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NORTH-AMERICAN GRASS *GLYCERIA STRIATA* (LAM.) HITCHC., A NEWCOMER IN CROATIAN FLORA

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Here we report the first records of the North American grass *Glyceria striata* (fowl mannagrass or ridged glyceria) in Croatia. Four localities were found in the Gorski Kotar region (Alpine Biogeographical Region) along the watercourses and two additional localities were observed at forest margins and clearings on the outskirts of the city of Zagreb (Continental Biogeographical Region). The species has been classified as a naturalized neophyte and warrants monitoring in the forthcoming period.

Keywords: alien species, disturbed habitats, neophyte, *Poaceae*

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U ovom radu predstavljamo prve nalaze sjevernoameričke vrste trave *Glyceria striata* (prugasta šenika) zabilježene u Hrvatskoj. Četiri lokaliteta su smještena u Gorskom kotaru (alpinska biogeografska regija) uzduž vodotokova, a dva na šumskim rubovima i čistinama na rubu grada Zagreba (kontinentalna biogeografska regija). Vrsta je klasificirana kao naturalizirani neofit, što zahtijeva praćenje stanja vrste u budućnosti.

Ključne riječi: strane vrste, utjecana staništa, neofit, *Poaceae*

INTRODUCTION

The native distribution of *Glyceria striata* encompasses North America, ranging from Alaska and Canada in the north to southern Mexico (Hultén, 1968; Scoggan, 1978; de Rzedowski & Rzedowski, 2001; Barkworth *et al*., 2007), and it has been categorized as a Boreo-American species. In Europe, it was first recorded in 1849, in France (Fournier, 1961). Following this initial record, additional observations from various European

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countries began to surface in the mid-20th century. To date, this allochthonous species has been reported in a total of 19 countries, including Switzerland in 1953, Estonia in 1956, Austria in 1966, Germany in 1971, Liechtenstein in 1972, Sweden in 1975, Ukraine in 1976, Poland in 1981, Finland in 1987, Slovenia in 1988, the Czech Republic in 1995, Italy in 1996, Russia in 1999, Spain and Belarus in 2009, Bosnia and Herzegovina in 2015, Belgium in 2017, Latvia in 2020 and the Netherlands in 2021 (cf. Vázquez & Cabeza. 2009; Piwowarski & Bartoszek, 2012; Chmiel *et al.* 2024). As noted by Oberdorfer (1994), *G. striata* in Europe shows a tendency for subatlantic-submediterranean distribution.

MATERIALS AND METHODS

An unstructured field survey was carried out in the summer of 2015 in Gorski Kotar region, and again in 2025 in both Gorski Kotar and on Mt Medvednica in the city of Zagreb. At the finding places of *Glyceria striata*, phytosociological relevés were carried out using an expanded Braun-Blanquet nine-degree scale (Braun-Blanquet, 1964; Barkman *et al.*, 1964; Dierschke, 1994). The nomenclature of vascular taxa follows Nikolić *et al.* (2026) and of bryophytes Alegro & Šegota (2026).

RESULTS AND DISCUSSION

Glyceria striata has been identified in six locations within Croatia to date (Tab. 1). Given that it represents a new species within Croatian flora, a brief description of the species has been provided in Appendix 1. It is notably different from all *Glyceria* species found in central Europe, primarily due to its small and numerous spikelets (Fig. 1). It may occasionally be mistaken for certain *Poa* species; however, the lack of keeled glumes and lemmas provides a clear distinction from these species (Dančák, 2002). The species was initially recorded in 2015 across four sites in the Gorski Kotar region (Northwest Croatia, Alpine Biogeographical Region), near the Slovenian border. Two additional localities were discovered in Gorski Kotar during the summer of 2025. Furthermore, two new sites were documented in 2023 and 2025 on the southern slopes of Mt Medvednica, at the outskirts of the city of Zagreb (Central Croatia, Continental Biogeographical Region) (Fig. 2). In addition to the single locality in northwestern Bosnia and Herzegovina (Milanović *et al.*, 2015), Croatian populations represent the only occurrences approaching Southeastern Europe (the Balkan Peninsula).

Tab. 1. Localities of *Glyceria striata* in Croatia with related WGS84 coordinates.

	Locality	**Y**	**X**
1.	Gerovčica River, near village of Gerovo	45.51616° N	14.63559° E
2.	Sušica River 1, between villages of Vode and Mali Lug	45.53211° N	14.64539° E
3.	Sušica River 2, between villages of Vode and Mali Lug	45.53008° N	14.64778° E
4.	Kupa River, upstream from the village of Gašparci	45.50743° N	14.77446° E
5.	Kupa River, downstream from village of Gašparci	45.50492° N	14.78764° E
6.	Kupa River, near village of Blatnik (downstream from village of Brod na Kupi)	45.47214° N	14.87928° E
7.	Zelengaj Forest Park, Zagreb	45.82257° N	15.96627° E
8.	Kraljevec Forest Park, Zagreb	45.83333° N	15.96683° E



Fig. 1. *Glyceria striata* – A) inflorescence with spikelets, B) inflorescence without spikelets, C) caryopsis, D) stem with leaves, E) ligule.

The species was initially found in alluvial shrub and forest stands along the Kupa and Sušica rivers, which are classified into two associations: *Lamio orvalae-Salicetum eleagni* Dakskobler, Šilc et Čušin ex Dakskobler 2007 (relevés 5 and 6 in Tab. 2) and *Lamio orvalae-Alnetum incanae* Dakskobler 2010 var. geogr. *Helleborus dumetorum* subtype *Salix alba* (Vukelić *et al*., 2017) (relevés 2 and 3 in Tab. 2), where the species displays

low abundances. Subsequently, the species was observed in the macrophytic vegetation of the Gerovčica and Kupa River beds, again with low abundances, inhabiting margins of the riverbeds (relevés 1 and 4 in Tab. 2). Vegetation of these rivers is characterized by a dominance of aquatic bryophytes (*Cinclidotus riparius, C. aquaticus, C. fontinaloides, Fontinalis antipyretica, Rhynchostegium riparioides, Cratoneuron filicinum, Hygrohypnum luridum, Brachythecium rivulare, Palustriella falcata*, etc.). This is the most widespread community dominated by aquatic bryophytes in Croatia, having a wide ecological amplitude, with the centre of its distribution in the Dinaric–Continental Subecoregin. This vegetation typically inhabits fast-flowing, cold karstic rivers with permanent discharge (Rimac *et al*., 2022). Finally, the species was found in two forest parks on the southern slopes of Mt Medvednica (Central Croatia). The species was found to be thriving in open habitats along disturbed forest edges along the forest path belonging to oak-hornbeam forests (the alliance *Erythronio-Carpinion* (Horvat 1958) Marinček in Wallnöfer *et al*. 1993) (relevés 7 and 8 in Tab. 2). The species was present in open habitats with varying moisture gradients, demonstrating greater competitiveness in wetter conditions compared to drier ones.

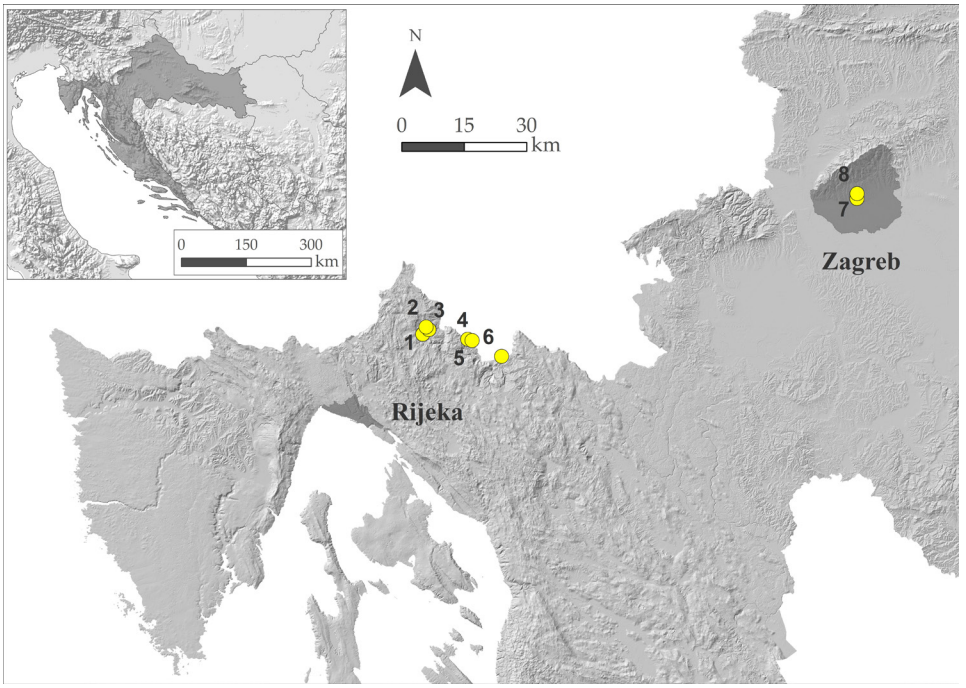


Fig. 2. Localities of *Glyceria striata* in Croatia; 1 – Gerovčica River, near village of Gerovo, 2, 3 – Sušica River, between villages of Vode and Mali Lug, 4 – Kupa River, upstream from village of Gašparci, 5 – Kupa River, downstream from village of Gašparci, 6 – Kupa River, near village of Blatnik (downstream from village of Brod na Kupi), 7 – Zagreb, Zelengaj Forest Park and 8 – Zagreb, Kraljevec Forest Park.

Tab. 2. Vegetation relevés with *Glyceria striata* in Croatia. The number of localities corresponds those listed in Tab. 1. Abundance ranks: + = up to 5 individuals; 1 = up to 50 individuals; 2m = more than 50 individuals, coverage < 5%; 2a = coverage 5–15%; 2b = coverage 15–25%; 3 = coverage 25–50%; 4 = coverage 50–75%; 5 = coverage over 75%. The bryophytes are marked with the letter **B**. The abbreviations of relevés: **Al** – *Lamio orvalae-Alnetum incanae*, **Sa** – *Lamio orvalae-Salicetum eleagni*, **Br** – aquatic bryophyte community, **Ca** – *Erythronio-Carpinion*.

Taxon	Locality							
	Al	Al	Sa	Sa	Br	Br	Ca	Ca
	3	2	5	6	1	4	8	7
***Glyceria striata* (Lam.) Hitchc.**	**1**	**+**	**+**	**+**	**1**	**+**	**3**	**+**
Alnus incana (L.) Moench	2	3						
Salix alba L.	3	+						
Salix alba L. (shrub)	3	+		+				
Urtica dioica L.	+	2					r	+
Alnus incana (L.) Moench (shrub)	1	+						
Anomodon viticulosus (Hedw.) Hook. et Taylor **B**	+	+						
Athyrium filix-femina (L.) Roth	+	+	+					2
Circaea lutetiana L.	+	+						
Geum urbanum L.	+	+					+	+
Humulus lupulus L.	1	+						
Petasites albus (L.) Gaertn.	+	1						
Stachys sylvatica L.	+	1					1	
Impatiens noli-tangere L.	+	+						
Isothecium alopecuroides (Lam. ex Dubois) Isov. **B**	+	+						
Phragmites australis (Cav.) Steud.	1							
Homalia trichomanoides (Hedw.) Brid. **B**	+							
Atrichum undulatum (Hedw.) P. Beauv. **B**	+							
Poa trivialis L.	+							
Dryopteris carthusiana (Vill.) H. P. Fuchs	+							
Dryopteris filix-mas (L.) Schott	+							+
Filipendula ulmaria (L.) Maxim.	+							
Fissidens bryoides Hedw. **B**	+							
Scirpus sylvaticus L.	+							
Solanum dulcamara L.	+							
Orthotrichum affine Schrad. ex Brid. **B**	+							
Polystichum aculeatum (L.) Roth	+							
Veratrum album L.	+							
Lamium maculatum (L.) L.		2						
Sambucus nigra L.		2						
Stellaria nemorum agg.		2						
Humulus lupulus L.		1						
Lunaria rediviva L.		1						
Abies alba Mill.		+						
Acer pseudoplatanus L. (shrub)		+						
Cardamine impatiens L.		+						
Carex sylvatica Huds.		+						
Galeopsis speciosa Mill.		+						
Galium aparine L.		+						
Glechoma hederacea L.		+					+	
Scopolia carniolica Jacq.		+						
Paris quadrifolia L.		+						
Populus nigra L.		+						
Stellaria media (L.) Vill.		+						
Rubus plicatus Weihe et Nees		+						

Taxon	Locality							
	Al	Al	Sa	Sa	Br	Br	Ca	Ca
	3	2	5	6	1	4	8	7
Salix eleagnos Scop.			3	4				
Cornus sanguinea L.			2	1				
Calliergonella cuspidata (Hedw.) Loeske **B**			+	2		1		
Salix eleagnos Scop. (shrub)			1	1				
Salix purpurea L.			+	2		+		
Melampyrum nemorosum L.			+	1				
Salvia glutinosa L.			+	+				
Acer campestre L. (shrub)			+	+			r	r
Calamagrostis varia (Schrad.) Host			+	+				
Cirsium oleraceum (L.) Scop.			+	+				
Heracleum sphondylium L.			+	+				
Fraxinus excelsior L. (shrub)			+	+				
Knautia drymeia Heuff.			+	+				
Rudbeckia laciniata L.			+	+				
Ranunculus cassubicus L.			+	+				
Pimpinella major (L.) Huds.			+	+				
Exsertotheca crispa (Hedw.) S. Olsson, Enroth et D. Quandt **B**			+					
Hacquetia epipactis (Scop.) DC.			+					
Hieracium murorum L.			+					
Aconitum lycoctonum L. ssp. *vulparia* (Rchb.) Nyman			+					
Actaea spicata L.			+					
Aposeris foetida (L.) Less.			+					
Aruncus dioicus (Walter) Fernald			+					
Berberis vulgaris L.			+					
Calamagrostis arundinacea (L.) Roth			+					
Alleniella complanata (Hedw.) S. Olsson, Enroth et D. Quandt **B**			+					
Campanula trachelium L.			+					
Carex alba Scop.			+					
Carex digitata L.			+					
Daphne mezereum L.			+					
Fraxinus excelsior L.			+					
Lysimachia nemorum L.			+					
Lysimachia nummularia L.			+					
Primula vulgaris Huds.			+					
Rhamnus alpina L. ssp. *fallax* (Boiss.) Maire et Petitm.			+					
Symphytum tuberosum L.			+					
Viola hirta L.			+					
Viola reichenbachiana Jord. ex Boreau			+					
Galium mollugo L.				+				
Impatiens parviflora DC.				+				
Cardamine enneaphyllos (L.) Crantz				+				
Agrostis capillaris L.				+				
Aesculus hippocastanum L.				+				
Anemone nemorosa L.				+				
Angelica sylvestris L.				+				
Anthriscus nitida (Wahlenb.) Hazsl.				+				
Arctium tomentosum Mill.				+				
Frangula alnus Mill.				+				
Epimedium alpinum L.				+				
Rhamnus cathartica L.				+				
Robinia pseudoacacia L. (shrub)				+				

Taxon	Locality							
	Al	Al	Sa	Sa	Br	Br	Ca	Ca
	3	2	5	6	1	4	8	7
Tussilago farfara L.				+				
Viola odorata L.				+				
Plantago major L.				+				+
Prunus cerasifera Ehrh.				+				
Saponaria officinalis L.				+				
Petasites hybridus (L.) P. Gaertn., B. Mey. et Schreb.	3	3	1	1				
Corylus avellana L. (shrub)	2	2	2	+				
Rubus caesius L.	3	3	2	+				
Aegopodium podagraria L.	2	1	1	+				+
Viburnum opulus L.	2	+	2	+				
Brachypodium sylvaticum (Huds.) P. Beauv.	+	+	2	1				
Brachythecium rutabulum (Hedw.) Schimp. **B**	+	+	+	1	1			
Euonymus europaeus L.	+	+	+	+				
Festuca gigantea (L.) Vill.	+	1	+	+			1	
Deschampsia cespitosa (L.) P. Beauv.		+	+	1		+		
Equisetum arvense L.		+	+	1				
Asarum europaeum L.		+	+	+				
Crepis paludosa (L.) Moench	+		+	+				
Ranunculus repens L.	+		+	+				
Senecio ovatus (P. Gaertn., B. Mey. et Scherb.) Willd.		+	+	+				
Mentha longifolia (L.) L.	+		+	+	1			
Lamium orvala L.		+	1					
Corylus avellana L.	+		1					
Ligustrum vulgare L.	+		+					
Lysimachia vulgaris L.	+		+					
Mercurialis perennis L.		+	+					
Plagiomnium undulatum (Hedw.) T. J. Kop. **B**		+	+					
Ranunculus lanuginosus L.	+		+				+	
Valeriana officinalis L.	+		+					
Hypnum cupressiforme Hedw. **B**		+	+					
Caltha palustris L.	+		+					
Acer pseudoplatanus L.		+		+				
Chaerophyllum hirsutum L.	+			+				
Crataegus monogyna Jacq.	+		+					
Polygonatum multiflorum (L.) All.	+		+					
Cinclidotus aquaticus (Hedw.) Bruch et Schimp. **B**						2a		
Hygrohypnum luridum (Hedw.) Jenn. **B**						2a		
Rhynchostegium riparioides (Hedw.) Cardot **B**						2a		
Cratoneuron filicinum (Hedw.) Spruce **B**					2m	2m		
Brachythecium rivulare Schimp. **B**					1	2m		
Agrostis stolonifera L.			+		2m	+		
Juncus articulatus L.					+	+		
Palustriella falcata (Brid.) Hedenäs **B**						2a		
Leptodictyum riparium (Hedw.) Warnst. **B**					2a			
Cinclidotus riparius (Host ex Brid.) Arn. **B**						2m		
Fissidens crassipes Wilson ex Bruch et Schimp. **B**						2m		
Fontinalis antipyretica Hedw. **B**						2m		
Dichodontium flavescens (Dicks.) Lindb **B**						1		
Dichodontium pellucidum (Hedw.) Schimp. **B**						1		
Leersia oryzoides (L.) Sw.					+			
Epilobium hirsutum L.					1			
Juncus inflexus L.					1			

Taxon	Locality							
	Al	Al	Sa	Sa	Br	Br	Ca	Ca
	3	2	5	6	1	4	8	7
Veronica beccabunga L.					+			
Jungermannia atrovirens Dumort. **B**						1		
Cinclidotus fontinaloides (Hedw.) P. Beauv. **B**						1		
Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort. **B**						+		
Pellia endiviifolia (Dicks.) Dumort. **B**						+		
Marchantia polymorpha L. **B**						+		
Hedera helix L.			+				+	4
Rubus sp.							1	1
Salix caprea L.							+	1
Duchesnea indica (Andrews) Focke							1	+
Eupatorium cannabinum L.	+			+			+	+
Pulmonaria officinalis L.		+					+	+
Rumex sanguineus L.							+	+
Solidago gigantea Aiton							r	+
Clematis vitalba L.				+			r	+
Equisetum telmateia Ehrh.							2	
Carex remota L.			+				3	
Lycopus europaeus L.	1						3	
Taraxacum officinale F. H. Wigg.							+	
Populus alba L. (shrub)							+	
Hypericum hirsutum L.							+	
Erigeron annuus (L.) Desf.				+			+	
Alnus glutinosa (L.) Gaertn. (shrub)							r	
Artemisia vulgaris L.							r	
Epilobium parviflorum Schreb.							r	
Fagus sylvatica L.								3
Rubus idaeus L.								3
Conyza canadensis (L.) Cronquist								+
Carpinus betulus L.				+				+
Juncus effusus L.								+
Quercus petraea (Matt.) Liebl. (seedlings)								+
Vicia cassubica L.								+
Fraxinus ornus L. (shrub)								r
Paulownia tomentosa (Thunb.) Siebold et Zucc.								r

In its native range in North America, *G. striata* grows in wet meadows, bog springs, peat bogs, shrubs, ditches, and other high-moisture habitats (Hitchcock, 1971). In its introduced distribution area in Europe, the species demonstrates similar habitat preferences concerning moisture; however, it frequently inhabits more or less disturbed, semi-natural environments (Melzer, 1966; Conert, 1992; Piwowarski & Bartoszek, 2012; Dančák, 2002). The habitat preferences of the species along the margins of alder and willow alluvial forests, streamside carr vegetation, and stream banks in Croatia are consistent with its documented ecological associations in Eastern and Central Europe (Tzvelev, 1976; Jogan, 1997; Dančák, 2002; Georges, 2002; Frey & Sokołowski, 2002). The population within forest parks in Zagreb thrives in disturbed forest edges and clearings that were partially impacted by the Teodor storm in 2013. This event has further facilitated the intrusion of various alien and/or invasive species, including *Duchesnea indica, Erigeron annuus, Conyza canadensis* and *Paulownia tomentosa*. It is plausible that this disturbance has encouraged the proliferation of *G. striata*, a naturalised neophyte in these locations.

Migration routes of *Glyceria striata* to Europe have not been fully explained. The distribution of *G. striata* in Europe and the history of its naturalization indicate that multiple independent introductions to Europe have occurred at various locations (Piwowarski & Bartoszek, 2012). Birds are primarily considered the agents responsible for both macro (North America to Europe) and micro (within Europe) transfers (Melzer, 1966; Haeupler, 1971; Babczyńska-Sendek & Sendek, 1989; Conert, 1992). This explanation serves as a straightforward account for the dispersal of small seeds from wetland plants to distant regions; however, there is currently no supporting evidence for this conclusion concerning *G. striata* (Piwowarski & Bartoszek, 2012). An alternative means of propagation could involve the introduction to Europe through mixed grass seeds sourced from the USA, which are frequently utilized in Europe (Melzer, 1983, 1984, 1998; Melzer & Wagner, 1991; Conert, 1992; Wörz, 1996). Korneck & Schnittler (1994) suggested that introduction could occur via horse fodder, while Seitter (1977) noted the potential for introduction alongside huckleberry (several North American *Vaccinium* species) seedlings. Consequently, it is most likely that some of the European populations originated from independent sources and that the pathways of introduction may have been diverse.

Since this study did not examine the introduction pathways of *G. striata* in Croatia, it can only be hypothesized that the population associated with streams and alluvial vegetation arrived from neighbouring Slovenia via fluvial dispersal. However, hydrochory is a known way of dispersal for this species of wet habitats (Chmiel *et al*., 2024). Over shorter European distances, seed dispersal may also occur through transportation on vehicle wheels, which could account for the presence of the species at synanthropic sites and certain forest locations (Raabe, 1986; Dančák, 2002; Piwowarski & Bartoszek, 2012). This could be the case within the forest parks in Zagreb, where vehicles employed in forest management activities may facilitate the spread of *G. striata*, along with notable human recreational activities occurring within these forest parks.

The species has been evaluated as potentially invasive in Central Europe due to its capacity for clonal growth (Weber & Gut, 2004). In Great Britain, where it has been cultivated regularly at the Royal Botanic Gardens in Kew, it has been classified as a potential alien species (Ryves *et al*., 1996). In the case of Croatia, it can be concluded that *G. striata* is a naturalized neophyte, while its invasive behaviour has still not been registered.

CONCLUSIONS

Glyceria striata was recorded at six localities across Croatia, encompassing both the Alpine and Continental biogeographical regions, and occurring in three distinct habitat types: alluvial alder and willow forests, bryophyte-dominated aquatic vegetation, and the margins of disturbed oak-hornbeam forests. The population within the Alpine biogeographical region is likely derived from adjacent Slovenian populations through surface-water connectivity, while the populations in the Continental biogeographical region have likely been established as a result of forest management practices and human recreational activities. This species has been classified as a naturalized neophyte and warrants monitoring in the forthcoming period.

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Appendix 1. Description of *Glyceria striata*

Glyceria striata (Lam.) Hitchc., Proc. Biol. Soc. Washington 41: 157 (1928)

Syn.: *G. nervata* (Willd.) Trin., *G. rigida* (Rydb.) Rydb., *Poa nervata* Willd., *P. striata* Lam., *Panicularia nervata* (Willd.) Kuntze, *P. rigida* Rydb.

Plants perennial, more or less tufted, pale green to grass green. Flowering stem (20–) 30–90 (–120) cm long, glabrous, slightly striated, with 4 to 6 nodes. Leaves 2–8 mm wide, acuminate, more or less in two rows, flaccid, scabridulous, flat or folded. Leaf sheaths closed to the top or open in the upper third, bottom-up scabrous, usually angled on the back. Membranous ligule 1–3 mm long, open or closed in the front and then tube-shaped, scabridulous on the adaxial side. Panicle 5–20 (–30) cm, erect to arched, open, the main axis scabrid; branches 2 to 3 at central panicle nodes, slender, scabrid, suberect, later divergent. Spikelets (2–) 3.0–4.0 (–4.5) mm long, with 3–7 florets, usually in the upper part of the branches, somewhat laterally compressed, ovate to oblong-ovate in outline, disarticulating in fruit. Glumes obtuse, ovate to obovate, sometimes tinged with violet, 1-veined, slightly

unequal, the lower 0.4–1.0 mm, the upper 0.7–1.5 mm. Lemmas 1.3–2.2 mm long, elliptic to obovate, obtuse, prominently 7-veined, membranous at the top margine, more or less glabrous. Paleas 1.3–2.1 mm long, narrowly obovate, subobtuse, 2-veined, on the top sometimes slightly divaricated. Anthers two, (0.3–) 0.4–0.6 mm long. Caryopsis 0.6–1.4 mm long. Flowering period: V–VII.