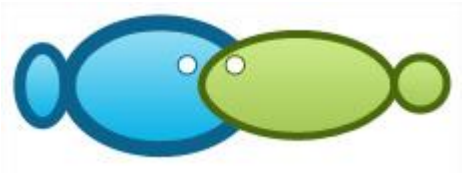


Biological features and long-term impact of invasive *Perccottus glenii* on native fish in a small water body

[1]Ganna Kotovska, [1]Ruslan Kononenko, [1]Nataliia Rudyk-Leuska, [1]Mykhailo Leuskyi, [2]Dmytro Khrystenko

[1] National University of Life and Environmental Sciences of Ukraine, Ukraine; [2] Institute of Fisheries of National Academy of Agrarian Sciences of Ukraine, Kyiv, Ukraine.
Corresponding author: D. Khrystenko, dskhrist@gmail.com

Abstract. Alien species play a critical role in freshwater ecosystems by replacing native species and ruining the existing ecological chains. Unfortunately, nonindigenous species are spreading around the world and some countries underestimate the impact that they can cause. In this study, we provided clear evidence about the impact of *Perccottus glenii* on the fish community of a small water body that can be treated as a case study for the dynamic of the native fish fauna in the small water bodies under an extensive pressure from the alien fish species. It was first detected in 2008, however, no actions were taken to eliminate the invader. Ukraine just did not have a strategy and action plan for these cases. The second investigation in 13 years showed dramatic changes in the fish community caused by *P. glenii* presence in the fish fauna. *P. glenii* almost totally replaced native fish populations within 13 years. This fish matured in the second year and spawned every year afterward. The population of invader had 5-year classes and experienced dramatic changes in their diet. The new conditions caused a shift from insects to fish predation in the diet of *P. glenii*, that also had a damaging effect on the fish community. The present study underlines the possible damaging effects of non-native fish species and the necessity to develop a strategy for alien species.
Key Words: alien fish species, nonindigenous species, biological invasion, fish fauna.

Introduction. The spread of alien species is one of the most urgent problems in the modern world. Human civilization has disrupted the natural isolation processes in ecosystems by creating transport and international trade (Verreycken 2015). The rapid development of scientific and technical progress has caused deep human intervention in natural ecosystems that caused the intentional and unintentional spread of nonnative species (Reshetnikov et al 2013). Decisions regarding the fight against biological invasions that are made today have a significant impact in the future, so management must be aware of their actions and the long-term consequences if preventive actions are not taken (Kuparinen et al 2023). The uncontrolled spread of alien species can cause the replacement of native and commercially valuable species with non-valuable alien species. That will have a significant negative impact on biosecurity, economy, and conservation (Kvach et al 2022). The appropriate strategies aim to prevent or reduce the number and scale of invasions of alien dangerous species into natural ecosystems, but Ukraine lacks of an effective system for countering invasions and uncontrolled distribution of alien fish species. A raw consumption approach to the aquatic bioresources leads to an increase in the uncontrolled spread of Asian carps in inland water bodies and with them the dispersal of the Chinese sleeper. Given a high anthropogenic pressure on commercially valuable fish species combined with a lack of pressure on the low-value invasive species,a shift in the succession of the ecosystem causing a replacement of the valuable species is highly probable (Somogyi et al 2023).

Chinese sleeper or Amur sleeper, *Perccottus glenii* Dybowski 1877, is one of the most aggressive invaders in the European freshwater bodies (Verreycken 2015; Kuparinen et al 2023). Its native area is far east of China and the Amur River basin. This

fish was recorded in Romania (Covaciu-Marcov et al 2017; Copilaş-Ciocianu & Pârvulescu 2011), Belgium (Verreycken 2015), Croatia (Caleta et al 2010), Poland (Grabowska et al 2009), Slovakia (Koščo et al 2008), Ukraine (Kvach et al 2020; Kvach et al 2021). The direct impact of invasions is out-competing native fish species in aquatic ecosystems, while the indirect consequence is the spreading of unusual diseases among the natural fish fauna (Kvach et al 2016; Sokolov et al 2023).The main aim of the present work was to investigate the potential of *P. glenii* to replace the native fish species in certain water bodies.

Material and Method

Description of the study sites. This study was performed on a typical small pond, situated in the Dnieper River basin, where *P. glenii* was detected in 2008 in small number. This case study could be extrapolated to more than 20,000 water bodies of this type in Ukraine, with a quite similar water quality and fish species composition. Using this water body as a model will help to describe the impact of the *P. glenii* on the natural fish fauna and the potential losses that it can cause. Another investigation was made in 2021. The results of these 2 studies can show how the fish fauna of the investigated water body changed over time without the required actions that should have been taken to reduce the *P. glenii* invasion. The reservoir on the territory of the Piskiv village council was created by regulating the flow of the Khocheva River and is located within the Ivankiv district of the Kyiv region. The type of pond is channel, and the type of flow regulation is seasonal. The dam is earthen. The spillway structure is an open sluice with manual adjustment of wooden shacks. The purpose of the channel is multiple: recreation, accumulation of runoff, commercial fish farming. The map with the location's coordinates is presented in the Figure 1.

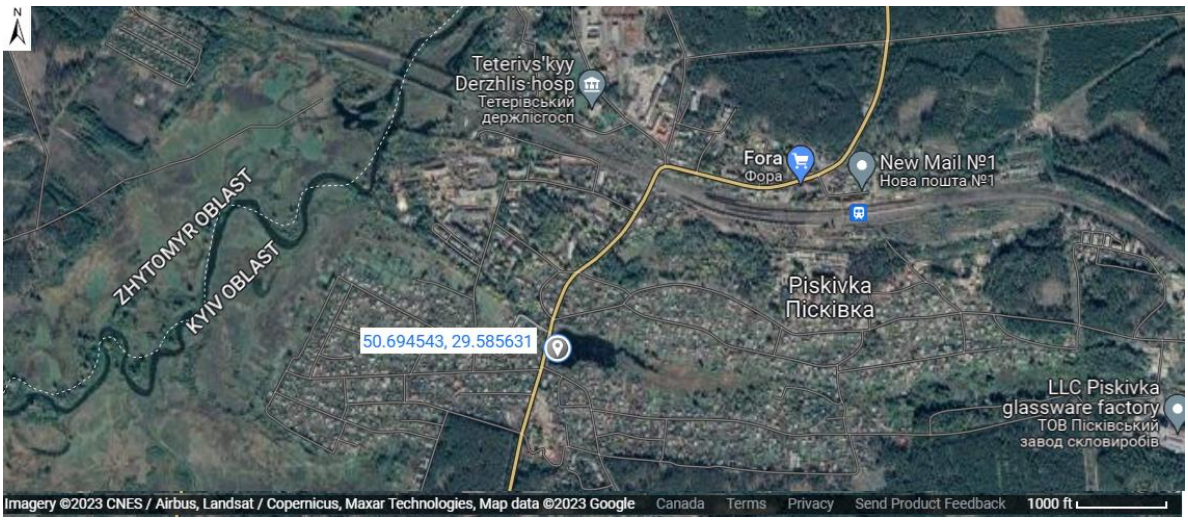


Figure 1. The location of the pond in the Piskivka village, Ukraine.

The main morphometric characteristics of the pond are given in the Table 1.

Table 1

The main morphometric characteristics of the water body

Volume, (million m^3)	*Mean/max. depth (m)*	*Width (km)*	*Length (km)*	*Water surface area (ha)*
0.03	0.8/1.8	0.184	0.202	3.7

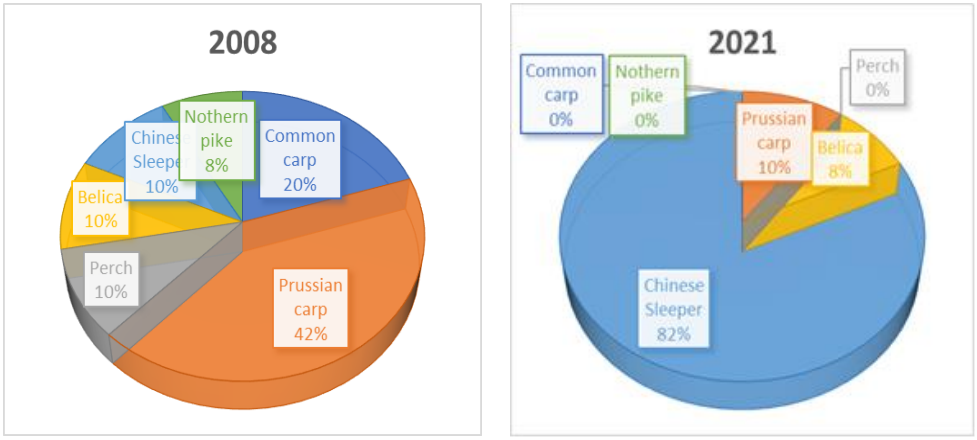
The pond water is colorless and odorless. According to its chemical composition, it belongs to the sulphated and calcarous group of waters. The level of mineralization was average. The content of biogenic elements was sufficient for the phytoplankton

development. The oxygen regime is satisfactory for hydrobionts, and no suffocation phenomena were observed in the reservoir. According to the main hydrochemical indicators, the water of the studied ponds meets the requirements for fish farming water bodies (Standards Association of Ukraine 2006) and is suitable for growing the main aquaculture products of Ukraine.

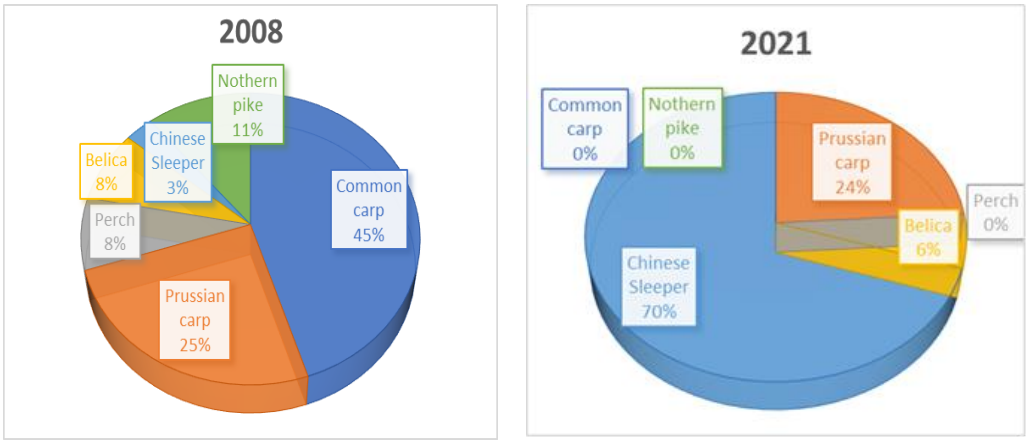
Data collection and methods. The sampling was performed in the pond located near the Piskivka village, Kyiv region, during the fishing seasons of 2008 and 2021 within the framework of annual monitoring fish surveys of the Institute of Fisheries of National Academy of Agrarian Sciences (IF NAAS), in the Dnieper River basin. The same sites were sampled during each year. The geographical coordinates of each sampling site were registered using a GPS receiver (Garmin Dakota 10). The ethical permission for investigations was proved by scientific fishing licenses of Kyiv state fishery inspections, because specimens of fish protected by commercial fishery rules were removed from the wild. The fish were caught using 24 standard gill nets: 70.0 m in length, and 3.0 m high. Their mesh size was 30, 36, 40, 45, 50, 55, 60, 65, 70, 75, 80, and 90 mm and two nets of each size were used (Ozinkovska et al 1998). All these gill nets operated simultaneously to omit errors (Froese 2006). These gillnets were used 7 days in March-April and September-October for each year. Fish of smaller size were caught with a push-net (10 m × 1 m × 1 mm of mesh size). The area of seine hauls depended on the water depth and bank steepness and ranged from approximately 10 to 100 m^2, which was measured visually using the seine length as a reference, according to the standard methodology (Ozinkovska et al 1998). The captured specimens were usually analyzed at the fisheries posts of IF NAAS, by performing the species identification (Kottelat & Freyhof 2007), then the wet weight determination (using a precision balance VTD-6EL) and the length measurements (with a standard bar of IF NAAS, with one mm accuracy).

Statistical analysis. Mathematical processing of the obtained data was performed on a computer using standard sets of statistical programs Microsoft Excel 2008 for Windows. Typing, editing, and editing of the text was carried out in the text editor Microsoft Word 2013 for Windows.

Results. The structure of fish fauna in the pond in 2008 was typical for the majority of freshwater ponds in Ukraine. It consisted of the 6 fish species: 4 cyprinids and 2 predators (Figure 2). Within the last 13 years, dramatic changes appeared in the fish communities. A lot of fish species disappeared from the water body and *P. glenii* appeared to be the main fish species in the water body.



a) b)



c) d)

Figure 2. Changes in the fish fauna composition and biomass portions of the pond in the Piskivka village, Ukraine between 2008 when the invasdion was detected 1st time and 2021: a) fish fauna structure at 2008; b) fish fauna composition at 2021; c) biomass proportion at 2008; and d) biomass percentage.

Figure 2 shows the changes that had occurred in the fish community of the pond within 13 years, without any actions that were supposed to facilitate the extraction of the *P. glenii* from the water body. In 2008 it was a standard pond dominated by the prissian carp in terms of quantity and by the common carp in terms of biomass. Predators contributed with about 28% in terms of frequency and 21% in terms of biomass. In 2021, certain fish species, such as the Northern pike, perch, and common carp disappeared, and the quantity and biomass of studied alien fish rocketed to 82% and 70%, respectively.

Biological features of the P. glenii. The obtained results significantly differ from the available literature data. Consequently, in the native habitat *P. glenii* is a medium-cycle fish with an age range of 7 age classes, while our research showed that *P. glenii* in the studied pond was recorded as a short-cycle species with a lifespan of up to 5 age groups. Data about length and weight are provided in Table 2.

Table 2

The length and weight of *Perccottus glenii* from the pond in the Piskivka village, Ukraine

Age	*Lenght (cm)*		*Body weight (g)*		*n*
	M±m	*Min-max*	*M±m*	*Min-max*	
0+	6.5±0.4	5.2-7.9	3.7±0.3	2.1-5.3	80
1+	8.8±0.3	6.5-12.9	8.7±0.8	5.1-18.7	58
2+	11.8±0.5	11.0-13.5	12.7±0.7	9.9-19.5	25
3+	13.2±0.1	13.0-13.5	36±0.9	32.2-40.4	25
4+	16.2±0.3	15.2-17.5	48.4±0.9	46.7-50.4	15

We did not find any fish aged more than 4+ in our investigation. Thus, we can conclude that within 5 years of life in these conditions, the general mortality eliminates *P. glenii* from the water body.

Sexual maturation, fertility, and reproduction. *P. glenii* first matured at the beginning of the second year and subsequently spawned every year. The smallest mature fish in our study was 65 mm long, at the age of 1. The largest one was 504 mm long at the age of 4. The smallest fish was 65 mm long, at the age of one year and produced 600-680 eggs, while the largest was 504 mm long and produced 2,285 eggs (Figure 3). Eggs were structured into two cohorts: the small ones (about 1 mm in diameter) and the

big ones (2.5 mm in diameter), which supports the hypothesis of a partial spawning of the studied fish.

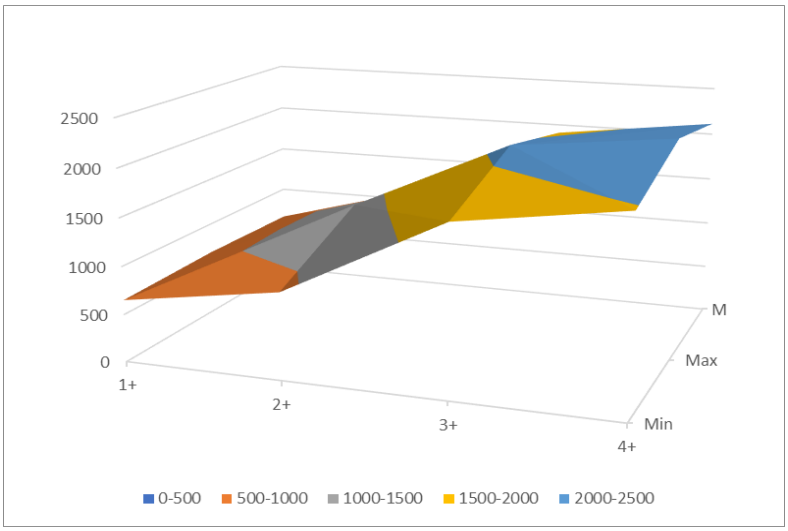


Figure 3. Fecundity of *Perccottus glenii* of the pond in the Piskivka village, Ukraine, in 2021.

The spawning terms of *P. glenii* were tracked in 2023 near the Piskivka village, Kyiv region. Two spawning peaks were observed: from May 4 to May 14, at a water temperature of 14.6-17.3°C, and from June 20 to 24, at a water temperature of 19.2-22.3°C. *Elodea canadensis* were most often used as spawning substrate. Males guarding this period were quite aggressive, as evidenced by numerous scratches on the body and bitten fins (most often the tail). The first spawning occurred in one-year-old females with a body length (SL) of of 6.5 cm and a weight of 5.1 g. Mature fish were only 30% of the total number in the catches. This species had a high mortality during the 1st year of its life: In the critical year, the population can lose a big cohort and downgrade its size.

Diet. The obtained results showed that small fish was a basis of the diet of *P. glenii*, starting from 4 cm SL and more. The value of other components did not exceed 30%. (Figure 4).

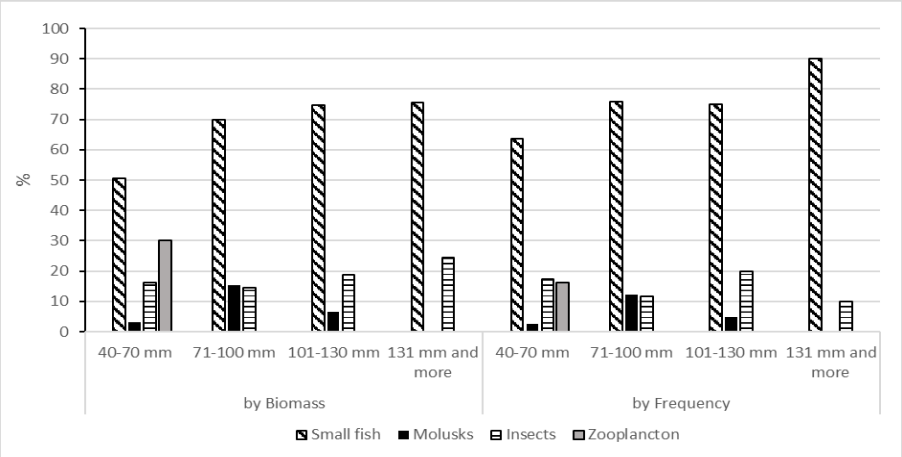


Figure 4. Diet of *Perccottus glenii* of the pond in the Piskivka village, Ukraine, in 2021.

Thus, in contrast to its native population that consumes insects, the introduced *P. glenii*'s diet is dominated by small and juvenile fish, (both in terms of frequency and biomass) (Figure 4). With the increase in body weight, the portion of fish in the diet composition increased.

Discussion. Information in the scientific literature about *P. glenii* is variable. Certain authors considerthat its damaging impact of this fish is dramatically overlooked and not critical. Koščo et al (2008) showed that the impact of this fish on the small water bodies of Slovakia was minimal: in over 10 years, this species was unable to establish a strong population and to compete with native fish species. The same data was reported from the the Dnieper River where, in a 20 years period, this fish species was not yet highly harmful. However, the current research presents the case study about the *P. glenii's* critical and dangerous impact on the fish populations from small water bodies and on the native ecosystems. The dynamics of populations over the 13 years of observation showed that *P. glenii* replaced the established fish community, supporting the thesis of a damaging impact of the alien species. Ukraine does not have a developed algorithm for actions that must be taken when alien fish species are detected. Therefore, no actions have been taken and the commercial and recreational use of the water body remained the same, while the quantity and biomass of the Prussian carp, which was the leading species in the pond in 2008, dropped dramatically. Initially, the part of the *P. glenii* in the community was of only about 10%, but it was sufficient to cause tremendous changes. During the next 13 years, the common carp, Northern pike, and perch disappeared from the fish community and were replaced by the studied species. One may argue that this is just a coincidence, nevertheless, the dramatic change in the diet of *P. glenii*, that actively consumed small fish, had impacted on the natural reproduction of native fish. Interestingly, in their natural area, the adult *P. glenii* consumes predominantly insects and has not a damaging impact on the populations. The absence of the preferred food supply has made this fish an avid predator; even cannibalism was observed in their behavior. Although the growth rates and the length of the age curve (with only 5 age groups) showed that the life conditions in the small water bodies of adoption are far from ideal for the introduced species, the *P. glenii* in its native area shows an age structure consisting of 7 age groups.

Conclusions. The current study has successfully demonstrated that *P. glenii* is a dangerous active invader that can replace the established fish fauna within a couple of decades. With the current trend of increasing pressures on the natural ecosystems and the absence of real control on the biological invasions of alien species, their spreading rate and damaging potential for the native fish communities of small water bodies can be significant and unpredictable. Ukraine needs a strategy for the prevention of biological invasions of the alien fish species and an action plan for downsizing the identified cases.

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Conflict of interest. The authors declare no conflict of interest.

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Authors:
Ganna Kotovska, Department of Hydrobiology and Ichthyology, National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony Str.15, Kyiv, 03041, Ukraine, e-mail: gannkot@ukr.net
Ruslan Kononenko, Department of Hydrobiology and Ichthyology, National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony Str.15, Kyiv, 03041, Ukraine, e-mail: ruslan_kononenko@ukr.net
Nataliia Rudyk-Leuska, Department of Hydrobiology and Ichthyology, National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony Str.15, Kyiv, 03041, Ukraine, e-mail:rudyk-leuska@ukr.net
Mykhailo Leuskyi, Department of Aquaculture, National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony Str.15, Kyiv, 03041, Ukraine, e-mail: leuskyi@nubip.edu.ua
Dmytro Khrystenko, Institute of Fisheries of National Academy of Agrarian Sciences of Ukraine, 135 Obuchivska Str., Kyiv, 03164, Ukraine, e-mail: dskhrist@gmail.com

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