

## Recent distribution of the Euro-Siberian-sub-Mediterranean species *Elatine alsinastrum* L. (Elatinaceae)

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**Abstract** – The general distribution of the endangered Euro-Siberian sub-Mediterranean species *Elatine alsinastrum* L. is provided using literature, web-sources and herbaria dataset. The distribution pattern shows some regularities: occurrence of locations along river valleys, formation of concentrated site clusters in some lowlands, wide distances between locations or site clusters or single locations between their clusters. The distribution patterns in central Europe seem to be rather well related to the history of the human migration in Europe at least since the Late Holocene. The scattered locations on the eastern part of the distribution area are likely to be a consequence of missing information, rather than to the fragmentation of its distribution.

**Keywords:** *Elatine alsinastrum*, ephemerophyte, distribution

### Introduction

The genus *Elatine* L. (*Malpighiales* Mart., *Elatinaceae* Dumort.) includes approximately 15–25 species occurring in temperate areas of both hemispheres, mostly in the northern. Besides *Elatine*, the family includes the genus *Bergia* L. (TUCKER 1986). Species of the genus *Elatine* are phytogeographically quite interesting, since they are found in all continents, except Antarctica, mainly in the temperate zones, and reach their greatest spread in the northern hemisphere, both in terms of species-diversity and number of locations. Despite this wide distribution, the species of *Elatine* occur rarely, and their sites are usually quite distant from each other (often more than 100 km). They are semi-aquatic therophytes adapted to live in periodically flooded environments. The numbers of populations and

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plants within a population usually show remarkable yearly fluctuations. The plants, usually characterized by an outstanding phenotypic variability and plasticity, have a very short reproduction period and may produce, when environmental conditions are favourable, many seeds, thus preserving the long lasting germination capacity (DEIL 2005; POPIELA and ŁYSKO 2010, 2011; POPIELA et al. 2010, 2011), as KASAHARA et al. (1967) that has been demonstrated for *Elatine triandra* Schkuhr (more than 50 years).

*Elatine alsinastrum* L. is taxonomically isolated within the family Elatinaceae, being the only taxon included in the subgenus *Potamopithys* (Adanson) Seub., and clearly differing from other species of the genus by the presence of leaves arranged in whorls and most frequently a longer and sturdier stem. Other species, with opposite leaves, are comprised in the subgenus *Elatine* (= *Hydropiper* Moesz.) with the sections: *Triandra* Seub. (= *Crypta* (Nutt.) Seub.) and *Elatinella* Seub. (TUCKER 1986). Accordingly, *E. alsinastrum* is relatively easy to identify and both herbarium materials and literature data can be considered reliable. It includes upright amphibian herbs, with stem erect or ascending, mostly simple; leaves in whorls of (4)8–17 (submerged) and of 3 (aerial); flowers usually 3 at a node, mostly sessile or short-stalked; sepals 4, petals 4 and stamens 8. Seeds cylindrical, 0.6–0.9 mm long, 0.2–0.3 mm width, almost straight to slightly bent (0–55°), pits conspicuous, (15–)17–21(–24) in each row.

The species occurs in two forms: the first is terrestrial, and it can be found in wet depressions, while the second is aquatic and can be found in shallow stagnant waters (30–50 cm deep), in flooded rice fields and meadows, pond waters and on their verges, lake shores, in periodically dry puddles and water bodies, drainage ditches, in wet depressions in cultivated fields and on wet roadsides. It frequently occurs with other ephemeral wetland species, such as *E. triandra* Schkuhr., *Limosella aquatica* L., *Lindernia procumbens* (Krock.) Philcox, *Cyperus fuscus* L., *Plantago major* L. s.l., *Gnaphalium uliginosum* L., *Eleocharis acicularis* (L.) Roem. et Shult., *Peplis portula* Schrnk. (class *Isoëto-Nanojuncetea* Br.-Bl. et Tüxen ex Br.-Bl. et al. 1952, associations: *Myosotido siculae-Isoëtetum velatae* Pottier-Alapetite 1952, *Eleocharito-Limoselletum aquaticae* Philippi 1968, *Lindernio-Eleocharitetum ovatae* Pietsch 1973, *Eleocharito acicularis-Schoenoplectetum supine* (Horvatić 1931) Sao et Ubrizsy in Ubrizsy 1951 (= *Elatini-Lindernietum procumbentis* Ubrizsy 1961), *Elatini alsinastrum-Juncetum tenageiae* Libbert 1932, *Ranunculo lateriflori-Limoselletum aquaticae* Pop 1968 (LIBBERT 1932; OBERDORFER 1957; PIETSCH 1973a, b; POTTIER-ALAPETITE 1952; BRULLO et MINISSALE 1998).

*Elatine alsinastrum* is an Euro-Siberian species, quite rare in the whole area of its distribution range (MEUSEL et al. 1978, HULTÉN and FRIES 1986, UOTILA 2009a). The aim of this work is to provide the current distribution of this endangered taxon.

## Material and methods

This paper is based on both analysis of floristic literature, distribution atlases, web-sources and examination of the specimens kept in 31 herbaria, 20 of them accessed by web. (Tab. 1). A total of 993 floristic data (700 from the literature and herbaria, 293 from the Web) are analyzed, priority being given to literature data over Websources. The latter were used only if considered to be reliable (e.g. if they did not deviate from the range or had an author and exact location or were delivered by herbarium servers). In consequence, 392 web data were removed.

Data were manually mapped using a satellite base image from Google Earth. Calibration, rectification to UTM grid and digitalization were done. The vector layers were prepared by conversion to WGS84 cartographic grid. Electronic data containing geographic co-ordinates were exported to SHP format. When geographic coordinates were missing, records were converted into text format. If detailed descriptions are missing and only cartographic grid locations are given, spatial queries connecting grid area and map were used. All analyses and maps were made using PostGIS database extension software and QGIS (Quantum GIS) application software working in the LINUX environment.

## Results

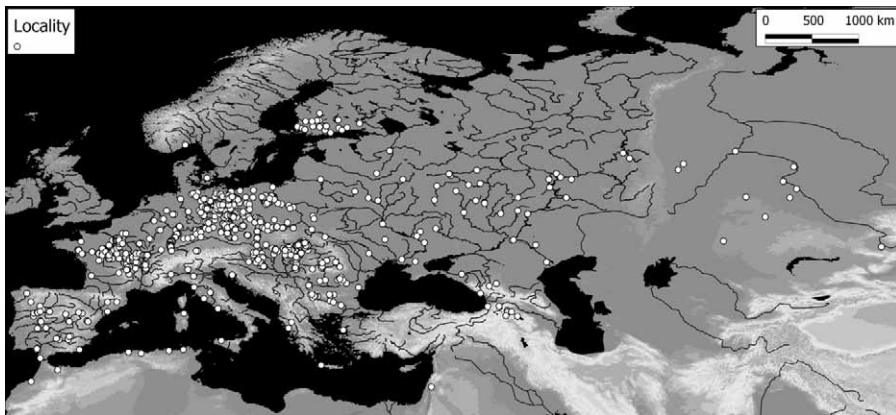
*Elatine alsinastrum* is a Euro-Siberian sub-Mediterranean species (Fig. 1). The analysis of the current distribution of *E. alsinastrum* allows us to infer that its distribution centre is in the lowland and upland areas of Europe situated to the north and west of Alps and Carpathians. The pattern of its distribution has the form of smaller and larger site clusters which are frequently far away from each other, even many kilometers. They are mainly located along the valleys of the major rivers. The highest concentration of sites was found in

**Tab. 1.** Literature, herbaria and web sources. Herbarium acronyms follow Index Herbariorum (THIERS 2012), but the herbarium full name is given when not listed there.

Area	Data
Asia, North and Eastern Europe (Russia, Kazakhstan, Armenia, Georgia, Ukraine, Moldova, Finland, Lithuania, Belarus)	ADYLOV 1983, CZEREPANOV 1995, GAGNIDZE 2005, GEIDEMAN 1986, GROSSHEIM 1962, KORSHINSKY 1898, KRYLOV 1939, KUUSK et al. 1996, MAEVSKY 1954, PAPCZENKOV 2006, PAVLOV 1963, PESCHKOVA 2006, PROKUDIN 1987, 1999, SHISHKIN and BOBROV 1974, SHISHKIN 1961, SMALLHAUSEN 1895, TAKHTAJYAN 1966, TICHOMIROVA 1986, TZVELEV 1996, UOTILA 2009b, VEDENKOV 1998, VOLOBAIEV 1991. Specimens found in the following herbaria: K*, B
Central, Southern and South-Eastern Europe (Poland, Czech Republic, Slovakia, Austria, Hungary, Romania, the Balkans, Italy)	BARINA and PIFKÓ 2007, BERGMEIER & ABRAHAMCZYK 2008, BLEČIĆ 1972, BOROS and VAJDA 1957, CESATI et al. 1868–86, DANIN 2004, DAVIS 1967, DESFAYES 2008, DIMITROVA 2009, DOSTÁL and ČERVENKA 1991, DOSTÁL 1989, FARKAS 1999, FINTHA 1994, FIORI and PALEOTTI 1896, GORI et al. 1998, GRDINIĆ et al. 2001, HAYEK 1927, HEJNÝ S. and SLAVÍK 1990, JAKAB 2005, JUHÁSZ-NAGY 1959, MOESZ 1908, MOLNÁR and GULYÁS 2001, MOLNÁR and PFEIFFER 1999, NIKOLIĆ and TOPIĆ 2005, NIKOLIĆ 1994, PEEV 1984, PETKOVIĆ et al. 1998, PIGNATTI 1982, PINKE et al. 2006, POPIELA 2001, POPIELA et al. 2012a, POPIELA et al. 2010, PROHÁZKA and KØISA 1999, SARIKA-HATZINIKOLAOU et al. 1994, 1997, SÁVULESCU 1955, SOÓ and MÁTHÉ 1938, STEVANOVIĆ 1999, TRINAJSTIĆ 1975, VLADIMIROV et al. 2010, Specimens found in the following herbaria: K*, B, BP, DE, SAMU, Kazinczy Ferenc Museum, Sátoraljaújhely (Hungary); University of Szeged, Szeged (Hungary); Szent István University, Gödöllo (Hungary); Kazinczy Ferenc Museum, Sátoraljaújhely (Hungary). Biodiversity occurrence data were provided by the University Museums of Norway.

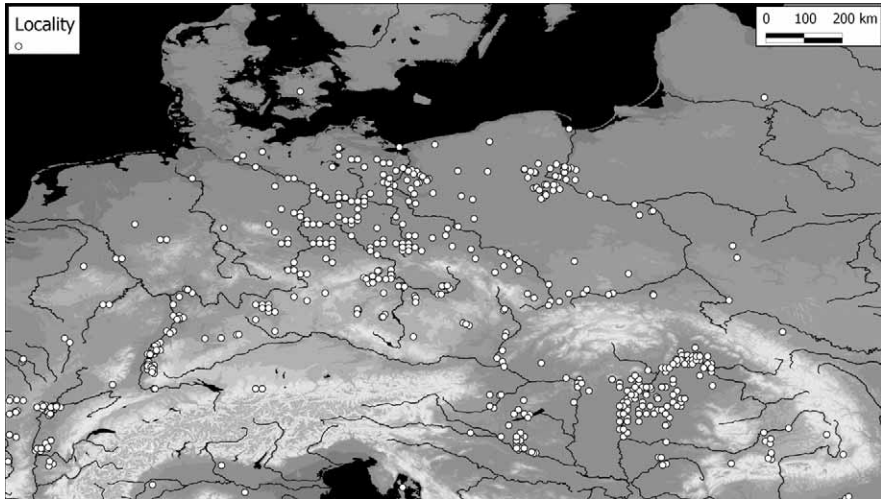
**Tab. 1.** – continued

Area	Data
Western and South-Western Europe and Northern Africa (France, Germany, Switzerland, Spain, Portugal, Morocco, Algeria, Tunisia)	<p>ANONYMUS 2005, ANTONETTI et al. 2006, BENKERT et al. 1996, BOLOMIER and CARTIN 1999, BOREAU 1849, BOUDIN et al. 2007, BUGNON et al. 1998, CIRUJANO and VELAYOS 1993, COUTINHO 1939, DIARD 2005, FENNANE et al. 1998, FORTUNE 2003, FRANCO 1971, FUKAREK and HENKER 2006, GAMISANS and JEANMONOD, 1993, GRENIER 1992, GUINOCHET et VILMORIN 1982, HAEUPLER and SCHÖNFELDER 1989, HAMMADA et al. 2004, JAHANDIEZ and MAIRE 1932, JEANMONOD and GAMISANS 2007, LE FLOCH and BOULOS 2008, LUNAIS et al. 1986, MULLER 2006, NETIEN 1993, POTTIER-ALAPETITE 1979, QUEZEL and SANTA 1962–1963, SAINT-LAGER 1873, SCHOTSMAN and OSSERDET 1967, TOURLET 1908, WOHLGEMUTH 1993.</p> <p>Specimens were found in the following herbaria: K*, B.</p> <p>Biodiversity occurrence data were provided by the following Herbaria: ABH; BC; CIBIO; COFC; E; FCO; GLM; HSS; IBF; Leiner-Herbar Konstanz; LUX; MA; MAF; MGC; OHN; SALA; SANT; SEV; STR; STU.</p> <p>Occurrence data were provided by Information System of the plants of Spain, Real Jardín Botánico, CSIC – Fundación Biodiversidad; retrieved November 20, 2011 from <a href="http://www.anthos.es">www.anthos.es</a>.</p> <p>Biodiversity occurrence data were provided by following database: Aranzadi Zientzi Elkarte; Botany (UPS); Bundesamt für Naturschutz/ Netzwerk Phytodiversitaet Deutschland; Cartografía de vegetación a escala de detalle 1:10.000 de la masa forestal de Andalucía; Flora exsiccata Bavarica; Florabank1; Inventaire national du Patrimoine naturel (INPN); Observations du Conservatoire botanique national du Bassin parisien.; Phanerogamic; Phytochorologie des départements français; Sistema de Información de la vegetación Ibérica y Macaronésica</p>



**Fig. 1.** Distribution area of *Elatine alsinastrum* L.

the French plains (Armorican Massif, Paris, and Aquitaine Basin), in the central zones of the Loire and Seine river valleys, in the upper part of the Rhine river valley, in the East German lowlands and in the western area of Poland, in the Oder and Vistula river valleys (Fig. 2).



**Fig. 2.** Distribution area of *Elatine alsinastrum* L. in central Europe.

Smaller site clusters are in western and central Europe, in the Bohemian Massif, in the Danube and Tisza river valleys, and in the Pannonian Basin. Furthermore, it is found in scattered locations in southern Europe and at the southern limit of its distribution range in single locations in Morocco, Algeria, Tunisia and Palestine. The distribution in eastern Europe (the area of the Vistula-eastern Carpathian Mountains) appears to be unclear (Fig. 1), probably because there is a scarcity of data on detailed locations from this area. Most of the Russian floras have scarce or no information about the occurrence of the taxon at issue or the available information is rather scattered. The analysis of floras of the Baltic countries and information from Belarus show that this species either occurs very rarely there or is absent. In Ukraine, it is found scattered over the whole territory, except the Crimea. There are only scattered locations of *E. alsinastrum* in the European part of Russia from the North and the South by the Volga and the Kama rivers. Site clusters of this taxon are also observed in the Stavropol Krai and Georgia and Armenia where it reaches the southern limit of its range in eastern Europe. In Siberia, single locations are found in the valleys of left tributaries of the Tobol River (the Iset and Tura rivers), in the Irtysh river valley, and in Kazakhstan. The largest number of observations in Siberia has come from natural locations: swamps, flooded meadows, lake shores, flooded lowlands, river meanders and the shores of drying up water bodies.

## Discussion

On the basis of fossil data and molecular findings, DAVIS et al. (2001) have raised a hypothesis that families of the order *Malpighiales* originate in the northern areas of South America, with subsequent migration to North America and later, via the Atlantic, to the Old World. This would suggest that the genus *Elatine* in the northern hemisphere has a history going back at least to the Early Tertiary and floras of that period (e.g. the Mediterranean Tertiary and the Madrean Tertiary), while the present range of the genus originated in the

Holocene. *E. alsinastrum* is the species with the most isolated taxonomic position within the family Elatinaceae; accordingly, a question arises about the formation of its range in the Holocene, the refuge for this species during the Pleistocene glaciations and the migration routes.

The distribution area of *E. alsinastrum* L. shows a remarkable geographic disparity and certain regularities: the formation of concentrated site clusters in some lowlands, and large distances between locations or site clusters or single locations between their clusters. The situation in central Europe appears to be well known, with smaller and larger site clusters (often along river valleys) which are frequently far away from each other, even many kilometers away. So, disjunctions inside the range seem to occur, indicating that the spreading of diaspores does not occur easily despite good habitat conditions. It is possible that the species is a relic of the former natural wetland flora, its sites thus able to remain permanent for a very long time (soil seed bank) and the distribution pattern is a reflection of history of colonization in Europe at least since the Late Holocene. Many locations have been changed by human beings and thus, it seems that the range of *E. alsinastrum* may be also extended anthropogenically, with human-created habitats; however, the species is also spread by birds. Dispersal of diaspores by water and marsh birds (epi- and/or endozoochoria) is possible, although documentation in the genus *Elatine* is only known for one species (KERNER 1895).

In a discussion of methodological problems in mapping the range of *E. alsinastrum* differences in the quality of data and the methods being used for their preparation should be emphasized. In this study, the universal WGS 84 coordinate system was used, while the maps employed are made in local or regional coordinate systems. The best method is calibration of maps in the system, in which they were made, followed by their vectorisation and reduction to a uniform coordinate system. Using this method, data do not lose quality when the map is being scaled up, while a point on it always preserves the specific scale (see also: POPIELA et al. 2012b).

The comparison of the maps resulting from the present study with those published earlier (MEUSEL et al. 1978, HULTÉN and FRIES 1986) shows a larger amount of data (also with reference to those available in the last twenty five years) and a greater precision, which was allowed by the mapping method adopted. Changes in the distribution of *E. alsinastrum* relate mainly to central Spain, and southern France. The method adopted has also allowed verification of the dispersal character of the distribution of the species in central Europe.

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