	.	.	1	+	+	.	.	.	.	.	7	29
.	+	.	+	.	2	.	+	.	+	.	.	.	.	.	.	.	.	7	29
.	.	3	.	.	.	.	+	2	+	.	.	5	.	1	.	.	1	7	29
.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	+	.	6	25
.	.	.	.	.	.	.	+	.	.	1	.	.	.	.	.	+	+	6	25
+	.	.	.	.	.	.	.	.	2	.	+	.	.	.	1	.	.	6	25
+	.	.	.	+	+	.	+	+	.	.	.	1	.	.	.	.	.	6	25
+	+	+	.	.	.	.	.	.	+	.	.	+	.	.	.	.	+	6	25
+	.	.	.	+	.	.	.	+	+	.	.	+	+	.	.	.	.	6	25
.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	4	5	21

Tab. 1. Continued

Relevé number					1	2	3	4	5	6
Plantago lanceolata L.	H	Co		ART, BUL, COR, MOL	.	+	1	.	2	.
Daucus carota L.	H	EA		ART, MOL	.	.	+	.	.	.
Silene vulgaris (Moench) Garcke subsp. *angustifolia* Hayek	H	EA		ART	.	.	.	.	.	.
Setaria verticillata (L.) P.Beauv.	T	Co		DIG	.	.	.	.	.	.
Rubus ulmifolius Schott	P	Med		RHA	.	.	.	.	.	.
Melilotus italicus (L.) Lam.	T	SEU		CHE	.	+	+	.	.	+
Mercurialis annua L.	T	Co		PAR	.	+	.	.	.	.
Anagallis arvensis L.	T	Co		PAR	.	.	+	.	.	.
Taraxacum officinale aggr.	H	Co			.	.	.	+	+	.
Conyza sumatrensis (Retz.) E. Walker	T	CuAd	invasive, AM	CHE, DIG	.	.	.	.	.	.
Senecio vulgaris L.	T	Co		PAR, SIS	.	.	.	.	.	.
Medicago sp.					.	.	.	.	.	.
Portulaca oleracea L.	T	Co		DIG	.	.	.	.	.	.
Sanguisorba minor Scop. subsp. *balearica* (Nyman) Muñoz Garm. & C. Navarro	H	SEU		FES	.	.	.	.	.	.
Pistacia lentiscus L.	P	Med		QUI	.	.	.	.	.	.
Ecballium elaterium (L.) A. Rich.	G	Med		CHE	+	.	.	.	.	.
Echium plantagineum L.	T	Med		CHE, CRU	+	+	.	.	.	.
Rumex pulcher L.	H	SEU		CHE	.	.	+	.	.	+
Convolvulus arvensis L.	G	Co		PAR, SIS	.	.	.	2	+	.
Dorycnium hirsutum (L.) Ser.	Ch	Med		ROS	.	.	.	2	.	.
Urospermum picroides (L.) Scop. ex F.W.Schmidt	T	Med		CHE	.	.	.	+	.	.
Verbascum thapsus L.	H	EU		ART, EPI	.	.	.	1	.	.
Dactylis glomerata L. subsp. *hispanica* (Roth) Nyman	H	Med		LYG	.	.	.	+	.	.
Hippocrepis emerus subsp. *emeroides* (Boiss. & Spruner) Lassen	P	Med		PUB	.	.	.	+	.	.
Malva sylvestris L.	H	Co		ART, CHE, SIS	.	.	.	.	+	.
Reseda phyteuma L.	T	SEU		SED, SIS	.	.	.	.	.	+
Cistus salvifolius L.	P	Med		ROS, LAV	.	.	.	.	.	.
Lactuca viminea (L.) J. et C. Presl	H	SEU		DRY, FES	.	.	.	.	.	.
Sonchus tenerrimus L.	T	Med		CHE, CYM	.	.	.	.	.	.
Scorpiurus muricatus L.	T	SEU		CHE, TUB	.	.	.	.	.	.
Amaranthus deflexus L.	T	CuAd	invasive, AM	DIG	.	+	.	.	+	.
Erica arborea L.	P	Med		QUI, LAU	.	+	.	.	.	.
Tagetes minuta L.	T	CuAd	invasive, AM		+	.	.	.	.	.
Dorycnium pentaphyllum Scop.	H	SEU		FES, ROS	.	.	.	+	.	.
Smilax aspera L.	P	Med		QUI	.	.	.	+	.	.

7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
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.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	2	8.3

Tab. 1. Continued

Relevé number					1	2	3	4	5	6
Tussilago farfara L.	G	EA		ART	.	.	.	+	.	+
Teucrium chamaedrys L.	Ch	SEU		FES, GER	.	.	.	+	.	.
Cichorium intybus L.	H	Co		ART	.	.	.	.	1	.
Herniaria glabra L.	T	EA		BUL, COR, POL	.	.	.	.	r	.
Crucianella latifolia L.	T	Med		THL	.	.	.	.	.	+
Geranium molle L.	T	Co		SIS	.	.	.	.	.	+
Euphorbia helioscopia L.	T	Co		PAR	.	.	.	.	.	+
Carduus nutans L. subsp. *micropterus* (Borbás) Hayek	H	Med	endemic, SP	ART	.	.	.	.	.	.
Vicia sp.					.	.	.	.	.	.
Inula verbascifolia (Willd.) Hausskn.	Ch	Med		ASP	.	.	.	.	.	.
Cynoglossum creticum Mill.	T	Med		ART, CHE	.	.	.	.	.	.
Bothriochloa ischaemum (L.) Keng	H	SEU		FES	.	.	.	.	.	.
Fumaria sp.					.	.	.	.	.	.
Colutea arborescens L.	P	Med		PUB	.	.	.	.	.	.
Aster squamatus (Spreng.) Hieron.	T	CuAd	invasive, AM	ART, LYG	.	.	.	.	.	.
Picnomon acarna (L.) Cass.	H	Med		ART, CHE	.	.	.	.	.	.
Satureja montana L. subsp. *variegata* (Host) P. W. Ball	Ch	Med		FES, ONO	.	.	.	.	.	.
Aurinia sinuata (L.) Griseb.	Ch	Med	endemic	ASP	.	.	.	.	.	.
Amaranthus retroflexus L.	T	Co		SIS	.	.	.	.	.	.
Cirsium arvense (L.) Scop.	G	EA		PAR, SIS	.	.	.	.	.	.
Melica ciliata L.	H	EA		FES, THL	.	.	.	.	.	.
Centaurea sp.					.	.	.	.	.	.
Echium italicum L.	H	Med		ART, CHE	.	.	.	.	.	.
Amaranthus viridis L.	T	SEU		DIG	+	.	.	.	.	.
Ajuga chamaepitys (L.) Schreb.	T	Med		PAR	.	.	+	.	.	.
Brachypodium retusum (Pers.) P. Beauv.	T	Med		LYG, ROS	.	.	.	+	.	.
Clematis flammula L.	P	Med		QUI	.	.	.	+	.	.
Rubia peregrina L.	P	Med		QUI	.	.	.	+	.	.
Verbena officinalis L.	H	Co		MOL	.	.	.	+	.	.
Verbascum sinuatum L.	H	Med		ART, CRU, LYG	.	.	.	.	+	.
Hyparrhenia hirta (L.) Stapf	H	Med		FES	.	.	.	.	.	+
Aethionema saxatile (L.) W. T. Aiton	Ch	SEU		SED, THL	.	.	.	.	.	.
Anthemis arvensis L.	T	EA		PAR	.	.	.	.	.	.
Helianthemum salicifolium (L.) Mill.	T	SEU		FES	.	.	.	.	.	.
Scrophularia canina L.	H	SEU		CHE, EPI	.	.	.	.	.	.
Eryngium amethystinum L.	H	Med		FES	.	.	.	.	.	.

7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
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.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4.2

Tab. 1. Continued

Relevé number					1	2	3	4	5	6
Linum tenuifolium L.	Ch	SEU		FES, ONO	.	.	.	.	.	.
Chrysopogon gryllus (L.) Trin.	H	Med		FES	.	.	.	.	.	.
Fumana ericifolia Wallr.	Ch	Med		ROS	.	.	.	.	.	.
Asparagus acutifolius L.	G	Med		QUI	.	.	.	.	.	.
Eryngium campestre L.	H	SEU		FES	.	.	.	.	.	.
Geranium columbinum L.	T	EA		SIS	.	.	.	.	.	.
Trifolium campestre Schreb.	T	Co		SED, TRA	.	.	.	.	.	.
Stachys cretica subsp. *salviifolia* (Ten.) Rech. f.	H	Med		ROS	.	.	.	.	.	.
Erodium cicutarium (L.) L'Hér.	T	Co		BUL, SED, SIS	.	.	.	.	.	.
Salvia officinalis L.	Ch	Med		FES	.	.	.	.	.	.
Petrorhagia prolifera (L.) P. W. Ball & Heywood	T	EA		SED	.	.	.	.	.	.
Raphanus raphanistrum L.	T	SEU		PAR	.	.	.	.	.	.
Hippocrepis biflora Spreng.	T	SEU		TRA	.	.	.	.	.	.
Beta vulgaris subsp. *maritima* (L.) Arcang.	H	Med		CAK	.	.	.	.	.	.
Citrullus lanatus (Thunb.) Matsum. & Nakai	P	CuAd			.	.	.	.	.	.
Chenopodium album L.	T	Co		SIS	.	.	.	.	.	.
Erica manipuliflora Salisb.	Ch	Med		ROS	.	.	.	.	.	.
Euphorbia characias subsp. *wulfenii* (Hoppe ex W. D. J. Koch) Radcl.-Sm.	P	Med		ASP, QUI	.	.	.	.	.	.
Fallopia baldschuanica (Regel) Holub	P	CuAd		PAR	.	.	.	.	.	.
Ficus carica L.	P	Med		CYM, QUI	.	.	.	.	.	.
Euphorbia peplus L.	T	Co		PAR	.	.	.	.	.	.
Piptatherum miliaceum (L.) Coss.	H	Med		LYG, QUI	.	.	.	.	.	.
Lotus corniculatus L.	H	Co		MOL	.	.	.	.	.	.
Thelygonum cynocrambe L.	T	SEU		CHE	.	.	.	.	.	.
Tordylium apulum L.	T	Med		CHE, TRA	.	.	.	.	.	.
Amaranthus hybridus L.	T	Co	invasive, N	SIS	.	.	.	.	.	.
Campanula lingulata Waldst. et Kit.	H	SEU		ASP	.	.	.	.	.	.
Microrrhinum minus (L.) Fourr. subsp. *minus*	T	EU		SIS, THL, TRA	.	.	.	.	.	.
Chaerophyllum coloratum L.	H	Med	endemic, NT, SP	FES	.	.	.	.	.	.
Cleistogenes serotina (L.) Keng	H	SEU		FES	.	.	.	.	.	.
Eleusine indica (L.) Gaertn.	T	CuAd	invasive, AF	DIG	.	.	.	.	.	.
Frangula rupestris (Scop.) Schur	P	Med		PUB, RHA	.	.	.	.	.	.
Galium firmum Tausch	H	Med	endemic, SP	ASP	.	.	.	.	.	.
Foeniculum vulgare Mill.	H	Med		ART, LYG	.	.	.	.	.	.
Reichardia picroides (L.) Roth	H	Med		CHE, LYG	.	.	.	.	.	.

7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
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of species occurring along roads were not previously detected in the flora of the surrounding communities (Jasprica in Nikolić, 2023). These species could have been introduced by human dispersal mechanisms via machinery during road construction (Schmidt, 1989) or migrated along the roads (Tikka *et al.*, 2001). Alternatively, it is also possible that this species group is not included in the list of surrounding species due to methodological limitations in the survey. However, according to van Dorp *et al.* (1997), migration rates of species along narrow and unproductive landscape features such as roads should be low.

On the other hand, the results of Pauchard & Alaback (2004) suggest that both alien and native species move along road corridors and that the elevation and land use of the surrounding matrix influence these invasion processes. Their findings also confirm the importance of early detection and control of invasive species and underscore the importance of considering surrounding land use when developing conservation strategies for the area as a whole.

Although this study is preliminary, the dominance of therophytes and Mediterranean taxa with a significant proportion of cosmopolitans is consistent with previous studies for anthropogenic habitats subject to intense human pressures (see e.g., Jasprica *et al.*, 2017). This is not unexpected, as the short generation time and large number of easily dispersed seeds make therophytes very effective colonizers with a high tolerance to disturbance. In general, these taxa have a significant impact on the physiognomy of this type of man-made habitat. Several studies have also shown that some

Fig. 2. Ruderal sites along the access roads to Pelješac Bridge in autumn 2022: above the village of Komarna on the mainland (A), near the villages of Brijesta (B), Dančanje (C) and Metohija (D), and above Prapratno Bay (E-F) on the Pelješac Peninsula (photo: N. Jasprica).

native species expand their range and reach new areas along roadsides (Brauer & Geber, 2002; Ahrens *et al*., 2014), which could lead to changes in biodiversity, species composition, and abundance of plant species.

The phytosociological spectrum, and in particular the considerable contribution of taxa of *Artemisietea vulgaris* and *Chenopodietea*, among others, suggests, at least in part, that the flora of the sites studied lacks links to the plant communities of its biogeographical context (e.g., Dunnett & Hitchmough, 2004). Interestingly, the most common taxa (e.g., *Diplotaxis tenuifolia*, *Sonchus asper* subsp. *glaucescens*, *Solanum nigrum*, *Parietaria judaica*, etc.) are associated with different classes. This was also discussed by Jasprica & Milović (2020) and is related to the type of habitat disturbance. However, it is important to emphasize that some roadsides are subjected to periodic disturbances that promote communities with a low stability (Jantunen *et al*., 2006). Furthermore, in many cases, roadsides provide only a limited area for vegetation establishment, which may reduce the probability of stable populations being established (Lázaro-Lobo & Ervin, 2019). In addition, roads and other anthropogenic disturbances can result in the absence of complete native communities and the presence of only a selection of species (Armstrong *et al*., 2019). Microsites suitable for the establishment of many local plant species could also be scarce along roadsides within a small area (Petrů & Menges, 2004).

In our case, the percentage contribution of the neophytes (9%) has also documented roads as corridors for the spread of non-native plants (Hansen & Clevenger, 2005). In general, the pattern of neophytes is most influenced by site conditions (Šilc *et al*., 2012).

Our study includes a floristic and ecological survey on only a relatively small area. Nevertheless, it can contribute to the overall knowledge of the flora of roadsides at the beginning of a colonization period, when anthropogenic influence and spontaneous overgrowth of vegetation are still low. However, from a purely scientific point of view, it would be interesting to determine species richness and plant sociology at the same sites over longer periods of road traffic. Seasonality of the survey could play a large role, and a survey in the spring after the road is completed could reveal annual species that are absent later in autumn. Our analysis will then help develop a broader understanding of the management and conservation potential of this habitat type.

In summary, roadside characteristics and species requirements strongly influence the role of roadsides as habitat, corridors, or barriers for plant species. In general, the positive effect of roadsides on non-native/weed species is overwhelmingly supported, while their effect on native species in the early stages of plant colonization across the Mediterranean is still not known. Some authors (e.g., Lázaro-Lobo & Ervin, 2019) suggest that the effects on native species are, on average, more positive than might have been expected. We suggest that native plant species should be used in roadside revegetation, especially in sections where new open habitats are created and in other parts that are sensitive to additional fragmentation.

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Appendix 1

Geographical coordinates of the relevés.

Tab. 1. Pelješac Peninsula (rels. 1-16, 21.-23.10.2022.): Rel. 1: 42.819598 N, 17.675894 E; Rel. 2: 42.823061 N, 17.680233 E; Rel. 3: 42.820327 N, 17.678168 E; Rel. 4: 42.822764 N, 17.669930 E; Rel. 5: 42.831298 N, 17.646754 E; Rel. 6: 42.830941 N, 17.647079 E; Rel. 7: 42.832278 N, 17.643281 E; Rel. 8: 42.836610 N, 17.631972 E; Rel. 9: 42.836455 N, 17.632419 E; Rel. 10: 42.840928 N, 17.605257 E; Rel. 11: 42.965626 N, 17.517887 E; Rel. 12: 42.848267 N, 17.592109 E; Rel. 13: 42.858439 N, 17.574851 E; Rel. 14: 42.865243 N, 17.567148 E; Rel. 15: 42.907982 N, 17.537841 E; Rel. 16: 42.919828 N, 17.527414 N; Mainland (rels. 17-24): (rels. 17-21, 29.10.2022.) 5.11.2022.), Rel. 17: 42.947245 N, 17.535142 E; Rel. 18: 42.947295 N, 17.534535 E; Rel. 19: 42.945445 N, 17.537004 E; Rel. 20: 42.941675 N, 17.537230 E; Rel. 21: 42.942405 N, 17.540717 E; (rels. 22-24, 5.11.2022.) Rel. 22: 42.964867 N, 17.517650 E; Rel. 23: 42.965223 N, 17.517555 E; Rel. 24: 42.841608 N, 17.602865 E.

Appendix 2

Syntaxa quoted in the text and table (in alphabetical order).

Artemisietea vulgaris Lohmeyer et al. in Tx. ex von Rochow 1951

Asplenietea trichomanis (Br.-Bl. in Meier et Br.-Bl. 1934) Oberd. 1977

Cakiletea maritimae Tx. et Preising in Tx. ex Br.-Bl. et Tx. 1952

Chenopodietea Br.-Bl. in Br.-Bl. et al. 1952

Cisto-Lavanduletea stoechadis Br.-Bl. in Br.-Bl. et al. 1940

Crataego-Prunetea Tx. 1962

Cymbalario-Parietarietea diffusae Oberd. 1969

Digitario sanguinalis-Eragrostietea minoris Mucina, Lososová et Šilc in Mucina et al. 2016

Drypidetea spinosae Quézel 1964

Epilobietea angustifolii Tx. et Preising ex von Rochow 1951

Festuco hystricis-Ononidetea striatae Rivas-Mart. et al. 2002

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

Fraxino orni-Quercion ilicis Biondi et al. ex Biondi, Casavecchia et Gigante 2013

Helianthemetea guttati Rivas Goday et Rivas-Mart. 1963

Helichryso-Crucianelletea maritimae Géhu et al. in Sissingh 1974

Koelerio-Corynephoretea canescentis Klika in Klika et Novák 1941

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

Molinio-Arrhenatheretea Tx. 1937

Oleo-Ceratonion siliquae Br.-Bl. ex Guinochet et Drouineau 1944

Ononido-Rosmarinetea Br.-Bl. in A. Bolòs y Vayreda 1950

Papaveretea rhoeadis S. Brullo et al. 2001 nom. conserv. propos.

Poetea bulbosae Rivas Goday et Rivas-Mart. in Rivas-Mart. 1978

Pruno lusitanicae-Lauretea azoricae Oberd. ex Rivas-Mart. et al. 1977

Quercetea ilicis Br.-Bl. ex A. Bolós et O. de Bolòs in A. Bolòs y Vayreda 1950

Quercetea pubescentis Doing-Kraft ex Scamoni et Passarge 1959

Sedo-Scleranthetea Br.-Bl. 1955

Sisymbrietea Gutte et Hilbig 1975

Stipo-Trachynietea distachyae S. Brullo in S. Brullo et al. 2001

Thlaspietea rotundifolii Br.-Bl. 1948

Trifolio-Geranietea sanguinei T. Müller 1962