FLORISTIC DIVERSITY OF THE STARA DRAVA WATER BODY NEAR BILJE (NORTHEAST CROATIA)

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Original scientific paper
Received: December 31st, 2023
Accepted: March 15th, 2024
HAE-23121
https://doi.org/10.33765/thate.15.1.2

ABSTRACT

The Stara Drava water body, located near the village of Bilje, northeast Croatia, with diverse aquatic, wetland and land habitats, maintains numerous wild fauna and flora species. The vascular flora of the Stara Drava was studied in the period from May to September 2020. A total of 142 plant species belonging to 116 genera and 53 families were recorded. The most species-rich plant families were Asteraceae, Poaceae and Lamiaceae, while the most common life forms were hemicryptophytes, hydrophytes and therophytes. Freshwater macrophytes comprise 24 species and have the significant role in the aquatic ecosystem. Alien flora is represented by 19 species, of which 14 are invasive alien plant species. According to their conservation status, five species are designated in one of the threats, and four species are proclaimed as strictly protected species in Croatia.

***Keywords*:** *flora, freshwater, biodiversity, invasive species*

INTRODUCTION

Freshwater ecosystems comprise rivers, wetlands, ponds, streams, and lakes. They support terrestrial and aquatic biodiversity, playing a crucial role in ecological processes and providing multiple benefits for human well-being through the ecosystem services, including provisioning, regulating, and cultural services [1].

Human activities, of which the most negative ones are habitat damage and destruction, have caused more extensive declines in freshwater ecosystems relative to other ecosystem types [2]. The diversity of river channel and floodplain wetlands support the freshwater biota. Deeper understanding of such water bodies will facilitate effective conservation and management of floodplains and support their ecosystem services [3].

The aquatic, wetland and land habitats along the Stara Drava water body enable development, functioning and integrity of the biocoenosis composed of a wide spectrum of organisms from different taxonomic groups, such as: viruses, bacteria, protozoans,

macrozooplankton, molluscs (4 species), dragonflies (11), butterflies (12), freshwater fishes (21), amphibians (3), reptiles (4), birds (49 species), mammals, as well as phytoplankton, periphytic algae and macrophytes [4].

The area of the Baranja region in Croatia has been the subject of several floristic studies in the past [5, 6], but the Stara Drava water body near Bilje has not been included in those studies, and there are no floristic records to date. Therefore, the presented floristic investigations of the said region have been conducted for the first time.

The aim of this paper is to describe floristic diversity and characteristics of the vascular flora of the Stara Drava water body near the village of Bilje in northeast Croatia.

MATERIAL AND METHODS

Study area

The Stara Drava water body is the former riverbed of the Drava River, located close to the left shoreline of the present river course between the City of Osijek and the village of Bilje, in northeast Croatia (Figure 1). Due to its very low flow velocity, it shows more characteristics of a standing water than of a flowing water [7]. Its total length is 11.3 km, and width up to 200 m, depending on climate and hydrological conditions. An extension of the Stara Drava is Kopačevo channel (3.7 km long) that connects it with Lake Sakadaš in Kopački rit Nature Park and with the hydrological system of the Danube River.

The climate belongs to Cfb type of temperate warm and moist climate with warm summers. The mean annual air temperature is 11.0 °C, and the mean annual rainfall amounts to 696 mm [8].

According to its nature protection status [9], the Stara Drava is located in the protected areas at international and national levels: UNESCO (United Nations Educational, Scientific and Cultural Organization) five-country Transboundary Biosphere Reserve Mura-Drava-Danube (Austria, Croatia, Hungary, Serbia, Slovenia); Mura-Drava Regional Park, and is included in two areas of the Natura 2000 ecological network in Croatia: Special Protection Area (SPA): HR1000016 Podunavlje i donje Podravlje, under the Birds Directive [10], and Site of Community Importance (SCI): HR2001308 Donji tok Drave, under the Habitats Directive [11].

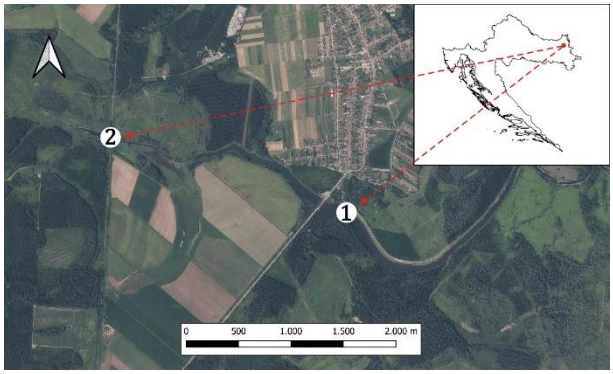

Figure 1. Geographical location of the Stara Drava near Bilje with sampling sites (Source: Digital orthophoto 2021, 2022, Web Map Service, State Geodetic Directorate)

Sampling data and analyses

The floristic research was carried out by field surveys done along the shoreline of the Stara Drava in the period from May to September 2020. Two sampling sites had been selected (Figure 2): site 1, near the road bridge (45º35’30’’N 18º41’22’’ E); site 2, near the railway bridge (45º35’50’’ N 18º42’38’’E).

The identification of plant species and determination of life forms was done using the standard reference works [12, 13], while the nomenclature follows the Flora Croatica Database [14]. Plant life forms are marked with abbreviations: P (Phanerophyta), Ch (Chamaephyta), H (Hemicryptophyta), Hy (Hydrophyta), T (Therophyta), and G (Geophyta).

Threat categories of plant species, defined by IUCN (International Union for Conservation of Nature), were determined using the web

portal: Red List of Wild Species of Croatia [15], and marked with abbreviations: VU (Vulnerable), NT (Near Threatened), and LC (Least Concern). Strictly protected species were determined according to the Ordinance on Strictly Protected Species [16, 17] and marked with the abbreviation: SP.

Figure 2. The Stara Drava near Bilje; sampling site 1 (top), and sampling site 2 (bottom)

Alien and invasive alien plant species were determined using the standard reference works [14, 18], and their areas of origin are marked with abbreviations: Af/As (Africa/Asia), Am (America, North and South), AmN (North America), As (Asia), and EA (Eurasia).

The list of recorded plant species is given in systematic order with families, genera, species and infraspecific taxa arranged in alphabetical order.

RESULTS AND DISCUSSION

A total of 142 vascular plant species, distributed among 116 genera and 53 families, have been recorded in the study area of the Stara Drava near Bilje (Table 1, Figure 3).

The most species-rich families are Asteraceae (11 %), Poaceae (9 %), Lamiaceae (8 %), and Fabaceae (6 %). The most species-rich genus is Ranunculus with four species, followed by Mentha, Polygonum, Rumex, Salix and Trifolium, with three species each.

The floristic diversity of the Stara Drava is compared with selected neighbouring or ecologically similar areas. The vascular flora of Kopački rit Nature Park, an internationally well-known wetland area in the floodplain of the Danube River in Croatia, comprises 572 species [19], while 289 species are recorded for the Savica, a suburban part of the town Zagreb with remnants of alluvial forests and vegetation of stagnant waters [20].

Table 1. List of plant species recorded in the Stara Drava near Bilje

Subclass / superorder, family and species name	Life form	Threat / Protection status	Alien / Invasive alien species / Origin
Polypodiidae			
Salviniaceae			
Salvinia natans (L.) All.	Hy		
Magnoliidae / Magnolianae			
Aceraceae			
Acer negundo L.	P		+ / + / AmN
Apiaceae			
Conium maculatum L.	H		
Oenanthe aquatica (L.) Poir.	Hy		
Pastinaca sativa L.	H		

Subclass / superorder, family and species name	Life form	Threat / Protection status	Alien / Invasive alien species / Origin
Araliaceae			
Hedera helix L.	P		
Asteraceae			
Asclepias syriaca L.	H		+ / + / AmN
Achillea millefolium L.	H		
Ambrosia artemisiifolia L.	T		+ / + / AmN
Ambrosia coronopifolia Torr. et A. Gray	G		+ / - / AmN
Arctium lappa L.	H		
Artemisia vulgaris L.	H		
Aster novi-belgii L.	H		+ / - / AmN
Bellis perennis L.	H		
Bidens frondosa L.	T		+ / + / AmN
Cirsium arvense (L.) Scop.	T		
Conyza canadensis (L.) Cronquist	T		+ / + / AmN
Erigeron annuus (L.) Pers.	H		+ / + / AmN
Eupatorium cannabinum L.	H		
Pulicaria dysenterica (L.) Bernh.	H		
Solidago canadensis L.	H		+ / + / AmN
Xanthium strumarium L. ssp. *italicum* (Moretti) D.Löve	T		+ / + / AmN
Boraginaceae			
Myosotis scorpioides L.	H		
Symphytum officinale L.	H		
Brassicaceae			
Alliaria petiolata (M. Bieb.) Cavara et Grande	H		
Capsella bursa-pastoris (L.) Med.	H		+ / - / EA
Cardaria draba (L.) Desv	H		
Rorippa amphibia (L.) Besser	H		
Rorippa austriaca (Crantz) Besser	H		
Caprifoliaceae			
Sambucus ebulus L.	P		
Sambucus nigra L.	P		
Caryophyllaceae			
Cerastium brachypetalum Pers.	T		
Myosoton aquaticum (L.) Moench.	H		
Stellaria media (L.) Vill.	T		
Silene latifolia Poir. ssp. *alba* (Mill.) Greuter et Bourdet	H		
Ceratophyllaceae			
Ceratophyllum demersum L.	Hy		
Cichoriaceae			
Cichorium intybus L.	H		
Taraxacum officinale Weber	H		
Tragopogon pratensis L. ssp. *pratensis*	H		
Convolvulaceae			
Calystegia sepium (L.) R.Br.	H		
Convolvulus arvensis L.	G		
Cornaceae			
Cornus sanguinea L.	P		
Euphorbiaceae			
Euphorbia cyparissias L.	H		
Fabaceae			
Amorpha fruticosa L.	P		+ / + / AmN
Coronilla varia L.	H		
Melilotus officinalis (L.) Lam.	H		
Robinia pseudoacacia L.	P		+ / + / AmN
Trifolium campestre Schreber	T		

Subclass / superorder, family and species name	Life form	Threat / Protection status	Alien / Invasive alien species / Origin
Trifolium pratense L.	H		
Trifolium repens L.	H		
Vicia grandiflora Scop.	H		
Vicia sepium L.	H		
Geraniaceae			
Geranium robertianum L.	T		
Haloragaceae			
Myriophyllum spicatum L.	Hy		
Juglandaceae			
Juglans regia L.	P		+ / - / As
Lamiaceae			
Ajuga reptans L.	T		
Galeopsis speciosa Mill.	T		
Glechoma hederacea L.	H		
Lamium maculatum L.	H		
Lamium purpureum L.	H		
Lycopus europaeus L.	H		
Teucrium scordium L.	H		
Mentha aquatica L.	H		
Mentha arvensis L.	H		
Mentha pulegium L.	H		
Prunella vulgaris L.	H		
Scutellaria galericulata L.	H		
Lentibulariaceae			
Utricularia vulgaris L.	Hy	SP	
Lythraceae			
Lythrum salicaria L.	H		
Malvaceae			
Althaea officinalis L.	H		
Malva sylvestris L.	H		
Menyanthaceae			
Nymphoides peltata (S. G. Gmelin) Kuntze	Hy		
Najadaceae			
Najas marina L.	Hy		
Nymphaeaceae			
Nuphar lutea Sibth. et Sm.	Hy		
Nymphaea alba L.	Hy		
Oleaceae			
Fraxinus angustifolia Vahl	P		
Papaveraceae			
Chelidonium majus L.	H		
Phytolaccaceae			
Phytolacca americana L.	G		+ / + / AmN
Plantaginaceae			
Plantago lanceolata L.	H		
Plantago major L.	H		
Polygonaceae			
Polygonum amphibium L.	Hy		
Polygonum aviculare L.	T		
Polygonum persicaria L.	T		+ / - / EA
Rumex crispus L.	H		
Rumex hydrolapathum Hudson	H		
Rumex obtusifolius L.	H		
Primulaceae			
Lysimachia nummularia L.	H		
Ranunculaceae			
Ranunculus acris L.	H		

Subclass / superorder, family and species name	Life form	Threat / Protection status	Alien / Invasive alien species / Origin
Ranunculus aquatilis L.	Hy		
Ranunculus repens L.	Hy		
Ranunculus sceleratus L.	T		
Resedaceae			
Reseda lutea L.	H		
Rosaceae			
Crataegus monogyna Jacq.	P		
Geum urbanum L.	H		
Potentilla anserina L.	H		
Potentilla reptans L.	H		
Prunus padus L.	P		
Rubus caesius L.	P		
Rubiaceae			
Cruciata glabra (L.) Ehrend.	H		
Galium aparine L.	T		
Galium palustre L.	H		
Salicaceae			
Populus alba L.	P		
Salix alba L.	P		
Salix caprea L.	P		
Salix purpurea L.	P		
Santalaceae			
Viscum album L.	Ch		
Scrophulariaceae			
Linaria vulgaris Mill.	H		
Veronica anagallis-aquatica L.	H		
Veronica persica Poir.	T		+ / + / As
Solanaceae			
Solanum dulcamara L.	Ch		
Trapaceae			
Trapa natans L.	Hy	NT / SP	
Urticaceae			
Urtica dioica L.	H		
Valerianaceae			
Valeriana officinalis L.	H		
Vitaceae			
Parthenocissus quinquefolia (L.) Planchin	P		+ / + / Am
Vitis vinifera L. ssp. *sylvestris* (C. C. Gmel.) Hegi	P	LC	
Magnoliidae / Lilianae			
Alismataceae			
Alisma plantago-aquatica L.	Hy		
Butomaceae			
Butomus umbellatus L.	Hy	NT	
Cyperaceae			
Carex hirta L.	G		
Cyperus fuscus L.	T	VU / SP	
Scirpus lacustris L. ssp. *lacustris*	G		
Scirpus maritimus L.	Hy	NT	
Hydrocharitaceae			
Hydrocharis morsus-ranae L.	Hy		
Iridaceae			
Iris pseudacorus L.	G	SP	
Lemnaceae			
Lemna minor L.	Hy		
Lemna trisulca L.	Hy		
Spirodela polyrhiza (L.) Schleiden	Hy		
Poaceae			

Subclass / superorder, family and species name	Life form	Threat / Protection status	Alien / Invasive alien species / Origin
Calamagrostis epigejos (L.) Roth.	H		
Cynodon dactylon (L.) Pers.	G		
Dactylis glomerata L.	H		
Echinochloa crus-galli (L.) P.Beauv.	T		
Eleusine indica (L.) Gaertn.	H		+ / + / Af, As
Eragrostis minor Host	T		
Glyceria maxima (Hartm.) Holmb.	Hy		
Hordeum murinum L.	T		
Phalaris arundinacea L.	Hy		
Phragmites australis (Cav.) Trin. ex Steud.	G		
Poa annua L.	T		
Poa pratensis L.	H		
Setaria viridis (L.) P.Beauv.	T		
Potamogetonaceae			
Potamogeton crispus L.	Hy		
Potamogeton pectinatus L.	Hy		
Typhaceae			
Typha angustifolia L.	G		

Nymphaea alba L.

Najas marina L.

Cyperus fuscus L.

Phytolacca americana L.

Figure 3. Some of the plant species recorded on the Stara Drava near Bilje

The analysis of plant life forms (Figure 4) revealed the highest prevalence of hemicryptophytes (47 %), followed by hydrophytes (17 %) and therophytes (15 %). The dominance of hemicryptophytes and therophytes is mostly related to climatic characteristics. This area is characterized by hot and dry summers and a high proportion of open habitats, which strongly favours the spread of therophytes.

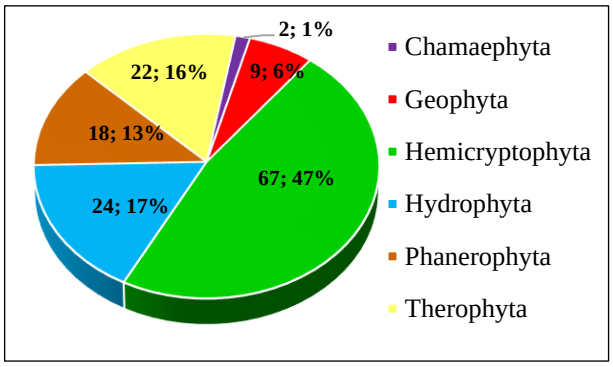

Figure 4. Life-form spectrum for the flora of the Stara Drava near Bilje

The high percentage of hydrophytes indicates the wide distribution of the aquatic and wetland habitats with plant communities of 24 species (17 % of the total flora), including submerged, floating-leaved and emergent macrophytes. In the flora of Kopački rit Nature Park hydrophytes count 65 species or 12.5 % of the total flora [21]. In the extensive floristic investigations of 216 oxbows along the Drava River in Croatia, macrophyte flora of 62 species is recorded, with richest diversity of 45 species in Županijski kanal, and lowest (14 species) in the area between Podravski Podgajci and Nehaj [22]. Županijski kanal, located in the middle course of the Drava River, connects many oxbows as former meanders of the Drava River, with low flow velocity and low depth that provides ecological conditions for the diverse aquatic and wetland vegetation. The lower course of the Drava River between Podravski Podgajci and Nehaj (river km 70-39) is characterised by sand deposits which is unstable substrate for growth and development of the macrophytes. The most frequent species were: *Ceratophyllum demersum*, *Lemna minor*, *Lemna trisulca*, *Spirodela polyrhiza*, *Myriophyllum spicatum* and *Phragmites australis*, which are also recorded in the flora of Stara Drava water body near Bilje.

Macrophytes are the primary producers in the aquatic ecosystem, provide food and shelter for various animal organisms and influence water quality [23].

Alien flora was represented with 19 species (13 % of total flora), or about 2 % of the total 1,193 species registered for the allochthonous flora of Croatia. Most of these plants (63 %) originated from North America, followed by Asia, Eurasia, and North and South America (Figure 5). Invasive alien plant species are represented by 14 species (10 % of the total flora) or 13% of the total 108 species registered in the Croatian flora [9].

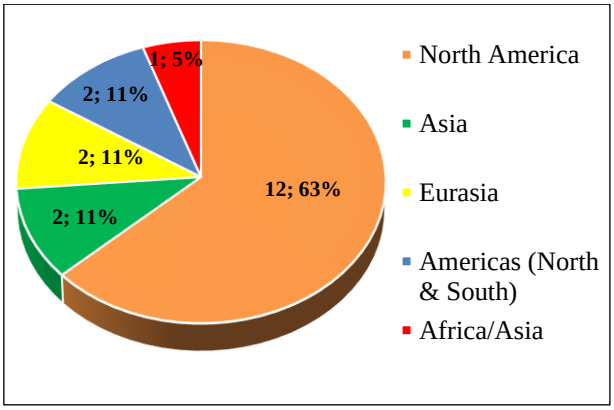

Figure 5. The geographical origin of alien plants of the Stara Drava near Bilje

In Kopački rit Nature Park there are 56 alien plant species (10 % of the total flora), of which 29 species (52 %) have origin from North and South America, and 13 species (23 %) from Asia. Invasive alien plant species are represented with 26 species (5 %) of the total flora [24]. The comparison showed that percentage of alien and invasive alien plant species is higher in the flora of Stara Drava, suggesting the higher disturbance intensity caused by anthropogenic activities, mainly using this area for the recreation, sport fishing, and vicinity of the road with very intensive traffic.

According to threat categories assigned in the Red List of Wild species of Croatia, five species (4 % of the total flora) belong to the categories: Vulnerable, one species: *Cyperus fuscus*; Near Threatened, three species: *Butomus umbellatus*, *Scirpus maritimus*, *Trapa natans*; Least Concern, one species: *Vitis vinifera* ssp. *sylvestris*. Status of strictly protected species at national level was assigned to four species: *Cyperus fuscus*, *Iris pseudacorus*, *Trapa natans*, and *Utricularia vulgaris*. The number of strictly protected

species is much lower than the 10 % in the Kopački rit Nature Park [21].

CONCLUSION

The Stara Drava water body, located near the village of Bilje, is a home to diverse biotic communities of wild fauna and flora. The floristic diversity, with 142 recorded vascular plant species, confirms significant ecological values of this area. Alien flora is represented with 19 species, among which 14 are invasive alien plant species. Comprehensive knowledge on flora provides an important tool for planning and implementing measures and activities with an aim to conserve biodiversity and improve the ecological services of the Stara Drava.

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