Equisetum fluviatile L. water horsetail (*Equisetaceae* Michx. ex DC.)
Equisetum fluviatile L. skrzyp bagienny (*Equisetaceae* Michx. ex DC.)

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Słowa kluczowe: *Equisetum fluviatile*, *Equisetum limosum*, skrzyp bagienny, zielarstwo, zbiorowiska roślinne, cykl życiowy, zróżnicowanie, hybrydyzacja
Key words: *Equisetum fluviatile*, *Equisetum limosum*, water horsetail, swamp horsetail, herbal medicine, plant communities, life cycle, diversity, hybridization

Streszczenie

Artykuł jest częścią cyklu, obejmującego opracowania dotyczące występujących w Polsce gatunków z rodzaju *Equisetum*. Opisywany tu gatunek, *Equisetum fluviatile* L. – skrzyp bagienny, jest przez niektórych autorów traktowany jako typowy dla całego rodzaju. Poniżej przedstawiono charakterystykę morfologiczną i anatomiczną gatunku, jego zróżnicowanie taksonomiczne, rozmieszczenie i przywiązanie do określonych typów siedlisk, a także zagrożenia, tradycyjne wykorzystanie oraz cykl życiowy. Przedstawiona została kompozycja fitochemiczna gatunku w kontekście dawnej i współczesnej fitoterapii.

Summary

The article is part of the series, devoted to studies on Equisetum species occurring in Poland. The species described here, *Equisetum fluviatile* L. – water horsetail, is regarded by some authors as typical for the entire genus. Among others, some morphological and anatomical characteristics of the species, its taxonomic diversity, distribution and association with specific habitat types, as well as threats, traditional use and life cycle are presented below. The phytochemical composition has been presented in the context of ancient and modern phytotherapy.

Introduction

The article is part of the cycle, presenting studies on *Equisetum* species occurring in Poland. The species described here, *Equisetum fluviatile* L. - water horsetail, is regarded by some authors as typical for the entire genus [1] and for this reason is described among the first ones. This species has a rich synonymy. The name *E. fluviatile* appears for the first time in Flora Lapponica [2] but the specimen confirming this species was not included in the Linnaeus collection until 1753, when the species received the epithet *limosum* [3] Ehrhart [4], merging the diagnosis of *E. fluviatile* and *E. limosum*, named the species the name *E. heleocharis*.

Methodology

Most of the data were collected by merging some literature sources [5-22] and original observations and research. The original metric data, including height, diameter, and number of main stem sheath teeth, were obtained from the measurement of more than 200 individuals from various positions throughout Poland. Detailed studies of the anatomical and morphological structure as well as intraspecies differentiation were carried out at 5 sites located in the Carpathians and its foothills, in the upper Silesia and in the Roztocze region. The phytosociological documentation was made based on the classic Braun-Blanquet method (1932) [23], omitting the sociability of species. Species inventory was recorded on homogeneous surfaces with a projection coverage ratio of seven degrees (r, +, 1, 2, 3, 4, 5). 10 sample phytosociological relevés documenting diversity of the plant communities in which *Equisetum limosum* occurs have been used in the study.

Description of the species

Sporophyte: Sporebearing and vegetative shoots similar, raised, green, shiny, often brownish at the bottom. They can reach 1.2 m of height and in the middle part of shoot they can be as thick as 1 cm. Vegetative stems are tapering up. Central hollow very wide, at least 3\4 in diameter, and often even 9\10 (Page 1997). Stem sheath adjacent except for the highest sporebearing stem sheath, which is funnel-shaped. Stem sheath teeth narrow-triangular (10-30) dark brown or black, shiny with a narrow white fringe, clearly visible in the teeth bottom. The fused part of stem sheath is clearly longer than teeth. Side branches are not present or form irregular whorls, rarely regularly branched,

4–7 angular. Side branches sheath loosely fitting or narrowly funnel-shaped but not curved. The first internode slightly shorter or almost equal with main stem sheath through which it overgrows. Sporebearing cone oval to ovate globose at the apex rounded, rarely slightly pointed, hollow inside.

Variability, differentiation, taxonomy: The species poorly diversified. The distinguished varieties and forms are mainly based on the degree of branching of the main shoot, its size and occupied habitats. They have no taxonomic significance.

Hybrids: *Equisetum fluviatile* L. × *Equisetum arvense* L. (= *E.* ×*litorale* Kühlew ex Rupr.) known mainly in southern Poland, however its distribution requires further research), *E. fluviatile* L. × *E. pratense* Ehrh. (= *E.* ×*mchaffieae* C. N. Page) observed in Scotland, does not occur in Poland, *E. fluviatile* L. × *E. telmateia* Ehrh. (= *E.* ×*willmotii* C. N. Page) reported in Ireland, does not occur in Poland, *E. fluviatile* L. × *E. palustre* L. (= *E. dycei* C. N. Page), reported in the British Isles, does not occur in Poland.

Reserve substances and secondary metabolites: Water horsetail contains methyl methionin sulfonate, dimethyl sulfide and dimethyl sulfone. As far back as in the nineteenth century, aconitic acid, also known as equsetic acid (horsetail acid), was detected in this species. From 500 g of fresh herb of the plant you can get 5.5 g of magnesium aconitate, in addition to calcium oxalate, potassium aconitate and 21.6 g of SiO_2 [24]. Dry herb ash (15.5-23.6%) contains 6.5-12% of silicic acid. In the 1930s, saponin was isolated from the herb. In water horsetail the presence of alkaloids (nicotine, palustrin), flavonoids: kaempferol glycosides (kaempferol-3-O-beta-D-glucoside, kaempferol-7-O-beta-D-glucoside, kaempferol-3-O-beta-D-sophoroside-7-O-beta-D-glucoside), quercetin glycoside (quercetin-7-O-beta-D-glucoside), gosypetines (7-O-glucoside gossypetin), herbacitrin (= 7-(β-D-Glucopyranosyloxy)-3,5,8-trihydroxy-2-(4-hydroxyphenyl)-4H-1-benzopyran-4-one) and apigenin glycoside (apigenin-4'O-beta-D-glucoside) was proved, as well as accumulation of fructose and glucose in spores [25].

The herb of *E. fluviatile* was used in folk medicine to treat cancer, oliguria, liver and lung diseases, as well as it was regarded as an antihemorrhagic agent [26, 27].

General distribution: *E. fluviatile* is a circumboreal species, occurs in the northern part of North America, Iceland, western, central, northern and partly southern Europe, in detached isolated islands in central Europe, the

Caucasus, in central Asia, China, in Eastern Siberia, Japan and in isolated positions in the Pacific islands, in northern and southern edges of Africa and as a non-native species in New Zealand.

Distribution in Poland: Distribution area: a common species throughout Poland [28].

Altitude range: lowland species, common in lower mountain locations, less frequent as altitude increases, but sporadically occurs even in high mountain locations.

Biology and ecology: Gametophyte is short-lived. Sporophyte is a long-lived rhizome with high adaptability and colonization abilities. Above-ground shoots usually appear in big clusters, often almost one-species patches. It occupies open places, at most only slightly shaded. It prefers moist to wet habitats and shallow stagnant or slow flowing water, moderately poor to rich, neutral to alkaline.

Phytocoenoses: The water horsetail phytocenotic spectrum comprises hygrophilic and hydrophilic habitats. Most often these are rush communities from the *Phragmitetea* class (Table 1, rel. 4-5), where it creates its own association named *Equisetetum fluviatilis* (Figure 1), and the alder from the *Alnetea glutinosae* class (Table 1, rel. 9), as well as moist meadows of the *Molinietalia* order (Figure 2) (Table 1, rel. 1-2) and bogs (Figure 3) (Table 1, rel. 3). It also occurs sporadically in riverside herbs (Table 1, rel. 6) and wet ruderal habitats of the *Artemisietea vulgaris* class (Table 1, rel. 7). It belongs to the distinguishing species of the bogged sub-association of *Carici remotae-Fraxinetum equisetetosum maximii* (Table 1, rel. 8), together with *Lycopus europaeus* and *Mentha aquatica*.

Figure 1. Picture of *Equisetetum fluviatilis* (Świdnica near Horyniec, 26.06.2013)

Figure 2. Wet meadow fleece with mass participation of the water horsetail (Szeliga, 12.07.2019)

Figure 3. Swampy bog with participation of the water horsetail (Świdnica near Horyniec, 26.06.2013)

Threat and protection: The water horsetail, as a common species in Poland, is not and has never been under legal protection. It occurs abundantly in all regions.

Ethnobotany: The water horsetail rhizomes contain starch and therefore were part of the diet of the ancient Romans [29]. *Equisetum fluviatile* is mentioned as a medicinal plant, both in earlier and modern registers [30, 31].

Table 1. Phytocoenoses with *Equisetum fluviatile* participation
Explanations: Szeliga relevés 1, 2 – meadows, Świdnica near Horyniec – bog, Zwiezło Nature Reserve – bank of the landslide pond, Dąbrowa Górnicza Pogoria III – reed community on the bank of an outcrop lake, Latoszyn – skirt community on the Wisłoka river bank, Warzyce – bottom of the railway embankment, Krajowice – marsh riparian forest, Szeliga relevé 9 – swampy alder.

Successive no of relevé	1.	2.	3.	4.	5.	6.	7.	8.	9.
Locality	Szeliga near Biłgoraj	Szeliga near Biłgoraj	Świdnica near Horyniec	Zwiezło Nature Rezerve	Dąbrowa Górnicza Pogoria III	Latoszyn near Dębica	Warzyce near Jasło	Krajowice near Jasło	Szeliga near Biłgoraj
Date	12.07.2019	12.07.2019	26.06.2013	27.08.2007	28.08.2019	04.08.2019	15.08.2019	26.06.2011	27.07.2019
Area [m^2]	25	25	5	2	5	2	2	75	100
Eksposition							N	W	
Slope [°]							30	5	
Cover of tree layer [%]								25	40
Cover of shrub layer [%]								20	40
Cover of herb layer [%]	100	100	85	25	60	95	85	75	85
Cover of moss layer [%]	15	5						15	35
Number of species	27	18	6	1	7	11	20	19	17
Ch. Cl. *Molinio-Arrhenatheretea*									
Ranunculus repens	1	+							
Ranunculus acris	+	+							
Holcus lanatus	1								
Vicia cracca							1		
Ch. Cl. *Molinietalia*									
Equisetum palustre	+	+					+		
Climacium dendroides d	2	1							
Mentha longifolia		1					+		
Deschampsia caespitosa	1								
Angelica sylvestris	+								
Geranium palustre	+								
Ch. All. *Filipendulion ulmariae*									
Lythrum salicaria	+	+			+		+		+
Filipendula ulmaria	3	+					+		
*Lysimachia vulgaris**							+	+	
Ch. All. *Molinion caeruleae*									
Selinum carvifolia	2	+							
Galium boreale	+	+							
Betonica officinalis	+								

Successive no of relevé	1.	2.	3.	4.	5.	6.	7.	8.	9.
Locality	Szeliga near Biłgoraj	Szeliga near Biłgoraj	Świdnica near Horyniec	Zwiezło Nature Rezerve	Dąbrowa Górnicza Pogoria III	Latoszyn near Dębica	Warzyce near Jasło	Krajowice near Jasło	Szeliga near Biłgoraj
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Cover of moss layer [%]	15	5						15	35
Number of species	27	18	6	1	7	11	20	19	17
Ch. All. *Calthion*									
*Cirsium oleraceum**	2	+					1	1	
*Caltha palustris**	1	3						3	
Myosotis palustris	+	+						+	
Cirsium rivulare	1	+							
Epilobium palustre	+								
Juncus effusus	+								
D. All. *Calthion*									
Geum rivale	2	2							
Ch. Cl. *Scheuchzerio-caricetea nigrae*									
Menyanthes trifoliata			5						1
Comarum palustre			+						+
Carex limosa			+						
Ch. Cl. *Phragmitetea* et Ch. O. *Phragmitetalia*									
Equisetum fluviatile	**1**	**2**	**1**	**2**	**1**	+	**1**	**1**	+
Poa palustris	1	+	+						+
Phalaris arundinacea						+	+		
Phragmites australis					4				
Lysimachia thyrsiflora					1				
Scutellaria galericulata									+
Ranunculus flammula									+

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Cover of moss layer [%]	15	5						15	35
Number of species	27	18	6	1	7	11	20	19	17
Ch. Cl. *Artemisietea vulgaris*									
Urtica dioica	+					+	+	1	3
Rubus caesius						4	3		
Artcium lappa							1		
Ch. O. *Convolvuletalia sepium*									
Epilobium hirsutum					1		1	+	
Solidago serotina						1	1		
Eupatorium cannabinum						+			
Ch. O. *Glechometalia hederaceae*									
Glechoma hederacea						+			
Lamium maculatum						+			
Chaerophyllum aromaticum							1		
Geum urbanum							+		
Ch. Cl. *Querco-Fagetea*									
Aegopodium podagraria							+		
Corylus avellana b								+	
Corylus avellana c								+	
Fraxinus excelsior c								+	
Ch.O. *Fagetalia sylvaticae*									
Impatiens noli-tangere								2	
Lysimachia nemorum								+	

Successive no of relevé	1.	2.	3.	4.	5.	6.	7.	8.	9.
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Cover of moss layer [%]	15	5						15	35
Number of species	27	18	6	1	7	11	20	19	17
Ch. All. *Alno-Ulmion* et Ch. SAll. *Alnenion glutinoso-incanae**									
Plagiomnium undulatum d	1	1						2	
*Alnus glutinosa** a								2	3
*Alnus glutinosa** b								2	2
*Alnus glutinosa** c						1		1	1
*Chrysosplenium alternifolium**								+	
Ch. Ass. *Carici remotae-Fraxinetum*									
Carex remota								+	
Equisetum telmateia							2	2	
Rumex sanguineus								1	
Ch. Cl. *Alnetea glutinosae* et Ch. O. *Alnetalia glutinosae* et Ch. All. *Alnion glutinosae*									
Salix cinerea b									2
Salix cinerea c									1
Thelypteris palustris									2
Solanum dulcamara									1
Lycopus europaeus					+			+	1
Carex elongata									+

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Inne									
Galeopsis speciosa	+							+	
Rhytidiadelphus squarrosus d	1								
Carex diandra			+						
Ranunculus sceleratus					+				
Humulus lupulus						1			
Galeopsis tetrahit						+			
Symphytum officinale							2		
Convolvulus arvensis							+		
Sphagnum palustre d									3
Frangula alnus b									1
Frangula alnus c									+
Polygonum hydropiper									1

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