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Ecological features of the alien species *Pistia stratiotes* L. in different habitats of the secondary distribution range (Ukraine)

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Key words: invasive species, macrophytes, aquatic ecosystems, morphometric parameters.

Ključne besede: invazivne vrste, makrofiti, vodni ekosistemi, morfometrični parametri.

Abstract

We have analyzed structural and dynamic characteristics (production, morphometric parameters, phytocoenotic features and invasive behavior) of two locations with the alien species *Pistia stratiotes* L. in different types of water bodies, by origin, use and trophic status (a drainage canal and oxbow lake) in the outskirts of Kyiv. It is possible that in the case of increased anthropogenic eutrophication due to inorganic nitrogen, mother plants become smaller and more compact. The variability of morphological features increases. We also have distinguished growth of invasive potential of the species in the conditions of the water bodies of the region.

Izvleček

V članku smo analizirali strukturne in dinamične značilnosti (proizvodnja, morfometrični parametri, fitocenološke značilnosti in invazivnost) na dveh lokacijah, kjer uspeva tujerodna vrsta *Pistia stratiotes* L., v različnih vodnih telesih glede na nastanek in trofičnost (odvodni kanal in mrtvica) na obrobju Kijeva. Mogoče je, da v primeru povečane antropogene evtrofikacije s strani anorganskega dušika materinske rastline postanejo manjše in bolj kompaktne rasti, poveča se raznolikost morfoloških značilnosti. Prav tako smo opazili povečanje potenciala invazivnosti vrste v vodnih telesih preučevane regije.

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Introduction

During the twentieth century, the basic climatic conditions of Europe have undergone significant changes. Thus, in Ukraine, the average annual air temperature increased in the eastern region by 2.7–2.8 °C, in the northwestern region by 1.1–1.7 °C (FCCC, 2009). The effects of such climate change are the spread of thermophilic invasive species. Convenient corridors for the invasions of southern alien species are aquatic ecosystems: they are azonal, open to intrusion due to the network structure, have free ecological niches owing to significant anthropogenic transformation.

Pistia stratiotes L. is one of pantropic invasive hydrobionts in the Europe's hydrographic networks. It is a potentially dangerous alien species which responds positively to the gradual increase in average annual water temperatures and has been on the EPPO list of invasive plants since 2012 (Chapman at al., 2017). In 2016, *P. stratiotes* was identified as a priority for risk assessment in accordance with the requirements of Regulation 1143/2014 (Branquart et al., 2016; Tanner et al., 2017). *P. stratiotes* presents a high phytosanitary risk for the endangered area within the EPPO region with a low uncertainty. The overall probability that *P. stratiotes* will continue to enter the EPPO region is high, as this species is widely cultivated and constantly traded within the EPPO region (EPPO, 2018).

Pistia stratiotes is a member of a monotypic genus of the Araceae family. It is a free-floating macrophyte whose biological and ecological features contribute to its rapid development and ability to expand (Aston, 1973; Cook et al., 1974; Holm et al., 1977; Sainty & Jacobs, 1981; Neuenschwander et al., 2009).

Invasions of this species in European water bodies began at the end of the previous century. The facts of numerous finds in Europe of this period are determined in the Netherlands, Denmark, Germany; in France, Spain, Italy – one-time finds are known (Mennema, 1977; Diekjobst, 1984; Pilipenko, 1993; Murillo et al., 2005; Verloove, 2006; Šajna et al., 2007; Brundu et al., 2012; Hussner, 2012; Boršić & Rubinić, 2018; Jaklič at al., 2020). These are cases of successful naturalization of the species in thermal waters (Šajna et al., 2007). The plant appears in shallow and warm urban water bodies of more continental regions (Eastern Europe) during abnormally hot summers or water bodies which receive technically heated water (Barmin & Kuzmina, 1993; Prokopuk & Zub, 2020). The facts of naturalization of the species in Eastern Europe are unknown.

Ways of penetration of the species into secondary range were different. i.e. escape from confinement (the species is popular in aquaria, in outdoor garden pools and other ornamental ponds), and release in nature (deliberate introduction by amateurs) (Scalera & Genovesi, 2016). Interconnected waterways are excellent penetration corridors. The plant is also spread by water flows and wind over long distances in slow-flowing rivers and stagnant waters.

The species can be transmitted by birds, which enables vegetative and generative diasporas of *P. stratiotes* to overcome significant distances between isolated water bodies (Adebayo et al., 2011). One of the mechanisms of invasive dominance of the species in aquatic phytocoenoses is considered to be allelopathic interaction with representatives of the local aquatic flora (Aliotta et al., 1991). In the secondary range, *P. stratiotes* is able to produce seeds (Šajna et al., 2007; Neuenschwander et al., 2009; Buzgo, 2015; Jaklič et al., 2020), but more often *P. stratiotes* reproduces vegetatively. It forms small colonies with daughter plants attached to the mother plant with stolons, developing in the axils of the lower leaves. Distribution is enhanced by separation of daughter plants, which form new colonies.

It is due to the intentional release of *P. stratiotes* that it entered the water bodies and water streams of Ukraine. Phytoinvasion of *P. stratiotes* in natural water bodies is facilitated by a high concentration of man-made objects in the region with water use with the subsequent return of its to natural reservoirs (Dubyna & Ustymenko, 2014). There are general trends towards further invasive spread of water lettuce in Ukraine and adjacent territories (Mosyakin & Kazarinova, 2014). This fact makes it relevant to study the biology and ecology of the species in the regional conditions.

The basis of the distribution management of *P. stratiotes* is a comprehensive study of the distribution patterns of this species within the secondary range and determination of key factors in enabling invasive potential. Indicators of the viability of the invasive species in the new conditions are its structural and dynamic characteristics: reproduction rate, density, phytomass produced, morphometric parameters, the ability to form adapted ecomorphs in variable environmental conditions and others.

Our research is aimed to determine the regional features of morphology, phenotypic variability and production indicators of the species depending on the habitat of distribution. We want to show that in the conditions of the secondary range the type of biotope determines the invasive properties of *P. stratiotes* and the potential ability to naturalization.

Material and methods

Study area

The research was conducted on the southern border of Kyiv within the left-bank floodplain of the Dnipro River (Figure 1). Kyiv is located on the border of forest and forest-steppe physiographic areas. The area of the city is 836 km^2. The Dnipro and its floodplain are the natural axis of the city. The urban areas along the coast are over 20 km long. The climate is moderately continental, with mild winters and warm summers. The average monthly temperatures in January are –3.5 °C, in July +20.5 °C. The average annual precipitation is 649 mm, with the maximum precipitation in July (88 mm) and the minimum one in October (35 mm). In winter, snow covers Kyiv with the average snow height in February of 20 cm and the maximum one of 440 cm (Osadchyy et al., 2010).

During 2013–2021, we monitored the spread of alien macrophytes in water bodies of the city and its outskirts (Prokopuk & Zub, 2020). Two locations of the species were selected for the structural analysis: (i) in the lothic artificial water body – the drainage canal of the Bortnytchy protective dam; (ii) in the lentic natural water body – a floodplain water body of the Dnipro River – Zoloche Lake.

In order to hydrotechnically protect the suburban residential areas of the Dnipro River left bank from floods of the Kaniv water body, the Bortnytchy protective dam was built, with a drainage canal. It is nearly 16 km long, and it is connected through 5 cross regulators with the Dnipro River down the city of Kyiv.

Zoloche Lake is an oxbow lake of the Dnipro River floodplain. Today it is transformed in the process of urban planning, it is deepened, and one of the components of the drainage hydraulic system and has a hydraulic connection with the Dnipro River through the cross regulator.

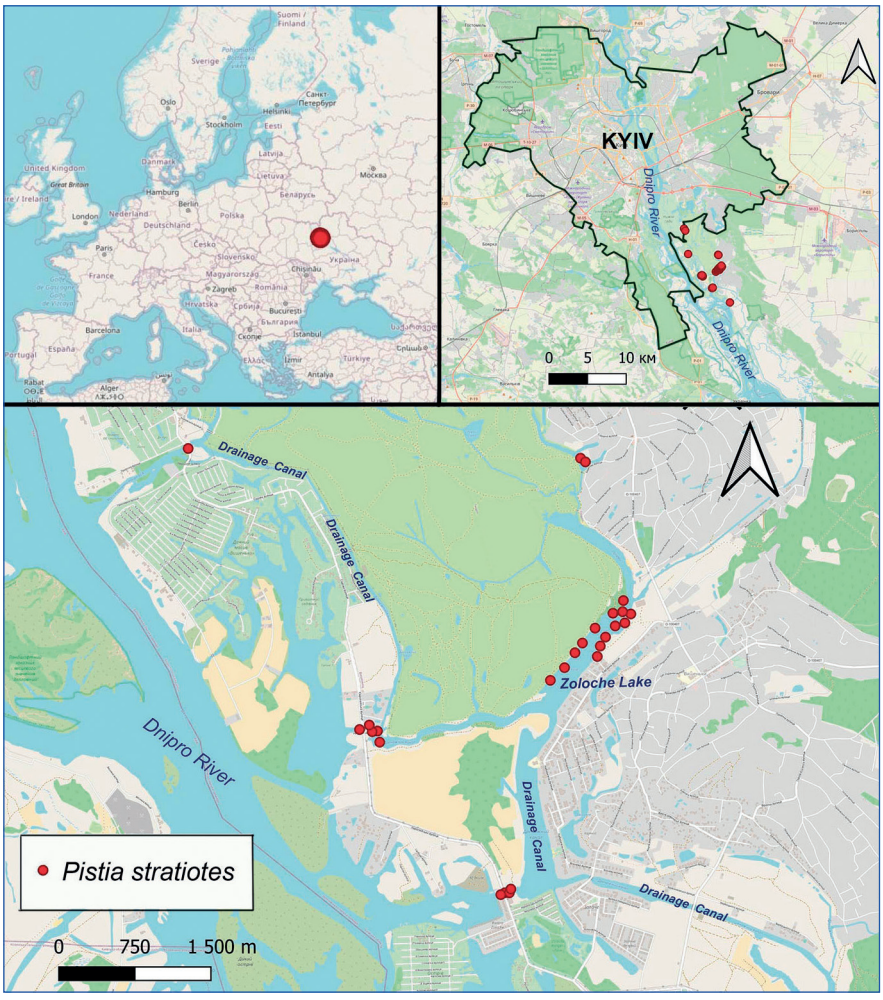

Figure 1: Location of the studied territory in Ukraine (A – on the map of Europe; B – the outskirts of Kyiv; C – drainage canal and oxbow lake. Red dots indicate *Pistia stratiotes* locations).
Slika 1: Lokacija znotraj območja raziskav v Ukrajini (A – na zemljevidu Evrope; B – obrobje Kijeva; C – odvodni kanal in mrtvica. Rdeče točke označujejo lokacije z vrsto *Pistia stratiotes*.

Field sampling

The materials were the results of population studies with two locations of *P. stratiotes* in habitats characterized by different hydrological and trophic conditions:

– drainage canal (two research sites – 50° 17' 05.5" N, 30° 41' 16.5" E; 50° 17' 58.5" N, 30° 40' 09.8" E) – lotic type, mesotrophic waters.
– floodplain water body (three research sites – 50° 18' 29.6" N, 30° 42' 18.2" E; 50° 18' 34.9" N, 30° 42' 19.0" E; 50° 18' 25.0" N, 30° 41' 56.5" E) – lentic type, eutrophic waters.

Locations were selected according to the criterion where the peak of *P. stratiotes* development was the largest dur-

ing the studied period, as well as where the reappearance of the species was confirmed. There were exactly 5 of them. The research was conducted during the growing seasons in October 2019–2021 by general hydrobotanical methods (Fasset, 1969; Wood, 1975). Phytomass samples were selected at the end of the growing season (October 2020), when the species reached its maximum distribution, and local populations – the maximum density and phytomass. Samples were selected at all research sites from the test plots with an area of 0.25 m² in sites with the highest density of mats with subsequent drying to air-dry phytomass. The sample for the calculation of morphometric data was taken from the same samples. Morphometric indicators of 351 maternal and 57 filial plants in the floodplain have been analyzed; 150 maternal and 270 filial plants – in the drainage channel. The number of adult and filial plants, rosette leaves and veins on the leaf surface was counted. Evaluation of morphometric parameters included measurements of the size of roots, rosettes, leaves of maternal, and filial plants. The presence of flowers in plants was recorded.

The research was performed with recording water temperature, basic hydrochemical and tropho-saprobiological characteristics. Hydrochemical measurements were performed using a PH-meter/OVP-meter/conductometer/TDS-meter EZODO 8200M. We measured conductivity, ion content of dissolved salts, total mineralization and pH. Water was studied for nutrient content by the colorimetric method using the DR/890 Colorimeter. We measured concentration of NO_2^-, NO_3^-, NH_4^+, PO_4^{3-} in water. Water samples were taken from the near-surface layer once in the period of sampling *Pistia* phytomass. Tropho-saprobiological type of water bodies was determined according to Romanyuk et al. (1998).

Data analysis

The results of the research were processed by the Principal component analysis PCA performed using the 'ade4' package (Dray & Dufour, 2007) in R software (R Core Team, 2020). Considering different units of variables, e.g. length and number, we have chosen a normed PCA that bases on scored and centered variables. Two pairs of coordinates obtained in the PCA were used to draw a correlation circle, or variables scores, that is a superposition of principal components and column scores, and factor map that is the superposition of principal axes or variable loadings and row scores. Factor map was plotted for (i) individual plants, (ii) maternal and filial plants, (ii) and two studied water bodies.

We used nested analysis of variance ANOVA to assess the effect of two factors, a plant type and water body, on plants' morphological traits. The plant type factor was nested within the water body factor and six plants' traits were the response variables. The analysis was performed using 'stats' package for R (R Core Team, 2020).

Scientific names of plant species are given in accordance with the International Plant Names Index (IPNI, 2021).

Results

Until 2020, macrophytes in the drainage canal in the areas without engineering shore protection and with shallow water, were represented by coastal fragmentary mats of *Phragmites australis* (Cav.) Trin. et Steud., *Glyceria maxima* (C. Hartm.) Holmberg, *Typha angustifolia* L. and, occasionally – *Typha latifolia* L. Among the mats of helophytes there are synusia of duckweeds (*Lemna minor L., Spirodela polyrhiza* (L.) Schleiden, *Hydrocharis morsus-ranae* L. and *Salvinia natans* L. The next vegetation belt, also fragmentary, is formed by communities of *Nuphar lutea* (L.) J.E. and *Trapa natans* L. In some places there are separate curtains of *Sparganium erectum* L. The basis of hydrophytes in early summer are co-dominant communities of *Elodea canadensis* Michx. and *Ceratophyllum demersum* L., *Najas marina* L., *Myriophyllum spicatum* L., *Potamogeton perfoliatus* L., *Stuckenia pectinata* (L.) Borner, and *Caulinia minor* (All.) Coss. *Stratiotes aloides* L. coenoses have developed in the areas protected by emergent plants. Since 2015, the canal has witnessed *Elodea nuttallii* (Planch.) H. St. John, which sometimes replaced *Elodea canadensis*. At the end of summer, one can see single specimens of *Egeria densa* (Planch.) Casp.

Until 2020, vegetation of Zoloche Lake was typical for floodplains of the region: after the belt of helophytes composed of *P. australis*, *G. maxima* and *T. angustifolia,* a belt of plants with floating leaves forms dominated by *N. lutea* and *N. alba* L., with separate rosettes of *T. natans* and among submerged macrophytes there are coenoses of *P. perfoliatus, M. spicatum,* and *E. canadensis*. In 2014-2015 there was a boom of *E. densa*, in subsequent years there were only a few specimens of the plant.

At the end of the growing season (September-October) in 2020, both water bodies underwent a complete change in the phytocoenotic pattern of vegetation: *P. stratiotes* formed dense monodominant mats with a total cover percentage of 100%. Its growth covered the water surfaces with a continuous mat (Figure 2), with other hydrophytes occurring not often.

Figure 2: General view of the surface of the studied water objects with mats of *P. stratiotes*: a drainage canal in the area of gateway-regulator № 3 (August, 2020) (left); Zoloche floodplain Lake (October, 2020) (right); Kyiv, Ukraine.
Slika 2: Pogled na površino raziskovanih vodnih teles, prekritih z vrsto *P. stratiotes*: odvodni kanal na območju uravnalnih vrat št. 3 (avgust 2020) (levo); jezero na poplavni ravnici Zoloche (oktober 2020) (desno); Kijev, Ukrajina.

Mass development of *P. stratiotes* was accompanied by low concentrations of inorganic nitrogen in the waters of the drainage canal (Table 1). Excess of organic matter here determined the content of inorganic phosphorus, with an excess of nitrates and phosphates within the oxbow lake.

In the studied locations, large amounts of phytomass of mats of the species are formed. In the canal they were 6.16 kg/m² (raw phytomass)/0.319 kg/m² (air-dried), and in the floodplain Zoloche Lake these indicators were lower – 5.53/0.278 kg/m², respectively. On average, 222 plants in the canal and 231 in the floodplain water body were recorded per 1 m².

The largest maternal plant was recorded in the floodplain lake with a rosette size of 49 cm in diameter and with 13 leaves and the root of 18 cm in length. The largest plant in the canal was a plant of 30 cm in diameter with 14 leaves and the root of 35 cm in length. The

Table 1: Physico-chemical and tropho-saprobiological characteristics of the studied habitats
Tabela 1: Fizikalno-kemične in trofično-saprobiološke značilnosti raziskovanih habitatov.

Habitat type	Drainage canal	Floodplain water body
pH	7.6	8.8
Conductivity, μS	416	231
Total mineralization, ppm	269	308
Salt, (mg\dm³)	207	186
NO_2^- (mgN\dm³)	0.001	0.041
NO_3^- (mgN\dm³)	0.1	3.4
NH_4^+(mgN\dm³)	0.01	0.21
PO_4^{3-}(mgP\dm³)	0.34	2.75
Temperature (°C)	+9	+9
Saprobity	β'–mesosaprobic	β"–mesosaprobic
Trophicity	mesotrophic	eutrophic

smallest ones were 6 cm in diameter in the canal and 2.5 cm in the floodplain lake.

The average morphometric parameters of *P. stratiotes* were higher in the drainage canal (Table 2): plants with rosette diameter by 20% larger were formed here, with longer leaves and roots which produced more filial plants.

Table 2: Morphometric characteristics of *P. stratiotes* in different habitats (average value and standard deviation).

Tabela 2: Morfometrične značilnosti vrste *P. stratiotes* v različnih habitatih (povprečna vrednost in standardni odklon).

Morphometric characteristics	Drainage canal		Floodplain lake	
	Maternal plants	Filial plant	Maternal plants	Filial plant
Rosette diameter, cm	16.33±8.06	3.68±1.64	12.82±7.12	10.49±5.19
Number of veins	7.00±0.87	5.87±1.01	6.96±1.25	6.95±0.93
Number of leaves	8.67±3.00	4.47±1.08	8.79±2.85	6.19±2.49
Leaf length, cm	6.57±4.59	1.76±1.25	5.15±3.48	4.51±3.09
Root length, cm	17.89±8.77	4.53±1.72	14.61±9.74	12.77±9.46

However, larger filial plants formed in the floodplain lake (almost three times larger) with more and much longer leaves and three times longer roots. Variability of features in filial plants in this water body was much greater than in those of the drainage canal.

Flowers and buds were recorded on 8% of the plants collected (the floodplain lake).

In both locations, the species successfully overwintered. And although in 2021 we did not notice such a massive boom of plants, both locations exhibited abundant mats of *P. stratiotes* at the end of summer.

To evaluate the relationship of plants morphometric parameters from two studied populations with the characteristics of habitats factor analysis was used (Table 3).

The variables were assessed by constructing a correlation circle of morphometric data. There is a group of three almost horizontal and much related indicators (Figure 3A): number of leaves, the diameters of rosettes and number of veins correlate with each other in both habitats. Longer roots lead to an increased number of leaves.

Figure 3 (B, C, D) shows the factor maps (sample values) for individual plants (B), maternal and filial plants (C) and water bodies (D). Ellipses represent standard deviations. Points depicted close together have similar values. In the floodplain lake (Zoloche Lake) maternal plants predominate, in the drainage channel – filial plants.

Table 3: Nested design ANOVA results examining the effect of plant type and water body (plant types nested in a water body) on plants morphological traits.

Tabela 3: Rezultati testa ANOVA z gnezdasto zasnovo, ki oceni vpliv tipa rastline in vodnega telesa (tip rastline gnezden znotraj vodnega telesa) na morfološke znake rastlin.

Trait	Factor	Model			
		Sum-of-squares (SS)	Degrees of freedom	Mean squares (MS)	p
Rosette diameter, cm	water body	1350	1	1350	<0.001
	plant type	1385	2	693	<0.001
	residuals	19850	443	45	
Root length, cm	water body	1781	1	1781	<0.001
	plant type	1426	2	713	<0.001
	residuals	38829	443	88	
Number of leaves	water body	344	1	344	<0.001
	plant type	455	2	227	<0.001
	residuals	3281.0	443	7	
Number of veins	water body	26	1	26	<0.001
	plant type	9	2	4	<0.05
	residuals	631	443	1	
Leaf length, cm	water body	33	1	33	<0.05
	plant type	139	2	69	<0.001
	residuals	3204	443	7	
Leaf length/ Root length	water body	3	1	3	<0.001
	plant type	0.210	2	0.1050	<0.001
	residuals	443	443	0.0753	>0.1

Discussion

Coenopopulations of *P. stratiotes* in the region are common for meso-eutrophic and eutrophic waters (Lushpa, 2009; Kazarinova at al., 2014; Afanasyev & Savitskiy, 2016). Analysis of species preferences based on the results of our own research has shown that *P. stratiotes* is characterized by a wide ecological valence in terms of phosphate content in water (occurred in water bodies with phosphate concentration of 0.01–2.75 mgP/dm³) (Zub & Prokopuk, 2020). The species prefers habitats which are rich in mineral phosphorus compounds. At high values of phosphates content (0.30 mgP/dm³ and more) populations with high abundance are formed (Zub & Prokopuk, 2020).

Deficiency and excess of mineral nitrogen can be considered as a limiting factor for the development of *P. stratiotes* coenopopulations. Ecological preferences of the species for this indicator are within the limits characteristic of meso-eutrophic waters, *P. stratiotes* disappeared in the case of increasing the concentration of mineral nitrogen to 4.3 mgN/dm³ and reducing the content of phosphorus in phosphates to 0.01 mgR/dm³ (Zub & Prokopuk, 2020). We assume that lower rates of the produced phy-

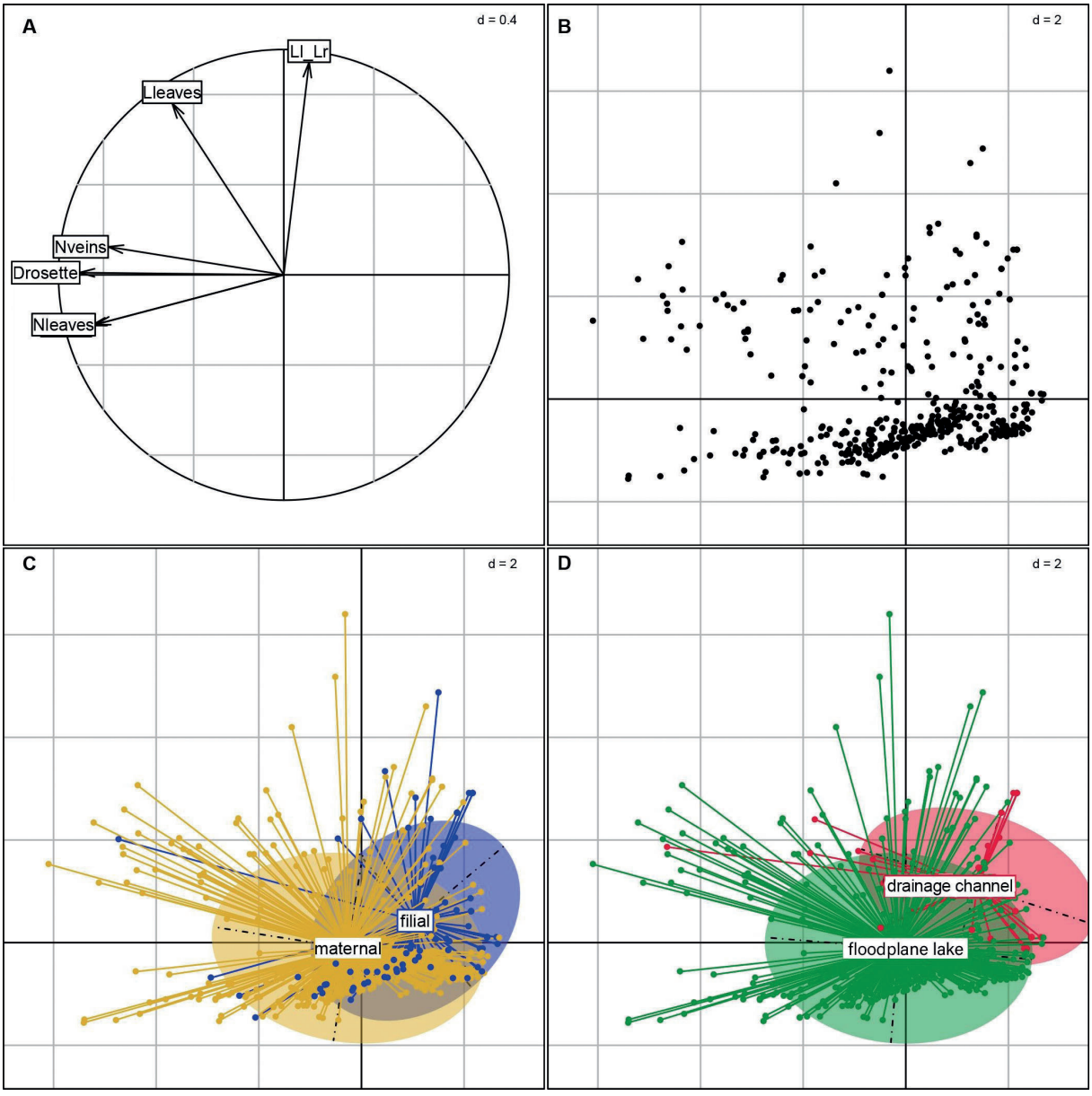

Figure 3: The results of Principal component analysis: correlation circle of the morphological data, i.e. scores of the morphological variables (A); factor maps, i.e. sample scores, for individual plants (B), maternal and filial plants (C), and water bodies (D). Letter d denotes the size of the grid. Ellipses have standard deviations.

Slika 3: Rezultati analize glavnih komponent: korelacijski krog podatkov o morfologiji, t.j. vrednosti morfoloških spremenljivk (A); faktorski zemljevidi, t.j. vrednosti vzorcev za posamezne rastline (B), materinske in hčerinske rastline (C), in vodni telesi (D). Črka "d" označuje velikost mreže. Elipse predstavljajo standardne odklone.

tomass and average size of *P. stratiotes* in Zoloche Lake can be explained by the influence of high content of nitrate nitrogen in water (see Table 1). Probably, this fact has predetermined a smaller number of filial plants in this local population.

In the drainage canal, where the waters correspond to the meso-eutrophic type were formed – young vegetative individuals predominated (see Figure 3C). Accordingly, this local population is characterized by higher invasive potential. Invasive potential, or invasiveness of alien plants (Burda & Pridatko, 2005) is the ability of alien species to spread in new local conditions and to create in disturbed or natural phytocoenoses stable local populations, well adapted to the new environment.

P. stratiotes can be used to indicate the conditions of water bodies: in case of increased water trophism (mainly, manifestations of anthropogenic eutrophication due to inorganic nitrogen), maternal plants become smaller and more compact (see Table 2). Variability of morphological features of plants increases (see Figure 3D). The modern literature confirms bioindication properties of the species: *P. stratiotes* is an organism that responds sensitively to changes in the aquatic environment by growth and density of stands (Ružičková et al., 2020).

The research localities were characterized by much less average length of leaves and roots of both maternal and filial plants than the data provided in the literature for earlier invasions (Kazarinova et al., 2014; Ružičková et al., 2020). This indicates that populations are in the early stages of species invasion (Thompson, 2000). However, the maximum size of plants (30 cm in diameter – the drainage canal and 49 cm – floodplain water body) is comparable to those given in the literature: the parameters of the rosettes of the largest maternal plants from the Seversky Donets River (Kharkiv region, Ukraine) were 40-45 cm in diameter (Kazarinova et al., 2014); in the rivers of Slovakia, the largest maternal plant had a rosette with the diameter of 47 cm (Ružičková et al., 2020). Sampling was realized in the same period in the end of vegetation period and the same climatic zone.

The morphological changes of *P. stratiotes* are primarily influenced by environmental conditions and population density (Thompson, 2000; Ružičková et al., 2020), but morphological parameters may indicate the degree of naturalization of the species. Plants that were first recorded in the urban ornamental ponds of Kyiv were much smaller in size, with the diameter of the rosettes of 5.8–17.5 cm (Prokopuk, 2017). For comparison, in the ponds of the Republic of Adygea, the first plants also had lower values: the diameters of large rosettes reached 26 cm (Shapovalov & Saprykin, 2016). We can assume that for regions with a moderate climate and natural temperatures in autumn-winter period, the small size of the rosettes is evidence of the first invasions of the species. Over time, the size of plants (average and maximum values) becomes larger, and we can consider this being a feature of naturalization of the species.

Unfortunately, there are no data concerning study of *P. stratiotes* wintering in Ukraine. Wintering of *P. stratiotes* in Europe is noted in Germany for the Erft River (Hussner & Heiligtag, 2013). They point out that in the winter months the number of *P. stratiotes* plants decreases due to low growth rates, and mostly young plants dominate. However, at next summer phytomass stocks increased, and in the summer months plants up to 60 cm in diameter.

Since 2012, we have observed permanent coenopopulations of the species in a number of localities of the city. Until 2020, *P. stratiotes* behaved as a distinct edificator, but did not manifest itself as a transformer species; according to the degree of naturalization we evaluated it as an ephemerophyte (casual alien plants) (Zub & Prokopuk, 2020).

The results of the 2020–2021 study enable us to make slightly different general conclusions. The full-fledged structure of populations with a predominance of young plants, active vegetative propagation, the ability to form generative organs, as well as the ability to survive adverse winter conditions indicates the formation of normal populations (plants are fully developed) and according the degree of naturalization today show the features of colonophyte (naturalized plants) (term according to Thellung, 1918–1919).

Higher produced phytomass can be considered as a feature of naturalization of *P. stratiotes*. For example, for one of the first invasions of the species in the region (Sviatoshynsky pond, Kyiv), 2.47–4.38 kg/m² of raw phytomass was produced within the period of the most massive development (air-dry – 0.24–0.38 kg/m²) (Prokopuk, 2017). For the local populations of *P. stratiotes* of the drainage canal, this value is twice as high. We have witnessed formation of extremely huge reserves of phytomass – for example, for Zoloche Lake, the total reserves of phytomass for the research period can be estimated at more than 345 tons.

The features of *P. stratiotes* as a transformer species are also noting. We have witnessed that 100% of the floodplain water body, with nearly 80% of the drainage canal covered with mats of plants. Even 50% of the water surface area covered by *Pistia stratiotes* is a real threat to the immersed species, sensitive to light, oxygen content and pH level (Olkhovich et al., 2017). Such mats limit development of macrophytes through shading and a mechanical barrier which prevents enriching water with oxygen due to atmospheric aeration. Due to development of phytocoenosis of *P. stratiotes*, in 2014 in the valley of the Siversky Donets (about 70% of floodplain areas were covered with a continuous layer of plants of the species), there were changes in the degree of water trophism from meso-eutrophic to eutrophic (in lotic hydroecosystems – to hypereutrophic) (Kazarinova at al., 2014).

The transition of phytomass of *P. stratiotes* to detritus delayed regeneration of natural trophic conditions for several years (Kazarinova at al., 2014). We are to investigate the influence of the mass development of the species on the ecosystems of floodplain water bodies in the middle reaches of the largest river in Ukraine – the Dnipro.

Conclusions

P. stratiotes is a known invasive species which responds to various conditions and spreads rapidly in a vegetative and generative way. In mesotrophic lotic conditions, the species forms more productive populations, dominated by young vegetative individuals and is characterized by higher invasive potential. Conditions of lentic floodplain water bodies contribute to formation of larger plants, the ability to form generative organs, aging of the coenopopulation and formation of significant reserves of phytomass within one water body.

In the case of increased anthropogenic eutrophication due to inorganic nitrogen, mother plants become smaller and more compact. The variability of morphological features increases. Mineral nitrogen deficiency and excess can be considered as a limiting factor for development of local populations of *P. stratiotes*. Ecological preferences of the species with regard to the type of trophism are within the meso-eutrophic waters.

Mass development of the species on drainage canals and a number of floodplain lakes of the left bank of the Dnipro River on the southern border of Kyiv in 2019-2021 enables to make assumptions about the increased degree of naturalization of *P. stratiotes* in Ukraine (from ephemerophyte to colonophyte) and invasive status (from Casual alien plants to Naturalized plants).

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