



Distribution and ecology of *Wolffia arrhiza* (L.) Horkel ex Wimm. In the lowland part of Lower Silesia (Poland)

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Abstract

Genus *Wolffia* Horkel ex Schleiden (*Araceae*, former *Lemnaceae*) includes 11 species that are the smallest of known flowering plants. The genus is widespread in the world. In Europe, the only native species is *Wolffia arrhiza*. In Poland, it is considered to be relatively rare and until the end of the 20th century it was known from small number of populations dispersed throughout the country Poland. Our research focused on Lower Silesia population of *Wolffia arrhiza*. The study included the verification of historical sites of this species known from the literature and an inventory of the contemporary occurrence. It also aimed to explain the pattern of *W. arrhiza* occurrence in selected habitats and determine the ecological conditions and phytocoenoses of the reservoirs it inhabits. The research of the species showed extinction of historical sites and the current presence in 12 water reservoirs of different origin, size, depth and management method. The share of *W. arrhiza* in phytocoenosis patches in the individual reservoirs is very diverse and ranges from 15 to 80%. Presented data supplement the information on the occurrence of *W. arrhiza* in western Poland as well as provide new information on its biology and ecology.

Keywords Ecology · Floristic structure · Lower Silesia · New records *Wolffia arrhiza* (L.) Horkel ex Wimm

Introduction

The genus *Wolffia* (*Araceae*, former *Lemnaceae*) includes 11 species of the smallest of known flowering plants. The genus is widespread, it was noted all over the world excluding north-eastern Asia while in Europe only *Wolffia arrhiza* is a native species. In Poland, it is considered to be relatively rare and until the end of the 20th century it was known from a tens populations dispersed throughout the country. More often it was recorded in area of central Poland from western to eastern borders, rarely in northern and southern part of the country (Celiński 1954; Olaczek and Krzywański 1970; Tomaszewicz 1979; Samosiej and Kucharski 1986; Zając and Zając 2001). Currently, in Poland there is a constant increase in the number of localities of this species, which is particularly surprising when compared to the

small number of populations recorded in the 20th century (Dajdok and Proćków 2003; Janyszek and Grzelak 2007; Nowak and Cwener 2007; Wójciak and Urban 2009; Krawczyk 2010; Krechowski et al. 2010; Kościółek and Wołek 2011; Koprowski and Łachacz 2013). This tendency seems to be connected with the rise in temperatures in the winter season, which explains the increase in the number of other rare pleustonic species (Pietryka et al. 2018). The assessment of the number of *Wolffia arrhiza* sites has always been very difficult due to the fact that it is a highly mobile plant. Due to its small size and method of reproduction, it is easily transported by birds, by wind (snatched from dried up reservoirs) or by flood to other locations, but it also often disappears from the reservoirs it was present for longer periods (Garjeanne 1903; Afranowicz 2002). In Lower Silesia, *W. arrhiza* was reported in lowlands and Sudetes foreland from the vicinity of Wrocław, Wołów, Wińsko, Wąsosz, Żmigród, Prusice, Świdnica and Niemcza (Celiński 1954; Samosiej and Kucharski 1986). In 2003, it was included into regional red list as LC (Least Concern) (Kaćki et al. 2003). This study includes a revision of the historical sites of *Wolffia arrhiza* in Lower Silesia and the inventory of its contemporary sites. The research aimed to explain the pattern of *W.*

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Table 1 Site characteristics

Objects	Surface [a]	Depth [m]	pH	Conductivity [μ S/cm]	ATPOL/ coordinates of positions	Type of water reservoir	Human impact
1.Lenartowice	15	3–4	6.62–7.20	202.5–756.4	BE3716 51.24,16.80	mid-field reservoir	3
2.Głębowice	63.3	2–3	6.96–8.32	403.4–487.5	BE0782 51.45,16.74	pond	2
3. the “Łacha Jelcz” nature reserve	1.61	1.5–2	7.33–7.52	482.0–519.2	CE5180 51.01,17.30	oxbow lake	1
4.Wilkszyn	8.65	0.5–1.5	7.13–7.22	213.2–295.6	BE3880 51.19,16.86	pond	5
5.Wrocław Janówek, ecological side	3.17	0.1–0.5	6.36–6.89	200.5–211.3	BE3862 51.20,16.89	mid-forest reservoir	2
6.Wrocław, Janówek, by the Bystrzyca River	26.55	0.2–1.5	6.88–7.02	310.0–322.5	BE3883 51.18,16.90	oxbow lake	2
7.Wrocław, Nowa Karczma, ecological side	1.79	0.2–0.5	6.24–6.39	364.0–392.5	BE3884 51.18,16.91	mid-forest reservoir	2
8.Wrocław, Bystrzyca Valley Landscape Park	3.3	0.2–0.5	7.15–7.35	815.9–838.1	BE4759 51.12,16.84	pond	5
9.Wrocław, Pracze Odrzańskie	34.92	0.1–1.0	7.91–7.95	355.2–398.7	BE3893 51.17,16.89	oxbow lake	3
10.Skałka	36.18	2–3	7.20–7.92	372.8–432.1	BE4797 51.08,16.82	mid-field reservoir	4
11.Wrocław-Zgorzelisko	9.56	1–1.5	7.7–7.90	680.90–707.8	BE494 51.13,17.12	oxbow lake	4
12.Wilczyce	9.13	1.5–2.0	7.28–7.50	587.4–620.60	BE496 51.12,17.13	oxbow lake	3

arrhiza occurrence in selected habitats and determine the ecological conditions and phytocoenoses of the reservoirs it inhabits.

Materials and methods

The study was carried out in 2017–2021 in oxbow lakes and small water reservoirs in the lowland part of Lower Silesia. The research included the verification of historical sites of this species known from the literature and an inventory of the contemporary occurrence of *Wolffia arrhiza*. The reservoirs inhabited by *W. arrhiza* were assessed in terms of their origins, ecological conditions and anthropogenic changes. The degree of anthropopression was assessed on a five-point scale, where 1 means no human impact and 5 means significant intensity of anthropopression. Basic physico-chemical parameters of water (conductivity, pH) of the studied reservoirs were determined. Plants identified according to Rothmaler (2000, 2002) and Bog et al. (2020). Latin nomenclature of vascular plants was adopted after Mirek et al. (2020). Plant communities including the studied species were also analyzed nomenclature of syntax was given according to Matuszkiewicz (2011). The location of new *Wolffia arrhiza*. sites was done according to the ATPOL grid (Komsta 2016; Verey 2017).

Results

According to the literature data (Celiński 1953), in Lower Silesia 17 sites of *Wolffia arrhiza* were recorded,. Sites described in literature did not give precise location; the species presence was recorded from a certain zone, not from a specific water reservoir. The site found in the area given in literature was considered to be a confirmation of the historical data. Among the sites of *Wolffia arrhiza* in Lower Silesia known from the literature, only one seemed to be currently confirmed with sufficient probability. Generally, 6 sites have been recorded in Wrocław, including one still existing historical site described by Celiński (1954). Moreover, the inventory conducted in Lower Silesia lowland revealed the presence of *W. arrhiza* in 12 water reservoirs of different origin (e.g. mid-field reservoir or oxbow lake), size (from 1.79 to 63.3 a), depth (from almost dried up to several meters deep), and management method (Table 1). The share of *W. arrhiza* in phytocoenosis patches in the individual studied reservoirs was very diverse and ranged from 15 to 80% (Fig. 1).

A detailed characteristics of contemporary *Wolffia arrhiza* sites is presented below.

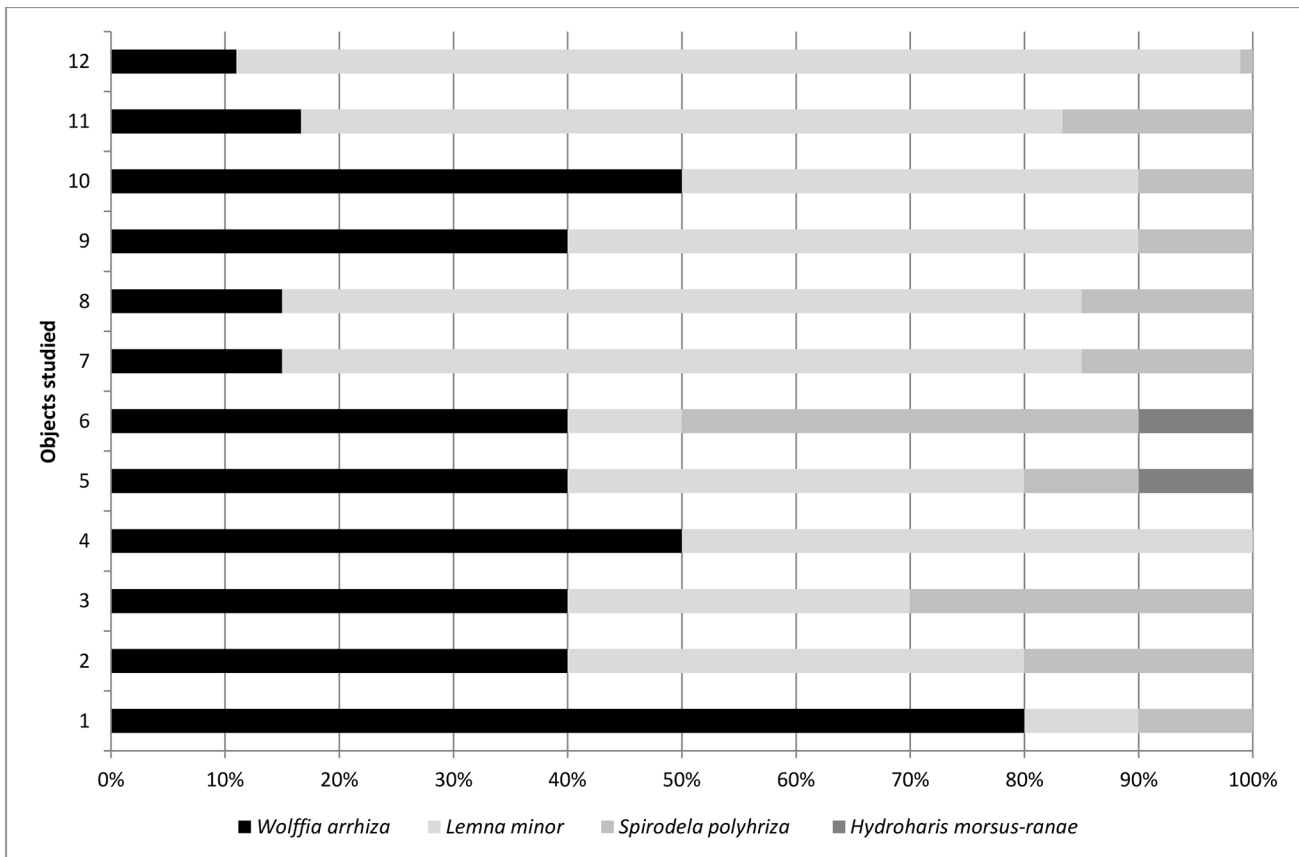


Fig. 1 Percentage of pleustonic species in the studied localities

Site 1 – lenartowice

A small, mid-field, endorheic reservoir adjacent to a large oxbow lake of the Oder River. The water surface of the reservoir was almost completely covered with pleustonic communities with a dominance of *Wolffia arrhiza* and a marginal share of *Lemna minor* L. and *Spirodela polyrhiza* (L.) Schleid. (Figures 1 and 2. a-b). The reeds were poorly developed, limited to the narrow belts of *Glycerietum maximae* Hueck 1931, *Typhetum latifoliae* Soó 1927, *Sparganietum erecti* Roll 1938 and *Caricetum acutiformis* Sauer 1937 with a share of *Acorus calamus* L., *Cicuta virosa* L., *Iris pseudacorus* L., *Rumex hydrolapathum* Hudson and *Juncus effusus* L., *Lysimachia vulgaris* L., *Lythrum salicaria* L., *Sanguisorba officinalis* L. The reservoir was surrounded by a belt of trees separating it from cultivated fields, a dirt road and a wet wasteland.

Site 2 – Głębowice

A pond in a neglected rural park, used only by a few anglers. The water surface was covered with a very dense mosaic of pleustonic communities, composed mainly of *Lemna*

minor and *Spirodela polyrhiza*, with a small share of *Wolffia arrhiza* (Figs. 1 and 2L). The reeds were well-developed in some places, built by patches of *Typhetum latifoliae*, *Sparganietum erecti*, *Glycerietum maximae* and *Phragmitetum australis* (Gams 1927) Schmale 1939. There was a visible share of *Glyceria maxima* (Hartm.) Holmb., *Iris pseudacorus*, *Rumex hydrolapathum* Hudson., *Scirpus sylvaticus* L. in the pond.

Site 3 – the “Łacha Jelcz” nature reserve

A small water reservoir, located opposite a large oxbow lake which is habitat to the protected species *Trapa natans* L., not exposed to any anthropogenic pollution. The water surface was almost completely covered with pleustonic communities of *Lemna minor*, *Spirodela polyrhiza* and *Wolffia arrhiza* (Figs. 1 and 2g). The reeds were poorly developed, occurred only narrow belt of *Glycerietum maximae* and *Caricetum acutiformis* with a share of *Cicuta virosa* and *Iris pseudacorus*. The site was shaded by the surrounding trees.

Fig. 2 *Wolffia arrhiza* sites: **a–b** Lenartowice, **a** a view of the mid-forest water reservoir, **b** *Wolffia arrhiza*, *Spirodela polyrhiza* and *Lemna minor*, **c–e** Wilkszyn, **c** a view of the church pond, **d–e** *Wolffia arrhiza*, *Lemna minor*, **f** Nowa Karczma – ecological site, a view of the mid-forest water reservoir, **g** “Łacha-Jelcz” nature reserve, a view of the oxbow lake, **h–j** Janówek – ecological site, **h** a view of the mid-forest water reservoir, **i–j** *Wolffia arrhiza*, *Spirodela polyrhiza* and *Lemna minor* L., **k** Janówek – by the Bystrzyca River, *Hydrocharis morsus-ranae*, *Wolffia arrhiza* and *Lemna minor*, **l** Głębowice, a view of the pond



Site 4 – Wilkszyn

A small rural water reservoir with artificial outlet, surrounded by mowed anthropogenic grasslands adjacent to dirt roads. The reservoir was subjected to very strong human pressure. It was almost completely covered with pleustonic communities with an equal share of *Lemna minor* and *Wolffia arrhiza* (Figs. 1 and 2c-e). The reeds were poorly developed and were mainly composed of small patches of *Phragmites australis*, *Sparganium erectum* and *Glycerium plicatum* (Kulcz. 1928) Oberd. 1954 with a small share

of *Carex acutiformis* Ehrh., *Carex gracilis* Curtis, *Phalaris arundinacea* L., *Typha latifolia* L.

Site 5 – Wrocław, Janówek, an ecological site

A small, mid-forest reservoir almost completely covered with pleustonic communities with a significant share of *Wolffia arrhiza* and *Spirodela polyrhiza* and a smaller share of *Lemna minor* and *Hydrocharis morsus-ranae* L. (Figures 1 and 2h-j). The rush vegetation was underdeveloped, limited to small patches of *Caricetum acutiformis*, *Caricetum gracilis* (Graebn. et Hueck 1931) R. Tx. 1937

and *Glycerietum plicatae*. The reservoir was not exposed to anthropogenic transformations and was completely not exploited by humans.

Site 6 – Wrocław, Janówek, by the Bystrzyca River

Elongated, u-shaped oxbow lake of the Bystrzyca River, exposed to surface run-off from cultivated fields in the eastern part. The shaded part of the reservoir was without pleustonic communities, while in the well-lit part, the water surface was covered with pleustonic communities with a significant share of *Wolffia arrhiza* and *Spirodela polyrhiza* and a smaller share of *Lemna minor*. The accompanying species were *Ceratophyllum demersum* L. and *Hydrocharis morsus-ranae* (Figs. 1 and 2k). The reeds were well developed, consisting of mosaic patches of *Phragmitetum australis*, *Caricetum gracilis* and *Caricetum acutiformis*, with a share of *Butomus umbellatus* L., *Iris pseudacorus* and *Phalaris arundinacea*.

Site 7 – Wrocław, Nowa Karczma, an ecological site

A small fragment of an oxbow lake of the Oder River, no longer connected to the original reservoir, shallow and shaded, difficult to access and not exposed to anthropogenic influence. The water surface was covered with dominant *Lemna minor* with a small share of *Wolffia arrhiza* and *Spirodela polyrhiza* (Figs. 1 and 2f). The reeds composed of *Glycerietum maximae* and *Glycerietum plicatae* patches were well developed.

Site 8 – Wrocław, Bystrzyca Valley Landscape Park

An elongated, narrow (3 m) ditch with stagnant water, widening from the western side into a small, semicircular pond. The reservoir and its banks were subject to very strong human pressure. Reed vegetation appeared only in the form of narrow belts of *Phalaris arundinacea*, *Phragmites australis* (Cav.) Trin. ex Steud) and clumps of *Iris pseudacorus* and *Typha latifolia* L. The water surface was covered with pleustonic communities dominated by *Lemna minor* with a very small share of *Wolffia arrhiza* and *Spirodela polyrhiza* (Fig. 1).

Site 9 – Wrocław, Pracze Odrzańskie

A significantly elongated, narrow and curvy oxbow lake, very shallow in some places, with an advanced terrestrialization process. The water surface was covered with *Lemna minor* as a dominant species, with a significant share of *Wolffia arrhiza* and a smaller share of *Spirodela polyrhiza* (Fig. 1). *Ceratophyllum submersum* L. is abundantly

present in the water depths. In the reeds, individual patches were quite clearly demarcated from each other and show a mono-species character. The dominant patches were *Typhetum latifoliae*, *Phragmitetum australis*, *Caricetum gracilis*, *Caricetum acutiformis* and *Sparganietum erecti*. The reservoir was exposed to surface runoff from adjacent gardens and anthropogenic influence from the nearby settlement.

Site 10 – Skalka

A shallow pond, heavily polluted with municipal waste, located adjacent to cultivated fields. The water surface is almost completely covered with pleustonic communities dominated by *Lemna minor* and *Wolffia arrhiza* with a small share of *Spirodela polyrhiza* (Fig. 1). Moreover, *Ceratophyllum demersum* was found in the depth. Well-developed reeds consisted of a mosaic of *Phragmitetum australis*, *Glycerietum maximae*, *Typhetum latifoliae*, *Caricetum gracilis*, *Caricetum acutiformis* and *Phalaridetum arundinaceae* (Koch 1926 n.n.) Lib. 1931 patches.

Site 11 – Wrocław – Zgorzelisko

The old river bed of Widawa River, elongated and bent in the shape of a boomerang with the arms pointing to the west. From the north and north-east, it was adjacent to the flood embankment and a narrow belt of trees at its base; on the other sides, it bordered by a mosaic of semi-natural meadow and rush inter-embankment communities (the land form of *Phragmitetum australis*), small trees, and poorly developed shrubs in the form of willow thickets. Littered. Poorly developed pleustonic communities were dominated by *Lemna minor*, and accompanied by *Wolffia arrhiza* and *Spirodela polyrhiza*. In the subsurface layer, there was a significant share of *Ceratophyllum submersum*. The rush was well-developed in the southern and south-western parts, dominated by *Caricetum gracilis* with a share of *Rorippa amphibia* (L.) Besser, *Iris pseudacorus*, *Rumex hydro-lapathum* Hudson, *Lythrum salicaria* L., and *Oenanthe aquatica* (L.) Poir. Less developed strips of *Glycerietum maximae* and clumps of *Iridetum pseudacori* also occurred.

Site 12 – Wilczyce

An elongated, boomerang-shaped old river bed of Widawa River, with the arms facing to the south-west. From the north and north-east, it bordered by the flood embankment and a belt of trees at its base; on the other side by the semi-natural meadows and rushes. The reservoir was overgrown with rushes, but the free water surface opened in several places. In each such “bay”, the coverage of pleustonic communities was slightly different. Pleustonic communities

were well-developed, with the dominance of *Lemna minor*, a variable share of *Wolffia arrhiza* and a slight accompaniment of *Spirodela polyrhiza*. In rush, the monospecific form of *Phragmites australis* dominated, it overgrew the banks and a significant part of the reservoir's canopy. Less developed patches of *Glycerietum maximae*, stripes of *Caricetum gracilis*, and small-area clumps of *Iridetum pseudacori* occurred mainly in the eastern and western ends of the reservoir. They were accompanied by *Rumex hydro-lapathum*, *Lysimachia vulgaris* L., *Lythrum salicaria* and *Acorus calamus*.

Discussion

The first sites of *Wolffia arrhiza* in Poland were found in the middle of 19th century in the western part of the country, where the climatic conditions were most favorable for the growth and development of this plant (Fiek 1881). Until recently, *Wolffia* was considered a rare or even receding sub-Atlantic species and is included into The Red List of Vascular Plants of Lower Silesia (Category of threat in Lower Silesia – LC – Least Concern) (Kącki et al. 2003). In recent decades, however, new *Wolffia* populations have been recorded in Central and Northern Europe. Moreover, there was the first report of the flowering of the species from Germany, so far considered sterile in this part of the continent (Schmitz and Kelm 2017). In Poland, the populations/sites of *Wolffia arrhiza* appeared even in the coldest, north-eastern part of the country (Endler and Juśkiewicz 1996; Falkowski 1999; Afranowicz 2002; Endler and Grzybowski 2002; Falkowski and Nowicka-Falkowska 2004; Czerpak and Piotrowska 2005; Piotrowska et al. 2008). These facts seem to be related to the gradual warming of the climate.

The submitted studies supplement the information on the current distribution of *W. arrhiza* in the area of Lower Silesia. Twelve sites were found in the research area, of which 11 were new and one was probably a confirmation of the historical position recorded in Wrocław in the 1950s. (Celiński 1954). Other historical sites have not been confirmed. This fact may indicate the disappearance of the population in the analyzed reservoirs, but also partly results from the imprecise location of the old sites. On the other hand, new sites of this species were found during the search for historical populations and extending the search to the surrounding reservoirs. It is also surprising that most of the new *Wolffia* sites occur in bodies of water close to other reservoirs, but where the species has not been found.

The distribution of other pleuston species populations confirms that they often form abundant phytocoenoses in one water body, but are not found in the nearby one, often in the immediate vicinity (Keddy 1976; Pietryka et al. 2018).

The analysis of the method and dynamics of colonization by species belonging to the former *Lemnaceae* family is difficult and it is still problematic to formulate a pattern for this process. This also applies to *Wolffia arrhiza*. Its occurrence is very labile; on a site abundant in specimens in a given growing season, in the next season there may be no plants at all. Garjeanne (1903) already observed the high mobility of the *Wolffia* population and linked it to its small size. Small plants can be carried by flood like other water taxa, but also by waterfowl or even by wind from dry reservoirs. However, this does not explain the presence of *Wolffia* in one reservoir, and its complete absence in another located in close vicinity. In Lower Silesia, the alternating abundant occurrence or complete disappearance of the *W. arrhiza* has been recorded since 2003 in three reservoirs in Nowa Karczma and Janówek in Wrocław. In the course of the current research, the species was not found in these sites, but it was abundant in another, located in the same ecological site.

Not only is the occurrence of the plant itself variable, but also the systems of phytocoenoses created by this species are labile. The species composition of pleustonic communities is the result of quite random processes, such as the presence of waterfowl, anthropogenic changes, and weather conditions (Diekjobst 1983; Dajdok and Proćków 2003; Koprowski and Łachacz 2013). Most often, *Wolffia* coexists with *Spirodela polyrhiza*, *Lemna minor* and *Hydrocharis morsus-ranae*, often being the dominant in phytocoenoses. It can also form single-species patches, form synusia in plots of other phytocoenoses or penetrate the reeds zone, forming complex communities (Mical et al. 1997; Fischer 2006).

The conducted research confirmed that in some of the studied reservoirs, *Wolffia* definitely co-dominates in pleuston, accompanied by *Lemna minor* and *Spirodela polyrhiza*. Pleuston plants usually formed a thick coat cover on the surface of the reservoir, causing very strong shading of the deeper layers, which in most of the analyzed cases resulted in a lack of underwater vegetation. The presence of *Ceratophyllum demersum* or *Ceratophyllum submersum* was recorded only in three reservoirs. They are species which tolerate light deficiency quite well (Tomaszewicz 1979; Podbielkowski and Tomaszewicz 1982; Samosiej and Kucharski 1986). Overall, it can be seen that the phytocoenoses with *Wolffia arrhiza* in these habitats are rather poor, with low species diversity, because the thick and dense coat mat limits the development of underwater vegetation. By causing partial or complete elimination of other species of aquatic plants, they ultimately lead to the floristic poverty of reservoirs (Samosiej and Kucharski 1986; Czerpak and Piotrowska 2005).

It is difficult to clearly define the habitat requirements of *Wolffia*. It was reported from various reservoirs of anthropogenic origin (post peat bogs, ponds, ditches, canals) or

small natural reservoirs (oxbow lakes, midfield depressions) were usually under the constant influence of human activity like runoff of fertilizers from fields and leachate from animal husbandry, watering holes, etc. (Samosiej and Kucharski 1986; Afranowicz-Cieślak and Koziura 2011; Koprowski and Łachacz 2013). Some researchers consider *Wolffia arrhiza* to be a pioneer species, resistant to changing ecological factors due to its ability to change nutrition methods (autotrophy, mixotrophy, and even heterotrophy) and the ability to fix atmospheric nitrogen. The species is attributed a significant tolerance to the pH level, trophic, temperature as well as type, depth, shading or management method of the reservoir. It also has a wide tolerance to toxic factors, e.g. chemical pollution (Mical et al. 1997; Czerpak and Piotrowska 2005; Suppadit et al. 2008). Koprowski and Łachacz (2013) report a conductivity in the range of 210–654 $\mu\text{S}/\text{cm}$ and a neutral to alkaline pH 6.64–7.85 for the *Wolffia* sites in post-peat pits as typical for the growth of lemniids. On the other hand, Diekjobst (1983) gives a pH range of 4.8–5.0 (conditioned by acid rain) and a conductivity of 260–310 $\mu\text{S}/\text{cm}$ from a pond on the edge of the Ruhr (Germany). The ability to withstand such low pH values proves the species' significant plasticity.

This is confirmed by the current research on new habitats of *Wolffia* in Lower Silesia. In the analyzed reservoirs, the habitat conditions varied both in terms of pH and conductivity. Their pH ranged from 6.24 to 8.32, and the conductivity range was 202.5–756.4 $\mu\text{S}/\text{cm}$. The reservoirs, depending on their size and surroundings, were at least partially shaded, but *Wolffia* also occurred in places highly exposed to sunlight. It is also impossible to define these habitats in terms of depth – they were both deep and very shallow, or actually drying out. There was also no connection between anthropogenic influence and the occurrence of the species; *Wolffia* occurred equally well in highly exposed reservoirs and those entirely without anthropogenic pressure.

It is surprising, however, that in some cases the reservoirs covered with *W. arrhiza* were located in close proximity to others with similar physico-chemical parameters, but where this species did not occur. Despite its lability and apparent ease of transfer to other sites, *Wolffia* does not inhabit all the reservoirs located in the closest distance, although pleustonic plants from lemniids were present there. It is all the more surprising that *W. arrhiza* is able to double its numbers after only 30 days (in sewage after only 14 days) by vegetative reproduction. It is much faster than other species from the lemniids (Czerpak and Piotrowska 2005; Piotrowska et al. 2008). The absence of *Wolffia* in the reservoirs in the immediate vicinity is all the more difficult to explain as it moves quite quickly to other, distant sites. Local transfer of these small plants by birds should result in the colonization of the closest reservoirs, because live specimens

die quickly without water (Diekjobst 1983). Perhaps the factor limiting its occurrence is the competitive relationship between aquatic plants. Macrophyte allelopathy is not yet fully understood, but it is known that allelochemicals often inhibit many physiological processes in other types of aquatic vegetation (Gostyńska et al. 2022). The reservoirs in the immediate vicinity of the new *Wolffia* sites were inhabited by *Nuphar lutea* (L.) Sm. and *Nymphaea alba* L. The proliferation of pleustonic communities may adversely affect nymphaeid populations by, for example, shading the lower part of the petioles. The ability of nymphaeids to secrete allelopathic compounds may limit the development of pleustonic species (Gross 2003). It could be one of the reasons why *Wolffia* is absent in neighboring reservoirs.

The problem of inhabiting these particular water reservoirs still requires careful analysis. The recorded increase in the number of *Wolffia* populations in Poland will allow for wider research aimed at defining the habitat requirements of the species. Thanks to this, it will be possible to answer the question why its occurrence is so variable.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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