



INVASIVE SPECIES IN THE NETHERLANDS



Ecology of naturalized invasive species *Lindernia dubia* (L.) Pennell in the Netherlands

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Key words

Lindernia dubia
invasive alien species
phytosociology
wetlands
Littorelletea uniflorae
Isoeto-Nanojuncetea
Bidentetea tripartitae

Abstract – *Lindernia dubia* (L.) Pennell, a North American species, is still a rare and ephemeral neophyte in the Netherlands, but is invading the country rapidly now. We expect it to become a threat to plant biodiversity in Dutch wetlands. To describe its ecological and phytosociological position and assess its possible risk status we investigated known sites in the Netherlands.

Being a pioneer species on open, muddy soil, more or less rich in nutrients, more or less acid, it occurs in different phytosociological classes: Littorelletea uniflorae, Phragmitetea, Isoeto-Nanojuncetea and Bidentetea tripartitae. We consider the species as possibly harmful to vegetations belonging to the Littorelletea uniflorae and some associations of the Isoeto-Nanojuncetea, as those vegetations are already threatened by drainage and atmospheric deposition of nitrogen; they contain several species of the Dutch Red list for vascular plants and the size and growth rate of many characteristic plants makes them vulnerable to out-competing by *Lindernia dubia*.

Samenvatting – Schijngenadekruid (*Lindernia dubia* (L.) Pennell; Fig. 1, 2) is een kleine eenjarige plant, behorend tot een eigen familie (Fischer et al. 2013), de Linderniaceae, die nauw verwant is aan de Gratiolaceae en Plantaginaceae en vroeger werd geplaatst in de Scrophulariaceae s.l. De plant is haarloos en vormt geen rozet, groeit liggend tot opstijgend, met op doorsnede vierkante stengels tot 20 cm lang. De bladen zijn ongedeelde, tegenoverstaand, (bijna) zittend en elliptisch. Ze zijn glanzend helder groen (verkleurend naar rood in de nazomer) met een licht getande rand en handvormige, bijna parallelle nervatuur. De bloemen hebben gelijkvormige kelklobben, een aan de basis vergroeide, 2-zijdig symmetrische, tweelippige kroon van 5–10 mm, die roze lila tot blauwachtig violet is, en één stijl, twee staminodiën en twee vruchtbare meeldraden. Vroege (Lewis 2000) of late (Pennell 1935) bloemen kunnen cleistogaam zijn. De vruchten zijn elliptische tot kegelvormige doosvruchten die ongeveer even lang zijn als de blijvende kelktanden, met vele langwerpige, gele zaden van minder dan 0,5 mm lang. Schijngenadekruid, zoals de naam al zegt, kan worden verward met Genadekruid (*Gratiola officinalis* L.), of met ‘waterereprijsen’ (*Veronica* spp.). Waterereprijsen hebben een minder 2-zijdig symmetrische en vergroeide bloemkroon, een op doorsnede ronde stengel en bladen met onduidelijke of geveerde nervatuur. Genadekruid heeft grotere bloemen met ongelijke kelktanden.

Schijngenadekruid is een neofyt die van origine voorkomt in het stroomgebied van de Mississippi in Noord Amerika. De soort groeit daar op slikke oeveren van rivieren, meren en kleinere vijvers meertjes en plassen (Pennell 1935, Lewis 2000). De soort heeft zich in de loop van de 20^e eeuw wereldwijd verbreid in Midden en Zuid Amerika, Zuidoost Azië, Japan, en recent ook in India. Sinds 1850 heeft Schijngenadekruid voet aan wal gezet in Europa (Nantes) en heeft zich van daaruit verspreid over Zuid-Europa, Midden Europa en de Balkan. In Zuid-Europa komt de soort voor en/of wordt verspreid in rijstvelden, in Midden-Europa heeft de soort zich verspreid via visvijvers. De soort komt vrijwel overal in het Europese areaal ook in natuurlijke ecosystemen voor.

In 1994 werd de soort aangetroffen in België (Vannerom 1994). De eerste vondst in Nederland dateert uit 2004 in een poel in Oldenzaal door A. van Renssen (Zijlstra et al. 2005, verspreidingsatlas.nl); vermoedelijk was hier sprake van tuin- of vijverafval. Pas in 2008 kwam de plant weer in beeld, en wel langs de Grensmaas, waar de soort aan Belgische zijde al iets eerder was gevonden. In 2012 werd de soort aangetroffen op de Ewijkse Plaat, langs de Waal, niet ver van de lokatie waar dat jaar Eivormige waterbies (*Eleocharis ovata*) weer was terug gevonden. In 2014 volgde een aantal nieuwe groeiplaatsen in zwakgebufferde tot zure ovaten op wat lemige zandbodden in Noord Limburg, Brabant en Huizen (Noord-Holland!). Vanaf dat jaar lijkt de soort zich echt uit te breiden, de bekende populaties houden stand en de soort duikt in 2016 bovendien op in de Schoutenwaard, aan de Nederrijn bij Randwijk (Gelderland). Een actueel beeld van de verspreiding in Nederland is te zien in Fig. 3.

Schijngenadekruid is een soort die in Nederland, volgens de definitie van Richardson et al. (2000), inmiddels zonder enige twijfel een genaturaliseerde invasieve exoot is. Het verspreidingspatroon door de tijd en de prominente aanwezigheid (directe of indirecte observatie) van watervogels op alle groeiplaatsen doen veronderstellen dat watervogels vrijwel zeker

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Samenvatting (vervolg)

betrokken zijn bij de verspreiding van Schijngenadekruid in Nederland. We treffen de soort aan op in de (na-)zomer droogvallende oevers of bodems van ondiepe plassen, nevengeulen en vennen. Dat kunnen zeer voedselrijke en slibrijke bodems zijn in het rivierengebied, waar de soort meestal groeit in nitrofiële vegetaties behorende tot de Tandzaadklasse, of de Rietklasse. Hier is de groeivorm van Schijngenadekruid robuust, vrijwel rechtopstaand. We denken dat deze soort, die overigens van nature in wat voedselrijkere milieus thuishoort, hier niet veel schade aan bijzondere inheemse soorten of vegetaties kan aanrichten. Zowel deze soorten als vegetaties zijn zelf bijzonder concurrentiekrachtig.

Anders ligt dat bij de lokaties in het pleistocene deel van Nederland. De soort groeit hier aan oevers van vennen in een kleinbladige, kruipende vorm die tamelijk bodembedekkend kan zijn. Deze groeivorm is zeker niet zo alles-verstikkend als *Watercrassula* (*Crassula helmsii*) dat kan doen. Desalniettemin vermoeden we dat juist in dit soort milieus de kwetsbare soorten, behorend tot het Isoeto-Nanojuncetea en het Littorelletea uniflorae kunnen worden verdrongen door deze soort. Bij natuurontwikkelingswerkzaamheden in dit soort milieus (plaggen) zou aandacht kunnen worden besteed aan het reinigen van apparatuur en zouden de eerste planten van deze soort kunnen worden verwijderd, zodat de beoogde inheemse doelsoorten een stapje voorsprong hebben.

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INTRODUCTION

Distribution, Taxonomy, Recognition and Ecology

Lindernia dubia (L.) Pennell (Fig. 1, 2) originates from North America where it grows in the catchment of the Mississippi River (Pennell 1935). It occurs in wet ditches, wet meadows, borders of ponds and lakes, depressions and along streams (Lewis 2000). Its current distribution has expanded to the entire North American continent, Central America and a large part of South America (Pennell 1935, Lewis 2000, Fischer et al. 2013). Nowadays it is a cosmopolitan weed; it is more or less naturalised in Japan (Yamazaki 1993), China and Taiwan (Shu 1998) and has been discovered in India recently (Krishnasamy & Arumugam 2015).

In Europe it has first been established at Nantes in France in 1850 (Coste 1937, Lloyd 1868) and it further spreaded through Europe. It is now present in Spain and Portugal (Rico 1997), Italy (Pignatti 1982), Poland (Drobnik & Buchalik 2004), Hungary and Slovakia (Molnár et al. 2000, Schmotzer 2015, Hrvínák et al. 2016), the Czech Republic (Kurka 1990, Šumberová et al. 2012), Belgium (Vannerom 1994), Germany (Jage 1964), Switzerland (Lauber et al. 2012), Romania (Ciocârlan & Costea 1994), Bulgaria (Markova 1995) and Serbia (Randelović et al. 2006, Tomović et al. 2007). Šumberová et al. (2005) mention hydrochory, avichory, ichtychory and dispersal via fishpond management equipment as possible ways of dispersal of the seeds.

The current distribution in the Netherlands (Fig. 3) shows that *Lindernia dubia* has a widely scattered distribution already, especially in the southeastern border provinces Limburg and Noord-Brabant. However, the species was first discovered in northeastern Netherlands in a pond near Oldenzaal, Province of Overijssel, in 2004 by Andries van Renssen (Zijlstra et al. 2005, verspreidingsatlas.nl). No herbarium specimen has been collected. This first record was considered as garden waste or a garden pond plant adventive. The following years, there were no new records. In 2008 it was discovered at the Grensmaas area near Meerssen alongside the floodplains of the River Meuse on the Belgian-Dutch border. Another four years later it was discovered at Beuningen at the shores of the River Rhine. In 2013 a few new localities at the Grensmaas area were discovered. In 2014, a few isolated localities in northern Limburg and Brabant in oligotrophic ponds followed and it was found too in an oligotrophic pond in Huizen, in the Province of Noord-Holland, far away from its known distribution at that time (waarneming.nl and verspreidingsatlas.nl). During the following years it was also expanding rapidly in oligotrophic ponds in the western part of the Brabant province. In 2016, the first record at the River Nederrijn was collected.

The genus *Lindernia* All. has traditionally been placed under various subfamilies in Scrophulariaceae in the broad sense. After the disintegration of the Scrophulariaceae s.l. it has been placed under various 'new' families, such as Anthiraceae and Plantaginaceae. Albach et al. (2005) confirmed that Linderniaceae are clearly separate from Plantaginaceae and are a monophyletic group. However, the genus *Lindernia* All. itself, with approximately 100 species, turned out to be polyphyletic and has been split up by Fischer et al. (2013). The remaining genus *Lindernia* s.str., to which *Lindernia dubia* belongs, contains 30 species, the majority of them occurs in (sub-)tropical Africa and Southeast Asia; a few species are known from southeastern North America, the Caribbean and Eurasia.

The plant is glabrous and has no rosettes at any growth stage, it forms ascending or procumbent quadrangular branches up to 20 cm. Leaves are entire, opposite, (sub-)sessile and elliptical in shape. They are glossy bright green (turning red in late summer) with slightly dentate margins and digitate, almost parallel venation. The flower has equal calyx lobes, a gamopetalous, zygomorphic bilabiate corolla of 5–10 mm, that is pinkish lilac to bluish violet, one style, two staminodes and two fertile stamens. Early (Lewis 2000) or late (Pennell 1935) flowers can be cleistogamous. The fruits are elliptical to conical capsules, about as long as the persistent calyx lobes, with numerous oblong yellowish seeds that are less than 0.5 mm long.

Two subspecies are distinguished by Pennell (1935): the nominate subspecies and subsp. *major* (Pursh) Pennell. The latter is an ascending plant, with an attenuate leaf base, with pedicels less than 10 mm long and shorter than the bracts. The nominate subspecies is more slender and divaricately

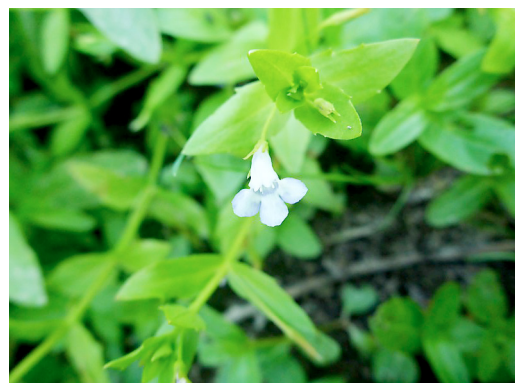


Fig. 1. A flowering plant of *Lindernia dubia* (L.) Pennell near Venlo, Province of Limburg. Photo: Erik Simons, 2016.



Fig. 2. Comparison between large form of *Lindernia dubia* (L.) Pennell (left), small form (middle two plants) and *Veronica scutellata* L. (right). Photo: Erik Simons, 2014.

spreading, with a broadened leaf base, with pedicels 10–30 mm long and longer than the bracts. Pennell (1935) mentions that 'intergradation is complete' between those two subspecies, and that many plants in the Mississippi bed bare short pedicels early in the season that grow larger later in the season. Lewis (2000) does not accept the subspecies anymore (although she distinguishes four varieties). However, in Japan the subspecies are maintained and some recent research suggest separate lineages (Yoshino et al. 2006).

In the Netherlands *Lindernia dubia* (L.) Pennell may be confused with common European wetland *Veronica* species (like *V. anagallis-aquatica* L. (s. str.), *V. catenata* Pennell, and *V. scutellata* L.). These, however, have a less zygomorphic and gamopetalous corolla, have round stems in cross-section and have leaves with pinnate or unclear venation. A rare species in the Netherlands, *Gratiola officinalis* L., also resembles *Lindernia dubia*, but it has more linear leaves, larger flowers and a calyx with unequal lobes.

Although wetlands and (semi-)aquatic habitats on European scale are generally less invaded by alien plant species than anthropogenic habitats (Chytrý et al. 2009), the ecological and economic impact of some species can be considerable. About 25% of the world's worst invasive species are wetland species. Invasive plant species in wetlands have adverse effects on biodiversity and structural heterogeneity. Rivers are 'sinks' in the landscape; flooding creates gaps in the vegetation cover and transport

propagules of opportunistic (invasive) plants that can quickly establish on wet and nutrient rich soils (Zedler & Kercher 2004).

Lindernia dubia (L.) Pennell is known to be an invasive annual species in aquatic habitats, for instance in floodplains in Japan, Bulgaria (Tzonev & Šumberová 2004) and Central Europe (Müller & Okuda 1998, Jagel 1994, Schmotzer 2015, Hrivnák et al. 2016), in fish storage pond bottoms (sic!) in Central, Eastern and Western Europe (Šumberová et al. 2012, Tomović et al. 2007, Vannerom 1994) and in rice paddies in several countries in South and East Europe (Koch 1954, Vasconcellos 1971, Webb & Philcox 1972, Carretero 1989, Tzonev & Šumberová 2004). In rice paddies and fish storage ponds it shows to be resistant to sulfonylurea (Yoshino et al. 2006, Uchino & Watanabe 2002).

In this study we aim at investigating its ecology, its phytosociological position and its possible invasiveness for the Netherlands.

METHODS

We visited ten localities, from 2014 till 2016; most of them already known (verspreidingsatlas.nl, waarneming.nl) and some new (added to the said databases), we made vegetation relevés according to the Braun-Blanquet method (Westhoff et al. 1995). In total, 15 relevés were made (Fig. 4), which are stored in the Dutch

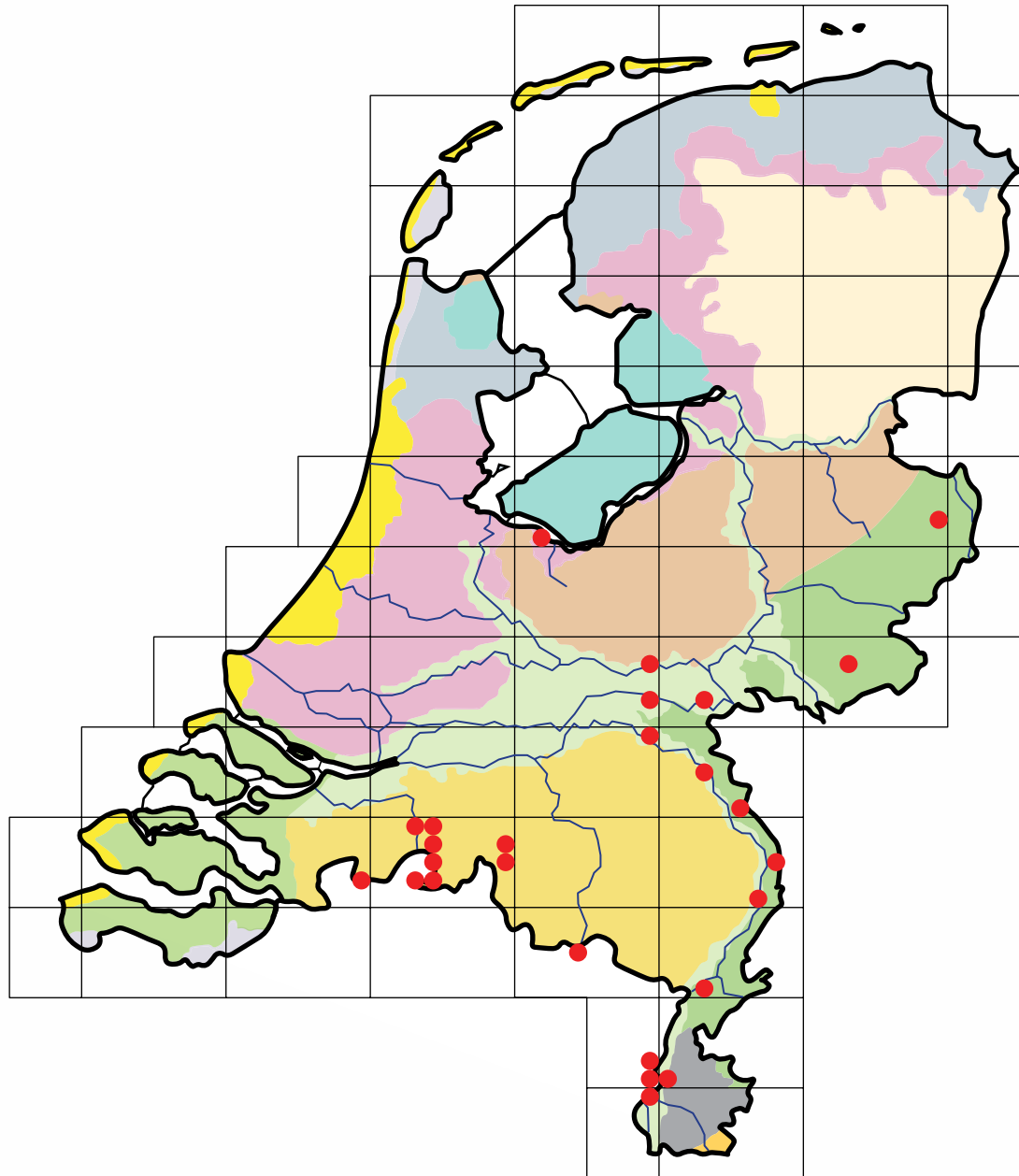


Fig. 3. Current distribution (16 January 2018) of *Lindernia dubia* (L.) Pennell in the Netherlands. Based on FLORON/NDFF data and the distribution map generated by verspreidingsatlas.nl; the floristic districts indicated by colours in the map are based on [Meijden \(2005\)](#).

National Vegetation Database using TurboVeg ([Hennekens & Schaminée 2001](#)) and analysed using JUICE ([Tichý 2002](#)) by manually ordering species and relevés according to recent phytosociological literature ([Schaminée et al. 1995](#), [Šumberová & Lososová 2011](#)). Additional observations were retrieved from photos in waarneming.nl (waarneming.nl last visited 30-10-2017). We used an open source Geographic Information System ([QGIS 2017](#)) to plot the relevés in a map.

Herbarium collections in L and WAG (acronyms according to Index Herbariorum, [Thiers 2017](#)) have been seen and new specimens have been collected and stored in WAG, with duplicates to be sent to PR and/or other herbaria.

RESULTS, WITH DESCRIPTIONS OF THE LOCALITIES

In the sense of [Richardson et al. \(2000\)](#), *Lindernia dubia* in the Netherlands is now a naturalized invasive species. There are many sustainable populations over several life cycles which produce reproductive offspring at considerable distance from the parent plants. The transition, from a casual alien plant (2004) to a naturalized invasive species (2013–2014) thus has taken about ten years.

All visited localities are situated in flat areas 0–30 m above sea level with a temperate atlantic northwestern European climate. Vegetations are rather open pioneer communities with low vegetation cover of mainly annual pioneer species on sandy, loamy or clayish soil. Direct (sightings) or indirect (grazed vegetation, excrements) signs of the presence of waterfowl (mainly geese

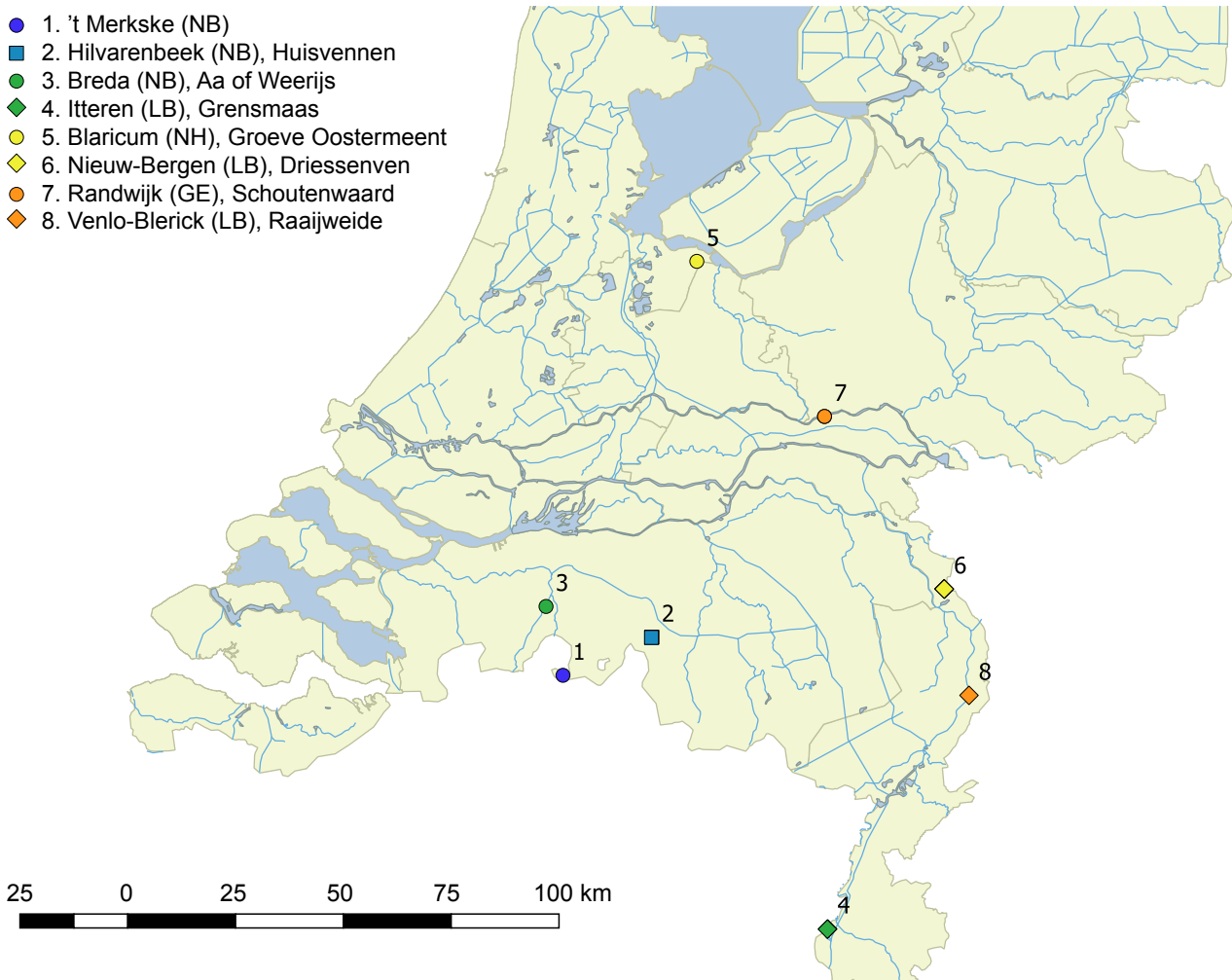


Fig. 4. Localities of relevés of *Lindernia dubia* in The Netherlands. Illustration: Erik Simons, 2017. Colours indicate vegetation classes (see text).

and some ducks) were observed at all localities. Herbarium records and records at waarneming.nl suggest it flowers from July till October, but the start of florescence is without doubt mainly dependent on the time at which shores and shallow ponds fall dry. On the other hand, the flowering period can be prolonged when the plants are not inundated and there is no frost in late autumn. After the first frost period, the plants quickly turn red and will probably die off.

We discovered two morphological forms (Fig. 2): on nutrient rich clayish soils the plants are quite stout and broad leaved, growing ascending to erect. On shores of oligotrophic ponds, the plants are considerably smaller, narrow leaved and more or less procumbent, being able to form quite dense mats. Apart from the size, we didn't see any real morphological differences between the two forms, the small plants are simply smaller and more procumbent versions of the larger plants. Both forms produce roots at the nodes, this is also the case for the ascending stout forms on nutrient rich soil.

As the broadened leaf base is a character of subsp. *dubia*, whilst the short pedicels point towards the nominate subspecies (or variety sensu Lewis 2000), and the growth forms point towards both subspecies, we tend not to distinguish infraspecific taxa within *Lindernia dubia* for the Netherlands. It is possible that the large form corresponds to chasmogamous plants, while the small procumbent form is (predominantly) cleistogamous, but this needs to be studied.

At all localities, the proportion of cleistogamous flowers is high or even dominant, which is in line with Lambinon (2004). Vuilleminot (2014) suggests this could be an adaptive trait; either the ecological circumstances could be less suitable for entomogamy or the morphological traits (as an adaptation to ecological circumstances) of a plant line or population have become fixed by means of autogamy.

In the Netherlands, *Lindernia dubia* is found in three vegetation classes (and in their transition zones): the Littorelletea uniflorae, the Isoetes-Nanojuncetea, the Bidention tripartitae, and, in lesser extent, in the Phragmitetea. This is in line with the vegetation types in (Central and Western) Europe in which this species occurs (Hrvinák et al. 2016). The following is a description of the localities with reference to the relevé numbers made at each locality. See Table 1 for a synoptic table of the relevés.

1. The locality at 't Merkske is a low vegetation but with high cover at the shore of an oligotrophic shallow pond on loamy sand, falling dry during summer. It is a clear example of a Littorelletea uniflorae-Eleocharitetum acicularis Malcuit 1929 (Littorelletea uniflorae) with *Elatine hexandra* (Lapierre) DC., *Eleocharis multicaulis* (Sm.) Desv., *Eleocharis acicularis* (L.) Roem. & Schult. and *Hypericum elodes* L. Like other localities at oligotrophic ponds, *Lindernia dubia* grows here in a small, narrow leaved procumbent form, resembling *Crassula helmsii* (Kirk) Cockayne, an invasive species that is present here as well. Relevé number 2.

Table 1. Synoptic table of relevés with *Lindernia dubia* (L.) Pennell in the Netherlands made in the years 2014–2016. Cover scale is Braun-Blanquet B-D&S. Latitude and longitude are in [decimal degrees](#) (WGS84). Species are arranged by their affinity to vegetation classes according to [Schaminée et al. \(1995\)](#). Additional species are mentioned in the [Appendix](#). Abbreviations: Authors: ES = E. L. A. N. Simons, MJ = M. G. M. Jansen, RH = R. Haveman, IR = I. de Ronde; localities: Province of Noord-Brabant: BRED = Breda, Aa of Weerij, HILV = Hilvarenbeek, Huisvennen, MERK = 't Merkske; Province of Limburg: ITTE = Itteren, Grensmaas, NBER = Nieuw-Bergen, Driessenven, VENL = Venlo-Blerick, Raaijweide; Province of Gelderland: RAND = Randwijk, Schoutenwaard; Province of Noord-Holland: BLAR = Blaricum, Groeve Oostermeent.

Relevé number	11	12	2	9	3	5	4	6	7	10	15	1	8	13	14
Authors	ES	ES	ES & MJ	ES & MJ	ES & MJ	ES & MJ	ES & MJ	ES & MJ	ES & MJ	ES & MJ	ES	ES & MJ	ES & MJ	RH, IR, ES	ES
Date	17 Sep 2016	17 Sep 2016	7 Oct 2014	8 Oct 2014	8 Oct 2014	8 Oct 2014	8 Oct 2014	8 Oct 2014	8 Oct 2014	20 Sep 2014	30 Sep 2016	7 Oct 2014	8 Oct 2014	15 Sep 2016	30 Sep 2016
Latitude	51,499	51,498	51,418	50,890	51,597	51,597	51,597	51,597	51,597	52,282	51,959	51,561	50,890	51,375	51,959
Longitude	5,108	5,106	4,812	5,690	6,090	6,085	6,085	6,085	6,085	5,255	5,687	4,753	5,691	6,165	5,687
Elevation (m)	15	14	14	41	20	19	19	19	19	3	7	10	43	17	7
Relevé area (m²)	1,00	1,00	4,00	4,00	4,00	6,00	6,00	6,00	9,00	2,25	1,00	4,00	9,00	1,00	1,00
Total cover (%)	30	70	20	30	30	80	40	95	70	20	90	70	20	40	90
Cover herb layer (%)	30	70	20	30	30	80	30	95	70	20	90	70	20	40	80
Cover moss layer (%)	0	1	3	0	1	25	15	20	40	5	15	0	0	0	40
Cover algae layer (%)	0	0	0	95	30	70	70	10	0	0	0	0	95	0	0
Average height herb layer (cm)	1	5	8	10	2	4	4	5	5	3	5	10	10	30	2
Maximum height herb layer (cm)	15	15	25	60	5	10	10	50	50	15	10	50	60	100	10
Locality	HILV	HILV	MERK	ITTE	NBER	NBER	NBER	NBER	NBER	BLAR	RAND	BRED	ITTE	VENL	RAND
LINDERNIA DUBIA	1	+	1	1	+	2a	1	2a	2b	1	+	1	1	+	+
Littorelletea uniflorae															
<i>Juncus bulbosus</i>		2a	1		1	1	1	1	1	2a					
<i>Hypericum elodes</i>		+	1			+			+						
<i>Eleocharis acicularis</i>			2a			4		2a	3						
<i>Crassula helmsii</i>	2a	2b													
<i>Pilularia globulifera</i>	1	+													
<i>Elatine hexandra</i>	2a		2m												
<i>Littorella uniflora</i>	+														
<i>Eleocharis multicaulis</i>			+												
Caricetalia nigrae															
<i>Hydrocotyle vulgaris</i>		1	1			1	r	2a	1						
<i>Ranunculus flammula</i>		+									+				
<i>Calliergonella cuspidata</i>			2m					2b							
<i>Carex oederi</i> subsp. <i>oederi</i>										2a					
Isoeto-Nanojuncetea															
<i>Juncus bufonius</i>	2a	2a				1	1		1	+	2b			+	+
<i>Lythrum portula</i>	2a		1		3	1	1	1	2a			2a			
<i>Persicaria minor</i>		+			1	1	2a		+			2a			
<i>Gnaphalium uliginosum</i>					+	1	+		+		2b			+	1
<i>Poa annua</i>		+		+		1	1							+	
<i>Callitriche brutia</i>					1	1	1	1	+						
<i>Riccia glauca</i>					1	2a	2a		2b						
<i>Cyperus fuscus</i>				r							2a			+	+
<i>Riccia cavernosa</i>							1				2a				3
<i>Gnaphalium luteo-album</i>		1								1					
<i>Fossombronina foveolata</i>		+								1					
<i>Pohlia bulbifera</i>						2b	2m								
<i>Atrichum undulatum</i>							1	1							
<i>Bryum argenteum</i>							2a		2a						
<i>Physcomitrella patens</i>											2a				2m
<i>Pellia endiviifolia</i>							1								

Continue on next page

Table 1 (continued)

Relevé number	11	12	2	9	3	5	4	6	7	10	15	1	8	13	14
Bidentetea tripartitae															
<i>Ranunculus sceleratus</i>	+			+	r	+	r				+	r	r	+	+
<i>Rorippa palustris</i>					+	r	+				2a	r	r	+	1
<i>Plantago intermedia</i>		2a		+							3		1	+	2a
<i>Bidens cernua</i>			1		r							+		2a	
<i>Veronica catenata</i>				+							2b		+		2b
<i>Limosella aquatica</i>	+										2a				4
<i>Persicaria lapathifolia</i>				2a									2a	+	
<i>Persicaria amphibia</i>							+	+						+	
<i>Bidens tripartita</i>		+					r								
<i>Rorippa sylvestris</i>				+									r		
<i>Chenopodium rubrum</i>														1	
<i>Potentilla supina</i>															+
<i>Rumex palustris</i>															+
Polygono hydropiperis-Veronicetum anagallidis-aquaticae															
<i>Veronica anagallis-aquatica</i>				2b									2b	2a	
<i>Nasturtium officinale</i>												+			
<i>Leersia oryzoides</i>														+	
Phragmitetea															
<i>Lycopus europaeus</i>		+	r		r	r	+	+		1		r			
<i>Lythrum salicaria</i>				1								1	1	2b	
<i>Mentha aquatica</i>				r					r	1		+			
<i>Myosotis laxa</i>		r							r			2a			
subsp. <i>cespitosa</i>															
<i>Rumex conglomeratus</i>						r	+						1		
<i>Myosotis scorpioides</i>												2a			
subsp. <i>scorpioides</i>															
<i>Equisetum palustre</i>														1	
Molinio-Arrhenatheretea															
<i>Juncus articulatus</i>		2a				1	r	4	1	1					
<i>Juncus effusus</i>								1	1			r			
<i>Lotus pedunculatus</i>			1									1			
<i>Cirsium palustre</i>								r	+						
Plantaginetea majoris															
<i>Agrostis stolonifera</i>				2a									+	2a	
<i>Alopecurus geniculatus</i>			1									2a			
<i>Plantago major</i>								+	+						
Aquatic herbs															
<i>Callitriche platycarpa</i>								1	+						
<i>Callitriche obtusangula</i>												2b			
<i>Lemna minor</i>			2m												
<i>Lemna minuta</i>					2m										

Appendix Table 1. Species with low frequency and / or low cover and little phytosociological importance, in alphabetical order; with relevé numbers and cover.

Achillea ptarmica relevé 9, cover +; *Agrostis canina* 6, r; *Alisma plantago-aquatica* 13, r; *Berula erecta* 9, +; 8, r; *Betula pubescens* 11, r; 12, +; *Betula species* 10, +; *Callitriche stagnalis* 8, +; *Cardamine occulta* 8, +; *Cardamine pratensis* 5, r; *Cirsium* sp. 13, r; *Conyza canadensis* 4, r; *Cotula coronopifolia* 1, +; *Galium palustre* 12, +; *Isolepis setacea* 10, +; *Jacobaea vulgaris* subsp. *vulgaris* 4, +; *Juncus conglomeratus* 9, r; *Jungermannia gracillima* 4, 1; *Pellia epiphylla* 10, +; *Persicaria hydropiper* 6, r; *Phalaris arundinacea* 9, +; *Poa humilis* 10, +; *Polytrichum commune* 2, 2m; *Ranunculus repens* 9, r; 8, r; *Rorippa amphibia* 1, r; 8, r; *Rumex obtusifolius* 8, +; *Sagina procumbens* 7, r; *Salix alba* 13, 2a; *Salix species* 5, r; 10, +; 1, r; 13, +; *Senecio inaequidens* 4, +; *Solidago gigantea* 9, r; 8, r; *Stellaria uliginosa* 4, r; *Veronica beccabunga* 9, +.

2. Huisvennen near Hilvarenbeek is also an oligotrophic pond, on loamy soil. Two relevés made here can easily be assigned to the *Pilularietum globuliferae* Tüxen ex Müller et Görs 1960 (*Littorelletea uniflorae*) with species like *Elatine hexandra*, *Pilularia globulifera*, *Hypericum elodes*, *Littorella uniflora* (L.) Asch. Some Isoeto-Nanojuncetea are present as well, like *Fossombronia foveolata* Lindb., *Limosella aquatica* L., *Gnaphalium luteo-album* L. and *Juncus bufonius* L. Relevé numbers 11 and 12.
3. The locality at the Aa of Weerijss river close to Breda is a nature area in which the original meanders of a small river have been restored. There is active erosion on a steep shore on nutrient rich clayish soil. The vegetation here was relatively dense, consisting of some perennial amphibious species like *Lythrum salicaria* L., *Alopecurus geniculatus* L., *Nasturtium officinale* R. Br., etc. The presence of *Lythrum portula* (L.) D.A. Webb and *Alopecurus geniculatus* shows that the soil is not extremely nutrient rich. Several stout plants of *Lindernia dubia* were found here. We assign this vegetation to Polygono hydropiperis-Veronicetum anagallidis-aquaticae Zonneveld ex Schaminée & Weeda 1995 (Phragmitetea). Relevé number 1.
4. A locality near Itteren (Grensmaas) at the shore of the River Meuse is a river shore on heavy nutrient rich clay with large pebbles, close to the water. This shore has recently fallen dry, the herb cover is low, although brown algae cover almost 95%. Accompanying species: *Ranunculus* spp., *Persicaria* spp., *Rorippa* spp., *Plantago major* subsp. *intermedia* (Gilib.) Lange, *Nasturtium officinale*, *Veronica anagallis-aquatica* L. s. str. A few stout plants of *Lindernia dubia*. Interestingly, *Cardamine occulta* Hornem. was present in our relevés, which marked the first (documented) record of this species as a completely spontaneous plant in a natural biotope for the Netherlands. We assign the vegetation of the two relevés to Polygono hydropiperis-Veronicetum anagallidis-aquaticae Zonneveld ex Schaminée & Weeda 1995 (Phragmitetea) although it has elements of Polygono-Bidentetum (Koch 1926) Lohm. 1950, Plantaginetea majoris and other vegetations belonging to the Phragmitetea class. Relevé numbers 8 and 9.
5. Blaricum Groeve Oostermeent is an oligotrophic pond. The soil is sandy here and the surrounding area is a moist heathland (Oxycocco sphagnetetea) with some Caricion nigrae (Parvocaricetea) elements. The top soil layer has recently been removed at the time of our visit and hence the vegetation cover was low. With species like *Isolepis setacea* (L.) R. Br., *Juncus bufonius* and *Fossombronia foveolata* we assign this to the Cicendietum filiformis Allorge 1922 (Isoeto-Nanojuncetea) although *Cicendia filiformis* (L.) Delarbre itself was not present in our relevé. Relevé number 10.
6. The locality at Driessenven is a low vegetation but with high cover at the shore of an oligotrophic shallow pond on loamy sand, falling dry during summer. Five relevés were made and we place these vegetations in the Nanocyperion flavescentis alliance (Isoeto-Nanojuncetea), although typical species of *Littorelletea uniflorae* and *Bidentetea* vegetations are present as well. Typical species: *Cyperus fuscus* L., *Plantago major* subsp. *intermedia*, *Eleocharis acicularis*, *Lythrum portula*, *Juncus bulbosus*, *Bidens tripartita* L., *Lycopus europaeus* L., *Hypericum elodes* and many bryophytes such as *Riccia* spp., *Pohlia* spp. *Lindernia dubia* in the small procumbent form is able to cover 10–30% of the vegetation. Relevé numbers 3–7.
7. At Randwijk Schoutenwaard two relevés were made where *Lindernia dubia* grows in a shallow river arm of the River Nederrijn, which falls dry during summer causing temporary disconnection from the main river. The soil is clayish and

nutrient rich, and the vegetation is intensively grazed by geese. It is a mosaic of vegetations belonging to *Eleocharition ovatae* Philippi 1968 (syn: *Nano-Cyperion flavescentis* Koch 1926), alliance (possibly *Cyperetum micheliani* Horvatić 1931) vegetation with species like *Cyperus fuscus*, *Juncus bufonius*, *Gnaphalium uliginosum* L., *Physcomitrella patens* Hedw.) Bruch & Schimp., *Riccia cavernosa* Hoffm. and *Polygono-Bidentetum* (Koch 1926) Lohm. 1950 and *Eleocharito acicularis*-*Limoselletum aquaticae* Wendelberger-Zelinka 1952 (both *Bidentetea* class) vegetations with *Potentilla supina* L., *Veronica catenata*, *Rumex palustris* Sm. and *Bidens* spp. Relevé numbers 14 and 15.

8. At a more northern locality along the River Meuse at Venlo-Blerick, Raaijweide only one relevé was made. This vegetation can be assigned to the *Bidentetea* class, possibly *Chenopodietum rubri* Timár 1950 or *Polygono-Bidentetum* (Koch 1926) Lohm. 1950. Some elements of the *Polygono hydropiperis-Veronicetum anagallidis-aquaticae* (Phragmitetea) are present as well, e.g., *Leersia oryzoides* (L.) Sw. and *Veronica anagallis-aquatica*. Only a few plants of *Lindernia dubia* are present here. Relevé number 13.

DISCUSSION

At this moment, we do not see reason to distinguish infraspecific taxa within what is now considered as *Lindernia dubia* in the Netherlands. Species in open wet pioneer communities belonging to the *Bidentetion tripartitae* and *Isoeto-Nano-Juncetea* classes show morphological and anatomical plasticity. That allows them to survive in an environment subject to sudden and rapid changes in humidity of the substrate, changes in the amount of available nutrients and the amount of light (Šumberová & Lososova 2011). However, one has to keep in mind that speciation in introduced alien species by means of adaptive radiation, even with diminished genetic diversity, can occur rapidly (e.g., Dlugosch & Parker 2008). It is not unlikely that new lineages within this taxon evolve quickly, as may be the case in Japan (Yoshino et al. 2006). In the Netherlands, cleistogamy could play a role in isolation of populations with different morphological traits from each other.

Two types of wetlands in the Netherlands are vulnerable to this invasive species: shores and floodplains of (large) rivers and nature restoration areas.

Several oligotrophic wetland nature areas in the Netherlands have been overgrown by more trivial perennial species because of natural succession enhanced by dehydration, acidification and nitrification of the top soil layer (Schaminée et al. 1995). Nature restoration projects often aim to re-establish typical pioneer communities of oligotrophic ponds and marshes by means of removing the top soil layer. But, by doing so, ideal circumstances for forementioned opportunistic invasive pioneer species are created on a semipermanent base. A species like *Crassula helmsii* for example can form 'monocultures' in less than two growing seasons in oligotrophic ponds in the Netherlands where the top soil layer has been removed in order to restore Isoeto-Nanojuncetea or *Littorelletea uniflorae* vegetations; *C. helmsii* is thought to be easily dispersed by waterfowl, or even equipment that is used for nature restoration.

Based on the visited sites we think the negative impact of *Lindernia dubia* on nutrient rich soil, belonging to the *Bidentetea*-*tripartitae* or *Phragmitetea* class with larger plants, will be minimal, the species will not easily out-compete fastgrowing nitrophilous stout erect plants, e.g., belonging to the genera *Persicaria* and *Rumex* (Polygonaceae), *Ranunculus* (Ranunculaceae), *Bidens* (Asteraceae), etc. Further, communities of this class are widespread

and not endangered in the Netherlands and they do not contain many rare or endangered species.

The possible impact of *Lindernia dubia* on vegetations belonging to classes of less nitrophilous, acid to neutral soils could be more adverse however. Vuillemenot (2014) also thinks that *L. dubia* can have a negative impact to more or less identical vegetation types in France. Communities belonging to the Littorelletea uniflorae and Isoeto-Nanojuncetea classes have declined the last decades as a result of intensification of agriculture, drainage and atmospheric nitrification and acidification (Schaminée et al. 1995). Many of the species of those communities are small, or even minute (*Elatine* spp., *Callitriche* spp., *Cicendia filiformis*), or grow in open, slender rosettes (*Littorella uniflora*, *Lobelia dortmanna* L., *Isoetes* spp. and small *Juncus* spp.), many of them occur on the Dutch Red List for vascular plants (Sparrius et al. 2014). We think the dense procumbent form of *L. dubia* has the potential to out-compete those species. Šumberová et al. (2012) confirms dispersal of seeds via vehicles or equipment in fish farming, and Schmotzer (2015) suggests hydrochory. However, we think dispersal of seeds of this species in the Netherlands occurs mainly by waterfowl. The small seeds are suitable for endozoochory (oral comm. Erik Kleyheeg).

As all visited localities are isolated from each other; and the presence of waterfowl was very clear, we are almost certain that *Lindernia dubia* in the Netherlands is spread by waterfowl. Waterfowl may be an important pathway of introduction but is frequently ignored in databases and risk assessments on invasive species (Green 2016). Several studies, e.g., Morton & Hogg (1989), show that the proportion of species adapted for dispersal by birds is significantly higher for invasive plants compared to native flora. They show that conspecific populations in the introduced range can be better adapted to zoochory compared to populations in the native range. Further research should be carried out in order to assess the processes behind the spread of *L. dubia*.

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REFERENCES

- Albach DC, Meudt HM, Oxelman B. 2005. Piecing together the "New" Plantaginaceae. *Amer. J. Bot.* 92: 297–315.
- Carretero JL. 1989. *La vegetación emergente de los arrozales Europeos*. *Anales Biol., Fac. Biol., Univ. Murcia* 15 (Biología Vegetal 4): 135–141.
- Chytrý M, Pyšek P, Wild J, Pino J, Maskell LC, Vilf M. 2009. European map of alien invasions based on the quantitative assessment across habitats. *Diversity & Distrib.* 15: 98–107.
- Ciocărlan V, Costea M. 1994. *Lindernia dubia* (L.) Pennell, specie nouă în flora României. *Analele Ști. Inst. Delta Dunării*: 7–8.
- Coste H. 1937. *Flore descriptive et illustrée de la France, de la Corse et des contrées limitrophes*, III: 1–808. Paul Klincksieck, Paris.
- Dlugosch KM, Parker IM. 2008. Founding events in species invasions: genetic variation, adaptive evolution, and the role of multiple introductions. *Mol. Ecol.* 17: 431–449.
- Drobnik J, Buchalik M. 2004. *Lindernia dubia* (Scrophulariaceae) – nowy gatunek we florze Polski. *Fragm. Florist. Geobot. Polon.* 11: 5–14.
- Fischer E, Schäferhoff B, Müller K. 2013. The phylogeny of Linderniaceae – The new genus *Linderniella*, and new combinations within *Bonnaya*, *Craterostigma*, *Lindernia*, *Micranthemum*, *Torenia* and *Vandellia*. *Willdenowia* 43: 209–238.
- Green AJ. 2016. The importance of waterbirds as an overlooked pathway of invasion for alien species. *Diversity & Distrib.* 22: 239–247.
- Hennekens SM, Schaminée JHJ. 2001. TURBOVEG, a comprehensive data base management system for vegetation data. *J. Veg. Sci.* 12: 589–591.
- Hrivnák R, Kochjarová J, Šumberová K, Schmotzer A. 2016. Alien wetland annual *Lindernia dubia* (Scrophulariaceae): the first recently mentioned localities in Slovakia and their central European context. *Biologia* 71: 281–286.
- Jage H. 1964. *Lindernia dubia* auch in Deutschland. *Zur Flora und Vegetation des mittleren Elbtales und der Dübener Heide* 3. *Wiss. Z. Martin-Luther-Univ. Halle-Wittenberg, Math.-Naturwiss. Reihe* 13: 673–680.
- Jagel A. 1994. Das Grosse Büchsenkraut *Lindernia dubia* (L.) Pennell im Elbtal zwischen Lauenburg und Wittenberge. *Florist. Rundbr.* 27: 107–109.
- Koch W. 1954. Pflanzensoziologische Skizzen aus den Reisfeldgebieten des Piemont (Po-Ebene). *Vegetatio* 5: 487–493.
- Krishnasamy J, Arumugam R. 2015. American species of *Lindernia dubia* (L.) Pennell-occurrence in India. *Biological Forum – An International Journal* 7: 48–51.
- Kurka R. 1990. *Lindernia dubia*-nový zavlečený druh v Československu [*Lindernia dubia*-a new introduced species in the Czechoslovakia]. *Zprávy Českoslov. Bot. Společn. Českoslov. Akad. Ved.* 25: 47–48.
- Lambinon J, Delvosalle L, Duvigneaud J. 2004. *Nouvelle flore de la Belgique, du Grand-Duché de Luxembourg, du Nord de la France et des régions voisines* (Ptéridophytes et Spermatophytes), ed 5. *Jardin botanique national de Belgique*, Meise.
- Lauber K, Wagner G, Gygax A. 2012. *Flora Helvetica*. Haupt Verlag, Bern.
- Lewis DQ. 2000. A revision of the New World species of *Lindernia* (Scrophulariaceae). *Castanea* 65: 93–122.
- Lloyd MJ. 1868. Une Plante Nouvelle Pour La Flore De France (Ilysanthes Gratioloides). *Bull. Soc. Bot. France* 15: 155–158.
- Markova M. 1995. *Lindernia* All. In: Kozhuharov S. (ed.), *Flora Reipublicae Bulgaricae* 10: 21–24. Editio Acad. "Prof. Marin Drinov", Sofia.
- Meijden R van der. 2005. *Heukels' Flora van Nederland*, 23rd edition. Wolters-Noordhoff, Groningen / Houten.
- Molnár VA, Pfeiffer N, Ristow M. 2000. Adatok hazai Nanocyperion-fajok ismeretéhez IV. A *Lindernia dubia* (L.) Pennell [Scrophulariaceae] Magyarországon. [Data to the knowledge of Nanocyperion-species in Hungary IV. *Lindernia dubia* (L.) Pennell in Hungary]. *Kitaibelia* 5: 279–287.
- Morton JK, Hogg EH. 1989. Biogeography of Island Floras in the Great-Lakes. 2. Plant dispersal. *Canad. J. Bot.* 67: 1803–1820.
- Müller N, Okuda. 1998. Invasion of alien plants in floodplains – a comparison of Europe and Japan. In: Starfinger U, Edwards K, Kowarik I, Williamson M. (eds): *Plant Invasions: Ecological Mechanisms and Human Responses*: 321–332. Backhuys Publishers, Leiden.
- Pennell FW. 1935. The Scrophulariaceae of eastern temperate North America. *Monogr. Acad. Nat. Sci. Philadelphia* 1: 1–650.
- Pignatti S. 1982. *Lindernia* in: *Flora d'Italia* 2: 524–525. Italia Edagricole, Bologna.
- QGIS Las Palmas 2.18.14. 2017. QGIS – A Free and Open Source Geographic Information System. Website: <https://qgis.org/nl/site/>.
- Randelović V, Zlatković B, Randelović N, Jušković M. 2006. In: Vladimirov V, Tan K, Stevanović V. 2006. New floristic records in the Balkans. *Phytol. Balcan.* 12: 107–128.
- Richardson DM, Pyšek P, Rejmánek M, Barbour MG, Panetta DF, West CJ. 2000. Naturalization and invasion of alien plants-concepts and definitions. *Diversity & Distrib.* 6: 93–107.
- Rico E. 1997. *Lindernia* All. in: Castroviejo S, Aedo C, Laínz M, Muñoz Garmendia F, Nieto Feliner G, Paiva J, Benedí C (eds.). *Flora iberica* 8: 149–152. Real Jardín Botánico, CSIC, Madrid.
- Schaminée JHJ, Weeda EJ, Westhoff V (eds). 1995. *De Vegetatie van Nederland*. 2. Plantengemeenschappen van wateren, moerassen en natte heiden: 161–220. Opulus Press, Uppsala / Leiden.
- Schmotzer A. 2015. Occurrence of *Lindernia dubia* (L.) Pennell in the Ipoly valley (Hungary and Slovakia). *Stud. Bot. Hung.* 46: 77–89.
- Shu MC. 1998. *Lindernia*. In: Wu ZY & PH Raven (eds.). *Flora of China*. Vol. 18: 30–37 (Scrophulariaceae through Gesneriaceae). Science Press, Beijing / Missouri Botanical Garden Press, St. Louis.
- Sparrius LB, Odé B, Beringen R. 2014. Basisrapport Rode Lijst Vaatplanten 2012 volgens Nederlandse en IUCN-criteria. *FLORON Rapport* 57. FLORON, Nijmegen.
- Šumberová K, Lososová Z. 2011. Vegetace jednoletých nitrofilních vlhkominálních bylin (Vegetation of annual nitrophilous wetland herbs). In: Chytrý M (ed.), *Aquatic and wetland vegetation*: 34–381. Academia, Praha.
- Šumberová K, Lososová Z, Ducháček M, Horáková V, Fabšičová M. 2012. Distribution, habitat ecology, soil seed bank and seed dispersal of threatened *Lindernia procumbens* and alien *Lindernia dubia* (Antirrhinaceae) in the Czech Republic. *Phyton (Horn)* 52: 39–72.
- Šumberová K, Horáková V, Lososová Z. 2005. Vegetation dynamics in exposed pond bottoms in the Českobudějovická basin (Czech Republic). *Phytocoenologia* 35: 421–448.
- Thiers B. 2017 [continuously updated]. Index herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden, Bronx, NY. Website: <http://sweetgum.nybg.org/ih/> (last visited 03 March 2017).
- Tichý L. 2002. JUICE, software for vegetation classification. *J. Veg. Sci.* 13: 451–453.
- Tomović G, Vukojičić S, Niketić M, Lakušić D. 2007. *New chorological data on some threatened and rare plants in Serbia*. *Arch. Biol. Sci.* 59: 63–73.
- Tzovev R, Šumberová K. 2004. New data on the chorology of some little

- known adventive species on the banks of the Danube River in Bulgaria. *Phytol. Balcan.* 10: 207–209.
- Uchino A, Watanabe H. 2002. Mutations in the acetolactate synthase genes of sulfonyleurea-resistant biotypes of *Lindernia* spp. *Weed Biol. Managem.* 2: 104–109.
- Vannerom H. 1994. Omtrent de vondst van *Lindernia dubia* (L.) Pennell (Scrophulariaceae), nieuw voor de Belgische Flora, en de evolutie van de Platweiers te Zonhoven (prov. Limburg). *Dumortiera* 55–57: 23–26.
- Vasconcellos JC. 1971. Recente introdução de infestantes exóticas. *Simpos Nacional Herbologia* 1: 1–5.
- verspreidingsatlas.nl (last visited 16-01-2018).
- Vuilleminot M. 2014. *Surveillance de l'apparition et de l'évolution des espèces exotiques envahissantes de Franche-Comté. Lindernia dubia* (L.) Pennell. *Bilan stationnel*. Conservatoire botanique national de Franche-Comté -Observatoire régional des Invertébrés.
- waarneming.nl (last visited 30-10-2017).
- Webb DA, Philcox D. 1972. 2. *Lindernia*. In: Tutin TG et al. (eds.), *Flora Europaea*. 3. Diapensiaceae to Myoporaceae: 203–204. Cambridge Univ. Press.
- Westhoff V, Schaminée JHJ, Stortelder AHF. 1995. De analytische fase van het vegetatieonderzoek. In: Schaminée JHJ, Stortelder AHF, Westhoff V (eds.), *De vegetatie van Nederland*. 1. Inleiding tot de plantensociologie – grondslagen, methoden en toepassingen: 63–80. Opulus Press, Uppsala/Leiden.
- Yamazaki T. 1993. Scrophulariaceae. In: Iwatsuki K, Yamazaki T, Boufford DE, Ohba H (eds.), *Flora of Japan*. IIIa. Angiospermae Dicotyledoneae Sympetalae (a): 336–341. Kodansha, Tokyo.
- Yoshino N, Wang G-X, Ito M, Auld B, Kohara, Enomoto T. 2006. Naturalization and dissemination of two subspecies of *Lindernia dubia* (Scrophulariaceae) in Japan. *Weed Biol. Managem.* 6: 174–176.
- Zedler JB, Kercher S. 2004. Causes and Consequences of Invasive Plants in Wetlands: Opportunities, Opportunists, and Outcomes. *Crit. Rev. Pl. Sci.* 23: 431–452.
- Zijlstra OG, Stolkwijk PF, Bielen JW. 2005. Bijzondere vondsten FWT-FLORON 2004. *Hypericum* 4: 18–26.

APPENDIX

Collected herbarium specimens

Coordinates are in degrees, minutes, seconds (WGS84), acronyms of herbaria are according to Thiers (2017).

- E.L.A.N. Simons & E.J. Slootweg 964* (WAG), Ewijkse Plaat, near Ewijk and Beuningen. 51° 52' 53.56" N, 5° 44' 29.53" E. 23 September 2012.
- E.L.A.N. Simons, M.G.M. Jansen & J. Rovers 1388* (WAG), Breda, Aa of Weerijds. 51° 33' 40.11" N, 4° 45' 10.97" E. 7 October 2014.
- E.L.A.N. Simons, M.G.M. Jansen & J. Rovers 1389* (WAG), south of Breda, close to Castélré, 't Merkske. 51° 25' 4.8" N, 4° 48' 41.74" E. 7 October 2014.
- E.L.A.N. Simons & M.G.M. Jansen 1390* (WAG), Nieuw-Bergen, Driessenven. 51° 35' 50.08" N, 6° 5' 7.16" E. 8 October 2014.
- E.L.A.N. Simons, R. Haveman & I. de Ronde 1977*, (WAG), Venlo, Raaijweiden. 51° 22' 29.79" N, 6° 9' 54" E. 15 September 2016.
- E.L.A.N. Simons & J. van Laerhoven 1981*, (WAG), NW of Hilvarenbeek, Huisvennen. 51° 29' 54.51" N, 5° 6' 27.81" E. 17 September 2016.
- E.L.A.N. Simons 1986*, (WAG), Schoutenwaard, south shore of Nederrijn river, Randwijk. 51° 57' 30.74" N, 5° 41' 13.19" E. 30 September 2016.
- E.L.A.N. Simons 2103*, (WAG), Keent. 51° 46' 32.34" N, 5° 42' 7.76" E. 14 October 2017.

In 2017, several new populations have been found (with links to the records in waarneming.nl):

- 10-09-2017: Gendtse Polder, close to Waal river (Gelderland), by Erik Slootweg (<https://waarneming.nl/waarneming/view/143913495>).
- 03-09-2017: De Plateaux, close to Valkenswaard (Noord-Brabant) by Rutger Barendse, Kim Lotterman, Niels Eimers, Erik Slootweg (<https://waarneming.nl/waarneming/view/143629810>).
- 12-07-2017: Milsbeek-Gebrande Kamp, south of Nijmegen, along the River Meuse (Limburg). Herbarium specimen: *G.M. Dirkse & S.M.H. Hochstenbach s.n.* (MUSNIJM), Milsbeek, Gebrande Kamp, noordoever Maas. 51° 43' 6.62" N, 5° 55' 48.12" E. 12 July 2017.
- 14-09-2017 Varsseveld (Gelderland) by Benno te Linde (<https://waarneming.nl/waarneming/view/144054329>).
- 14-10-2017 Keent, by Erik Slootweg, Erik Simons, Niels Eimers et al. (<https://waarneming.nl/waarneming/view/145014772>). Herbarium specimen *E.L.A.N. Simons 2103* (see above for further details).