

Taxonomic notes on *Puccinellia teyberi* (Poaceae), a critical species of Croatian flora

Sandro BOGDANOVIĆ^{1,3*}, Salvatore BRULLO², Antun L. ALEGRO¹, Ivana REŠETNIK¹
 & Božena MITIĆ¹

¹Department of Botany and Botanical Garden, Faculty of Science, University of Zagreb, Marulićev trg 9a, 10000 Zagreb, Croatia; e-mail: sandro@botanic.hr

²Dipartimento di Biologia, Università degli Studi di Catania, A. Longo 19, 95125 Catania, Italy; e-mail: salvo.brullo@gmail.com

³Department of Agricultural Botany, Faculty of Agriculture, University of Zagreb, Svetosimunska 25, 10000 Zagreb; e-mail: sbogdanovic@agr.hr

Abstract: *Puccinellia teyberi* Hayek (Poaceae) is a critical species of the Croatian flora, described for the first time as *Atropis rupestris* Teyber from two small islets of central Adriatic Sea. Nomenclature, lectotypification, morphology, karyology, leaf anatomy, palynology, ecology and conservation status of this taxon are examined. According to these data, it must be treated as a distinct species, taxonomically related to *P. convoluta* and *P. festuciformis*. Besides, it represents a neoendemic apomictic species, confined to rocky costal places and having a punctiform distribution.

Key words: apomixis; Croatia; endemic; karyology; leaf anatomy; morphology; Poaceae; *Puccinellia*

Introduction

The genus *Puccinellia* Parl. (Poaceae) is represented in Croatia by four taxa; *P. distans* (L.) Parl. subsp. *distans*, *P. distans* subsp. *limosa* (Schur) Jáv., *P. fasciculata* (Torr.) E. P. Bicknell and *P. festuciformis* (Host) Parl. subsp. *festuciformis* (Ilijanić & Topić 2000; Nikolić & Topić 2005; Nikolić 2011). They are perennial species growing in costal or inland salt marshes, where they are member of halophilous plant communities. Peculiar populations occur also in the rocky places and cliffs of two small islets of the central Adriatic Sea (Kamik and Jabuka). Populations from these islets are morphologically and ecologically well differentiated from the other above mentioned taxa. They were described by Teyber (1911) as *Atropis rupestris* on specimens collected by himself (WU). Later, Hayek (1933) transferred this species to the genus *Puccinellia*, but he changed the name in *Puccinellia teyberi* because the Teyber's epithet was not available for use, since the binomial *Puccinellia rupestris* was previously applied to another species by Fernald & Weatherby (1916). From those days onwards, this species due to its rarity and lack of herbarium specimens is not well known. In particular, Hughes & Halliday (1980), Domac (1994), Ilijanić & Topić (2000) treated it as a synonym of *P. festuciformis*. In order to clarify the taxonomy of this plant, field investigation was carried

out on the two islands where it occurs. Actually, it is widespread in the rocky places together with several rare or endemic species well adapted to the sea spray.

A detailed morphological study has revealed that this plant is well differentiated from the other known species of *Puccinellia*, showing for the type of leaf, inflorescence, upper glume, lemma and anther closer relationships mostly with *P. convoluta* (Hornem.) Hayek, rather than with *P. festuciformis*. Furthermore, the karyological analysis revealed that it is an apomictic taxon with $2n = 5x = 35$ and therefore it should be considered as a distinct species.

Material and methods

The morphological study was based on herbarium specimens (CAT, CNHM, WU and ZA) and on living plants, collected at the *locus classicus* (Islet of Kamik, Croatia). The karyological analyses were made on mitotic plates from root-tip cells of plants cultivated in the Botanical Garden of Zagreb (Croatia). The root-tips were pretreated according to Monserrat-Martí & Monserrat-Martí (1986) with 2mM 8-hydroxyquinoline for 24 h at 4°C, then fixed in ethanol-acetic acid (3:1), conserved in ethanol 70%, then immersed for the enzymatic digestion in 8% cellulase, 4% pectinase Y-23 and 4% hemicellulase in incubator at 37°C for 30–40 min, and stained according to DAPI technique using 4'-6-diamidino-2-phenylindole. Metaphase handling and chromo-

* Corresponding author

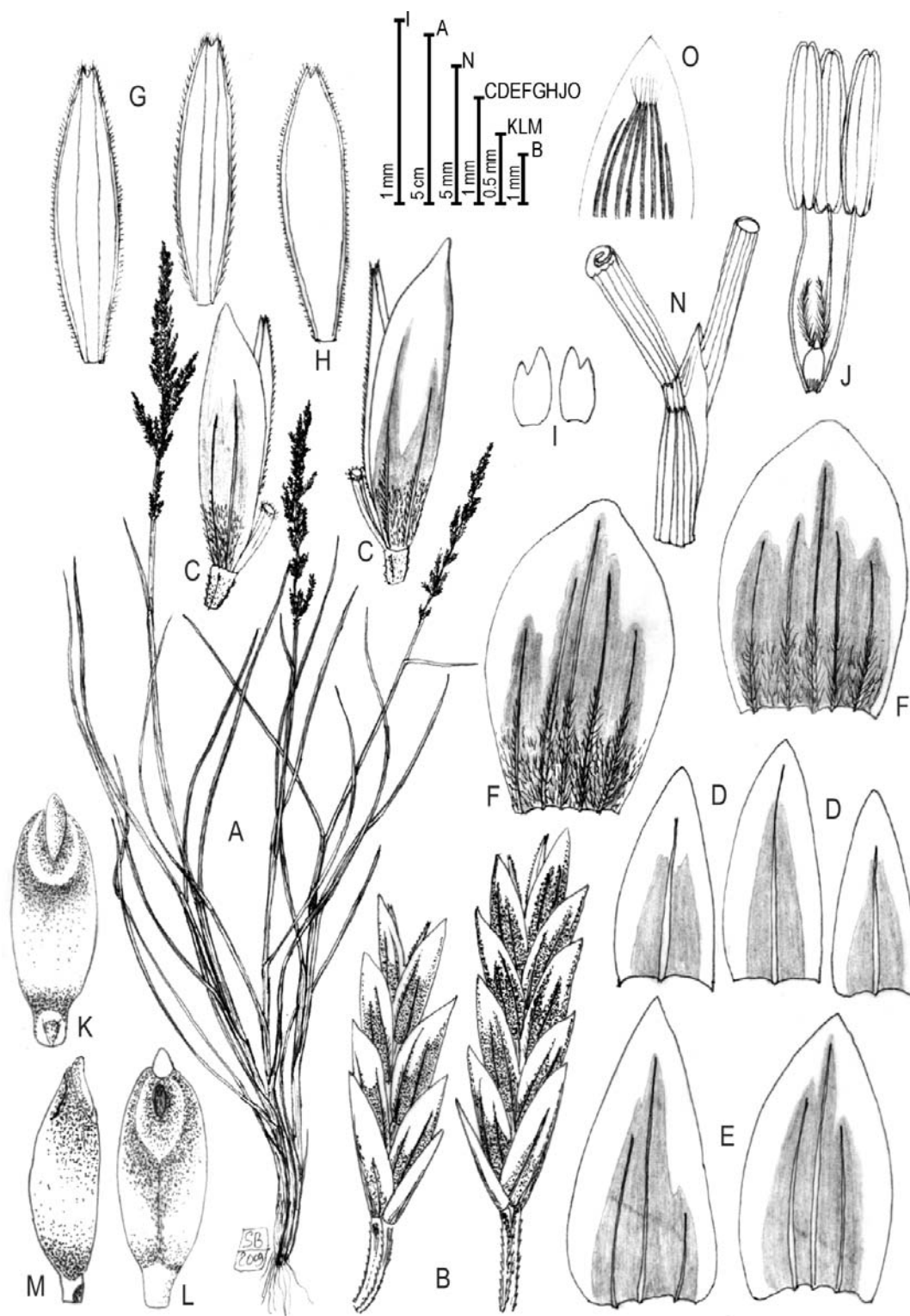


Fig. 1. *Puccinellia teyberi* (from type locality). A – habit; B – spikelets; C – flowers; D – lower glumes; E – upper glumes; F – lemmas; G – paleas (ventral view); H – palea (dorsal view); I – lodicules; J – stamens and pistil; K – caryopsis (ventral view); L – caryopsis (dorsal view); M – caryopsis (lateral view); N – leaf with ligule; O – ligule.

some counts were conducted using the Olympus BX51 with phase contrast.

Leaf anatomy was studied on cultivated plant material from the type locality. The median parts of leaf blade were used. The material was shortly boiled in water, then conserved in a solution of distillate water, ethanol 96% and glycerine (2:2:1). Leaf cross sections were hand made and

embedded in glicerine-jelly according to Sieben (1920) and Gerlach (1977).

The pollen samples were obtained from field collection. Fresh, mature pollen was collected at the beginning of anthesis and stored dry. For the hydrated condition, pollen was rehydrated in water for a few seconds, dehydrated in acidified 2,2-dimethoxypropane (DMP) and critical-point-dried

(Halbritter 1998). The samples were then sputter coated with gold and investigated on a JEOL JSM-T 300 scanning electron microscope at the Institute of Botany and Botanical Garden of the University of Vienna. Descriptions follow Punt et al. (2007) and Hesse et al. (2009).

Results

Puccinellia teyberi Hayek, Repert. Spec. Nov. Regni Veg. 30: 274 (1933) (Fig. 1)

Type: *Atropis rupestris* Teyber, Scoglio Kamik westl. von Lissa, 05.06.1911, *Teyber* s.n. (lectotype WU 0033118, isolectotype WU 0033117).

Syn: *Atropis rupestris* Teyber, Österr. Bot. Z. 61: 457 (1911), non *Puccinellia rupestris* (With.) Fernald & Weath., *Rhodora* 18: 10 (1916); *Atropis convoluta* (Horn.) Griseb. var. *caesia* Hackel in Degen, Magyar Bot. Lapok 10: 316 (1911), *nom. nud.*

Description: Perennial, caespitose; culms erect; 20–45 cm long. Leaf-sheaths open for most of their length. Ligule membranaceous, glabrous, triangular-lanceolate, 2.5–3 mm long, acute. Blade of basal leaf conduplicate, in the upper leaves convolute, 10–150 mm long; 2.6–3.7 mm wide. Abaxial leaf-blade surface smooth, adaxial one smooth to scaberulous. Leaf-blade margins smooth. Leaf-blade apex rounded. Inflorescence a panicle, lanceolate to linear-elliptical, contracted to slightly open; 5–15 cm long, 0.5–5 cm wide; inferior nodes 2–6 branched, superior ones (1)2–5 branched. Panicle branches scabrous. Spikelet pedicel ciliate-scabrous, 1–2 mm long. Spikelets linear to linear-elliptical, laterally compressed, 5–12 mm long, 5–9 flowered, with diminished florets at the apex. Floret callus glabrous. Glumes persistent, dissimilar, shorter than spikelet. Lower glume lanceolate, acute, 1-veined, 1.3–2.2 mm long, membranous, without keel. Upper glume lanceolate, acute, 3-veined, 2.5–3 mm long, membranous, without keel. Lemma oblong, obtuse to rounded, integer, 5-veined, 2.2–3 mm long, membranous, without keel, pubescent below. Palea linear-elliptical, 2.2–2.7 mm long, keel uniformly ciliolate, shortly bifid at apex, with teeth 0.1 mm long. Anthers 1.5–1.7 mm long. Lodicules shortly bifid, 0.4 mm long. Ovary glabrous, 0.4 mm long; stigma 0.6 mm long. Caryopsis 1.8–2 mm long with well developed hilum.

Phenology: late April to early June.

Chromosome number: $2n = 5x = 35$ (Fig. 2). The investigated population, coming from Kamik (type locality) is characterized by a pentaploid chromosome complement, since the basic number in the genus *Puccinellia* is $x = 7$. From the literature, this count is reported for the first time in this genus. In fact, in the previously examined species of *Puccinellia* the somatic chromosome numbers $2n = 14, 28, 42, 56, 70, 84$ were found (Church 1949; Kožuharov & Kuzmanov 1968; Monserrat-Martí & Monserrat-Martí 1986; Devesa 1987; Julià & Monserrat-Martí 1988; Julià & Vilodre 1994).

Leaf anatomy: The transversal leaf section of the basal leaves show a typical conduplicate shape, with

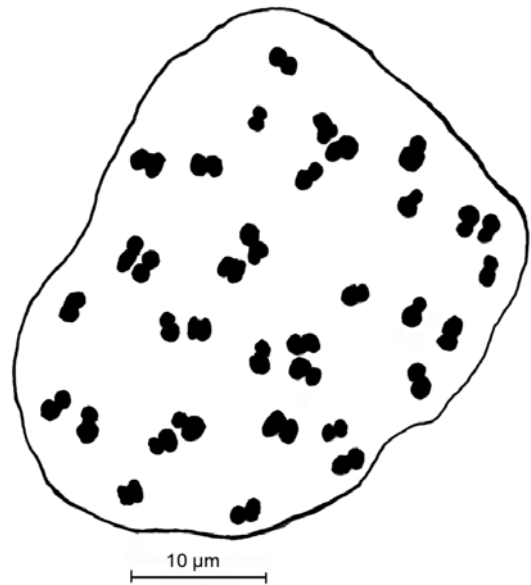


Fig. 2. Metaphase plate of *Puccinellia teyberi*.

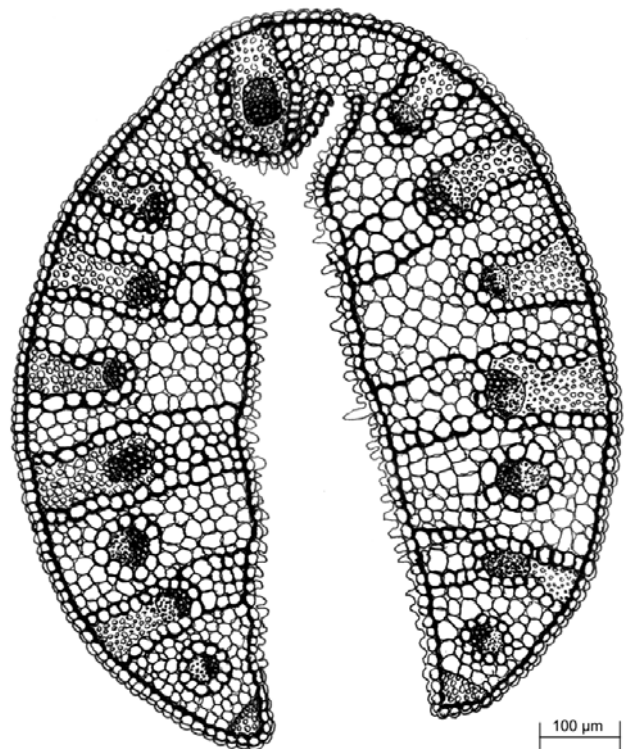
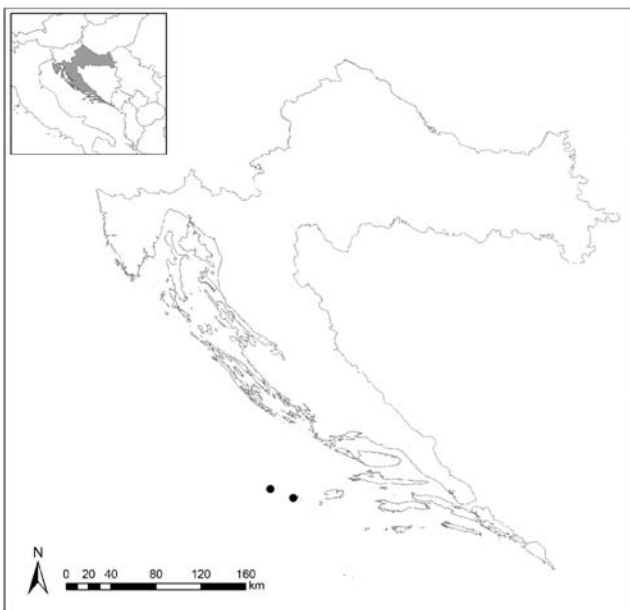


Fig. 3. Transversal leaf section of *Puccinellia teyberi*.

two sides of blade applied parallelly, unribbed in adaxial face (Fig. 3). Epidermis of the abaxial face is characterized by big irregular smooth cells, while in the adaxial face the cells are smaller and often papillate. Adaxial bulliform cells occur laterally to midrib. The mesophyll is homogenous and compact. The vascular bundles are 13–14, most of them are included in the sclerenchyma girders, sometimes the smallest ones are unaccompanied by sclerenchyma.

Table 1. Comparison between the morphological and karyological diagnostic characters of *Puccinellia teyberi* and allied species.

Character	<i>P. teyberi</i>	<i>P. convoluta</i>	<i>P. festuciformis</i>
Plant size (cm)	20-45, caespitose	20-50, caespitose	35-100, solitary or lax caespitose
Leaf blade size (mm)	10-150 x 2.6-3.7, conduplicate to convolute	30-140 x 0.5-1.5, convolute	70-220 x 1-2.5, conduplicate
Leaf blade abaxial surface	smooth	scaberulous	smooth
Leaf blade adaxial surface	smooth to scaberulous	rough	smooth
Leaf blade margin	smooth	scaberulous	smooth
Leaf blade apex	rounded	acuminate	acuminate
Ligule shape	triangular-lanceolate, acute	ovate-triangular, acute	ovate-triangular, acute
Ligule length (mm)	2.5-3	2-4	1.5-4.3
Panicle length (cm)	5-15	8-15	12-30
Panicle width (cm)	0.5-5	1-10	3-8
Panicle shape	lanceolate to linear elliptical, contracted to slightly open	linear-elliptical to elliptical, open or contracted	oblong, lax, erect-patent to patent
Nodes inferior of panicle	2-6 branched	2-5 branched	2-5 branched
Nodes superior of panicle	(1) 2-5 branched	1 branched	1-3 branched
Spikelet length (mm)	5-12	5-13	6-12
Spikelet flower number	5-9	4-9	5-11
Spikelet shape	linear to linear-elliptical, compressed	linear to ovate-linear, compressed	oblong, compressed
Lower glume shape	lanceolate, 1-veined	ovate-lanceolate, 3-veined	lanceolate to ovate, 3-veined
Lower glume length (mm)	1.3-2.2	2-2.5	2.5-3.6
Upper glume shape	lanceolate, 3-veined	ovate-lanceolate, 3-veined	lanceolate, 3-veined
Upper glume length (mm)	2.5-3	2.5-3	3.5-5
Upper glume apex	acute	subobtuse	acute
Lemma shape	oblong, 5-veined	oblong, 5-veined	lanceolate, 5-veined
Lemma length (mm)	2.2-3	3-3.5	3.5-5
Lemma apex	obtuse to rounded, integer	obtuse to rounded, erose	truncate, erose
Palea length (mm)	2.2-2.7	2.5-3	3.5-5
Palea indumentum	keel with small subequal cilia	keel with cilia, cilia longer below	keel with cilia, cilia longer below
Palea apex	shortly bifid with teeth 0.1 mm long	shortly bifid with teeth 0.05 mm long	shortly bifid with teeth 0.05 mm long
Anther length (mm)	1.5-1.7	1.5-2	2-3
Lodicule length (mm)	0.4, shortely bifid	0.6, longely bifid	-
Stigma length (mm)	0.6	1	-
Caryopsis length (mm)	1.8-2	1.3-1.8	-
Chromosome number	2n=5x=35	2n=2x=14, 2n=4x=28	2n=6x=42
Habitat	rocky coast	salt marsh	salt marsh

Fig. 4. Distribution map of *Puccinellia teyberi* in Croatia.

Pollen morphology: The pollen grains in the genus *Puccinellia* are monoporate and rather uniform, showing an oval to spheroidal shape, with a surfaces covered by granular ornamentation (Fernandez 1987; Ovchinnikova 1990; Julià & Villodre 1994). In particular, the pollen grains of *P. teyberi* are spheroidal with medium-sized (26–50 μm), in equatorial outline circular and operculate (Fig. 5). Exine surface is with granular ornamentation. Besides, the survey of external morphology of mature pollen grains as emphasized by various authors, seems does not have a taxonomic inference (Page 1978; Dahlgren et al. 1985). However, size of pollen grains of *P. teyberi* confirms theory about pollen grain diameter and ploidy level in some other *Puccinellia* taxa (Julià & Villodre 1994).

Distribution: According to literature, herbarium investigation and field survey, *Puccinellia teyberi* occurs in two small inhabitant islets of the Croatian coast (Fig. 4). In particular, it is localized in the volcanic rock of Jabuka (previously known as Pomo) and in the limestone of Kamik, were it is quite frequent.

Habitat and life form: This species is a caespitose

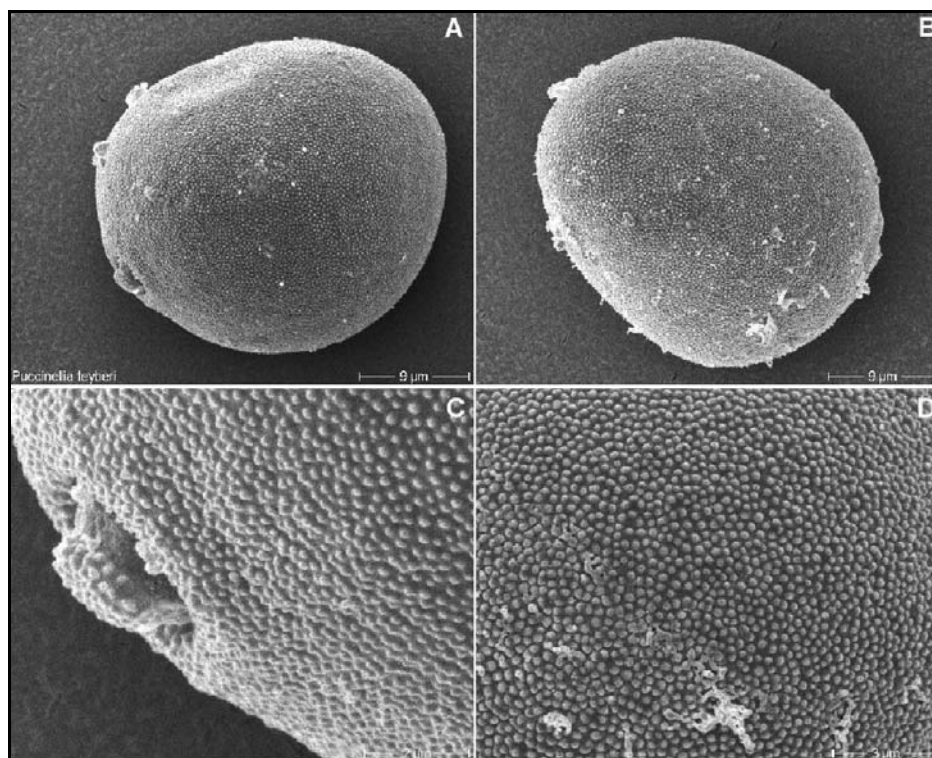


Fig. 5. Pollen grains of *Puccinellia teyberi* (SEM). A, B – equatorial view; C – aperture with pore; D – detail of exine surface.

hemcryptophyte clearly linked to the crevices of rocky slopes and cliffs. It is a halophyte, indifferent to the substrate, well adapted to sea aerosol, growing from sea level up to 30–40 m of altitude, where it is a member of a plant community belonging to *Crithmo-Limonietea* Br.-Bl. 1947. Usually, it grows together with *Limonium vestitum* (C. E. Salmon) C. E. Salmon, *Crithmum maritimum* L., *Frankenia pulverulenta* L., *Convolvulus cneorum* L., *Allium commutatum* Guss., *Aurinia leucadea* (Guss.) K. Koch subsp. *scopulorum* (Ginzb.) Plazibat, *Lavatera arborea* L., *Suaeda vera* J. F. Gmelin, *Lotus cytisoides* L., *Centaurea crithmifolia* Vis, *Centaurea friderici* Vis. subsp. *jabukensis* (Ginzb. & Teyber) Greuter and *Senecio leucanthemifolius* Poir.

Conservation status: At present, the only known populations of *P. teyberi* are circumscribed to the small islets of Kamik and Jabuka, where most of individuals grow on inaccessible cliffs. This is a threatened species at risk of extinction with a small populations which comprises a low number of individuals (ca. 250) restricted to the costal rocks. Based on the criteria adopted by IUCN (2010), the following specific category is proposed: B2 ab (i, iii, v) + D2. The species should be included in the Red List of the vascular flora of Croatia as vulnerable (VU).

Discussion

According to morphological, karyological, ecological and chorological data, *P. teyberi* should be treated as a distinct species, as previously highlighted by Ginzberger (1921), Hayek (1933), Lovrić (1981), Pavletić (1983) and Bogdanović et al. (2009). As concerns

its lectotypification, in the protologue Tyber (1911) reported that he examined specimens coming from Kamik and Pomo (nowadays Jabuka). In Vienna herbarium (WU) there are six sheets collected by Teyber himself or by other collectors and revised by him, used for the description of this species. Therefore, all these specimens can be considered as syntypes. Among them, the specimen no. WU 0033118 is chosen as lectotype, because this herbarium sheet is published (Abb. 1) by Teyber (1911) as illustration of *Atropis rupestris*, while the other illustration (Abb. 2) correspond to the isolecotype (WU 0033117).

From the morphological point of view, *P. teyberi* shows closer relation mainly with *P. convoluta*, belonging to the cycle of *P. festuciformis*, characterized by conduplicate or convolute leaves (Table 1). In particular, *P. teyberi* and *P. convoluta* have in common the more compact and caespitose habit of smaller size (max. 50 cm tall), panicle shorter (max. 15 cm long), contracted or slightly opened, linear spikelet, shorter glume (max. 3 mm long) and anthers (max. 2 mm long), while *P. festuciformis* s.str. shows normally a lax caespitose habit of bigger size (up to 100 cm tall), panicle up to 30 cm long, lax and more or less patent, oblong spikelet, longer glume (up to 3.5–5 mm long) and anthers (2–3 mm long). However, numerous morphological differences allow to differentiate very well *P. teyberi* from *P. convoluta*. The most relevant diacritical feature regards some vegetative structures as well as the reproductive ones. In particular, *P. teyberi* is characterized by leaf blade 2.6–3.7 mm wide, smooth in abaxial face, with acute apex, ligule triangular-lanceolate, lower glume lanceolate, 1-veined, upper glume lanceolate, acute,



Fig. 6. *Puccinellia convoluta*. A – habit; B – spikelets; C – flowers; D – lower glumes; E – upper glumes; F – lemmas; G – palea (ventral view); H – palea (dorsal view); I – lodicules; J – stamens and pistil; K – caryopsis (ventral view); L – caryopsis (dorsal view); M – caryopsis (lateral view); N – leaf with ligule; O – ligule.

lemma integer at the apex, 2.2–3 mm long, palea 2.2–2.7 mm long, with subequal cilia, lodicule 0.4 mm long, caryopsis 1.8–2 mm long, while *P. convoluta* (Fig. 6) differs in having leaf blade 0.5–1.5 mm wide, scaberrulous in abaxial face, with apex acuminate, ligule ovate-triangular, lower glume ovate-lanceolate, 3-veined, upper glume ovate-lanceolate, subobtusate, lemma erose at the apex, 3–3.5 mm long, palea 2.5–3 mm long, with unequal cilia, longer below, lodicule 0.6 mm long, caryopsis 1.3–1.8 mm long.

These species differ also in the chromosome complement and ecological requirements. *Puccinellia teyberi* is a pentaploid species, linked to rocky coastal places, as cliffs and steep slopes, instead *P. convoluta* shows a diploid or tetraploid chromosome number and likes the periodically submerged depressions with halomorphic soil, such as salt marshes. As concerns *P. festuciformis*, this species has the same ecology of *P. convoluta*, but has a hexaploid chromosome complement.

On the basis of its morphological features, punc-

tiform distribution, chromosome number and peculiar ecology, *P. teyberi* can be considered a neoendemic species with apomictic origin. Besides, as emphasized by Nikolić et al. (2008), Kamik and Jabuka represent the Adriatic islets with the greater concentration of narrow endemics. In fact, these islets are characterized by a very poor florula but rich in local endemics, 28.6% for Kamik and 17.5% for Jabuka. Most of these endemics have a quite recent origin, e.g. *Centaurea crithmifolia* Vis., *C. friderici* Vis. subsp. *jabukensis* (Ginz. & Teyber) Greuter, *C. × pomoensis* Teyber, *Limonium vestitum* (C. E. Salmon) C. E. Salmon and *Aurinia leucadea* (Guss.) K. Koch subsp. *scopulorum* (Ginz.) Plazibat, which represent microendemics or neoendemics.

Representative Specimen Examined: *Atropis rupestris* Teyber, Scoglio Pomo, 03.–09.06.1911, *Teyber* (syntype WU 0033120); *Atropis rupestris* Teyber, Scoglio Pomo. Nur auf Pomo und Kamik, 03.06.1911, *Teyber* (syntype WU 0033119); *Atropis convoluta* Fries. var. *caesia* Hack. in litt., Flora Dalmatica, Scoglio Kamik; in rupestribus maritimis, 31.07.1905, *de Degen* (syntype WU 0033122); Aus Samen vom Scoglio Kamik, westl. v. Lissa, Dalmatien, leg. A. Degen 1905, cult. hort. bot. Vind., Angebaut: 05.04.1912, eingelegt: 19.06.1913, *Teyber* (WU 0033123); *Glyceria maritima*, Scog. Pomo, manu Botteri (syntype WU 0033121); Aus Samen vom Scoglio Kamik, westl. v. Lissa, Dalmatien, leg. A. Teyber 05.06.1911, cult. hort. bot. Vind., Angebaut: 04.1912, eingelegt: 19.06.1913, *Teyber* (WU 0033124); Dalmacija; školj Kamik zapadno od Sv. Andrije, 07.06.1964, *Trinajstić* 6766 (CNHM); Školj Kamik, 07.06.1964, *Trinajstić* 6767 (CNHM); Školj Kamik, 07.06.1964, *Trinajstić* 6768 (CNHM); Školj Kamik, 07.06.1964, *Trinajstić* 6769 (CNHM); Otok Kamik, zapadno od Sv. Andrije (materijal sakupljen na loc. class.) stijene uz obalu mora, 27.05.2005, *Bogdanović* (CAT, ZA); Otok Kamik, vršni plato, 25.04.2008, *Bogdanović* (ZA).

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