Perspectives in Plant Ecology, Evolution and Systematics 13 (2011) 55–69

Contents lists available at ScienceDirect

Perspectives in Plant Ecology, Evolution and Systematics

journal homepage: www.elsevier.de/ppees

Biological Flora of Central Europe

Biological Flora of Central Europe: *Euphorbia palustris* L.

Christina Wärner[a], Erik Welk[b], Walter Durka[c], Burghard Wittig[a], Martin Diekmann[a,*]

[a] *Vegetation Ecology and Conservation Biology, Department of Ecology, FB 2, University of Bremen, Leobener Str., D - 28359 Bremen, Germany*
[b] *Institute of Biology, Martin Luther University Halle-Wittenberg, Am Kirchtor 1, D - 06108 Halle, Germany*
[c] *Department of Community Ecology, Helmholtz Centre for Environmental Research - UFZ, Theodor-Lieser-Str. 4, D - 06120 Halle, Germany*

ARTICLE INFO

Article history:
Received 12 November 2009
Received in revised form 25 January 2011
Accepted 1 February 2011

Keywords:
Distribution range
Endangered species
Habitat requirements
Life history
Plant communities
Reproduction
River corridor plant

ABSTRACT

Euphorbia palustris L. (Euphorbiaceae) is a tall perennial hemicryptophyte, native to Europe and small parts of adjacent Western Asia. It is considered a so-called river corridor plant that is exclusively or predominantly confined to the basins of large rivers. As most natural habitats along European rivers have been destroyed and the remaining habitats fragmented and degraded by the regulation of watercourses, land reclamation, and agricultural intensification, *E. palustris* is now endangered in most of Central Europe. To enhance its conservation, to give scientific advice for its management and to supplement the scarce information about the species available from the literature, this paper reviews its taxonomy, morphology, distribution, habitat requirements, life cycle, population biology and genetics as well as the conservation status across its distribution range.

Introduction

"*Euphorbia*, which Rudbeck called *Tithymalus maximus Oelandicus*, grew abundantly here in the middle of the field close to a little brook, Fällbäcken, although we had never seen it wild in Sweden before; it grew as shrubs a few ells tall; the stem perishes each year; the leaves are alternate, lanceolate, obtuse and entire. . . .We saw this plant later on during the day here and there in the meadows on the *alvar*-land." (Linné, 1745).

This citation from Linné's journey to Öland and Gotland is probably the first scientific description of the biology and ecology of *Euphorbia palustris* L., a nowadays rare and, in most parts of Central Europe, endangered species. This article deals with the taxonomy, morphology, distribution, habitat requirements, life cycle, population biology, and genetics of this species, following the outline for the Biological Flora of Central Europe (Matthies and Poschlod, 2000). To provide a comprehensive overview we used already published information as well as unpublished data. Personal observations of the species' ecology were conducted in the years 2005, 2006, and 2007 in 12 populations located along the Weser and Elbe river systems in North-western Germany. Unless otherwise stated, data given without a published literature source refer to these investigations. Most quantitative information in the sections "Morphology" and "Reproduction" is based on our own measurements in the above populations, where also data on environmental conditions were gathered (chapters "Habitat" and "Regional response to abiotic factors"). Additional information was obtained while compiling and analyzing data on the geographical distribution of the species. Information given in the section "Germination" is based on experiments conducted at the University of Bremen. Studies of the demography of *E. palustris* were carried out in three relatively large populations and form the basis for the chapters "Life cycle", "Spatial distribution of plants within populations" and "Herbivores and pathogens". Finally, genetic information provided in the section "Genetic data" is derived from own microsatellite analyses. In general, it has to be kept in mind that this monograph of *E. palustris* is based predominantly on data material and the literature from Central Europe, while the range centre of the species is located in Eastern Europe. In spite of this potential bias we hope that this paper contributes to a better understanding of the species' ecology and the causes behind its severe decline in many parts of Europe.

Taxonomy and morphology

Taxonomy

Euphorbia palustris L., Spec. Plant. I: 462 (1753) (Euphorbiaceae) – Sumpf-Wolfsmilch, marsh spurge.

* Corresponding author. Tel.: +49 421 21862920; fax: +49 421 21862929.
E-mail address: mdiekman@uni-bremen.de (M. Diekmann).

1433-8319/$ – see front matter © 2011 Elsevier GmbH. All rights reserved.
doi:10.1016/j.ppees.2011.02.001

Homotypic synonyms: *Tithymalus palustris* (L.) Garsault, Fig. Pl. Méd.: 592 (1764), – *Galarhoeus palustris* (L.) Haw., Syn. Pl. Succ.: 145 (1812).

Heterotypic synonyms: *Euphorbia nuda* Velenovsky, Fl. Bulg.: 506–507 (1891) – *Euphorbia velenovsky* Bornm., Bot. Jb. 66: 117 (1933), nom. illeg. – *Euphorbia sauliana* Boreau ex Boiss., DC. Prodr. XV/2: 1266 (1866).

The genus *Euphorbia* belongs to one of the largest dicotyledonous plant families, the Euphorbiaceae, which includes 300 genera and 8000 species (Webster, 1987) occurring in all parts of the world except the arctic regions, and having its distribution centre in the tropics. Because of its tremendous morphological diversity, encompassing broad-leaved trees in the tropical rainforest, succulents in arid ecosystems, perennial herbs mainly in Europe, annual weeds, and even a floating water plant (*Phyllanthus fluitans* Benth.), the taxonomy of the family is still disputed (Webster, 1987).

Euphorbia is a large genus of over 2000 species of almost cosmopolitan terrestrial distribution, which is sub-divided into many subgenera and sections (Govaerts et al., 2000). While the genus is rich in species in subtropical, semi-arid areas, particularly in Africa, much fewer species occur in cooler regions, such as the European and West Asian temperate to boreal zones (Kuzmanov, 1964). *E. palustris* is a species of the subgenus *Esula* Pers. that consists of about 500 species and is considered a native Eurasian group (Park, 1998). Within this group, the section *Tulocarpa* (Raf.) Prokh. (sect. *Tithymalus* (Scop.) Boiss. subsect. *Galarrhaei* Boiss.) includes tall perennial herbs and small shrubs, predominantly distributed in sub-meridional and temperate Eurasia. Therein, *E. palustris* belongs to the subsection *Lutescentes* Prokh. (ser. *Lutescentes* (Prokh.) Radcliffe-Smith). Its closest relatives are *Euphorbia soongarica* Boiss., *Euphorbia lamprocarpa* Prokh., and *Euphorbia aristata* Prokh. (Baikov, pers. comm.). Govaerts (Catalogue of Life, 2007) included these species into a broader concept of *E. palustris*, although they seem to be clearly distinguished by their fruit morphology. Species like *Euphorbia semivillosa* Prokh. that was sometimes included in an *E. palustris* aggregate differ in being not entirely glabrous. While the morphological and ecological similarity of *E. lamprocarpa* and *E. aristata* to *Euphorbia soongorica* was already advocated by Lipsky (1897), there is a larger difference between *E. palustris* and *E. soongorica* with regard to their habitat preferences. The latter occurs in temporarily moist, often strongly saline, open habitats of sub-continental (mountain) steppe regions (Pavlov, 1963), whereas *E. palustris* is more strongly tied to seasonally wet riparian habitats in lowland river corridor ecosystems. The placement of *E. soongarica*, *E. lamprocarpa*, *E. aristata*, and *E. palustris* in a separate Series *Soongaricae* Baikov (Baikov, 2003a,b, 2007) seems justified (also see World Checklist, 2009). Accordingly, Meusel et al. (1978) described *E. palustris* as a lowland species within a group of mountain steppe plants of Western Asia. Molecular-genetic studies on the phylogenetic relationships of *E. palustris*, however, are lacking.

Morphology

E. palustris is a perennial herb resembling a small willow shrub in its habit. Flowering plants reach a height of 70–180 cm (120 cm on average, 95% CI 119–122). The distinct system of thick, fleshy roots shows a number of peculiarities in the course of its development. Since the main root and the hypocotyl of the seedling are building a persistent fleshy taproot, at this stage the species is classified as turnip geophyte (Rauh, 1937; Fig. 1). From the third growing season onwards the turnip starts to split into several branches. A central rootstock, however, persists, increases in size with age and lignifies. Furthermore, basal persistent segments of the new branches

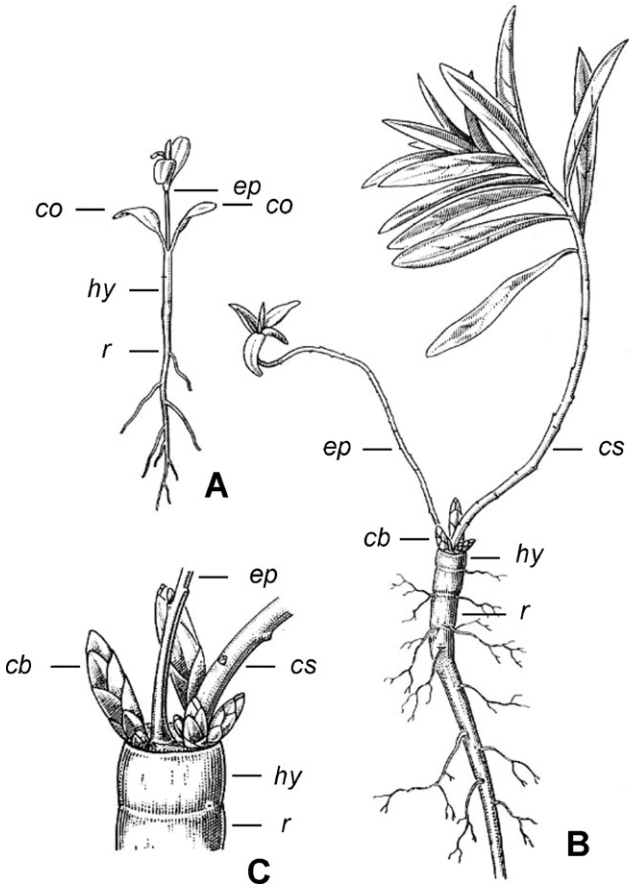

Fig. 1. *Euphorbia palustris*. (A) Seedling, (B) one year-old plant, (C) top of the beet of a one year-old plant. r—root, hy—hypocotyl, ep—epicotyl, co—cotyledon, cs—cotyledon shoot, cb—cotyledon bud.
Modified from Rauh (1937).

grow and give rise to innovation from axillary buds (Fig. 2). These branches could be identified as stem axes with adventitious rooting by means of a microscopy cross section. The belowground stem axes, which emanate laterally from the central rootstock, are thickest (diameter between 5 and 10 cm) in the upper part (Lukasiewicz, 1962). The roots grow diagonally into the soil down to a depth of 1 m (Hejny, 1960; Lukasiewicz, 1962). These characteristics indicate that the storage organ of individuals older than three years

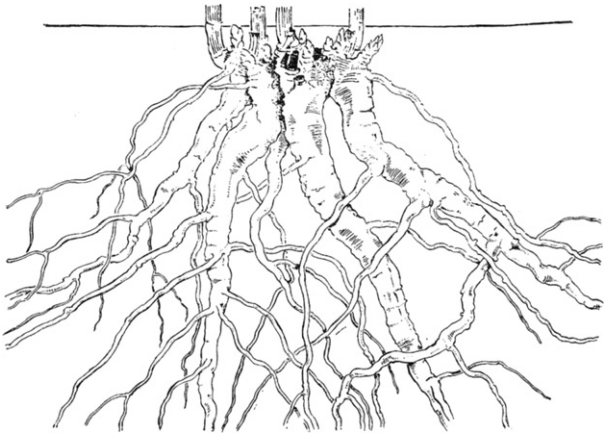

Fig. 2. Upper part of *Euphorbia palustris*' lasting organs. State in autum (Lukasiewicz, 1962).