

INFLUENCE OF ALIEN SPECIES *PISTIA STRATIOTES* L., 1753 ON REPRESENTATIVE SPECIES OF GENUS *SALVINIA* IN UKRAINE

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ABSTRACT

This work purpose was to find the impact of *Pistia stratiotes* L., 1753 - a new species on the territory of Ukraine, on the vitality of other free-floating hydrophytes so-called pleuston - *Salvinia natans* (L.) All., 1785, *S. laevigatum* (Humb. and Bonpl. ex Willd.) Heine, 1968, to determine the degree of stability and competitiveness of these species for resources in natural ecosystems relatively to the undesirable species. To find out the influence of *P. stratiotes* on other free-floating on the water surface plant species which compete for elements of nutrition among each other, we have investigated changes in the content of photosynthetic pigments in *S. laevigatum* and *S. natans*, which were exhibited with *P. stratiotes* for 14 days. Besides changes in water indices, oxygen content, mineralization and pH, were measured.

ZUSAMMENFASSUNG: Einfluss der fremdländischen Art *Pistia stratiotes* L. 1753 auf die einheimischen repräsentativen Arten der Gattung *Salvinia* in der Ukraine.

Vorliegende Untersuchungen hatten zum Ziel den Einfluss von *Pistia stratiotes* L., 1753 - eine neu eingebürgerte Art in der Ukraine – auf die Vitalität anderer schwimmender Hydrophyten, dem so genannten Pleuston, wie *Salvinia natans* (L.) All., 1785, *S. laevigatum* (Humb. and Bonpl. ex Willd.) Heine, 1968 zu ermitteln sowie den Stabilitätsgrad und die Konkurrenzkraft dieser Arten als Ressourcen in natürlichen Ökosystemen im Verhältnis zu der neueingebürgerten zu bestimmen. Um den Einfluss von *Pistia stratiotes* L. auf andere Wasserwurzler zu denen sie in einem Konkurrenzverhältnis bezüglich der Nährstoffe stehen, herauszufinden, wurden Veränderungen im Gehalt photosynthetischer Pigmente bei *Salvinia laevigatum* und *S. natans*, untersucht und die Arten zusammen mit *P. stratiotes* für 14 Tage in Versuchskonditionen zusammengestellt. Neben Veränderungen in den Wasserzeigerwerten wurden auch Sauerstoffgehalt, Mineralisierung und pH-Werte gemessen.

REZUMAT: Influența speciei adventive *Pistia stratiotes* L. 1753 asupra speciilor indigene reprezentative din genul *Salvinia* din Ucraina.

Lucrarea a avut ca obiectiv studierea impactului speciei *Pistia stratiotes* L., 1753 – o specie neofită pe teritoriul Ucrainei – asupra vitalității altor specii plutitoare hidrofite, așa zisul pleuston, cum ar fi *Salvinia natans* (L.) All., 1785 și *S. laevigatum* (Humb. and Bonpl. ex Willd.) Heine, 1968, de asemenea a fost determinat gradul de stabilitate și de competitivitate a acestor specii ca resurse în ecosisteme naturale, în comparație cu specia neofită. Pentru a determina influența speciei *Pistia stratiotes* L. asupra altor specii plutitoare pe suprafața apei, cu care se află în relații de concurență în ceea ce privește nutrienții, au fost analizate schimbări în conținutul de pigmenți fotosintetici la speciile *Salvinia laevigatum* și *S. natans*, ele fiind expuse împreună cu *P. stratiotes* timp de 14 zile în condiții de experiment. Pe lângă schimbări în indicatorii apei, a fost măsurat și conținutul în oxigen, mineralizarea și valorile de pH.

INTRODUCTION

Non-aboriginal invasions are one of the greatest environmental problems of the present, which is acute due to the active processes of biotic globalization (*, 2001; **, 2016; Anastasiu et al., 2017). Problem of extrusion of indigenous species of aquatic plants from the places of their natural existence by invasive plants, which came from artificial growing conditions (technical reservoirs, aquariums) to natural reservoirs, becomes a large scale (May, 2006). Usually, the tropical plants die at low temperatures in winter, but the presence of numerous heat and power plants, industrial enterprises in Ukraine which operate water with a further dumping it in hot water reservoirs, increases the temperature of water in natural reservoirs, creating conditions for hibernation of invasive species (Kazarinova, 2014).

The penetration of the tropical species water lettuce, *Pistia stratiotes*, into the territory of Ukraine and its massive development, which is associated with climate change and rising winter temperatures, is already a real ecological threat to hydrosystems in some regions of Ukraine. Since 1976, this tropical plant began to reclaim water reservoirs in Europe (May, 2006; Sajna et al., 2007; Neuenschwander, 2009; Soloviova, 2009; CABI Invasive Species Compendium online data sheet, 2011), and since 2010 it has been seen in the water bodies of Ukraine, namely in the Kyiv and Kharkiv regions on the rivers Dnipro, Udai, and Siversky Donets (Chorna, 2006; Lushpa, 2009; Mosiakin and Kazarinova, 2014a; Mosiakin and Kazarinova, 2014b). In the summer of 2013, on the river Siversky Donets, a large-scale phytoexpansion of this species was conducted on the aquatic ecosystem, which caused an ecological catastrophe, taking in a short time the channel part and the flood plain basins connected with the main water artery of the region (Vasenko et al., 2013a; Vasenko et al., 2013b). *Pistia stratiotes* are considered malicious weeds (Martins, 2003; Camargo et al., 2003) because in a short period of time, it can completely cover the surface of a small reservoir, dooming it to drain.

Salvinia laevigatum does not grow in Ukraine, though it is common in North and South America. The plant has a high invasive potential. Imported from California U.S.A., it has become widespread, displacing local aquatic plants (Haynes, 2000). In Ukraine, this plant is popular among aquarists (Cyriling, 1991), that is why it has a high risk of getting into natural aquatic reservoirs.

In order to preserve the biological diversity of Ukrainian water reservoirs, it is necessary to investigate and control the processes of spreading of aggressive tropical species and their impact on indigenous flora. Therefore, the purpose of the work was to find out the impact of *Pistia stratiotes* (the new species) on the territory of Ukraine, and on the vitality of other free-floating hydrophytes called pleuston (*Salvinia natans* and *Salvinia laevigatum* – the latter also an introduced species) to determine the degree of stability and competitiveness of these species for resources in natural ecosystems relative to the undesirable species.

MATERIAL AND METHODS

The researched elements were three species of aquatic pleuston plants: invasive species, the effect of which was studied – *Pistia stratiotes* L. (Fig. 1) and two species of the genus *Salvinia* – *Salvinia natans* (L.) All. (Fig. 2) and *Salvinia laevigatum* Humb. And Bonplex Willd. (Fig. 3). *S. natans* is an intrinsic species for Ukraine that occurs in waters and valleys of the Dnipro, Desna, Siversky Donets, Dniester, Danube, Uzh, Latorytsia, and Borzhava rivers, estuaries, artificial reservoirs of Dnipro cascade, forest-steppe and steppe ponds (Dubyna et al., 2003), and belongs to rare species that needs protection (Didukh, 2009).



Figure 1: *Pistia stratiotes*.



Figure 2: *Salvinia laevigatum*.



Figure 3: *Salvinia natans*.

Cultures of aquatic plants were grown in the aquaculture complex of the NSC “Institute of Biology and Medicine” in aquariums of 40-60 liters of settled water at optimum conditions: illumination of 6,000 lux, water temperature 18-25°C, pH 6-7.5.

During the experiment, plants approximately equal in appearance, size and without visible damages were placed in special three liters aquariums filled with settled tap water, and exposed for 14 days under optimal lighting conditions (5,000 lux), water temperature (19-20°C), pH (6-7) and initial mineralization (237 mg/l). According to the experiment design, plants of *P. stratiotes* were also placed into aquariums.

Options for the first experiment:

First option/control – the area of the water surface (S) in the aquarium no *P. stratiotes*;

Second option - ¼ part, or 25% S covered by *P. stratiotes*;

Third option - ½ part or 50% S covered by *P. stratiotes*.

The content of pigments measurement in experimental plants and quantitative indices of oxygen content in water, pH and mineralization were carried out at one, seven, and 14 days.

Determination of the content of pigments was carried out by spectrophotometric method (Havrylenko et al., 1975) on a spectrophotometer Shimadzu UV-1800, for the following wave lengths 440, 644 and 662 nm, and calculated on one g of dry weight (DW).

The oxygen content was measured using a portable oximeter – Hanna, pH – using pH-Meter PH-107, mineralization – using TDS Meter TDS-2.

All biological repetitions and analytical replicates in the experiment were performed at least in triplicate. The data were subjected to statistical analysis using the Microsoft Office Excel software, and were considered significant (according to the Student’s t-criterion) at the significance level of $p \leq 0.05$. Data are expressed as means of replicates $\pm$ standard deviation.

RESULTS AND DISCUSSION

To find out the influence of *P. stratiotes* on other free-floating water surface plant species which compete for elements of nutrition among each other, we have investigated changes in the content of photosynthetic pigments in *S. laevigatum* and *S. natans*, which were grown together with *P. stratiotes* for 14 days. Besides, we measured changes in water indices, included oxygen content, mineralization and pH.

Since in our previous studies (Olkovich et al., 2017) the evident changes in the content of photosynthetic pigments by the effects of *P. stratiotes* on submerged water plants were observed only on the 14th day, the evaluation of the content of pigments in pleuston was also carried out on the 14th day.

Yellowing of leaves in the experimental plants (*S. laevigatum* and *P. stratiotes*) and the absence of yellowing and even more intense green coloration of *S. natans* leaves, which were kept together for 14 days, were admitted after visual observations.

According to the results of our studies, the effect of *P. stratiotes* on the content of chlorophyll a and b in *S. laevigatum* on the 14th day of the experiment in both options decreased (from 0.01 mg/g to 0.008 mg/g for 25% S covered by *P. stratiotes*, and from 0.01 mg/g to 0.009 mg/g for 50% S covered by *P. stratiotes*), and content of carotenoids remained unchanged and constant at 0.004 mg/g for 14 days (Fig. 1).

In all variants the chlorophyll a content was predominant, and the ratio of chlorophyll a/ chlorophyll b was doubled, which corresponds to the normal state of the pigment apparatus and the optimal vitality of aqueous plants.

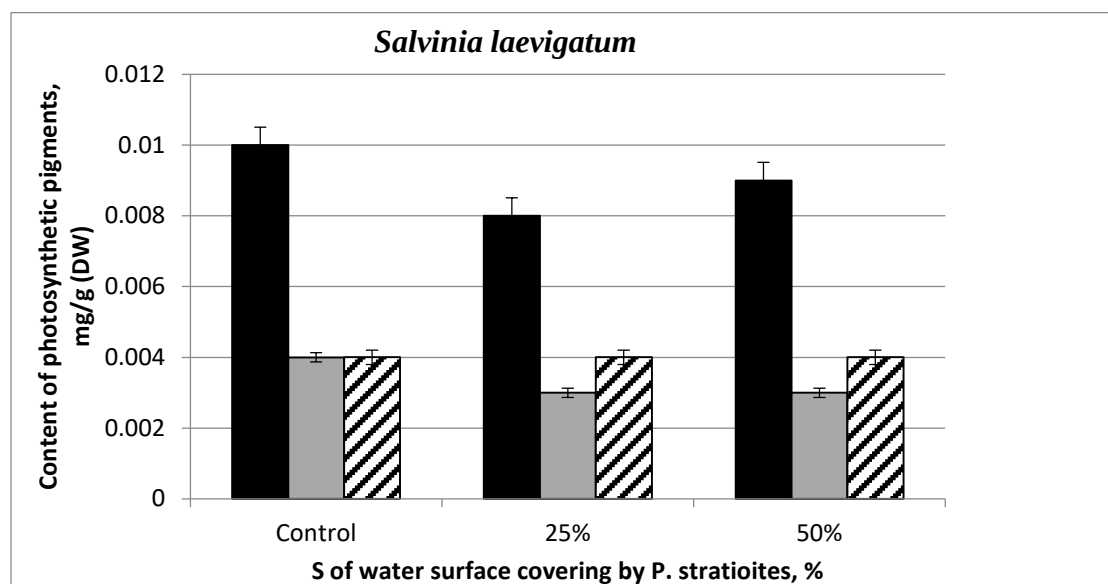


Figure 1: Content of photosynthetic pigments in *S. laevigatum* effected by *P. stratiotes* at 14th day.

The unexpected changes occurred on the 14th day in the content of pigments of *S. natans*. The content of chlorophyll a increased twice in 25% S and 1.5 times in 50% S covered by *P. stratiotes*. The content of chlorophyll b decreased by two times in 25% S, but doubled in 50% S by *P. stratiotes*. The content of carotenoids did not change for option 25% S and increased by 1.5 times in 50% S (Fig. 2). Thus, in the case of wider spreading on the water surface by *P. stratiotes*, an increase of carotenoids content in *S. natans* was observed, and therefore protective mechanisms associated with carotenoid pool were included. In the case of covering the water surface area by *P. stratiotes* on 25%, protective mechanisms were not used. Probably, this effect was not strong enough for triggering reparatory mechanisms, so it can be considered not threatening for studied species.

Such unexpected increase in the total content of chlorophylls in *S. natans* indicates a positive effect of *P. stratiotes* on this plant. Moreover, it was stronger in the case of fewer plants in the aquarium. But in the case of increasing ratio of biomass per 1 l of water, the positive effect was reduced, as evidenced by the significant rising of the carotenoid content under these researched conditions. It is known that *S. natans* is not a water content-demanding plant, but more demanding to light, and possibly even a slight decrease in the amount of light that has fallen on the plant due to shading has led to such a rapid increase in the content of chlorophyll a, which is the main photosynthetic pigment. Such an interesting effect may also be caused by changes in water parameters for the long stay of *P. stratiotes*, primarily oxygen content, pH, and mineralization level, which we will discuss in more detail later.

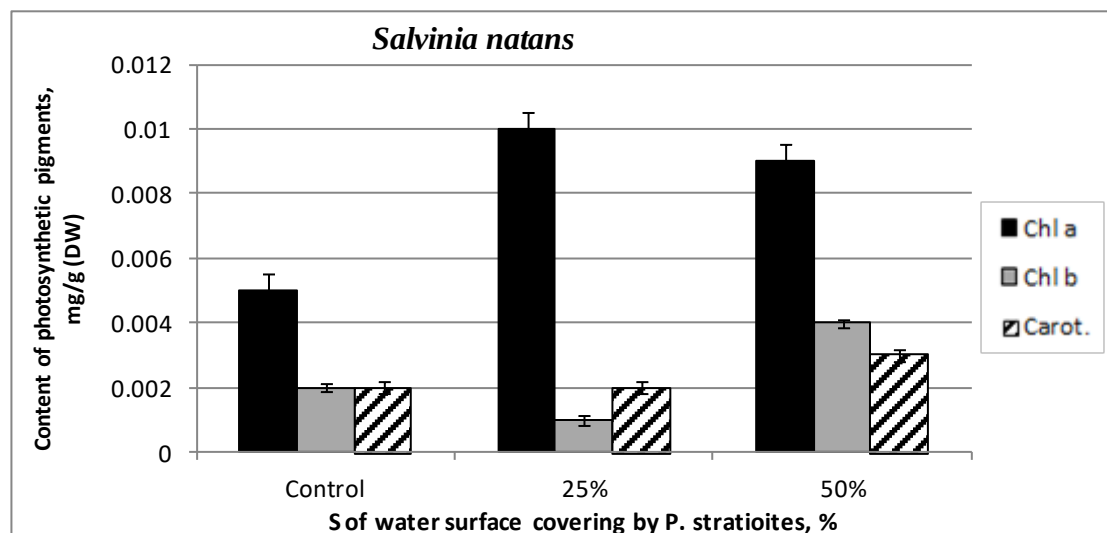
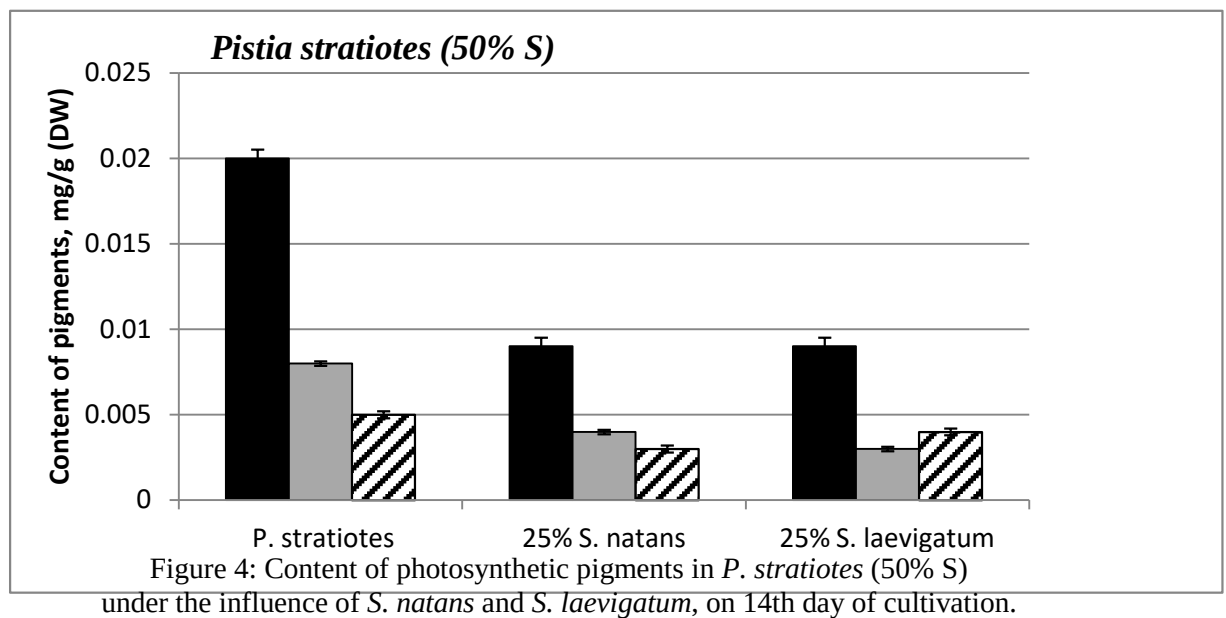
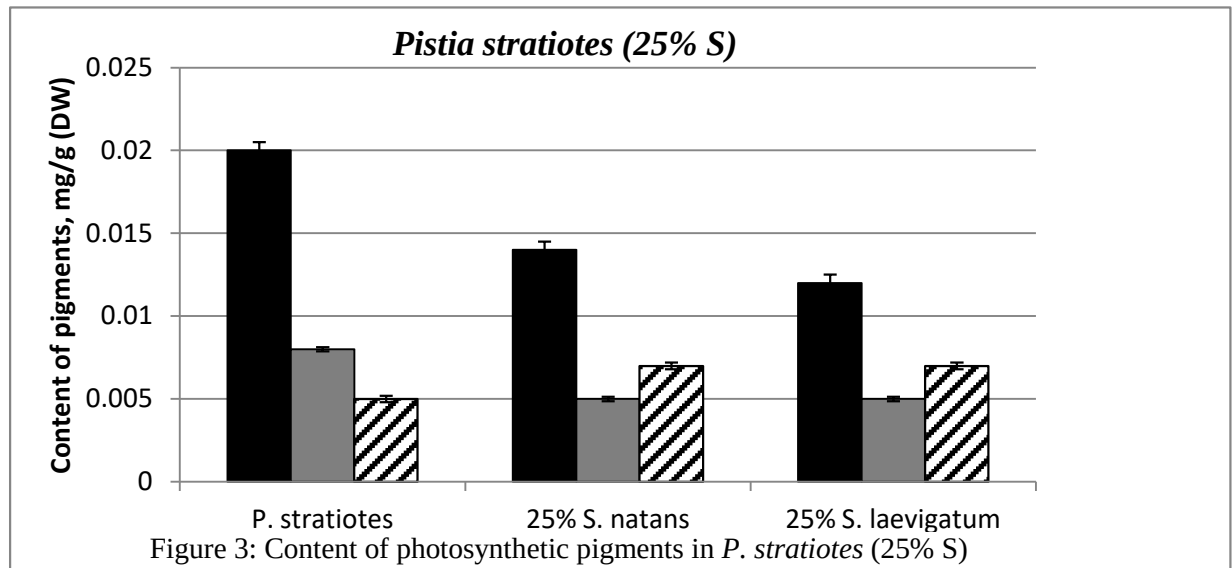


Figure 2: Content of photosynthetic pigments in *S. natans* effected by *P. stratiotes* at 14th day.

Our previous studies showed the negative effects of *Pistia* on the content of pigments and the overall productivity of the submerged water plants – *Vallisneria spiralis* L. and *Ceratophyllum demersum* L. and positive on *Elodea canadensis* Michx. (Olkhovich et al., 2017). By current research, we tried to confirm or deny the negative influence of *P. stratiotes* on pleuston water plants. The obtained results of this influence were not unequivocal.

Since visual observations of morphological changes in the studied free-floating water plants revealed yellowing of leaves not only in *S. laevigatum*, but also in *P. stratiotes*, whose effect on experimental plants was evaluated, we have analyzed the changes in content of photosynthetic pigments in *P. stratiotes* under conditions of co-cultivation of these plants. The results of these studies are presented in figures 3 and 4.



Quantitative indices of the content of pigments convincingly indicate the influence of *S. laevigatum* and *S. natans* on *Pistia* itself. So, the total content of chlorophylls due to contents of chlorophyll a and b were increased, however carotenoid content was reduced. The trend of changes, for both studied species – *S. laevigatum* and *S. natans*, was similar. With increasing density of *P. stratiotes* on the water surface, the impact of other species on it was stronger. Probably, in this case, the competitive impact on the supply of nutrients increases with the increase of *P. stratiotes* biomass per l of water, and not in favour of *P. stratiotes*, as evidenced by an increase in the content of pigments in *S. natans*, which was discussed earlier. Since carotenoids expanded the spectrum of photosynthesis, providing absorption of 10 to 20% of the energy of solar quanta, with about 50% of energy absorbed in the short-wave region – the high energy region, these pigments act as auxiliary light absorption by transferring the energy of their electron-excited state to chlorophyll a.

According to the results of our studies, significant changes in the influence of *P. stratiotes* on the content of the pigments of the studied species in any of the variants were not observed. Even the most significant changes were admitted in the pigment content of *P. stratiotes* itself, especially in the case of 50% of water surface coverage by *P. stratiotes*. This testifies to the resistance of the studied pleuston species to *P. stratiotes*, in contrast to the submerged plant species, primarily due to the absence of direct influence of shading of these species and the decreasing of water temperature under the cover of *P. stratiotes*.

It is known that in natural water basins of Ukraine, *S. natans* is a rare plant that is even included into the Red Book, its resistance to the influence of *P. stratiotes*, and even the probable increase in productivity in its presence, is impressive. The results of our research indicate that in the case of prolonged competition for energy resources, the possible change in the biodiversity of artificial ecosystems takes place in favour of *S. natans*, which can not be considered as a negative consequence of the after effect of *P. stratiotes*.

In order to assess the influence of *P. stratiotes* on water quality and its suitability for other pleuston species, we have carried out determination of oxygen content, pH of the medium and degree of mineralization of water.

Soluble in water, oxygen is a compulsory component for the existence of most aquatic organisms, including macrophytes. The concentration of oxygen in water influences on the all hydrobionts and the direction of biochemical and hydrobiological processes. When the surface of the water reservoir is covered with plants or a chemical film, and there is no water circulation, then stagnation develops, which leads to the replacement of species of hydrobionts with a narrow ecological amplitude for species with a wide amplitude, which simplifies the species diversity of water basin.

The content of oxygen in water depends on the ratio of two opposite processes: oxygenation and reduction of oxygen in it. Water enrichment with molecular oxygen occurs due to the flow from the atmosphere and its allocation during photosynthesis by water plants (Romanenko, 2001; Bezmaternyh, 2009).

Coastal and aquatic plants, allocating oxygen during photosynthesis, positively affect the oxygen regime of the coastal zone of the water reservoir. Bacteria and algae, which live on the surface of plants, are actively involved in purifying water. In the thickets of coastal and aquatic plants, the phytophilic fauna develops, which also takes part in the self-purification of the water and bottom sediments, with benthic organisms utilizing the organic matter of the silt. The influence of these processes in water increases as well as the content of dissolved oxygen and nutrients increases, its transparency leads to decreasing of the water mineralization and the number of intermediate products of decomposition of organic matter.

Photosynthesis in water reservoirs occurs at shallows, mainly in surface layers of water, well-lit and warmed, where most of the aquatic plants are concentrated (Bezmaternyh, 2009).

Free-floating plants on the water surface have advantages over the availability of oxygen in relation to the submerged species, and they are located closest to the light source and have the ability to absorb the largest spectrum of rays of physiologically active radiation. Strongly expanding and intensely covering the water surface, pleuston can block the access of oxygen from the layers of the atmosphere and obscure not only the immersed species that grow under them, but also those growing near these species on the surface, reducing the intensity of photosynthetic processes and the overall productivity of reservoirs. This causes a lack of oxygen in the water basin. At the same time, free-floating species are also actively photosynthetic plants, which probably saturate with oxygen, although stomata, through which oxygen is primarily released, are located on the upper side of the leaf that comes in direct contact with the atmosphere, makes this issue uncertain. In any case, as a positive effect, namely an increase in the level of oxygen, and a negative effect – a decrease in the level of oxygen, will lead to a series of events that will lead to a change in the balance in the reservoir, the consequences of which may be totally unexpected.

We tried to find out what is the oxygen regime in water, where pleuston grow in the presence of a species not typical for Ukrainian reservoirs – *P. stratiotes*. The results of the studies are presented in tables 1 and 2.

Table 1: Oxygen content in water during cultivation of *S. natans* (25% S) in presence of *P. stratiotes*.

Duration of the experiment, day/days	Oxygen content, mg/l		
	Control (pure <i>S. natans</i>)	25% S covered by <i>P. stratiotes</i>	50% S covered by <i>P. stratiotes</i>
1	6.24 ± 0.01	6.24 ± 0.01	6.24 ± 0.02
7	6.29 ± 0.04	6.82 ± 0.01	6.7 ± 0.05
14	6.85 ± 0.03	7.73 ± 0.01	7.52 ± 0.04

The oxygen content gradually increased from 6.24 mg/l to 6.85 mg/l in the water where only *S. natans* grew (control) for 14 days. The same happened with experimental variants, and the oxygen content in the presence of *P. stratiotes* increased significantly in relation to control. So on the 14th day of the experiment, the oxygen content for 25% coverage of surface area by *P. stratiotes* was 7.73 mg/l, and 50% coverage by *P. stratiotes* was 7.52 mg/l. An increase in the oxygen content in water, which coexisted with *S. natans* and *P. stratiotes*, is well matched with an increase in the content of pigments in *S. natans*. Oxygen enrichment in experimental variants is associated with an increase in the intensity of photosynthesis of *S. natans* influenced by *P. stratiotes*.

Table 2: Oxygen content in water during cultivation of *S. laevigatum* (25% S) in presence of *P. stratiotes*.

Duration of the experiment, day/days	Oxygen content, mg/L		
	Control (pure <i>S. laevigatum</i>)	25% S covered by <i>P. stratiotes</i>	50% S covered by <i>P. stratiotes</i>
1	6.24 ± 0.01	6.24 ± 0.01	6.24 ± 0.02
7	7.93 ± 0.04	7.62 ± 0.01	7.75 ± 0.05
14	7.60 ± 0.03	7.84 ± 0.01	7.81 ± 0.04

At the exposure of pure culture *S. laevigatum* on the 7th day of the experiment the oxygen content increased sharply by 1.69 mg/l, and at the 14th day, it decreased slightly (by 0.33 mg/l). Under the influence of *P. stratiotes*, oxygen content during two weeks also gradually increased from 6.24 mg/l to 7.84 mg/l and from 6.24 mg/l to 7.81 mg/l for 25% S and 50% S coverage by *P. stratiotes*. Thus, in the presence of *P. stratiotes*, the oxygen content was slightly higher (0.21-0.24 mg/l) than in the control option. Such changes in the content of oxygen in water can not be considered threatening for the existence of other hydrobionts, including the studied pleuston species, because they are normal for natural reservoir fluctuations. It is known that near the thickets of *Potamogeton*, *Vallisneria*, *Elodea* and other immersed plants, the concentration of dissolved oxygen in water on summer days can rise to 10-12 mg/l, and to 6-7 mg/l in non-growth regions (Korotkevich, 1976; Ipatova and Dmitrieva, 2006). Pleuston also emit oxygen from the leaves to the roots and stems, thus influencing the formation of the gas regime of the surface layers of water.

The pH indicator characterizes the active reaction of the medium, on which the development of hydrobionts depends. During intense photosynthesis, the pH can rise to 10 and above, due to almost complete disposal of water from free carbon dioxide by water plants, and increasing the alkalinity of the medium with carbonates (Bezmaternyh, 2009). The pH of water changes throughout the day in natural reservoirs. At night, the water is acidified as a result of separation during the breathing of carbon dioxide. In the afternoon, the alkalinity of water increases due to the consumption of CO₂ by plants (Romanenko, 2001). The pH is reflected in the water-salt metabolism of hydrobionts. The concentration of hydrogen ions not only determines the limits of the distribution of aquatic organisms, but also affects their life.

We tried to find out what is the pH of the water in which the pleuston is exposed in the presence of a new invasive species – *P. stratiotes*. The results of the studies are presented in tables 3 and 4.

Table 3: pH of the water during cultivation of *S. natans* (25% S) in presence of *P. stratiotes*.

Duration of the experiment, day/days	Oxygen content, mg/L		
	Control (pure <i>S. natans</i>)	25% S covered by <i>P. stratiotes</i>	50% S covered by <i>P. stratiotes</i>
1	7.7 ± 0.04	7.7 ± 0.5	7.7 ± 0.02
7	8.6 ± 0.01	8.4 ± 0.03	8.6 ± 0.01
14	8.7 ± 0.01	8.4 ± 0.02	8.3 ± 0.02

The initial level of pH to the plant exposure was 7.7. During the week it reached the level of 8.3-8.6, namely, the studied species, due to the primarily photosynthesis and respiration, contributed to the sublimation of the environment. There was no significant difference in *Salvinia* exposure separately and compatible with *Pistia*. It can be stated that the effect of *Pistia* on *Salvinia* does not occur due to changes in the pH of the medium.

Table 4: pH of the water during cultivation of *S. laevigatum* (25% S) in presence of *P. stratiotes*.

Duration of the experiment, day/days	pH		
	Control (pure <i>S. laevigatum</i>)	25% S covered by <i>P. stratiotes</i>	50% S covered by <i>P. stratiotes</i>
1	7.7 ± 0.04	7.7 ± 0.5	7.7 ± 0.02
7	8.4 ± 0.01	8.3 ± 0.03	8.3 ± 0.01
14	8.2 ± 0.01	8.4 ± 0.02	8.2 ± 0.02

Similar processes were observed at the exposure of *S. laevigatum*. The pH level of 7.7 (the water on which the plants were originally grown) in seven days changed to 8.2-8.4 and remained stable for the next week. The alkalization of water in the presence of plants occurs due to the consumption of CO₂ by plants during photosynthetic activity. No significant difference between the experimental variants was observed, and therefore the influence of *P. stratiotes* on the change in pH of the medium did not occur.

An important role in the life of hydrobionts is played by salt dissolved in water. The values for aquatic organisms have the following indicators: ionic composition of water and salinity – the total amount of water dissolved in mineral salts. The bulk of the saline composition of natural water is represented by the ions: HCO₃⁻, Cl⁻, SO₄²⁻, Ca²⁺, Mg²⁺, Na⁺, and K⁺. Fresh and salty waters differ in the ratio of these ions. In fresh waters, hydrocarbons number about 60% of the total amount of salts, and less than 10% are chlorides. The level of mineralization of water is an important indicator of the status of the water reservoir and the possibility of existence in it certain species of aquatic plants. As the mineralization of water increases, its density and viscosity also increase (Bezmaternyh, 2009; Kurilov, 2009).

We tried to find which changes of the level of mineralization would occur in water for the compatibility of the studied pleustons. The results of the studies are presented in tables 5 and 6.

Table 5: Water mineralization at exposure of *S. natans* (25% S) in the presence of *P. stratiotes*.

Duration of the experiment, day/days	Water mineralization, mg/l		
	Control (pure <i>S. laevigatum</i>)	25% S covered by <i>P. stratiotes</i>	50% S covered by <i>P. stratiotes</i>
1	240 ± 2.0	240 ± 4.2	240 ± 2.7
7	271 ± 6.1	254 ± 7.8	260 ± 5.3
14	313 ± 7.5	232 ± 3.1	227 ± 4.1

The mineralization of water in aquariums in which the *S. natans* were exhibited, has changed in the control variant from one day to 14 days from 240 mg/l to 313 mg/l, and under the influence of *P. stratiotes*: from 240 mg/l to 232 mg/l, and from 227 mg/l to 276 mg/l at 25% S and 50% S respectively. So, on the 14th day a significant decrease in mineralization in experimental variants relative to the control was marked, which may be the evidence of intense absorption of mineral elements by invasive species that's characterized by high growth potential. In the control variant (pure *S. natans*), during two weeks a gradual increase in mineralization (240 mg/l – one day, 270 mg/l – seven days, 313 mg/l – 14 days) was observed, and in the experimental group an increase was admitted at the 7th day (14 mg/l at 25% S and 20 mg/l at 50% S), and then, on the 14th day of exposure a sharp decline in mineralization (on seven mg/l at 25% S and 13 mg/l at 50% S) in relation to the starting value (240 mg/l).

Table 6: Water mineralization at exposure of *S. laevigatum* (25% S) in the presence of *P. stratiotes*.

Duration of the experiment, day/days	Water mineralization, mg/l		
	Control (pure <i>S. laevigatum</i>)	25% S covered by <i>P. stratiotes</i>	50% S covered by <i>P. stratiotes</i>
1	240 ± 2.0	239 ± 4.2	240 ± 2.7
7	268 ± 6.1	234 ± 7.8	236 ± 5.3
14	239 ± 7.5	233 ± 3.1	221 ± 4.1

In studies with *S. laevigatum* the level of mineralization increased by 18 mg/l on the 7th day, but on the 14th day returned to the original value (239 mg/l). The influence of *P. stratiotes* was manifested in reduction of the mineralization level. Besides, in the case of an increase of the number of *P. stratiotes* this effect was stronger, thus, at 14th days at 25% S it decreased by six mg/l, and at 50% S – by 19 mg/l. In the control variant, the level of mineralization on the 14th day was the highest (239 mg/l), and at 50% S by *P. stratiotes* – the lowest (221 mg/l).

CONCLUSIONS

Significant negative changes due to the influence of *P. stratiotes* on the content of pigments of the studied species (*S. natans*, and *S. laevigatum*) did not occur, while there was a decrease in the content of pigments in *P. stratiotes* itself in the presence of *S. natans*.

In *S. natans* plants the content of chlorophyll a increased 1.5-2 times, and the content of chlorophyll b increased twice in 50% S by *P. stratiotes*. The content of carotenoids did not change and increased 1.5 times at 25% S and 50% S by *P. stratiotes* respectively.

In the presence of *P. stratiotes*, the content of chlorophyll in *S. laevigatum* during the studied period did not significantly decrease (from 0.01 mg/g to 0.008 mg/g), and carotenoids did not change at all. In all variants the chlorophyll a content was predominant, and the ratio of chlorophyll a/chlorophyll b was greater than two, which corresponds to the normal state of the photosynthetic pigment apparatus and the optimal vitality of aqueous plants.

The oxygen content in water on which only *S. natans* grew had gradually increased from 6.24 mg/l to 6.85 mg/l for 14 days, and in the presence of *P. stratiotes* at 25% S of coverage to 7.73 mg/l, and at 50% S – up to 7.52 mg/l. In the presence of *P. stratiotes* in variants with *S. laevigatum*, the oxygen content was also higher (by 0.21 and 0.24 mg/l, respectively) than in the control version.

It has been established that in the presence of *S. natans* and *S. laevigatum*, the level of mineralization of water has been increased, and on the contrary in the presence of *P. stratiotes* decreased. The pH of water remained unchanged in the presence of *P. stratiotes* with the species studied.

In the case of prolonged presence (during 14 days) during competition for energy resources, alteration of the species composition of artificial ecosystem in favour of *S. natans* is possible, which can be considered as a positive consequence of the after effect of *P. stratiotes*. Since *S. natans* is a rare plant in the natural waters of Ukraine, which is even included into the Red Book, its resistance to the influence of *P. stratiotes* and even the probable increase in productivity under its presence is pleasantly impressive.

Extension of the range of distribution and acceleration of the course of invasive *P. stratiotes* in the territory of Ukraine, which have been observed in recent years, will unequivocally cause changes in groups of pleuston species. This species, in cases of rapid spreading in Ukraine's water basins, can lead to environmental problems associated with the alterations in the composition of aquatic ecosystems, as well as the simplification of their biodiversity.

REFERENCES

1. Anastasiu P., Preda C., Bănăduc D. and Cogălniceanu D., 2017 – Alien species of European Union concern in Romania, *Transylvanian Review of Systematical and Ecological Research*, 19.3, The Wetlands Diversity, 93-106, ISSN-L 1841-7051, ISSN 2344-3219, 2017.
2. Bezmaternyh D., 2009 – Aquatic ecosystems: composition, structure, function and use (manual), Barnaul: ASU Publ., 97.
3. CABI Invasive Species Compendium online data sheet, 2011 – *Pistia stratiotes* (water lettuce). CABI Publishing. <http://www.cabi.org/isc/datasheet/41496> (24.11.2014).
4. Camargo A., Henry-Silva G. and Pezzato M. 2003 – Crescimento e produção primária de macrófitas aquáticas em zonas litorâneas, in Henry R. (ed.). *Ecótonos nas interfaces dos ecossistemas aquáticos*, São Carlos: Fundibio/Rima, 213-232. (in Spanish)
5. Chorna H., 2006 – Flora of forest-steppe water bodies and wetlands of Ukraine, Vascular plants, K.: Phytosociocenter, 184.
6. Cyrlling M., 1991 – Aquarium and aquatic plants, Hidrometeoisdat, 255.
7. Didukh Y., 2009 – The Red Book of Ukraine, Flora, K.: Globalconsalting, 900.
8. Dubyna D., Sheliakh-Sosonko Y., Zhmud O., Dvoretzkyi T. and Dzuba T., 2003 – Danube biosphere reserve, Flora, Phytosociocenter, Kyiv, Ukraine.
9. Havrylenko V., Ladyhyna M. and Khandobina L., 1975 – Large Practicum of Plant Physiology, M.: High school, 392.
10. Haynes R., 2000 – *Limnobiolum Richard*, Flora of North America, 22, 28-29.
11. Ipatova B. And Dmitrieva A., 2006 – Use of water plants for heavy metals toxicity diagnosing, Bioindication in the monitoring of freshwater systems: Proceedings of the International Conference, Saint-Petersburg, 63-64.
12. Kazarinova H., Hamulya Y., Hromakova A., 2014 – Massive expansion of *Pistia stratiotes* (*Araceae*) in the Siverskyi Donets river (Kharkiv region). *Ukrainian Botanical Journal*, Vol. 71. 1, 17-21.
13. Korotkevich L., 1976 – To the issue of using the properties of bur reed in water purification, *Aqua resources*, 5, 198-204.
14. Kurilov O., 2009 – Hydrobiology: lecture notes, Part II, Odesa, Ukraine, 202.
15. Lushpa V., 2009 – Water lettuce (*Pistia stratiotes* L.) in the Holosiiv pond in Kyiv, *Research Journal of the National University of Life and Environmental Sciences of Ukraine*, 134, 1, 147-152.

16. Martins D. 2003 – Caracterização química das plantas aquáticas coletadas no reservatório de Salto Grande (Americana-SP), *Planta Daninha*, 21, 21-25. (in Spanish)
17. May S., 2006 – Invasive aquatic and wetland plants (Invasive species), NY.: Chelsea House, 108.
18. Mosiakin A. And Kazarinova H., 2014a – Modelling of *Pistia stratiotes* (Araceae) invasive spreading based on the software-analysis of climate factors, *Ukrainian Botanical Journal*, 71, 5, 549-557.
19. Mosiakin A. And Kazarinova H., 2014b – Modelling of *Pistia stratiotes* (Araceae) invasive spreading based on the software-analysis of climate factors, *Ukrainian Botanical Journal*, 71, 4, 25-31.
20. Neuenschwander P., Julien M., Center T. and Hill M., 2009 – *Pistia stratiotes* L. (Araceae). Biological Control of Tropical Weeds Using Arthropods, New York: Cambridge University Press, 332-352.
21. Olkhovich O., Taran N., Svetlova N., Batsmanova L., Aleksiyyenko M. and Kovalenko M., 2017 – Assessment of the influence of the invasive species *Pistia stratiotes* (Araceae) on some species of submerged macrophytes of natural water bodies of Ukraine, *Hydrobiological Journal*, 53, 5.80, 75-84, Romanenko V., 2001 – The fundamentals of hydroecology, K.: Oberegy, 728.
22. Sajna N., Haler M., Skornik S. and Kaligarić M., 2007 – Survival and expansion of *Pistia stratiotes* L. in a thermal stream in Slovenia, 87, 75-79.
23. Soloviova V., 2009 – Adventive flora of natural and artificial reservoirs of Samara region, Samara Scientific Center News, 11, 1, 4, 611-616.
24. Vasenko A., Starko N., Vernychenko D., Lunhu M. and Persianov H., 2013a – About emergence of *Pistia stratiotes* in water bodies of Kharkiv region, IX International scientific and practical conference Environmental safety: problems and solutions: collection of articles UkrNIIEP, 1, 190-195.
25. Vasenko A., Starko N. and Lunhu M., 2013b – About presence of *Pistia stratiotes* in Kharkiv region, Scientific Tobolsk: proceedings of the X scientific and practical conference, Tobolsk, Tumensk publisher, 69-71.
26. Bezmaternyh D., 2009 – Aquatic ecosystems: composition, structure, function and use (manual), Barnaul: ASU Publications, 97.
27. *, 2001 – Global Strategy on Invasive Alien Species, Convention of Biological Diversity, SBSTTA Sixth Meeting, Montreal, 52, <http://www.biodiv.org>.
28. **, 2016 – European Commission, Commission Implementing Regulation (EU) 2016/1141 of 13 July 2016 adopting a list of invasive alien species of Union concern pursuant to regulation (EU) No 1143/2014 of the European Parliament and of the Council, *Official Journal of the European Union*, L 189/4, 14 July 2016.