Ukrainian Journal of Natural Sciences
№ 15
Український журнал природничих наук
№ 15

ISSN: 2786-6335 print
ISSN: 2786-6343 online

БІОЛОГІЯ

UDC 594.3:504.5:543.395(477.282.2)
DOI https://doi.org/10.32782/naturaljournal.15.2026.1

ECOTOXICOLOGICAL FEATURES OF *PLANORBARIUS CORNEUS* SENSU LATO (MOLLUSCA: GASTROPODA: PULMONATA: PLANORBIDAE) ALLOSPECIES FROM UKRAINIAN RIVER NETWORK UNDER IMPACT OF SYNTHETIC DETERGENTS

Yu. V. Ikonnikova[1]

We studied the action of different widespread in Ukraine non-phosphate ("LOSK", "Friends") and phosphate ("Savex", "Teo Bebe") detergents in different concentrations (0.001–1000 mg/L) on the ecotoxicological features of vicarious genetic allospecies of great ramshorn Planorbarius corneus sensu lato, "western" and "eastern". The main toxicological indexes (LC_0, LC_{50}, LC_{100}), latent period, lethal time, mean lethal time, and coefficients of endurance and adaptation were established for both allospecies. It was found that by toxicity scale used detergent belong to the weakly toxic ("LOSK", "Friends"), very toxic ("Teo Bebe") and highly toxic ("Savex"), presenting the following order: «Savex» > «Teo Bebe» > «LOSK», «Friends». Under the impact of toxicants in applied concentrations the experimental molluscs developed the irreversible pathological process of intoxication, composing of five phases: latent, stimulation, depression, sub-lethal and lethal. Under the impact of equal concentrations of detergents applied in the experiments, the mortality of "eastern" allospecies was higher than that of "western" one. Obtained ecotoxicological indexes demonstrate the different sensitivity of two allospecies for used toxicants ($p \leq 0,05$). The "eastern" allospecies appeared to be much more sensitive and less adapted for different detergents' impact than "western" allospecies. That's why both P. corneus s. lato allospecies can be used as indicator objects in monitoring of pollution level by these detergents of nature water bodies of Ukraine.

Key words: *freshwater molluscs, surfactants, ecotoxicological parameters, aquatic ecosystem pollution.*

ЕКОТОКСИКОЛОГІЧНІ ОСОБЛИВОСТІ АЛОВИДІВ *PLANORBARIUS CORNEUS* SENSU LATO (MOLLUSCA: GASTROPODA: PULMONATA: PLANORBIDAE) ГІДРОМЕРЕЖІ УКРАЇНИ ЗА ВПЛИВУ РІЗНИХ СИНТЕТИЧНИХ МИЮЧИХ ЗАСОБІВ

Ю. В. Іконнікова

Досліджено вплив різних концентрацій (0,001–1000 мг/л) широко застосовуваних в Україні безфосфатних («LOSK», «Друг») і фосфатних («Savex», «Teo Bebe») миючих засобів на екотоксикологічні особливості генетичних аловидів-вікаріантів витушки рогової Planorbarius corneus s. lato – «західного» і «східного». Встановлено значення основних токсикологічних показників (LC_0, LC_{50}, LC_{100}), межі латентного періоду, летальний час і летальний середній час, а також коефіцієнти

[1] Assistant at the Department of Botany, Biological Resources and Conservation of Biological Diversity (Zhytomyr Ivan Franko State University, Zhytomyr)
e-mail: Ikonnikova-Y@zu.edu.ua
ORCID: 0000-0001-6887-0529

витривалості та пристосування для обох аловидів. З'ясовано, що за шкалою токсичності речовин для аловидів P. corneus s. lato використані синтетичні миючі засоби належать до категорій слабкотоксичних («LOSK», «Друг»), сильнотоксичних («Teo Bebe») і високотоксичних («Savex») речовин, формуючи за ступенем зменшення токсичності такий ряд: «Savex» > «Teo Bebe» > «LOSK» > «Друг». У піддослідних молюсків за дії досліджених концентрацій токсикантів розвивався незворотний патологічний процес – отруєння, що включало п'ять фаз: латентну, стимуляційну, депресивну, сублетальну та летальну. Смертність особин аловиду «східного» за однакових концентрацій використаних у дослідах детергентів була вищою порівняно з аловидом «західним». Отримані значення екотоксикологічних показників свідчать про різну чутливість аловидів витушок до впливу досліджених токсикантів (p≤0,05). Аловид «східний» виявився значно чутливішим і менш пристосованим до дії різних СМЗ, ніж аловид «західний». Отже, обидва аловида-вікаріанти P. corneus s. lato можуть бути рекомендовані як індикаторні об'єкти для біомоніторингу рівня забруднення природних вод України синтетичними детергентами.

***Ключові слова**: прісноводні молюски, поверхнево-активні речовини, детергенти, екотоксикологічні показники, забруднення водних екосистем.*

Introduction

In modern world, the human's actions have caused the set of global ecological problems for Earth's hydrosphere (Sveum & Elamonovich, 2022; Uwajewa et al., 2022). From the end of XX – beginning of XXI centuries, the different synthetic detergents have gotten into the surface waters of Ukraine progressively as municipal wastes and wastes of several industries (light, oil refining and petrochemical, industry of synthetic rubber, fibers and toxic chemicals) (Романенко, 2001). The production of detergents grows yearly, as their assortment also does. These detergents are characterized by emulsifying, dispersive and lightening features and contain the synthetic surface-active compounds (15–25%).

They are well-soluble in water, however, are slowly decaying, and thus settle in water bodies for long. Getting into the nature ecosystems, these pollutants are involved into the circulation of substances, being oxidized and adsorbed by suspensions and bottom substrates, that somewhat lowers their concentrations in water. The level of biochemical oxidation of these pollutants depends as on their chemical composition and structure, as on the environmental conditions (Mousavi & Khodadoost, 2019). By now, the water bodies without detergents are almost absent in Ukraine, and the level of river network pollution by them exceeds the established norms of their MPC (0,5 mg/L for anion-active, 0,1 mg/L for non-ionic) in tens and hundreds of times (Дудник і Євтушенко, 2013).

The consequence of the wide detergents application has become the increase of phosphorus in Ukrainian wastewaters, which can migrate and accumulate in bottom sediments and in hydrobionts, provoking the intensive growth of water plants biomass, which causes the eutrophication of water bodies (Савлучинська та ін., 2013). The detergents containing phosphates are quite caustic and causes excessive foam production, impoverishing the water of soluble oxygen, and deteriorating the feeding chains (Mathew et al., 2013; Divya, 2015; Toledo et al., 2021). In modern days, along the phosphate-containing detergents exist there are become more used the less toxic non-phosphate detergents (Уваєва, 2018). Their impact, as the impact of all others detergents, is multifactorial and is caused in two ways. The first (direct) – the impact of these pollutants on the behavioral, physiological, biochemical and biological processes occurring in hydrobionts' organisms, changing them one or another way (Logeswari et al., 2021; Borah, 2022). It is known that under the certain detergent concentrations, the set of physiological processes in freshwater molluscs become impaired: filtration (Уваєва і Сарган, 2011; Уваєва, 2012, 2018; Stadnychenko et al., 2019), respiration (Бабич і Стадниченко, 2022; Астахова, 2023), hematological (Стадниченко і Янович, 2004; Бабич та ін., 2021; Махневич і Стадниченко, 2021) and trophological indexes (Стадниченко, 2005). The second (indirect) impact of detergents on hydrobionts is caused by the changes in physical, physico-chemical and chemical water features, i.e. their life environment. That's because the hydrobionts can change water pH and salinity, making difficult the biological processes of oxidation of organic pollutions, and thus influencing the oxygen consumption by water organisms (Chandanshive, 2013; Білик та ін., 2021). Besides, the detergents can cause the mutagenic, embryotoxic and gonadotoxic impact on hydrobionts (Уваєва, 2018).

The study of impact of different detergents on the water ecosystems and their inhabitants, particularly the molluscs playing important role in the bioindication of water environment

state, is actual (Дідух, 2012). The danger of this toxicants use consist of them impairing the normal water aeration, impairing the respiration of hydrobionts. That's why it is expedient to found out the impact of different detergents on viability of great ramshorn allospecies.

The aim of present study is to establish the features of impact of different concentrations of widely used in Ukraine non-phoshate («LOSK», «Friends») and phosphate («Savex», «Teo Bebe») detergents by the ecotoxicological indexes of "western" and "eastern" allospecies of *P. corneus* s. lato, and to estimate the expedience of use of these allospecies in biomonitoring of Ukrainian water ecosystems state.

Material and methods

The material was the individuals of great ramshorn *P. corneus* s. lato of the same age collected by hand in June-August 2021: 670 individuals of "western" allospecies (shell diameter – 25,62±0,12 mm) from the Sluch river (Prypiat basin) near Myropol settlement (50°06'29.0''N 27°41'27.2''E), and 665 individuals of "eastern" allospecies (shell diameter – 24,12±0,22 mm) from the Sula river (left Dnipro tributary) near Romny city (50°44'13.5''N 33°29'49.5''E) (Fig. 1).

Allospecies were identified by the conchiological traits (Гарбар, 2003, 2009). Before the experiment, the animals delivered to laboratory were acclimation during 14 days (Babych et al., 2021): aquarium volume – 10 L, animals' density – 5 ind./L, water temperature – 18–20°C, pH – 7,2–7,7, DO – 7,0–8,2 mg O_2/L. Renewing of the environment was daily, as well as feeding by soft water plants (*Cladophora sp.*, *Miriophyllum spicatum* L.) collected at the sites of material collecting.

The toxicological experiment was conducted according to a standard method (Бабич і Пінкіна, 2021). The following detergents were used as toxicants: non-phosphate–«LOSK»(«Henkel»,Poland)and«Friends» (TM «Friends», Ukraine), phosphate – «Savex» («Ficosota Syntez», Bulgaria) and «Teo bebe» («Ficosota Syntez», Bulgaria) at concentrations of 0,001–1000 mg/L. The exposure duration was 48 hours. The solutions were prepared using dechlorinated (by 2-days ageing) tap water from Zhytomyr water network (t° – 18–20° C, pH – 7,2–7,7, DO – 7,0–8,2 mg O_2/L). Renewing of the toxic environment was daily. The results were registered in 10, 30 minutes, 1, 2, 4, 6, 24, 48 hours.

Fig. 1. Map showing the type localities of *Planorbarius corneus* s. lato allospecies: black circle – "western"; black square – "eastern"

The indexes of impact of used toxicants on the experimental molluscs were established via monitoring of the individuals' behavior and their overall state. The changes in motion behavior, feeding intensity, epithelial covers impairments and mucus secretion were registered. The endurance coefficient was determined by the formula of $EC=E_k/E_n$, where the E_k – time of death of all experimental animals; E_n – time of death of the first experimental animal (Бабич і Пінкіна, 2021). Adaptation coefficient was calculated by the formula (Malacea, 1968) of $AC=E_e/E_c$, where the E_e – the mean time of all experimental animals' death, E_c – the mean time of all control group animals' death.

The results of experiments were analyzed using standard methods of basic variation statistics in software Statistica 6.0 (Hill & Lewicki, 2007).

Results and Discussion

Surface active substances enter the organisms of molluscs mainly via osmosis through the epithelial body coverings and, to a lesser extent, with food intake. These toxicants cause the direct toxic action to hydrobionts: anion- and cation-active compounds act as resorbing neuro-paralytic and hemolytic poisons, non-ionogenic – as local poisons. Also, for all the surface active substances it is proved the existence of membranotropic function (change of cell membranes' structure and permeability) (Дудник і Євтушенко, 2013). Under the chronic intoxication by the synthetic detergents, their accumulation in the pancreas and the organism exhausting occurs.

Results (Table 1) showed that the threshold concentrations of the tested toxicants and the main toxicological parameters (LC_0, LC_{50}, and LC_{100}) were lower for the "eastern" allospecies than for the "western" allospecies. It was established that the tested synthetic detergents belong to three toxicity categories for the great ramshorn: weakly toxic ("LOSK", "Friends"), very toxic ("Teo Bebe"), and highly toxic ("Savex"), forming the following decreasing toxicity order: "Savex" > "Teo Bebe" > "LOSK" > "Friends".

It was established that studied allospecies differed by the lethality level under the impact of all used detergents (Table 2). Under the 0,1 mg/L water solution of "Teo Bebe", the "eastern" allospecies had 100% survival rate, while the 30% of "eastern" allospecies had died by the experiment end.

The length of the latent period during intoxication process was also different between allospecies (Table 3). In the range 0,001–10 mg/L, this index was higher in "western" than in "eastern" allospecies. The length of latent period under the action of used

Table 1

The main toxicological characteristics of *P. corneus* s. lato allospecies under the exposure of different synthetic detergents (48 hours)

Indicator, mg/L	**"Western" allospecies**				**"Eastern" allospecies**			
	"Savex"	**"Teo Bebe"**	**"LOSK"**	**"Friends"**	**"Savex"**	**"Teo Bebe"**	**"LOSK"**	**"Friends"**
Threshold concentration	0,001	0,01	0,1	0,5	0,0001	0,001	0,01	0,1
LC_0	0,05	0,5	1	1	0,01	0,05	0,1	1
LC_{50}	0,5	10	250	500	0,1	1	100	250
LC_{100}	10	100	800	1000	1	50	500	1000
Toxicity rate	0,5	10	250	500	0,1	1	100	250

Table 2

Mortality (%) of allospecies under the exposure of different synthetic detergents

Concentration, mg/L	**"Western" allospecies**				**"Eastern" allospecies**			
	"Savex"	**"Teo Bebe"**	**"LOSK"**	**"Friends"**	**"Savex"**	**"Teo Bebe"**	**"LOSK"**	**"Friends"**
0,01	0	0	0	0	0	0	0	0
0,1	40	0	0	0	50	30	0	0
1,0	100	30	0	0	100	50	10	0
10	100	50	10	20	100	100	30	30
100	100	100	30	40	100	100	50	50
1000	100	100	100	100	100	100	100	100

detergents decreased from lower to higher their concentrations. The first symptoms of intoxication (weakening of motion activity in molluscs, intensification of secretory function of secretory cells in their epithelium covers) were observed in experimental molluscs under the impact of detergent "Savex" in its concentration of 0,001 mg/L after 24,3 h in "western" allospecies and only after 21,2 in "eastern" allospecies ($p \leq 0,05$). This indicates a higher sensitivity of the latter allospecies to the action of the tested toxicant. With increasing of detergents' concentrations, the manifestations of symptoms were registered earlier in "eastern" than in "western" allospecies. Additionally, they appeared the fastest in the environments intoxicated by detergent "Savex" and the slowest – by detergent "Friends" (in both allospecies).

The adaptation coefficients indicates the adaptation level of studied allospecies to the impact of used synthetic detergents . The highest indexes were registered for impact of detergent "Savex", and the lowest – detergent "Friends" (Table 4). This impact also was registered earlier in "eastern" than in "western" allospecies. So, the adaptation coefficient was registered 30 minutes earlier under the "Savex" detergent impact, 40 minutes earlier under the "Teo Bebe" detergent impact, "LOSK" – 20 minutes, "Friends" – 10 minutes.

With increasing of toxicants' concentrations, both allospecies demonstrated the increase of endurance coefficient – however, the "eastern" allospecies had them lower than "western" one did (Table 5). Under the impact of surface active compounds, the endurance coefficient of both allospecies were the lower, the lower was the concentration of used toxicants. Its value depended as on the range of physiological status indexes' fluctuation, as on their toxic-resistance. Under the low detergent concentrations, it was impossible to calculate the numeric values of molluscs' endurance coefficient due to the absence of 100%-lethality by the end of acute experiment. It was established, that "western" allospecies was more adapted to the impact of all used detergents comparing to the "eastern" allospecies ($p \leq 0,05$).

For both *P. corneus* s. lato allospecies there were established the limits of toxicants' concentrations (from threshold to maximal lethal) presenting the zone of toxic action (Table 6). By the level of action, the ranges of these concentrations were lower for "eastern" than for "western" allospecies. Obtained values show the speed of intoxication in studied allospecies and level of its reversibility (Дудник і Євтушенко, 2013). Aforementioned phosphate and non-phosphate detergents caused the intoxication in "eastern" allospecies under lower concentrations and earlier than in "western" allospecies. Under the impact of different concentrations of phosphate («Savex» and «Teo Bebe») and non-phosphate

Table 3

Latent period (hours) of *P. corneus* s. lato allospecies under the exposure of different synthetic detergents

Concentration, mg/L	**"Western" allospecies**				**"Eastern" allospecies**			
	"Savex"	**"Teo Bebe"**	**"LOSK"**	**"Friends"**	**"Savex"**	**"Teo Bebe"**	**"LOSK"**	**"Friends"**
	M±m	**M±m**	**M±m**	**M±m**	**M±m**	**M±m**	**M±m**	**M±m**
0,001	24,3±1,12	25,3±1,05	–	–	21,2±1,19*	22,3±1,09*	–	–
0,01	22,1±1,20	23,1±1,24	24,4±1,07	25,2±1,21	19,4±1,05*	20,5±1,21*	21,5±1,01*	22,3±1,19*
0,1	16,3±1,16	18,5±1,30	19,2±1,14	21,4±1,18	13,1±1,08*	14,5±1,28*	16,1±1,32*	17,4±1,21*
1,0	5,5±1,08	6,4±1,11	7,3±1,22	9,0±1,02	4,1±1,15	5,2±1,13	6,2±1,25	6,5±1,31*
10	0,5±1,27	1,1±1,02	2,1±1,15	3,5±1,08	0,3±1,01	0,5±1,31	1,4±1,27	2,3±1,20
100	0,2±1,04	0,3±1,21	0,4±1,19	0,4±1,28	0,1±1,14	0,1±1,14	0,3±1,07	0,3±1,11
1000	–	–	0,3±1,13	0,3±1,07	–	–	0,2±1,19	0,2±1,23

*Note: * – statistically significant differences ($p \leq 0,05$) between P. corneus s. lato allospecies.*

Table 4

Adaptation coefficient (hours) of *P. corneus* s. lato allospecies under the exposure of different synthetic detergents

Detergent	**"Western" allospecies**	**"Eastern" allospecies**
"Savex"	3,30	3,00
"Teo Bebe"	2,50	2,10
"LOSK"	1,30	1,10
"Friends"	1,10	1,00

(«LOSK» and «Friends») detergents, the studied allospecies developed the clearly expressed phasic pathological process of intoxication. Under the threshold concentrations, there were no intoxication symptoms registered in molluscs, and the duration of their ethological and physiological reactions were within the normal range. By the moment of the end of experiment, the status of molluscs remained at the same level as in control group. Such a reaction to the aforementioned toxicant dose indicates (Harbar et al., 2021) the duration of the first and longest phase of their intoxication – asymptomatic latent.

Under the sub-lethal concentrations of detergents, the studied allospecies demonstrated the first ethological and physiological impairments. Among such symptoms there were the attempts of molluscs to avoid the toxic environment via increasing their motion activity. It is caused by the presence of nervous connection between their osphradies and columellar muscle and foot muscles (Бабич і Пінкіна, 2021). Also, under the same conditions for both allospecies the stimulation of their feeding and mating behavior was demonstrated. Such defensive reactions are typical for the second phase of intoxication – a stimulation. It was established that such symptoms were always observed 1-2 hours later and under the higher detergents' concentrations in "eastern" allospecies, which appeared to be more sensitive and less toxic-resistant than "western" allospecies. One of the molluscs' defensive reactions to the toxic agent was the intensification of mucus secretion by secretive cells of their epithelial body covers, that slowed the speed and volume of percutaneous entry of toxicants into molluscs' organisms. In some time, the layer of skin mucus thinned and exfoliated, due to which the particles of coagulants of different size and shape got into the water. Under the detergent "Savex" impact, by the moment of experiment's end the sliming covered the body surface in only 55% of individuals in "western" and 64% in "eastern" allospecies, while under the "LOSK" impact – 44% and 56%, respectively.

Under the chronic-lethal concentrations of synthetic detergent "Teo Bebe" the mortality was 39% in "western" and 45% in "eastern" allospecies, while under the same condition but detergent "Friends" – 30% and 39%, respectively. Other experimental animals were in oppressed state. Under the impact of

Table 5

Endurance coefficient (hours) of *P. corneus* s. lato allospecies under the exposure of different synthetic detergents

Concentration, mg/L	"Western" allospecies				"Eastern" allospecies			
	"Savex"	"Teo Bebe"	"LOSK"	"Friends"	"Savex"	"Teo Bebe"	"LOSK"	"Friends"
	M±m	M±m	M±m	M±m	M±m	M±m	M±m	M±m
0,1	1,21±1,20	–	–	–	2,27±1,13*	-	-	-
1,0	1,54±1,09	2,15±1,18	–	–	2,62±1,03*	2,82±1,12	-	-
10	2,13±1,05	2,69±1,22	–	–	3,14±1,24*	3,74±1,31*	-	-
100	2,77±1,31	3,21±1,11	–	–	3,72±1,17*	4,25±1,18*	-	-
1000	–	–	3,32±1,10	3,54±1,16	-	-	3,51±1,15	3,78±1,19

*Note: * – statistically significant differences (p≤0,05) between P. corneus s. lato allospecies.*

Table 6

Rating of synthetic detergents concentrations (mg/L) according to the effect on *P. corneus* s. lato allospecies

Detergent	Subthreshold	Sublethal	Chronic lethal	Acutely lethal
"Western" allospecies				
"Savex"	0,0001 and lower	0,01 – 0,001	1 – 0,1	10 – 40
"Teo Bebe"	0,001 and lower	0,1 – 0,01	40 – 1	100 – 50
"LOSK"	0,01 and lower	1 – 0,1	80 – 50	150 – 100
"Friends"	0,1 and lower	10 – 1	150 – 100	180 – 160
"Eastern" allospecies				
"Savex"	0,00001 and lower	0,001 – 0,0001	0,1 – 0,01	5 – 1
"Teo Bebe"	0,0001 and lower	0,01 – 0,001	1 – 0,1	50 – 10
"LOSK"	0,001 and lower	0,1 – 0,01	40 – 1	80 – 60
"Friends"	0,01 and lower	1 – 0,1	80 – 50	150 – 100

detergent "Teo Bebe" and "Friends" the situation was similar. Besides, for both allospecies there was registered the edema due to impairment of their water balance. This is one of the defensive physiological reactions in molluscs, which allows them to soften the toxic action of surface active compounds via "diluting" of impacting concentration of these compounds (Пінкіна, 2010; Бабич і Пінкіна, 2021).

Under acute lethal concentrations the studied molluscs tried to avoid the toxic environment by emerging to water surface tension film and placing themselves above it. The significant portion of molluscs lay immovable at the bottom. 43% of "western" and 54% of "eastern" allospecies demonstrated the sharp increase of their body volume (1,5–2 times) and decrease of contractibility of columellar muscle, which didn't allow molluscs to fully retract the head and foot into shell, from which they hung out (falling out reaction). According to some researchers (Пінкіна, 2010; Harbar et al. 2021), this is the consequence of kidney functioning impairment, causing the different levels of destruction and eventual death of kidney cells. Such impairments of cell membranes are typical for depressive and sub-lethal phases of pathological process. "Western" allospecies developed it earlier and had it weakly expresses than "eastern" allospecies. By the end of experiment (48 hours), all the experimental individuals were dead, which corresponds with the final lethal phase of intoxication. The lethal time for both allospecies was registered. With increasing of concentrations of used detergents, the length of lethal time (Table 7) and mean lethal time (Table 8) decreased in both allospecies. It happened the fastest under the "Savex" impact, and the latest – under "Friends" impact. The reversibility of intoxication caused by these toxicants was quite insignificant. With increasing concentrations, the lethal and mean lethal times were registered always 1–2,3 hours earlier for "eastern" than for "western" allospecies, which indicates its more sensitivity for the used toxicants impact ($p \leq 0,05$).

The mortality index was higher in "eastern" than in "western" allospecies under the impact of all used concentrations of detergents. It may be the consequence of its inhabiting the tougher environment, with higher temperatures and drier climate within its range (Left-Bank Ukraine and the extreme South of Steppe natural-geographic zone) (Гарбар, 2006).

So, the zones of toxic action of phosphate («Savex» and «Teo Bebe») and non-phosphate («LOSK» and «Friends») synthetic detergents on the *P. corneus* s. lato differ by

Table 7

Lethal time (hours) of *P. corneus* s. lato allospecies under the exposure of different synthetic detergents

Concentration, mg/L	"Western" allospecies				"Eastern" allospecies			
	"Savex"	"Teo Bebe"	"LOSK"	"Friends"	"Savex"	"Teo Bebe"	"LOSK"	"Friends"
	M±m	M±m	M±m	M±m	M±m	M±m	M±m	M±m
0,01	35,1±1,22	36,4±1,05	–	–	32,1±1,18*	33,2±1,16*	–	–
0,1	27,2±1,17	29,3±1,19	–	–	24,2±1,22*	25,4±1,22*	–	–
1,0	17,4±1,25	18,1±1,13	–	–	14,1±1,05*	15,2±1,27*	–	–
10	7,1±1,28	7,9±1,26	30,2±1,02	31,4±1,08	6,2±1,14	6,5±1,15	26,5±1,14*	27,2±1,17*
100	0,2±1,15	0,3±1,32	18,5±1,13	19,3±1,16	0,1±1,03	0,2±1,26	15,1±1,31*	16,2±1,22*
1000	–	–	3,4±1,32	4,1±1,20	–	–	3,1±1,09	4,5±1,23

*Note: * – statistically significant differences ($p \leq 0,05$) between P. corneus s. lato allospecies.*

Table 8

Mean lethal time (hours) of *P. corneus* s. lato allospecies under the exposure of different synthetic detergents

Concentration, mg/L	"Western" allospecies				"Eastern" allospecies			
	"Savex"	"Teo Bebe"	"LOSK"	"Friends"	"Savex"	"Teo Bebe"	"LOSK"	"Friends"
	M±m	M±m	M±m	M±m	M±m	M±m	M±m	M±m
0,1	42,3±1,16	43,2±1,28	–	–	39,1±1,17*	40,5±1,31*	–	–
1,0	22,1±1,23	26,4±1,02	–	–	18,5±1,12*	23,1±1,15*	–	–
10	13,3±1,18	15,1±1,23	–	–	10,4±1,20*	12,2±1,25*	–	–
100	4,2±1,21	4,5±1,22	47,3±1,19	48,5±1,18	3,2±1,12	4,1±1,14	43,1±1,29*	44,2±1,22*

*Note: * – statistically significant differences ($p \leq 0,05$) between P. corneus s. lato allospecies*

concentrations: "eastern" allospecies is more vulnerable under the lower concentrations, which indicates its lower toxic-resistance. Obtained ecotoxicological indexes (length of latent period, lethal and mean lethal times, adaptation and endurance coefficients) indicates that "eastern" allospecies is more sensitive and less endurance to the detergents impact comparing to "western" allospecies. It also demonstrated the first signs of irreversible intoxication (weakening of motion activity, increased mucus secreting by epithelial secretory cells) earlier than in "western" one. This indicates the higher viability of "western" allospecies, caused by its better adaptation to the regular conditions of river network in nature-geographic zone of Ukraine. With increasing of the used synthetic detergents, the time of latent period occurrence fastens, and the lethal and mean lethal times shorten.

Conclusions

The obtained results of the ecotoxicological study indicate significant differences in the sensitivity of *Planorbarius corneus* s. lato allospecies to the action of phosphate and non-phosphate synthetic detergents. It was established that the "eastern" allospecies is characterized by lower toxic resistance, which is reflected in reduced threshold concentrations, a shorter latent period of intoxication, and lower values of adaptation and endurance coefficients compared to the "western" allospecies.

The revealed differences in behavioral and physiological responses of molluscs confirm the feasibility of using both allospecies of the great ramshorn as sensitive bioindicator objects in the monitoring system of natural water pollution in Ukraine by synthetic detergents. Their combined application allows increasing the informativeness of assessing sublethal pollution levels and enables timely detection of adverse changes in aquatic ecosystems.

The established toxicological parameters can be applied for ecological risk assessment, development of regional water quality standards, and prediction of the potential impact of domestic wastewater on the structure and functioning of freshwater mollusc communities.

Bibliography

Babych Yu., Uvayeva O., Stadnychenko A. Food preferences of the great ramshorn *Planorbarius corneus* (Linnaeus, 1758) allospecies (Mollusca: Gastropoda: Planorbidae) from the Ukrainian river system. *Folia Malacologica*. 2021. Vol. 29. No 4. P. 204–211. https://doi.org/10.12657/folmal.029.023

Borah S. Adverse Effects of Different Detergents on Fish: A Review. *Research & Reviews : Journal of Ecology and Environmental Sciences*. 2022. Vol. 10. № 2. P. 1–15. https://doi.org/10.4172/2347-7830.10.02.001

Chandanshive N.E. Studies on toxicity of detergents to *Mystus montanus* and change in behaviour of fish research journal of animal. *Veterinary and fishery science*. 2013. Vol. 1. № 9. P. 14–19.

Divya S.R. An evaluation of the effect of a detergent on dissolved oxygen consumption rate of *Anabas testudineus*. *International Journal of Fisheries and Aquatic Studies*. 2015. Vol. 2. № 6. P. 46–48.

Harbar O., Harbar D., Stadnychenko A., Babych Yu. Ecotoxicological responses of two *Planorbarius corneus* s. lato (Mollusca, Gastropoda) allospecies to exposure of heavy metals. *International Journal of Aquatic Biology*. 2021. Vol. 9. № 6. P. 423–431. https://doi.org/10.22034/ijab.v9i6.1356

Hill T., Lewicki P. Statistics. Methods and Applications. Tulsa : StatSoft, 2007. 800 p.

Logeswari D., Kandhasamy K., Majeeth F.A., Rajasekara P.M., Sharmila B.G. Effect of sublethal concentrations of commercial detergents on the protein content of selective freshwater fishes. *Bulletin of Pure & Applied Sciences- Zoology.* 2021. Vol. 40a. №1. P. 127–139. https://doi.org/10.5958/2320-3188.2021.00016.4

Malacea I. Untersuchungen uber die Gewohnung der Fische on hohe Konzentrationen toxischer Substanzen. *Archiv für Hydrobiologie*. 1968. Vol. 65. № 1. P. 74–95.

Mathew E., Sunitha P.T., Thomas P.L. Effect of different concentration of detergent (Surf) on dissolved oxygen consumption in *Anabas testudineus*. *IOSR journal of environmental science, toxicology and food technology*. 2013. Vol. 5. № 3. P. 1–3. https://doi.org/10.9790/2402-0530103

Mousavi S.A., Khodadoost F. Effects of detergents on natural ecosystems and wastewater treatment processes: a review. *Environmental Science and Pollution Research.* 2019. Vol. 26. P. 26439–26448. https://doi.org/10.1007/s11356-019-05802-x

Stadnychenko A.P., Uvayeva O.I., Vyskushenko D.A. The influence of detergents on the cilia locomotion activity of epithelium in Sinanodonta Woodiana (Mollusca, Unionidae). *Біологія та екологія*. 2019. Т. 5. № 1. С. 103–106. https://doi.org/10.33989/2414-9810.2019.5.1.195127

Sveum M., Elamonovich K.S. The problem of water pollution and causes. *Galaxy International Interdisciplinary Research Journal.* 2022. Vol. 10. № 6. P. 1009–1011.

Toledo N.A.B., Contreras C.H., Corredor C.A.A., Pérez C.A.R. Effect of biodegradable detergents on water quality. *Natural Volatiles and Essential Oils.* 2021. Vol. 8. № 5. P. 12080–12095.

Uwajewa O., Stadnyczenko A., Babycz J. Słodkowodna małakofauna na Ukrainie w warunkach rosnącego antropogenicznego zanieczyszczenia środowiska. *Problemy wspołczesnej malakologii 2022* : XXXVI Krajowe Seminarium Malakologiczne (12-14.05.2022). Toruń, 2022. S. 49–50.

Астахова Л.Є. Вплив синтетичних миючих засобів на легеневе й поверхневе дихання аловидів *Planorbarius* (superspecies) *corneus sensu* lato (Mollusca, Gastropoda, Pulmonata, Planorbidae) гідромережі України. *Український журнал природничих наук.* 2023. Вип. 5. С. 15–22. https://doi.org/10.32782/naturaljournal.5.2023.2

Бабич Ю., Пінкіна Т. Вплив іонів важких металів на екотоксикологічні показники витушки рогової (Mollusca, Gastropoda, Pulmonata, Bulinidae). *Вісник Львівського університету. Серія біологічна.* 2021. Вип. 84. С. 76–83. https://doi.org/10.30970/vlubs.2021.84.07

Бабич Ю.В., Стадниченко А.П. Вплив фосфатного миючого засобу «Savex» на показники легеневого дихання аловидів *Planorbarius corneus* s. lato (Mollusca, Gastropoda, Pulmonata, Planorbidae) гідромережі України. *Біологічні дослідження – 2022 :* зб. наук. пр. Житомир : ПП «Євро-Волинь», 2022. С. 79–81.

Бабич Ю.В., Ковалевська О.О, Залужний В.Я., Махневич Д.С., Стадниченко А.П. Вплив різних концентрацій СМЗ «Вухатий нянь» на стабільність гомеостазу внутрішнього середовища «західного» аловиду витушки (Mollusca, Gastropoda, Pulmonata, Bulinidae). *Актуальні питання біологічної науки* : зб. статей. Ніжин : НДУ імені Миколи Гоголя, 2021. С. 85–87.

Білик Т.І., Веренікін О.М., Леонтьєва Т.О. Вплив сучасних мийних засобів на гідробіонти-фільтратори водних екосистем. *Екологічні науки.* 2021. Вип. 34. № 7. С. 122–128. https://doi.org/10.32846/2306-9716/2021.eco.7-34.21

Гарбар Д.А. Діагностичне значення конхіологічних ознак молюсків роду *Planorbarius* (Bulinidae, Gastropoda, Pulmonata). *Вісник Житомирського державного педагогічного університету.* 2003. № 11. С. 238–240.

Гарбар Д.А. Конхіологічні особливості *Planorbarius corneus* s. lato (Gastropoda, Pulmonata) фауни України. *Науковий вісник Ужгородського університету. Серія Біологія.* 2009. Т. 26. С. 56–61.

Гарбар Д.А. Молюски роду Planorbarius (Gastropoda, Pulmonata, Bulinidae) фауни України: аналіз морфологічних, каріологічних і генетичних ознак : автореф. дис. … канд. біол. наук. Київ, 2006. 21 с.

Дідух Я.П. Основи біоіндикації. Київ : Наукова думка, 2012. 360 с.

Дудник С.В., Євтушенко М.Ю. Водна токсикологія: основні теоретичні положення та їхнє практичне застосування : навчальний посібник. Київ : Видавництво Українського фітосоціологічного центру, 2013. 297 с.

Махневич Д.С., Стадниченко А.П. Вплив поверхнево-активних речовин на вікові фізико-хімічні особливості гемолімфи витушки рогової (*Planorbarius corneus*) (Mollusca, Gastropoda, Bulinidae). *Біологічні дослідження – 2021* : зб. наук. пр. Житомир : ПП «Євро-Волинь», 2021. С. 96–98.

Пінкіна Т.В. Екотоксикологічна характеристика ставковика озерного за дії на нього важких металів водного середовища. *Природничий альманах. Серія : Біологічні науки.* 2010. № 14. С. 138–151.

Романенко В.Д. Основи гідроекології. Київ : Обереги, 2001. 728 с.

Савлучинська М.О., Горбатюк Л.О., Платонов О.М., Пасічна О.О., Бурмістренко С.П., Кукля І.Г., Каглян Н.М., Арсан О.М. Фосфор мийних засобів та його вплив на водяні організми (огляд). *Наукові записки Тернопільського національного педагогічного університету імені Володимира Гнатюка. Серія Біологія.* 2013. Т. 56. № 3. С. 119–125.

Стадниченко А.П. Вплив поверхнево-активних речовин і трематодної інвазії на живлення і травлення рогової витушки (Mollusca: Pulmonata: Bulinidae). *Вісник Державного агроекологічного університету.* 2005. № 2(15). С. 120–125.

Стадниченко А.П., Янович Л.М. Вплив поверхнево-активних речовин на вміст глюкози у різних органах перлівниці (Mollusca: Unionidae). *Науковий вісник Ужгородського університету. Серія Біологія.* 2004. Вип. 15. С. 1–3.

Уваєва О.І. Вплив безфосфатного детергента на фільтраційну роботу калюжниці болотяної. *Екологічні науки.* 2018. Т. 2. № 1 (20). С. 86–91.

Уваєва О.І. Порушення очищувальної роботи *Viviparus contectus* (Mollusca: Opistobranchia: Viviparidae) за сумісної дії детергентів та трематодної інвазії. *Науковий вісник Волинського національного університету ім. Лесі. Українки. Біологічні науки.* 2012. Т. 27. № 2. С. 45–49.

Уваєва О.І., Сарган А.П. Вплив синтетичних миючих засобів на фільтраційну здатність прісноводних молюсків. *Наукові записки Тернопільського національного педагогічного університету ім. Володимира Гнатюка. Серія Біологія.* 2011. Вип. 2 (47). С. 147–150.

References

Babych, Yu., Uvayeva, O., & Stadnychenko, A. (2021). Food preferences of the great ramshorn *Planorbarius corneus* (Linnaeus, 1758) allospecies (Mollusca: Gastropoda: Planorbidae) from the Ukrainian river system. *Folia Malacologica*, 29 (4), 204–211. https://doi.org/10.12657/folmal.029.023 [in English].

Borah, S. (2022). Adverse Effects of Different Detergents on Fish: A Review. *Research & Reviews: Journal of Ecology and Environmental Sciences*, 10 (2), 1–15. https://doi.org/10.4172/2347-7830.10.02.001 [in English].

Chandanshive, N.E. (2013). Studies on toxicity of detergents to *Mystus montanus* and change in behaviour of fish research journal of animal. *Veterinary and fishery science*, 1 (9), 14–19. [in English].

Divya, S.R. (2015). An evaluation of the effect of a detergent on dissolved oxygen consumption rate of *Anabas testudineus*. *International Journal of Fisheries and Aquatic Studies*, 2 (6), 46–48. [in English].

Harbar, O., Harbar, D., Stadnychenko, A., & Babych, Yu. (2021). Ecotoxicological responses of two *Planorbarius corneus* s. lato (Mollusca, Gastropoda) allospecies to exposure of heavy metals. *International Journal of Aquatic Biology*, 9 (6), 423–431. https://doi.org/10.22034/ijab.v9i6.1356 [in English].

Hill, T., & Lewicki, P. (2007). Statistics. Methods and Applications. Tulsa : StatSoft [in English].

Logeswari, D., Kandhasamy, K., Majeeth, F.A., Rajasekara, P.M., & Sharmila, B.G. (2021). Effect of sublethal concentrations of commercial detergents on the protein content of selective freshwater fishes. *Bulletin of Pure & Applied Sciences- Zoology,* 40a (1), 127–139. https://doi.org/10.5958/2320-3188.2021.00016.4 [in English].

Malacea, I. (1968). Untersuchungen uber die Gewohnung der Fische on hohe Konzentrationen toxischer Substanzen. *Archiv für Hydrobiologie*, 65 (1), 74–95. [in English].

Mathew, E., Sunitha, P.T., & Thomas, P.L. (2013). Effect of different concentration of detergent (Surf) on dissolved oxygen consumption in *Anabas testudineus. IOSR journal of environmental science, toxicology and food technology,* 5 (3), 1–3. https://doi.org/10.9790/2402-0530103 [in English].

Mousavi, S.A., & Khodadoost, F. (2019). Effects of detergents on natural ecosystems and wastewater treatment processes: a review. *Environmental Science and Pollution Research,* 26, 26439–26448. https://doi.org/10.1007/s11356-019-05802-x [in English].

Stadnychenko, A.P., Uvayeva, O.I., & Vyskushenko, D.A. (2019). The influence of detergents on the cilia locomotion activity of epithelium in Sinanodonta Woodiana (Mollusca, Unionidae). *Біологія та екологія*, 5 (1), 103–106. https://doi.org/10.33989/2414-9810.2019.5.1.195127 [in English].

Sveum, M., & Elamonovich, K.S. (2022). The problem of water pollution and causes. *Galaxy International Interdisciplinary Research Journal*, 10 (6), 1009–1011. [in English].

Toledo, N.A.B., Contreras, C.H., Corredor, C.A.A., & Pérez, C.A.R. (2021). Effect of biodegradable detergents on water quality. *Natural Volatiles and Essential Oils,* 8. (5), 12080–12095. [in English].

Uwajewa, O., Stadnyczenko, A., & Babycz, J. (2022). Słodkowodna małakofauna na Ukrainie w warunkach rosnącego antropogenicznego zanieczyszczenia środowiska. *XXXVI Krajowe Seminarium Malakologiczne «Problemy współczesnej malakologii 2022».* Toruń, 49–50 [in Poland].

Astakhova, L.Ye. (2023). Vplyv syntetychnykh myiuchykh zasobiv na leheneve y poverkhneve dykhannia alovydiv *Planorbarius* (superspecies) *corneus* sensu lato (Mollusca, Gastropoda, Pulmonata, Planorbidae) hidromerezhi Ukrainy [Influence of synthetic detergents on the pulmonary and direct surface respiration of *Planorbarius* (superspecies) *corneus* sensu lato allospecies (Mollusca, Gastropoda, Pulmonata, Planorbidae) of the hydrological network of Ukraine]. *Ukrainskyi zhurnal pryrodnychykh nauk [Ukrainian Journal of Natural Sciences]*, 5, 15–22. https://doi.org/10.32782/naturaljournal.5.2023.2. [in Ukrainian].

Babych, Yu., & Pinkina, T. (2021). Vplyv ioniv vazhkykh metaliv na ekotoksykolohichni pokaznyky vytushky rohovoi (Mollusca, Gastropoda, Pulmonata, Bulinidae) [Influence of heavy metal ions on

ecotoxicological indicators of *Planorbarius corneus* (Mollusca, Gastropoda, Pulmonata, Bulinidae)]. *Visnyk Lvivskoho universytetu. Seriia biolohichna [Visnyk of the Lviv University. Series Biology]*, 84, 76–83. https://doi.org/10.30970/vlubs.2021.84.07 [in Ukrainian].

Babych, Yu.V., & Stadnychenko, A.P. (2022). Vplyv fosfatnogho myjuchogho zasobu «Savex» na pokaznyky leghenevogho dykhannja alovydiv *Planorbarius corneus* s. lato (Mollusca, Gastropoda, Pulmonata, Planorbidae) ghidromerezhi Ukrajiny [The influence of the phosphate detergent "Savex" on the parameters of pulmonary respiration of allospecies *Planorbarius corneus* s. lato (Mollusca, Gastropoda, Pulmonata, Planorbidae) of the water network of Ukraine]. *Zbirnyk naukovykh prats "Biolohichni doslidzhennia – 2022" [Collection of scientific works "Biological research – 2022"*]. Zhytomyr, 79–81 [in Ukrainian].

Babych, Ju.V., Kovalevsjka, O.O., Zaluzhnyj, V.Ja., Makhnevych, D.S., & Stadnychenko, A.P. (2021). Vplyv riznykh koncentracij SMZ «Vukhatyj njanj» na stabiljnistj ghomeostazu vnutrishnjogho seredovyshha «zakhidnogho» alovydu vytushky (Mollusca, Gastropoda, Pulmonata, Bulinidae) [The effect of different concentrations of the "Eared Nanny" SMZ on the stability of the internal environment of the "western" allospecies mollusc (Mollusca, Gastropoda, Pulmonata, Bulinidae)]. *Zbirnyk statej "Aktualjni pytannja biologhichnoji nauky" [Collection of articles «Current issues of biological science»]*. Nizhyn, 85–87 [in Ukrainian].

Bilyk, T.I., Verenikin, O.M., & Leontieva, T.O. (2021). Vplyv suchasnykh myinykh zasobiv na hidrobionty-filtratory vodnykh ecosystem [Influence of modern detergents on aquatic filter-filters of aquatic ecosystems]. *Ekolohichni nauky [Environmental Sciences]*, 34 (7), 122–128. https://doi.org/10.32846/2306-9716/2021.eco.7-34.21. [in Ukrainian].

Gharbar, D.A. (2003). Diaghnostychne znachennja konkhiologhichnykh oznak moljuskiv rodu Planorbarius (Bulinidae, Gastropoda, Pulmonata) [Diagnostic Importance of Conchologycal Features of the Molluscs of the Genus Planorbarius (Bulinidae, Gastropoda, Pulmonata)]. *Visnyk Zhytomyrsjkogho derzhavnogho pedaghoghichnogho universytetu [Bulletin of Zhytomyr State Pedagogical University]*, 11, 238–240. [in Ukrainian].

Gharbar, D.A. (2009). Konkhiologhichni osoblyvosti Planorbarius sorneus s. lato (Gastropoda, Pulmonata) fauny Ukrajiny [Conchiological features of Planorbarius corneus s. lato (Gastropoda, Pulmonata) of Ukraine fauna]. *Naukovyj visnyk Uzhghorodsjkogho universytetu. Serija Biologhija [Scientific Bulletin of the Uzhhorod University. Series Biology]*, 26, 56–61. [in Ukrainian].

Gharbar, D.A. (2006). Moljusky rodu Planorbarius (Gastropoda, Pulmonata, Bulinidae) fauny Ukrajiny: analiz morfologhichnykh, kariologhichnykh i ghenetychnykh oznak: avtoreferat dysertaciji kandydata biologhichnykh nauk [Molluscs of the genus Planorbarius (Gastropoda, Pulmonata, Bulinidae) of the fauna of Ukraine: analysis of morphological, karyological and genetic features: abstract of the dissertation of the candidate of biological sciences]. Kyiv [in Ukrainian].

Didukh, Ya.P. (2012). Osnovy bioindykatsii [Basics of bioindication]. Kyiv : Naukova dumka [in Ukrainian].

Dudnyk, S.V., & Jevtushenko, M.Ju. (2013). Vodna toksykologhija: osnovni teoretychni polozhennja ta jikhnje praktychne zastosuvannja [Aquatic toxicology: basic theoretical principles and their practical application]. Kyiv : Vydavnytstvo Ukrainskoho fitosotsiolohichnoho tsentru [in Ukrainian].

Makhnevych, D.S., & Stadnychenko, A.P. (2021). Vplyv poverkhnevo-aktyvnykh rechovyn na vikovi fizyko-khimichni osoblyvosti hemolimfy vytushky rohovoi (Planorbarius corneus) (Mollusca, Gastropoda, Bulinidae) [The influence of surface-active substances on the age-related physicochemical features of the hemolymph of the horned sea urchin (*Planorbarius corneus*) (Mollusca, Gastropoda, Bulinidae)]. *Zbirnyk naukovykh prats "Biolohichni doslidzhennia – 2021" [Collection of scientific works "Biological research – 2022"*]. Zhytomyr, 96–98 [in Ukrainian].

Pinkina, T.V. (2010). Ekotoksykolohichna kharakterystyka stavkovyka ozernoho za dii na noho vazhkykh metaliv vodnoho seredovyshcha [Ecotoxicological characteristics of *Lymnaea stagnalis* under the impact of heavy metals in the water environment]. *Pryrodnychyi almanakh. Seriia: Biolohichni nauky [Scientific Bulletin of Natural Sciences. Series: Biological Sciences]*, 14, 138–151. [in Ukrainian].

Romanenko, V.D. (2001). Osnovy hidroekolohii [Basics of hydroecology]. Kyiv : Oberehy [in Ukrainian].

Savluchynsjka, M.O., Ghorbatjuk, L.O., Platonov, O. M., Pasichna, O.O., Burmistrenko, S.P., Kuklja, I.Gh., Kaghljan, N.M., & Arsan, O.M. (2013). Fosfor myjnykh zasobiv ta jogho vplyv na vodjani orghanizmy (oghljad) [The influence of phosphorus from detergents on aqatic animals (a review)]. *Naukovi zapysky Ternopiljsjkogho nacionaljnogho pedaghoghichnogho universytetu imeni*

Volodymyra Ghnatjuka [Scientific Issue Ternopil Volodymyr Hnatiuk National Pedagogical University], 56 (3), 119–125 [in Ukrainian].

Stadnychenko, A.P. (2005). Vplyv poverkhnevo-aktyvnykh rechovyn i trematodnoji invaziji na zhyvlennja i travlennja roghovoji vytushky (Mollusca: Pulmonata: Bulinidae) [The effect of surface-active substances and trematode infestation on feeding and digestion of the horned snail (Mollusca: Pulmonata: Bulinidae)]. *Visnyk Derzhavnogho aghroekologhichnogho universytetu [Bulletin of the State Agroecological University]*, 2(15), 120–125 [in Ukrainian].

Stadnychenko, A.P., & Yanovych, L.M. (2004). Vplyv poverkhnevo-aktyvnykh rechovyn na vmist hliukozy u riznykh orhanakh perlivnytsi (Mollusca: Unionidae) [The effect of surface-active substances on the glucose content in various organs of the pearl mussel (Mollusca: Unionidae)]. *Naukovyi visnyk Uzhhorodskoho universytetu. Seriia Biolohiia [Scientific Bulletin of the Uzhhorod University. Series Biology]*, 15, 1–3. [in Ukrainian].

Uvajeva, O.I. (2012). Porushennja ochyshhuvaljnoji roboty *Viviparus contectus* (Mollusca: Opistobranchia: Viviparidae) za sumisnoji diji deterghentiv ta trematodnoji invaziji [Violation of the cleaning work of *Viviparus contectus* (Mollusca: Opistobranchia: Viviparidae) under the combined action of detergents and trematode infestation]. *Naukovyj visnyk Volynsjkogho nacionaljnogho universytetu im. Lesi Ukrajinky [Lesya Ukrainka Eastern European National University Scientific Bulletin]*, 27 (2), 45–49 [in Ukrainian].

Uvajeva, O.I. (2018). Vplyv bezfosfatnogho deterghenta na filjtracijnu robotu kaljuzhnyci bolotjanoji [The effect of phosphate-free detergent on the filtration performance of a marsh pond]. *Ekologhichni nauky [Environmental sciences]*, 2 (1), 86–91 [in Ukrainian].

Uvajeva, O.I., & Sarhan, A.P. (2011). Vplyv syntetychnykh myiuchykh zasobiv na filtratsiinu zdatnist prisnovodnykh moliuskiv [The influence of synthetic detergents on the filtration capacity of freshwater molluscs]. *Naukovi zapysky Ternopiljsjkogho nacionaljnogho pedaghoghichnogho universytetu imeni Volodymyra Ghnatjuka [Scientific Issue Ternopil Volodymyr Hnatiuk National Pedagogical University]*, 2 (47), 147–150 [in Ukrainian].

Дата першого надходження статті до видання: 26.12.2025
Дата прийняття статті до друку після рецензування: 30.01.2026
Дата публікації (оприлюднення) статті: 31.03.2026