

The flora of Istria: Juncaceae

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A checklist, key and distribution were prepared for the Juncaceae family after research into the Istrian flora was completed. According to the checklist, the Juncaceae family in Istria includes two genera (*Juncus* and *Luzula*) and 27 taxa (species, subspecies and varieties). During research in 2003 and 2004, two new taxa were discovered in the Istrian flora: *Juncus hybridus* Brot. in ephemeral and wet locations along the Premantura Peninsula and *Juncus littoralis* C.A. Mey ssp. *tommasinii* (Parl.) Arcang. at the mouth of the Raša River.

Key words: flora, Istria, Juncaceae

Introduction

Research into the Istrian flora within the framework of the »Flora of Istria« project has been under way since 1987. General checklists, keys and distribution maps for plant families were drafted as a result (STARMÜHLER 1998). The Juncaceae family has been investigated since 2000 and the first checklist was published in 2002 (BERNHARDT 2002).

Materials and methods

Our research into the Juncaceae family in Istria included work in the field as well as the analysis of herbarium specimens. Field research was carried out of between 2000–2004. Following the rationale of the «Flora of Istria» project the target area included Trieste (Italy), parts of Slovenia, the Istrian Peninsula and the northern part the Kvarner islands Cres and Krk (STARMÜHLER 1998). Systematic research, for the most part, was done according to the principles of KIRSCHNER (2002). In order to determine the distribution of Juncaceae, materials from different herbaria (STARMÜHLER 1998, SCHARFETTER and BERNHARDT 2002) were used along with our other recent specimen collections of the research area.

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Results and discussion

Systematic research and variations

The *Juncaceae* family within the »Flora of Istria« was represented by two genera (*Juncus* and *Luzula*) and 27 plant taxa (Tab. 1). According to the checklist, the *Juncus* genus is represented by the 21 taxa (18 species and 3 subspecies), while the *Luzula* genus revealed the presence of 6 taxa (3 species, 1 subspecies and 2 varieties). Within the »Flora of Istria« project, the *Luzula* genus is represented by all species from the checklist. However, two *Juncus* species (*J. atratus* Krock., *J. minutulus* Albert et Jahang) from the checklist were not found (PLAZIBAT 2000).

Tab. 1. The checklist of the Juncaceae family of Istria.

No.	Genus / Species
JUNCUS L.	
1.	<i>J. acutiflorus</i> Ehrh. ex Hoffm.
2.	<i>J. acutus</i> L.
3.	<i>J. acutus</i> L. ssp. <i>Acutus</i>
4.	<i>J. anceps</i> Laharpe
5.	<i>J. articulatus</i> L.
6.	<i>J. atratus</i> Krock.
7.	<i>J. bufonius</i> L.
8.	<i>J. capitatus</i> Weigel
9.	<i>J. compressus</i> Jacq.
10.	<i>J. conglomeratus</i> L.
11.	<i>J. depauperatus</i> Ten.
12.	<i>J. effusus</i> L.
13.	<i>J. gerardii</i> Loisel. ssp. <i>gerardii</i>
14.	<i>J. hybridus</i> Brot.
15.	<i>J. inflexus</i> L.
16.	<i>J. littoralis</i> C.A.Mey. ssp. <i>tommasinii</i> (Parl.) Arcang.
17.	<i>J. maritimus</i> Lam.
18.	<i>J. minutulus</i> Albert et Jahand.
19.	<i>J. subnodulosus</i> Schrank
20.	<i>J. tenageia</i> L.f.
21.	<i>J. tenuis</i> Willd.
LUZULA DC.	
22.	<i>L. campestris</i> (L.) DC.
23.	<i>L. forsteri</i> (Sm.) DC.
24.	<i>L. luzuloides</i> (Lam.) Dandy et Wilmott ssp. <i>luzuloides</i>
25.	<i>L. multiflora</i> (Ehrh. ex Retz.) Lej. var. <i>multiflora</i>
26.	<i>L. multiflora</i> (Ehrh. ex Retz.) Lej. var. <i>pallescens</i> Hoppe ex Sturm
27.	<i>L. pilosa</i> (L.) Willd.

It should be noted that KIRSCHNER (2002) included the species *Juncus depauperatus* Ten. in the species *J. inflexus* L., but he saw herbaria material from Italy which were »very depauperate« and differed from *J. inflexus* by the length of the perianth. However, we established that both species may be clearly differentiated in our area not only by morphological parameters, but also by ecological and phenological aspects (*J. depauperatus* blooms later and inhabits dryer habitats).

The *Juncus bufonius* complex in general, as is the case in Istria, has been insufficiently studied to date, because the species are very similar and systematically are closely related, showing a high degree of phenotypical plasticity as remarked per *J. bufonius* / *J. ranarius* (BERNHARDT et al. 1996, BERNHARDT and KOCH 2003) and per *J. bufonius* / *J. minutulus* (BERNHARDT 1993). Hence, further taxonomic and experimental studies are necessary as well as molecular investigations (in preparation).

Generally, the plasticity of *Juncus* is very high. In *J. articulatus* L. the water level dynamics and soil nutrients introduce plasticity in morphological parameters and strategy type (BERNHARDT 1995).

For the *Luzula* genus there is some confusion between the taxa *L. multiflora*, *L. divulgata* and *L. campestris*. We deem the species *Luzula divulgata* Kirschner needs to be included in the flora of Istria because in 2004 on Krk a hybrid between *L. multiflora* and *L. divulgata* was discovered (KIRSCHNER 1979). However, more research is needed prior to any final decisions.

Determination key

To identify the plant taxa within the family Juncaceae in Istria, we offer the adjusted determination key (except the species *J. anceps* Laharpe):

JUNCACEAE Juss.

- 1 Leaves glabrous, mostly gently rounded, pointed or cylindrical like stalk, capsules with numerous seeds **Juncus**
- 1* Leaves at least with long hairs near base, linear, like blades of grass, capsules with 3 seeds **Luzula**

Juncus L.

- 1 Annual plant 2
- 1* Perennial plant. 6
- 2 Flowers solitary 3
- 2* Flowers usually aggregated in dense groups of 2–20; seeds 0.3–0.5 mm in length. – Annual plant, 5–20 cm in height. – Wet, slightly saline ruderal environments. IV–VII **J. hybridus** Brot.
- 3 Leaf sheaths at the point with laterally pulled up auricles; inner perianth segments brown with green central stripe, leathery at edges, equal in length to capsule; flowers in loosely branched cymose inflorescence. Annual herb, 5–30 cm in height. Sand and clay low-lime soils. V–VII **J. tenageia** L. f.
- 3* Leaf sheaths without auricles; perianth segments greenish 4

- 4 Capsule 3–5 mm in length; usually with 6 anthers, anthers at least $\frac{2}{5}$ of the length of the filaments. Annual herb, 10–25 (–40) cm in height. Mud pools, ponds, wet roads. IV–VI ***J. bufonius* L.**
- 4* Capsule 2.5–3.0 mm in length; 3 anthers, anthers at least $\frac{1}{4}$ – $\frac{1}{3}$ length of filaments. Annual herb, 1–5 (–10) cm in height. Wet roads, fields, ruderal regions. IV–VII ***J. minutulus* Albert & Jahand.**
- 5 Leaves and bracts filamentous or \pm cylindrical or sharply-pointed, typical for *Juncus*-species (Fig. 1. a) 6
- 5* Leaves otherwise, not situated only at the base or on lower part of plant, but also in the upper parts of the plant (Fig. 1. b, c) or with long terminal bract 12
- 6 Leaves and bracts sharply-pointed or at least hardy, more than 3 mm in diameter 7
- 6* Leaves and bracts not pointed or hardy, less than 3 mm in diameter (important: bracts of *J. inflexus* may be hardy and slightly pointed, but they are thin!) 9
- 7 Perianth segments yellowish-green; capsule of equal length to perianth segments (Fig. 1. d). Perennial plant, 50–100 (–120) cm in height. Sea cliffs, coastline, halophytic regions. V–VIII ***J. maritimus* Lam.**
- 7* Perianth segments brown to reddish-brown; capsule substantially longer than perianth segments (Fig. 1. e, f) 8
- 8 Capsule 4 \times 6 mm; 80–120 seeds. Perennial plant, 50–150 cm in height. Sea cliffs, coastline, halophytic regions. IV–VII ***J. acutus* L. ssp. *acutus***
- 8* Capsule 2 \times 4 mm; 25–70 seeds. Perennial plant, 50–150 cm in height. Coastlines. V–VII ***J. littoralis* C. A. Mey. ssp. *tommasinii* (Parl.) Arcang.**
- 9 Stems with cross partitioned cortex (aerenchyma), grey or blue-green colour, not shiny, furrowed; leaf sheaths blackish-brown to blackish-red. 10
- 9* Stems with not cross partitioned cortex, not shiny or a shiny green colour; leaf sheaths yellowish to reddish-brown 11
- 10 Capsule same length as perianth segments; plant blue-green colour. – Perennial plant, 30–60 cm in height. At edges of streams, springs, coastlines, wet meadows, edges of underbrush. V–VII ***J. inflexus* L.**
- 10* Capsule 1.5–2 times longer than perianth segments; plant greenish colour Perennial plant, 50–120 cm in height. Edges of streams, springs. V–VII ***J. depauperatus* Ten.**
- 11 Stem and leaves shiny dark green colour, smooth (only dry leaves show over 35 fine lengthwise grooves); bract appearing as stem at base of inflorescence (virtually) without enlargement; inflorescence mostly \pm loose; 6 anthers. Perennial plants, 30–150 cm in height. Edges of streams, springs, ponds, wetlands. VI–VIII ***J. effusus* L.**
- 11* Stems and leaves green, not shiny, with 12–13 lengthwise grooves; bract appearing as stem, slightly enlarged at base of inflorescence; inflorescence very compact, ball-like in appearance; usually with 3 anthers. Perennial plant, (20–) 40–100 cm in height. Edges of streams, springs, flat peatlands. V–VII ***J. conglomeratus* L.**
- 12 All flowers compacted into 1 (–3) heads; outer perianth segments much longer than inner perianth segments. Annual herb, 3–10 (–15) cm in height. Wet meadows, ponds. V–VII ***J. capitatus* Weigel**

- 12* Flowers ± solitary, in several groups or mostly in 1–3 heads; all perianth segments ± equal length 13
- 13 Stem leafless or with only one basal leaf, but with bract directly underneath terminal inflorescence; leaves 1–2 mm thick; perianth segments sharply-pointed. Perennial plant, 15–40 cm in height. Wet ruderal regions. VI–IX ***J. tenuis* Willd.**
- 13* Stem with one leaf above base (not including bracts directly underneath inflorescences!); leaves 0.5–3.0 mm thick 14
- 14 Flowers ± solitary (sometimes the highest flowers somewhat approached), each with 2 small bracteoles at base; leaves 1–2 mm wide; perianth segments ± rounded. 15
- 14* Flowers in groups; stems thicker than 1 mm; most leaves >1 mm in width, not very hardy; plant generally taller than 30 cm, grasslike in appearance. 16
- 15 Perianth segments 2–3 mm, almost half the length of the capsule (Fig. 1. g). Perennial plant, 15–30 cm in height. Wet meadows, ruderal regions. VI–VI ***J. compressus* Jacq.**
- 15* Perianth segments 4 mm in length, equal in length to capsule (Fig. 1. h). Perennial plant, 15–50 cm in height. – Halophytic regions, coastlines, wet meadows. V–VII ***J. gerardii* Loisel. ssp. *gerardii***
- 16 Leaves lengthwise and transverse septa. The septa filled with spider-like cortex, all perianth segments blunt. Perennial plant, 50–120 cm in height. Wet meadows, coastlines. VII–VIII ***J. subnodulosus* Schrank**
- 16* Leaves only transverse septa. The septa filled with spider-like cortex or completely hollow; all perianth segments sharply-pointed. 17
- 17 Internal leaf septa completely hollow (without spider-like cortex); stem erect; capsule brown, gradually lengthwise tapered; longer than perianth segments; plant reproduces by rhizomes. Perennial plant, (30–) 40–80 (–100) cm in height. Wet meadows, edges of underbrush. VII–IX ***J. acutiflorus* Ehrh. ex Hoffm.**
- 17* Internal leaf septa at least with solitary spider-like cortex or complete spider-like cortex; stem erect or ascending; capsule short tapered or egg-shaped 18
- 18 Leaves 5–7 – angled in cross-section, when fresh show exceptionally pronounced lengthwise stripes; capsule with clearly visible, long, frequently slanted beak, equal in length to perianth segments; perianth segments sharply-pointed (Fig. 1. i). Perennial plant, 30–100 cm in height. Wetland meadows. VII–IX ***J. atratus* Krock.**
- 18* Leaves round or elliptical in cross-section, without lengthwise stripes; capsule with short, spiky tip, longer than perianth segments (Fig. 1. j); all perianth segments equal in length, inner perianth segments blunt. Perennial, 10–60 cm in height. Banks of creeks and rivers, mud bogs, wetlands, fish ponds, wet meadows. VI–VIII ***J. articulatus* L.**

***Luzula* DC.**

- 1 Flowers in dense heads or in panicles 2
- 1* Flowers solitary or in racemose or cymose (loosely arranged) inflorescences 3
- 2 Anthers 2–6 times longer than filaments (Fig. 1. k); seed with short appendage (Fig. 1. m); inflorescence with 1 (virtually) sessile and several short branched spikes of 3–12 flow-

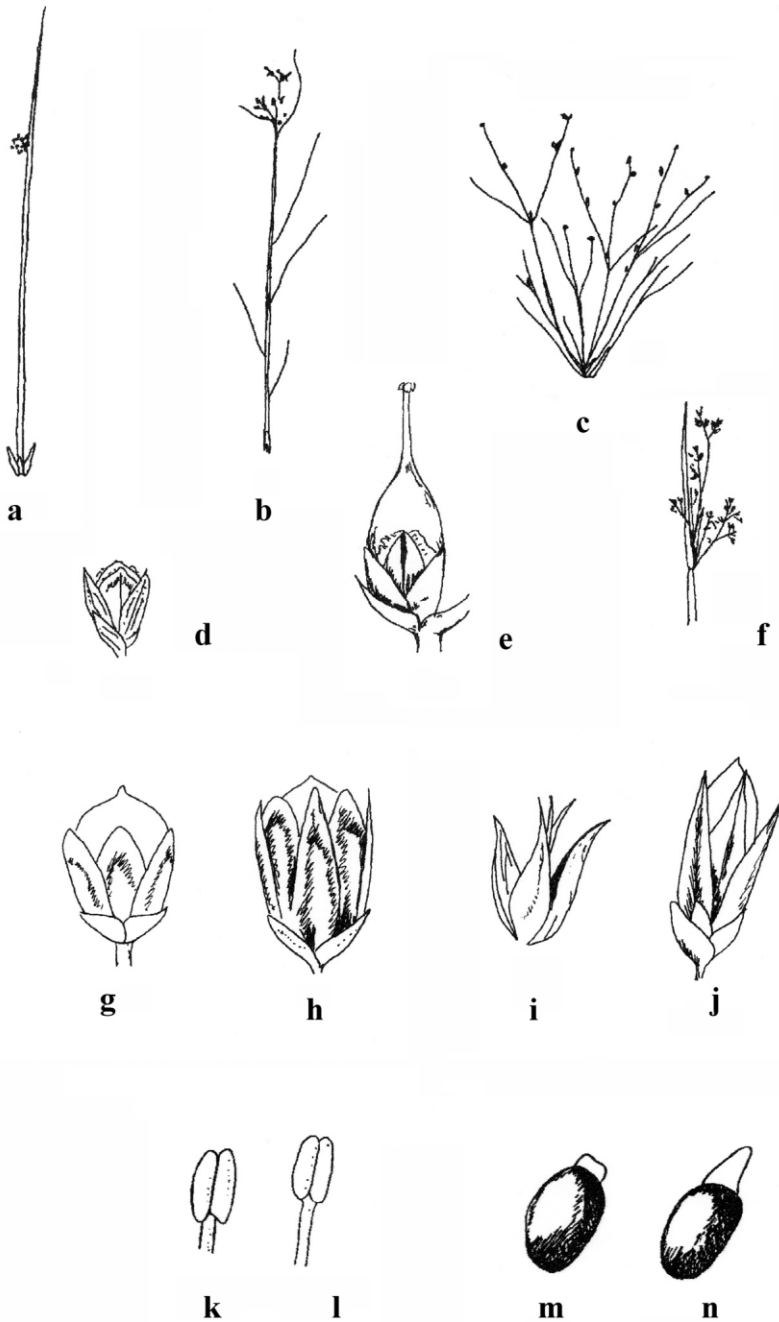


Fig. 1. Morphological characteristic of Juncaceae. *Juncus*: a – lateral inflorescences, b, c – terminal inflorescences, d – *Juncus maritimus*, e, f – *Juncus acutus*, g – *Juncus compressus*, h – *Juncus gerardii* ssp. *gerardii*, i – *Juncus atratus*, j – *Juncus articulatus*; *Luzula*: k – *Luzula campestris*, l – *Luzula multiflora*, m – seed with short appendage, n – seed with extended appendage.

- ers; plant with short aboveground or underground rhizomes, 5–20 (–25) cm in height. Karst heath, karst areas. III–V *L. campestris* (L.) DC.
- 2* Anthers 1–1.5 times longer than filaments (Fig. 1. l); seed with extended appendage (Fig. 1. n); inflorescence mostly with long branched spikes of 8–18 flowers; plant without rhizomes. Perennial plant, (15–) 20–50 cm in height. Edges of forests and underbrush. IV–V *L. multiflora* (Ehrh. ex Retz.) Lej. var. *multiflora* var. *pallescens* Hoppe ex Sturm
- 3 Flowers aggregated in groups of 3 or more; loose inflorescences; capsule of equal length to perianth segments. Perennial plant, 30–60 (–70) cm in height. Edges of beech forests, mixed deciduous forests. V–VII *L. luzuloides* (Lam.) Dandy et Wilmott ssp. *luzuloides*
- 3* Flowers solitary, rarely several flowers in pairs 4
- 4 Basal leaves 5–10 mm wide; branches of inflorescences erect, during fruit-bearing period bent back; appendage of seed equal in length to seed, curved. Perennial plant, 15–30 (–40) cm in height. Forests, edges of forests. IV–V *L. pilosa* (L.) Willd.
- 4* Basal leaves 1–3 mm wide; branches of inflorescences erect, rarely bent back during fruit-bearing period; appendage of seed shorter than seed, straight. Perennial plant, 15–30 (–40) cm in height. Deciduous forests, edges of underbrush, macchia thickets. III–V *L. forsteri* (Sm.) Dc.

Distribution

During research in 2003 and 2004, two new taxa were established in the flora of Istria: *Juncus hybridus* in ephemeral and wet locations along the Premantura Peninsula and *J. littoralis* ssp. *tommasinii* at the mouth of the Raša River. We also established the presence of the following taxa: *J. anceps*, *J. atratus*, *J. capitatus*, *J. minutulus*, and *J. tenageia*, which we considered new findings (BERNHARDT and BRITVEC 2004, TOPIĆ and ŠEGULJA 2000).

For *Juncus capitatus* and *J. tenageia*, we only have one old herbaria specimen from the Pula Marshes (1886). We discovered very new and unique evidence of *J. littoralis* ssp. *tommasinii* (at the mouth of the Raša River), *J. hybridus* (Čićarija), *J. acutiflorus* (Vrbnik, Krk), *J. compressus* (new for Cres and Krk), *J. hybridus* (Premantura) and *J. anceps* (Trieste and Raša River). *Juncus compressus* was found on Krk and Cres only at the wet border of pools inside of sheep grazing meadows. Grazing seems to be an important factor to promote open spaces that can be colonized by *J. compressus* (ESSELINK et al. 2000, BERNHARDT and KOCH 2003).

The most widely distributed taxa in the coastal regions of Istria, in highly saline locations, are *J. maritimus* and *J. acutus* ssp. *acutus*, which also appears in non-saline environments, while the species *J. inflexus* and *J. articulatus* are also widely distributed in the interior of Istria. On typical saline grasslands, such as at the mouth of the Raša and Mirna rivers or on Cres Island near Osor, we frequently find *J. gerardii* ssp. *gerardii*.

Among the genus *Luzula*, the taxa *L. luzuloides* ssp. *luzuloides* seems to be the most frequent species, while the species *L. pilosa* can only be found on Cres Island.

To complete studies about the distribution and variation of species from the Juncaceae (*Juncus*, *Luzula*) family, further research is necessary. Presumably, the presentation of a determination key indicates pending activities of collection and to mapping of *Juncus*- and *Luzula* taxa.

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References

- BERNHARDT, K.-G., 1993: Populationsökologische Untersuchungen an *Juncus bufonius* an sekundären Abgrabungsstandorten. Z. f. Ökologie u. Naturschutz 2, 157–162.
- BERNHARDT, K. G., 1995: Unterschiedliche Besiedlungsstrategien von *Juncus articulatus* als kolonisierende Art an Stillgewässern. Verh. Ges. f. Ökologie 24, 93–98.
- BERNHARDT, K.-G., 2002: Checklist für die Juncaceae. Carinthia 2, 545–602.
- BERNHARDT, K.-G., BRITVEC, M., 2004: The flora of Istria: *Juncaceae*. Proc. Abstr. Croatian Botanical Symposium, Zagreb, 13.
- BERNHARDT, K.-G., KOCH, M., 2003: Restoration of a salt marsh system: temporal change of plant species diversity and composition. Basic Appl. Ecol. 4, 441–451.
- BERNHARDT, K.-G., TESMER, J., RUTH, C., SCHURBOHM, H., 1996: Die Vegetation der Karrendorfer Wiesen. Natur und Naturschutz in Mecklenburg-Vorpommern 32, 84–100.
- ESSELINK, P., ZIJLSTRA, W., DIKEMA, K. S., VAN DIGGELEN, R., 2000: The effects of decreased management on plant-species distribution patterns in a salt marsh nature reserve in the Wadden Sea. Biol. Conserv. 93, 61–76.
- KIRSCHNER, J., 1979: A new species of the *Luzula campestris-multiflora* complex in Central Europe. Folia Geobot. Phytotx. 14, 431–435.
- KIRSCHNER, J., 2002: *Juncaceae* 3. *Juncus* subg. *Agathryon*. Species Plantarum: Flora of the World, Part 8, Australian Biological Resources Study, Environment Australia, Canberra.
- PLAZIBAT, M., 2000: *Juncaceae* Juss. In: NIKOLIĆ, T., (ed.), Flora Croatica, Index florae Croaticae, Pars 3. Nat. Croat. 9 (Suppl. 1), 120–123.
- SCHARFETTER, E., BERNHARDT, K.-G., 2002: Das Herbarium des Institutes für Botanik der Universität für Bodenkultur. Bericht über das 10. Österreichische Botanikertreffen. Bundesanstalt für alpenländische Landwirtschaft Gumpenstein, Irnding, 183–184.
- STARMÜHLER, W., 1998: Vorarbeiten zu einer Flora von Istrien. Carinthia 2, 535–576.
- TOPIĆ, J., ŠEGULJA, N., 2000: Floristic and ecological characteristics of the southernmost part of Istria (Croatia). Acta Bot. Croat. 59, 179–200.