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THE CONTEMPORARY DISTRIBUTION OF THE AQUATIC TERTIARY RELICT PLANT SPECIES OF THE BERN CONVENTION IN EASTERN POLESYE

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Abstract:
In spite of modern trends in the development of the eastern Polesye flora, the relict have been preserved in the aquatic ecotopes of Europe, including eastern Polesye. The paper highlights the peculiarities of the distribution in the region of three aquatic Tertiary relics preserved by the Bern Convention. According to the results of a field research, the degree of a modern rarity of the aquatic relict species in eastern Polesye was established, in particular, a very rare species (*Aldrovanda vesiculosa*), a moderately rare species (*Trapa natans*) and a relatively rare species (*Salvinia natans*). The current distribution of these relict species in the region has been positively affected by the increase in the values of maximum temperatures and isotherms of the summer months. A negative impact is made by the abrupt changes in the hydrological regime and the growth of anthropogenic eutrophication of reservoirs. *Aldrovanda vesiculosa* eliminates with minor changes in living conditions; *Salvinia natans* is the most tolerant to anthropogenic factors, but shows annual fluctuations in numbers; *Trapa natans* is stable distributed and has a tendency to expanding of its populations. The relics are the dominants of the *Salvinio–Spirodeletum* (polyrrhizae), *Lemno–Utricularietum vulgaris*, *Spirodelo–Aldrovandetum vesiculosae*, *Trapetum natantis* and *Trapo–Nymphoidetum* (*peltatae*) communities.

Key words: anthropogenic influence, aquatic vegetation, Bern Convention, eastern Polesye, Tertiary relict.

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INTRODUCTION

Biodiversity, including plant species diversity, is threatened worldwide as a result of anthropogenic pressures such as an increase of pollutants and climate change. Rare species in particular are on the verge of becoming extinct. Habitat preference of rare plant species may play an important role in determining why some species are rare (Wamelink *et al.*, 2014). Among rare plants, the aquatic ones are the most vulnerable, as the anthropogenic influence on the aquatic environment can cause irreversible changes in hydroecosystems. The aquatic macrophytes and their communities are quite sensitive indicators of the state of the natural environment of their existence: aquatic, land and air (Dubyna *et al.*, 1993). After all, the stenotopic species are the first to respond to even minor changes in the habitat. That is why such species are under the international protection. The Convention on the Conservation of European Wildlife and Natural Habitats (1979) regulates the species conservation by imposing restrictions on taking species from the wild and on exploitation. It constitutes a commitment to protect the species habitats. A particular emphasis is given to endangered and vulnerable species. The species recorded in Appendix I of the Bern Convention may not be taken from the wild or harmed. The habitats of these species are subject to strict protection, with the choice of the habitat protection measures left to signatory states (Convention…1979). The aquatic species that are under protection of the Bern Convention, in particular the representatives of the tertiary flora – *Aldrovanda vesiculosa* L., *Salvinia natans* (L.) All. and *Trapa natans* L. have preserved in the aquatic ecotopes of Europe, including eastern Polesye. We have already considered the peculiarities of distribution, phytocenotic conditions and protection in eastern Polesye of some (primarily land) species of the Bern Convention (Lukash, 2007). The purpose of this study

was to identify the modern (in the 21st century) localities of the aquatic relic species recorded in the Bern Convention, to determine the phytocenotic and ecological conditions of these species growth in eastern Polesye, as well as to determine the factors limiting their distribution.

REGIONAL SETTING

The area of eastern Polesye occupies 3.25 million hectares. Its territory is on the left bank of the Dnieper within the Gomel region (Belarus), Briansk region (Russia), Chernihiv and Sumy regions (Ukraine). The Dnieper forms the natural western boundary of eastern Polesye. In the north the border of eastern Polesye runs along the Rzhavka, Chechera, Lipa, Uza, Sozh rivers and covers the lower part of the Sozh – Besed and Besed – Iput interfluves. In the south and south-west the border of the research region corresponds to the border with the forest-steppe, in the east it is confined by the spurs of the Central Russian Plain and includes the Revna – Snov and Desna – Nerussa interfluves (Lukash and Kirvel, 2018).

The flora of eastern Polesye is relatively young, formed mainly in the glacial period. Since the receding of the Dnieper glacier to the territory of the region there has been a migration of various floral elements. Due to the global warming in the flora of eastern Polesye in the Holocene, in addition to the species of the *Pinus* L. and *Betula* L. genera, the thermophilic species of the *Quercus* L., *Ulmus* L., *Tilia* L., *Acer* L. genera and moisture-loving species of the *Carpinus* L., *Picea* A. Dietr. and even *Fagus* L. genera, as well as hygro- and hydrophilic grasses have spread. The eastern part of Polesye is marked by a significant spread throughout the postglacial period of the steppe flora and vegetation, traces of which have survived to the present day (Lukash, 2008).

The modern flora of the vascular plants of eastern Polesye, which includes 1320 species, belongs to the flora of a moderately cold type with the Mediterranean features. In eastern Polesye there is the reduction in the habitat and elimination of the populations of the aboriginal plant species, primarily boreal. The climatic suppression of the species located in the region on the southern or northern border of the habitat is manifested in a phytocenotic activity decrease, a shift in the age spectra of the populations and violation of the phenophases. The main ways of modern changes in the borders of the habitats and species migration in eastern Polesye are the regressive northeastern, progressive eastern, northwestern, western and northern ones.

For example, the Central European species extend their range to the east, inhabiting the natural ecotopes with non-climax vegetation. In the 20th century there was a partial xerophytization of the flora of eastern Polesye, which generally maintains a hygromesophilic character. The number of the xerophytic species in the contemporary flora of eastern Polesye has increased due to the adventitious species. The complete transformation of natural ecotopes in the region creates the favorable conditions for the intensive spread in a short time on the local territory of new, not typical for the region species from other climatic zones. In eastern Polesye there is an adaptive perturbation of the floroecotopological structure of the vegetation under the influence of changed living conditions (Lukash, 2009). Despite the modern trends in the development of the vascular plants flora of eastern Polesye, the relic species have preserved in the aquatic ecotopes of Europe, including eastern Polesye.

MATERIAL AND METHODS

The location of rare species were discovered in eastern Polesye during the expeditionary studies of flora and vegetation, which were carried out in 2001–2020 by the route method. The geobotanical relevés were made according to generally accepted methods (Korchagin, 1976): the species composition of the phytocenosis and the projective coverage (%) of the general and individual species were recorded. Identification of plant communities and their syntaxonomy was performed in accordance with the monograph (Dubyna, 2006).

The names of the syntaxons (class, order and union) are given according to the "Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities" (Mucina *et al.*, 2016). The nomeclature of the plant taxa follows the Plant List (2013).

The literary sources and herbarium materials of M.H. Kholodnyi Institute of Botany of NAS of Ukraine (*KW*), M.M. Hryshko National Botanical Garden of the National Academy of Sciences of Ukraine (*KWHA*), T. H. Shevchenko National University "Chernihiv Colehium", Francisk Skorina Gomel State University were also analyzed.

RESULTS

According to the results of the field research, the degree of a modern rarity of the aquatic relic species in eastern Polesye was established.

A very rare species (3 modern locations) is *Aldrovanda vesiculosa* (Fig. 1). It is a relic of the Tertiary flora (Berta, 1961). Its range of occurrence is rather wide (Europe, Asia, Africa, Australia), although the number of its localities is relatively small. The majority of them have been in Europe, but are no longer confirmed (Cross and Adamec, 2020). The distribution of *A. vesiculosa* in eastern Polesye is limited by the climatic factors and the lack of seed propagation. The growth in a reservoir is temporary due to the fact that the species is very sensitive to the anthropogenic eutrophication and water pollution. Thus, 6 localities of this rare species, discovered in the XX century on the territory of eastern Polesye, are lost due to the changes in the ecological regime of the biotopes of this species or their destruction. For comparison, exploration of the *Aldrovanda vesiculosa* localities in Poland proved that in 63% of cases the reason for *Aldrovanda* extinction was anthropopressure (Kamiński, 2006).

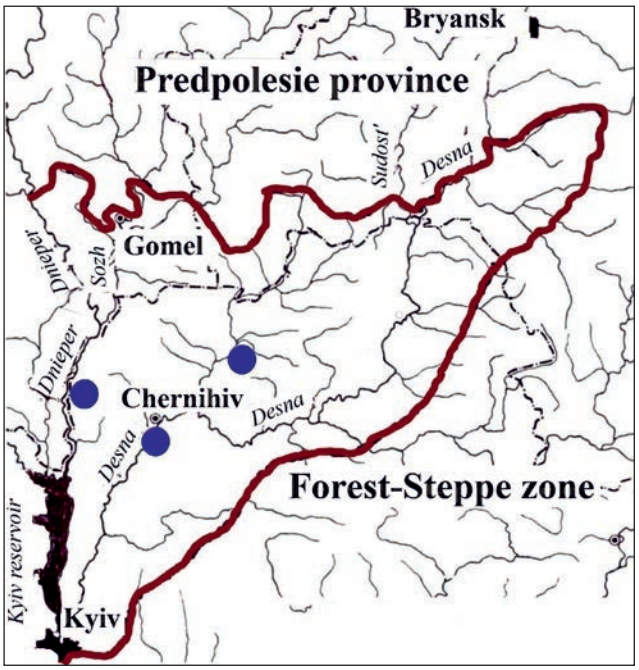

Fig. 1. Schematic map of the *Aldrovanda vesiculosa* range in eastern Polesye.

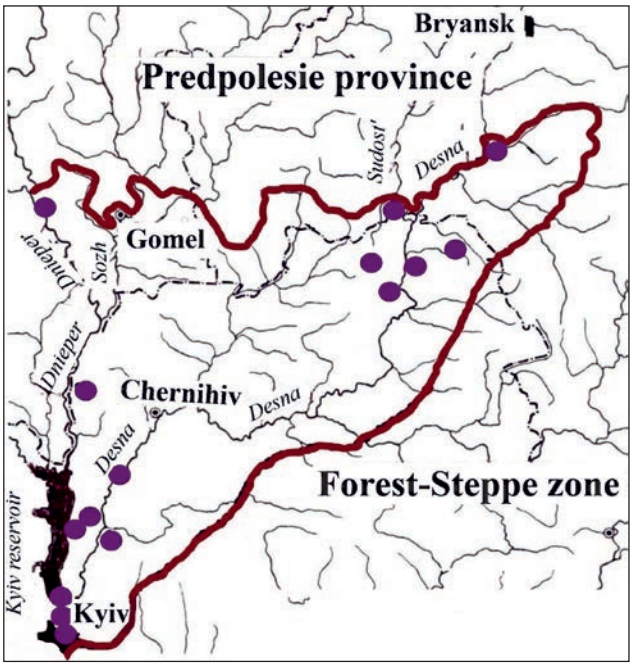

Fig. 2. Schematic map of the *Trapa natans* range in eastern Polesye.

A moderately rare species (12 modern localities) – *Trapa natans* (Fig. 2). This tertiary relic has a wide native range extending from western Europe and Africa to eastern and southeastern Asia. The species has been introduced into North America and Australia (Marković *et al.*, 2015).

There are no threats to the spread of this relic species on the territory of eastern Polesye. None of its known localities disappeared during the last century. In some localities

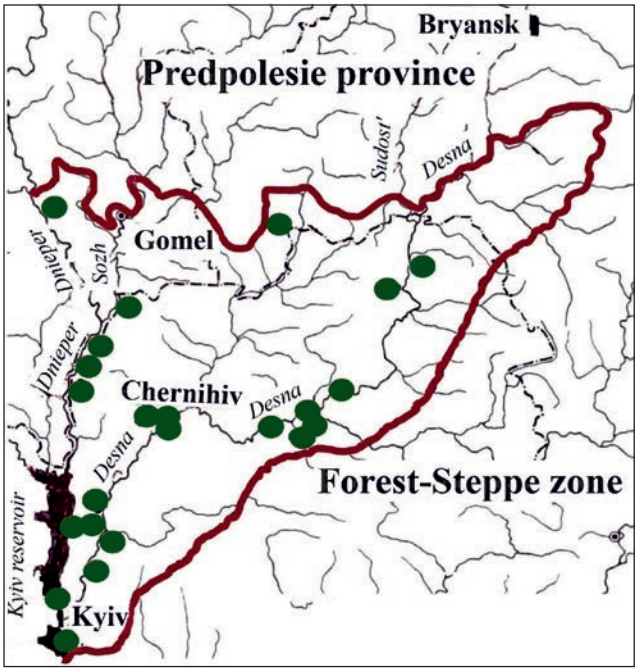

Fig. 3. Schematic map of the *Salvinia natans* range in eastern Polesye.

there is only a decrease in the area of populations due to overgrowing of reservoirs. During the last 20 years, there has been a significant increase in the area of the T. natans communities in the shallow water of the Kyiv Reservoir. A weak anthropogenic eutrophication of habitats stimulates the development of *T. natans*.

A relatively rare species (over 25 modern localities) – *Salvinia natans* (Fig. 3). It is a tertiary relic species with an extensive geographical range from Central and Eastern Europe to south-eastern Asia (Meusel *et al.*, 1965). The plant is associated with areas of sub-oceanic temperate, subtropical and tropical climates (Rothmaler *et al.*, 1986).

The number of *S. natans* populations varies considerably from year to year; the species may disappear in some resevoirs and appear in others. The species is sensitive only to abrupt changes in the hydrological regime. The main threat factor is the drying up of reservoirs, which has been observed in eastern Polesye during the recent years due to the climate changes and sinking of the groundwater levels. That is why about 10% of the habitats of the relic species in small reservoirs of eastern Polesye have been lost during the recent decades.

According to the results of the field research, the syntaxonomic affiliation of the phytocenoses in which the relic species grow has been established (Table 1).

DISCUSSION

Aldrovanda vesiculosa is a species having a quite broad phytosociological amplitude (it occurs in different plant associations and thus has various relations with the abundant group of macrohydrophytes), whereas as regards the

Table 1. Floristic composition of the aquatic plant communities with the participation of the relict species in eastern Polesye.

Relevé number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Cover [%]	85	70	95	70	60	85	85	70	50	35	65	80	35	40	75	55	30	100	95	55	100	100	60
Ch. *Lemnetea minoris*, *Lemnetalia minoris*																							
Lemna minor	4	2	3	4	1	4	2	1	•	3	2	2	•	3	•	•	•	•	•	•	•	•	+
Spirodela polyrrhiza	2	2	2	2	2	2	+	+	•	2	4		4	1	•	•	+	•	•	•	•	2	•
Hydrocharis morsus–ranae	•	•	•	2	•	•	•	•	2	•	•	2		+	•	2	+	+	•	•	•	+	•
Lemna trisulca	2	+	2	•	•	•	2	•	3	•	1	2			•	•	•	•	•	•	•	•	•
Lemna gibba	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	5	•	•	•	•
Ch. *Lemnion minoris*																							
Wolfia arrhiza	•	4	5	•	1	4	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
D. *Salvinio–Spirodeletum (polyrrhizae)*																							
Salvinia natans	4	2	+	+	5	1	4	5	4	+	1	2	•	•	+	+	+	•	•	1	+	•	1
D. *Utricularion vulgaris*																							
Utricularia vulgaris	•	•	•	•	•	•	•	•	•	•	•	4	+	+	•	•	•	•	•	•	•	•	•
D. *Lemno–Utricularietum vulgaris, Spirodelo–Aldrovandetum vesiculosae*																							
Aldrovanda vesiculosa	•	•	•	•	•	•	•	•	•	•	•	1	2	1	•	•	•	•	•	•	•	•	•
Ch. *Potametea, Potametalia*																							
Potamogeton perfoliatus	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	+	+	+	1	+
Myriophyllum verticillatum	•	•	•	•	•	•	•	•	•	•	•	1	•	•	•	+	+	•	•	+	•	+	•
Elodea canadensis	•	•	•	•	•	•	•	•	•	•	•	1	•	•	+	•	•	•	•	•	•	+	+
Ch. *Nymphaeion albae*																							
****Ch. *Nupharo lutei–Nymphaeetum albae***																							
Ch. *Nymphaeetum candidae																							
Ch. *Trapetum natantis*																							
*Ch. *Trapo–Nymphoidetum peltatae***																							
****Nuphar lutea*	•	•	•	•	•	•	•	•	•	•	•	1	•	•	5	•	•	•	•	•	•	•	1
****Nymphaea alba*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•	•	1	•	2
***Nymphaea candida*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	4	•	+	•	1	•	•	•
**Nymphoides peltata*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	3	4
**, **Trapa natans*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	2	5	2	3	5	3	2
Other species																							
Ceratophyllum submersum	•	•	•	•	•	•	•	•	•	•	•	1	•	•	•	•	•	•	•	•	•	•	•
Sagittaria sagittifolia	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•	2	•
Stratiotes aloides	•	•	•	•	•	•	•	•	+	•	•	2	•	•	+	2	•	•	•	•	•	•	•

Note: D. – differential species, Ch. – characteristic species.

Dates and locality of the relevés: 1 – 11/07/2019, reclamation canal "Mlynok" (the Borzna district, Chernihiv region, Ukraine); 2 – 04/08/2019 – the floodplain of the Desna river (the city of Chernihiv, Ukraine); 3 – 17/08/2018, the riverbed of the Bilous river (the city of Chernihiv, Ukraine); 4 – 18/08/2019, the riverbed of the Stryzhen river (the city of Chernihiv, Ukraine); 5 – 18/08/2019, the floodplain of the Desna river (the city of Chernihiv, Ukraine); 6 – 23/08/2015, lake "Vorona" (the Borzna district, Chernihiv region, Ukraine); 7 – 19/07/2016, the left bank floodplain of the Desna river in the surroundings of the Spaske village (the Sosnytsia district, Chernihiv region, Ukraine); 8 – 20/08/2016 – the left bank floodplain of the Sozh river (the Ripky district, Chernihiv region, Ukraine); 9 – 12/07/2020, lake Bolhach, the floodplain of the Dnieper river (the Ripky district, Chernihiv region, Ukraine); 10 – 21/07/2017, the Rudnia village, the Mesha river near the bridge, near the dam created by beavers within (the Kozelets district, Chernihiv region, Ukraine); 11 – 25/07/2016 – an old riverbed of the Desna river in the surroundings of the Yevmynka village (the Kozelets district, Chernihiv region, Ukraine); 12 – 25/08/2019, lake Bolhach, the floodplain of the Dnieper river (the Ripky district, Chernihiv region, Ukraine); 13 – 07/06/2019, the pond in the hydropark, the floodplain of the town of Snovsk (the Chernihiv region, Ukraine); 14 – 25/07/2020, lake Perekop, the floodplain of the Desna river, the surroundings of the Shestovytsia village (the Chernihiv district, Chernihiv region, Ukraine), 15 – 21/07/2014, the lake in the floodplain of the Desna river, the Domnytsia village (the Mena district, Chernihiv region, Ukraine); 16 – 11/09/2007, the pond in the Pokrovske village (the Klymov (Klymovo) district, Briansk region, Russia); 17 – 29/08/2007 – the left bank floodplain of the Dnieper river, lake Vyr (on the border of the Homel and Buda-Kosheliv districts, Homel region, Belarus); 18 – 10/09/2007, the floodplain of the Desna river, the surroundings of the Krasnoie village (the Trubchevskyi district, Briansk region, Russia); 19 – 29/07/2019, lake Kozerohy (the Chernihiv district, Chernihiv region, Ukraine); 20 – 25/07/2016, lake Adrianove (the Ripky district, Chernihiv region, Ukraine); 21 – 15/06/2017, Kyiv Reservoir within the Mizhrichynskyi Regional Landscape Park, 1.5 km to the west from the Kosachivka village (the Kozelets district, Chernihiv region, Ukraine); 22 – 12/09/2007, the riverbed of the Sudost river, the surroundings of the Lukin village (the Poharskyi district, Briansk region, Russia); 23 – 18/07/2016, the right bank floodplain of the Desna river (the Novhorod-Siverskyi district, Chernihiv region, Ukraine).

Syntax: 1–11 – *Salvinio–Spirodeletum* (*polyrrhizae*) Slavnić 1956; 12 – *Lemno–Utricularietum vulgaris* Soó (1928) 1938; 13, 14 – *Spirodelo–Aldrovandetum vesiculosae* Borhidi et Komlódi 1959; 15 – *Nupharo lutei–Nymphaeetum albae* Nowiński 1930; 16 – *Nymphaeetum candidae* Miljan 1956; 17–21 – *Trapetum natantis* Th. Müller et Görs 1960; 22,23 – *Trapo–Nymphoidetum peltatae* Oberdorfer 1957.

Projective coverage scale in points: ±% (single individuals), 1 – 1–4%, 2 – 5–15%, 3 – 16–25%, 4 – 26–50%, 5 – >50%.

chemistry of the habitat it is rather a stenotopic species (Kamiński. 1987). In eastern Polesye, the habitat of this species is found in the *Spirodelo–Aldrovandetum vesiculosae* Borhidi et Komlódi 1959 and *Lemno–Utricularietum vulgaris* Soó (1928) 1938 associations, *Utricularion vulgaris* Passarge 1964 alliance, *Lemnetalia minoris* O. de Bolòos et Masclans 1955 order, *Lemnetea* O. de Bolòs et Masclans 1955 class. The projective coverage of *Aldrovanda vesiculosa* does not exceed 10% (Table 1: relevés 12–14). Recently discovered habitats of *Aldrovanda vesiculosa* in eastern Polesye are located in the reservoirs of the anthropogenic origin (Table 1: relevés 13, 14) with the optimal chemical composition of water for this species. R. Kamiński (1987) notes that the best conditions for its growth are in water bodies having coenotic relations and water chemistry characteristic of eutrophic-dystrophic habitats with a proper ratio of inorganic substances and primarily of calcium to organic substances. The chemical factors having the greatest influence on the growth of *A. vesiculosa* are habitat reaction, contents in water of humic acids, calcium, magnesium and sodium. Habitat differentiation from the point of water chemistry and bottom sediments corresponding largely to *A. vesiculosa* population differentiation in individual and group characters shows not only the significant effect of water chemistry on growth and ecological organization of the population, but that changes in physico-chemical and biotic conditions of the habitat are the main cause of the disappearance of this plant (Kamiński, 1987).

Trapa natans in eastern Polesye forms the communities of the *Trapetum natantis* Th. Müller et Görs 1960 association belonging to the *Nymphaeion albae* Oberdorfer 1957 alliance, *Potametalia* W. Koch 1926 order, *Potametea* Klika in Klika et Novák 1941 class (Table 1: relevés 17–21).

These communities are formed in closed or low-flowing reservoirs with sandy or silty and sandy (often with a significant admixture of detritus) bottom sediments with a neutral, slightly acidic or slightly alkaline reaction of the habitat. The largest area is occupied by these communities in the Kyiv Reservoir (Table 1: relevé 21). Shallow waters on the flooded territories of the former Dnieper floodplain are the ecotopes favorable for the development of the *Trapetum natantis* Th. Müller et Görs 1960 communities because the water level of 50–70 cm is favorable for the development of the communities. In phytocenoses, the relic species has a projective coverage of 30 to 100%.

On the Sudost River (the right tributary of the Desna River) and the coastal shallow water of the Desna River and its floodplain lakes with the neutral or weakly alkaline reaction of the environment at the alluvial sediments of *T. natans* together with *Nymphoides peltata* (S.G. Gmel.) O. Kuntze forms the *Trapo-Nymphoidetum peltatae* Oberdorfer 1957 community (Table 1: relevés 22–23). Note that *Nymphoides peltata* is a Holocene relic (Saksonov *et al.*, 2011), a plurizonal circumpolar species, its geographical range being in the temperate zone of Eurasia (Săndulescu *et al.* 2016). The total projective coverage of the phytocenoses is 60–100%, *Nymphoides peltata* – 20–50%, *Trapa natans* – 15–25%. Among other species there are the species of the *Lemnetea minoris* R. Tx. 1955 (*Hydrocharis morsus–ranae* L., *Spirodela polyrrhiza* (L.) Schleid.), *Potametea* Klika in Klika et Novák 1941 (*Potamogeton perfoliatus* L., *Elodea canadensis* Michx.), and *Sagittaria sagittifolia* L. classes.

Among hydatoaerophytes, *Nymphoides peltata* is the most adaptable to drying and excessive flooding of ecotopes. At the same time the morphological changes concern only the leaves (Dubyna *et al.*, 1993). However, the species prefers shallow waters up to 50 cm, due to the slow growth and development of the seedlings. Under such conditions, the species is the most competitive in the communities with *Trapa natans* (Table 1: relevé 21). With increasing anthropogenic eutrophication of reservoirs, a significant increase in the water level *Nymphoides peltata* disappears, *Trapa natans* is only left.

In the conditions of eastern Polesye *Salvinia natans* most often occurs in the floodplain of the Desna River in the communities of the *Salvinio–Spirodeletum (polyrrhizae)* Slavnić 1956 association (Table 1: relevés 1–11). These communities occupy closed or low-flowing reservoirs, which are well warmed up, with a neutral or weakly alkaline reaction of the environment, silty-sandy and silty-peaty bottom sediments, slight fluctuations of the water level. Sometimes the above-mentioned cenoses are subjected to anthropogenic pressure, being in the places of cattle grazing and recreation. Less frequently, *S.natans* occupies the communities belonging to the *Nymphaeion albae* Oberdorfer 1957 alliance. *S.natans* also occurs in the communities of the *Trapetum natantis* Th. Müller et Görs 1960 association (Table 1: relevés 17, 20, 21), which were formed in the eutrophic closed silty-sandy, with a significant admixture of detritus, and bottom sediments. Very rarely *S.natans* occurs in the communities of the *Nuphareto lutei–Nymphaeetum albae* Nowinski 1930 et Tomaszewicz 1977 (Table 1: relevé 15) and *Nymphaeetum candidae* Miljan 1956 (Table 1: relevé 16) associations, found in shallow ponds. The range of the projective coverage of *S.natans* varies from single individuals to 45%.

The frequency of the species growth in eastern Polesye decreases in the northern direction, which is probably due to a decrease in the values of maximum temperatures and isotherms, especially in the summer months. According to the results of the previous studies (Lukash and Rak, 2008) it was found that in the urban reservoirs, as well as in the natural reservoirs that do not experience the anthropogenic pressure, the number of *S. natans* populations is affected by the summer air temperature and water level in the reservoirs. The anthropogenic eutrophication of reservoirs in the initial stages leads to increased vitality of the species populations.

CONCLUSIONS

In the modern flora of eastern Polesye there are three aquatic Tertiary relics covered by the protection of the Bern Convention, in particular: *Aldrovanda vesiculosa* (very rare species), *Trapa natans* (moderately rare species), *Salvinia natans* (relatively rare species).

The current distribution of these relic species in the region depends on the climatic factors (primarily temperature), changes in water levels in the reservoirs, as well as the anthropogenic pressure on the aquatic ecosystems (primarily, the degree of the anthropogenic eutrophication of the reservoirs). In general, the increase in the value of maximum temperatures and isotherms of the summer months is favorable for all the species. The evidence of this is the new locality of *Aldrovanda vesiculosa*. However, the growth of this species in the region is unstable, as it is the most sensitive to the changes in any living conditions. *Salvinia natans* is the most tolerant to the anthropogenic factor, eliminates only when destroying biotopes. *Trapa natans* in eastern Polesye shows the stability of its spreading and under the favorable conditions (increase of shallow water areas and insignificant eutrophication of the reservoirs) shows the tendency to the population spreading.

Most often, relics are the dominants of the communities belonging to the *Lemnetea* O. de Bolòs et Masclans 1955 (*Salvinio–Spirodeletum (polyrrhizae)* Slavnić 1956, *Lemno–Utricularietum vulgaris* Soó (1928) 1938, *Spirodelo-Aldrovandetum vesiculosae* Borhidi et Komlódi 1959 associations) and P*otametea* Klika in Klika et Novák 1941 (*Trapetum natantis* Th. Müller et Görs 1960 and *Trapo-Nymphoidetum peltatae* Oberdorfer 1957 associations) classes.

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