Equisetum palustre L. marsh horsetail (*Equisetaceae* Michx. ex DC.)

Equisetum palustre L. skrzyp błotny (*Equisetaceae* Michx. ex DC.)

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Słowa kluczowe: *Equisetum palustre*, skrzyp błotny, zielarstwo, zbiorowiska roślinne, cykl życiowy, zróżnicowanie, hybrydyzacja
Key words: *Equisetum palustre*, marsh horsetail, herbal medicine, plant communities, life cycle, diversity, hybridization

Streszczenie

Rodzaj *Equisetum* L. jest obecnie jedynym żyjącym przedstawicielem, niegdyś bardzo licznej w gatunki rodziny *Equisetaceae*. Do dziś przetrwało zaledwie około 15 gatunków. Jednym z nich jest skrzyp błotny. Skrzypy nie były dotąd szczegółowo badane pod względem cytochemicznym. Niniejsza praca przedstawia krótką charakterystykę morfologiczną i anatomiczną gatunku, jego zróżnicowanie taksonomiczne, rozmieszczenie i przywiązanie do określonych typów siedlisk, a także zagrożenia, tradycyjne wykorzystanie oraz cykl życiowy. Nieco szerzej została przedstawiona kompozycja fitochemiczna gatunku w kontekście dawnej i współczesnej fitoterapii.

Summary

The *Equisetum* L. genus is the only living representative of the *Equisetace* family which used to be very large. Only about 15 species have survived to this day. The marsh horsetail is one of them. Horsetails have not been the subject of detailed cytochemical studies so far. This paper briefly presents, 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. The phytochemical composition has been treated slightly more broadly in the context of ancient and modern phytotherapy.

Introduction

Equisetum is the only living representative of the relict *Equisetaceae* family. Currently, it is represented by only 15 species and more than 20 hybrid taxa naturally inhabiting various habitats in different regions of the world, except Australasia and Antarctica. In Poland there are 9 species in two subgenera: *Equisetum* and *Hippochaete* [1] and 4 hybrids [2]. Unfortunately, despite the small number of species, no detailed and comprehensive studies of the properties of individual species have been done so far. The authors of this study would like to start a series of articles that complement the above-mentioned gap in the literature on the subject. In a similar way in the near future all domestic species of the genus *Equisetum* will be described.

Methodology

Most of the data were collected by merging some literature sources [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20] 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 10 sites located in the foothills of the Carpathians and in the Sandomierz Basin.

The phytosociological documentation was made based on the classic Braun-Blanquet method [21], 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 palustre* occurs are used in the study.

Description of the species

Sporophyte: Sporebearing (fig. 1) and vegetative shoots similar, overlapping or raised, green, usually irregularly branched, rarely completely unbranched. Can reach up to 50 cm in height, thick up to 0.5 cm. Central hollow very narrow. Stem sheaths close-fitting at the bottom, loose above. Main shoot sheaths teeth triangular with a wide, white, parchment-like rim, (4) 8-12, green bottom with a dark brown or black tip. Dark color sometimes goes

down to the base of the teeth. Often the dark tip of the tooth with 1 or 2 light, transverse stripes. Teeth sometimes combined into patches of several. Side branches with 4-5 (6-7) teeth, with narrow central hollow. The first internodes of the lateral branches clearly shorter than the main stem sheath piercing. Side branches sheaths teeth widely lanceolate, sharp. Deeply growing rhizome, without central hollow, with numerous, elongated bulbs and long internodes.

Figure 1. Sporebearing stem of *Equisetum palustre* (Warzyce near Jasło, 26.06.2018)

Variability, differentiation, taxonomy: Extremely variable species. A number of forms with no taxonomic significance have been distinguished, mainly as a plasticity effect caused by habitat conditions.

Hybrids: *E. palustre* L. × *E. fluviatile* L. (= *E. dycei* C. N. Page), observed on the British Isles, does not occur in Poland. *E. palustre* L. × *E. telmateia* Ehrh. (= *E.* ×*font-queri* Rothm.) discovered at one site in Poland (Kąclowa near Grybów) [2], was found many times in various parts of western and central and southern Europe. *E. palustre* L. × *E. arvense* L. (= *E.* × *rothmaleri* C.N. Page, = *E.* × *torgesianum* Rothm.) is absent in Poland, known from the British Isles and from the European part of Russia.

Reserve substances and secondary metabolites: *Equisetum palustre* winter bulbs contain mainly starch but also some simple sugars. The content of phytotherapeutic substances is similar to that found in *E. arvense*, but has not been studied in detail. The presence of lutein was found in the marsh horsetail

herb [22], as well as a large amount of alkaloids, even up to 96–302 mg/100 g dry mass [23]. Alkaloid-free individuals are encountered independently. The marsh horsetail contains a relatively large amount of thiaminase which breaks down vitamin B1 [24], causing serious disturbances in the vitamin economy of animals [23]. Toxic components also include piperidine alkaloids, e.g. palustrin, whose herb content is about 0.3% and depends on the development phase, habitat and climatic conditions.

Figure 2. Wet meadow fleece with mass participation of marsh horsetail (Smereczne near Dukla, 23.05.2013)

Equisetum palustre produces alkaloids, polyphenols and lipids. Alkaloids are represented by nicotine, palustrine and palustridine [25].

Kaempferol and quercetin glycosides have been identified among flavonoids. They synthesize equisetolic acid (= triacontanedioic acid; Triacontanedioic acid = Equisetolic acid) and sterols. Palamitic acid was detected amongst lipids. The coloration of the sporebearing part is due to the presence of carotenoids, lutein and rhodoxanthine. Among sugars, sucrose, maltose, trehalose, raffinose and oligosaccharides have been identified [26]. Phenolic acids synthesized in the horsetail include caffeic and ferulic acid. Some authors report the 0.95% alkaloid content in *E. palustre*. 2.3 g palustrine was isolated from 52 kg of dried herb of this species. In the 1950s, 60 mg of palustridine was isolated from 400 kg of fresh herb. Some authors estimate the alkaloid content in the *E. palustre* herb within 0.28–0.44%. Such differences result

not only from the quantification method, but also from the origin and development phase of plants at the time of harvest. Some analytical studies indicating the presence of dimethyl sulfone in the herb (1.12 g/66 kg of dried material) [27] are interesting.

The raw material of *E. palustre* contains: silicic acid, alkaloids (palustrin 0.01%, palustridine, nicotine), beta-methoxypyridine, thymine, saponins, essential oil, dimethylsulfone, aconitic acid, flavones (kaempferol-3-rhamnosyl-glucoside-7-glucoside, kaempferol-3,7-diglucoside with 5 glucose molecules and with the rest of rhamnose) [28].

General distribution: *E. palustre* is a circumboreal species, occurs in large numbers in Iceland, Western, Central, Northern and partially Southern Europe, in Eastern Europe only on some isolated island range, in Asia within isolated patches and sites, among others in Asia Minor, in the Caucasus and in South Caucasus, Kazakhstan, Kyrgyzstan, Mongolia, Afghanistan, China, Pakistan, Tibet, Japan, Korea, Siberia up to Kamchatka, in the northern part of North America mainly in Alaska and Canada, further south only in isolated range patches.

Distribution in Poland: Distribution area: a common species throughout Poland, only slightly rarer locally in the central part of the country and in Silesia [29].

Altitude range: lowland species, occupying positions in lower mountain locations, as the height above sea level increases, it becomes less common.

Biology and ecology: Gametophyte is short-lived. Sporophyte is a long-lived rhizome plant with high adaptability and colonization abilities. Aboveground shoots usually appear in small clusters, but in favorable conditions they can form almost one-species patches. It occupies moderately lit, poorly or temporarily shaded places. It prefers moist to wet habitats, also temporarily flooded, meso- to eutrophic, slightly acidic to slightly alkaline.

Phytocoenoses: It occurs on moist and wet meadows of the *Molinion* (tab. 1, rel. 1) and *Calthion* (tab. 1, rel. 2–3) alliances, often also on wet roadside and ditches (tab. 1, rel. 5), in moist crops from the *Stellarietea mediae* class (tab. 1, rel. 8), as well as in reeds of the *Phragmitetea* class (tab. 1, rel. 4). Among the riverside forests, it positively distinguishes the *Caltho-Alnetum* swamp alder (tab. 1, rel. 10). It also occurs in ruderal habitats (tab. 1, rel. 9), if humidity conditions allow, on the banks of stagnant and slow flowing waters (tab. 1, rel. 7), in sand and gravel excavations, on the bottom of drained water reservoirs (tab. 1, rel. 6). It also grows on railway embankments, reaching the rhizome at least to the depth of the groundwater table.

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

Ethnobotany: *Equisetum palustre* is mentioned as a medicinal plant, both in ancient and modern sources [30, 31]. The species is considered harmful and even very poisonous to animals [32, 33].

Table 1. Phytocoenoses with *Equisetum palustre* participation. Explanations: Józefów, Smereczne, Komańcza – meadows, Suchodół – reed community, Warzyce – roadside ditch, Bruśnik - drained pond bottom, Siepietnica –excavation bank, Trzcinica – field crop, Przysieki – railway embankment, Myscowa – riparian wet forest

Successive no of relevé	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
Locality / Date	**Józefów 26.06.2004**	**Komańcza 29.05.2005**	**Smereczne 10.06.2015**	**Suchodół 19.05.2016**	**Warzyce 15.07.2018**	**Bruśnik 10.09.2009**	**Siepietnica 12.07.2011**	**Trzcinica 05.07.2004**	**Przysieki 12.08.2019**	**Myscowa 03.07.2002**
Area [m²]	25	100	25	50	2	2	1	10	2	50
Exsposition		N	SE					NE		S
Slope [°]		5	5					5		5
Cover of tree layer [%]										20
Cover of shrub layer [%]										50
Cover of herb layer [%]	100	100	100	100	60	80	20	60	30	60
Number of species	30	17	21	13	11	5	5	7	6	23
Ch. Cl. *Molinio-Arrhenatheretea*										
Alopecurus pratensis	1	2	1		+					
Poa pratensis	+	+	1	+						
Ranunculus acris	1	+	1							
Vicia cracca		+	+	+						
Holcus lanatus	+			2						
Trifolium dubium	+		+							
Prunella vulgaris	+									
Achillea millefolium	+									
Lotus corniculatus	+									
Lathyrus pratensis		+								
Cardamine pratensis				+						
Plantago lanceolata					+					
Trifolium pratense					+					
Daucus carota					+					
Ch. Cl. *Molinietalia*										
Equisetum palustre	**1**	**1**	**1**	**+**	**1**	**2**	**+**	**+**	**2**	**1**
Lysimachia vulgaris	+	+	2	1						+
Angelica sylvestris	1	+	1	+						
Lychnis flos-cuculi	+	1	+	+						

Successive no of relevé	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Locality / Date	Józefów 26.06.2004	Komańcza 29.05.2005	Smereczne 10.06.2015	Suchodół 19.05.2016	Warzyce 15.07.2018	Brusnik 10.09.2009	Siepietnica 12.07.2011	Trzcinica 05.07.2004	Przysieki 12.08.2019	Myscowa 03.07.2002
Geranium palustre	1	+	1							+
Lythrum salicaria	+		+	+			+			
Filipendula ulmaria	2	2		1						
Valeriana officinalis	+	+	1							
Cirsium palustre	r	+	+							
Deschampsia caespitosa	3									
Mentha longifolia										+
Ch. All. *Molinion caeruleae*										
Selinum carvifolia	1		1							
Betonica officinalis	+		1							
Molinia caerulea	1									
Dianthus superbus	+									
Galium boreale	+									
Gladiolus imbricatus	+									
D. All. *Molinion caeruleae*										
Briza media	+									
Linum catharticum	+									
Pimpinella saxifraga	+									
Ch. All. *Calthion*										
Myosotis palustris	+	+	1	+						+
Cirsium oleraceum		+	1	1						+
Juncus effusus	+		+				+			
Cirsium rivulare		3	1							
Caltha palustris			4							
D. All. *Calthion*										
Geum rivale		+	1							+
Ch. Cl. *Phragmitetea* et Ch. O. *Phragmitetalia*										
Phragmites australis				4						
Typha angustifolia							1			
Ch. Cl. *Artemisietea vulgaris*										
Urtica dioica					1					+
Linaria vulgaris									+	
Eupatorium cannabinum										+
Ch. O. *Glechometalia hederaceae*										
Glechoma hederacea					2					
Geum urbanum					+					
Ch. All. *Aegopodion podagrariae*										
Lamium album					3					
D. All. *Aegopodion podagrariae*										
Aegopodium podagraria					1					1

Successive no of relevé	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Locality / Date	Józefów 26.06.2004	Komańcza 29.05.2005	Smereczne 10.06.2015	Suchodół 19.05.2016	Warzyce 15.07.2018	Brusnik 10.09.2009	Siepietnica 12.07.2011	Trzcinica 05.07.2004	Przysieki 12.08.2019	Myscowa 03.07.2002
Ch. Cl. *Isoeto-Nanojuncetea*										
Plantago intermedia						+	2			
Ch. O. *Cyperetalia fusci*										
Isolepis setacea						4				
Gnaphalium uliginosum						1				
Ch. Cl. *Stellarietea mediae*										
Stellaria media								1		
Anagalis arvensis								+		
Ch. O. *Polygono-Chenopodietalia*										
Galinsoga ciliata								2		
Ch. Cl. *Agropyretea intermedio-repentis* et **Ch. O. *Agropyretalia intermedio-repentis***										
Equisetum arvense	+				+			+	1	
Convolvulus arvensis								1	1	
Elymus repens									+	
Poa compressa									+	
Ch. Cl. *Querco-Fagetea*										
Fraxinus excelsior a										2
Fraxinus excelsior b										1
Fraxinus excelsior c										+
Corylus avellana b										2
Corylus avellana c										1
Salvia glutinosa										+
Poa nemoralis										+
Ch.O. *Fagetalia sylvaticae*										
Aposeris foetida										+
Ranunculus cassubicus										+
Ch. All. *Alno-Ulmion*										
Alnus incana a										2
Alnus incana b										3
Alnus incana c										1
Caltha laeta										3
Carex pendula										2
Equisetum telmateia										1
Astrantia major										+
Geranium phaeum										+
Valeriana simplicifolia										+
Others										
Solanum tuberosum cult.								3		
Ranunculus sceleratus						1				
Vicia dumetorum										+

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