

# CHANGES IN THE DISTRIBUTION OF *ANISUS VORTICULUS* (TROSCHER, 1834) (GASTROPODA: PLANORBIDAE) IN THE CZECH REPUBLIC, MONITORING AND NOTES ON HABITAT REQUIREMENTS

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**ABSTRACT:** The data on the distribution of *Anisus vorticulus* (Troschel) in the Czech Republic are summarised and analysed, including information on habitats, co-occurrence and monitoring data from selected sites. The species occurs mainly in the floodplains of the biggest Czech rivers. It has always been rare; in the Czech Republic it mostly inhabits small pools and oxbows. Stream regulation, eutrophication and destruction of sites have gradually caused a considerable decline in its population. Selected sites have been monitored since 1999. The highest recorded abundance is 632 specimens per monitoring plot (0.5×0.5 m) and generally fluctuates from 2 to 150 individuals per plot. The highest densities are usually recorded in pools overgrown with *Lemna trisulca*. A gradual decline or probable extinction have been documented; they mainly result from changes caused by natural succession. Intentional transfers (repatriations, introductions) of *A. vorticulus* have been tested and the results show that they may constitute a conservation measure.

**KEY WORDS:** *Anisus vorticulus*, distribution, habitat requirements, monitoring, Czech Republic

## INTRODUCTION

The Little Whirlpool Ramshorn Snail *Anisus vorticulus*, a Western Palaearctic species (TERRIER et al. 2006), is listed as critically endangered in the Czech Republic (BERAN et al. 2005); its extinction or a decrease in its population density have been observed in most European countries (VAN DAMME 2012). This dramatic change has made the species a candidate for inclusion in the EU Habitats Directive (proposal of the Czech Republic during expansion, 2004) (COLLING & SCHRÖDER 2006, ZETTLER & WACHLIN 2010). It is listed in both Annex II (species of community interest requiring special conservation areas) and Annex IV (strict protection) of the Directive. Its

inclusion was probably the main trigger for many studies throughout Europe (e.g. TERRIER et al. 2006, GLÖER & GROH 2007, ZETTLER 2013) and was also the main reason for a more detailed research in the Czech Republic.

The aims of this study were a) summarising and analysing the distribution of *Anisus vorticulus* in the Czech Republic and its changes, b) supplementing data on its habitat requirements and co-occurrence with other freshwater molluscs and c) summarising the first results of monitoring at selected sites in the Czech Republic.



## MATERIAL AND METHODS

Data used in this paper come from the author's database containing more than 57,000 records of aquatic molluscs in the Czech Republic. The records are a result of the author's own field research since 1993; some come from many published and unpublished papers, as well as private and museum collections since 1825. Most of the records of *A. vorticulus* since 1995 result from the author's field research. The main sampling method used was washing vegetation or sediments on a metal sieve (diameter 20 cm, mesh size 0.8 mm), combined with searching the surface of plants, stones, wood and artificial materials (e.g. plastic bags and bottles). All the data (94 sites) were used for the distributional analysis (including altitudinal range) while more complete data obtained by the author in 1995–2014 were used in the analysis of habitat preferences and co-occurrence (47 sites). Records of freshwater molluscs in

all the studied localities were used for the analysis of co-occurrence. Selected sites with *A. vorticulus* were monitored (in the beginning irregularly, then usually every two years, mostly in spring or summer) since 1999 (Appendix 1). A square frame of 0.5×0.5 m was used to sample; the vegetation and sediments were washed on a metal sieve (diameter 20 cm, mesh size 0.8 mm), and all freshwater molluscs were identified and counted. The vegetation was recorded, and the results were compared with the recorded abundance of *A. vorticulus*. Plants were identified to species or genus using KUBÁT et al. (2002), and the nomenclature followed the same publication. Freshwater molluscs were identified based on various shell characteristics and/or copulatory organs. Specimens for dissection were killed in hot water and then preserved in 70% ethanol. The classification used follows HORSÁK et al. (2013).

## RESULTS

### DISTRIBUTION IN THE CZECH REPUBLIC

#### U n t i l 1 9 4 9

There are no references to *Anisus vorticulus* in the oldest monograph of molluscs of the Czech Republic (SLAVÍK 1868). The first mention of the species was made more than twenty years later (ULIČNÝ 1892–95), recording its occurrence in pools of the Labe (Elbe) lowlands near Pardubice (eastern Bohemia, map. field 5959) and Neratovice (central Bohemia, 5753), while ZIMMERMANN (1916) found the snail in Moravia in the Dyje floodplain (Danube River basin) near Lednice (map. field 7166). Later, several sites were found in Bohemia in the Labe lowlands (e.g. LOŽEK 1946). In total, 27 records exist from the Czech Republic prior to the end of 1949 (Fig. 1). Most of them are concentrated in the Labe lowlands, but some are located in other areas (map. fields 5849, 5963).

#### 1 9 5 0 – 1 9 7 9

Only 20 records of the species were made in that period, all in lowland areas. Some of them were published (LOŽEK 1955, 1957, 1958, HUDEC 1956, 1962, BRABENEC 1976).

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There are no records until 1996; 23 sites were found from 1996 to 1999. The sites are mainly located in lowland areas along the Morava and Dyje Rivers in southern Moravia (BERAN & HORSÁK 1998, 1999); isolated sites were also found in Bohemia in the Labe lowlands (map. fields 5753, 5755, 5959) (BERAN

1997a, b, 1998), central Moravia in the Morava River basin (map. fields 6369) (BERAN 2000) and Moravian Silesia in the Odra River basin (HORSÁK 2000).

#### 2 0 0 0 – 2 0 1 4

In this period, and especially since 2004 (see: Introduction), much attention was given to the species' distribution which yielded more data. Its occurrence was verified at almost all of the historical sites, several new sites were found (e.g. BERAN 2002, 2010, BERAN & ŠKODOVÁ 2013) and selected sites were regularly monitored.

In total, there are 223 sets of data on the occurrence of *A. vorticulus* in the Czech Republic, covering 94 sites. The snail is mainly found in the floodplains of the biggest Czech rivers (Labe, Morava, Dyje, Bečva and Odra), and only several isolated sites are located outside these floodplains (Fig. 1). Sites with recent occurrence of *A. vorticulus* are scattered throughout the floodplains. The only exception is the Dyje and Morava floodplain in south Moravia where there are more than ten records (Fig. 1).

### ALTITUDE AND HABITATS

Nearly all known sites of *A. vorticulus* (92 out of 94) are situated at altitudes of 140 to 240 m (Fig. 2). Only two are located at 294 and 398 m.

Among the habitats, ditches, oxbows and sandpits (Fig. 3) combined constituted a similar proportion as pools (20 sites, 43%). Ponds (Fig. 4) and wetlands were the habitats at two and three sites, respectively. Pools in the floodplains of large rivers were the pre-

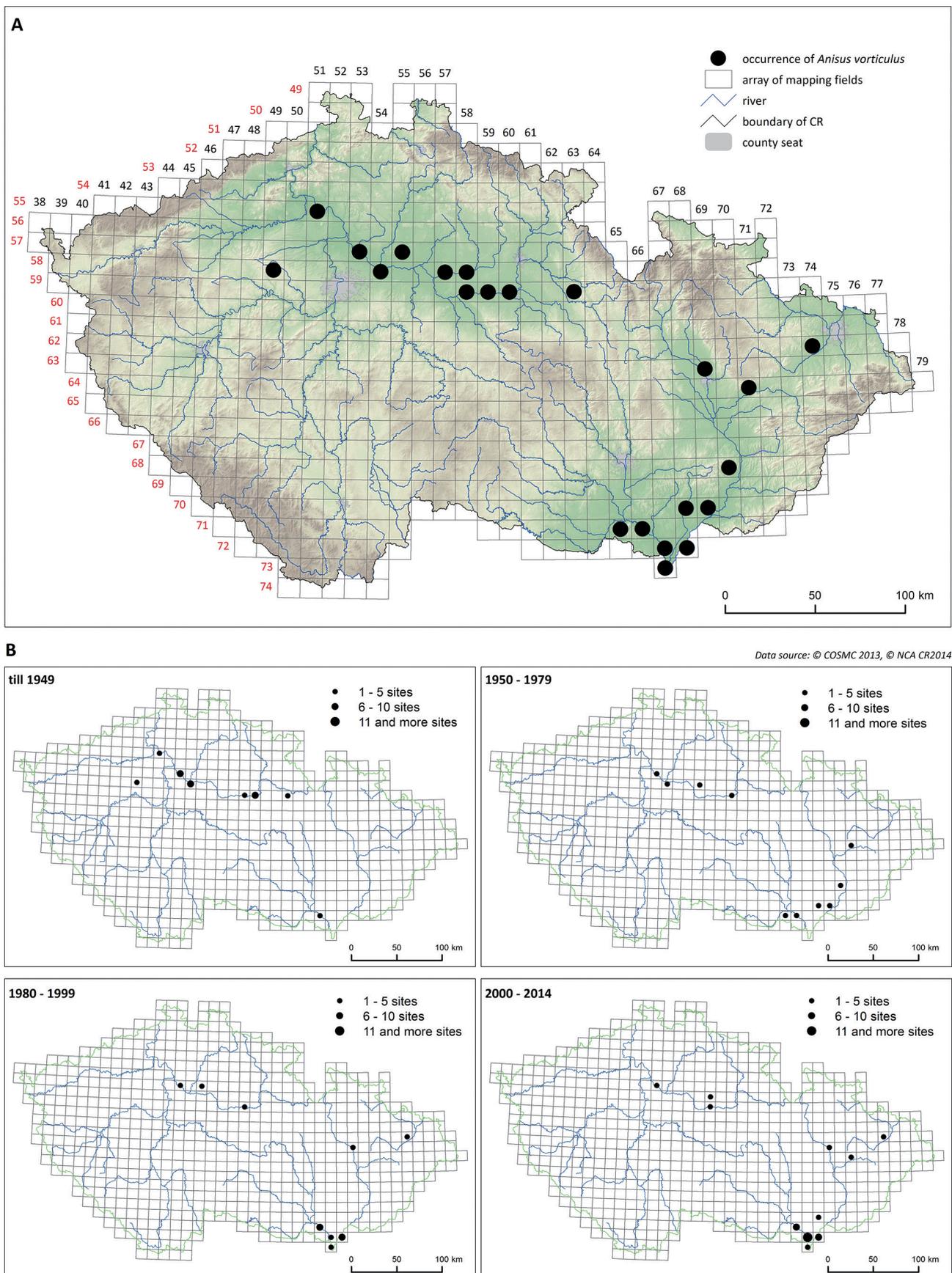


Fig. 1. Distribution of *Anisus vortivulus*: A – in the Czech Republic; B – distribution in different periods. Distribution without results of intentional transfer (see: [Appendix 2](#)). Drawn by J. VRBA

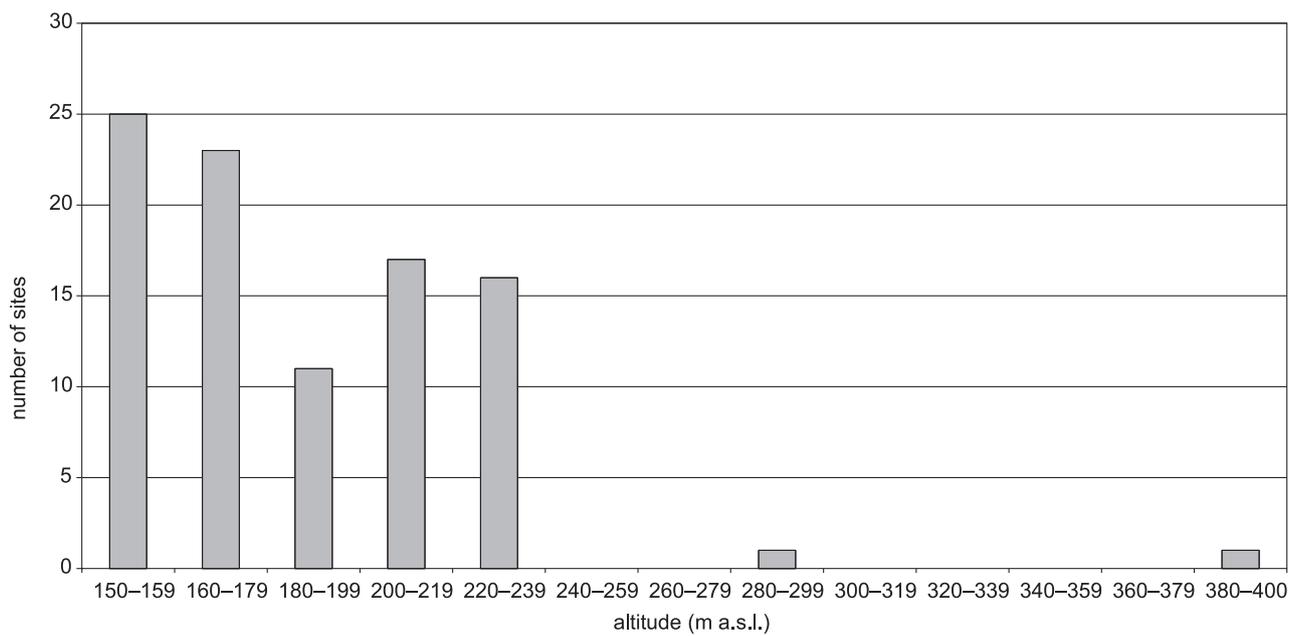


Fig. 2. Altitude of all sites with *Anisus vorticulus*



Figs 3–6. Localities of *Anisus vorticulus*: 3 – south-eastern pool in the sandpit near Týn nad Bečvou, overgrown by *Lemna trisulca* and *L. minor* until 2008 (site 5, [Appendix 1](#)); 4 – Písečný rybník Pond, one of the biggest sites with *A. vorticulus* (site 12, [Appendix 1](#)); 5 – pool Jelito in the Plané Loučky Nature Reserve, inhabited by an abundant population of *A. vorticulus*, in 2014 overgrown by *Hottonia palustris* (site 9, [Appendix 1](#)); 6 – pool near the Lány castle, dried up in 2012 but in 2010 and 2014 inhabited by an abundant population (site 19, [Appendix 1](#)). Photo: L. BERAN

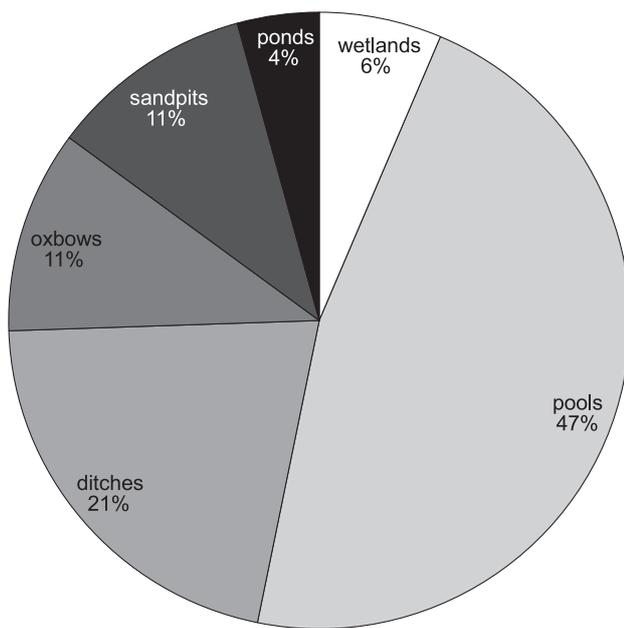


Fig. 7. Different types of habitats of *Anisus vorticulus*: wetland – shallow water body overgrown by aquatic macrophytes usually without open water surface, pool – shallow and small water body usually of natural origin, overgrown by aquatic macrophytes, with open water surface, ditch – elongated water body, usually artificial, oxbow – more extensive and deeper water body in a river floodplain, of natural origin and usually with banks and shallow parts overgrown by aquatic vegetation, sandpit – artificial water body created by sand or gravel quarrying, pond – artificial water body with a dam, usually used for fish production

ferred habitat for *A. vorticulus* (Figs 5–6). This was the case in 22 out of 47 sites (47%) studied since 1995 (Fig. 7).

Water bodies smaller than 0.1 ha were preferred (29, 62%); together with water bodies of 0.1–0.5 ha they constituted 85% of the sites of *A. vorticulus* (Fig. 8). The species was rarely found in larger water bodies, and only one site in the Czech Republic exceeded 10 ha.

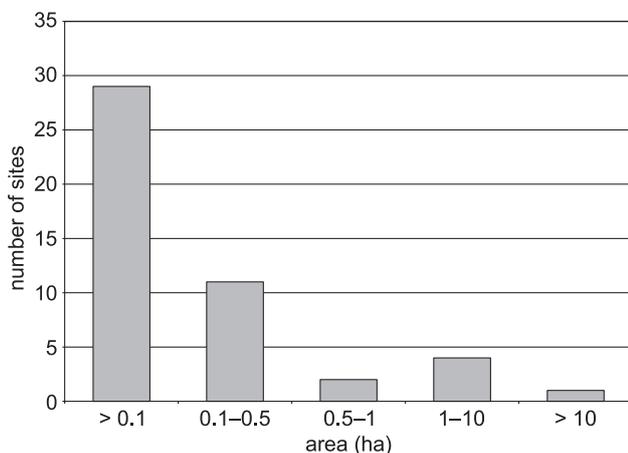


Fig. 8. Size of sites with *Anisus vorticulus*

*A. vorticulus* was mostly found in sunlit, well-vegetated water bodies. In larger water bodies or water bodies with more open water the species occurred mostly in overgrown littoral with diverse vegetation. Plants occurring typically in the habitats of *A. vorticulus* included *Lemna trisulca*, *L. minor*, *Spirodella polyrrhiza*, *Typha latifolia* (especially dead leaves), *Ceratophyllum* spp., *Batrachium* spp., *Glyceria maxima*, *Myriophyllum* spp., *Carex* spp. and *Hottonia palustris* (see also Appendix 1). The highest densities were usually found in pools overgrown with *Lemna trisulca* (Fig. 3). A decrease in this plant was documented during monitoring of selected sites.

### MONITORING

Nineteen selected sites in the Labe, Odra and Morava river basins (Fig. 9) were monitored (in the beginning irregularly, then usually every two years) since 1999 (Appendix 1). The trends varied between the sites and, consequently, those were divided in three categories (Figs 10A–C). A gradual decline and probable extinction were documented at several sites (Fig. 10A). At some localities the species was recorded rather sporadically (Fig. 10B), while other sites held more abundant populations (Fig. 10C), and often *A. vorticulus* was the dominant species. Although most sites were studied only once in two years, considerable fluctuations were observed. The highest recorded abundance was 632 specimens per plot (0.5×0.5 m); it usually fluctuated between 2 and 150 individuals per plot. The highest densities were usually recorded in sunlit pools overgrown with *Lemna trisulca*. In some cases, drying up of the habitat (pool) was observed, but the situation usually did not affect the population (site 19, see: Figs 6, 10C).

### CO-OCCURRENCE

In the 47 water bodies studied, *A. vorticulus* co-occurred with 42 molluscs. The richest site harboured 24 species. The frequency of co-occurrence of particular species with *Anisus vorticulus* varied considerably (Fig. 11). Species common in lowlands and inhabiting shallow and vegetated stagnant waters (*Planorbarius corneus*, *Planorbis planorbis*, *Anisus vortex*, *Lymnaea stagnalis*, *Stagnicola palustris*, *Hippeutis complanatus*, *Viviparus contectus*, *Valvata cristata*) dominated and occurred in more than half of the sites. Another 12 species (*Bithynia tentaculata*, *Radix auricularia*, *Gyraulus albus*, *Segmentina nitida*, *Gyraulus crista*, *Radix balthica*, *Acroloxus lacustris*, *Galba truncatula*, *Musculium lacustre*, *Bithynia leachii*, *Sphaerium nucleus*, *Pisidium obtusale*) co-occurred with *A. vorticulus* in 23 to 10 sites.

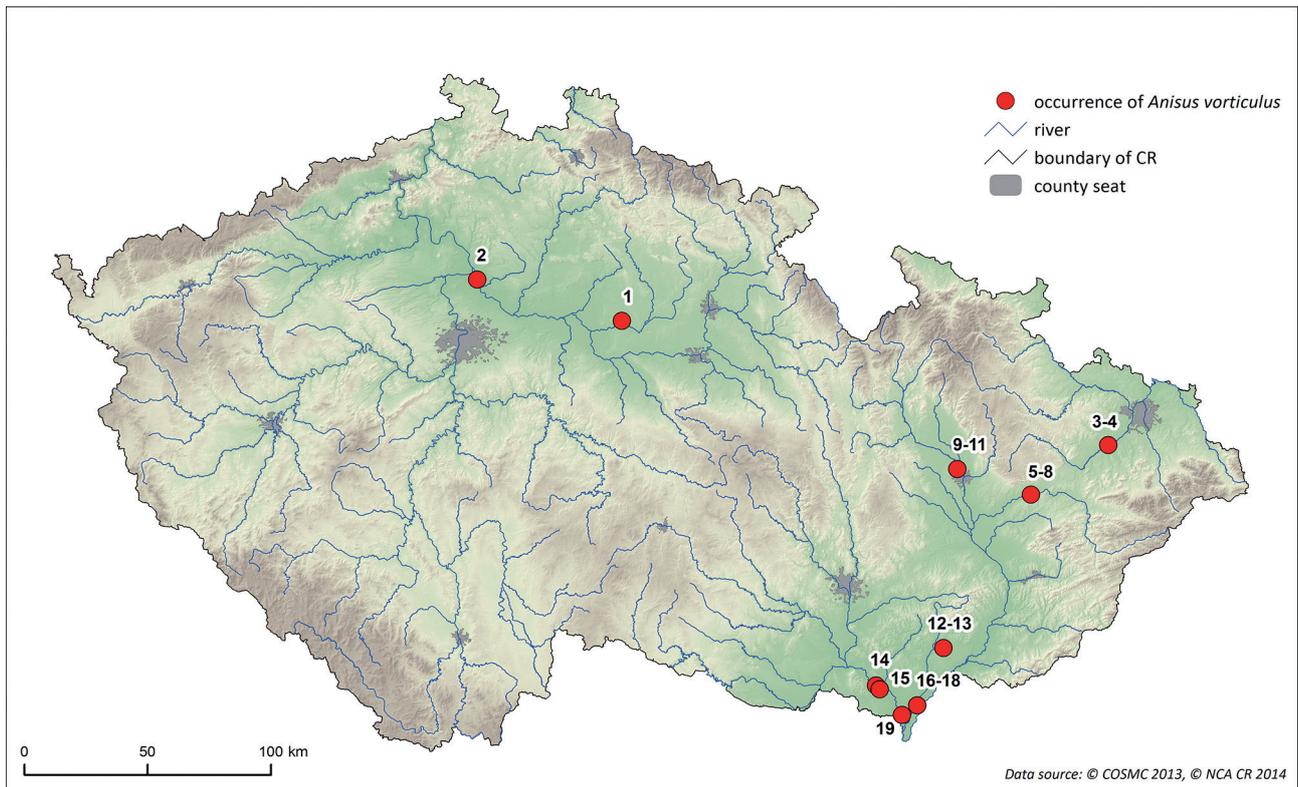


Fig. 9. Location of monitoring sites of *Anisus vorticulus* in the Czech Republic. For description of monitoring sites see Appendix 1. Drawn by J. VRBA

## REPATRIATION, INTRODUCTION

Intentional transfers (repatriations, introductions) of *A. vorticulus* started in 1997. The main reason was the small likelihood of the snail's spread to new sites after the regulation of rivers and loss of suitable habitat. Such new sites are rare and often very far apart. The results of the transfers are shown in Appendix 2. In all four cases the transfers were successful, although in the early years the presence of *A. vorticulus* was not usually observed because of the small population size that was probably below detection limits. An abundant population developed at only one site (Lázně Bohdaneč, see Appendix 2). However, at one site (Mělník), which was subject to eutrophication caused by ducks, the population of *A. vorticulus* died out. The experiment took place mostly in Bohemia (western part of the Czech Republic, Labe River basin) where there were a few remaining populations of the species. The material for the transfers was obtained from a single locality which was destroyed in 2006 (site 2, see: Appendix 1). In two cases (Lázně Bohdaneč, Libice nad Cidlinou), newly created pools were used for the transfer because in recent years there had been no suitable habitats for *A. vorticulus* in these areas. The pools were created

according to the management plans for both localities, which are protected areas (Lázně Bohdaneč – National Nature Reserve Bohdanečský rybník a rybník Matka, Libice nad Cidlinou – National Nature Reserve Libický luh). In the case of Lázně Bohdaneč *A. vorticulus* was transferred into one of eight new pools in 2002. The species colonised only this pool and a connected pool ca. 10 m away. None of the other pools, located at a distance of between 30 and 100 m, was colonised during the 12 years despite being almost identical in nature.

In Moravia (eastern part of the Czech Republic, Morava River basin) several specimens were transferred to an old pool overgrown with *Lemna trisulca* and *L. minor* in the Bečva River basin (Lipník n. B., Appendix 2). The material was collected at site Týn n. B. SE pool (see: Appendix 1), ca. 4 km from the site of introduction. This transfer was probably successful. In all the cases, material from the closest possible site was used for repatriation. This material was collected from the site and directly transferred.

Since 2009, transfers have also been attempted in other cases but it is too short a period for conclusive results. The breeding of the species has not yet been used for re-introduction purposes; in all cases individuals from the closest site have been transferred.

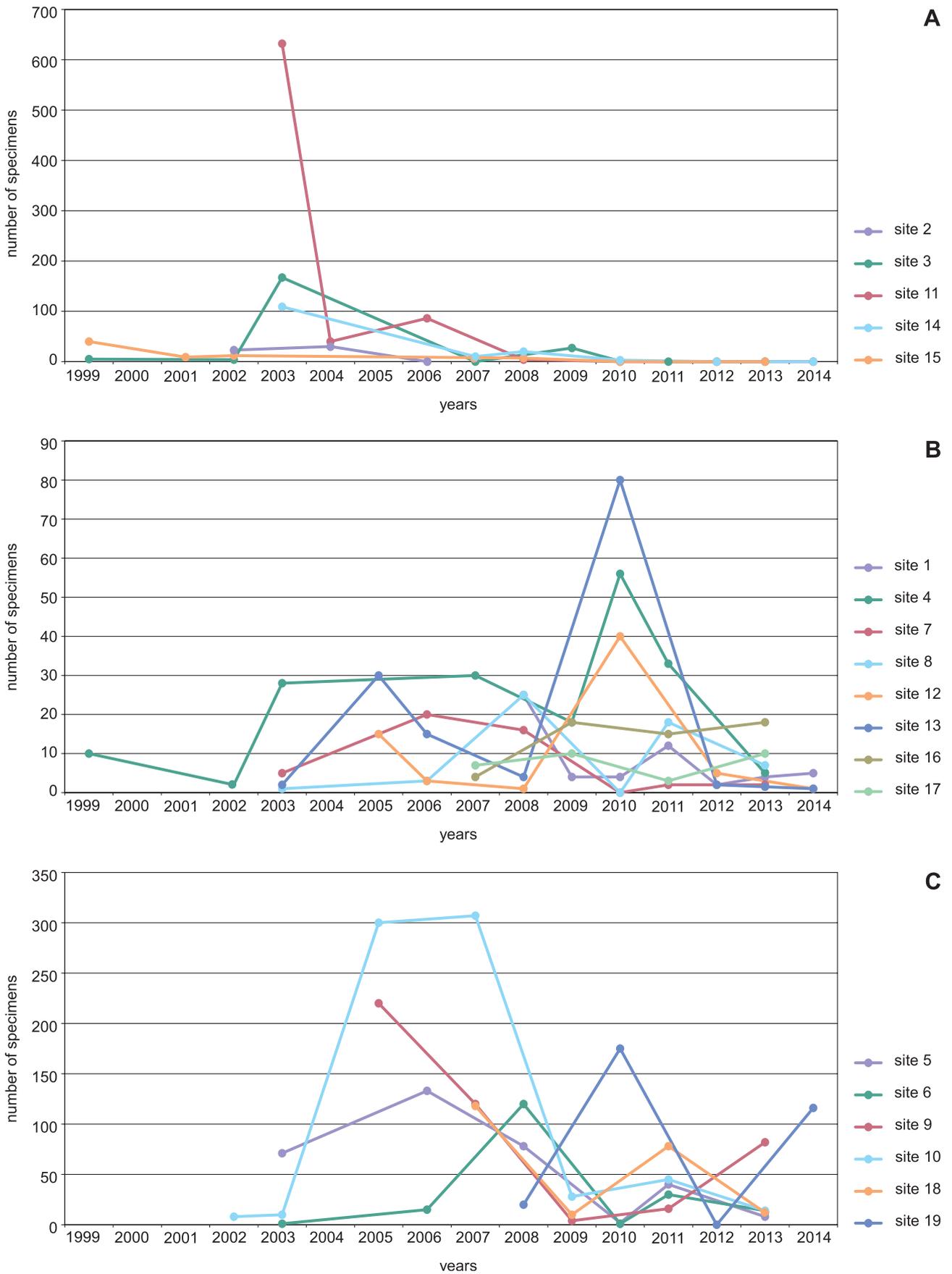


Fig. 10A–C. Number of recorded specimens of *Anisus vorticulus* at monitoring plots. For description of monitoring sites see Appendix 1, for their location see Fig. 9

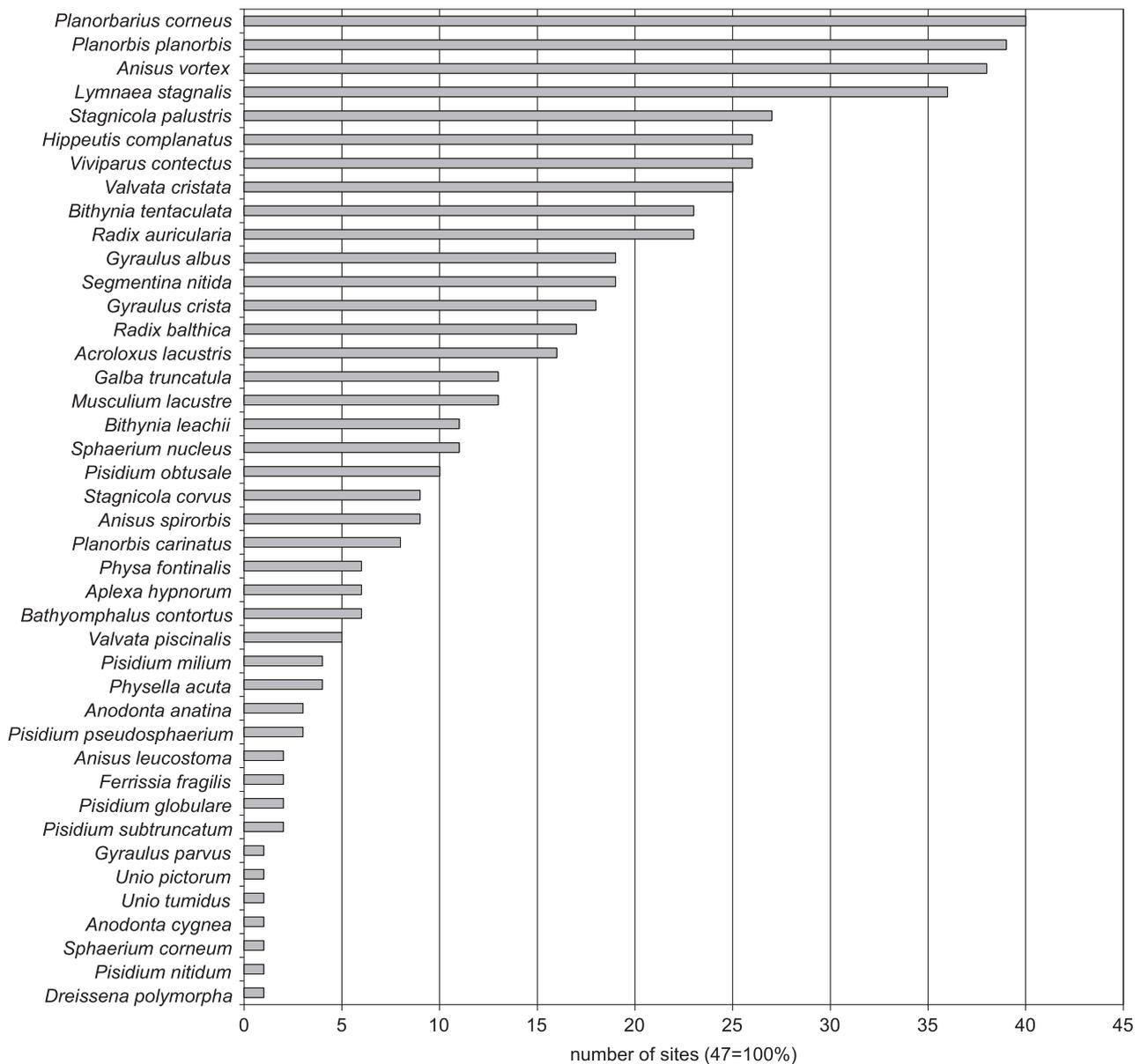


Fig. 11. Frequency of co-occurrence of particular species with *Anisus vorticulus*

## DISCUSSION

The Little Whirlpool Ramshorn Snail has been a rare mollusc in the Czech Republic since it was first recorded at the end of the 19th century. The nature of the landscape in the Czech Republic, which is predominantly above the altitude of 200 m and lacking extensive lowlands (compared to e.g. Poland or Germany to the north or Hungary to the south), is the main reason for its rare occurrence and its being limited almost exclusively to floodplains of the biggest rivers and adjacent areas. This is also the reason why most of the sites are at altitudes of 150 to 240 m.

The amount of information from particular periods varies. However, it is dependent on the activities of the specialists working at the time rather than on

changes in the snail's distribution. Especially during the last ten years the amount of available data on the occurrence of *A. vorticulus* increased, but this is primarily due to the increased interest in the species.

It can be assumed that, originally, the snail was more common on floodplains than it is today. Stream regulation, eutrophication and destruction of some sites caused a considerable decline in its population. The impact of regulation is especially visible when the Morava (lower river stretch) and Labe (Elbe) rivers are compared. In the case of the Morava River, the regulation was performed in the second half of the 20th century. At present, there is a large number of oxbows and pools with *A. vorticulus*. In con-



trast, the regulation of the Labe River was performed more than 100 years ago, and the Little Whirlpool Ramshorn Snail is almost extinct in its floodplains.

The rare occurrence of *A. vorticulus* in the Czech Republic is similar to the situation in many other European countries or their parts. In the neighbouring countries it is listed as “near threatened” in Poland (ZAJĄC 2005), “in danger of extinction” in Austria (FRANK & REISCHÜTZ 1994), and “critically endangered” in Germany (JUNGLUTH & KNORRE 2009) and Slovakia (ŠTEFFEK & VÁVROVÁ 2006). This species is also listed as “regionally extinct” in Saxony (SCHNIEBS et al. 2006). GLÖER & DIERCKING (2010) confirmed its rare occurrence in Hamburg where *A. vorticulus* was among very rare species.

The Czech Republic is poor in large natural water bodies (lakes) while its ponds are currently subject to significant eutrophication and overstocking, and dam reservoirs are situated outside the distribution range of *A. vorticulus*. In most cases the species is found in smaller pools and oxbows on floodplains, in contrast to the situation, for example, in north-western Germany where it is found mainly in larger glacial lakes (ZETTLER 2013), or to that in the western part of Croatia where large populations are found in the lakes of the Krka National Park (BERAN 2009, BERAN unpublished data). On the other hand, TERRIER et al. (2006) refer to various smaller water bodies on floodplains as the most typical habitat in many European countries; PIECHOCKI (1979) provides a similar information for Poland. KILLEEN (1999) and WATSON & ORMEROD (2004) found this species in relatively small ditches in England.

With regard to the creation of a number of larger secondary water bodies (sandpits on floodplains, extensive brown coal mines), in the future, the development of appropriate conditions can be expected in these habitats, while the condition of the pools and oxbows on the floodplains will, in the absence of proper management, rapidly deteriorate.

Published data on mollusc assemblages in which *A. vorticulus* occurs are poor. ZETTLER (2013) studied malacocoenoses of lakes, peat holes and fens in north-western Germany. *Valvata cristata*, *Bathymphalus contortus*, *Hippeutis complanatus*, *Bithynia tentaculata*, *Pisidium pseudosphaerium*, *P. obtusale*, *P. milium*, *Segmentina nitida*, *Gyraulus crista*, *Acroloxus lacustris*, *Stagnicola palustris*, *Anisus vortex* and *Bithynia leachii* were recorded in more than half of the 45 sites with *A. vorticulus*. The same author also compared sites with (45) and without (72) *A. vorticulus* and identified species typically co-occurring with it (*P. obtusale*, *P. milium*, *P. pseudosphaerium*, *B. leachii*, *S. palustris*, *V. cristata*, *B. contortus*, *B. tentaculata*, *A. vortex*, *H. complanatus*, *G. crista*, *Physa fontinalis*, *S. nitida*). This set was named “the *Anisus vorticulus*-community”. The results show a slightly different situation in the

Czech Republic where the most frequently encountered species, recorded at more than half of the 47 sites, include *P. corneus*, *P. planorbis*, *A. vortex*, *L. stagnalis*, *S. palustris*, *H. complanatus* and *Viviparus contectus*. The differences may be primarily due to differences in habitat: while in north-western Germany the sites studied were mostly lakes, peat holes and fens, in the Czech Republic the predominant habitats were mostly shallow pools, ditches, oxbows and sandpits. Data on the occurrence of freshwater molluscs from all the studied localities were used for the analysis of co-occurrence while ZETTLER (2013) used only data obtained from frames of 0.5×0.5 m. This may also explain the differences in the results.

*Anisus vorticulus* requires well-vegetated water bodies (PIECHOCKI 1979, BERAN 1997a, 2002, TERRIER et al. 2006) which was confirmed during this study. On the other hand, WATSON & ORMEROD (2004) found that the abundance of the species increased with abundance of floating plants, but decreased with abundance of submerged plants. This difference was not observed during the present study; on the contrary, the highest densities of *A. vorticulus* were usually observed in pools overgrown with *Lemna trisulca*, and also the monitoring results indicated that at some sites an abundant occurrence of *A. vorticulus* was associated with the presence of *Lemna trisulca*. In many other sites the species lived in littoral with diverse vegetation including floating, submerged and also emerged plants without any obvious preference to particular plant species or type of vegetation. Some authors (e.g. KILLEEN 1999, GLÖER & GROH 2007, GLÖER & DIERCKING 2010) also refer to preference to sunlit habitats, and a similar tendency was observed in this study.

The highest densities of *Anisus vorticulus* were found in pools overgrown with *Lemna trisulca*, where the greatest abundance was 632 specimens per plot (50 × 50 cm, that is, density of 2,528 ind./m<sup>2</sup>). This density was much higher than that mentioned in GLÖER & GROH (2007), who recorded the highest density of over 300 ind./m<sup>2</sup>, while GLÖER & DIERCKING (2010) in Hamburg observed 482 ind./m<sup>2</sup>. The density of 4 to 616 ind./m<sup>2</sup> was given by ZETTLER (2013). The differences in abundance and population size over the years were very significant; it is clear that under inappropriate conditions (e.g. drying) *A. vorticulus* can survive and, when suitable conditions return, it can quickly multiply to form an abundant population (see: Fig. 10C, site 19). GLÖER & GROH (2007) and GLÖER & DIERCKING (2010) mentioned the ability of this species to quickly multiply in suitable conditions, and GLÖER & GROH (2007) also stressed its ability to survive drying out in summer. It is possible that drying may lead to changes in the site (drying, mineralisation) and it may also extend the existence of shallow pools.



Although a simple sampling method was used, and the results could be affected by a number of factors (e.g. different life-cycle stages at the time of sampling), long-term changes could be detected in most of the monitored sites due to the relatively long period of monitoring. In many of them a gradual decline or probable extinction of *A. vorticulus* were observed, probably mainly resulting from changes caused by natural succession. In undisturbed floodplains the natural process is compensated for by creation of new sites, but new habitats cannot arise after river regulation. The problem can be solved by an appropriate management of the existing sites (e.g. felling of trees on banks, removal of sediment). The other possibility is transfer (introduction) to suitable habitats. This was tested in the Czech Republic at several sites within the snail's known range. The results showed that this might be a possible conservation measure. For now, only a direct transfer of individuals collected at the nearest possible location was used. According to G. Falkner (TERRIER *et al.* 2006) *A. vorticulus* can be easily bred in relatively small aquaria (about 0.5 to 1 litre, depth of water 4–5 cm). This allows for production of large numbers of offspring from very few parents within one or two years. The method should be tested under the conditions of the Czech Republic in the future.

## CONCLUSION

In the Czech Republic, the Little Whirlpool Ramshorn Snail is classified as Critically Endangered, and the results of the study confirm its status. *A. vorticulus* is almost extinct, and its habitats are gradually disappearing, primarily due to stream regulation and changes in land use. Without active support (renewal of pools, introductions) the reduction in the num-

The basic problem is that in the Czech Republic at present there are only a few suitable places for *A. vorticulus*. Sunlit and overgrown oxbows and pools have been slowly disappearing, and small sandpits in floodplains, which are appropriate for this gastropod, have been replaced by huge sandpits which are not yet suitable. In the last 10–15 years, however, creation and restoration of various pools (mostly sunlit and shallow) has become a regular part of the management of protected areas. These pools are usually created for amphibians, or aquatic invertebrates such as dragonflies, and can be used also for introduction of *A. vorticulus* within its known distribution range. Although the knowledge of ecological preferences is too scanty to specify the most suitable habitats for the species, in the case of abundant populations and/or sufficient numbers of bred individuals it is possible to transfer different numbers of snails to pools and thus substitute the role of floods or other natural vectors of its dispersal. The Czech Republic is situated on the watershed of three large rivers (Labe, Odra, Morava – a tributary of the Danube) belonging to three catchment areas (North Sea, Baltic Sea, Black Sea). Transferring material between the different basins does not seem advisable, which is a problem especially in the case of the Odra and the Labe river basins, where there are only few sites.

ber of sites where it may live is likely to lead to its extinction.

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## Appendix 1

Description of selected monitored sites with *Anisus vorticulus*. Abbreviations: m. field – code of mapping field for faunistic mapping (according to PRUNER & MÍKA 1996), alt. – altitude (m a.s.l.); Batspp. – *Batrachium* spp., Carspp – *Carex* spp., Cerspp – *Ceratophyllum* spp., Glymax – *Glyceria maxima*, Hotpal – *Hottonia palustris*, Hydmor – *Hydrocharis morsus-ranae*, Iripse – *Iris pseudacorus*, Junspp – *Juncus* spp., Lemtri – *Lemna trisulca*, Lemmin – *L. minor*, Nuplut – *Nuphar lutea*, Phrcom – *Phragmites communis*, Potpec – *Potamogeton pectinatus*, Spipol – *Spirodella polyrrhiza*, Typlat – *Typha latifolia*, Utraus – *Utricularia australis*

Site	Co-ordinates	M. field	Alt.	Years of monitoring	Area (ha)	Habitat	Vegetation
Labe River basin							
1. Kněžičky, wetland	50°09'42"N, 15°20'02"E	5858	233	08, 09, 10, 11, 12, 13, 14	0.15	shallow sedge marsh	Carspp, Phrcom
2. Kly, small sandpit	50°18'02"N, 14°30'26"E	5753	159	02, 06 (destroyed)	0.35	shallow sandpit	Typlat, Lemtri, Cerspp, Utraus, Glymax
Odra River basin							
3. Studénka, E pool	49°42'21"N, 18°04'56"E	6274	239	99, 03, 07, 09, 10, 11, 13	0.09	shallow pool	Glymax, Lemtri
4. Studénka, W pool	49°42'19"N, 18°04'46"E	6274	239	99, 03, 07, 09, 10, 11, 13	0.06	shallow pool	Lemtri (slowly decrease from dominant plant to less than 10%), Batspp, Potpec, Glymax, Carspp, Lemmin
Morava River basin							
5. Týn n. B., SE pool	49°31'36"N, 17°38'30"E	6471	238	03, 06, 08, 10, 11, 13	0.12	shallow gravel pit	until 2008 Lemtri (80–90%), Cerspp (5–10%), Lemmin, Carspp, from 2010 (after flood) nearly without Lemtri, w. surface almost without vegetation
6. Týn n. B., NE pool	49°31'37"N, 17°38'31"E	6471	238	03, 06, 08, 10, 11, 13	0.05	shallow gravel pit	Lemtri (30–60% of w. surface), Lemmin, Carspp, after flood in 2010 w. surface almost without vegetation
7. Týn n. B., SW pool	49°31'36"N, 17°38'29"E	6471	238	03, 06, 08, 10, 11, 13	0.01	shallow and overshadowed gravel pit	until 2008 Lemtri (90%), Lemmin, from 2010 (after flood) nearly without Lemtri, w. surface almost without vegetation
8. Týn n. B., NW pool	49°31'37"N, 17°38'29"E	6471	238	03, 06, 08, 10, 11, 13	0.06	shallow gravel pit	Lemtri, Carspp, from 2010 (after flood) nearly without Lemtri, w. surface almost without vegetation
9. Horka n. M., pool Jelito	49°37'24"N, 17°13'53"E	6369	220	03, 04, 06, 08, 10, 12, 14	0.01	shallow pool	Lemtri (decrease), Lemmin, Hydmor, Hotpal
10. Horka n. M., pool Izákova	49°37'24"N, 17°13'54"E	6369	220	03, 04, 06, 08, 10, 12, 14	0.02	shallow pool	Lemtri (decrease from dominant plant to less than 10%), Lemmin, Hydmor, Hotpal
11. Horka n. M., pool Kolečko	49°37'20"N, 17°14'02"E	6369	220	03, 04, 06, 08, 10, 12, 14	0.003	dredging pool	Lemtri, Lemmin
12. Milotice, W part of Písečný rybník Pond	48°57'44"N, 17°08'58"E	7068	184	03, 05, 06, 08, 10, 12, 14	10.1	fishpond	Typlat, Cerspp, Lemtri, Lemmin, Utraus
13. Milotice, E part of Písečný rybník Pond	48°57'51"N, 17°09'18"E	7068	184	03, 05, 06, 08, 10, 12, 14	5.6	fishpond	Typlat, Cerspp, Lemtri, Lemmin, Utraus



Site	Co-ordinates	M. field	Alt.	Years of monitoring	Area (ha)	Habitat	Vegetation
14. Nejdek, pool Bažina u Azantu	48°49'27"N, 16°46'37"E	7166	174	03, 07, 08, 10, 12, 14	0.3	shallow pool	Carspp, Junspp, Cerspp, Lemtri, Lemmin
15. Lednice, pool	48°48'36"N, 16°47'51"E	7166	165	99, 01, 02, 08, 10, 12, 13	0.1	shallow pool	Lemtri (abundant only in 1999), Glymax, Carspp
16. Tvrdonice, N pool	48°45'02"N, 17°00'10"E	7268	156	07, 09, 11, 13	0.2	pool	Spipol, Lemmin
17. Tvrdonice, oxbow	48°44'58"N, 17°00'10"E	7268	156	07, 09, 11, 13	1.1	oxbow	open w. surface with Nuplut, banks overgrown by Carspp, Glymax, Iripse, Phrcom, Lemtri
18. Tvrdonice, small pool	48°44'58"N, 17°00'04"E	7268	156	07, 09, 11, 13	0.05	shallow pool	Lemtri (30–70% of w. surface), Glymax, Carspp, in 2013 overgrown by Carspp without open w. surface
19. Břeclav, pool by the Lány castle	48°42'55"N, 16°55'10"E	7267	152	08, 10, 12, 14	0.45	shallow pool	Lemtri, Lemmin, Batspp,

## Appendix 2

Introduction of *Anisus vorticulus* and its results. Abbreviations: m. field – code of mapping field for faunistic mapping (according to PRUNER & MÍKA 1996), alt. – altitude (m a.s.l.), 97, 98, ..... 13, 14 – years (1997–2014); 20, 30, 50 – number of transferred individuals, – – visit without positive results, x – few specimens, xx – scattered occurrence, xxx – abundant occurrence, no mark – without visit

Site	Co-ordinates	M. field	Alt.	Habitat	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Labe River basin																						
Lázně Bohdaneč	50°05'56"N, 15°39'54"E	5959	218	shallow dredging pools						50	–	–			x	xx	xx			xxx		
Libice n. C.	50°07'03"N, 15°10'33"E	5857	190	shallow dredging pool								50			x	x	x	x	x		x	
Mělník	50°21'06"N, 14°29'14"E	5652	163	shallow sandpit	50	20	–	–	x, 50	x				–								
Morava River basin																						
Lipník n. B.	49°31'20"N, 17°35'53"E	6471	227	shallow pool												30			x		x	