

NEW RECORDS OF *VERTIGO GEYERI* LINDHOLM, 1925, *V. MOULINSIANA* (DUPUY, 1849) AND *V. ANGUSTIOR* JEFFREYS, 1830 (GASTROPODA: PULMONATA: VERTIGINIDAE) IN POLAND

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ABSTRACT: New localities of *Vertigo geyeri* Lindholm, *V. moulinsiana* (Dupuy) and *V. angustior* Jeffreys were found in 2011–2014, in three provinces in Poland: Wielkopolskie, Lubuskie and Podlaskie. The field survey was preceded by pinpointing potentially suitable habitats using maps, orthophotomaps and available botanical data. Each of 60 sites was explored in situ for molluscs for 60 minutes. We discovered 4 sites of *V. geyeri* (Podlaskie province only), 17 sites of *V. moulinsiana* (8 in Wielkopolskie, 5 in Lubuskie and 4 in Podlaskie) and 27 sites of *V. angustior* (5 in Wielkopolskie, 8 in Lubuskie and 14 in Podlaskie). In western Poland the vertiginids were found usually in wet or damp sedge meadows bordering lakes, small rivers or ditches whereas in the eastern part of the country the studied species were found in alkaline fens with thick brown moss layer.

KEY WORDS: *Vertigo angustior*, *Vertigo moulinsiana*, *Vertigo geyeri*, habitat, wetlands, Poland, conservation, Natura 2000

INTRODUCTION

Vertigo geyeri Lindholm, 1925, *V. moulinsiana* (Dupuy, 1849) and *V. angustior* Jeffreys, 1830 (Figs 1–3) are listed in Annex II of the EU Habitats Directive (EEC 1992) as well as in the IUCN Red List of Threatened Species (IUCN 2014). As a member of the EU, Poland is obliged to make every effort to maintain populations of these species in a good shape. An effective programme of their conservation can be developed only based on data on vertiginid occurrence and habitat requirements. However, the knowledge of their distribution in Poland is still incomplete. Thus, we surveyed three provinces of Poland: Wielkopolskie, Lubuskie and Podlaskie, to

locate possible sites of *V. geyeri*, *V. moulinsiana* and *V. angustior*.

V. geyeri is a Eurasian species (KERNEY 1999, MENG 2008, HOFFMANN et al. 2010). The snail occurs in open, permanently wet, calcareous areas such as spring, alkaline and rich fens (HORSÁK & HÁJEK 2005, KILLEEN et al. 2011, ZAJĄC et al. 2012, WILLING 2013). The best indicator of the optimum habitat for this species is the presence of a tufa-forming springs (KILLEEN et al. 2011, SCHENKOVÁ et al. 2012), where ground water levels do not decrease below 0.1 m (KUCZYŃSKA & MOORKENS 2010). *V. geyeri* is considered to be a glacial relict in Poland and



Figs 1–3. Shells of: 1 – *V. geyeri*; 2 – *V. moulinsiana*; 3 – *V. angustior*

was recorded from about 20 sites in lowland and upland region of the country (SCHENKOVÁ et al. 2012, ZAJĄC et al. 2012). According to the IUCN Red List of Threatened Species, *V. geyeri* is a species of least concern (Lc), with stable population trend (KILLEEN et al. 2011). It is also included in the Red List of Threatened Animals in Poland with NT (near threatened) category (WIKTOR & RIEDEL 2002).

V. moulinsiana is an Atlantic-Mediterranean species (POKRYSZKO 1990) of wet, calcareous habitats. The snail occurs in swamps, fens and marshes, bordering rivers, lakes and ponds, or in river floodplains. *V. moulinsiana* prefers open situations, however it occurs also in semi open habitats as well as in well-preserved alder carrs densely vegetated by sedges (KILLEEN 2003). It thrives in habitats where the water levels are very close to the ground surface or above it, for at least some of the year (TATTERSFIELD & MCINNES 2003). The species was found in about 30 sites in Poland (e.g. MYZYK 2004, LIPIŃSKA et al. 2012, SULIKOWSKA-DROZD 2014, 2015) and it is regarded as critically endangered in the country (category CR in the Polish Red Data Book, POKRYSZKO 2004). The species is also included in the Red List of Threatened Animals in Poland (CR category)

(WIKTOR & RIEDEL 2002). The IUCN Red List of Threatened Species classifies *V. moulinsiana* as threatened with VU (vulnerable) category (KILLEEN et al. 2012).

Among the studied species, *V. angustior* seems to be the most common in Poland: it has over 100 records in the country (KSIĄŻKIEWICZ et al. 2012). It is a mainly European species, distributed from southern Scandinavia to the Mediterranean and from Ireland to the Caspian Sea, with scattered localities in many countries (CAMERON et al. 2003). Its preferred habitats are moderately moist (the species does not tolerate inundation), calcareous and open (e.g. POKRYSZKO 1990, CAMERON et al. 2003, KSIĄŻKIEWICZ 2010, MYZYK 2011). In the lowlands of Poland, *V. angustior* occurs in damp sedge meadows whereas in the mountains it inhabits spring fens (KSIĄŻKIEWICZ et al. 2012). The IUCN Red List of Threatened Species classified *V. angustior* as NT – near threatened whose population has a decreasing trend (MOORKENS et al. 2012). The species is strictly protected in Poland and is listed in the Polish Red Data Book (POKRYSZKO 2004) as well as in the Red list of threatened animals in Poland with EN category (endangered) (WIKTOR & RIEDEL 2002).

MATERIALS AND METHODS

The research was conducted in western, north-western and north-eastern Poland in 2011–2014 and included wetland areas in three provinces: Wielkopolskie, Lubuskie and Podlaskie (Figs 4–14). We verified a total of 60 potentially suitable sites for *V. geyeri*, *V. moulinsiana* and *V. angustior*: 26 within the area of Lubuskie, 16 sites in Wielkopolska and 18 sites in Podlaskie. Selection of habitats matching requirements of the studied vertiginids was in most cases based on maps, orthophotomaps and available botanical data and included treeless or semi-open, wetland areas, covered by sedge vegetation, often alkaline fens.

Each chosen site was explored in situ for molluscs by two of the authors for about 30 minutes (total:

about 60 minutes) or by one author for 60 minutes. The search involved fragments of sites best suited to the microhabitat preferences of the veriginids, selected based on the literature (e. g. POKRYSZKO 1990, CAMERON et al. 2003, KILLEEN 2003, KUCZYŃSKA & MOORKENS 2010). Within each studied site 3–5 such fragments were selected and examined. The number of fragments searched in each site depended on the total habitat area and the area of patches potentially suitable for the studied species. The search time was equally divided between fragments (e. g. 2 fragments per site – 30 minutes for each fragment, 3 fragments per site – about 20 minutes for each fragment, etc.) and the search was continued within specified period of time on each fragment, regardless of the results.

The new records of the vertiginids given in the Results section are signed with the initials of the author/authors who explored the site. The CORINE habitat type of *Vertigo* sites was determined using the Interpretation Manual of European Union Habitats (EUROPEAN COMMISSION 1996).

We examined leaves and stems of plants as well as searched and sieved the litter using 0.5 mm sieve and checking briefly the separated particles on a

white tray for the smallest gastropods. Most individuals were identified in situ using a magnifying glass; only doubtful snails were checked in the laboratory under the stereomicroscope and identified using descriptions provided by WIKTOR (2004). During the field work we also noted other terrestrial gastropod species which were found in the leaf litter during the vertiginid survey.

RESULTS

We examined a total of 60 potentially suitable sites of *V. geyeri*, *V. moulinsiana* and *V. angustior*. We discovered 4 sites of *V. geyeri*, 17 sites of *V. moulinsiana* and 27 sites of *V. angustior* in Poland (Figs 4, 7–8, 11, 13). Sites where none of these species was detected were included in another publication (KSIĄŻKIEWICZ & GOŁDYN, in preparation).

SITES OF *V. MOULINSIANA* AND *V. ANGUSTIOR* IN WIELKOPOLSKA PROVINCE

In the Wielkopolska province we examined a total of 16 potentially suitable sites for the studied vertiginids. We discovered 8 new sites of *V. moulinsiana* and 5 new sites of *V. angustior* (Figs 4, 7). Species of

terrestrial gastropods that co-occurred with the vertiginids in each site are listed in Table 1.

Site 1.1. 52°14'51"N, 16°49'23"E (leg. BG & ZK), habitat code: 53.2

A wetland on the north-eastern shore of lake Budzyńskie, overgrown with common reed (*Phragmites australis*) and lesser pond sedge (*Carex acutiformis*), ca. 1.2 ha in area. The site is locally flooded and remains damp during the whole season. Tens of individuals of *V. moulinsiana* were discovered in the site. The wetland is protected as part of the Wielkopolski National Park and within Natura 2000 (Ostoja Wielkopolska, PLH300010 and Ostoja Rogalińska PLB300017).

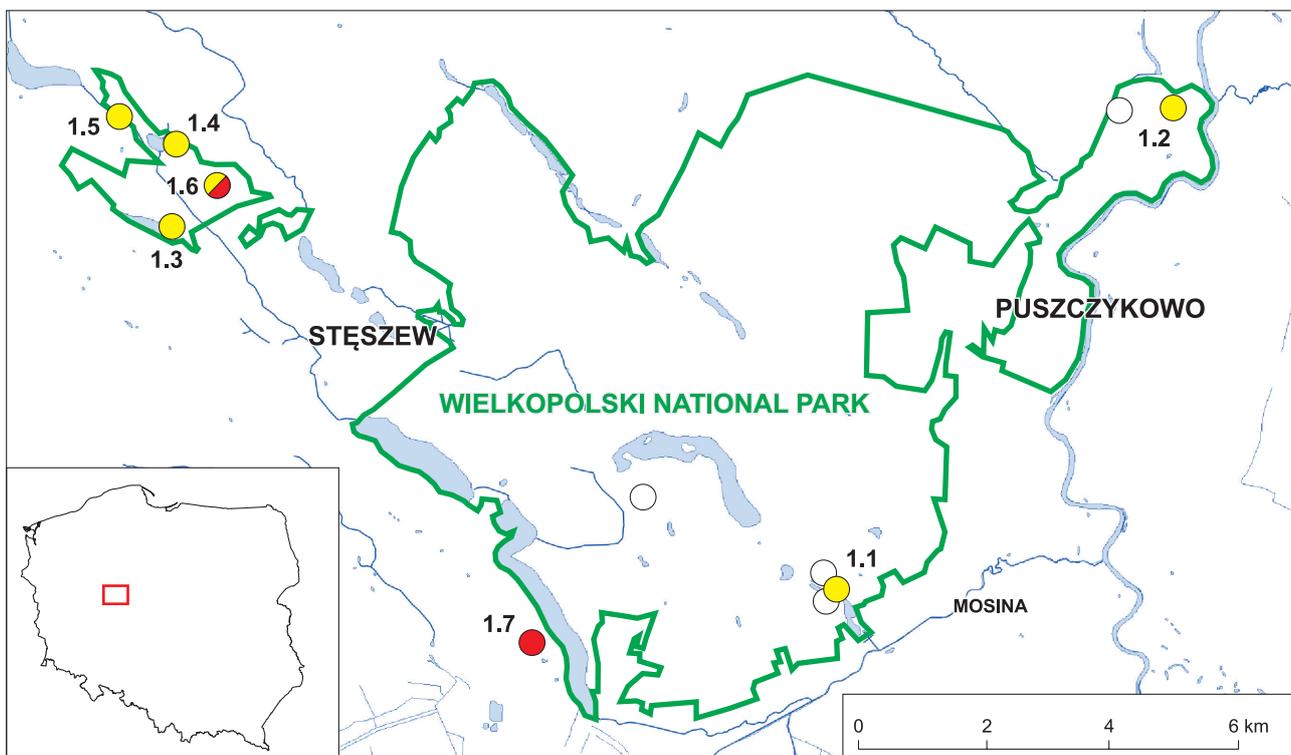


Fig. 4. Distribution of sites in Wielkopolska province (sites with vertiginid species numbered 1.1–1.7): red circles – sites of *V. angustior*, yellow circles – sites of *V. moulinsiana*, open circles – sites where conditions were suitable but no vertiginids were found, green line – borders of the Wielkopolski National Park



Table 1. List of species recorded in the studied sites during surveys of *V. moulinsiana* and *V. angustior* in Wielkopolska province

Species	Site										
	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.11
<i>Carychium minimum</i> O. F. Müller, 1774	-	+	-	+	-	+	-	-	+	-	-
<i>Succinea cf. putris</i> (Linnaeus, 1758)	+	+	+	+	+	+	-	-	+	-	+
<i>Cochlicopa lubrica</i> (O. F. Müller, 1774)	-	-	-	-	-	-	-	-	+	-	+
<i>Vertigo antivertigo</i> (Draparnaud, 1801)	+	+	+	-	-	-	-	-	+	-	+
<i>Vertigo moulinsiana</i> (Dupuy, 1849)	+	+	+	+	+	+	-	-	-	+	+
<i>Vertigo angustior</i> Jeffreys, 1830	-	-	-	-	-	+	+	+	+	-	+
<i>Pupilla pratensis</i> Clessin, 1871	-	-	-	-	-	+	-	-	-	-	-
<i>Punctum pygmaeum</i> (Draparnaud, 1801)	-	+	-	-	-	-	-	-	-	-	-
<i>Arion rufus</i> (Linnaeus, 1758)	-	-	-	-	-	-	-	-	+	-	-
<i>Arion intermedius</i> Normand, 1852	-	-	-	-	-	+	-	-	-	-	+
<i>Nesovitrea hammonis</i> (Ström, 1765)	-	+	-	-	-	-	-	-	-	-	-
<i>Zonitoides nitidus</i> (O. F. Müller, 1774)	-	+	+	+	+	+	-	-	+	-	+
<i>Deroceras leawe</i> (O. F. Müller, 1774)	-	+	-	-	-	-	-	-	+	-	-
<i>Euconulus fulvus</i> (O. F. Müller, 1774)	+	+	-	+	-	+	-	-	+	-	+
<i>Perforatella bidentata</i> Gmelin, 1791	+	+	-	-	-	-	-	-	-	-	-
<i>Perforatella rubiginosa</i> (Schmidt, 1853)	-	-	-	+	-	-	-	-	+	-	-
<i>Trochulus hispidus</i> (Linnaeus, 1758)	-	+	+	+	+	+	-	-	+	-	-



Fig. 5. An extensively used part of site 1.6 (Wielkopolska province), habitat of *V. angustior*

Site 1.2. 52°19'04"N, 16°53'56"E (leg. BG & ZK), habitat code: 53.2

A sedge meadow with *C. acutiformis* overgrowing the bottom of a former oxbow of the Warta river, ca. 6.6 ha in area. The meadow is periodically flooded; it remains wet during the whole season. It is fairly open, shaded only in its edges. In this site only one, empty shell of a young *V. moulinsiana* was found. It is possible that the population of the species in this site is sparse or the individual was accidentally transferred from a nearby population. The site is protected as part of the Wielkopolski National Park and within Natura 2000 (Ostoja Wielkopolska, PLH300010).

Site 1.3. 52°17'47"N, 16°40'06"E (leg. BG & ZK), habitat code: 53.2

A wetland on the north-eastern and north-western shores of lake Wielkowiejskie, densely overgrown with *C. acutiformis* and *P. australis*, ca. 8.5 ha in area. It consists of a mosaic of permanently inundated, temporarily inundated and permanently damp plots. The edges of the site are partially shaded by alders. Tens of individuals of *V. moulinsiana* were found in the wetland. The site is protected as part of the Wielkopolski National Park and within

Natura 2000 (Ostoja Wielkopolska, PLH300010 and Ostoja Rogalińska PLB300017).

Site 1.4. 52°18'34"N, 16°39'35"E (leg. BG & ZK), habitat code: 53.2

A sedge meadow with *C. acutiformis*, partially shaded by willow shrubs and extensively used, locally overgrown with *P. australis*, ca. 6.5 ha in area. The site is located within the backwaters of the Samica Stęszewska river and is periodically flooded. Tens of individuals of *V. moulinsiana* were found there. The area is protected as part of the Wielkopolski National Park and within Natura 2000 (Ostoja Wielkopolska, PLH300010 and Ostoja Rogalińska PLB300017).

Site 1.5. 52°18'43"N, 16°39'32"E (leg. BG & ZK), habitat code: 53.2

A sedge meadow with *C. acutiformis*, surrounding lake Trzcielińskie and locally overgrown with *P. australis*. The area, of ca. 12 ha, consists of very damp and inundated plots and in its eastern part borders on the Samica Stęszewska river. Tens of individuals of *V. moulinsiana* were found in the site. The area is protected as part of the Wielkopolski National Park and within Natura 2000 (Ostoja Wielkopolska, PLH300010 and Ostoja Rogalińska PLB300017).



Fig. 6. A part of site 1.6 near the Samica Stęszewska river (Wielkopolska province), habitat of *V. angustior* and *V. moulinsiana*

Site 1.6. $52^{\circ}17'42''\text{N}$, $16^{\circ}40'31''\text{E}$ (leg. BG & ZK), habitat code: 53.3

An extensively used sedge meadow, of ca. 152 ha (Figs 5–6). The area is fairly open (sparsely covered with willow scrubs), crossed by numerous ditches and the Samica Stęszewska river in the western part. The moderately damp, mown part of the meadow yielded a few individuals of *V. angustior*, while on the margins of the site also a few individuals of *V. moulinsiana* were found – the species resided in the vicinity of ditches, which are excluded from mowing, the soil is waterlogged and densely covered with reeds. This meadow was earlier described as a new site of *Pupilla pratensis* (KSIĄŻKIEWICZ & GOŁDYN 2013). The site is part of the buffer zone of the Wielkopolski National Park and is protected within Natura 2000 (Ostoja Wielkopolska, PLH300010 and Ostoja Rogalińska PLB300017).

Site 1.7. $52^{\circ}14'16''\text{N}$, $16^{\circ}45'28''\text{E}$ (leg. BG & ZK), habitat code: 53.2

A damp sedge meadow with *C. acutiformis* and *C. paniculata*, in its wettest part passing into a reed bed (*P. communis*, *Typha latifolia*). The site, ca. 1.7 ha in area, is located near lake Dymaczewskie. It is partially shaded by scrubs and consists of damp and inundated plots. Over a dozen individuals of *V. angustior* were found in the site which is part of the buffer zone of the Wielkopolski National Park.

Site 1.8. $52^{\circ}38'47''\text{N}$, $16^{\circ}11'23''\text{E}$ (leg. BG), habitat code: 53.3

An intensively used sedge meadow of ca. 2 ha. The site is fairly open and mostly dried out, however some small parts of the meadow, which were excluded from mowing, remained moderately damp. In such plots a few individuals of *V. angustior* were discovered. The area is protected as part of the Sierakowski Landscape Park and within Natura 2000 (Puszcza Notecka PLB300015).

Site 1.9. $52^{\circ}36'59''\text{N}$, $16^{\circ}15'28''\text{E}$ (leg. BG), habitat code: 53.2

An open, wet sedge meadow dominated by *C. acutiformis*, ca. 1 ha in area. Except a few patches, it is intensively mown. In these patches over a dozen individuals of *V. angustior* were recorded. The area is protected as part of the Sierakowski Landscape Park and within Natura 2000 (Puszcza Notecka PLB300015).

Site 1.10. $52^{\circ}36'02''\text{N}$, $16^{\circ}01'48''\text{E}$ (leg. BG), habitat code: 53.2

A wet sedge swamp of ca. 0.1 ha, located in the eastern part of lake Chalinek. The site is partially shaded by the surrounding deciduous forest. Tens of individuals of *V. moulinsiana* were recorded there. The area is protected as part of the Sierakowski Landscape Park and within Natura 2000 (Ostoja Międzychodzko-Sierakowska PLH300032 and Puszcza Notecka PLB300015).

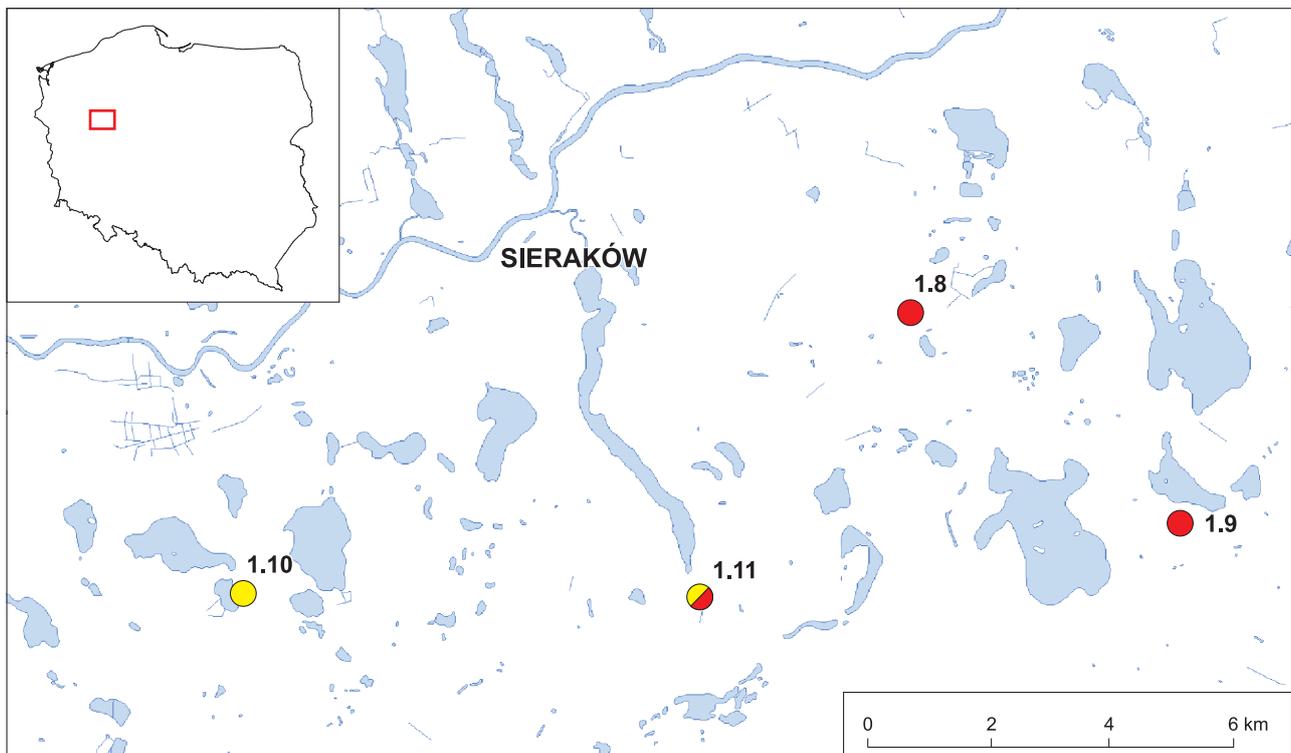


Fig. 7. Distribution of sites 1.8–1.11 in Wielkopolska province, environs of Sieraków: yellow circles – sites of *V. moulinsiana*, red circles – sites of *V. angustior*



Site 1.11. $52^{\circ}36'10''\text{N}$, $16^{\circ}08'34''\text{E}$ (leg. BG), habitat code: 53.2

A wet sedge meadow dominated by *C. acutiformis*, ca. 4 ha in area, mostly inundated and locally overgrown with reeds (*P. australis*). Tens of individuals of *V. moulinsiana* and a few *V. angustior* were found in the site. *V. angustior* resided on the least marshy edges of the site while *V. moulinsiana* was found in the central part of the meadow, on the leaves of reed and sedges in the wettest patches. The area is protected as part of the Sierakowski Landscape Park and within Natura 2000 (Ostoja Międzychodzko-Sierakowska PLH300032 and Puszcza Notecka PLB300015).

SITES OF *V. MOULINSIANA* AND *V. ANGUSTIOR* IN LUBUSKIE PROVINCE

In the Lubuskie province we examined a total of 26 potentially suitable sites for the studied vertigi-

inids (Fig. 8). We recorded 5 new sites of *V. moulinsiana* and 8 new sites of *V. angustior*. Species of terrestrial gastropods that co-occurred with the studied vertiginids in each site are listed in Table 2.

Site 2.1. $52^{\circ}02'54.7''\text{N}$, $14^{\circ}48'36.1''\text{E}$ (leg. ZK & BG), habitat code: 53.2

A wet sedge meadow dominated by *C. acutiformis*, partially shaded by alders, ca. 6 ha in area. The site is adjacent to lake Baginiste and is subject to local inundation. Over a dozen individuals of *V. angustior* were found in the meadow. The site is protected as part of the Krzesiński Landscape Park.

Site 2.2. $52^{\circ}03'05.9''\text{N}$, $14^{\circ}48'19.5''\text{E}$ (leg. ZK & BG), habitat code: 53.2

A sedge meadow dominated by *C. acutiformis*, ca. 24 ha in area. It constitutes a mosaic of relatively damp and wet patches. It is fairly open, but shaded in

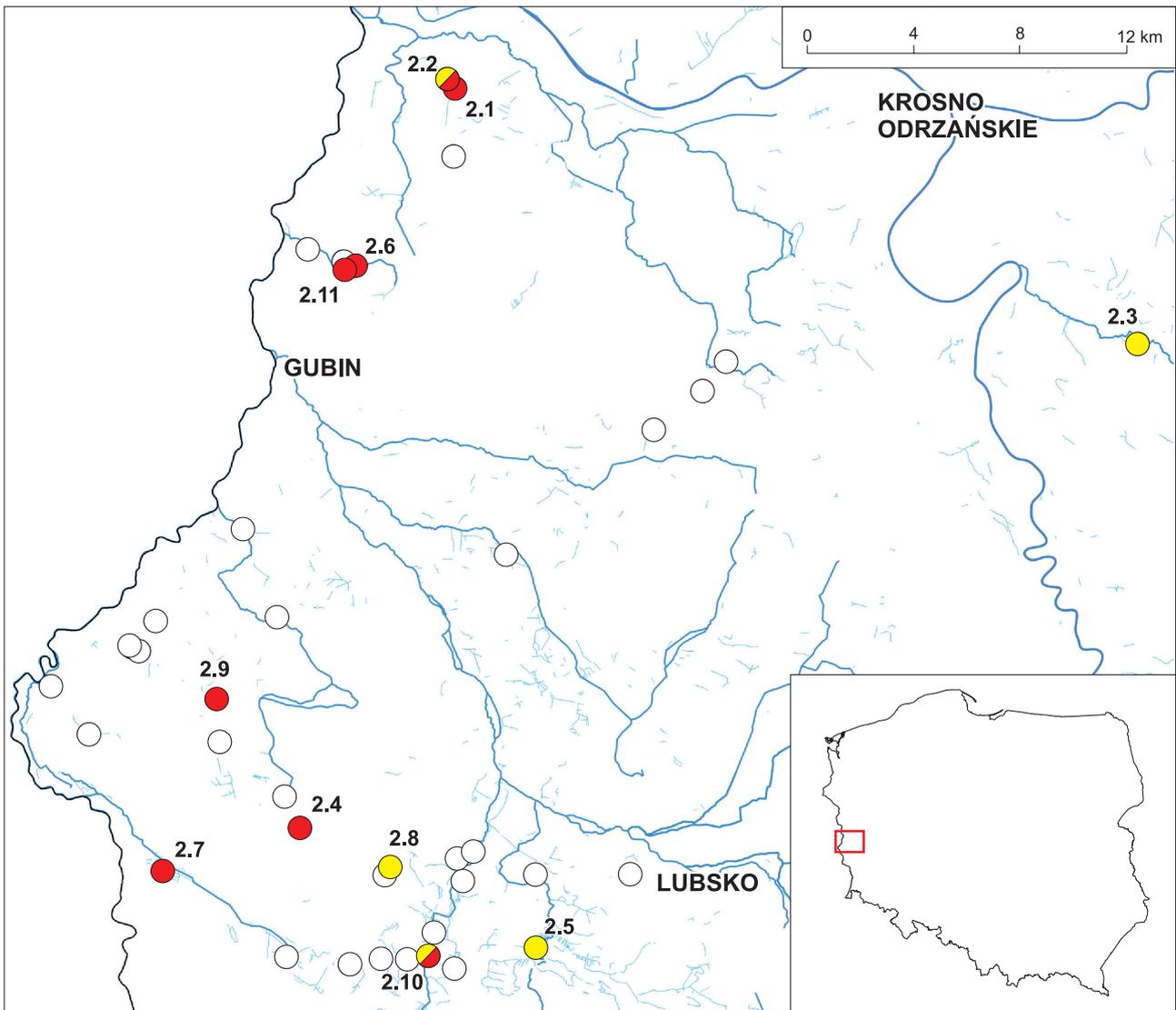


Fig. 8. Distribution of sites in Lubuskie province (sites with vertiginid species numbered 2.1–2.11): red circles – sites of *V. angustior*, yellow – sites of *V. moulinsiana*, open – sites where conditions were suitable but no vertiginids were found

Table 2. List of species recorded in the studied sites during surveys of *V. moulinsiana* and *V. angustior* in Lubuskie province

Species	Site										
	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11
<i>Carychium minimum</i> (O. F. Müller, 1774)	-	+	-	+	-	-	-	+	+	+	+
<i>Carychium tridentatum</i> (Risso, 1826)	-	-	-	+	-	-	+	-	-	-	-
<i>Succinea</i> cf. <i>putris</i> (Linnaeus, 1758)	+	+	+	+	+	+	+	+	+	+	+
<i>Cochlicopa lubrica</i> (O. F. Müller, 1774)	-	+	-	-	-	-	-	-	-	-	-
<i>Cochlicopa nitens</i> (Gallenstein, 1852)	-	-	+	-	-	+	-	-	+	-	-
<i>Columella aspera</i> Waldén, 1966	+	-	-	-	-	-	-	-	-	+	-
<i>Truncatellina cylindrica</i> (Férussac, 1807)	-	-	-	-	-	+	-	-	-	-	-
<i>Vertigo antivertigo</i> (Draparnaud, 1801)	-	-	+	-	-	-	+	+	-	-	+
<i>Vertigo moulinsiana</i> (Dupuy, 1849)	-	+	+	-	+	-	-	+	-	+	-
<i>Vertigo pygmaea</i> (Draparnaud, 1801)	-	+	-	-	+	-	-	-	-	-	+
<i>Vertigo substriata</i> (Jeffreys, 1833)	-	-	-	-	-	-	-	-	-	+	-
<i>Vertigo angustior</i> Jeffreys, 1830	+	+	-	+	-	+	+	-	+	+	+
<i>Pupilla pratensis</i> Clessin, 1871	-	+	-	-	-	-	-	-	-	-	-
<i>Vallonia costata</i> (O. F. Müller, 1774)	-	-	-	-	-	+	-	-	-	-	-
<i>Vallonia pulchella</i> (O. F. Müller, 1774)	-	+	-	-	-	+	+	-	-	-	-
<i>Punctum pygmaeum</i> (Draparnaud, 1801)	-	+	-	-	+	+	+	-	+	+	+
<i>Discus rotundatus</i> (O. F. Müller, 1774)	-	-	-	-	-	-	-	-	-	+	-
<i>Arion rufus</i> (Linnaeus, 1758)	-	-	+	-	-	-	-	-	-	-	-
<i>Arion subfuscus</i> (Draparnaud, 1805)	+	-	-	-	-	-	-	+	-	-	+
<i>Arion intermedius</i> Normand, 1852	-	-	-	-	-	-	-	-	-	+	-
<i>Vitrina pellucida</i> (O. F. Müller, 1774)	-	-	-	+	-	-	-	-	-	+	-
<i>Eucobresia diaphana</i> (Draparnaud, 1805)	-	-	+	-	-	-	-	+	+	+	-
<i>Vitrea crystallina</i> (O. F. Müller, 1774)	-	-	+	+	+	-	+	-	-	-	-
<i>Aegopinella</i> sp.	-	-	-	+	-	-	-	-	-	-	-
<i>Nesovitrea hammonis</i> (Ström, 1765)	+	+	-	-	-	+	+	-	-	+	+
<i>Zonitoides nitidus</i> (O. F. Müller, 1774)	-	+	+	-	+	-	+	+	+	+	-
<i>Deroceras laeve</i> (O. F. Müller, 1774)	+	+	-	-	-	-	-	-	+	+	+
<i>Euconulus fulvus</i> (O. F. Müller, 1774)	-	-	-	+	+	+	+	+	+	+	+
<i>Perforatella bidentata</i> Gmelin, 1791	-	-	+	+	+	-	+	-	-	+	+
<i>Perforatella incarnata</i> (O. F. Müller, 1774)	-	-	+	+	+	-	+	-	-	+	+
<i>Trochulus hispidus</i> (Linnaeus, 1758)	-	-	-	-	-	-	-	+	-	-	-
<i>Arianta arbustorum</i> (Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	-	-
<i>Cepaea hortensis</i> (O. F. Müller, 1774)	-	-	-	-	+	-	-	-	-	+	-
<i>Cepaea</i> sp. (juveniles)	-	-	-	+	-	+	-	-	-	-	-
<i>Helix pomatia</i> Linnaeus, 1758	-	-	-	+	-	-	-	-	-	-	-

its edges by alders and locally by scrubs. Over a dozen individuals of *V. angustior* and *V. moulinsiana* were found in the site. The meadow was earlier described as a new site of *Pupilla pratensis* (KSIĄŻKIEWICZ & GOŁDYN 2013). The area is protected as part of the Krzesiński Landscape Park.

Site 2.3. 51°58'29.2"N, 15°11'21.7"E (leg. ZK & BG), habitat code: 53.2

A sedge meadow dominated by *C. acutiformis*, ca. 0.11 ha in area, mostly shaded by alders, dried out and eutrophicated. A few individuals of *V. moulinsiana* were found there. The site is protected as part of the Nature Park "Rynna Pławska".

Site 2.4. 51°47'43.2"N, 14°44'56.9"E (leg. ZK & BG), habitat code: 53.2

A damp sedge meadow dominated by *C. acutiformis*, in the vicinity of lake Brodzkie. The site, of 0.27 ha, is partially shaded by alders. It yielded over a dozen individuals of *V. angustior*. The site is protected within Natura 2000 ("Jeziorko Brodzkie" PLH80052).

Site 2.5. 51°45'33.7"N, 14°52'50.6"E (leg. ZK & BG), habitat code: 53.2

A sedge swamp in the vicinity of lake Żurawno, dominated by creeping sedges, ca. 24 ha in area. Its central part is crossed by the Rzczyca river, and thus is subject to periodical inundation. Tens of individuals of *V. moulinsiana* were found there. The site is pro-

tected as part of the Nature Park “Zachodnie okolice Lubska” and within Natura 2000 (Uroczyska Borów Zasiieckich PLH80060).

Site 2.6. $51^{\circ}59'12.0''\text{N}$, $14^{\circ}45'41.4''\text{E}$ (leg. ZK & BG), habitat code: 53.2

A dried out sedge meadow in the vicinity of homestead and fishponds. The site, of ca. 0.02 ha, is surrounded by ditches and partially shaded by alders. A few individuals of *V. angustior* were found there. The site is protected as the Nature Park “Gubińskie Mokradła”.

Site 2.7. $51^{\circ}46'40.5''\text{N}$, $14^{\circ}40'34.7''\text{E}$ (leg. ZK & BG), habitat code: 53.2

A clump sedge community dominated by *Carex paniculata*, ca. 0.05 ha in area. The site remains wet during the year and is partially shaded by alders. Within the clumps a few individuals of *V. angustior* were found. The site is protected as the Nature Park “Dolina Nysy”.

Site 2.8. $51^{\circ}47'01.4''\text{N}$, $14^{\circ}47'57.5''\text{E}$ (leg. ZK & BG), habitat code: 53.2

A sedge swamp dominated by *C. acutiformis*, near a fish pond. The site, of ca. 0.4 ha, is mostly inundated (Fig. 9). The submerged patches are locally overgrown with reed (*P. australis*). The site is fairly open, however its edges are shaded by alders. Tens of individuals of *V. moulinsiana* were found there. The site is protected as the Nature Park “Zachodnie okolice Lubska”.

Site 2.9. $51^{\circ}50'14.2''\text{N}$, $14^{\circ}41'59.9''\text{E}$ (leg. ZK & BG), habitat code: 53.2

An open, moderately damp sedge meadow dominated by *C. acutiformis*, ca. 0.2 ha in area, partially eutrophicated and surrounded by wastelands with ruderal vegetation. In this site over a dozen individuals of *V. angustior* were found.

Site 2.10. $51^{\circ}45'16.2''\text{N}$, $14^{\circ}49'22.2''\text{E}$ (leg. ZK & BG), habitat code: 53.2

A sedge meadow surrounded by alder carr. The area, of 0.2 ha, is shaded by trees and dominated by sedges *C. paniculata* and *C. acutiformis* (Fig. 10). The site constitutes a mosaic of wet and moderately damp



Fig. 9. Site 2.8 in the Nature Park “Zachodnie Okolice Lubska” (Lubuskie province), habitat of *V. moulinsiana*



Fig. 10. Site 2.10 in the Nature Park “Zachodnie Okolice Lubska”, habitat of *V. angustior* and *V. moulinsiana*

patches. Over a dozen individuals of *V. angustior* and *V. moulinsiana* were found in the meadow. The site is protected as part of the Nature Park “Zachodnie okolice Lubska” and within Natura 2000 (Uroczyska Borów Zasięckich PLH80060).

Site 2.11. $51^{\circ}59'06.8''\text{N}$, $14^{\circ}45'21.5''\text{E}$ (leg. ZK & BG), habitat code: 53.2

A wet sedge meadow near a lake, dominated by *C. acutiformis*, ca. 3 ha in area. In the vicinity of the lake the vegetation is inundated, and the meadow's edges remain very damp. The area is fairly open, only the edges are shaded by alders. It yielded a few individuals of *V. angustior*.

SITES OF *V. GEYERI*, *V. MOULINSIANA* AND *V. ANGUSTIOR* IN PODLASKIE PROVINCE

In the Podlaskie province we examined a total of 18 potentially suitable sites for the studied vertiginids (Figs 11, 13). We recorded 4 sites of *V. geyeri*, 4 sites of *V. moulinsiana* and 14 sites of *V. angustior*. Species of terrestrial gastropods that co-occurred with these vertiginids in each site are listed in Table 3.

Site 3.1. $53^{\circ}43'34.4''\text{N}$, $23^{\circ}21'29.4''\text{E}$ (leg. UBB, ZK & BG), habitat code: 54.2

A partly eutrophicated alkaline fen, ca. 4 ha in area, located about 0.3 km south of the Biebrza river. The site is partially shaded by shrubs and borders with farmlands. Tens of individuals of *V. angustior*. The site is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.2 $53^{\circ}17'58.7''\text{N}$, $22^{\circ}36'12.3''\text{E}$ (leg. UBB, ZK & BG), habitat code: 54.2

An open alkaline fen of ca. 4,900 ha; 50% of the fen is mown every two years using modified snowcats equipped with blades. Tens of individuals of *V. angustior* and *V. moulinsiana* were found in the site; their presence was restricted to the edges which were excluded from mowing. The site is adjacent to the Biebrza river and remains wet during the whole season. The fen is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

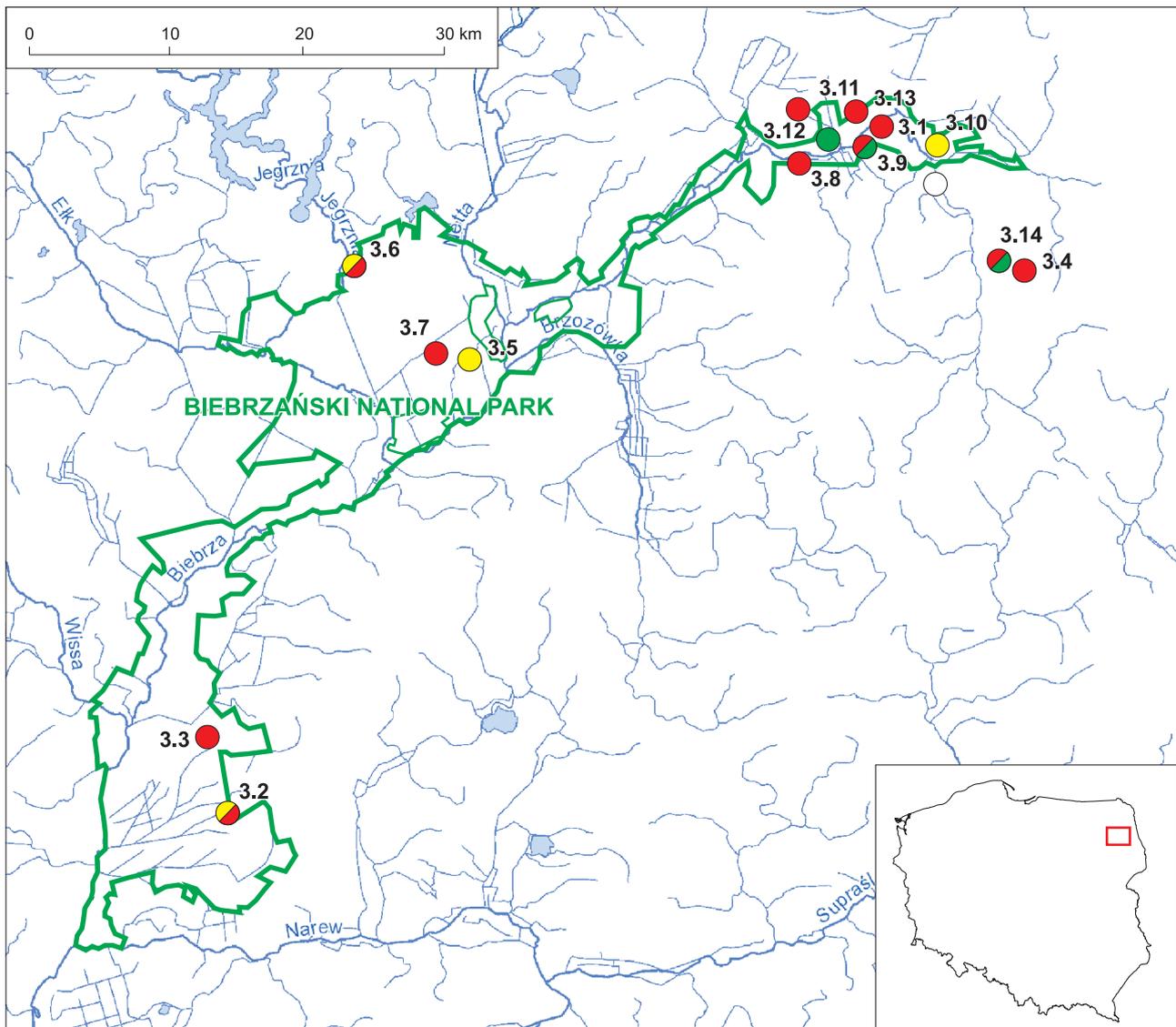


Fig. 11. Distribution of sites in Podlaskie province (sites with vertiginid species numbered 3.1–3.14): red circles – sites of *V. angustior*, yellow circles – sites of *V. moulinsiana*, green circles – *V. geyeri*, open circles – sites where conditions were suitable but no vertiginids were found, green line – borders of the Biebrzański National Park

Site 3.3. $53^{\circ}20'57.2''N$, $22^{\circ}35'2.4''E$ (leg. UBB, ZK & BG), habitat code: 53.2

An open sedge community dominated by reed beds, and in places by stolon sedges; occasionally mown. The habitat, of ca. 1,870 ha, borders the Biebrza river in its western part. It is locally flooded, but the range of inundation varies with year and season and depends on the cycle of the river. The site remains wet during the whole season. Tens of individuals of *V. angustior* were found there. The area is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.4. $53^{\circ}37'29.2''N$, $23^{\circ}30'22.3''E$ (leg. UBB, ZK & BG), habitat code: 54.2

The site includes a moist, fibrous tussock sedge community (*Caricetum appropinquatae*) at the edge

and an alkaline mire in the centre. The area, of ca. 5 ha, is located between two rivers: Sidra (ca. 3.8 km west of the site) and Biebrza (ca. 1.3 km east of the site). The site is surrounded by mown meadows/farmlands. A few individuals of *V. angustior* were found there. We also found *Pupilla pratensis* in the site; it is the fifth record of this species from Poland (GOLDFUSS 1883, HORSÁK et al. 2012, KSIĄŻKIEWICZ & GOŁDYN 2013).

Site 3.5. $53^{\circ}35'17.8''N$, $22^{\circ}53'33.1''E$ (leg. UBB, ZK & BG), habitat code: 53.2

An open reed bed habitat by the Kopytkówka river, surrounded by farmland. The area, of ca. 18 ha, is infrequently flooded and remains wet during the year. Tens of individuals of *V. moulinsiana* were found in the site. The area is protected as part of the buffer zone of the Biebrzański National Park, the Nature

Table 3. List of species recorded in the studied sites during surveys of *V. moulinsiana*, *V. angustior* and *V. geyeri* in Podlaskie province

Species	Site																
	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12	3.13	3.14	3.15	3.16	3.17
<i>Carychium minimum</i> O. F. Müller, 1774	+	+	+	+	-	+	+	-	+	+	+	+	-	-	-	-	-
<i>Carychium</i> sp. (juveniles)	-	-	-	-	-	-	-	+	-	+	-	-	+	-	-	-	-
<i>Succinea</i> cf. <i>putris</i> (Linnaeus, 1758)	+	+	+	+	+	+	+	-	-	+	-	-	-	-	-	-	-
<i>Cochlicopa lubrica</i> (O. F. Müller, 1774)	+	-	-	-	-	-	+	+	-	+	+	-	-	-	-	-	-
<i>Vertigo antivertigo</i> (Draparnaud, 1801)	-	+	+	-	+	+	-	-	+	+	+	+	+	-	-	-	-
<i>Vertigo moulinsiana</i> (Dupuy, 1849)	-	+	-	-	+	+	-	-	-	+	-	-	-	-	-	-	-
<i>Vertigo pygmaea</i> (Draparnaud, 1801)	-	-	-	+	-	-	+	-	+	+	+	-	-	-	-	-	-
<i>Vertigo substriata</i> (Jeffreys, 1833)	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-	-	-
<i>Vertigo angustior</i> Jeffreys, 1830	+	+	+	+	-	+	+	+	+	-	+	-	+	+	+	+	+
<i>Vertigo geyeri</i> Lindholm, 1925	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-	+
<i>Pupilla pratensis</i> Clessin, 1871	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Vallonia pulchella</i> (O. F. Müller, 1774)	+	-	-	+	-	-	-	+	+	-	-	+	+	-	-	-	-
<i>Punctum pygmaeum</i> (Draparnaud, 1801)	-	-	-	+	-	+	+	+	+	+	+	+	+	-	-	-	-
<i>Vitrina pellucida</i> (O. F. Müller, 1774)	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Nesovitrea hammonis</i> (Ström, 1765)	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Zonitoides nitidus</i> (O. F. Müller, 1774)	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-
<i>Euconulus alderi</i> (Gray, 1840)	-	-	-	-	+	+	+	+	-	+	+	-	-	-	-	-	-
<i>Euconulus fulvus</i> (O. F. Müller, 1774)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Fruticicola fruticum</i> (O. F. Müller, 1774)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Perforatella bidentata</i> Gmelin, 1791	+	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-

Park “Dolina Biebrzy” and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.6. $53^{\circ}39'20.1''N$, $22^{\circ}46'21.1''E$ (leg. UBB, ZK & BG), habitat code: 53.2

A wet sedge meadow of ca. 180 ha, in the valley of the Jegrznia river. The area is partly flooded, fairly open, shaded only on the edges. A dozen individuals of *V. angustior* and *V. moulinsiana* were found in the meadow. The site is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.7. $53^{\circ}35'21.9''N$, $22^{\circ}51'4.8''E$ (leg. UBB, ZK & BG), habitat code: 53.3

A moderately damp sedge meadow, partly shaded by alder and birch trees, ca. 23 ha in area. The site is located about 1.5 km west of the Kopytkówka river. Tens of individuals of *V. angustior* were found in the meadow. The site is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.8. $53^{\circ}42'14.3''N$, $23^{\circ}15'55.4''E$ (leg. UBB, ZK & BG), habitat code: 54.2

A calcareous fen, occasionally mown, bordered in its northern part by the Biebrza river, ca. 30 ha in area (Fig. 12). It is in part much shaded by shrubs and trees; the ground water level is disturbed by the ditches in its central part. Tens of individuals of *V.*

angustior were found in the fen. The site is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.9. $53^{\circ}42'44.1''N$, $23^{\circ}20'12.7''E$ (leg. UBB, ZK & BG), habitat code: 54.2

An alkaline fen of ca. 140 ha, scarcely shaded by shrubs and bordering the Biebrza river in its north-western part; only occasionally mown. Over a dozen individuals of *V. geyeri* and *V. angustior* were found in the fen. The site is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.10. $53^{\circ}42'33.3''N$ $23^{\circ}25'4.5''E$ (leg. UBB, ZK & BG), habitat code: 53.2

A sedge community dominated by *Carex vesicaria* overgrown by sparse alder trees, located about 1 km east of the Biebrza river. The area, of ca. 50 ha, is flooded. Tens of individuals of *V. moulinsiana* were found there. The site is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.11. $53^{\circ}44'9.1''N$, $23^{\circ}19'50.3''E$ (leg. UBB, ZK & BG), habitat code: 54.2

Alkaline mires of ca. 250 ha, in the vicinity of the Biebrza river. Over a dozen individuals of *V. angustior* were found in the vegetation dominated by *Equisetum fluviatile*, located on the edges of the site. The site



Fig. 12. Site 3.8 (Podlaskie province) in the Biebrzański National Park, habitat of *V. angustior*

is protected as part of the buffering zone of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.12. $53^{\circ}43'6.4''\text{N}$, $23^{\circ}17'55''\text{E}$ (leg. UBB, ZK & BG), habitat code: 54.2

A wetland complex including alkaline fens of different conservation status, largely overgrown by *Sphagnum* mosses and cranberry *Oxycoccus palustris* in its northern part, ca. 200 ha in area. The site is fairly open and wet during all seasons. Over a dozen individuals of *V. geyeri* were found in the fen. The site is protected as part of the Biebrzański National Park and within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.13. $53^{\circ}44'21''\text{N}$, $23^{\circ}16'09''\text{E}$ (leg. UBB, ZK & BG), habitat code: 54.2

A drained fen with characteristic plant species still remaining, e.g. *Liparis loeselii*. Habitat dominated by *Carex rostrata* and *C. appropinquata*, bordered with young alder forest and willow shrubs, ca. 50 ha in area. The fen is not mown and is undergoing secondary succession of vegetation. Its western part is crossed by numerous ditches, the eastern part holds old dikes, not maintained. Over a dozen individuals of *V. angustior* were found in the site. The area is located in the buffer zone of the Biebrzański

National Park and protected within Natura 2000 (Ostoja Biebrzańska, PLB200006 and Dolina Biebrzy, PLH200008).

Site 3.14. $53^{\circ}37'57''\text{N}$, $23^{\circ}28'40''\text{E}$ (leg. ŁK), habitat code: 54.12

An alkaline fen with calcareous tufa, ca. 0.5 ha in area (Fig. 14), partly dried out and overgrown with a reed bed (*Phragmites australis*) and alder trees. The moss layer consists of calcicole species: *Limprichtia cossonii*, *Philonotis calcarea* and *Fissidens adianthoides*; also calcicole orchids occur in the fen: *Epipactis palustris*, *Liparis loeselii* and *Dactylorhiza baltica*. Tens of individuals of *V. geyeri* and *V. angustior* were found there. The site is protected within Natura 2000 (Źródlika Wzgórz Sokólskich PLH200026).

Site 3.15. $54^{\circ}22'44.5''\text{N}$, $22^{\circ}53'08''\text{E}$ (leg. ŁK), habitat code: 54.2

A fairly open mire of ca. 4 ha, mainly composed of patches of well-preserved transitional bog with characteristic plants, such as *Empetrum nigrum*, *Oxycoccus microcarpus*, *Salix lapponum* and *Sphagnum fuscum*. In some patches the vegetation indicates alkaline soil (e.g. *Menyanthes trifoliata*, *Baeothryon alpinum*, *Dactylorhiza incarnata*). In such patches, in the S.W. part of the site, a few individuals of *V. angustior* were found. The site is protected within Natura 2000 (Torfowiska Gór Sudawskich PLH200017).

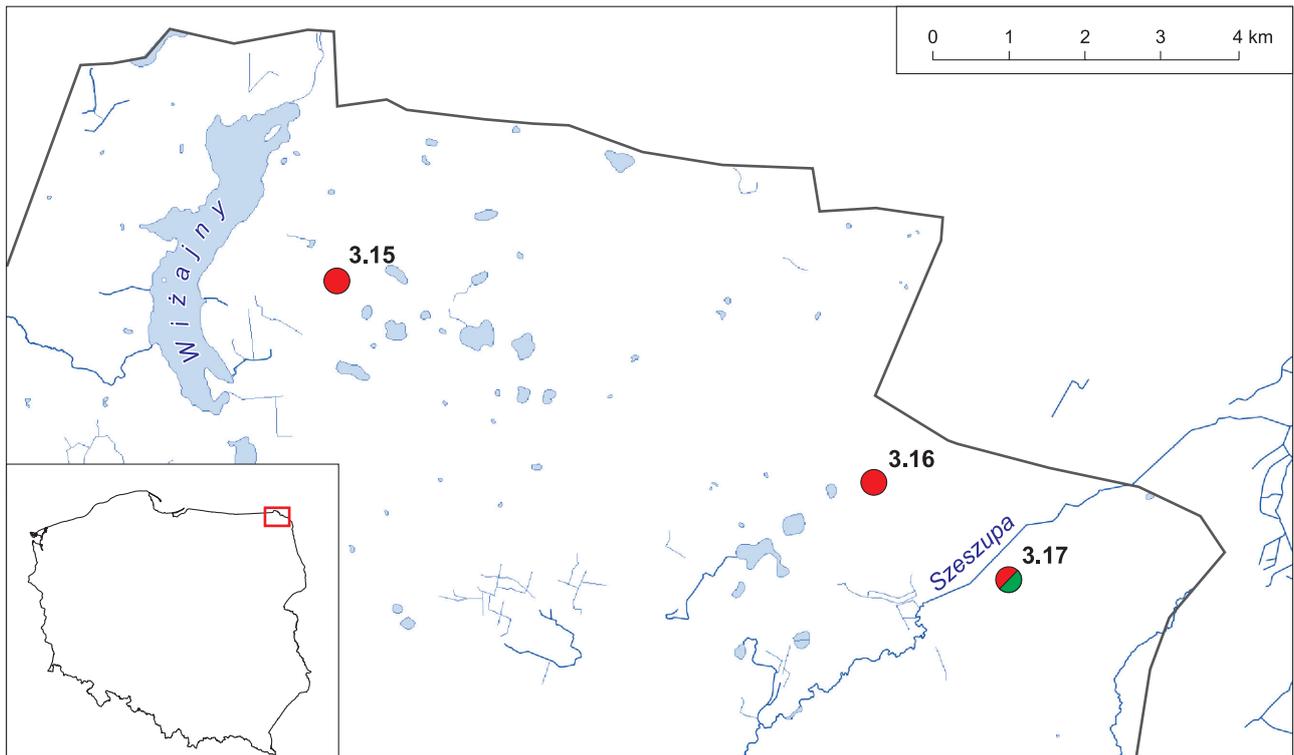


Fig 13. Distribution of sites 3.15–3.17 in the northern part of Podlaskie province: red circles – *V. angustior*, green circles – *V. geyeri*

Site 3.16. $54^{\circ}21'05''\text{N}$, $22^{\circ}59'33''\text{E}$ (leg. ŁK), habitat code: 54.2

A moderately rich fen of ca. 2 ha, bordering a lake. The area is fairly open and remains wet during the whole season. Calcicole mosses such as *Scorpidium scorpioides* and *Aulacomnium palustre* are abundant.

Also calcicole vascular plants are present, e.g. *Epipactis palustris*, *Utricularia intermedia* and *Menyanthes trifoliata*. One individual of *V. angustior* was found in the fen. The site is protected within Natura 2000 (Dolina Szeszupy PLH200016).



Fig. 14. Site 3.14 in the Natura 2000 area (Źródlika Wzgórz Sokólskich PLH200026), habitat of *V. geyeri* and *V. angustior*



Site 3.17. 54°20'20.5"N, 23°01'06"E (leg. ŁK), habitat code: 54.2

A partially drained calcareous spring fen of ca. 1.4 ha, located on a river's valley margin. In its upper spring part, the area is overgrown with *Petasites hybridus* passing into a rich fen and a *Carex rostrata* sedge-

moss meadow in seepage, drained areas. The site is partially shaded, overgrown with trees and becomes dry in summer. A few individuals of *V. geyeri* and tens of *V. angustior* were found in the fen. The site is protected within Natura 2000 (Dolina Szeszupy PLH200016).

CONCLUSIONS

V. moulinsiana and *V. angustior* were found in all of the studied provinces, namely: Wielkopolskie, Lubuskie and Podlaskie whereas *V. geyeri* was found only in Podlaskie province. The presence of *V. geyeri* may be limited to the eastern part of Poland because of the suitable climatic conditions and availability of favourable habitats: well preserved fens, which remain very damp during the whole year, where the ground water level is stable. Under somewhat similar conditions, *V. geyeri* is also known from spring fens in the mountains of southern Poland (e.g. HORSÁK & HÁJEK 2005, ZAJĄC et al. 2012). In Podlaskie province, *V. angustior* was recorded in alkaline patches of partially acidified habitats. At first glance such habitats seemed to be inadequate for

the species. However, the sites were previously alkaline, the acidification process was caused by the disturbed water level resulting in expansion of peat mosses. Thus, the first impression of vertiginid sites may be misleading and the suitability should be considered individually for each such site, taking into account also its history.

The knowledge of the distribution of *V. moulinsiana*, *V. angustior* and *V. geyeri* has increased significantly in recent years, and it may be necessary to re-evaluate their status in the Polish Red Data Book (POKRYSZKO 2004). However, it should be remembered that the presence of these species usually indicates valuable wetland ecosystems and thus they can be regarded as umbrella species.

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