

The distribution of *Elatine hydropiper* L. (Elatinaceae)

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Abstract

A distribution map of *Elatine hydropiper* L. (Elatinaceae), which belongs to the Euro-Siberian phytogeographic element, has been prepared based on literature and web-based data. The distribution range of the taxon, comparison to previous maps and reliability of the results are discussed.

Keywords: vascular plants, *Elatinella*, map, chorology, *Isoëto-Nanojuncetea*, Europe, Asia

Introduction

Elatine hydropiper L. is a tiny, inconspicuous plant of aquatic and seasonally flooded habitats. It belongs to a small, cosmopolitan family Elatinaceae that has been comprised in taxonomic system in various manners over the last century, which reflects its uncertain phylogenetic position (see for example [1-5]). Molecular studies have supported the old hypothesis of Cambessedes [6], comprising the family within the order Malpighiales, while the closest taxonomic relations seeing between Elatinaeae and Malpigiaceae, a tropical family of mostly trees and shrubs [7,8].

The family Elatinaceae includes only two genera, i.e. *Elatine* and *Bergia*, the latter being mainly Old World tropical [9,10]. About 15-25 species of the genus *Elatine* are being found in both hemispheres in moderate climate. In subgenus *Elatine* (species with opposite leaves) *E. hydropiper* is one of the eight species comprised in the section *Elatinella*, a double number of stamens in relation to petals being its distinctive feature [9]. Seven species of this section is being found in Europe, i.e. *E. brochonii* Clavaud, *E. gussonei* (Sommier) Brullo & al., *E. hexandra* (Lapierre) DC. *E. hungarica* Moesz, *E. hydropiper*, *E. macropoda* Guss. and *E. orthosperma* Düben, some of them also in North Africa, three in Europe and North Asia (*E. hungarica*, *E. hydropiper* and *E. orthosperma*), and one in North America (*E. californica* Gray) [9,11-17]. Although the distribution areas of most taxa of the section *Elatinella* are rather well

known, quite much work is still needed to check identity of all already now available data and herbarium material. There are also new data being gathered while mapping methods with the use of satellite base maps allow preparation of more precise maps in various scales at present.

The aim of this paper is to present the distribution of *Elatine hydropiper* in the world on the basis of current data and to discuss of the state of knowledge of this range.

Material and methods

The area of *Elatine hydropiper* is presented based on floristic and phytosociological literature (analogue data in the form of location list, information about positions or maps) and web-based sources (electronic data; Tab. 1). Locations were placed if taxon description raised no taxonomic doubts, in some cases, it was possible to verify the identity from specimens at the Kew Herbarium (K), the Herbarium of Natural History Museum in London (BM) and the Herbarium of Botanischer Garten und Botanisches Museum Berlin-Dahlem (B). In case of accurate literature source data, they had priority over the web-based ones. Web-based data were placed on the map only when they seemed to be reliable, i.e. they did not deviate from the range, had an author and exact location or were delivered by herbarium servers. Altogether, there were 2816 floristic data analysed, including 1523 literature and herbarium data and 1293 ones coming from web-based sources; 1068 web-based data were removed because they were to be found in literature or seemed to be unreliable. To sum up, the maps were made on the basis of 1748 floristic data, including 225 ones coming from web-based sources. The maps (Fig. 1, Fig. 2) illustrate localities of *E. hydropiper* s. str., i.e., they do not include localities of *E. orthosperma* Düben and *Elatine spathulata* Gorski, except those determined by Uotila to *E. hydropiper* s. str. (see [12,18]). Furthermore, the localities given under names generally accepted synonyms of *E. hydropiper* s. str., were used, i.e.

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Tab. 1 Literature and web sources from which data were used to present the distribution of *Elatine hydropiper*.

| Area | Data |
|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Skandinavia | [11,12,18,37,38] Data provided by: EUNIS – European Environment Agency, Vascular plant collection of Jyväskylä University Museum – Jyväskylä University Museum – The Section of Natural Sciences, Paleobiology Database – Marine Science Institute, UCSB, Herbarium of Oskarshamn (OHN) – GBIF-Sweden, Lund Botanical Museum (LD) – GBIF-Sweden, Plants (GBIF-SE:Artdatabanken) – GBIF-Sweden, Botany (UPS) – GBIF-Sweden, Vascular Plant Herbarium, Oslo (O) – Natural History Museum, University of Oslo, Vascular Plants, Field notes, Oslo (O) – Natural History Museum, University of Oslo, University Museums of Norway (MUSIT), Hatikka Observation Data Gateway – Finnish Museum of Natural History, National Vegetation Data bank – NLBIF, Wetland Inventory (NV) – GBIF-Sweden, Vascular plant herbarium, Agder naturmuseum og botaniske hage – Natural History Museum, University of Oslo, Vascular Plants, Field notes, Agder naturmuseum (KMN) – Natural History Museum, University of Oslo, Vascular Plant Herbarium, Trondheim (TRH) – Natural History Museum, University of Oslo, Vascular Plants, Field notes, Trondheim (TRH) – Natural History Museum, University of Oslo (Accessed through GBIF Data Portal [39]) |
| The middle, southern and eastern Europe and northern Asia | [17,20-29,40-91] |
| The western and southwestern Europe and northern Africa (the British Islands, France, Belgium, the Netherlands, Germany, Switzerland, Algeria) | [36,92-108] |

Elatine hydropiper subsp. *gyrosperma*, *Elatine schkuhriana* K. Heyne, *Elatine oederi* Moesz, *Elatine hydropiper* subsp. *oederi* (Moesz) F. Herm., *Elatine hexandra* subsp. *major* (A. Braun) Arcang., *Elatine gyrosperma* (Fr.) Meinsh., and *E. hydropiper* var. *major* (A. Braun) Fiori.

Analogue data were mapped manually using satellite base map. In case of paper maps, calibration and rectification to UTM grid was made earlier and digitalisation was performed. The vector layers prepared this way were converted to WGS84 cartographic grid. Electronic data containing geographical coordinates were exported to *.shp format and then, due to their diversity, were given common cartographic system WGS84. When geographical coordinates were missing, they were converted into text format and then, in case of detailed information about position, a record was digitalised manually on a satellite base map prepared earlier. When accurate description was missing and position was given in cartogram grid only, a cartogram was made according to principles for a given atlas followed by using spatial queries connecting grid area with map. All analyses and maps were made using PostGIS spatial database extension software as well as QGIS application software operating in the LINUX environment.

Results

Elatine hydropiper belongs to the Holarctic element, the Euro-Siberian sub-element (distinction consistent with the approach of Pawłowska [19]). The presented maps (Fig. 1, Fig. 2) point to the concentration of locations in the Central and Northern Europe although a clear reduction in the density of locations towards the east may be caused by poorer botanical survey of these areas, further data in local publications are not so easy to trade and could be omitted. The European range seems to be well-known: most locations is being found in

Central European lowland, mainly in river valleys, with the eastern limit of its dense range being reached in the western part of Poland and the western one in the Rhine Valley and the central part of the Bohemian Massif. Single locations or location clusters are being found in France (Seine Valley, South Loire River Basin) as well as in western England, Wales, south-western Scotland and north-eastern Ireland. It is very rarely reported from South and Southeastern Europe (to the south of the Alps and the Carpathian Mountains). It is frequently reported in south-eastern Norway, southern Sweden and south-eastern Finland as well as in the area of the Gulf of Finland. There are single locations known in Belarus, Ukraine, the Baltic Countries and in the European part of Russia. In Siberia, the species occurs mainly in the valleys of Ob, Irtysh, Yenisei and Angara Rivers as well as on Lake Baikal.

Discussion

Despite the very variable form and shape of oblong leaves, *Elatine hydropiper* is a taxon having rather well-defined morphological features. Quadruple, sessile flowers, eight stamens and horseshoe-shaped seeds are the most important ones of them. It can be confused with *E. californica*, *E. gussonei* and *E. hungarica* with which it is most closely related and which also have very characteristic horse-shaped or strongly curved seeds but flowers have pedicels (also short ones). The correct determination requires a stereomicroscope, and the additional problem is that under unfavorable conditions plants may remain sterile, and, also, several species grows often mixed. The first two taxa are also characterised by completely different geographical range, i.e. *E. californica* is a North-American species (western part of the continent) while *E. gussonei* is probably an endemic species of the Mediterranean islands, Malta and Lampedusa. The distribution of *E. hungarica* is poorly known

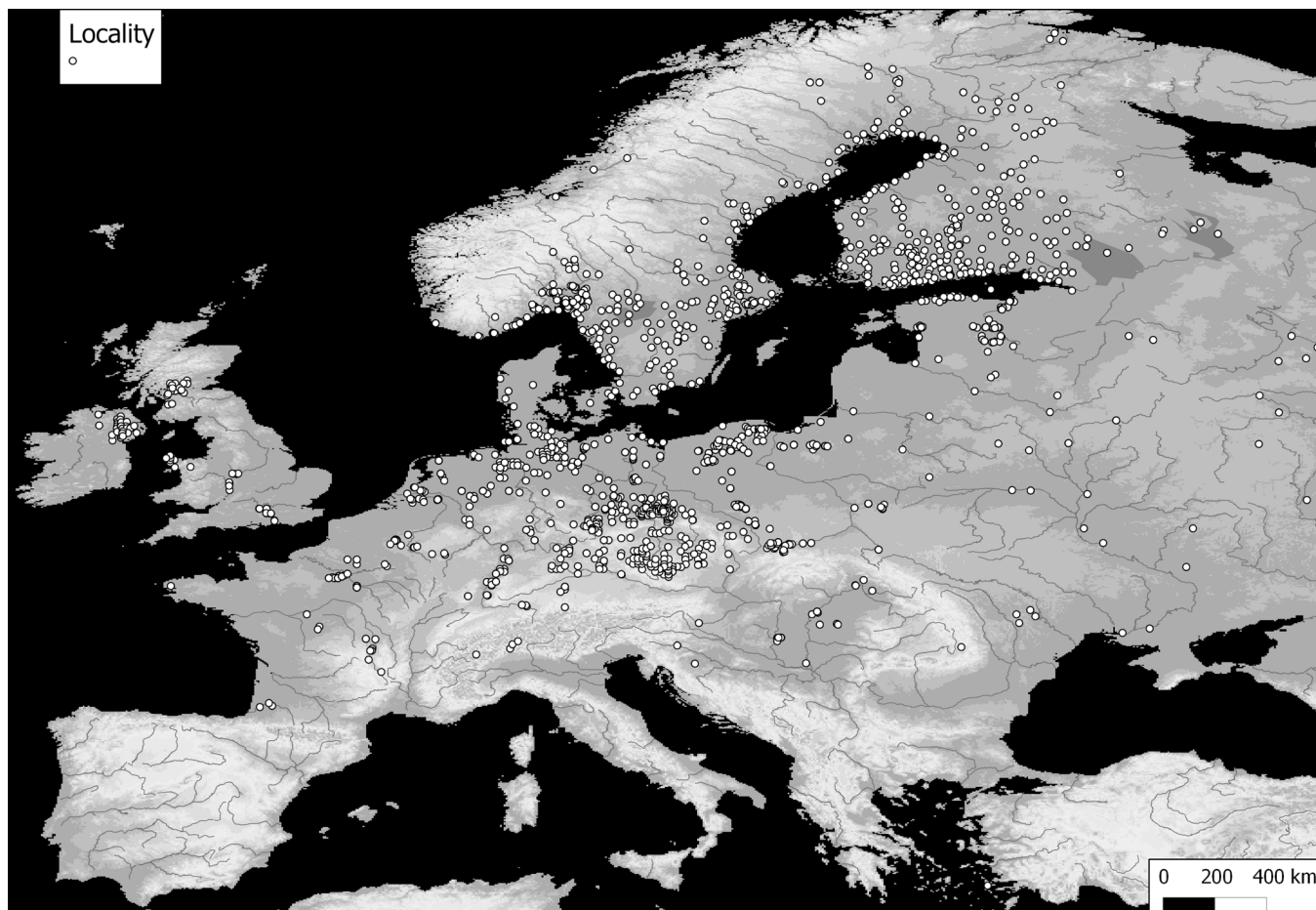


Fig. 1 Distribution of *Elatine hydropiper* L. in Europe.

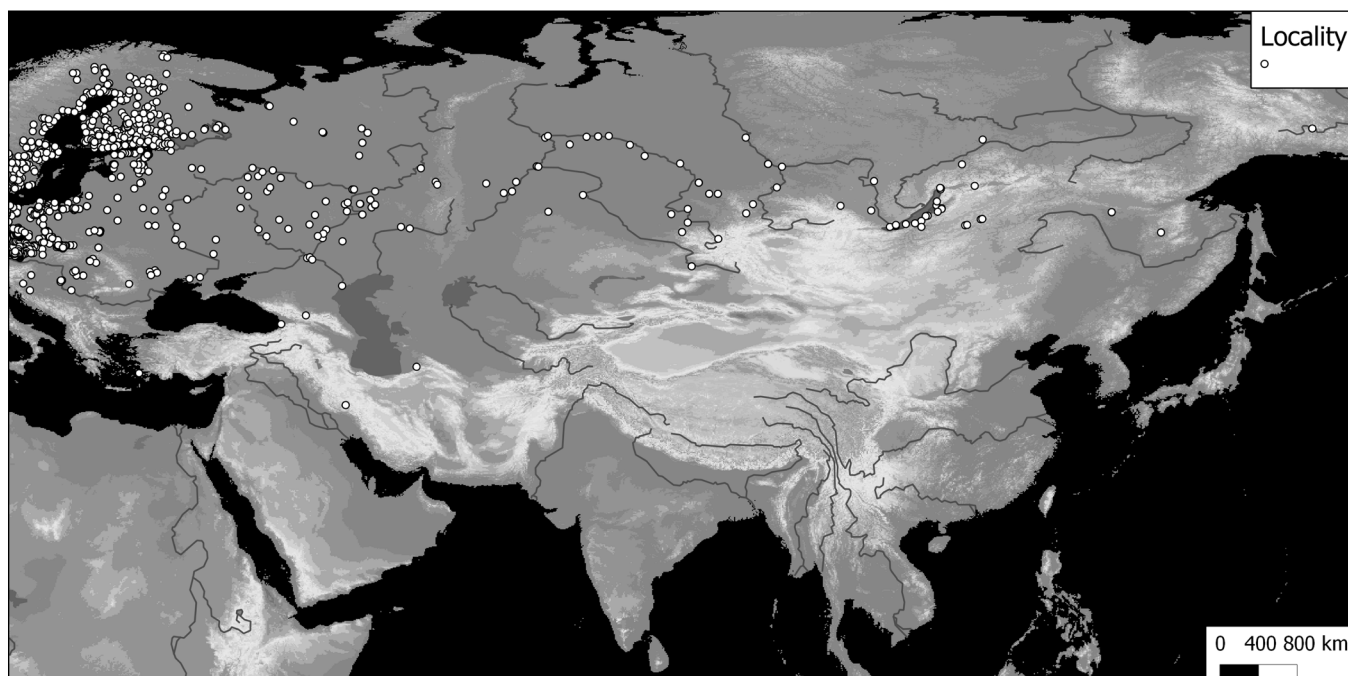


Fig. 2 Distribution of *Elatine hydropiper* L. in East Europe and Asia.

but most probably Euro-Asiatic, being however more southern and eastern compared with *E. hydropiper* [9,15,20-24]. The range of *E. hydropiper* overlaps to large extent (at least in the northern part) that of *E. orthosperma*, being however well distinguishable from it if fruit-bearing specimens are collected (straight seeds in *E. orthosperma*); see also Uotila [12,18].

Like all other species of this genus, *Elatine hydropiper* is being found in shallow waters and in places undergoing seasonal floods. In North Europe (Scandinavia), these are most often shallow waters of lakes and calm (stagnant) waters of rivers (most frequently to 50 cm deep), rarely on wet soil above the water line, also in ditches and ponds. In Central Europe, it is most frequently reported on the shores and bottoms of seasonally dried fish breeding ponds while certain historic locations are from natural habitats – lake shores, river banks and old river-beds. The latter habitats are also most frequently reported from East Europe and North Asia [12,18,20,25-31]. *E. hydropiper* is most frequently being found in communities of the alliance *Elatini-Eleocharition ovatae*, in patches of the association *Eleocharo-Caricetum bohemicae* Klika 1935 (syn. *Heleocharetum ovatae* Moor 1936) [30,32,33] and aquatic communities of the alliance *Isoëtium* [34].

The genus *Elatine* in the northern hemisphere has most probably a long history going back at least to the early Tertiary and floras of this period: the Mediterranean Tertiary and the Madrean Tertiary ones ([16,17] and references cited there), whereas the present range of the species was formed in Holocene. The formation of distribution range of ephemeral wetland flora through general dispersal of diaspores by water and marsh birds (exozoochoria) is possible; but this phenomenon is however very poorly examined, while no documentation is available for the genus *Elatine* at all ([35] and references cited there, as well [36]). The distribution of *E. hydropiper* requires further examination. It is relatively well known in Central Europe; it has a form of smaller and larger site clusters which are frequently far away from each other, even many kilometers away. They are mainly located in the valleys of major rivers. If this reflects the true distribution of the species, disjunctions inside the range occurring, indicate that the spreading of diaspores does not occur easily while the range pattern has a relatively stable character. Most locations known at present in Central Europe are being reported from habitats of the anthropogenic origin, namely from drained fish ponds seasonally flooded. This indicates to anthropogenic expansion of the home range of the taxon under discussion, at least with regard to the number of locations. In European parts of Russia and in Asia most analysed floras confirm the occurrence of *E. hydropiper* whereas their locations are being rarely reported. Therefore, in such areas their study is necessary, and in the meantime the species distribution can be determined only hypothetically.

One of the basic problems in mapping the distribution of *Elatine hydropiper* were differences in the quality of data and the methods being used for their preparation. Geographic co-ordinates were easiest to find for literature and herbarium floristic data. Published maps are a much less accurate source; we used cartogram- and point-type maps. Data transfer from cartogram-type maps is always burdened with error which results from the size of basic cartogram unit. Differentiated scale of point-type maps is often an obstacle for their matching to geographic space. Paper maps are made at a specific scale and when it is being increased the points lose detail. Additionally, when using information on maps, it is required to bring them

to uniform co-ordinate system. In this study, the universal WGS 84 co-ordinate system was used, while the maps being used by us are made in local or regional co-ordinate systems. The best method is calibration of maps in the system, in which they were made, followed by their vectorisation and bringing to uniform co-ordinate system. Vector data are not prone to deformations as the raster ones and their greatest advantage is that each point can be given attributes in database comprising, among others, information about the location, author and data source. Moreover, such data do not lose quality when the map is being scaled up, while a point on it always preserves the specific scale. When compared to maps of *E. hydropiper* distribution being published earlier [11,13,14], the maps presented here are characterised by larger amount of data (also those being freshly obtained or made available in the last twenty years) and much greater precision, which was allowed by the mapping method adopted.

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