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Do cytowania:

Mystkowska I., Zarzecka K., Ginter A., Dmitrowicz A., Wartość lecznicza i fizjoterapeutyczna miodu pszczelego, *Herbalism*, 2023, 1(9), s. 154–165.

***Equisetum arvense* L. field horsetail (*Equisetaceae* Michx. ex DC.)**

***Equisetum arvense* L. skrzyp polny (*Equisetaceae* Michx. ex DC.)**

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Keywords: *Equisetum arvense*, field horsetail, herbal medicine, plant communities, life cycle, diversity, hybridization

Słowa kluczowe: *Equisetum arvense*, skrzyp polny, zielarstwo, zbiorowiska roślinne, cykl życiowy, różnicowanie, hybrydyzacja

Summary

The article is part of the series, devoted to studies on *Equisetum* species occurring in Poland. The species described here, *Equisetum arvense* L. – field horsetail, is regarded 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.

Streszczenie

Artykuł jest częścią cyklu obejmującego opracowania dotyczące występujących w Polsce gatunków z rodzaju *Equisetum*. Opisany tu gatunek, *Equisetum arvense* L. – skrzyp polny, jest uznawany za typowy dla całego rodzaju. Poniżej przedstawiono charakterystykę morfologiczną i anatomiczną gatunku, jego różnicowanie 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.

Introduction

The article is presenting studies on *Equisetum arvense* L. – field horsetail, which is regarded by some authors as typical for the entire genus [1] and, additionally, is the most popular and the most dispersed *Equisetum* species in the world. The name

E. arvense was given by Linnaeus in *Species Plantarum* [2], and all of synonymous names are later. Field horsetail is most commonly used as a herbal material and most information regarding the use of horsetails in phytotherapy applies to this species. The widespread merging of *Herba Equiseti* and *Equisetum arvense* dried herb means that the knowledge and correct identification of the collected herb of this species is particularly important because it affects the quality of commercially available raw material to the greatest extent.

This work is part of a series of studies on species of the genus *Equisetum*, of which two articles have been published so far, concerning *E. fluviatile* [3] and *E. palustre* [4]. The aim of the work is to gather basic knowledge about this species, both in terms of its morphological characteristics, habitat preferences, systematic position and intraspecific diversity, as well as its importance as a herbal species. Such descriptions are very lacking in the national botanical bibliography of medicinal plants.

Methodology

Most of the data were collected by merging some literature sources [1, 5–23] 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 1000 individuals from various positions throughout Poland, and additionally Slovakia, Ukraine, Turkey and Georgia. Detailed studies of the anatomical and morphological structure as well as intraspecies differentiation were carried out at 20 sites located in the Carpathians and its foothills, in the upper Silesia, Zulavy Marshland and Sandomierz Basin.

The phytosociological documentation was made based on the classic Braun-Blanquet method [24], 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). 7 sample phytosociological relevés documenting diversity of the plant communities in which *Equisetum arvense* occurs have been used in the study.

Description of the species

Sporophyte: Above-ground shoots are varied into early spring (March–April) sporebearing (fertile) and growing later vegetative ones. Fertile shoots growing to (20) 25 cm tall, yellowish or red-brown after spore maturation die. Main sporebearing shoots sheaths can be up to 2.5 cm long, funnel-shaped, brown, with 6–12 teeth, which are often fused together in several broadly acuted patches. The cone up to 3.5 cm length is located high above the highest internode, strobile up to 3.5 cm long, with full center. Vegetative shoots are grass- or blue-green, up to 40 (50) cm tall, with (6)

10–18 (20) teeth and with central hollow less than $\frac{1}{2}$ of its diameter. Teeth triangular, narrowly whitish edged, at least black at the top. Side branches unbranched or less often branched 1–2 times (sometimes irregularly), 4 (6) angled. The edges of the twigs are clear, sharp, separated by a v-shaped groove [19]. Teeth of side branches sheaths are usually protruding, sometimes clearly arched. Rhizomes are without a central duct, with numerous, ovoid winter bulbs, the size of hazelnuts. Bulbs, in addition to their importance as a reservoir of food resources, can also play a role as vegetative propagules [25, 26].



Figure 1. Spore bearing shoots of *Equisetum arvense* on crop field (Ladzin near Krosno, 20.03.2013).

Source: own archive.

Variability, differentiation, taxonomy: Probably the most diverse among all horsetails. Forms, varieties and subspecies reported have no taxonomic significance, rather as phenological forms or habitat adaptations. Numerous forms have been distinguished on the basis of the size or habit of the plant, without having features that allow them to be easily and clearly distinguished. Among taxa, distinguished based on the height of shoots or the degree of branching of sterile shoots, more than 60 forms and varieties are mentioned [27–33].

Equisetum arvense L. field horsetail (*Equisetaceae* Michx. ex DC.)

There are several significant *E. arvense* morphotypes, such as *E. arvense* fo. *serotinum* or *E. arvense* fo. *spiralis*, distinguished from typical individuals by having special features, which is probably caused by homeoses [34, 35].

Hybrids: *E. arvense* L. × *E. pratense* Ehrh. (= *E. × montellii* Hiitonen, *E. × suecicum* Rothm.; both names published incorrectly, taxa not confirmed by Lubienski [36]), *E. arvense* L. × *E. telmatiea* Ehrh. (= *E. × robertsii* T.D. Dines.; previously incorrectly as *E. × dubium* Dost.) known for 5 localities in southern Poland, otherwise given from Great Britain, *E. arvense* L. × *E. fluviatile* L. (= *E. × litorale* Kühlew ex Rupr.) known mainly from southern Poland (its distribution requires further research), *E. arvense* L. × *E. palustre* L. (= *E. × rothmaleri* C.N. Page, = *E. × torgesianum* Rothm.) does not occur in Poland, *E. arvense* L. × *E. sylvaticum* L. (= *E. × lofotense* Lubienski) does not occur in Poland, *E. arvense* L. × *E. diffusum* D. Don. (= *E. × wallichianum* D. Don.).

Reserve substances and secondary metabolites: Winter tubers contain mainly starch but also some simple sugars. Assimilation shoots contain about 10% of mineral salts, of which 2/3 is silicic acid [37]. According to Nowiński [38], 1 kg DM the herb contains 34.2 g of potassium, 1.15 g of phosphorus, 285 mg of iron and 28 mg of manganese. Hegnauer [39] reports that *E. arvense* contains 16.1–17.8% ash, half of which is silica, and 1.5–2.5% KCl. Bradley [40] shows a total content of mineral salts of 15%, mainly silica and silicic acid (5–8%). According to the same author, the content of flavonoids in the herb reaches 1%. There are two chemotypes of *Equisetum arvense*: European – containing kaempferol and quercetin, and Asian-North American – containing apigenin and luteolin. The European chemotype also contains genquanin and protogenquanin (O-methylated flavones). From horsetail herb, you can also distill essential oil (about 0.01%), which is dominated by hexadecahydrofarnesylacetone, cis-geranylacetone, thymol and phytol [37]. *Equisetum arvense* also has the ability to produce anthraquinone derivatives and saponins. A previously reported compound called equisetonin turned out to be a saponin complex associated with sugar and a flavonoid, with a hemolytic effect [41].

General distribution: *E. arvense* is a circumboreal species, occurs in North America, except for the southern edges, in western, central, southern and northern part of Europe, on the south-west coasts of Greenland and in Iceland, otherwise in the form of detached lobes in eastern Europe, south-west Asia, central Asia, northern India, China, Japan, eastern Siberia, the north-eastern tip of Africa, and isolated positions on the Atlantic islands, in South and Central America. As an alien and invasive species, it occurs in Australia, New Zealand and New South Wales.

Distribution in Poland: Distribution area: the most common species of domestic horsetail species [42], widespread in all regions.

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 geophyte with huge adaptability and colonization abilities. Above-ground shoots usually appear in clusters, often occupy large areas, especially on initial surfaces, when they can form one-species patches. It occupies open places, at most only slightly shaded. It prefers as well moderately poor as rich substrates, from dry to moist, moderately acidic to neutral, from rubble and sandy to heavy clays. There is no data on requirements and frequency of gametophytes.



Figure 2. Comparison of spore bearing shoots of *Equisetum arvense* (on the left) and *E. telmateia* (on the right) (Warzyce near Jasło, 24.04.2021).

Source: own archive.

Equisetum arvense L. field horsetail (*Equisetaceae* Michx. ex DC.)

Phytocoenoses: The phytocenotic spectrum of field horsetail includes various communities (Table 1) from forest and scrub, through meadows, mainly from the alliance *Arrhenatherion*, crop communities from the class *Stellarietea mediae*, to ruderal associations from the class *Artemisietea vulgaris*. Particularly often it occurs in patches of roadsides and railways embankments from the class *Agropyretea intermedio-repentis*, for which it is a character species.



Figure 3. Vegetative stem of *Equisetum arvense* flanked with *E. telmateia* on old railway embankment (Jareniówka near Jasło, 24.08.2006).

Source: own archive.

Table 1. Phytocoenoses with *Equisetum arvense* participation.

Successive no of relevé	1.	2.	3.	4.	5.	6.	7.
Locality	Trzcinica-Topoliny near Jasło	Krosno-Turaszówka	Jareniówka near Jasło	Jasło-Niegłowice	Dębowiec near Jasło	Kurzyna Średnia near Ulanów	Rudnik upon San
Date	17.05.2022	13.08.2018	24.08.2006	13.06.2021	25.07.2015	19.06.2021	21.08.2022
1	2	3	4	5	6	7	8
Area [m ²]	4	4	2	4	2	25	25
Exposition	–	NE	–	N	–	–	N
Slope [°]	–	10	–	15	–	–	5
Habitat	crop field	rubble	railway embankment	railway embankment	roadsides	meadow	meadow
Cover of herb layer [%]	90	30	50	70	20	100	95
Number of species	10	12	10	11	6	21	19
Cultivated plant							
<i>Hordeum vulgare</i> cultivar	5						
Ch. Cl. Stellarietea mediae							
<i>Stellaria media</i>	+						
<i>Setaria viridis</i>	+						
<i>Lapsana communis</i>	+						
<i>Anagalis arvensis</i>	r						
Ch. O. Centauretalia cyani							
<i>Centaurea cyana</i>	1						
<i>Papaver rhoeas</i>	+						
Ch. Cl. Artemisietea vulgaris							
<i>Artemisia vulgaris</i>		2					
<i>Urtica dioica</i>	r	1	1	1			
<i>Dipsacus sylvestris</i>		1					
<i>Lamium album</i>			+				

Equisetum arvense L. field horsetail (*Equisetaceae* Michx. ex DC.)

1	2	3	4	5	6	7	8
Ch. O. Onopordetalia acanthii							
<i>Linaria vulgaris</i>		1					
<i>Melilotus albus</i>		1					
<i>Tanacetum vulgare</i>		1					
<i>Melilotus officinalis</i>		+					
Ch. Cl. Agropyreteea intermedio-repentis et Ch. O. Agropyretalia intermedio-repentis et Ch. All. Convolvulo-Agropyron repentis							
<i>Equisetum arvense</i>	1	1	3	3	2	1	1
<i>Convolvulus arvensis</i>	+	+	1	1	2	+	
<i>Elymus repens</i>		1	1		1		
<i>Poa compressa</i>			+		1		
Ch. Cl. Molinio-Arrhenatheretea							
<i>Dactylis glomerata</i>						3	3
<i>Arrhenatheretum elatioris</i>						2	2
<i>Trifolium repens</i>						+	2
<i>Achillea millefolium</i>						1	1
<i>Lotus corniculatus</i>						1	1
<i>Trifolium pratense</i>						1	1
<i>Campanula patula</i>						+	+
<i>Daucus carota</i>						+	+
<i>Plantago lanceolata</i>						+	+
<i>Lythrum salicaria</i>				1		+	
<i>Poa pratensis</i>						2	
<i>Lysimachia nummularia</i>						1	
<i>Rumex acetosa</i>						1	
<i>Dactylorhiza majalis</i>						+	
<i>Holcus lanatus</i>						+	

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1	2	3	4	5	6	7	8
<i>Lychnis flos-cuculi</i>						+	
<i>Ranunculus repens</i>						+	
<i>Cerastium holosteoides</i>							+
<i>Lathyrus pratensis</i>							+
<i>Leucanthemum vulgare</i>							+
<i>Vicia cracca</i>							+
<i>Trifolium hybridum</i>							+
<i>Lysimachia vulgaris</i>				+			+
<i>Equisetum palustre</i>				1			
<i>Poa annua</i>			+				
<i>Plantago major</i>					+		
Others							
<i>Rubus caesius</i>			1	2	+		
<i>Aegopodium podagraria</i>		+	1				
<i>Calamagrostis epigejos</i>				1			
<i>Galium aparine</i>				1			
<i>Alchemilla sp.</i>							1
Sporadic (+): (relevé 2) <i>Galega vulgaris</i> , (relevé 3) <i>Quercus robur</i> c, (relevé 4) <i>Acer negundo</i> c, <i>Acer platanoides</i> c, (relevé 6) <i>Stellaria graminea</i> , <i>Ranunculus polyanthemos</i> , (relevé 7) <i>Pimpinella saxifraga</i> , <i>Cuscuta europaea</i> .							

Source: own research.

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

Ethnobotany: Field horsetail tubers were a valuable source of food for North American Indians and Inuits [43]. *Equisetum arvense* is mentioned as a medicinal plant, both in earlier and modern registers [44, 45]. It belongs to the typical detoxifying, silica and diuretic herbs. In osteoarthritis, horsetail herb is recommended in combination with analgesic and anti-inflammatory herbs (flower and herb

of meadowsweet, willow bark, root of devil's claw) [46–48]. Shoots were used to polishing the dishes, and the fabrics dyed in herb decoction were getting gray-yellow color [49].

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