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A morphometric reassessment of *Armeria dalmatica* (Plumbaginaceae) from Dalmatia, Croatia

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ABSTRACT:
Armeria dalmatica is a local endemic species from Croatia, originally described by Beck in 1898. Its taxonomic status has been interpreted differently over time, causing confusion among botanists. According to most official data sources, *A. dalmatica* is currently not accepted as a distinct species and is considered a synonym of *A. canescens*. A morphometric study, carried out on populations of both *A. dalmatica* and the closely related *A. canescens*, revealed clear morphological differentiation between the two taxa. The results of this study indicate that the most diagnostic morphological characters are: sheath length, spikelet bract width, calyx tube length, calyx limb length, and awn length. An identification key for distinguishing *A. canescens* from *A. dalmatica* is provided. Finally, the distribution and ecology of *A. dalmatica* have been revised, leading to the conclusion that it is a halophyte as well as a halotolerant species, growing in only a few localities in North Dalmatia.

Keywords: *Armeria canescens*, endemic species, Mediterranean flora, morphometrics, taxonomy, typification.

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INTRODUCTION

Armeria Willd. is the third most numerous genus within the family Plumbaginaceae Juss. after the genera *Limonium* Mill. and *Acantholimon* Boiss., comprising 108 species (Malekmohammadi *et al.* 2024). *Armeria* includes caespitose perennial herbs which are mainly distributed in the Holarctic region with a disjunct range in the Chile-Patagonian area (Lawrence 1940; POWO 2025). The highest diversity, in terms of taxonomic richness, is found on the Iberian Peninsula (Greuter *et al.* 1989). Hybridisation and introgression are known to occur among *Armeria* species (Feliner 1997; Fuertes Aguilar *et al.* 1999; Villa-Machío *et al.* 2023), making taxonomic studies of this genus challenging. In addition, botanists interpreted the taxonomic status of certain taxa within this genus differently, which further complicates the understanding of its taxonomy, including that of *A. dalmatica* Beck (see Nikolić *et al.* 2015). Finally, the nomenclature of the genus is also quite complex (e.g. Iamonico *et al.* 2024).

Armeria dalmatica was described by Beck (1898) based on the materials he had collected on the islands of Pag and Brač in Croatia and on Mt. Velež (southern Bosnia and Herzegovina). He noted that the newly proposed species was similar to *A. canescens* (Host) Boiss., but differed from it by having filiform leaves, a smaller capitulum, and white flowers. Beck (1898) also pointed out the clear geographical separation of the *A. canescens* populations from some other *Armeria* species from the Balkan Peninsula, including *A. dalmatica* and *A. undulata* (Bory & Chaub.) Boiss.

Forty years later, Novák (1938) changed the status of *A. dalmatica* from species to variety rank, as *A. canescens* var. *dalmatica* (Beck) Novák, providing data on its distribution in Dalmatia, Herzegovina, and Montenegro. In addition, he distinguished three forms within the variety: f. *typica* Novák [an invalid name (Art. 24.3 of the *Madrid Code*), corresponding to f. *dalmatica*], f. *rosea* Beck ex Novák (based on the flower colour which is pink *vs.* white in f. *dalmatica*), and f. *pseudodalmatica* Novák, a transitional form between var. *dalmatica* and *A. canescens* var. *canescens* (indicated as "*eu-canescens* (Host) Novák", an invalid name according to Art. 24.3 of the *Madrid Code*). About 40 years later, Trinajstić (1980) proposed a new status, designating the species as *A. canescens* subsp. *dalmatica* (Beck) Trinajstić. In the following year, Trinajstić (1981) provided a more detailed description, noting the major differences between this subspecies and the type subspecies in the capitulum diameter (1–1.5 cm *vs.* 2–2.5 cm), flower colour (white *vs.* pink), the shape of the inner leaves (narrowly linear and involute *vs.* rarely narrowly linear and involute) and the calyx length (6–7 mm *vs.* 7–8 mm).

The taxonomic status of *A. dalmatica* is still unclear and not uniformly interpreted (e.g., Greuter *et al.* 1989; Nikolić *et al.* 2015). Several botanists have recognised *A. dalmatica* as a separate species (Domac 2002; Pezzetta 2011), while others consider it at subspecies level (Domina 2011; Nikolić 2020; GBIF 2025), following Trinajstić's standpoint. On the other hand, some authors suggest that *A. dalmatica* is a synonym of *A. canescens* (Lawrence 1940; Arrigoni 2015; POWO 2025; WFO 2025). For instance, in *Flora Europaea* (Pinto de Silva 1972), *A. dalmatica* is not recognised as an independent taxon, but is included in *A. canescens*.

In addition to *A. dalmatica*, the closely related *A. canescens* has also been recorded in Croatia (Nikolić 2020). It was originally described under the name *Statice canescens* Host based on material from the Dalmatian mountains (see Scassellati *et al.* 2011). *Armeria canescens* is a morphologically highly polymorphic species (Novák 1938; Pinto de Silva 1972), growing in Croatia on limestone geological substrate in the alliance *Scorzonerion villosae* Horvatić 1949 (Nikolić *et al.* 2015). It has also been recorded in Albania, Bosnia and Herzegovina, Greece, North Macedonia, Montenegro and Serbia (Buzurović & Jakovljević 2022), while its occurrence in the Apennine Peninsula is questionable (Scassellati *et al.* 2013; Arrigoni 2015; Bartolucci *et al.* 2024).

The aims of the present study are to clarify the taxonomic status of *A. dalmatica* defining its morphological, ecological, and chorological features, in comparison with the related *A. canescens*.

MATERIAL AND METHODS

The study area is situated in southeastern Europe, in the western part of the Balkan Peninsula, within the Dinaric Mountain system, where limestone formations dominate the geological substrate. The region spans contrasting bioclimatic zones, ranging from the Mediterranean climate along the Adriatic coast—the habitat of *A. dalmatica*—to the temperate continental climate in the inland mountainous areas, where *A. canescens* occurs.

Table 1. Details of the sampled populations of *Armeria canescens* and *A. dalmatica* used in this study.

Pop. no.	Taxon name	Locality	Individuals	Voucher	Coordinates	Elevation (m)
1	*A. canescens*	Mt Biokovo (CRO)	13	BEOU-72499	43.289622 N 17.087123 E	1240
2		Mt Mosor (CRO)	11	BEOU-72500	43.521298 N 16.610394 E	818
3		Mt Dinara (BH)	13	BEOU-43660	43.92540 N 16.62808 E	1550
4		Brač island (CRO)	10	BEOU-72501	43.316657 N 16.602452 E	560
5	*A. dalmatica*	Pag island (CRO)	10	BEOU-72502	44.455359 N 15.026841 E	58
6		Nin (CRO)	10	BEOU-72503	44.255014 N 15.168961 E	1

* Pop. no.–population number, BH–Bosnia and Herzegovina, CRO–Croatia.

Table 2. A summary of the morphometric analysis of the morphological characters and the results of analysis of variance (ANOVA). The significant differences between morphological characters ($p < 0.05$) are highlighted in bold. The total number of measured individuals is 67 (20 belonging to *Armeria dalmatica* and 47 to *A. canescens*).

Morphological characters	*Armeria canescens*				*Armeria dalmatica*				ANOVA	
	Min	Max	LQ	UQ	Min	Max	LQ	UQ	F	p
Scape length (cm)	21.5	63.8	34.7	49.4	35.1	65.8	43.5	59.2	17.8	**0.00**
Capitulum diameter (mm)	11.0	22.0	14.0	18.0	11.0	19.0	14.0	17.0	8.57	**0.00**
Outer leaf length (mm)	30.1	124	42.4	64.7	47.6	138	61.8	103	13.8	**0.00**
Outer leaf width (mm)	1.20	5.32	2.14	3.24	1.80	3.88	2.16	3.40	16.4	**0.00**
Inner leaf length (mm)	56.0	231	95.1	129	70.9	199	116	157	6.41	**0.00**
Inner leaf width (mm)	0.91	5.32	1.54	2.60	1.13	3.05	1.37	2.13	10.5	**0.00**
Sheath length (mm)	8.72	29.9	16.3	21.3	15.1	36.2	22.2	29.6	12.4	**0.00**
Outer involucral bract length (mm)	5.27	11.1	6.99	8.47	4.75	9.00	5.62	7.77	3.40	**0.01**
Outer involucral bract width (mm)	2.66	4.80	3.09	4.04	2.99	4.78	3.38	4.38	8.09	**0.00**
Inner involucral bract length (mm)	6.39	10.7	7.37	8.57	5.70	9.80	7.22	8.37	5.45	**0.00**
Inner involucral bract width (mm)	3.47	6.91	4.52	5.69	3.52	6.20	4.44	5.40	5.70	**0.00**
Spikelet pedicel length (mm)	0.00	0.75	0.29	0.64	0.00	0.65	0.00	0.4	8.27	**0.00**
Spikelet bract length (mm)	5.81	10.2	6.96	8.35	6.52	9.72	7.68	8.8	0.75	0.59
Spikelet bract width (mm)	3.74	7.59	5.14	6.10	4.39	7.90	6.22	6.8	5.95	**0.00**
Calyx length (mm)	5.18	8.04	6.50	7.34	5.72	8.31	6.34	7.4	3.25	**0.01**
Calyx tube length (mm)	2.40	3.96	3.07	3.42	2.98	4.36	3.49	4.1	11.6	**0.00**
Calyx limb length (mm)	3.01	4.71	3.36	4.00	2.32	3.98	2.76	3.2	19.4	**0.00**
Calyx pedicel length (mm)	1.27	3.15	1.86	2.45	1.51	3.11	2.00	2.6	2.67	**0.03**
Awn length (mm)	0.65	2.02	0.97	1.37	0.50	1.09	0.60	0.8	28.4	**0.00**

* Min–minimum value, Max–maximum value, LQ–lower quartiles, UQ–upper quartiles.

The plant material was collected from five localities in Croatia (the islands of Pag and Brač, Nin, and Mts. Mosor and Biokovo) during May and July 2023–2024, and from one locality in Bosnia and Herzegovina (Mt. Dinara) in July 2015. Plant material of *A. dalmatica* was collected from two coastal localities in northern Dalmatia, Croatia: Nin and the island of Pag, both situated within the Mediterranean bioclimatic zone, characterised by mild, wet winters and hot, dry summers. Specimens of *A. canescens* were sampled from three localities in central Dalmatia (the island of Brač, Mt. Biokovo, and Mt.

Table 3. Factor loading of the first two principal components and standardised coefficients of the first two discriminant axes based on the morphological characters for groups defined as populations.

Morphological characters	PCA		CDA	
	PC1	PC2	DA1	DA2
Scape length	-0.89	-0.05	-0.39	-0.56
Capitulum diameter	-0.68	-0.09	-0.01	-0.23
Outer leaf length	-0.68	0.44	-0.72	0.27
Outer leaf width	-0.63	0.14	0.08	-0.84
Inner leaf length	-0.71	0.39	0.67	0.27
Inner leaf width	-0.50	0.16	0.06	-0.11
Sheath length	-0.57	0.33	-0.45	-0.17
Outer involucral bract length	-0.20	-0.53	0.25	0.16
Outer involucral bract width	-0.50	-0.46	-0.25	-0.17
Inner involucral bract length	-0.49	-0.67	0.26	-0.07
Inner involucral bract width	-0.38	-0.62	0.55	-0.57
Spikelet pedicel length	-0.07	-0.51	0.37	-0.80
Spikelet bract width	-0.30	0.20	-0.72	0.74
Calyx length	-0.28	-0.69	-0.39	0.03
Calyx tube length	-0.57	-0.05	-0.51	-0.06
Calyx limb length	0.21	-0.81	0.56	0.14
Calyx pedicel length	-0.67	-0.27	0.07	0.49
Awn length	0.43	-0.66	0.56	0.25

* PC1 and PC2–factor loadings of principal component analysis (PCA), DA1 and DA2–standardized coefficients of canonical discriminant analysis (CDA).

Mosor, Croatia) and one inland locality (Mt. Dinara, Bosnia and Herzegovina). These sites belong to the sub-Mediterranean zone of the central Adriatic region, where Mediterranean influences transition towards continental conditions. Details on the geographic coordinates and altitude of each sampled locality are provided in Table 1.

For morphological analyses, 10–13 individuals per population (67 individuals in total) were collected and preserved in a mixture consisting of equal volumes (v/v) of 50% ethanol and 85% glycerol. Although 70% ethanol is commonly used, in this case the preservation quality of the plant material was improved by our modification. By using 50% ethanol, a more pliable plant material was obtained, which was easier to manipulate and prepare for further analysis. The voucher specimens are deposited in the Herbarium BEOU (the herbaria codes cited in this section follow Thiers (2025).

A total of 19 quantitative morphological characters were examined (Table 2). The selection of morphological characters was based on the data from the regional flora (Nikolić 2020), previous studies on *Armeria* (Larena *et al*. 2006; Scassellati *et al*. 2013) and personal observations of diagnostic and potentially important morphological characters. The vegetative and reproductive organs were placed on graphoscope foil and fixed with transparent scotch

tape. They were then scanned with a digital resolution of 600 dpi. Most of the quantitative characters were measured using Digimizer Image Analysis software (MedCalc Software, Belgium), while the scape length and capitulum diameter were measured with a graduated ruler. Qualitative characters were examined with a stereomicroscope (Leica MZ75), but they were not included in the statistical analyses.

Statistical analyses were performed using STATISTICA 7 software (StatSoft 2008). Analysis of variance (ANOVA) and canonical discriminant analysis (CDA) were conducted with groups defined as populations, while descriptive statistics and box/whisker plots were generated using species as groups to show the most significant characters for distinguishing *A. dalmatica* from *A. canescens*. The identification key was based on quantitative morphological characters, with the values given as interquartile ranges, and the extreme values given in brackets.

The chorological analyses were conducted on plant material from the following herbaria collections (preserved at BEO, BEOU, CNHM, PRC, ZA, and ZAGR) and literature data. The distribution of *A. dalmatica* is presented on a 10 × 10 km grid map, based on the Military Grid Reference System (MGRS) projection (Lampinen 2001).

The articles cited throughout the text follow the *International Code of Nomenclature for algae, fungi, and plants*, hereafter reported as "ICN" (Turland *et al.* 2025).

RESULTS

Analysis of variance (ANOVA) showed that most of the morphological characters were statistically significant ($p < 0.05$, Table 2) with the exception being the length of the spikelet bract, which was consequently excluded from further analyses.

The first three principal components of the PCA analysis explained 59.4% of the total variability (28.1%, 20.8%, and 10.5%, respectively). The length of the scape and the inner leaf are the morphological characters which contributed most strongly to the variability along the first component, while calyx limb length contributed to the highest variability along the second component (Table 3). The scatterplot of PC1 *vs.* PC2 did not show any clear delimitation either between *A. canescens* and *A. dalmatica*, or among populations of the same species (Fig. 1). Similarly, those of PC1 *vs.* PC3 and PC2 *vs.* PC3 showed no distinct grouping of the species or populations within the same species.

The first two discriminant axes of the CDA analysis explained 82.8% of the total discrimination (61.3%, 21.5%, respectively, Fig 2). The clear separation of two groups was revealed along the first axis, each consisting exclusively of populations belonging to one species. (Fig. 2). The highest contribution to the separation of the two groups was provided by the following morphological characters: outer leaf length and spikelet bract width, both along the first CDA axis (Table 3). The individuals recognised as *A. canescens* populations were separated in the positive part of the first axis, whereas the individuals of *A. dalmatica* were separated in the negative part. The populations of *A. dalmatica* (Pag and Nin), which grow under different environmental factors, were separated along the second axis (DA2). Additionally, the *A. dalmatica* population from Nin is characterised by higher values for most characters compared to the population from Pag, with the exception of outer involucral bract length and spikelet bract width (Table S1).

Based on the results shown in Fig. 3, the species *A. dalmatica* is characterised by a shorter calyx limb and awn compared to *A. canescens*, while it has a longer sheath, outer leaves, and calyx tube, as well as wider spikelet bract.

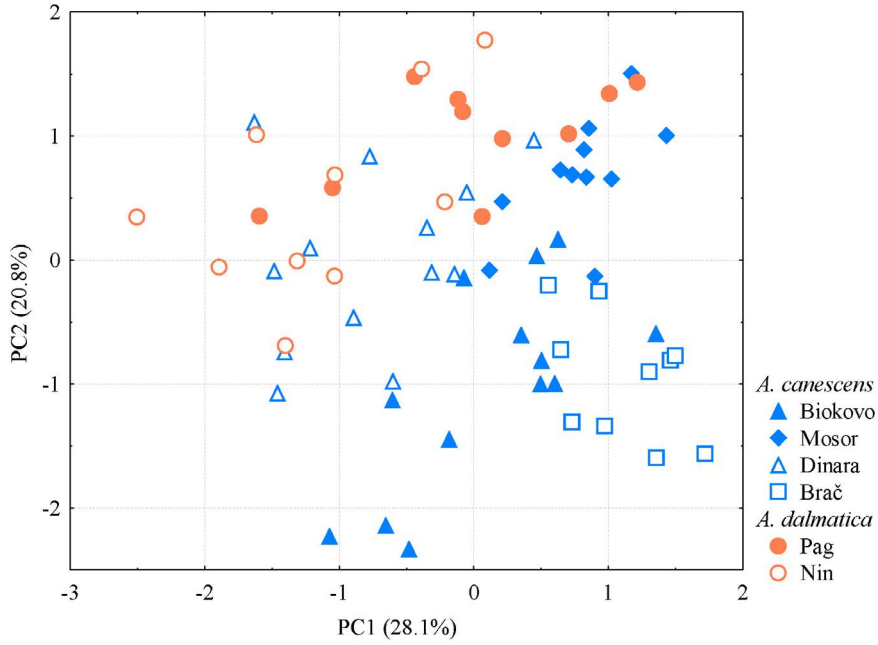

Fig. 1. Principal component analysis (PCA) of the morphometric data for six populations (four of *Armeria canescens* and two of *A. dalmatica*) on the first (PC1) and second (PC2) components. Populations within a single species are marked with different symbols, while species are marked with different colours – *A. canescens* (blue) and *A. dalmatica* (coral).

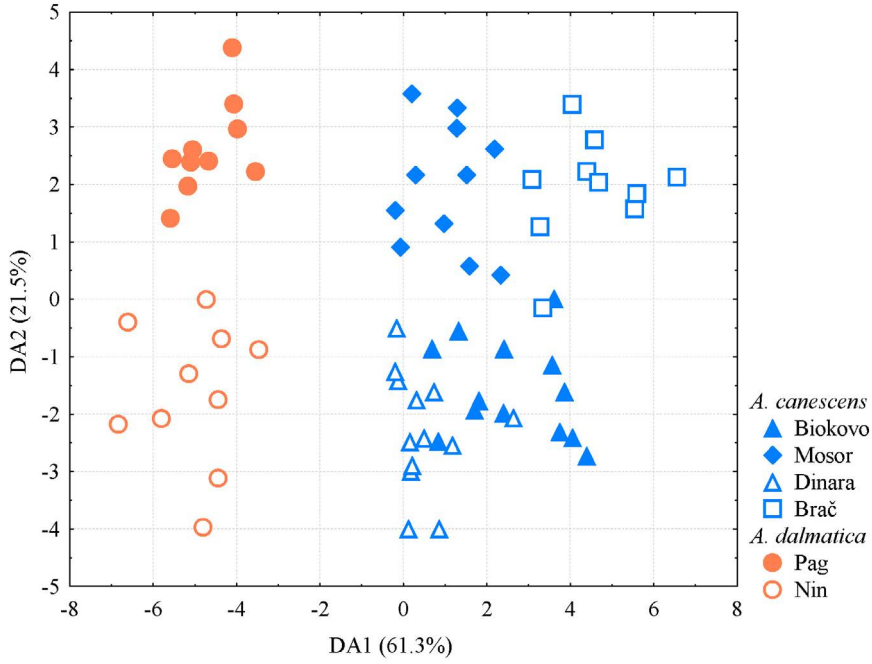

Fig. 2. Canonical discriminant analysis (CDA) of the morphometric data for six populations (four of *Armeria canescens* and two of *A. dalmatica*) on the first (DA1) and second (DA2) axes. Populations within a single species are marked with different symbols, while species are marked with different colours – *A. canescens* (blue) and *A. dalmatica* (coral).

The corolla colour (a qualitative character) did not contribute to distinguishing these two species. In populations of *A. dalmatica*, individuals have white to pale pink flowers. In populations of *A. canescens*, pink flowers predominate in the Dinara and Mosor populations; both white and pink flowers are present in the Biokovo population, while all individuals in the Brač population have white flowers.

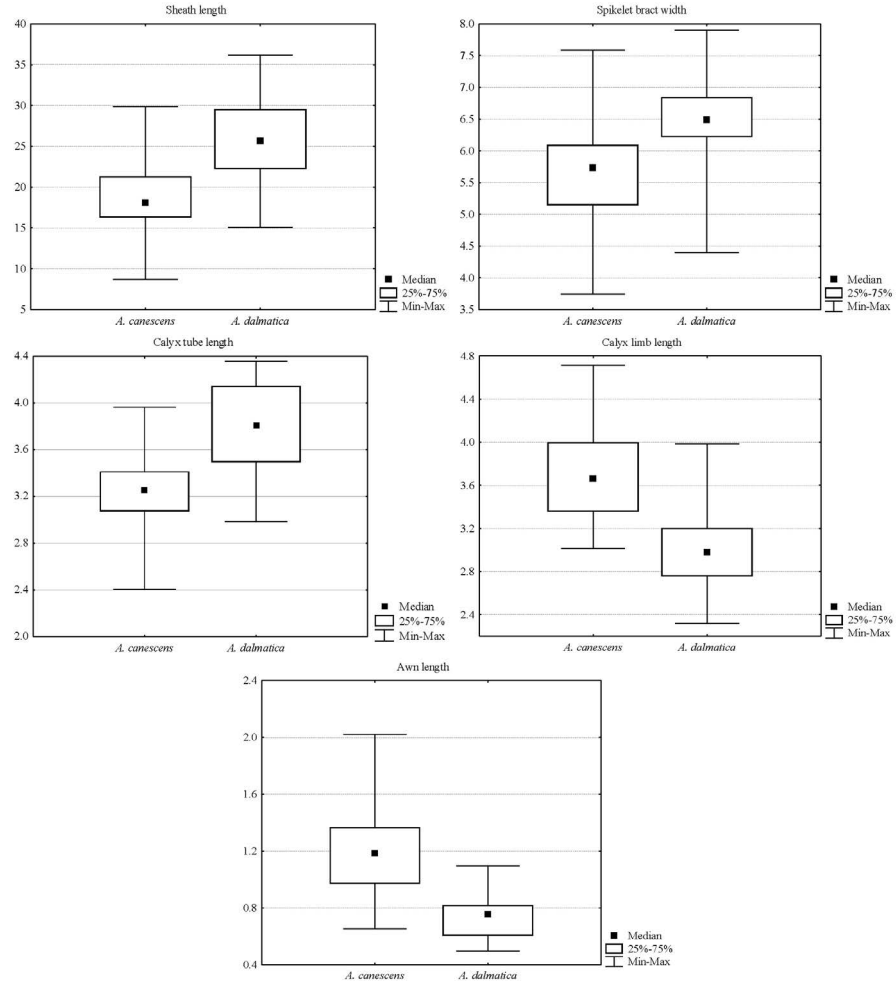

Fig. 3. Variability of the selected morphological characters for *Armeria canescens* and *A. dalmatica*.

Taxonomic treatment

Armeria dalmatica Beck (1898: 16)

≡ *Armeria canescens* subsp. *dalmatica* (Beck) Trinajstić (1980: 6)

– *Armeria canescens* var. *dalmatica* f. *typica* (Beck) Novák (1938: 12), *nom. inval.* (Art. 24.3 of ICN).

Ind. loc.:—[CROATIA. Pag island] "in Felshaiden der Insel Pago"; [CROATIA. Brač island, Vidova Gora] "auf dem S. Vitoberge der Insel Brazza"; [BOSNIA AND HERCEGOVINA. Mt Velež] "auf dem Velez".

Lectotype (designated by Novák (1938), as "typus" and, therefore, accepted as correct lectotypification according to Art. 7.11 of ICN): CROATIA. Pag island, 11 June 1897, *Beck s.n.* (PRC!) (Fig. 4).

Notes. Beck (1898) indicated three localities in the protologue and stated that he had collected plant material, but did not specify the numbers of the collections or specimens. These indications may be considered syntypes (Art. 9.6 of ICN). Based on the observation of Beck's original material from the island of Brač and Mt. Velež, our field investigations, and the examination of other herbarium material, we noted that forms of *A. canescens* could actually grow at these localities. Therefore, the only acceptable type locality for *A. dalmatica* would be the island of Pag and Novák's use of the PRC specimen is here confirmed to be correct. In his description of *A. canescens* var. *dalmatica* f. *dalmatica* (as "*typica*"), Novák (1938) referred to a specimen from the island

Fig. 4. Lectotype of *Armeria dalmatica* (PRC!).

of Pag deposited in the PRC herbarium as the type, but failed to mention the herbarium sheet number or type category. We found only one specimen in the PRC herbarium with data matching the protologue.

Description. A perennial caespitose herb with branched woody rootstock. Leaves glabrous, minutely dotted, mainly linear to rarely filiform, obtuse to cuspidate, margins narrowly scarious, often involute, dimorphic; outer leaf (47.6–)61.8–103(–138) × (1.8–)2.2–3.4(–3.9) mm; inner leaf (70.9–)116–157(–198.8) × (1.1–)1.4–2.1(–3.1) mm. Scape erect, glabrous, (35.1–)43.5–59.1(–65.8) cm high; sheath (15.1–)22.2–29.6(–36.2) mm long. Capitulum hemispheric,

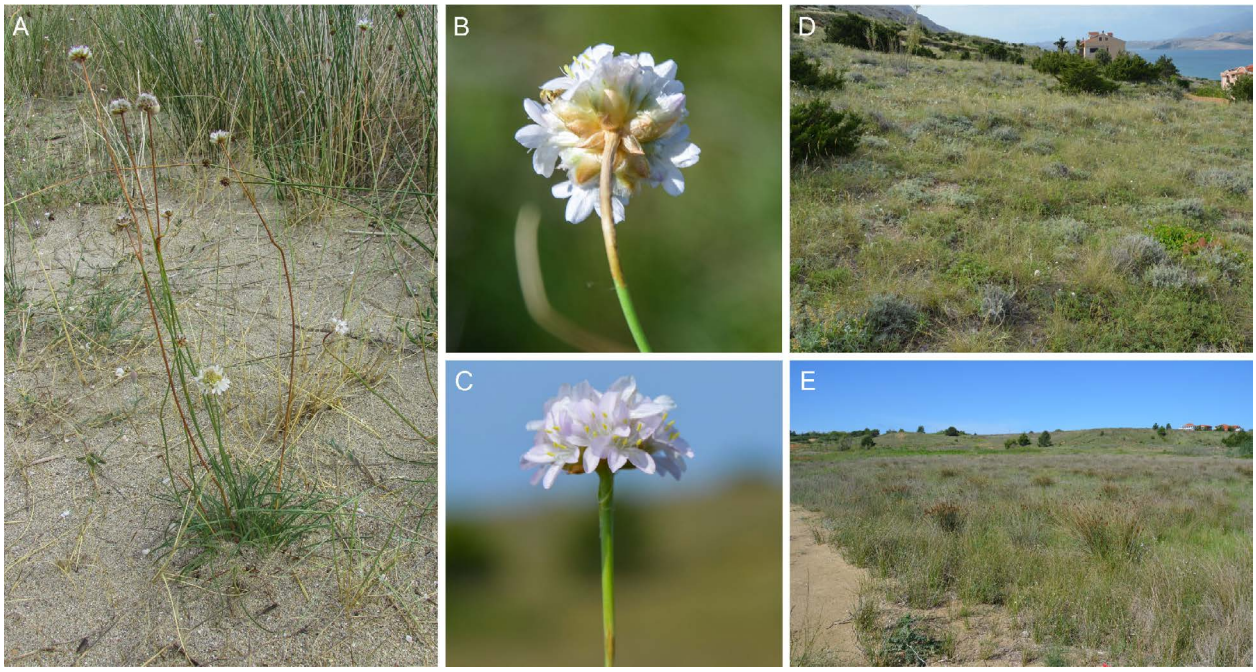

Fig. 5. *Armeria dalmatica* Beck – A) Habitus; B) Involucre; C) Capitulum; D) Habitat on the island of Pag; E) Habitat on Kraljičina Beach near the town of Nin.

(11–)14–17(–19) mm wide. Outer involucral bracts (4.8–)5.6–7.8(–9) × (3–)3.4–4.4(–4.8) mm, scarious, oval to obovate, acuminate to cuspidate, with a narrow hyaline margin; inner involucral bracts (5.7–)7.2–8.4(–9.8) × (3.5–)4.4–5.4(–6.2) mm, scarious, obovate, truncate to rounded, with a narrow hyaline margin. Spikelet 2-3 flowered, subsessile or sessile; spikelet bracts shiny, membranous, obovate, rounded, (6.5–)7.7–8.8(–9.7) × (4.4–)6.2–6.8(–7.9) mm. Calyx (5.7–)6.3–7.4(–8.3) mm long, hirsute, holotrichous; pedicel (1.5–)2–2.6(–3.1) mm long, tube (3–)3.5–4.1(–4.4) mm long; limb (2.3–)2.8–3.2(–4) mm long, with membranous triangular lobes; awn (0.5–)0.6–0.8(–1.1) mm long. Corolla white to pale pink (Figs. 3 & 5A–C).

Phenology. Flowering time is from May to June; fruiting time is in July.

Distribution and ecology. This species occurs in several localities of North Dalmatia in Croatia: on the island of Pag growing on the limestone near the seacoast and, in the vicinity of the town of Nin, in sandy coastal habitats (Fig. 6). On the island of Pag, the species grows in dry grasslands, which have developed on abandoned vineyards, within the endemic association *Armerio dalmaticae-Helichrysetum italici* Horvatić 1963 nom. invers. (Terzi *et al.* 2024) (Fig. 5D), while near the town of Nin it has been recorded within the psammophytic vegetation of the order *Ammophiletalia* Br.-Bl. et Tx. ex Westhoff et al. 1946 (Bogdanović *et al.* 2018) and within tall-rush saline wetland vegetation of the order *Juncetalia maritimi* Br.-Bl. ex Horvatić 1934 (Fig. 5E).

Additional specimens examined. Pag, plaža [beach] Sveti Duh, [MGRS 33T VK92], 44.50229167 N, 14.97518333 E, peskovi [sands], 0 m, 11.07.2014, *U. Buzurović & S. Bogdanović s.n.* (BEO 53379!); Pag, na putu ka plaži [on the way to the beach] Sveti Duh, [MGRS 33T VK92], krečnjak [limestone], 10.07.2017, *U. Buzurović & S. Bogdanović s.n.* (BEO!); Pag, cesta [road] Sveti Duh–Girišće, [MGRS 33T VK92], 44.483436 N, 14.993289 E, suhi kamenjarski travnjak [dry rocky grassland], napušteni vinograd [abandoned vineyard], 11.07.2014, *S. Bogdanović & U. Buzurović s.n.* (ZAGR 38869!); Pag, Pag–Bošana, [MGRS 33T WK02], 44.455359 N, 15.026841 E, kamenjari [rocky ground], krečnjak [limestone], 58 m, 07.06.2024, *L. Milivojević s.n.* (BEOU 72502!); Pag, okolina grada

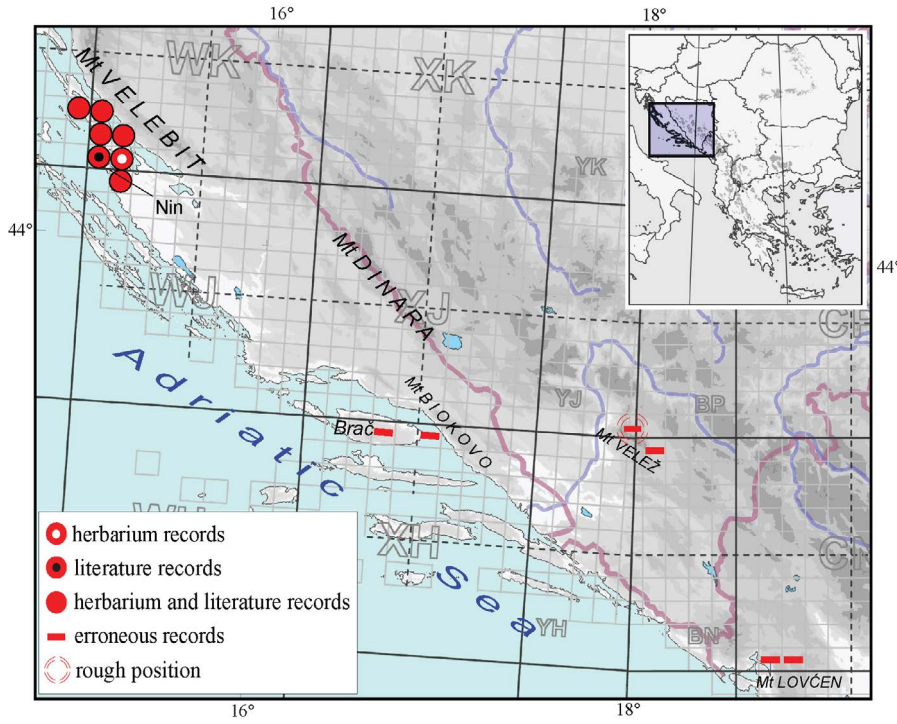

Fig. 6. Distribution of *Armeria dalmatica* based on herbarium and literature records. All erroneous records of *A. dalmatica* refer to *A. canescens*.

[in the vicinity of the town], [MGRS 33T WK02], zapušteni vinogradi [abandoned vineyards], as. vrste [associated species] *Artemisia lobelia*, 01.05.1959, *I. Trinajstić 2127. 1421.* (CNHM 600:ZAG; 1843:T!); Pag, Dinjiško polje, [MGRS 33T WK11], 12.06.1965, *I. Trinajstić 8291.*(CNHM 600:ZAG; 1844:T!); insula Pago, San Giovanni Razanka, [MGRS 33T WK01], 26.05.1912, *J.B. Kümmerle 27.562* (ZA 9206!); insulae Pago, ad Pago, [MGRS 33T WK02], in sterilibus, 25.07.1881, *V. Borbás s.n.,* sub. *Armeria vulgaris*, (ZA!), insulae Pago, ad Pago, in lapidosis, 06.1884, *V. Borbás s.n.*, sub. *Armeria canescens*, (ZA!), Nin, Ždrijac, [MGRS 33T WJ19], 44.24777778 N, 15.1895 E, peskovi [sands], 0 m, 11.07.2014, *U. Buzurović & S. Bogdanović s.n.* (BEO 53380!); Nin, Ždrijac, [MGRS 33T WJ19], 44.24777778 N, 15.1895 E, peskovi [sands], 0 m, 11.07.2014, *U. Buzurović & S. Bogdanović s.n.* (BEO 53381!); Nin, Ždrijac, [MGRS 33T WJ19], 44.2429292 N, 15.191841 E, pješčana plaža [sandy beach], 11.07.2014, *S. Bogdanović & U Buzurović* (ZAGR 39000!); Nin, Ždrijac, [MGRS 33T WK10], pješčana plaža [sandy beach], 16.06.2006, *S. Bogdanović s.n.* (ZAGR 52840!); Nin, Ždrijac, [MGRS 33T WK10], pješčana plaža [sandy beach], 16.06.2006, *S. Bogdanović s.n.* (ZAGR 52841!); Ravni Kotari, Nin, [MGRS 33T WJ19], 20.08.1965, *I. Trinajstić 8519.* (CNHM 600:ZAG; 1845:T!); Nin, Sabunike–Privlaka, [MGRS 33T WK10], 44.258911 N, 15.158214 E, vlažna livada [wet meadow], 23.04.2016, *V.* Šegota *s.n.* (ZA 42664!), Nin, Sabunike, [MGRS 33T WK10], 23.04.2016, *V.* Šegota *s.n.* (ZA 7584!); Nin, Kraljičina plaža, [MGRS 33T WK10], 44.255014 N, 15.168961 E, 1 m, pesak [sand], 08.06.2024, *L. Milivojević s.n.* (BEOU 72503!); Nin, Sabunike, Kraljičina plaža, [MGRS 33T WK10], pješčana plaža [sandy beach], 23.04.2016, *S. Bogdanović s.n.* (ZAGR 45831!); Nin, Sabunike, Kraljičina plaža, [MGRS 33T WK10], 11.06.2016, *S. Bogdanović s.n.* (ZAGR 46159!).

DISCUSSION

The complex of *A. canescens* is morphologically highly variable and comprises numerous taxa, as observed by Novák (1938). Although *A. canescens* has previously been morphologically studied in the Balkans (Papanicolaou & Kokkini 1982) and the Apennine Peninsula (Scassellati *et al.* 2013), *A. dalmatica* was not included in these analyses. Based on morphometric analyses, literature, herbarium data, and field observations, the existence of morphological and ecological differences between *A. canescens* and *A. dalmatica* is evident. The morphological characters such as corolla colour, capitulum diameter, outer leaf width, and calyx length, were previously reported to be useful in distinguishing these two taxa (Trinajstić 1981; Domac 2002; Nikolić *et al.* 2015; Nikolić 2020). However, the results of our morphometric study show that capitulum diameter and corolla colour are not reliable diagnostic characters for differentiating between *A. canescens* and *A. dalmatica*. Trinajstić (1981) and Nikolić *et al.* (2015) stated that *A. dalmatica* has white flowers, while our comparative analysis showed that in both studied populations, individuals have both white and pale-pink flowers. Calyx length, a feature which was pointed out by Trinajstić (1981) as significant for distinguishing the two species, was not proved to be useful as a diagnostic character either. On the other hand, our results show that the length of calyx tube, calyx limb, and awn, are important for distinguishing these two species.

Earlier records of *A. dalmatica* in Montenegro (Rohlena 1942), Bosnia and Herzegovina (Beck 1898; Novák 1938; Beck *et al.* 1967; Nikolić *et al.* 2015) and on the island of Brač in Croatia (Beck 1898; Novák 1938; Nikolić *et al.* 2015) are incorrect and should be referred to as *A. canescens*. These incorrect identifications, as well as chorological confusions, are probably related to Beck's use of plants ascribing not only to *A. dalmatica*, but also (the island of Brač and Mt. Velež) to *A. canescens*. Based on our results, *A. dalmatica* is a halophyte or halotolerant species with a narrow distribution range in North Dalmatia, whereas, *A. canescens* has a wider distribution range on the Balkan Peninsula, growing in mountains on meadows and rocky grasslands on carbonate, silicate and ultramafic soils (Buzurović & Jakovljević 2022). It is worth noting that a similar situation can be observed in the related genus *Goniolimon* Boiss. [see e.g. Buzurović *et al.* (2020) who reported morphological and molecular differences between the local endemic coastal populations of *G. dalmaticum* Rchb. in Dalmatia and the Croatian inland populations of *G. tataricum* (L.) Boiss.].

Identification key

Sheath (8.7–)16.3–21.3(–29.9) mm long; spikelet bract (3.7–)5.1–6.1(–7.6) mm width; calyx tube (2.4–)3.1–3.4(–4.0) mm long, shorter as calyx limb; awn (0.7–)1.0–1.4(–2.0) mm long *A. canescens*

Sheath (15.1–)22.2–29.6(–36.2) mm long; spikelet bract (4.4–)6.2–6.8(–7.9) mm width; calyx tube (3.0–)3.5–4.1(–4.4) mm long, longer as calyx limb; awn (0.5–)0.6–0.8(–1.1) mm long *A. dalmatica*

CONCLUSION

The results of this study clearly indicate morphological and ecological differences between the species *A. dalmatica* and *A. canescens*, supporting their treatment as distinct species. It was also confirmed that the previous records on the distribution of *A. dalmatica* outside northern Dalmatia were the result of incorrect identifications and that this species has been recorded in several localities near the seacoast. However, as highlighted by Dayrat (2005), taxo-

nomic conclusions should ideally be based on multiple, independent lines of evidence. Our findings are therefore limited to morphological and ecological data derived from a restricted set of populations in Croatia. Further research integrating molecular, cytogenetic, and population-level analyses, as well as ecological niche modelling, is essential to provide a more comprehensive understanding of the evolutionary relationships and taxonomic boundaries within the *A. canescens* complex in southeastern Europe.

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REFERENCES

Arrigoni PV. 2015. Contribution to the study of the genus *Armeria* (Plumbaginaceae) in the Italian peninsula. *Flora Mediterranea* **25**: 7–32. https://doi.org/10.7320/FlMedit25SI.007

Bartolucci F, Peruzzi L, Galasso G, Alessandrini A, Ardenghi NMG, Bacchetta G, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Calvia G, Castello M, Cecchi L, Del Guacchio E, Domina G, Fascetti S, Gallo L, Gottschlich G, Guarino R, Gubellini L, Hofmann N, Iberite M, Jiménez-Mejías P, Longo D, Marchetti D, Martini F, Masin RR, Medagli P, Peccenini S, Prosser F, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T & Conti F. 2024. A second update to the checklist of the vascular flora native to Italy. *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology* **158**(2): 219–296. https://doi.org/10.1080/11263504.2024.2320126

Beck G. 1898. Flora von Südbosnien und der angrenzenden Hercegovina, 9. *Annalen des K.K. Naturhistorischen Hofmuseums* **13**: 1–32.

Beck G, Malý K & Bjelčić Ž. 1967. *Flora Bosnae et Hercegovinae 4, Sympetalae, 2*. Zemaljski muzej Bosne i Hercegovine u Sarajevu, Prirodnjačko odjeljenje, Sarajevo.

Bogdanović S, Šegota V & Alegro A. 2018. Resurrection of a regionally extinct taxon in Croatia–the case of *Ammophila arenaria* (L.) Link (Poaceae). *Acta Botanica Croatica* **77**(2): 214–217. https://doi.org/10.2478/botcro-2018-0013

Buzurović U & Jakovljević K. 2022. Plumbaginaceae Juss. In: Stevanović V & Niketić M (eds.), *Flora Srbije* ***3***, pp. 252–265, Srpska akademija nauka i umetnosti, Beograd.

Buzurović U, Tomović G, Niketić M, Bogdanović S & Aleksić JM. 2020. Phylogeographic and taxonomic considerations on *Goniolimon tataricum* (Plumbaginaceae) and its relatives from south-eastern Europe and the Apennine Peninsula. *Plant Systematics and Evolution* **306**: 1–22. https://doi.org/10.1007/s00606-020-01636-0

Dayrat B. 2005. Towards integrative taxonomy. *Biological Journal of the Linnean Society* **85**(3): 407–417. https://doi.org/10.1111/j.1095-8312.2005.00503.x

Domac R. 2002. *Flora Hrvatske: priručnik za određivanje bilja*. Školska knjiga, Zagreb.

Domina G. 2011. Plumbaginaceae Juss. In: Euro+Med Plantbase - the information resource for Euro-Mediterranean plant diversity. Available at: https://www.europlusmed.org/ [Accessed 07 March 2025].

Feliner GN. 1997. Natural and experimental hybridization in *Armeria* (Plumbaginaceae): *Armeria salmantica*. *International Journal of Plant Sciences* **158**(5): 585–592. https://doi.org/10.1086/297471

Fuertes Aguilar J, Rosselló JA & Nieto Feliner G. 1999. Nuclear ribosomal DNA (nrDNA) concerted evolution in natural and artificial hybrids of *Armeria* (Plumbaginaceae). *Molecular Ecology* **8**(8): 1341–1346. https://doi.org/10.1046/j.1365-294x.1999.00690.x

GBIF. 2025. Global biodiversity information facility. Available at: http://www.gbif.org/ [Accessed 07 March 2025].

Greuter W, Burdet HM & Long G. 1989. *Med-Checklist, 4*. Conservatoire Botanique de Genève, Genève & Berlin.

Iamonico D, Domina G, Tiburtini M & Peruzzi L. 2024. Typification of the names in *Armeria* (Plumbaginaceae) recorded for Italy. *Phytotaxa* **665**(3): 193–200. https://doi.org/10.11646/phytotaxa.665.3.2

Lampinen R. 2001. Universal Transverse Mercator (UTM) and Military Grid Reference System (MGRS). Available at: http://www.luomus.fi/en/utm-mgrs-atlas-florae-europaeae [Accessed 07 March 2025]

Larena BG, Aguilar JF & Feliner GN. 2006. Dispersal across southern Iberian refugia? Integrating RAPDs, sequence data and morphometrics in *Armeria* (Plumbaginaceae). *Folia Geobotanica* **41**: 305–322. https://doi.org/10.1007/BF02904944

Lawrence GHM. 1940. Armerias, native and cultivated. *Gentes Herbarum* **4**: 391–418.

Malekmohammadi M, Koutroumpa K, Crespo MB, Domina G, Korotkova N, Akhani H, von Mering S, Borsch T & Berendsohn WG. 2024. A taxonomic backbone for the Plumbaginaceae (Caryophyllales). *PhytoKeys* **243**: 67–103. https://doi.org/10.3897/phytokeys.243.122784

Nikolić T. 2020. *Flora Croatica. Vaskularna flora Republike Hrvatske 3*. Alfa d.d, Zagreb.

Nikolić T, Milović M, Bogdanović S & Jasprica N. 2015. *Endemi u Hrvatskoj flori*. Alfa d.d, Zagreb.

Novák FA. 1938. De Armeriis balcanicis nonnullis I. *Věstník Královské* České *Společnosti Nauk. Třida Matematicko-P*řírodověd*ecké* **1938**: 1–25.

Papanicolaou K & Kokkini S. 1982. *Armeria* (Plumbaginaceae) in Greek mountains. *Willdenowia* **12**(2): 213–219.

Pezzetta A. 2011. La flora endemico-vicariante delle penisole italiana e balcanica: origini e distribuzione geografica. *Annales, Series Historia Naturalis* **21**(1): 41–66.

Pinto de Silva AR. 1972. *Armeria* Willd. In: Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM & Webb DA (eds.), *Flora Europaea* ***3***, pp. 30–38, Cambridge University Press, Cambridge.

POWO. 2025. Plants of the world online. Available at: https://powo.science. kew.org/ [Accessed 07 March 2025].

Rohlena J. 1942. Conspectus Florae Montenegrinae. *Preslia* **20–21**: 1–506.

Scassellati E, Abbate G & Lucchese F. 2011. Lectotypification of *Statice canescens* Host and *Armeria majellensis* Boiss. (Plumbaginaceae). *Annnales Botanici Fennici* **48**: 455–458. https://doi.org/10.5735/085.048.0602

Scassellati E, Lucchese F & Abbate G. 2013. A morphometric study of *Armeria canescens* aggr. (Plumbaginaceae) in the Italian Peninsula. *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology* **147**(3): 743–750. https://doi.org/10.1080/11263504.2012.751069

StatSoft. 2008. STATISTICA (Data Analysis Software System), Version 7.0. StatSoft Inc., Tulsa. Available at: www.statsoft.com.

Terzi M, Jasprica N & Pesaresi S. 2024. Syntaxonomic Diversity of Rocky Dry Grasslands of the *Chrysopogono grylli-Koelerion splendentis* Along the East Adriatic. *Diversity* **16**(12): 718. https://doi.org/10.3390/d16120718

Thiers B. 2025. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. Available at: http://sweetgum.nybg.org/science/ih/ [Accessed 07 March 2025].

Trinajstić I. 1980. *Supplementum ad floram analyticam Jugoslaviae. 7*. Editio Universitatis Zagrabiensis – Liber, Zagreb.

Trinajstić I. 1981. *Analitička flora Jugoslavije 1(7)*. Sveučilišna naklada Liber, Zagreb.

Turland NJ, Wiersema JH, Barrie FR, Gandhi KN, Gravendyck J, Greuter W, Hawksworth DL, Herendeen PS, Klopper RR, Knapp S, Kusber W-H, Li D-Z, May TW, Monro AM, Prado J, Price MJ, Smith GF & Zamora Señoret JC. 2025. International Code of Nomenclature for algae, fungi, and plants (Madrid Code). *Regnum Vegetabile* **162**. Chicago: University of Chicago Press. https://doi.org/10.7208/chicago/9780226839479.001.0001

Villa-Machío I, Heuertz M, Álvarez I & Nieto Feliner G. 2023. Demography-driven and adaptive introgression in a hybrid zone of the *Armeria* syngameon. *Molecular Ecology* **33**(20): e17167. https://doi.org/10.1111/mec.17167

WFO. 2025. World flora online. Available at: http://www.worldfloraonline.org/ [Accessed 07 March 2025].

COMPREHENSIVE PLANT BIOLOGY

REZIME

Morfometrijska studija *Armeria dalmatica* (Plumbaginaceae) iz Dalmacije (Hrvatska)

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Armeria dalmatica je stenoendemična vrsta iz Hrvatske, opisana 1898. godine od strane Beck-a. Taksonomski status ove vrste je različito interpretiran u literaturi, što je dovelo do neusklađenosti stavova među botaničarima. Većina dostupnih podataka ukazuje da *A. dalmatica* trenutno nije prihvaćena kao zasebna vrsta i smatra se sinonimom od *A. canescens*. Morfometrijska studija sprovedena na populacijama vrste *A. dalmatica* i blisko srodne vrste *A. canescens* pokazala je da se jasno morfološki razlikuju. Rezultati ove studije pokazali su da su najvažniji dijagnostički karakteri: dužina omotača cvasti, širina brakteje klasića, dužina tubusa čašice, dužina slobodnog dela čašice i dužina zupca. Dat je ključ za razlikovanje *A. canescens* od *A. dalmatica*. Podaci o rasprostranjenju i ekologiji su revidirani i utvrđeno je da je *A. dalmatica* halofilna, kao i halotolerantna vrsta koja raste samo na nekoliko lokaliteta u Severnoj Dalmaciji.

Ključne reči: *Armeria canescens*, endemična vrsta, mediteranska flora, morfometrija, taksonomija, tipifikacija.