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Lindernia dubia (L.) Pennell: A NEW INVASIVE IN THE ROMANIAN BANAT AREA

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Abstract

In this paper we reporte the presence of the species Lindernia dubia (L.) Pennell in the flora of Banat (SW Romania) and at the same time we present a new place for this species in Romania. We found the species on the lake Surduc area. This is a 362 ha artificial lake, a protected area (nature reserve of national interest). We found Lindernia dubia here for the first time in 2005, in flooded areas periodically (on clay soils), on the shore of the lake as well as in the nearby arable fields. We suppose he arrived here with the fish he brought to populate his lake or by seeds brought through the birds. The size of the population depends on the fluctuation of water level. Being an invasive species, we believe it is necessary to monitor it; some authors say it extends into characteristic habitats while others consider it one of the most abundant invasive species from the Danube Delta.

Key words*: Lindernia dubia (L.) Pennell, Romanian Banat, invasive.*

INTRODUCTION

The genus *Lindernia* Allioni encompases about 70 species distributed throughout warm tropical and warm-temperate regions of New and Old World (Flora of China, 1998); recently, based on cpDNA sequences, many *Lindernia* species have been transfered to different genera within *Linderniaceae* (Les, 2017).

Formerly included in *Scrophulariaceae*, this genus belongs to *Linderniaceae* Borsch et al., K. Müller, & Eb. Fischer (Stevens, 2017). In Europe, the genus *Lindernia* is represented mainly by two species*: Lindernia procumbens* (Krock.) Philcox, native and *Lindernia dubia* (L.) Pennell, from North America, naturalized (Tutin et al., 1972). Marhold (2017,

The Euro+Med PlantBase) mentions also *Lindernia anagallidea* (Michx.) Pennel (*Lindernia dubia* var. *anagallidea* (Michx.) Cooperr.) from Italy, a species native from North America (Cook, 1985).

The most significant morphological differences between *Lindernia procumbens* (Krock.) Philcox and *Lindernia dubia* (L.) Pennell are documented by Molnár et al. (2000): length of leaves, length of pedicels, ratio of pedicels/leaf length. These two species may occur simultaneously in a habitat and may interbreed (Yoshino et al., 2006, in Schmotzer, 2015). *Lindernia dubia* (L.)

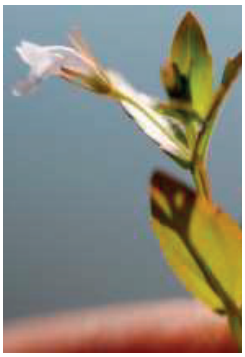
Pennell is characterized by: serrated leaves, floral pedicels shorter than the bracts, corolla longer than the calyx, two fertile stamens (Figure 1). *Lindernia procumbens* (Krock.) Philcox (Natura 2000 species code: 1725) is included in the Annex IV of the Council Directive 92/43/EEC among the species of community interest in need of strict protection. *Lindernia dubia* (L.) Pennell is an invasive, accidentaly introduced in France in 1850, by ships on the Loire river banks (Fournier, 1940, Simons & Jansen, 2018).

According to Marhold (2017), the species is to be found in: Bulgaria, France, Germany, Switzerland, Italy, Portugal, Slovenia, while DAISIE Database mentions *Lindernia dubia* (L.) Pennell present in: Belgium, Bulgaria, Czech Republic, France, Germany, Greece, Hungary, Italy, Macedonia, Portugal, Romania, Spain.

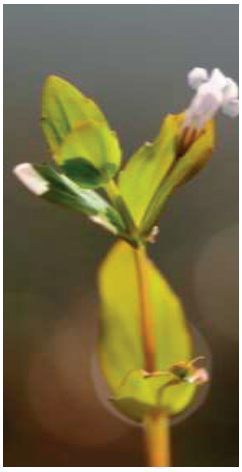
The Euro+Med PlantBase presents the following countries as a distribution for genus *Lindernia*: Armenia, Austria, Bulgaria, Czech Republic, Croatia, Egypt, France, Germany, Greece, Switzerland, Spain, Hungary, Italy, Portugal, Poland, Central European Russia, South European Russia, Romania, Slovakia,

Slovenia, Serbia (including Kosovo and Vojvodina), Asiatic Turkey, Ukraine and for the species *Lindernia dubia* (L.) Pennell, the following: Bulgaria, France, Germany, Spain, Italy, Portugal, Slovenia. The European areal of the species included also Poland (first mention: 2003, Drobnik & Buchalik, 2004).

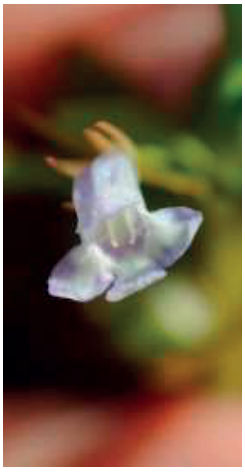
a) Lake shore with *Lindernia dubia*.



b) Corolla longer than the calyx.



c) Pedicel shorter than leaf length.



d) The two fertile stamens.

Figure 1. *Lindernia dubia* (L.) Pennell - overwiew of the habitat (a) and morphological aspects (b, c, d).

In Romania, *Lindernia dubia* (L.) Pennell have been identified for the first time in the Danube Delta by Ciocârlan & Costea, 1994, and is now one of the most abundant invasive species in the Danube Delta Nature Reserve (Doroftei & Anastasiu, 2014, Sîrbu et al., 2011, Anastasiu et al., 2014). *Lindernia* species are among the few annual species whose germination doesn't diminish in floodable conditions; *Lindernia dubia* (L.) Pennell germinates very well in the riparian areas of the rivers Loire and Allier (France), but if the water layer persists the plants do not grow (Abernethy & Willby, 1999). *Lindernia dubia*'s capacity to germinate both in floodable conditions and in non-flooded soil is also highlighted by Neff et al. (2009), Šumberová et al., 2012 and http://beta.floranorthamerica.org/Lindernia_dubia. In seasonally flooded habitats the ability to preempt the growth of flooding-sensitive annuals by germinating before water levels have fully receded will bestow a considerable competitive advantage and may account for the present abundance of *Lindernia dubia* (L.) Pennell in the riparian zone of sections of the Loire and Allier (Abernethy & Willby, 1999).

In the Czech Republic, Šumberová et al. (2005) discussing the two species, they appear in the marginal vegetation; *Lindernia dubia* (L.) Pennell regenerates earlier from the stock of seeds, while *Lindernia procumbens* (Krock.) Philcox appears at the end of June when there are high temperatures necessary for germination.

In this country, the species is also study by Horáková et al. (2005), Kaplan et al. (2016). In 1995, Seliškar et al. revised the *Lindernia* genus and first mentioned the *Lindernia dubia* (L.) Pennell species in the flora of Slovenia. In Slovakia, Hrivnák et al. (2016) discussing *Lindernia dubia* (L.) Pennell in its Central European context. In Bulgaria, both species grow in humid sandy places, in ponds and rice paddies. *Lindernia procumbens* (Krock.) Philcox is cited in 1889, *Lindernia dubia* (L.) Pennell appearing much later in 1984. Stojchev & Cheshmedziev (2005) investigate the anatomy of the two species and complete their chorology in Bulgaria with new data. The anatomical characteristics remain in close parameters, the observed differences refer only to a greater density of the epidermal cells and the stomata from the *Lindernia procumbens* (Krock.) Philcox leaf and the higher number of cavities and medullary rays from the *Lindernia dubia* (L.) Pennell stem.

Pignatti (2005) considers as main ecological differences between the two species of *Lindernia* the fact that *Lindernia procumbens* (Krock.) Philcox has slightly higher requirements for light, slightly lower for temperature, and slightly lower for humidity,

compared to *Lindernia dubia* (L.) Pennell. Ellenberg et al. (1992) present the two species as having the same light requirements (high) and *Lindernia procumbens* (Krock.) Philcox slightly more thermophilic.
Julve (2020a; 2020b) presents *Lindernia dubia* (L.) Pennell as a more thermophilic and more trophic soils. Both species are intolerant to salinity. Sanda et al. (2003), consider that there are no ecological differences between the populations of the two species in Romania, while Sarbu et al. (2013) say that *Lindernia dubia* (L.) Pennell needs less light and slightly higher temperature.

Figure 2. Geographical position of Surduc Lake.

During some researches on the flora and vegetation around Surduc Lake (Timiș County, W Romania, Figure 2), during 2005-2019 we followed the presence of invasive species populations, given that this area is subject to a chaotic tourist development (Neacșu et al., 2017). *Lindernia dubia* (L.) Pennell is among the species we found here.

MATERIALS AND METHODS

We conducted field research in July-September, during 2005-2019. The identification of the species was made according to the current determinants in Romania (Ciocârlan, 2009, Sârbu & Oprea, 2011), and according to Molnar et al. (2000) and Flora of China, 1998 (online edition). In the areas with populations of *Lindernia dubia* (L.) Pennell we also noticed the presence of other species of cormophytes. We also made observations on anthropogenic pressures. Nomenclature is according to Euro+Med PlantBase. Voucher specimens are stored in the Herbarium of Banat's University of Agricultural Sciences and Veterinary Medicine „King Michael I of Romania" from Timisoara.

RESULTS AND DISCUSSIONS

We found populations of *Lindernia dubia* (L.) Pennell in six areas of the shores of Surduc Lake (Figure 3). Given the characteristics of the habitat (accumulation lake on the edge of a small river, with a narrow valley), two ways in which *Lindernia dubia* (L.) Pennell got here seem more likely: together with the fish brought here for breeding or by seeds in the mud encrusted in birds' feathers and legs (natural zoochory).
Both anthropic and natural *Lindernia dubia* (L.) Pennell dispersion is considered by various authors (e.g. Thiébault, 2007, Schmotzer, 2015). Simons & Jansen (2018) present as a way of introduction the zoochory.

Figure 3. Zones with *Lindernia dubia* (L.) Pennell populations on the Lake Surduc shore.

We noticed that the morphology of *Lindernia dubia* (L.) Pennell specimens depends on the characteristics of the microhabitat:
a) along the shore with clay soil we met abundant populations, with vigorous specimens, ample, ascending or slightly procumbent stems, which take root at the nodes. When the soil is dry, it blooms. In autumn, the stems turn reddish. In these microhabitats are also found: *Eleocharis palustris* (L.) R. Br., *Eleocharis acicularis* (L.) Roemer et Schultes, *Lythrum portula* (L.) D. A. Webb, *Echinochloa crus-gali* (L.) Beauv., *Gypsophilla muralis* L., *Gnaphalium uliginosum* L., *Polygonum aviculare* L., *Polygonum lapathifolium* L., *Xanthium orientale* subsp. *italicum* (Moretti) Greuter;
b) on the waterfront, in the sandy areas, *Lindernia dubia* (L.) Pennell grows together

with: *Polygonum aviculare* L., *Trifolium repens* L., *Potentilla reptans* L, *Plantago media* L., *Bidens tripartita* L., *Alisma plantago-aquatica* L., *Echinochloa crus-galli* (L.) Beauv. These forms are vigorous, with ascending stems.

c) in the agricultural crops near the shore we found isolated specimens, small in size, with weak rooting.

In the whole studied area, the shores of the lake are occupied by populations of the following species: *Alisma plantago-aquatica* L., *Bidens tripartita* L., *Calystegia sepium* (L.) R.Br., *Carex riparia* Curtis, *Cyperus fuscus* L., *Echinochloa crus-galli* (L.) Beauv., *Eleocharis acicularis* (L.) Roemer et Schultes, *Eleocharis palustris* (L.) R. Br., *Gnaphalium uliginosum* L., *Gypsophila muralis* L., *Impatiens noli-tangere* L., *Juncus bufonius* L., *Juncus effusus* L., *Juncus tenuis* Willd., *Leersia oryzoides* (L.) Sw., *Leontodon autumnalis* L., *Lotus corniculatus* L., *Lysimachia vulgaris* L., *Lythrum hyssopifolia* L., *Lythrum salicaria* L., *Mentha pulegium* L., *Oenanthe aquatica* (L.) Poir., *Plantago media* L., *Polygonum aviculare* L., *Polygonum hydropiper* L., *Polygonum lapathifolium* L., *Polygonum persicaria* L., *Pulicaria vulgaris* Gaertn., *Ranunculus repens* L., *Rorippa amphibia* L. (Besser), *Rorippa sylvestris* L. (Besser), *Salix alba* L., *Salix cinerea* L., *Stachys palustris* L., *Trifolium pratense* L., *Trifolium repens* L., *Xanthium orientale* subsp. *italicum* (Moretti) Greuter.

In our research (Neacșu, 2008), we encountered on the shores of Lake Surduc and *Lindernia procumbens* (Krocker) Philcox and we included these phytocenoses in the vegetal association *Eleocharidetum acicularis* W. Koch 1926 em. Oberd. 1957, which we did not find later. Near the lake, *Lindernia procumbens* (Krock.) Philcox is also reported by Karácsonyi & Negrean (2012). From a phytosociological point of view, *Lindernia procumbens* (Krock.) Philcox is presented by Sârbu et al. (2013) as a characteristic species for *Isoëto-Nanojuncetea*, while *Lindernia dubia* (L.) Pennell is considered characteristic for *Nanocyperion*.

Mucina et al. (2016) presents the unit *Cypero-Lindernion dubiae* Müller-Stoll et Pietsch in T. Müller 1963 as synonym for *Eleocharition soloniensis* Philippi 1968, described as pioneer ephemeral rush-vegetation in temporarily flooded mesotrophic habitats of Central and Western Europe. *Lindernia dubia* (L.) Pennell is considered in Mucina et al. (2016) classification as a diagnostic species for the class *Oryzetea sativae* Miyawaki 1960 (www.synbioosys.alterra.nl/evc/).

CONCLUSIONS

In the paper, we signal a new place in Romania for *Lindernia dubia* (L.) Pennell: the shores of Surduc Lake. This habitat is represented by depression areas, flooded in spring, whose existence is conditioned by the water levels. When these areas are covered in water the species takes refuge on the nearby arable lands.

In the habitat near Surduc Lake, *Lindernia dubia* (L.) Pennell grows alongside other cormophyte species, most frequently being accompanied by: *Echinochloa crus-galli* (L.) Beauv., *Eleocharis acicularis* (L.) Roemer et Schultes, *Gypsophilla muralis* L., *Polygonum lapathifolium* L., *Alisma plantago-aquatica* L., *Bidens tripartita* L.

Due to the area occupied by the species on the lake shores and large population fluctuations from one year to another, as well as the status of the lake (protected and tourist area), we do not recommend drastic measures to manage the species, especially since there is a probability of reappears *Lindernia procumbens* (Krock.) Philcox. However, it is necessary to monitor the area and the lakes and ponds in the area, where *Lindernia dubia* (L.) Pennell could be spread by birds.

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