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RESEARCH ARTICLE

Age and growth of invasive alien fish species, *Perccottus glenii* and *Lepomis gibbosus*, in water bodies of Transcarpathia (Ukraine)

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Abstract. The Transcarpathia region of Ukraine is one of the most vulnerable regions for bioinvasions. There are five invasive and nine native species in the artificial water bodies of plain Transcarpathia. This study focused on the life-history traits of the Chinese sleeper *Perccottus glenii* Dybowski and pumpkinseed *Lepomis gibbosus* (L.). The standard length of the Chinese sleeper varied from 14.40 to 94.85 mm, and the total weight varied from 0.11 to 20.05 g. The standard length of pumpkinseed varied from 12.31 to 75.81 mm, and the total weight varied from 0.04 to 17.26 g. Both species form five age group populations dominated by young individuals and reach sexual maturity in their second year of life with a standard length of more than 40 mm. The combination of early maturation, rapid population turnover, and a broad size structure likely enhances the invasive success of both species under local conditions. These findings highlight the high adaptive potential of *P. glenii* and *L. gibbosus* and emphasize their capacity to establish stable populations, posing a long-term threat to native fish assemblages in artificial freshwater ecosystems of Transcarpathia.

Keywords: invasive alien species, *Lepomis gibbosus*, *Percottus glenii,* Transcarpathia

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Introduction

The Transcarpathia region of Ukraine is one of the most vulnerable regions for bioinvasions. The local climate is more comfortable for introducers than in other parts of Ukraine; winters are warm with an average temperature of -4°C, and in summer, the average temperature is 21°C (Kutsokon and Markovych 2015). All Transcarpathian waterbodies are located within the Danube Basin. Species native to East Asia (grass carp *Ctenopharyngodon idella* (Val.)*,* silver carp *(Hypophthalmichthys molitrix* (Val.)) were collected from local rivers during agricultural activities in the USSR. One of the most valuable parts of the successful introduction of fish species in the Transcarpathian flatlands is the large number of artificial waterbodies. Palamarchuk and Zakorchevna (2011) claim that 5.6 thousand hectares in Transcarpathia are occupied by canals, collectors, ditches, reservoirs, and ponds, occupying an area of 2.0 thousand hectares, and hydraulic and other water management facilities occupy 1.6 thousand hectares.

The composition of alien fish species in Transcarpathia is more similar to that of other countries (Slovakia and Hungary) in the Danube Basin than to that of other regions of Ukraine (Markovych and Kutsokon 2012). Studies on the ichthyofauna of Transcarpathia were conducted during the XX century. Vlasova (1956) listed 45 species of fish in the Tisza River Basin, and in subsequent works (Movchan 2000), the list was expanded to 60 species. According to the most recent data, 65 species of fish have been found in the Tisza River, of which 12 are invasive (Abram'yuk et al. 2020, Afanasyev et al. 2022, Tymoshenko 2022).

The Chinese sleeper *Perccottus glenii* Dybowski was first recorded for Transcarpathia in the 1990s (Kozub and Syvokhop 2000), later spread and is indicated by almost all researchers for the plain part of the water bodies. The Chinese sleeper is one of the three most common invasive alien fish species in Transcarpathia, along with the common carp *Cyprinus carpio* L. and topmouth gudgeon *Pseudorasbora parva* (Temminck & Schlegel) (Abram'yuk et al. 2020, Afanasyev et al. 2022, Tymoshenko 2022). The native range of the Chinese sleeper includes northeastern China, the northern part of the Korean Peninsula, and the Russian Far East (Nikolsky 1956). The Chinese sleeper was brought to St. Petersburg (Russia) in 1916, and it has been spreading rapidly in eastern and central Europe (Kottelat and Freyhof 2007, Reshetnikov 2013). The history of the Central European population of the Chinese sleeper began in 1972, when it was found in the Velykyi Lubin fish farm (Dniester River basin) near Lviv, Ukraine (Kutsokon 2017). In the late 1980s, it was recorded in the Vishnya River (a tributary of the San) by Movchan (1989). There were numerous later records from the Vistula River basin in western Ukraine, including the Shatsky Lakes (Bigun and Afanasyev 2011), rivers of the Danube basin the lower Danube (Kvach 2012), Southern Buh, Dnipro and its tributaries (Kutsokon 2017), and Siversky Donets (Honcharov and Drohvalenko 2024). There are few papers about growth of the Chinese sleeper in European populations, but for Ukrainian populations there are only data on its distribution (Kutsokon 2017), feeding (Bigun and Afanasyev 2011), and parasites (Kvach et al. 2013).

The pumpkinseed *Lepomis gibbosus* (L.) has been known since 1914-1918 in the Danube Basin in Romania (Shcherbukha 1982), from where it was introduced to Transcarpathia. Pumpkinseed, one of the most successfully introduced fish species in Europe, may occur in different types of water bodies. Small eutrophic lakes and marshlands are typical habitats for this species. In most cases, pumpkinseed is considered to be released into water bodies by anglers (Garcia-Berthou et al. 2005). Pumpkinseed is native to North America and was introduced to Europe in the 18th century as an ornamental fish. In the Danube Basin, the species has been known since the beginning of 1914-1918 in Romania (Shcherbukha 1982), and in Ukraine, the first findings date back to 1989 (Movchan 1989). Currently, there is evidence of the presence of pumpkinseed in all three river basins of the Carpathian region (Stankevych-Volosyanchuk et al. 2023). For now, in Ukraine there are data about pumpkinseed in the lower reaches of the Danube, the Yalpug and Kagul estuaries, Lake Sasyk, the lower reaches of the Dniester (delta and Dniester estuary), the Odesa Gulf, the Tyligul, Berezan and Dnipro-Buh estuaries, and the floodplain reservoirs of the lower Dnipro, the Southern Buh basin, the inland reservoirs of Crimea, and the Dnipropetrovsk region (Diripasko et al. 2008, Fedonenko and Marenkov 2013). The latest finds of this species are known from the reservoirs of the Northern Azov Sea: the Kakhovka Canal, the Molochna River, and the Kalmius River (Diripasko et al. 2008), the Zaporizhzhia Reservoir on the Dnipro River (Fedonenko and Marenkov 2013) and the Siverskyi Donets River (Koval and Foroshchuk 2020). There are data about distribution (Diripasko et al. 2008, Fedonenko and Marenkov 2013, Khutornoi et al. 2023), morphological features of the pumpkinseed from different Ukrainian rivers (Afanasyev et al. 2017, Marenkov and Nesterenko 2018, Koval and Foroshchuk 2020), parasites (Yuryshynets et al. 2019, Kvach et al. 2023), nutrition and reproduction (Marenkov and Nesterenko 2018, Nesterenko and Marenkov 2018, Nesterenko et al. 2021). The aim of this study was to establish the size-age structure of two alien invasive fish species in some water bodies of the plain Transcarpathia.

Materials and Methods

Study area

Sampling was conducted at five locations (four canals and one pond) in the Transcarpathia region (Ukraine) in the summer of 2015 (Table 1, Figure 1). All sampling sites were located in flatlands. All samples were collected near the shore at a depth of 1.5 m. The BA and DR samples were collected from canals located near the villages of Barkasovo and Drahynya, respectively, in the Mukachevo district. The VY sample was collected from a canal located near the village of Perekhrestya in the Vynohradiv District. The PI and TY samples were collected in the Uzhhorod District from a pond located near the village of Pidhorb and from a canal located near the village of Tysauifalu, respectively.

Data analysis

Age determination was conducted for the Chinese sleeper and the pumpkinseed. These two species were selected because they were the only invasive species present at all five sampling sites. Other invasive species were observed at only three or four locations. In total, 95 Chinese sleeper and 100 pumpkinseed specimens were examined.

Fish were sampled using a 7 m long seine net with a mesh size of 5 mm, as well as a landing net with a mesh size of 5 mm. All specimens were preserved in 4% formaldehyde solution. For each individual, ten scales were removed from above the lateral line and below the dorsal fin. Standard length (SL) was measured to the nearest 0.1 mm using

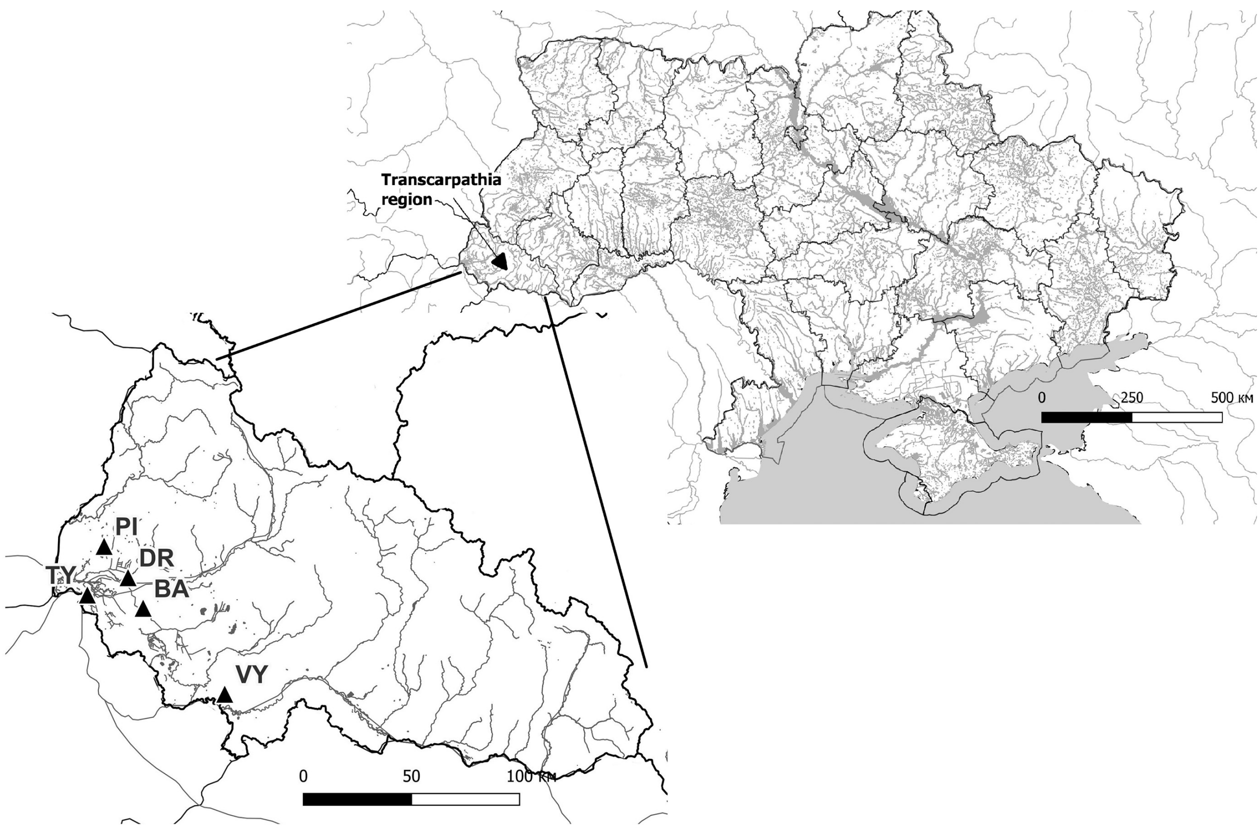

Figure 1. Sampling area. Locations listed in the Table 1.

Table 1
Characteristics of the sampling locations

Location	ID	Coordinates	Date	Type of waterbody	Number of fish species	Parameters								
						Temperature	Oxygen (mg L^{-1})	pH	GH	NO_3 (mg L^{-1})	Cl (mg L^{-1})	Depth (cm)	Emergent plants (% area)
Barkasovo	BA	48.372532, 22.509959	21.07.2015	canal	12	24	6-7	7.5	16	20	0.3	40-110	90-95
Drahynya	DR	48.456310, 22.446688	22.07.2015	canal	10	27	5-6	7.4	16	15	0.0	40-130	60-85
Pidhorb	PI	48.543023, 22.348144	23.07.2015	pond	10	29	2	6.6	8	20	2.3	30-100	5
Perekhresty a (Vylok)	VY	48.134682, 22.849130	24.07.2015	canal	9	31	8	7.4	16	5	0.0	40-100	15
Tysauifalu	TY	48.408851, 22.277981	26.07.2015	canal	6	28	7	7.8	16	2	0.3	50-150	60-80

a slide caliper, and body weight was recorded to the nearest 0.01 g using an electronic balance. Gonads were examined by laboratory dissection of each specimen, and sex was determined by visual inspection.

Age determination for both species was based on a scale analysis. Previous studies have demonstrated the applicability of scales for age determination in Chinese sleeper (Grabowska et al. 2011, Czerniejewski et al. 2020). Scale preparation for microscopic examination followed standard laboratory protocol. The scales were immersed in a 3% ammonia solution and separated individually using fine needles. After cleaning the epithelial residues, each scale was mounted between two tightly pressed microscope slides. Each slide was labeled with the specimen identification number, standard length, and body weight, and subsequently left to dry (Bagenal 1978).

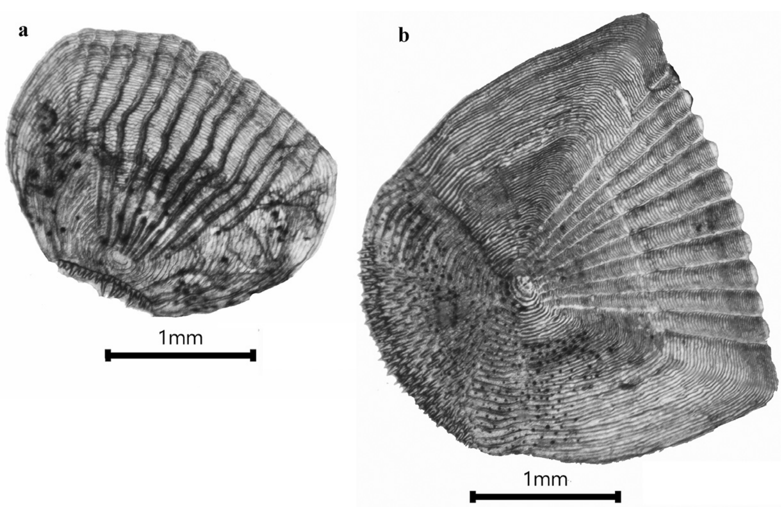

Figure 2. Scales of the Chinese sleeper (a) and the pumpkinseed (b).

Dried scales were examined using a Konus Crystal stereo microscope (magnification: 7 × – 45 ×). Digital images were captured using a SIGETA M3CMOS 15.0 MP digital camera equipped with an FMA050 lens. The total scale radius and annuli radii were measured using ToupTek ToupView software (version 3.7.2270). Measurements were taken from the scale focus to the outer edge of each annulus along the longest axis of the scale (Figure 2).

Species richness was calculated as the total number of species recorded in each sample. The stability of occurrence (C_i) was calculated using the formula (Rechulicz et al. 2015):

$$C_i = 100 * s_i / s_t$$

where s_i is the number of sample sites where species 'i' was present, and s_t is the total number of sample sites.

The dominance index (n%) was calculated using the formula described by Rechulicz et al. (2015):

$$n\% = 100 * n_i / N$$

where n_i is the number of individuals of species 'i' and N is the total number of fish.

The length-weight relationship (LWR) was calculated according to Ricker (1975):

$$W = a\ SL^b$$

where W is the weight (g), SL is the standard length (mm), a is the scaling coefficient, and b is the shape parameter (allometric growth coefficient). A value of b = 3 indicates isometric growth, while values deviating from 3 suggest allometric growth (Tesch 1971). When b < 3, the fish grows faster in length than in weight, and when b > 3, the fish grows faster in weight than in length (Karachle and Stergiou 2012).

Growth parameters were calculated using Bertalanffy's method (Ricker 1975):

$$L_t = L_\infty\ (1 - exp(-K(t - t_0)))$$

where L_t is the fish length at age t (years), and L_∞, K, and t_0 are coefficients.

Oocyte development was examined using the gametogenesis classification scheme proposed by Shykhshabekov et al. (2014). Individual absolute fecundity (IAF) was defined as the total number of mature oocytes in the ovaries of each female. Because all examined individuals were small, it was possible to count all the oocytes within the entire ovary (Marenkov 2018). Absolute fecundity (AF) was calculated as the mean number of oocytes in females of a given size or age class (Marenkov 2018). Relative fecundity (RF) was expressed as the number of oocytes per unit body weight. RF was calculated according to the following formula (Marenkov 2018):

$$RF = AF\ m^{-1}$$

where AF is absolute fecundity and m is body weight (g).

The gonadosomatic index (GSI) was calculated as the ratio of the weight of the gonads to the body weight of the fish in percentage, according to the formula (Ashwini and Girish 2012):

$$GSI = (Pg \times 100) / P$$

where Pg is the gonad weight (g) and P is the total fish weight (g).

Statistical analyses

The Shapiro-Wilk test was used to assess the normality of the data distribution. The Mann-Whitney test was used to compare the standard length among groups (Sheskin 2000). All statistical tests were conducted at a significance level of $\alpha = 0.05$. Statistical processing was performed using the PAST and R software. Simpson's (D) and Shannon's diversity indices (H), and Margalef's richness index (M) were calculated using Jørgensen and Fath (2008).

Results

Almost all the studied water bodies had loamy bottoms. Water temperatures ranged from 24 to 31°C, and most sites were characterized by non-flowing water, low transparency, and depths of up to 1-1.5 m. The lowest oxygen concentration was recorded in the pond near the village of Pidhorb (PI sample), where it reached only 2 mg L^{-1}, whereas oxygen concentrations in the canals ranged from 5 to 8 mg L^{-1} (Table 1). A total of 14 fish species were recorded, five of which were invasive alien species. Species richness in individual water bodies ranged from 6 to 12 species (Table 1).

Species diversity

A total of 1509 fish were caught during the research: 684 from PI, 322 from DR, 236 from BA, 185 from VY, and 65 from TY. The catches confirmed 14 fish species at all sampling sites. Species richness varied from 6 (TY sample) to 12 (BA sample) (Table 2). Only

Table 2
Diversity indices (the abbreviations are explained in Table 1)

Indices	BA	DR	PI	VY	TY
Species richness	12	10	10	9	6
Simpson's diversity index	0.77	0.77	0.57	0.77	0.48
Shannon's diversity index	1.69	1.68	1.08	1.77	1.00
Margalef's diversity index	2.01	1.56	1.38	1.53	1.20

Table 3
Number (N), dominance index (n%) and stability of occurrence (C_i) of fish species

		n%		
Species	N	mean	St. error	Ci
Esox lucius	3	0.23	0.17	40
Percottus glenii	121	10.20	5.22	100
Rhodeus amarus	197	13.62	8.11	80
Leucaspius delineatus	152	13.02	4.46	80
Perca fluviatilis	3	0.48	0.31	40
Ameiurus melas	329	15.96	6.98	80
Cobitis elongatoides	369	11.88	10.03	60
Rutilus rutilus	3	0.23	0.17	40
Pseudorasbora parva	23	1.40	0.66	80
Alburnus alburnus	47	3.19	1.95	80
Lepomis gibbosus	98	17.24	13.46	100
Scardinius erythrophthalmus	12	1.17	0.44	100
Carassius gibellio	134	11.35	7.63	60
Misgurnus fossilis	1	0.03		20

three species were common to all samples, two of which were invasive alien species (Table 3). Most species were present in 2-4 locations. In the VY sample, there were four species with a dominance index of n%>10: Prussian carp *Carassius gibelio* (Bloch), black bullhead *Ameiurus melas* (Raf.), sunbleak *Leucaspius delineatus* (Heckel), and Chinese sleeper *P. glenii*. In the BA sample, the most common species were Chinese sleeper *P. glenii*, European bitterling *Rhodeus amarus* (Bloch) and *L. delineatus*. In the DR sample, the most common species were *R. amarus*, belica *L. delineatus,* and *C. gibelio*. In the PI sample, the dominant species were Danubian spined loach *Cobitis elongatoides* Băcescu & Mayer and *A. melas*. In the TY sample, the most common species were *L. gibbosus* and *A. melas, respectively*. From total of 14 species, 5 were invasive and 9 were native. Invasive species were unevenly distributed among the studied water bodies in this study. Chinese sleeper and pumpkinseeds were caught at all locations. Black bullheads were absent in the DR sample. Stone moroko were absent in the TY sample. Prussian carp were absent in the BA and TY samples.

The three most abundant species in each sample were analyzed. In two samples, one invasive alien species was among the three most represented species: Chinese sleeper in BA (30.1%) and Prussian carp in DR (15.7%). In the remaining three samples, two of the three most abundant species were invasive: black bullhead (39.6%) and pumpkinseed (2.2%) in PI; Prussian carp (39.5%) and black bullhead (20.5%) in VY; and pumpkinseed (71.2%) and

Table 4
Length-weight relationship of the Chinese sleeper and the pumpkinseed. 1 - individuals with undefined sex were rejected before analyses

Species	Sex	n	a	St. error	CI 95% (a)	b	St. error	CI 95% (b)	r^2
Chinese sleeper	total	95	4.4×10^{-5}	0,1	3.8×10^{-5} - 5.1×10^{-5}	2.85	0.02	2.81 - 2.90	1
	males[1]	28	6.1×10^{-5}	0,3	3.2×10^{-5} - 1.2×10^{-4}	2.78	0.07	2.62 - 2.93	0.98
	females[1]	12	4.9×10^{-6}	1,3	2.5×10^{-5} - 9.7×10^{-5}	3.39	0.30	2.67 - 4.10	0.90
Pumpkinseed	total	100	2.4×10^{-5}	0,1	1.9×10^{-5} - 2.9×10^{-5}	3.09	0.03	3.03 - 3.15	0.99
	males[1]	21	1.0×10^{-5}	0,5	3.9×10^{-6} - 2.7×10^{-5}	3.30	0.12	3.06 - 3.54	0.98
	females[1]	12	4.6×10^{-6}	0,7	9.6×10^{-7} - 2.2×10^{-5}	3.50	0.17	3.12 - 3.88	0.97

black bullhead (15.2%) in TY. In the PI pond, there is a tendency for the fish community to be dominated by only two species, Danubian spined loach and black bullhead.

Life-history traits of *P. glenii* and *L. gibbosus*

The standard length of the Chinese sleeper varied from 14.40 to 94.85 mm, and the total weight varied from 0.11 to 20.05 g. The mean standard length was 41.54 ± 22.78 mm, and the mean weight was 3.44 ± 4.39 g. The standard length of the pumpkinseed varied from 12.31 to 75.81 mm, and the total weight varied from 0.04 to 17.26 g. The mean standard length was 32.34 ± 19.4 mm, and the mean weight was 2.69 ± 4.18 g. The mean standard length and weight by sex for both species are shown in Figure 3. For the Chinese sleeper Mann-Whitney U test showed no significant difference between mean length and weight between males and females (for length U = 143, z = 0.72, P = 0.47; for weight U = 148, z = 0.58, P = 0.56). For the pumpkinseed Mann-Whitney U test showed significant difference between mean length and weight between males and females (for length U = 67, z = 2.19, P = 0.03; for weight U = 72, z = 0.2, P = 0.05).

Immature specimens constituted 57.9% of all the Chinese sleeper individuals. Males accounted for 29.5% and females for 12.6%. The length-weight relationship is shown in Table 4. Growth of the Chinese sleeper was allometric and varied for males and females, whereas for the pumpkinseed, there was no such difference. There were no specimens of both species with standard length between 30 and 40 mm (Figure 4). We can assume that both species become mature at a length greater than 40 mm during the second year of life. For both species, the maximum observed age was 5 years (age group 4+). The most common age group was 0+ for both species, but within mature specimens, the 2 + age group prevailed for both species. For the Chinese sleeper, the von Bertalanffy equation was Lt=101.28*[1-exp(-0.37*(t+0.73))]. For the pumpkinseed von Bertalanffy equation was Lt=74.16*[1-exp(-0.64*(t+0.47))].

The absolute fecundity of female Chinese sleeper ranged from 230 to 1043 eggs, and the relative fecundity ranged from 30.62 to 202.92 eggs per gram of body weight. The average value of relative fecundity was 96.54 ± 67.65 eggs per gram of body weight. The absolute fecundity of female pumpkinseed ranged from 1098 to 5993 eggs, and the relative fecundity ranged from 107.59 to 958.03 eggs per gram of body weight. The average value of relative fecundity was 372.54 ± 275.19 eggs per gram of body weight. The gonadosomatic index (GSI) ranged from 0.16% to 9.02% for pumpkinseed and from 0.47% to 6.07% for Chinese sleeper. For both species, the GSI values in males were significantly lower than those in females (Figure 5; Mann-Whitney test for Chinese sleeper: U = 91, z = 2.26, P = 0.02; for pumpkinseed: U = 26, Z = 3.72, P = 0.0002).

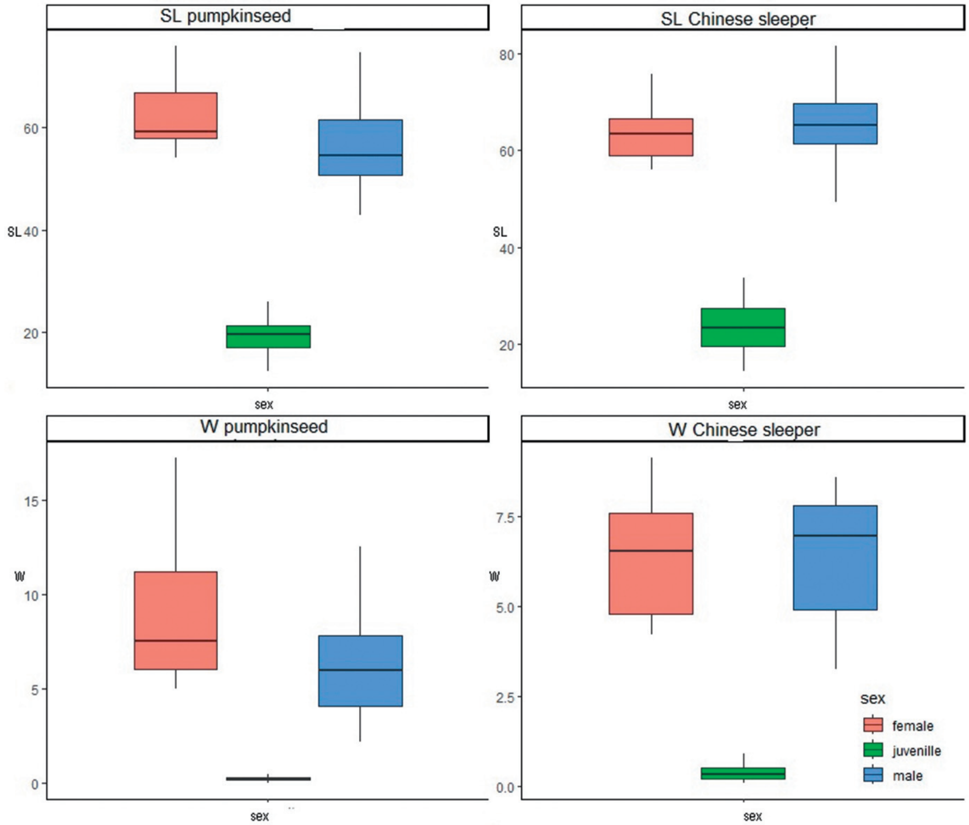

Figure 3. Mean standard length (SL, mm) and weight (TW, g) by sex.

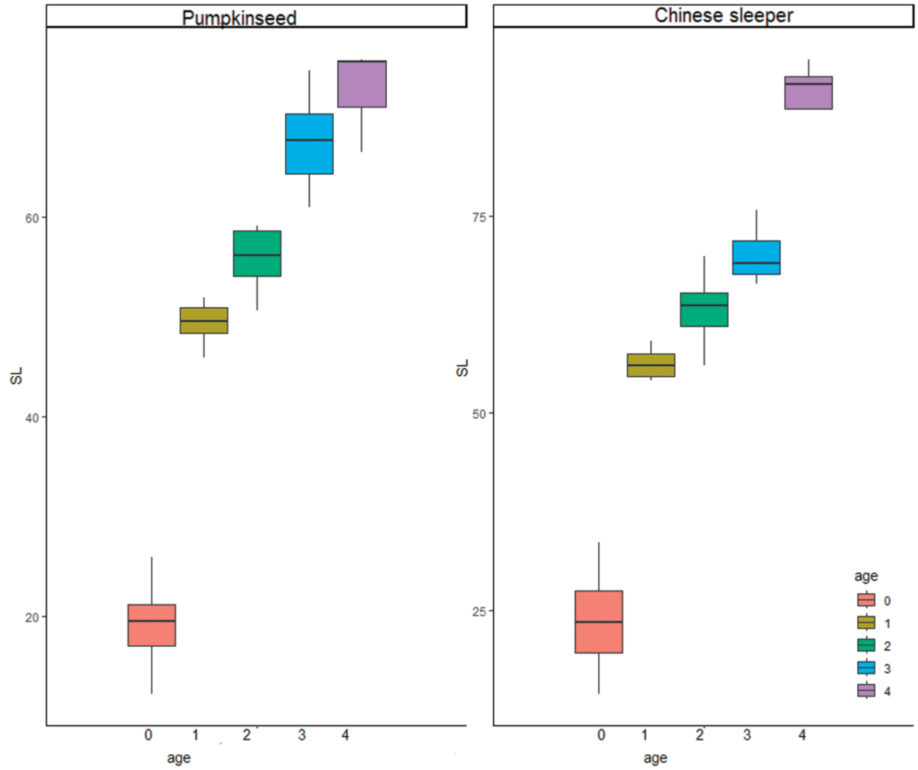

Figure 4. Standard length (SL, mm) of the Chinese sleeper and the pumpkinseed in different age.

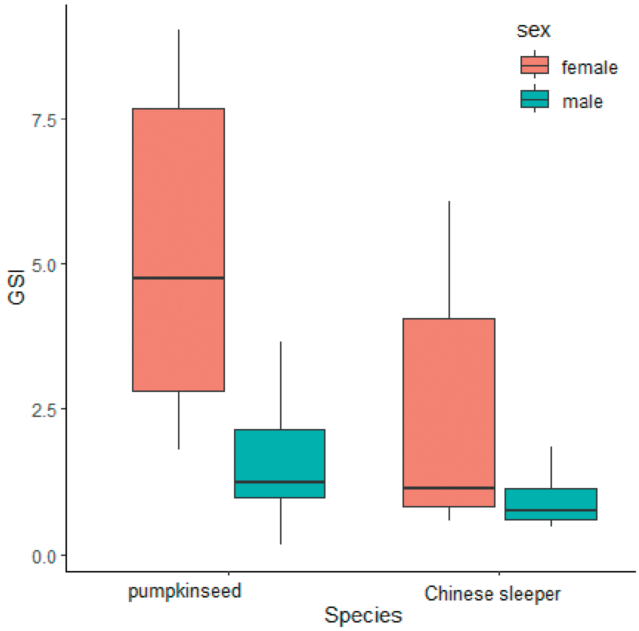

Figure 5. Mean GSI (%) for the Chinese sleeper and the pumpkinseed.

Discussion

Totally there were 14 fish species found in studied area. Nine species were native, and five were alien invasive. None of the native species were abundant at all locations, but two invasive species (Chinese sleeper and pumpkinseed) were. In the Tysza River subbasin, 66 species have been registered (Abram'yuk et al. 2020, Afanasyev et al. 2022, Tymoshenko 2022). The studied waterbodies were artificial and had significantly lower species richness. The smallest Simpson's diversity index was lower in the TY sample. In the pond sample (PI), Simpson's diversity index indicated an average value, whereas the remaining samples showed identical values. Overall, all samples exhibited moderate levels of diversity. Shannon's diversity index revealed a generally similar pattern, also indicating moderate diversity; however, the TY sample was characterized by low diversity, which corresponded to its lower species richness and overall diversity.

Sampling was conducted only once and during a single season, which imposes clear limitations on the interpretation of our results. In particular, the observed size, age structure, and sex-related differences may reflect seasonal or short-term conditions rather than stable population patterns.

Literature data show that the size of the Chinese sleeper varies considerably in its geographic range. The largest specimens sampled in the Moscow region (Russian Federation) reached a total length of 250 mm and 10 years of age (Reshetnikov 2003). In Central Europe, the fish are younger and characterized by smaller lengths (Nyeste et al. 2017, Skoric et al. 2017, Czerniejewski et al. 2020) than in its natural range. The largest males (130 mm SL) and females (142 mm SL) were observed in the Włocławek Reservoir on the Vistula River, Poland (Grabowska et al. 2011). In our samples, the largest specimen was 95 mm SL. It is smaller than that of other Ukrainian rivers.

The obtained a values fell within the range of $3*10^{-7}$ to $7*10^{-5}$ recorded for European populations (Nyeste et al. 2017, Skorić et al. 2017, Czerniejewski et al. 2020). The recorded *b-value* was 2.85. The values reported for the Chinese sleeper in its native range are 2.6-3.08 (Liu et al. 2013, Huang et al. 2014). For European populations, *b* values range from 2.92 to 3.32 (Grabowska et al. 2011, Nyeste et al. 2017, Skorić et al. 2017). Our data also support this trend in the European population.

The growth of the Chinese sleeper varies in different populations that is typical of fish with a wide range of distribution (Mann 1991). At the invaded areas, the length gain is greater than in native range (Grabowska et al. 2011). This may be due to a decrease in length gain after the fish reach maturity. In native areas, the Chinese sleeper reaches maturity at the age of 2+ and 3+ (Bogutskaya and Naseka 2002), whereas the age at maturity varies in non-native populations. According to Grabowska et al. (2011), females reach maturity at the age of 1+ and males at the age of 2+. However, according to Czerniejewski et al. (2020), both sexes reach maturity at age 1+. All specimens in our study were mature in the second year of life, for both sexes. The largest immature specimen had an SL of 33.6 mm, and the smallest mature specimen was 49.3 mm and aged 1+.

The von Bertalanffy growth parameters estimated for the Chinese sleeper in this study ($L_\infty \approx$ 101 mm and K = 0.37) indicate a relatively rapid attainment of asymptotic size, but overall smaller maximum size and steeper growth rates than those reported for more established invasive populations in Central Europe, where L_∞ values can exceed 175 mm with much lower growth coefficients ($K \approx 0.10$), suggesting slower but more prolonged growth under different environmental conditions in river systems (Czerniejewski et al. 2025). Such interpopulation differences in growth dynamics support the idea that local habitat conditions, including temperature, productivity, and density of competitors or predators, strongly mediate life history expression in invasive Chinese sleeper populations across Europe (Czeglédi et al. 2025). The Chinese sleeper is a successful invasive species because of its fast maturity, multiple spawning events, extended breeding season, and care of offspring (Grabowska and Przybylski 2015). There is data about growth differences between males and females during the first two years of life, males growth faster and bigger than females (Grabowska et al. 2011, Nyeste et al. 2017, Czerniejewski et al. 2020). This could be due to gonad development during the first two years of life because the energy channelled into the gonads detracts from somatic growth (Kozłowski 1996). Alternatively, it could be a limitation of somatic growth due to oxygen deprivation (Pauly 2021). In the canals and ponds of the Transcarpathian flatlands, there was no difference in the growth of males and females. This lack of sexual dimorphism in growth may indicate favorable environmental conditions, such as abundant food and limited competition, which allow both sexes to achieve similar sizes early in their lives.

The sex ratio of Chinese sleeper in invasive populations is usually close to 1:1 (Grabowska et al. 2011, Nyeste et al. 2017). Czerniejewski et al. (2020) showed a different trend with male dominance. The same trend was observed in our samples, where females were less abundant than males. This could be related to the care of the offspring. While males guard their eggs and aggressively defend the nest (Wałowski and Wolnicki 2010, Grabowska et al. 2011), they are easier to catch in nearshore areas. Male nest-guarding behavior may concentrate predation or harvesting pressure on males, which could temporarily skew local population dynamics but does not appear to prevent overall population growth.

The pumpkinseed average length is 10 to 15 cm, but it can reach a maximum length of 40 cm in its native area (Scott and Crossman 1973). In European waters, it is smaller (Copp et al. 2002, 2004). Water quality, temperature, population density, and the presence of other fish species can affect the growth rate of pumpkinseed (Holtan 1998). Klaar et al. (2004) explained size difference between native and non-native populations of pumpkinseed by the higher density of fish population and competition in the colonization of new environmental niches, as well as trophic competition (territorialism). Pumpkinseeds from the Jablanica Reservoir are 8–15 cm long, rarely 30 cm (Trožić-Borovac et al. 2003). It weighs from 200 to 400 g, and the largest recorded body mass is 630 g (Halilović et al. 2021). In Northern Ireland, pumpkinseeds grow up to an average length of 10-15 cm and reach a maximum weight of 300 g (Halilović et al. 2021). The mean total body length of pumpkinseed from our research was 56.6 mm, and the mean weight was 6.7 g, which was smaller than that in other studies.

The maximum age reported for the European populations of pumpkinseed is 8 years, and in the case of the waters of natural occurrence of this species, even 10 years (Copp et al. 2004). A small number of age groups in the investigated population is common for pumpkinseed populations. The similar age structure was reported for several other pumpkinseed populations from different types of water bodies and geographical latitudes (Constantinescu 1981, Gutierrez-Estrada et al. 2000, Villeneuve et al. 2005, Bobori et al. 2006, Uzunova et al. 2008). In Bulgaria, the majority of populations from small ponds have three or four age groups, whereas larger reservoirs have one or two more age groups (Uzunova et al. 2008). In our study, the population structure was similar, consisting of five age groups (from 0+ to 4+) with a predominance of small specimens. Some other studies confirm similar characteristics, but the prevailing age groups were 1+ and 2+ (Gutierrez-Estrada et al. 2000, Villeneuve et al. 2005, Uzunova et al. 2008, Konečná et al. 2015). After reaching maturity, body growth becomes much slower owing to the significant energy allocation to breeding and gonad development (Justus and Fox 1994). The dominance of small individuals within the population can also be attributed to lower depths, which provide suitable conditions for spawning and dense vegetation, serving as shelter for the young-of-the-year and a lack of predators. These pond features predetermine low mortality among young fish (Bertschy and Fox 1999). This earlier maturity, coupled with the dominance of young individuals, suggests high recruitment and rapid population turnover, which are advantageous for the colonization and persistence of pumpkinseed in artificial and small natural water bodies.

The maximum age recorded in the studied water bodies was five years (age group 4+). In general, the samples contained most of the yearlings (0+). Among the sexually mature individuals, three-year-olds (2+) were the most represented. In another studied population from Ukraine, namely from the Zaporizke Reservoir (Marenkov and Nesterenko 2018), seven age groups (from 0+ to 7+) were noted, with the most represented yearlings, and the reproductive core of the pumpkinseed population was females at the age of 5 years. Sexual maturity occurs in the second year of life at a standard length of more than 40 mm, which is earlier than that in other European populations (Copp et al. 2002). Typically, pumpkinseed becomes sexually mature at two years of age at a standard length of 50-65 mm (Copp et al. 2002), a difference that may be partly related to the longevity of this species in the studied reservoirs, as it can live up to eight years in the expensed range and up to ten years in the native range (Copp et al. 2002), although there are populations with a small number of age groups (Uzunova et al. 2008) and a small number of older groups (Douligeri et al. 2023).

Pumpkinseed in the Transcarpathian water bodies exhibited much smaller average size (L_∞ = 74.16 mm) than typical European populations. K = 0.64 indicates a more rapid growth rate. Most introduced populations in northwestern and central Europe show a range of growth trajectories, with total lengths at age 2 often between 55 and 93 mm and maximum ages generally up to 3–4 years, reflecting responses to local thermal regimes and resource availability (Cucherousset et al. 2009). The early maturity at a relatively small size observed in our study aligns with patterns described in other non-native populations in Greece and Bulgaria, where individuals also matured by the second year, and populations were dominated by young age classes under pond or stream conditions (Uzunova et al. 2008, Douligeri et al. 2023). These comparisons suggest that the life-history strategies of invasive fish in Europe frequently favor fast juvenile growth and early reproduction, likely enhancing population establishment and persistence in novel habitats.

Conclusion

The Transcarpathia region is vulnerable to the introduction of invasive alien species. In the current study, five invasive fish species were recorded in four canals and one pond in the study area. Chinese sleeper and pumpkinseed are the most common alien invasive species in these waterbodies. For the Chinese sleeper, the maximum standard length was 94.85 mm, and the maximum total weight was 20.05 g. The maximum standard length of pumpkinseed was 75.81 mm, and the maximum total weight was 17.26 g. There was no significant difference in the mean length and weight between males and females for Chinese sleeper. Pumpkinseed females were larger than males. The maximum age for both species was 4+, but the prevailing age group was yearlings. Given that sampling was conducted during a single season over a short period, these results provide only a snapshot of population characteristics and should be interpreted with caution.

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