Acta Bot. Croat. 79 (1), 43–54, 2019
DOI: 10.37427/botcro-2020-003

CODEN: ABCRA 25
ISSN 0365-0588
eISSN 1847-8476

Coastal sand dune vegetation of Velika plaža (Montenegro)

Danijela Stešević[1], Filip Küzmič[2], Đorđije Milanović[3], Milica Stanišić-Vujačić[1], Urban Šilc[2]*

[1] Faculty of Natural Sciences and Mathematics, University of Montenegro, Džordža Vašingtona bb, 81000 Podgorica, Montenegro

[2] Research Centre of the Slovenian Academy of Sciences and Arts, Institute of Biology, Novi Trg 2, 1000 Ljubljana, Slovenia

[3] Faculty of Forestry, University of Banja Luka, S. Stepanovića 75a, 78000 Banja Luka, Bosnia and Herzegovina

Abstract – Velika plaža (Ulcinj, Montenegro) is the largest sandy beach along the coast of the eastern Adriatic that still has well-developed sand-dune vegetation. Although the characterization of the flora and vegetation of Velika plaža has been addressed by many authors, knowledge on its vegetation remained poor. We made a phytosociological study of sandy beach vegetation comprising both dunal and wetland areas to provide a comprehensive survey of sand dune vegetation and habitat typology of Velika plaža. Based on 149 relevés (both from literature and recent field work), and with numerical classification (Flexible beta) and ordination (Non-metric multidimensional scaling) our results show that the vegetation of Velika plaža is much more diverse than previously known. Altogether, 19 plant communities from 6 vegetation classes were identified. Among them we described two new associations: *Cuscuto cesatianae-Phyletum nodiflorae* and *Onobrychido caput-galli-Vulpietum fasciculatae*.

Keywords: classification, endangered, habitat types, plant communities, psammophytic, sandy beach, syntaxonomy

Introduction

Sand dunes are one of the most extreme ecosystems due to abiotic environmental factors, and among the most endangered, due to various kinds of human impact (Maun 2009). These two factors account for the high research interest of the remaining sandy beaches and their biota.

Thirty coastal habitats are included in the European Red list of habitats as they are experiencing decline in extent and quality (Janssen et al. 2016). In fact it is estimated that about 70% of dune ecosystems of European coasts were lost during the last century due to urbanization (Brown and McLachlan 2002).

Velika plaža (Fig. 1) is the largest sandy beach along the eastern Adriatic coast with still well-developed vegetation. Coasts along the NE Adriatic are mainly rocky and steep (see Šilc et al. 2016a), and anthropogenic impact on many sandy beaches has destroyed or depauperated the vegetation, so that in some locations (Nin and Velika Saplunara, Croatia) only fragments are still developed. Surveys of sand dune vegetation (Marcenò et al. 2018, Šilc et al. 2016a) show gaps of vegetation data along the eastern Adriatic coast and our study contributes to filling them.

Characterization of flora and vegetation of Velika plaža have been researched by many authors (Bubanja 2016, Bubanja et al. 2019, and references therein). Recently several studies for different purposes were conducted to present the impact of alien species (Stešević et al. 2017a, Šilc et al. 2019), trampling (Šilc et al. 2017), and litter on vegetation (Šilc et al. 2018) as well as human impact in general (Šilc et al. 2016b), but a complete overview of vegetation communities has never been made. According to several authors (Trinajstić 1989a, Mijović 1994, Mijović et al. 2006, 2012,) only two plant communities were reported for Velika plaža: *Cakilo-Xanthietum italici* and *Euphorbio paraliae-Agropyretum junceiformis*; however, recent studies (Šilc et al. 2019, Stešević et al. 2017b) have suggested that the vegetation of Velika plaža is much more diverse.

The aim of our study was to make a comprehensive survey of sand dune vegetation of the largest sand beach system in Eastern Adriatic with own field work and literature data,

* Corresponding author e-mail: urban@zrc-sazu.si

and to present our results also in the view of habitat typology of Habitat Directive (European Communities Council 1992).

Materials and methods

Study area

Velika plaža in Ulcinj (Montenegro) is considered to be the northernmost and longest beach on the eastern Adriatic coast (ca. 12 km), with still well preserved sand dune vegetation. Since 1968, the beach has been recognized as a monument of nature (Official Gazette of the Socialist Republic of Montenegro, SRCG 30/68). According to the Spatial Plan of Special Purpose for the Coastal Zone, one spatial unit on the east side of Velika plaža is recognized as a newly protected nature reserve, with forests, marshes and meadows. The area is protected from trampling or grazing with a wooden fence (JPMD 2015). However, the rest of the beach, which represents more than 75% of the natural coast and 97% of whole sand dune system, is heavily impacted by tourism, illegal dumping, sand extraction and urbanization (Petrović and Karaman 2009). Eleven NATURA 2000 habitats are reported for the beach and its hinterland: Annual vegetation of drift lines (1210), Embryonic shifting dunes (2110), Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes, 2120), Fixed coastal dunes with herbaceous vegetation (grey dunes, 2130*), Humid dune slacks (2190), Dunes with *Euphorbia terracina* (2220), Mediterranean salt meadows (*Juncetalia maritimae*) (1410), *Brachypodietalia* dune grasslands with annuals (2240), Wooded dunes with *Pinus pinea* and/or *Pinus pinaster* (2270*), Mediterranean temporary ponds (3170), and *Salix alba* and *Populus alba* galleries (92A0) (Petrović et al. 2012). The site is included in the list of IPA areas (Petrović and Karaman 2009).

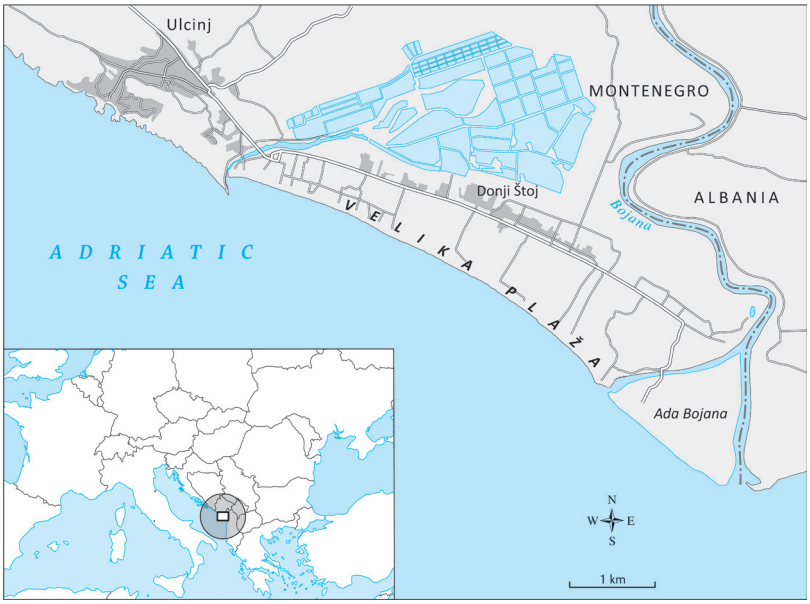

Fig. 1. Sandy beach Velika plaža in Montenegro.

Sampling and data analysis

In the period of 2012–2019 we recorded 93 relevés of all the vegetation types found on the sand dune system according to the standard Central European method (Braun-Blanquet 1964, van der Maarel 2005). The new relevés made on sand dunes (On-line Suppl. Tabs. 1 and 2) and some from the literature (Trinajstić 1989a, Mijović 1994, Mijović et al. 2006, 2012,) were entered into the Turboveg 2 database (Hennekens and Schaminée 2001).

For the first step, numerical classification, we used a larger (149 original and published relevés) and a smaller (93 original relevés) dataset to find out the general structure. As both analyses revealed similar pattern, for further numerical analysis we used only the original relevés as those from the literature had large plot sizes, were not made for syntaxonomical study or were frequently transitional. Nevertheless we used them in ordination analysis of whole dataset.

Numerical classification (Flexible beta (β = -0.25) and Relative Sørensen) was performed on the 93 original relevés. Some of the transitional relevés were later classified according to expert knowledge. Diagnostic species for the plant communities were determined in the JUICE program (Tichý 2002) by their fidelity values (Chytrý et al. 2002). The size of all groups was standardized to equal sizes (Tichý and Chytrý 2006), and the Fisher's exact test ($P < 0.05$) was applied. Species with Phi-coefficient values higher than 0.20 were considered as diagnostic.

Unweighted average ecological indicator values (Pignatti et al. 2005) of relevés were passively projected onto a non-metric multidimensional scaling (NMDS) biplot (Bray-Curtis distance measure used) to show ecological relationship among these relevés and to explain environmental gradients underlying the main ordination axes. Log transformed cover data were used as the input data and all 149 relevés were used in this analysis. Analysis was performed in program R (R Development Core Team 2012) using the vegan package in the JUICE program (Tichý 2002).

The nomenclature of taxa follows Euro+Med (2006). Syntaxonomical concepts and nomenclature of higher syntaxa follow Mucina et al. (2016). For the crosswalk between vegetation syntaxa and habitat types, we refer to the Catalogue of habitat types of Montenegro important for the Europe (Petrović et al. 2012).

Results

We compiled a set of 149 relevés (93 original) and identified 19 plant communities classified into six vegetation classes. They are presented in the syntaxonomical scheme and described in brief. The first classification, using the whole dataset of 149 relevés (not shown), identified two main clusters separating sand dune and wetland vegetation on the sandy beach. In the next step we classified each of these two clusters separately (Figs. 2, 3).

Tab. 1. Shortened synoptic table of studied syntaxa. Diagnostic species with fidelity index *phi* higher than 0.20 are presented. Columns: 1 – *Juncetum maritimo-acuti*, 2 – *Limonio narbonensis-Juncetum gerardii*, 3 – *Cuscuto cesatianae-Phyletum nodiflorae*, 4 – *Eriantho-Schoenetum nigricantis*, 5 – *Holoschoenetum romani*, 6 – *Cakilo-Xanthietum strumarii*, 7 –*Euphorbio paraliae-Agropyretum junceiformis*, 8 – *Medicagini marinae-Ammophiletum australis*, 9 – *Cutandia maritima* community, 10 – *Euphorbio terracinae-Silenetum nicaeensis*, 11 – *Onobrychido caput-galli-Vulpietum fasciculatae*, 12 – *Scirpetum maritimo-litoralis*, 13 – *Phragmitetum communis*, 14 – *Typhetum angustifoliae*, 15 – *Scirpetum lacustris*, 16 – *Cladietum marisci*, 17 – *Cyperetum longi*, 18 – *Cyperetum flavescentis*, 19 – *Cypero-Paspaletum distichi*.

Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Number of relevés	4	2	12	7	4	8	7	6	5	7	7	7	4	1	1	7	1	1	2
Juncus maritimus	57.6	---	---	25.6	3.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Juncus acutus	42	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Juncus gerardi	---	83.4	---	---	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Phyla nodiflora	---	---	49	---	---	---	---	---	---	---	---	12.5	---	---	---	---	---	---	---
Cuscuta australis ssp. *cesatiana*	---	---	43	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Centaurium spicatum	---	---	21.7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Polypogon maritimus	---	---	24.7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Bidens frondosus	---	---	24.2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Schoenus nigricans	---	---	---	74.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Tripidium ravennae	---	---	---	75.2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Rubus ulmifolius	---	---	---	28.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Linum bienne	---	---	---	24.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Serapias vomeracea	---	---	---	20.7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Scirpoides holoschoenus	---	---	22.3	7.8	30.3	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Carex distans	---	---	---	---	20.3	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Lysimachia vulgaris	---	---	---	---	20.3	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Xanthium orientale ssp. *italicum*	---	---	11.7	---	---	12.2	---	---	---	---	---	---	---	---	---	---	---	---	---
Cakile maritima	---	---	---	---	---	17.7	10.3	---	---	---	---	---	---	---	---	---	---	---	---
Salsola kali	---	---	---	---	---	18.2	---	---	23.8	---	---	---	---	---	---	---	---	---	---
Cyperus capitatus	---	---	---	---	---	---	35.3	19.6	---	---	---	---	---	---	---	---	---	---	---
Echinophora spinosa	---	---	---	---	---	12	29.9	13.6	---	---	---	---	---	---	---	---	---	---	---
Eryngium maritimum	---	---	---	---	---	11	29	13.6	---	---	---	---	---	---	---	---	---	---	---
Pancratium maritimum	---	---	---	---	---	---	22.7	---	7.1	---	9.7	---	---	---	---	---	---	---	---
Equisetum ramosissimum	---	---	---	---	---	---	26.5	---	---	---	---	---	---	---	---	---	---	---	---
Anisantha madritensis	---	---	---	---	---	---	24.6	---	---	---	---	---	---	---	---	---	---	---	---
Ammophila arenaria	---	---	---	---	---	---	---	66.8	---	---	---	---	---	---	---	---	---	---	---
Cutandia maritima	---	---	---	---	---	---	---	---	57	---	---	---	---	---	---	---	---	---	---
Phleum arenarium	---	---	---	---	---	---	---	---	40.8	---	---	---	---	---	---	---	---	---	---
Anisantha sterilis	---	---	---	---	---	---	---	---	23	---	21.8	---	---	---	---	---	---	---	---
Medicago littoralis	---	---	---	---	---	---	---	9.7	20.5	10.2	11.6	---	---	---	---	---	---	---	---
Calystegia soldanella	---	---	---	---	---	---	---	8.6	20.3	---	---	---	---	---	---	---	---	---	---
Euphorbia terracina	---	---	---	---	---	---	---	---	---	57.3	---	---	---	---	---	---	---	---	---
Artemisia campestris	---	---	---	---	---	---	9.5	---	---	40.6	---	---	---	---	---	---	---	---	---
Medicago marina	---	---	---	---	---	---	12.1	---	7.4	42.6	---	---	---	---	---	---	---	---	---
Vulpia fasciculata	---	---	---	---	---	---	---	3	---	39.3	47.2	---	---	---	---	---	---	---	---
Alkanna tinctoria	---	---	---	---	---	---	---	---	---	33.3	27.8	---	---	---	---	---	---	---	---
Hedypnois rhagadioloides	---	---	---	---	---	---	---	---	---	25.5	---	---	---	---	---	---	---	---	---
Valerianella sp.	---	---	---	---	---	---	---	---	---	20.7	---	---	---	---	---	---	---	---	---
Onobrychis caput-galli	---	---	---	---	---	---	---	---	5.3	---	70.6	---	---	---	---	---	---	---	---
Hypochaeris glabra	---	---	---	---	---	---	---	---	---	---	30.9	---	---	---	---	---	---	---	---
Lagurus ovatus	---	---	---	---	---	---	9.7	---	---	---	28	---	---	---	---	---	---	---	---
Typha latifolia	---	---	---	---	---	---	---	---	---	---	24.9	---	---	---	---	---	---	---	---
Dasypyrum villosum	---	---	---	---	---	---	---	---	---	---	20.7	---	---	---	---	---	---	---	---
Bolboschoenus maritimus	---	4.6	---	---	---	---	---	---	---	---	---	48.1	---	---	---	---	---	---	---
Juncus compressus	---	---	---	---	---	---	---	---	---	---	---	22.1	---	---	---	---	---	---	---
Phragmites australis	---	---	---	---	---	---	---	---	---	---	---	---	62.8	---	---	---	---	---	---
Baldellia ranunculoides	---	---	---	---	---	---	---	---	---	---	---	---	21	---	---	---	---	---	---
Nymphaea alba	---	---	---	---	---	---	---	---	---	---	---	---	20.3	---	---	---	---	---	---
Butomus umbellatus	---	---	---	---	---	---	---	---	---	---	---	---	29.3	---	---	---	---	---	---
Schoenoplectus lacustris ssp. *glaucus*	---	---	---	---	---	---	---	---	---	---	---	---	---	31.6	---	---	---	---	---
Potamogeton lucens	---	---	---	---	---	---	---	---	---	---	---	---	---	26	20.6	---	---	---	---
Utricularia vulgaris	---	---	---	---	---	---	---	---	---	---	---	---	---	27.3	27.3	---	---	---	---
Schoenoplectus litoralis	---	---	---	---	---	---	---	---	---	---	---	11.6	---	---	68.6	---	---	---	---
Cladium mariscus	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	86.7	---	---	---
Gratiola officinalis	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	20.4	---	---	---
Cyperus longus	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	96.7	---	---
Potentilla reptans	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	52.6	---	---
Oenanthe pimpinelloides	---	---	3.8	---	---	---	---	---	---	---	---	---	---	---	---	---	33.7	---	---
Poa trivialis	---	---	---	7.5	---	---	---	---	---	---	---	---	---	---	---	---	31.9	---	---
Calystegia sepium	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	52.2	---	---
Rumex conglomeratus	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	35.1	---	---
Vicia villosa ssp. *varia*	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	36.7	---	---
Verbena officinalis	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	32.4	---	---
Carex hirta	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	40.7	---	---
Holcus lanatus	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	40.7	---	---
Daucus carota	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	36.7	---	---
Quercus robur	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	36.7	---	---
Crepis vesicaria	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	36.7	---	---
Cyperus flavescens	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	90.4	---
Plantago major ssp. *intermedia*	---	---	---	---	---	---	---	---	---	---	---	8	---	---	---	---	---	30.4	---
Paspalum distichum	---	---	1.8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	85.6
Paspalum dilatatum	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	38.8

Syntaxonomical scheme

***Juncetea maritimi* Br.-Bl. in Br.-Bl. et al. 1952**
***Juncetalia maritimi* Br.-Bl. ex Horvatić 1934**
***Juncion maritimi* Br.-Bl. ex Horvatić 1934**
***Juncetum maritimo-acuti* Horvatić 1934**
***Cuscuto cesatianae-Phyletum nodiflorae* ass. nova hoc loco**
Holotypus: Tab. 2, relevé no. 10
***Limonio narbonensis-Juncetum gerardii* Géhu et Biondi 1994**
***Agropyro-Plantaginion maritimi* Horvatić 1934**
***Holoschoenetum romani* Tchou 1948**

***Cakiletea maritimae* Tx. et Preising ex Br.-Bl. et Tx. 1952**
***Thero-Atriplicetalia* Pignatti 1953**
***Euphorbion peplidis* Tx. ex Oberd. 1952**
***Cakilo-Xanthietum strumarii* (Beg. 1941) Pignatti 1958** (syn. *Xanthio-Cakiletum maritimae*, *Salsolo kali-Cakiletum maritimae* Costa et Manz. corr. Riv.-Mart. et al. 1992)

***Ammophiletea* Br.-Bl. et Tx. ex Westhoff et al. 1946**
***Ammophiletalia* Br.-Bl. et Tüxen ex Westhoff et al. 1946**
***Ammophilion* Br.-Bl. 1921**
Euphorbio paraliae-Agropyretum junceiformis Tüxen in Br.-Bl. et Tüxen 1952 corr. Darimont, Duvigneaud et Lambinon 1962 (syn. *Sporobolo-Elymetum farcti* (Gehu et al.) Gehu 1984, *Agropyretum mediterraneum* (Kuhn.) Br.-Bl. 1933, *Echinophoro-Elymetum farcti* Gehu 1988, *Eryngio-Cyperetum capitati* Dmitar Lakušić nom.nud. 2011)
Medicagini marinae-Ammophiletum australis Br.-Bl. 1921 corr. F. Prieto et T.E. Díaz 1991 (syn. *Ammophiletum australis* R. Lakušić 1965 inedit)
***Cutandia maritima* community**

***Isoëto-Nanojuncetea* Br.-Bl. et Tx. in Br.-Bl. et al. 1952**
***Nanocyperetalia* Klika 1935**
***Nanocyperion* Koch 1926**
***Cyperetum flavescentis* W.Koch ex Aichinger 1933**
***Verbenion supinae* Slavnić 1951**
***Cypero-Paspaletum distichi* Horvatić 1954**

***Phragmito-Magnocaricetea* Klika in Klika et Novák 1941**
***Bolboschoenetalia maritimi* Hejny in Holub et al. 1967**
***Scirpion maritimi* Dahl et Hadač 1941**
***Scirpetum maritimo-litoralis* (Br.-Bl. in Br.-Bl., Roussine et Nègre 1952) O. de Bolòs 1962**
***Phragmitetalia* Koch 1926**
***Phragmition communis* Koch 1926**
***Phragmitetum communis* Savič 1926**
***Typhetum angustifoliae* Soo 1927**
***Scirpetum lacustris* Chouard 1924**
***Saccharetalia ravennae* Biondi, Blasi et Casavecchia in Biondi et al. 2014**
***Imperato cylindricae-Saccharion ravennae* Br.-Bl. et O. de Bolos 1958**
***Eriantho-Schoenetum nigricantis* (Pignatti 1953) Géhu in Géhu et al. 1984**
***Magnocaricetalia* Pignatti 1953**
***Magnocaricion elatae* Koch 1926**
***Cladietum marisci* Allorge 1921**
***Cyperetum longi* Micevski 1957**

***Helianthemetea guttati* Rivas Goday et Rivas-Mart. 1963**
***Vulpietalia* Pignatti 1953 (syn. *Cutandietalia*)**
***Laguro-Vulpion fasciculatae* Géhu et Biondi 1994**
***Euphorbio terracinae-Silenetum nicaeensis* Lavrentiades 1964**
***Onobrychido caput-galli-Vulpietum fasciculatae* ass. nova hoc loco**
Holotypus: Tab. 3, relevé no. 3

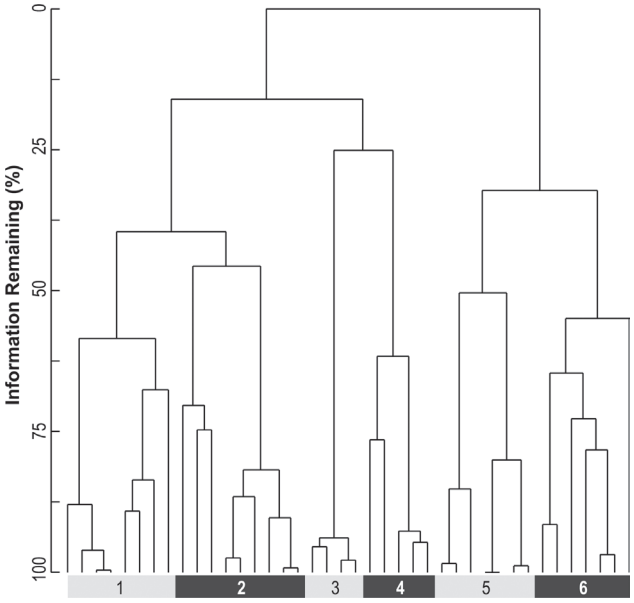

Fig. 2. Classification of sand dune vegetation of Velika plaža. Clusters: 1 – *Cakilo-Xanthietum strumarii*, 2 – *Euphorbio paraliae-Agropyretum junceiformis*, 3 – *Cutandia maritima* community, 4 – *Medicagini marinae-Ammophiletum australis*, 5 – *Euphorbio terracinae-Silenetum nicaeensis*, 6 – *Onobrychido caput-galli-Vulpietum fasciculatae*.

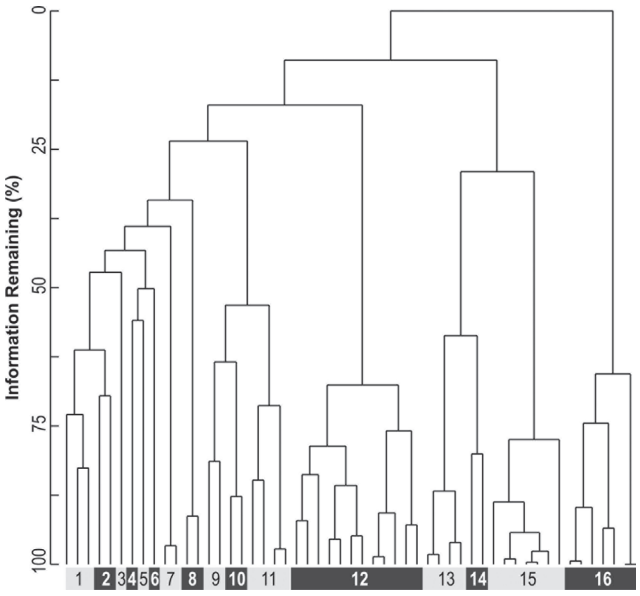

Fig. 3. Classification of wetland vegetation of Velika plaža. Clusters: 1 – *Juncetum maritimo-acuti*, 2-4 – *Holoschoenetum romani*, 5 – *Cyperetum flavescentis*, 6 – *Cyperetum longi*, 7 –*Limonio narbonensis-Juncetum gerardii*, 8 – *Cypero-Paspaletum distichi*, 9-11 – *Scirpetum maritimo-litoralis*, 12 – *Cuscuto cesatianae-Phyletum nodiflorae*, 13 – *Phragmitetum communis*, 14 – *Typhetum angustifoliae* and *Scirpetum lacustris*, 15 – *Cladietum marisci*, 16 – *Eriantho-Schoenetum nigricantis.*

Diagnostic species obtained by fidelity coefficient can only be considered as local because of the limited study area and many transitional stands (Tab. 1). Diagnostic species contain both differential and character species, some of which can be diagnostic for two plant communities.

Salt marshes

Juncetum maritimo-acuti is dominated by tall rushes (*Juncus maritimus* and *J. acutus*) and forms large stands in Velika plaža. It thrives in the back of the dunes on sand-silty substrate and is periodically flooded. *Scirpetum maritimo-litoralis* is a community dominated by *Bolboschoenus maritimus*, which occupies flooded areas with brackish water.

Cuscuto cesatianae-Phyletum nodiflorae ass. nova is found in flooded depressions on sand dunes that develop between higher parts of the dunes or behind them or along smaller streams of sub-saline water, additionally sometimes also on heavily trampled surfaces (Tab. 2). The soil is often silty and becomes compacted during summer droughts. The diagnostic species is *Cuscuta australis* ssp. *cesatiana,* known as a frequent inhabitant of sandy habitats, parasitizing on *Polygonum maritimum*, *Xanthium orientale* ssp. *italicum* and other psammopyhtes (Pignatti 1982). *Limonio narbonensis-Juncetum gerardii* is a helophytic community that thrives in stagnant brackish water that dries out during summer. Stands are species poor, dominated by *Juncus gerardi*. *Holoschoenetum romani* thrives in depressions most commonly in the backdunes. These are the lowest sites in the dune system and are flooded for the longest period of time.

Sand dunes

Cakilo-Xanthietum strumarii is found on the sand deposition zone, the first part of the beach following the aphytic zone. It is a species poor community, strongly influenced by sea waves, intense sand movement and salt water spraying. It occupies the nutrient rich drift line. The association is characterized by the presence of an alien species *Xanthium orientale* subsp. *italicum,* which is very abundant on Velika plaža in the first and the second vegetation zone.

The following plant communities on the sand dunes in the sea-inland zonation are still subjected to strong wind, waves, salt spray, and drought. Embryonic dunes are occupied by the stands of *Euphorbio paraliae-Agropyretum junceiformis*. This vegetation type is very common on Velika plaža and occupies flat, low sand dunes. In general sand dunes on Velika plaža are low compared to those in Albania or Italy. The next community in the zonation is the *Medicagini marinae-Ammophiletum australis*, where *Elytrigia juncea* is replaced by *Ammophila arenaria*, which further stabilizes the sand and makes these shifting dunes higher than the embryonic dunes. *Ammophila arenaria* stands are small and patchy on Velika plaža, forming loosely connected "dune islands" with steeper slopes. Wind and water erosion are more pronounced and the development of these stands is a result of micro topography and edaphic conditions and they are rare on Velika plaža. On the other hand embryonic, semi-fixed and fixed dunes are syndynamically connected and represent successional series (Fig. 4).

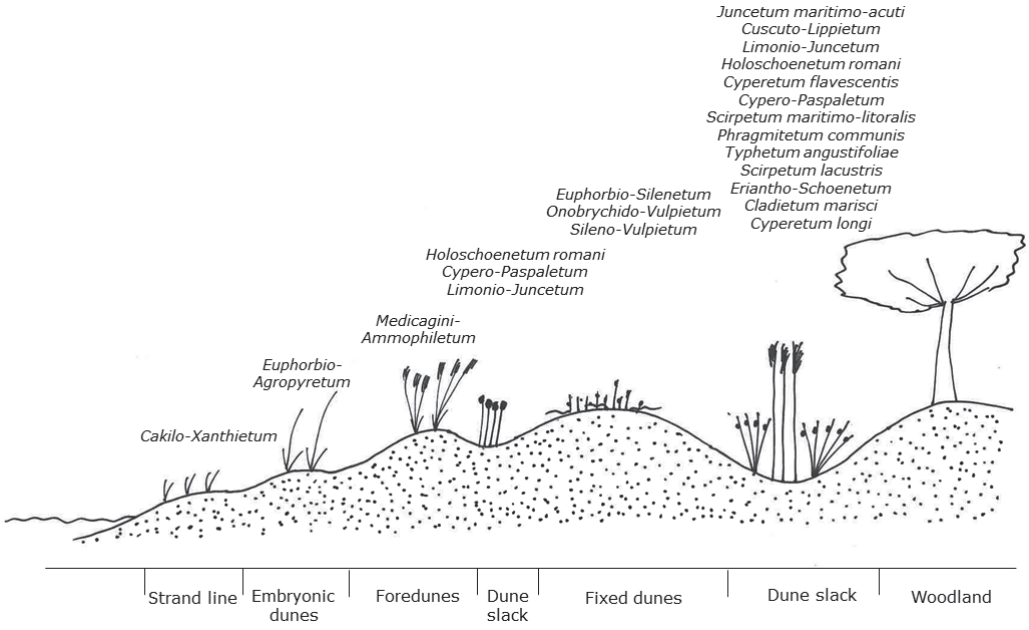

Fig. 4. Scheme of typical vegetation zonation on the sand beach Velika plaža.

Tab. 2. Phytosociological table of the *Cuscuto cesatianae-Phyletum nodiflorae* from Velika plaža (Ulcinj, Montenegro). * – nomenclatural type.

Relevé number	1	2	3	4	5	6	7	8	9	10*	11	12
Relevé number in On-line Suppl. Tab. 1	7	8	9	10	11	12	13	14	15	16	17	18
Relevé area (m²)	4	4	4	4	4	4	4	4	4	4	4	2
Cover herb layer (%)	70	60	70	45	60	40	80	70	70	70	50	80
Diagnostic species												
Phyla nodiflora	4	4	4	3	3	3	4	4	4	1	2	4
Cuscuta australis subsp. *cesatiana*	.	.	3	.	2	1	+	+	1	1	1	2
Juncetea maritimi												
Scirpoides holoschoenus	1	+	.	1	1	+	3	2	3	3	2	1
Juncus maritimus	.	.	.	.	.	.	2	1	+	1	.	.
Polypogon maritimus	1	+	.	.	.	.	.	1	+	+	.	.
Oenanthe pimpinelloides	.	.	.	.	.	.	.	.	.	.	+	+
Samolus valerandi	.	+	.	.	.	.	+	.	.	.	.	.
Phragmitetea												
Phragmites australis	+	.	.	+	+	+	+	.	.	.	.	.
Typha angustifolia	.	.	.	+	.	+	2	.	.	.	.	.
Bolboschoenus maritimus	.	1	.	.	.	1	1	.	.	.	.	.
Ammophiletea												
Tripolium pannonicum subsp. *tripolium*	+	.	.	+	1	.	.	.	+	1	+	.
Echinophora spinosa	.	.	.	.	.	.	.	.	.	.	r	r
Cynanchum acutum	.	.	.	.	.	.	.	.	+	.	.	.
Molinio-Arrhenatheretea												
Mentha aquatica	.	.	.	1	1	+	+	.	.	+	.	.
Juncus articulatus	.	+	+	1	.	.	+	.	.	.	.	.
Lythrum salicaria	.	+	+	.	.	+	.	.	.	.	.	.
Lotus corniculatus	+	+	.	.	.	.	.	.	.	.	.	.
Gratiola officinalis	.	.	+	.	1	.	.	.	.	+	.	.
Juncus compressus	.	.	.	.	.	+	.	.	.	.	.	.
Other species												
Xanthium orientale subsp. *italicum*	+	.	1	1	2	1	1	.	2	2	3	1
Bidens frondosus	.	.	.	+	1	.	.	.	.	+	+	+
Centaurium spicatum	+	.	.	.	.	.	+	1	1	2	+	.
Paspalum distichum	+	+	1	.	.	1	+	.	.	.	.	.
Dittrichia viscosa	+	.	.	+	.	.	.	+	.	.	+	.
Euphorbia maculata	+	.	1	.	1	.	.	.	.	.	.	.
Ranunculus sp.	.	.	.	.	.	.	.	.	.	.	+	+
Atriplex prostrata	.	.	.	.	.	.	.	.	.	.	r	r
Amorpha fruticosa	.	.	.	.	.	.	r	.	.	.	r	.
Salix alba	.	.	.	+	.	.	.	.	.	.	r	.
Lythrum hyssopifolia	.	.	1	.	.	.	+	.	.	+	.	.
Centaurium erythrea	.	+	.	.	.	.	.	.	.	.	.	+

Species present only in one relevé:
Tamarix dalmatica 1: +; *Rumex conglomeratus* 1: +; *Hypochaeris radicata* 2: +; *Parapholis incurva* 3: +; *Vitex agnus-castus* 4: +; *Baldellia ranunculoides* 4: +; *Leontodon* sp. 5: +; *Persicaria maculosa* 5: 1; *Cynodon dactylon* 7: 1; *Medicago littoralis* 8: +; *Periploca graeca* 9: +; *Plantago major* ssp. *intermedia* 9: +; *Limbarda crithmoides* 10: +; *Populus alba* 11: +.

Semi-fixed dunes with *Euphorbia terracina* are found behind the embyonic shifting dunes and are the next stage in the succession. This asssociation can be placed floristically between *Euphorbio-Agropyretum* and *Onobrychidi-Vulpietum*, although it is more similar to the latter association. We classified it as *Euphorbio terracinae-Silenetum nicaeensis*.

Fixed dunes are the last in the zonation before the onset of woody vegetation. The most widespread community is the ass. nova dominated by *Vulpia fasciculata* and *Onobrychis caput-galli*, which are also the diagnostic species of the association (Tab. 3). Stands occupy the greatest part of sand dunes, which are predominantly flat, compared to the previous dune zones with consistent (even if small) slopes, and are in a mosaic with *Ammophiletea* communities. Grasslands have the most closed vegetation cover which becomes more open due to human impact. Fragmentarily, on stabilized dunes, there are also stands of *Cutandia maritima*, representing the first stages of development towards *Onobrychido-Vulpietum*. Typical sand dune vegetation is best preserved in the south-eastern part of the beach, which is so far less touristically developed.

Dune slacks

Among other sand dune communities a great diversity of usually monodominant plant communities appears in wet dune slacks and depressions. Their floristic composition depends on the salinity of the water and period of flooding.

Phragmitetum communis is dominated by *Phragmites australis* and is widely distributed in the area, mostly in the back of the dunes where fresh water is present for a longer period. *Typhetum angustifoliae* is present in patches within *Phragmites australis* stands or around ponds in the hinterland.

Scirpetum lacustris is found in brackish water and is connected to *Phragmites* stands but flooded for longer periods.

Eriantho-Schoenetum nigricantis stands are developed in the depressions between the dunes with *Tripidium ravennae* and *Schoenus nigricans* as edificators of community. The site is flooded by subsaline water. *Cladietum marisci* occupies large areas with *Cladium mariscus* as the dominant species. *Cyperetum longi* thrives on wet soils, often near channels and is dominated by the tall sedge *Cyperus longus*.

Tab. 3. Phytosociological table of the *Onobrychido caput-galli-Vulpietum fasciculatae* from Velika plaža (Ulcinj, Montenegro). * – nomenclatural type.

Relevé number	1	2	3*	4	5	6	7
Relevé number in On-line Suppl. Tab. 1	63	64	65	66	67	68	69
Relevé area (m²)	20	15	25	15	15	16	8
Cover herb layer (%)	70	80	100	60	80	85	80
Diagnostic species							
Vulpia fasciculata	3	2	5	3	3	3	2
Onobrychis caput-galli	2	3	4	3	4	4	2
Alkanna tinctoria	2	+	3	.	1	.	1
Helianthemetea guttati							
Medicago littoralis	+	.	3	1	.	+	+
Hypochaeris glabra	.	1	2	.	1	+	1
Lagurus ovatus	.	.	+	2	+	+	1
Ammophiletea							
Pancratium maritimum	1	2	.	.	+	+	+
Cyperus capitatus	1	1	.	.	2	2	.
Echinophora spinosa	+	+	.	.	+	+	.
Medicago marina	3	2	.	+	.	.	.
Elytrigia juncea	.	.	.	+	+	+	.
Eryngium maritimum	+	.	.	.	1	.	+
Calystegia soldanella	.	.	.	.	.	.	.
Euphorbia terracina	.	.	.	.	.	2	+
Other species							
Crepis foetida	1	+	.	1	1	+	+
Anisantha sterilis	.	.	.	1	.	+	3
Erigeron annuus	.	+	.	.	+	+	.
Chondrilla juncea	.	.	.	1	.	+	+
Phleum arenarium	.	.	.	1	.	.	.
Xanthium orientale ssp. *italicum*	.	.	.	r	.	.	.
Dasypyrum villosum	.	.	.	.	+	.	1
Silene conica	.	.	+	.	1	.	.
Verbascum sinuatum	.	.	.	.	.	+	+
Petrorhagia saxifraga	.	.	.	.	.	+	1
Oenothera sp.	+	2	.	.	.	.	.

Other species:
Pseudorlaya pumila 1: +; *Linum trigynum* 1: +; *Euphorbia* sp. 2: 1; *Anagallis arvensis* 2: +; *Linum bienne* 3: +; *Plantago lanceolata* 3: r; *Cutandia maritima* 3: r; *Avena barbata* 4: +; *Cynodon dactylon* 7: +; *Imperata cylindrica* 7: +; *Carthamus lanatus* 7: +; *Tragopogon porrifolius* 7: +; *Plantago bellardii* 7: +; *Scirpoides holoschoenus* 7: +; *Oenothera biennis* agg.

Two dwarf cyperaceous communities developed on small surfaces are *Cyperetum flavescentis* and *Cypero-Paspaletum distichi*. They are found on wet, often flooded soils. Two *Paspalum* species dominate the stands; they are often trampled and their occurrence could be anthropogenic.

Moisture, salinity and nutrients are the most important ecological factors influencing the vegetation composition and spatial distribution of sand dunes (Fig. 5). These variables are also correlated to the first axis and salinity is correlated to the second axis of the NMDS plot. On the left side of the ordination diagram vegetation types of marshes and swamps in the centre are periodically flooded communities and on the right side communities of sand dunes are grouped. The centroid of group 2 (*Limonio-Juncetum gerardii*) is ecologically very similar to *Isoëto-Nanojuncetea* communities.

Plant communities identified on Velika plaža can be translated into eight habitat types according to Habitat directive (Tab. 4).

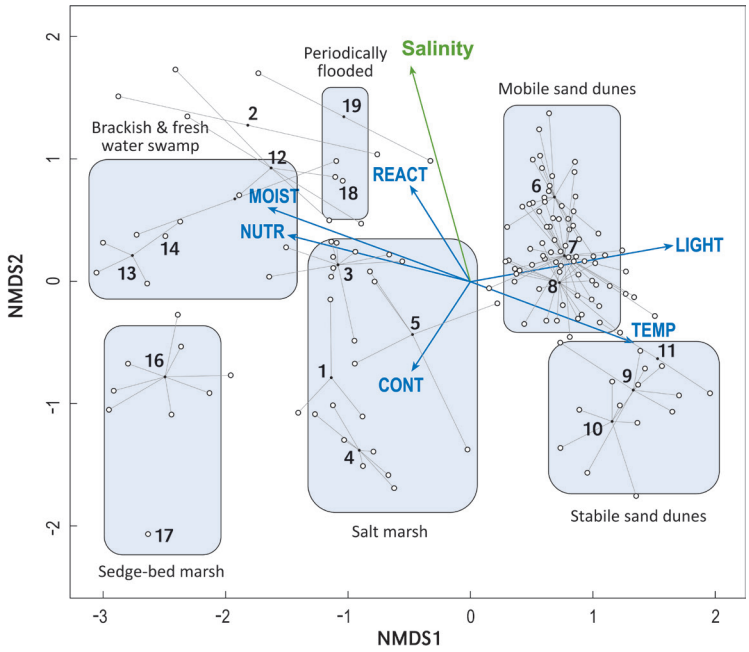

Fig. 5. Non-metric multidimensional scaling (NMDS) ordination spider-plot of the vegetation of Velika plaža. Numbers refer to centroids of vegetation types and dots represent relevés linked to the corresponding centroid (Tab. 1). Ecological indicator values are represented as arrows (MOIST-moisture, REACT-soil reaction, LIGHT-light, NUTR-nutrients, CONT-continentallity, TEMP-temperature). Plant communities found in similar site conditions are outlined. Stress value in two dimensions was 0.12.

Tab. 4. Classification of syntaxa (plant associations) on Velika plaža into Habitat Directive habitat types (European Communities Council 1992).

	Marceno et al. 2018	NATURA 2000 habitat type (Annex I 92/43/EEC)	Syntaxa
Zone without vegetation	Zone without vegetation	Mudflats and sandflats not covered by seawater at low tide 1140	
Deposition zone (drift line zone)	Strand line	Annual vegetation of drift lines 1210	*Cakilo-Xanthietum strumarii*
Embryonic dune	Embryonic dune	Embryonic shifting dunes 2110	*Euphorbio paraliae-Agropyretum junceiformis*
White dune	Foredune	Shifting dunes along the shoreline with *Ammophila arenaria* 2120	*Medicagini marinae-Ammophiletum australis*
	Fixed dune	Dunes with *Euphorbia terracina* 2220	*Euphorbia terracinae-Silenetum nicaeensis*
		Malcolmietalia dune grasslands 2230	*Onobrychido-Vulpietum fasciculatae*
Dune slack	Dune slack	Mediterranean salt meadows (*Juncetalia maritimae*) 1410	*Juncetum maritimo-acuti* *Cuscuto cesatianae-Phyletum nodiflorae* *Limonio narbonensis-Juncetum gerardii* *Scirpetum maritimo-litoralis* *Phragmitetum communis* *Typhetum angustifoliae* *Scirpetum lacustris* *Cladietum marisci*
		Humid dune slacks 2190	*Eriantho-Schoenetum nigricantis* *Cyperetum flavescentis* *Cypero-Paspaletum distichi* *Cyperetum longi* *Holoschoenetum romani*

Discussion

The vegetation of the sandy beach Velika plaža is very diverse in vegetation types and many of them have not previously been recorded there or anywhere else in Montenegro. The transitional geographic position of Velika plaža between the Adriatic and Ionian seas makes clear syntaxonomic classification of the plant communities of sand dunes difficult.

The vegetation of Velika plaža was frequently studied since the first mentions by Blečić and Lakušić (1976). Trinajstić (1989a) recorded the association *Sporobolo-Elymetum farcti* and later Mijović (Mijović 1994, Mijović et al. 2006, 2012) studied the zonation of sand dune vegetation, but mentioning only *Cakilo-Xanthietum italici* and *Echinophoro-Elymetum farcti* (=*Agropyretum mediterraneum*). All these authors identified only two plant communities: one on the drift line and the second on the dunes, without dividing it into different associations based on zonation and the stability of the dunes (Doing 1985, Marcenò et al. 2018). The dunes at Velika plaža are still well developed and the ideal zonation of dunes is still recognizable (Fig. 4) although human impact is present (Šilc et al. 2016a). We have confirmed several marsh and swamp associations, which have already been reported for Ulcinj and Montenegro in general but without relevé material (Blečić and Lakušić 1976). Additionally, Horvatić (1963) reported the presence of *Euphorbio paraliae-Agropyretum* for Budva-Sutoran area in Montenegro, which does not exist anymore.

Certain similarities can be found with the results of the vegetation study of the Buna River Protected Landscape in Albania (Fanelli et al. 2015), which is a natural continuation of Velika plaža to the south. However, in the sand dune vegetation on Velipoje beach today only drift line vegetation is present. The reasons are mainly erosion, but also the fast tourism development and intensive human impact on coastal areas in Albania. Still in the mid-1980s Mullaj (1989) found complete zonation on the sand dunes of Velipoje with *Cakilo-Xanthietum italici*, *Agropyretum mediterraneum*, *Ammophiletum arundinaceae* and *Sporoboletum*.

In Croatia sand dunes can be found fragmentarily in a few places with more or less depauperated plant composition of typical sand dune associations (Horvatić 1963, Trinajstić 1989b, Trinajstić and Jasprica 1998, Šilc et al. 2016b). Horvatić (1963) reports *Agropyretum mediterraneum*, *Euphorbio-Glaucietum petrosum*, and also *Cyperetum flavescentis* and *Cypero-Paspaletum distichi*.

On the Velika plaža we described a new plant association *Cuscuto cesatianae-Phyletum nodiflorae*. The species *Phyla nodiflora* (=*Lippia n.*) was first recorded for ex-Yugoslavia in Port-Milena channel, near Ulcinj (Bajić 1963). In the literature *Ph. nodiflora* occurs in four associations as a diagnostic species: *Lippio nodiflorae-Panicetum repentis* O. de Bolòs 1957, *Lippio nodiflorae-Paspaletum vaginati* Galán De Mera et al. 2009, *Fimbrystylo cymosae-Lippietum nodiflorae* de Foucault 1987 and *Kyllingo peruvianae-Phyletum nodiflorae* Vanden Berghen 1990 (de Foucault 1987, Vanden Berghen 1990). Only the first is present in Europe, while the others are typical for Peru, Guadalupe and Senegal, respectively. The association from Velika plaža is very similar to *Lippio nodiflorae-Panicetum repentis*, especially to stands from Sicily (Brullo and Sciandrello 2006), where *Ph. nodiflora* is a co-dominant species, while in Spain these are short, dense grass carpets of *Panicum repens* sometimes even without *Ph. nodiflora* (Royo Pla 2006). Syntaxonomical classification of *Lippio-Panicetum* varies among different authors. De Bolòs (1957) originally classified it into the alliance *Trifolio fragiferi-Cynodontion dactyli*, and the classification is followed by Royo Pla (2006) and Ninot et al. (2012). Brullo and Sciandrello (2006) classified it into *Paspalo-Agrostion semiverticillati* of the class *Molinio-Arrhenatheretea*. Mucina et al. (2016) classified the alliance into *Bidentetea tripartitae*.

Taking into account the ecological features of the habitat of the new association *Cuscuto cesatianae-Phyletum nodiflorae* and its floristic structure and composition, we classify it into the alliance *Juncion maritimi*, order *Juncetalia maritimi*, and the class *Juncetea maritimi*.

In the hinterland of Velika plaža, the species *Ph. nodiflora* thrives within stands of *Juncus maritimus*. Such a community is also reported for the Viluni lagoon in Albania in the vicinity of Velika plaža. It develops in retrodunal depressions characterized by brackish water and strong disturbance by erosion and grazing by cattle (Fanelli et al. 2015). Due to the presence of similar habitats along the Albanian coast, it is expected that the association *Cuscuto cesatianae-Phyletum nodiflorae* will have a wider and more southwards distribution, although the species is not mentioned in the coastal flora of Albania or in the list of Albanian plant communities (Mullaj 1989, Dring et al. 2002).

Classification of the newly described association *Onobrychido-Vulpietum* ass. nova into higher syntaxa presents a particular challenge. Stands show a floristic composition distinct from other plant communities in the zonation and a description of a new association is therefore justified. There are no literature references of a similar plant community from neighbouring Croatia or Albania (Šilc et al. 2016b). There are two similar associations reported from Italy: *Onobrychido caput-galli-Malcolmietum ramosissimae* Brullo, Scelsi et Spampinato 2001 and *Silene nicaeensis-Vulpietum fasciculatae* (Paradis and Piazza 1991) Géhu et Biondi 1994, but their floristic composition is different and characteristic species are not present in Velika plaža (Díez-Garretas et al. 2003).

Therophytic stands on semi-stabilised sand dunes in Europe are classified into different alliances in addition to the different synsystems present. Mucina et al. (2016) introduced two ephemeral therophytic orders on sand dunes of the class *Helianthemetea guttati*: *Vulpietalia* under salt-spray influence and *Malcolmietalia* without it. Within the first one three alliances from the Balkan Peninsula area are classified: *Psammo-Vulpion* from the North Adriatic coasts, *Vulpio-Lotion* along Balkan-Illyric coast and *Maresion nanae* on North Aegean sand dunes. Inclusion of the newly described association into *Vulpio-Lotion* would be geographically most eligible but stands lack many characteristic species, mainly of the genus *Trifolium* (Horvat et al. 1974). In fact, typical *Vul-*

pio-Lotion therophytic grasslands are found in the hinterland of Velika plaža and are not under the influence of salt-spray. In Montenegro in general grasslands of *Vulpio-Lotion* are developed mainly on inland lowlands and not on the sand dunes (pers. obser.).

A different classification was previously presented by Biondi et al. (2014) for Italy including two orders within the *Helianthemetea guttati* on sand dunes. *Cutandietalia* (a synonym for *Vulpietalia*) comprises two alliances *Alkanno-Maresion nanae* and *Laguro-Vulpion*. The main difference between these alliances is in the disturbance of sand dunes (Brullo et al. 2001). The latter includes annual, xerophytic, pioneer communities of Mediterranean and thermo-Atlantic dunes in an early state of alteration owing to both natural and anthropic causes. Characteristic species (*Vulpia fasciculata*, *Lagurus ovatus*) are also present in the stands of *Onobrychido-Vulpietum,* also under constant anthropogenic pressure, which corresponds to the alliance description. According to some authors, *Alkanno-Maresion nanae* and *Laguro-Vulpion* could be merged together with some additional alliances due to a lack of differential species, which would yield one alliance, spanning the whole northern Mediterranean coast (Díez-Garretas et al. 2003). On the other hand the alliance *Laguro-Vulpion fasciculatae* was put into the *Chenopodietea* class by Mucina et al. (2016) indicating anthropogenic influence. In our opinion *Onobrychido-Vulpietum* should be classified into the alliance *Laguro-Vulpion* as an additional part of the *Vulpietalia* order.

We classified the stands dominated by *Euphorbia terracina* into the existing association *Euphorbio-Silenetum nicaeensis*, described from Greece. It is found on more stabilised dunes (Lavrentiades 1964) and was classified into the *Crucianellion maritimae* alliance (Sýkora et al. 2003). Two out of three characteristic species according to Lavrentiades (1964) are present (*Euphorbia terracina* and *Hedypnois cretica*), but we are of the opinion that these stands should also be classified into the therophytic alliance *Laguro-Vulpion* instead of the chamaephyte-dominated alliance *Crucianellion*. The floristic similarity of *Euphorbio-Silenetum nicaeensis* and *Onobrychido-Vulpietum* is well supported by the dendrogram (Fig. 2) and ordination (Fig. 5).

Classification of *Paspalum distichum* (=*P. paspalodes*) dominated stands is dubious. At Velipoje they are classified as *Paspalo-Agrostidetum* Br.-Bl. 1936 (1952) (Fanelli et al. 2015) but in nearby Bosnia and Herzegovina (Hutovo blato) as *Cypero-Paspaletum distichi* Horvat 1954 (Jasprica et al. 2003). These communities are classified in different classes, *Molinio-Arrhenatheretea* and *Isoëto-Nanojuncetea*, respectively. Our stands fit better into the latter class with characteristic ephemeral, annual vegetation of flooded sites, although they are fragmentarily developed, and with many character and differential species (*Veronica anagalloides*, *Lotus tenuis, Bidens tripartitus*, *Inula britannica*, *Persicaria lapathifolia*) missing.

Fanelli et al. (2015) classified the association *Eriantho-Schoenetum nigricantis* into the class *Molinio-Arrhenatheretea*, but we are of the opinion that it should be classified into the alliance *Imperato cylindricae-Saccharion ravennae* and in the class *Phragmito-Magnocaricetea*, as suggested by Mucina et al. (2016).

Association *Holoschoenetum romani* was traditionally classified into *Molinio-Holoschoenion* (*Molinio-Arrhenatheretea*), but recently Mucina et al. (2016) described this alliance as seasonally flooded meadows on subsaline soils of the Western Mediterranean. On the other hand, Biondi et al. (2014) list the alliance *Agrostio stoloniferae-Scirpoidion holoschoeni* (a synonym of *Molinio-Holoschoenion*) for Italy. We are the opinion that this community should be classified into the *Juncetea* class.

Limonio narbonensis-Juncetum gerardii is traditionally classified into *Juncion maritimae* alliance (*Juncetea maritimi*), but in our case it shows high floristic similarity with the class *Isoëto-Nanojuncetea* (Fig. 5).

Cyperus longus appears as the dominant species in two communities: *Sparganio-Cyperetum longi* Horvatić 1939 and *Cyperetum longi* Micevski 1957 (Hadžiablahović 2018). The latter is found on Velika plaža in depressions, usually in contact with *Holoschoenetum vulgaris* stands (Landucci et al. 2013).

Although habitat types occurring on Velika plaža have already been reported (Petrović et al. 2012) we can now list them with the corresponding species composition. It should be pointed out that some of the plant communities were sampled for the first time on this beach. For protection of the sand dune system a prerequisite is to have a survey of plant communities and their translation into habitat typology (Tab. 3). Some of the listed habitats, however, should be translated into new types in the future: Dunes along the Mediterranean shoreline with *Ammophila arenaria* (new code 2280) and Mediterranean embryonic dunes (new code 2290) as proposed by Feola et al. (2011).

In the first report of habitat types in Montenegro *Cakilo-Xanthietum strumarii* was classified into habitat type 2110 (Petrović et al. 2012), but it should be distinguished as a particular habitat type, Annual vegetation of drift lines 1210. Habitat type 2220 with *Euphorbia terracina* was placed separately but our analysis shows high floristic similarity with *Onobrychido-Vulpietum fasciculatae* (habitat type 2230) and an analysis on a larger scale is needed to confirm the existence of this habitat type on Velika plaža. The most stable dunes were previously classified into Fixed coastal dunes with herbaceous vegetation (grey dunes) (2130*), but they should be now translated into *Malcolmietalia* dune grasslands (2230) (Biondi et al. 2012, Petrović et al. 2012, Prisco et al. 2012). A plant community with *Euphorbia terracina* was not confirmed in a previous survey of sand dune vegetation along the Eastern Adriatic (Šilc et al. 2016b).

Our results confirm for the first time the presence of plant communities of *Laguro-Vulpion* (and corresponding habitat types) along the north-eastern Adriatic coast and additional survey of such sand dunes is needed particularly in Albania to record any further stands to get a more comprehensive view on the vegetation type in the area. Transitional sand dune habitats (e.g. 2230 and 2210) are those with the highest

diversity of phytosociological associations (Prisco et al. 2012).

Important habitat types that are present on Velika plaža but not sampled in our study are 2270* Wooded dunes with *Pinus pinea* and/or *Pinus pinaster* and 91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*). Although pine forests in Velika plaža are planted they are an important habitat type and may maintain the "valuable" Mediterranean coastal biodiversity pool (Bonari et al. 2017). Riparian forests are under-researched in south-eastern Europe (Douda et al. 2016) and many of them have already been destroyed in the vicinity in Albania (Kárpáti and Kárpáti 1961). There is a potential for the existence of habitat type 2240 *Brachypodietalia* dune grasslands with annuals, which might be confirmed in the further vegetation sampling.

Acknowledgement

The research (D.S., U.Š., F.K.) was partly financed through the Rufford project (14048-1), programme P1-0236 (ARRS), and bilateral grant (BI-ME/16-17-018). D.M. acknowledges support by Daphne – Inštitút aplikovanej ekológie. Authors are grateful to Mihailo Jovičević and Danka Petrović for help during field work and discussions.

References

Bajić, D., 1963: Species *L. nodiflora* Rich new to flora of Yugoslavia. Radovi Poljoprivrednog Fakulteta Univerziteta u Sarajevu 12, 209–211 (in Bosnian).

Biondi, E., Blasi, C., Allegrezza, M., Anzellotti, I., Azzella, M.M., Carli, E., Casavecchia, S., Copiz, R., Del Vico, E., Facioni, L., Galdenzi, D., Gasparri, R., Lasen, C., Pesaresi, S., Poldini, L., Sburlino, G., Taffetani, F., Vagge, I., Zitti, S., Zivkovic, L., 2014: Plant communities of Italy: The Vegetation Prodrome. Plant Biosystems 148, 728–814.

Biondi, E., Burrascano, S., Casavecchia, S., Copiz, R., Del Vico, E., Galdenzi, D., Gigante, D., Lasen, C., Spampinato, G., Venanzoni, R., Zivkovic, L., Blasi, C., 2012: Diagnosis and syntaxonomic interpretation of Annex I Habitats (Dir. 92/43/EEC) in Italy at the alliance level. Plant Sociology 49, 5–37.

Blečić, V., Lakušić, R., 1976: List of plant communities of Montenegro. Glasnik Republičkog Zavoda za Zaštitu Prirode i Prirodnjačkog Muzeja u Titogradu 9, 57–98 (in Montenegrin).

Bonari, G., Acosta, A.T., Angiolini, C., 2017: Mediterranean coastal pine forest stands: Understorey distinctiveness or not? Forest Ecology and Management 391, 19–28.

Braun-Blanquet, J., 1964: Pflanzensoziologie. Grundzüge der Vegetationskunde. Springer Verlag, Wien.

Brown, A.C., McLachlan, A., 2002: Sandy shore ecosystems and the threats facing them: some predictions for the year 2025. Environmental Conservation 29, 62–77.

Brullo, S., Giusso Del Galdo, G.P., Siracusa, G., Spampinato, G., 2001: Considerazioni fitogeografiche sulla vegetazione psammofila dei litorali italiani. Biogeographia 22, 93–137.

Brullo, S., Sciandrello, S., 2006: La vegetazione lacustre del Biviere di Gela (Sicilia meridionale). Fitosociologia 42, 21–40.

Bubanja, N., 2016: Geobotanical characterization of vascular flora of Long Ulcinj beach and its hinterland in Montenegro. PhD thesis. University of Belgrade, Beograd (in Montenegrin).

Bubanja, N., Šinžar-Sekulić, J., Stevanović, V., 2019: Contribution to the flora of Velika plaža and its vicinity in Ulcinj (Montenegro). Biologia Serbica 41, 13–44.

Chytrý, M., Tichý, L., Holt, J., Botta-Dukat, Z., 2002: Determination of diagnostic species with statistical fidelity measures. Journal of Vegetation Science 13, 79–90.

de Bolòs, O., 1957: De vegetatione valentina. I. Collectanea Botanica. 5, 527–596.

De Foucault, B., 1987: Contribution a l'etude phytosociologique des paysages de Guadeloupe (Antilles françaises): la vegetation des plages et des falaises littorales. Phytocoenologia 15, 397–418.

Díez-Garretas, B., Asensi, A., Gavilán, R., 2003: Sabulicolous therophytic plant communities in the Mediterranean Region: a proposal of phytosociological synthesis. Phytocoenologia 33, 495–526.

Doing, H., 1985: Coastal fore-dune zonation and succession in various parts of the World. Vegetatio 61, 65–75.

Douda, J., Boublík, K., Slezák, M., Biurrun, I., Nociar, J., Havrdová, A., Doudová, J., Aćić, S., Brisse, H., Brunet, J., Chytrý, M., Claessens, H., Csiky, J., Didukh, Y., Dimopoulos, P., Dullinger, S., FitzPatrick, Ú., Guisan, A., Horchler, P.J., Hrivnák, R., Jandt, U., Kącki, Z., Kevey, B., Landucci, F., Lecomte, H., Lenoir, J., Paal, J., Paternoster, D., Pauli, H., Pielech, R., Rodwell, J.S., Roelandt, B., Svenning, J.-C., Šibík, J., Šilc, U., Škvorc, Ž., Tsiripidis, I., Tzonev, R.T., Wohlgemuth, T., Zimmermann, N.E., 2016: Vegetation classification and biogeography of European floodplain forests and alder carrs. Applied Vegetation Science 19, 147–163.

Dring, J., Hoda, P., Mersinllari, M., Mullaj, A., Pignatti, S., Rodwell, J., 2002: Plant communities of Albania – a preliminary review. Annali di Botanica Nuova Serie 2, 7–30.

Euro+Med, 2006: Euro+Med PlantBase – the information resource for Euro-Mediterranean plant diversity. Retreived April 2, 2016 from http://ww2.bgbm.org/EuroPlusMed/

European Communities Council 1992: Council Directive 92/43/CEE on the Conservation of Natural Habitats and of Wild Fauna and Flora. Official Journal L 206, 22/07/1992 P. 0007 – 0050.

Fanelli, G., De Sanctis, M., Gjeta, E., Mullaj, A., Attore, F., 2015: The vegetation of the Buna river protected landscape (Albania). Hacquetia 14, 129–174.

Feola, S., Carranza, M.L., Schaminée, J.H.J., Janssen, J.A.M., Acosta, A.T.R., 2011: EU habitats of interest: an insight into Atlantic and Mediterranean beach and foredunes. Biodiversity and Conservation 20, 1457–1468.

Hadžiablahović, S., 2018: The diversity of the flora and vegetation of Lake Skadar/Shkodra. In: Pešić, V., Karaman, G., Kostianoy, A.G. (eds.), The Skadar/Shkodra Lake Environment, 203–238. Springer, Cham.

Hennekens, S.M., Schaminée, J.H.J., 2001: TURBOVEG, a comprehensive data base management system for vegetation data. Journal of Vegetation Science 12, 589–591.

Horvat, I., Glavač, V., Ellenberg, H., 1974: Vegetation Südosteuropas. Gustav Fischer Verlag, Stuttgart.

Horvatić, S., 1963: Vegetation map of island Pag with general overview of vegetation units of Croatian coast. Prirodoslovna Istraživanja, Jugoslavenska Akademija znanosti i umjetnosti 33, 1–187 (in Croatian).

Janssen, J.A.M., Rodwell, J.S., Criado, M.G., Gubbay, S., Haynes, T., Nieto, A., Sanders, N., Landucci, F., Loidi, J., Ssymank, A.,

Tahvanainen, T., Valderrabano, M., Acosta, A., Aronsson, M., Arts, G., Attorre, F., Bergmeier, E., Bijlsma, R.-J., Bioret, F., Biţă-Nicolae, C., Biurrun, I., Calix, M., Capelo, J., Čarni, A., Chytrý, M., Dengler, J., Dimopoulos, P., Essl, F., Gardfjell, H., Gigante, D., Giusso del Galdo, G., Hájek, M., Jansen, F., Jansen, J., Kapfer, J., Mickolajczak, A., Molina, J.A., Molnár, Z., Paternoster, D., Piernik, A., Poulin, B., Renaux, B., Schaminée, J.H.J., Šumberová, K., Toivonen, H., Tonteri, T., Tsiripidis, I., Tzonev, R., Valachovič, M., 2016: European red list of habitats. 2. Terrestrial and freshwater habitats. Publications Office of the European Union, Luxembourg.

Jasprica, N., Carić, M., Batistić, M., 2003: The marshland vegetation (*Phragmito-Magnocaricetea*, *Isoëto-Nanojuncetea*) and hydrology in the Hutovo Blato Natural Park (Neretva River delta, Bosnia and Herzegovina). *Phyton*, Annales Rei Botanicae, *Horn* 43, 281–294.

Kárpáti, I., Kárpáti, V., 1961: Die zönologischen verhältnisse der Auenwälder Albaniens. Acta Botanica Academiae Scientarum Hungarica 7, 235–301.

Landucci, F., Gigante, D., Venanzoni, R., Chytrý, M., 2013: Wetland vegetation of the class *Phragmito-Magno-Caricetea* in central Italy. Phytocoenologia 43, 6–102.

Lavrentiades, G.J., 1964: The ammophilous vegetation of the Western Peloponnesos coasts. Vegetatio 12, 223–287.

Marcenò, C., Guarino, R., Loidi, J., Herrera, M., Isermann, M., Knollová, I., Tichý, L., Tzonev, R.T., Acosta, A.T.R., FitzPatrick, Ú., Iakushenko, D., Janssen, J.A.M., Jiménez-Alfaro, B., Kącki, Z., Keizer-Sedláková, I., Kolomiychuk, V., Rodwell, J.S., Schaminée, J.H.J., Šilc, U., Chytrý, M., 2018: Classification of European and Mediterranean coastal dune vegetation. Applied Vegetation Science 21, 533–559.

Maun, M.A., 2009: The biology of coastal sand dunes. Oxford University Press, New York.

Mijović, A., 1994: The xerohalophytic sand communities of the Long beach. Glasnik Instituta za Botaniku i Botaničke Bašte Univerziteta u Beogradu 28, 147–157.

Mijović, A., Popović, Z., Karadžić, B., Mijatović, M., Perišić, S., 2006: Distribution of xerohalophytic vegetation along the seaward and landward zone in south-Adriatic sandy beach (Montenegro). *Biotechnology* & Biotechnological Equipment 20, 30–35.

Mijović, A., Popović, Z., Vukov, T., Smiljanić, M., Matić, R., Bojović, S., 2012: Sand topography influences the distribution of xerohalophytic vegetation on a southern Adriatic beach in Montenegro. Plant Biosystems 146, 664–673.

Mucina, L., Bültman, H., Dierssen, K., Theurillat, J.-P., Dengler, J., Čarni, A., Šumberová, K., Raus, T., Di Pietro, R., Gavilán Garcia, R., Chytrý, M., Iakushenko, D., Schaminée, J.H.J., Bergmeier, E., Santos Guerra, A., Daniëls, F.J.A., Ermakov, N., Valachovič, M., Pigantti, S., Rodwell, J.S., Pallas, J., Capelo, J., Weber, H.E., Lysenko, T., Solomeshch, A., Dimopoulos, P., Aguiar, C., Freitag, H., Hennekens, S.M., Tichý, L., 2016: Vegetation of Europe: Hierarchical floristic classification system of plant, lichen, and algal communities. Applied Vegetation Science 19, 3–264.

Mullaj, A., 1989: Albanian coastal vegetation. Albanian Academy of Sciences, Tirana (in Albanian).

Ninot, J.M., Font, X., Masalles, R.M., Vigo, J., 2012: Syntaxonomic conspectus of the vegetation of Catalonia and Andorra. II: Ruderal communities. Acta Botanica Barcinonensia 53, 113–189.

Petrović, D., Karaman, M. 2009: Important plant areas in Montenegro – IPA Programme. NVO Zelena Gora, Podgorica

Petrović, D., Hadžiablahović, S., Vuksanović, S., Mačić, V., Lakušić, D., 2012: Catalogue of habitat types of Monenegro important for European Union. Regional Environmental Center Montenegro, Podgorica-Beograd-Zagreb (in Montenegrin).

Pignatti, S., 1982: Flora d'Italia. Edagricole, Bologna.

Pignatti, S., Mengoni, P., Pietrosanti, S., 2005: Valori di bioindicazione delle piante vascolari della flora d`Italia. Braun-Blanquetia 39, 1–97.

Prisco, I., Acosta, A.T.R., Ercole, S., 2012: An overview of the Italian coastal dune EU habitats. Annali di Botanica (Roma) 2, 39–48.

R Development Core Team, 2012. R: A language and environment for statistical computing. Retrieved October 15, 2015 from http://www.r-project.org.

Royo Pla, F., 2006: Flora i vegetació de les planes i serres litorals compreses entre el riu Ebro i la serra d'Irta. University of Barcelona, Barcelona.

Šilc, U., Mullaj, A., Alegro, A., Ibraliu, A., Dajić Stevanović, Z., Luković, M., Stešević, D., 2016a: Sand dune vegetation along the eastern Adriatic coast. Phytocoenologia 46, 339–355.

Šilc, U., Dajić Stevanović, Z., Ibraliu, A., Luković, M., Stešević, D., 2016b: Human impact on sandy beach vegetation along the southeastern Adriatic coast. Biologia 71, 865–874.

Šilc, U., Caković, D., Küzmič, F., Stešević, D., 2017: Trampling impact on vegetation of embryonic and stabilised sand dunes in Montenegro. Journal of Coastal Conservation 21, 15–21.

Šilc, U., Küzmič, F., Caković, D., Stešević, D., 2018: Beach litter along various sand dune habitats in the southern Adriatic (E Mediterranean). Marine Pollution Bulletin 128, 353–360.

Šilc, U., Stešević, D., Rozman, A., Caković, D., Küzmič, F., 2019: Alien species and their impact on sand dunes in NE Adriatic. In: Finkl, C.W., Makowski, C. (eds.), Impacts of Invasive Species on Coastal Environments: Coasts in Crisis, 113–143. Springer, Cham.

Stešević, D., Luković, M., Caković, D., Ružić, N., Bubanja, N., Šilc, U., 2017a: Alien species in sand dune plant communities on Velika plaža in Ulcinj (Montenegro). Periodicum biologorum 119, 239–249.

Stešević, D., Bubanja, N., Caković, D., Jogan, N., Luković, M., Šilc, U., 2017b: Synecology of *Cutandia maritima* (L.) Barbey, a rare psammophytic species along the Montenegrin Coast (East Adriatic Coast). Hacquetia 16, 181–187.

Sýkora, K.V., Babalonas, D., Papastergiadou, E.S., 2003: Strandline and sand-dune vegetation of coasts of Greece and of some other Aegean countries. Phytocoenologia 33, 409–446.

Tichý, L., 2002: JUICE, software for vegetation classification. Journal of Vegetation Science 13, 451–453.

Tichý, L., Chytrý, M., 2006: Statistical determination of diagnostic species for site groups of unequal size. Journal of Vegetation Science 17, 809–818.

Trinajstić, I., 1989a: Contribution to knowledge of the sand dunes vegetation of the *Ammophiletea* class on Montenegro coast. Crnogorska Akdemija Nauka i umjetnosti, Glasnik Odjeljenja Prirodnih nauka 7, 45–51 (in Croatian).

Trinajstić, I., 1989b: Vegetation of the class *Ammophiletea* Br.-Bl. et R. Tx. 1943 in the eastern Adriatic littoral of Yugoslavia. Colloques Phytosociologiques 19, 387–394.

Trinajstić, I., Jasprica, N., 1998: Vegetation of the class *Ammophiletea* Br.-Bl. et R. Tx. in the southern part of the Croatian littoral (Dalmatia). Natura Croatica 7, 79–83.

van der Maarel, E., 2005: Vegetation ecology. Blackwell, Malden.

Vanden Berghen, C., 1990: La végétation des sables maritimes de Ia Casamance (Sénégal méridional). Lejeunia NS 133, 1–84.