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THE LIFE HISTORY TRAITS OF THE CHINESE SLEEPER, *PERCCOTTUS GLENII* (PERCIFORMES, ODONTOBUTIDAE), AN INVASIVE ALIEN SPECIES IN UKRAINE

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The life history traits of the Chinese sleeper, *Perccottus glenii* (Perciformes, Odontobutidae), an invasive alien species in Ukraine. Shukh, A., Honcharov, H., Didenko, O., Podobailo, A., Kutsokon, Y. — *Perccottus glenii* Dybowski, 1877 is one of the freshwater fishes listed in the IAS list of Union Concern as an important invasive alien fish species. In Ukraine, it was recorded for the first time in the 1970s and now is widespread in all Ukrainian large river basins. Chinese sleeper from eight localities was studied: seven from the Dnipro River basin and one from the Siverskiy Donets River basin. In total, 403 specimens were examined. Standard length of Chinese sleeper in our samples varied from 10 mm to 143.6 mm. Total weight varied from 0.05 g to 79 g.

The largest female had a standard length of 138.6 mm. The biggest male had a standard length of 143.6 mm. Chinese sleeper become mature at age 1+ with a length near 40 mm. Males predominated in all samples. Immature specimens were dominating in five samples, while mature fish prevailed only in two samples. The *a* values varied from 0.000012 to 0.000059. The growth coefficient (*b*) ranged from 2.68 to 3.19.

Key words: age, Chinese sleeper, Dnipro basin, length-weight relationship, *Perccottus glenii*, Siverskiy Donets basin.

Introduction

The Chinese sleeper, *Perccottus glenii* Dybowski, 1877, is one of the most invasive freshwater fishes in Eurasia. The native range of Chinese sleeper includes north-eastern China, the northern part of the Korean Peninsula and the Russian Far East (Nikolsky, 1956).

Chinese sleeper was brought to St. Petersburg (Russia) in 1916 and it has been spreading very fast in eastern and central Europe (Reshetnikov, 2013; Kottelat & Freyhof, 2007). In the 1950s, it was found in shallow waters of the Gulf of Finland in the Baltic Sea. In the 1960s, the Chinese sleeper was introduced to Kazakhstan, Uzbekistan and the Lake Baikal mixed with Chinese carps. The history of the Central European population of the Chinese sleeper started in 1972, when it was found in the Velykyi Lubin fish farm (the Dniester River basin) near Lviv, Ukraine (Kutsokon, 2017). In the late 1980s, it was recorded in the Vishnya River (tributary of the San) by Movchan (1989). There were numerous later records from the Vistula River basin in western Ukraine, including the Lakes Shatsky (Bigun & Afanasyev, 2010), rivers of the Danube basin (Didenko et al., 2010; Markovych & Kutsokon, 2012), the lower Danube (Kvach, 2012), Southern Buh (Kutsokon et al., 2014), Dnipro (Sabodash et al., 2002) and its tributaries (Kutsokon, 2017), and Siversky Donets (Honcharov & Drohvalenko, 2024).

Invasion of Chinese sleeper into new localities still continues, via both active and passive dispersal. Human activities, such as fish cultivation, are considered one of the primary causes for introduction of the Chinese sleeper into geographically distant locations (Grabowska et al., 2020). The Chinese sleeper is included in the IAS list of Union Concern (European Commission, 2020) as an important invasive alien fish species.

The Chinese sleeper prefers lentic waters, canals, lakes, ponds, backwaters, and swamps with dense submerged vegetation and avoids lotic habitats (Kottelat & Freyhof, 2007; Rechulicz et al., 2015; Kutsokon, 2017). It is resistant to oxygen deficiency, moderate chemical pollution and significant temperature drops (Bogutskaya & Naseka, 2002), and can survive in low-productivity water bodies (Kutsokon et al., 2021). Moreover, this species is a wide-spectrum, omnivorous fish with a general preference for zooplankton in juvenile stages switching to benthos and smaller fish (including cases of cannibalism) in later stages (Koščo et al., 2008; Rau et al., 2017).

The Chinese sleeper can reduce the diversity of macroinvertebrates, amphibians, reptiles, and fishes (Koščo et al., 2008; Grabowska et al., 2009; Pupina et al., 2018; Reshetnikov, 2003, 2013) and can be considered as a serious threat to European freshwater ecosystems.

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 & Afanasyev, 2010), and parasites (Kvach et al., 2020; 2022). The aim of this study was to describe the age and sex structure, length-weight relationship of the Chinese sleeper populations in Ukraine.

Material and Methods

Study area and sampling

Sampling was conducted at eight locations in Ukraine during warm season (Table 1, Fig. 1). All sampling locations were lentic water bodies with dense macrophyte covers. A beach seine (8 m long, 0.5 cm mesh size) and a dip net (mesh size 0.5 cm) were used for sampling. All samples were captured near the shore at depths of approximately 1.5 m. In total, 403 specimens were sampled and examined. For each sampling site, other co-occurring fish species were also recorded and counted including predators and alien invasive species.

The research did not involve animal experimentation or harm.

The PE and KA samples were sampled in the Poltava Region. The PE sample was collected from the slow flowing river Perevod near Sasynyvka village. The substrate at the sampling site was silty with many macrophytes. The KA sample was collected in a large lake near Kaplyntsi village (Poltava Region). The substrate at the sampling site was sandy.

The RY and RZ samples were sampled in Rzyshchiv (Kyiv Region). The RY sample was collected in a small bay of the Kaniv Reservoir in Rzyshchiv. The sampling site has dense macrophyte cover and a very silty bottom. The RZ sample was collected in a small lake within Rzyshchiv.

Table 1. **Sampling locations**

Locality	ID	Latitude, N	Longitude, E	Date	Number of other species	Waterbody type	Area (ha)
Perevod River	PE	50.299501	32.408467	29.07.2023	18	River	–
Rybalska bay, Dnipro	RY	49.977691	31.0578289	18.06.2023	15	River bay	–
Zalissya, Lake Verkhne Velyke	ZA	50.763391	30.834580	7.08.2023	10	Lake	23
Zalissya, Lake Beztravne	ZB	50.72342	30.87195	5.09.2024	1	Lake	< 1
Rzyschyv, Lake	RZ	49.978390	31.057450	12.05.2023	1	Lake	0.15
Kaplyno, Uday River	KA	50.305448	32.612611	1.08.2022	3	Lake	8.4
Sukhiy Zhykhor quarry	SZ	49.951149	36.246979	16.09.2023	5	Quarry	1.4
Lake Berizka, Kyiv	BE	50.439164	30.579012	29.09.2021	9	Lake	2.6

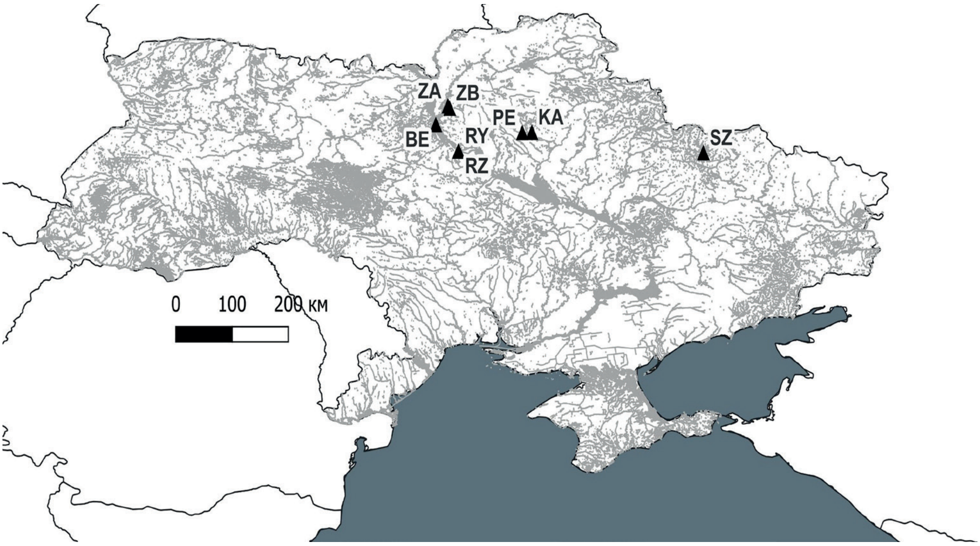

Fig. 1. Sample cites locations. ID listed in Table 1

The BE sample is from Lake Berizka in Kyiv. The bottom at the sampling site was silty with dense macrophyte beds.

The ZA and ZB samples were both taken in the Zalissya National Park (Kyiv Region). The ZA sample was collected from Lake Verkhne Velyke, while the ZB was sampled from Lake Beztravne. The ZA sample site is a large lake overgrown with macrophytes. The ZB is small forest lake.

The SZ sample was collected from the artificial quarry on the Sukhiy Zhykhor River (the Siverskiy Donets River basin) in Kharkiv (Kharkiv Region).

Sample processing

All samples after catching were preserved in a 4% formaldehyde solution. For each specimen standard length (SL) was measured to the nearest 0.01 mm using a slide caliper. Total weight was determined to the nearest 0.01 g with electronic scales. Every specimen was eviscerated and sex was determined by examining gonads visually. Age determination was conducted using scales as in some previous studies of Chinese sleeper (Skoric et al., 2017; Czerniejewski et al., 2020; Grabowska et al., 2011). Scales were prepared according to the classical method (Bagenal, 1978). For each specimen, ten scales were extracted from the area above the lateral line, beneath the dorsal fin.

Scale preparation for microscopy followed laboratory protocols (Bagenal, 1978). Scales were immersed in a 3% ammonia solution and individually separated using needles. After cleaning off epithelial residues, each scale was placed between two tightly pressed slides. Labels indicating specimen ID, weight, and length were affixed to each slide. The prepared slides were then left to dry.

Examination of dried scales was conducted using a Konus Crystal 7x-45x stereo microscope. Digital images were captured using a digital SIGETA M3CMOS 15.0MP camera with a FMA050 lens. Total scale radius and annuli radii were measured using ToupTek ToupView 3.7.2270 software. Measurements were taken from the scale center to the outer edge of each annulus along the largest diameter (Fig. 2).

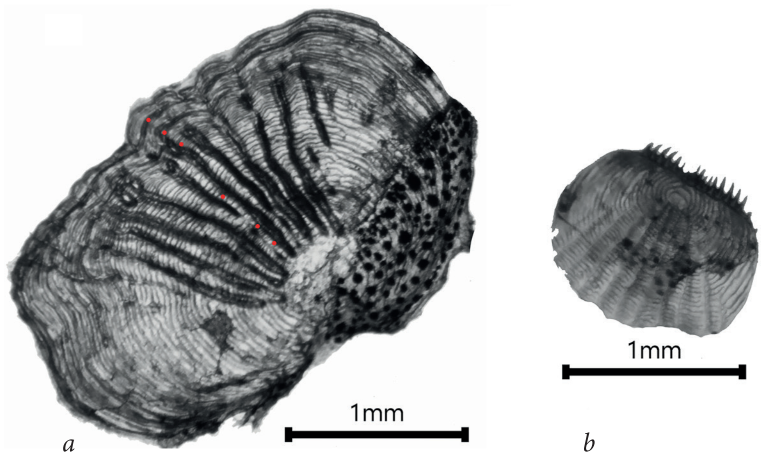

Fig. 2. Scales of the Chinese sleeper at age 6+ (*a*) and 0+ (*b*)

Statistical analysis

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

$$Lt = L\infty\ (1 - \exp(-K \times (t - t0)))$$

Where: Lt = Fish length at age t (years); L∞, K, t0 are coefficients.

The length-weight relationship (LWR) was calculated using the function (Ricker, 1975):

$$W = a \times SL^{\wedge}b$$

Where: W = Weight (g); SL = Standard length (mm); a = Scaling coefficient; b = 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 & Stergiou, 2012).

Fulton's condition factor (K) was calculated using the following formula (Froese, 2006):

$$K = 100 \times TW \times SL^{-3}$$

Where: TW = total weight (g); SL = standard length (cm).

Statistical analyses were performed as follows:

1. The Shapiro-Wilk test was used to assess the normality of data distribution.

2. Analysis of Variance (ANOVA) and Mann-Whitney test were used to compare standard lengths among different groups (Sheskin, 2000).

All statistical tests were conducted with a significance level of $\alpha = 0.05$. Statistical processing was performed using PAST and R software.

Results

Among samples collected, there were two samples from rivers and six samples from lakes. Two river samples were PE and RY. PE was sampled in the slow-flowing the Perevod River overgrown with vegetation. Chinese sleeper is not a common species in the Perevod River, it was small there and reached 66.9 mm SL. RY was sampled in the small bay on the Dnipro River. As opposed to PE sample Chinese sleeper from

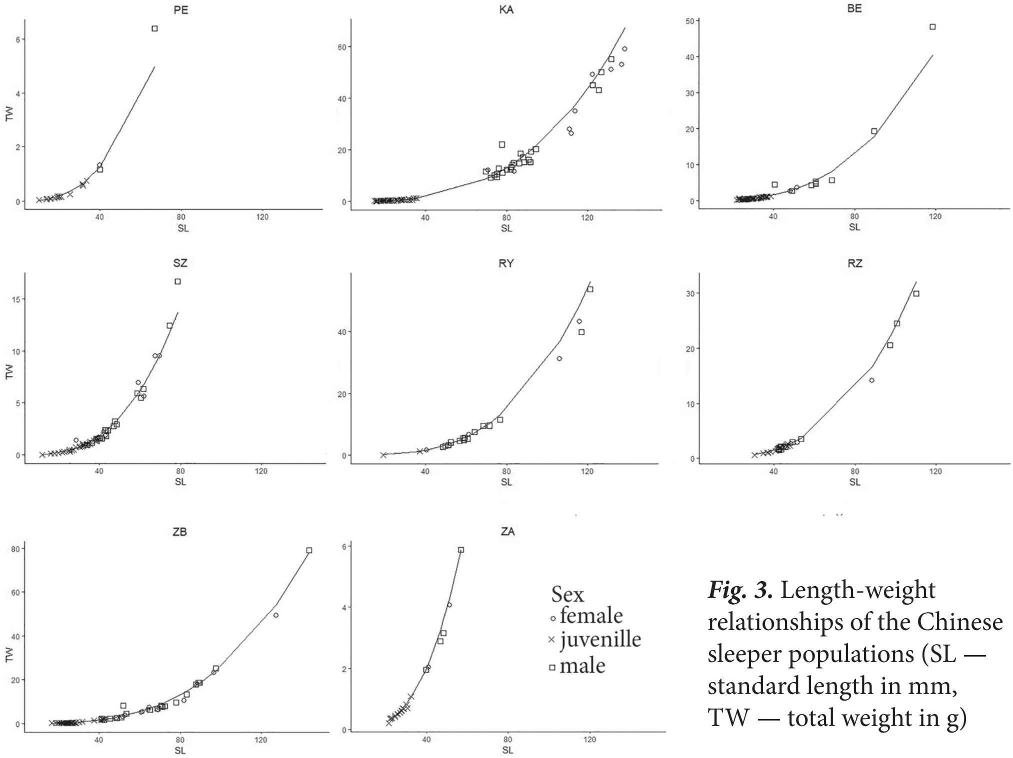

Fig. 3. Length-weight relationships of the Chinese sleeper populations (SL — standard length in mm, TW — total weight in g)

RY sample reached 121.4 mm SL. There was not a big amount of Chinese sleeper in both samples, but in the RY sample there were more adult age groups while most of the specimens in PE were immature and very small.

Samples from large lakes (area more than 1 ha) were SZ, KA, BE, ZA. ZA and SZ are both artificial lakes with no connection with nearest rivers while BE and KA are not. In these samples, sizes of Chinese sleeper highly varied. Specimens from the ZA sample were the smallest and reached 56.7 mm SL, in the SZ sample specimens were slightly larger and reached 78.7 mm SL. In the BE and KA, maximum standard length exceeded 115 mm.

RZ and ZB were sampled from small lakes (area less than 1 ha). In both samples Chinese sleeper formed abundant populations, and its standard length exceeded 110 mm.

Standard length of Chinese sleeper in samples varied from 10.0 mm to 143.6 mm (Fig. 3). Total weight varied from 0.05 g to 79 g. Mean standard length varied across sampling sites from 25.23 ± 13.12 mm (PE) to 66.42 ± 27.34 mm (RY) (Table 2).

ANOVA did not show significant differences in fish body sizes among most samples (Appendix 1).

Mature specimens predominated only in two samples (RY and RZ). In the RY sample, there were 85,7% of mature specimens. In RZ and SZ, the ratio between mature and immature fish was near 50/50: 53,1% of mature specimens in the RZ sample and 44,1% in the SZ sample. BE and PE had the highest share of immature specimens (85,5% and 85% respectively). ZA had 72,7% of immature specimens, ZB had 63,2% of immature specimens and KA had 59,3% of immature specimens.

Males predominated in all examined samples. Due to unequal presence of males and females in samples, only three samples, which had the most females, were used

Table 2. **Length and weight of the Chinese sleeper populations**

Sample	N	Standard length, mm				Total weight, g			
		Min	Max	Mean	Standard deviation	Min	Max	Mean	Standard deviation
PE	20	10.07	66.85	25.23	13.12	0.05	6.38	0.66	1.40
BE	76	21.76	118.56	34.53	15.24	0.25	48.21	1.94	5.90
RZ	32	30.44	110.14	50.46	19.47	0.63	29.96	4.50	7.17
RY	21	18.85	121.42	66.42	27.34	0.11	53.71	12.12	15.53
KA	86	14.76	138.55	53.39	38.39	0.07	59.0	9.99	15.39
SZ	59	11.54	78.71	38.33	14.50	0.05	16.63	2.35	3.14
ZA	22	21.65	56.69	32.20	10.33	0.22	5.87	1.31	1.46
ZB	87	16.52	143.63	43.11	26.43	0.16	78.95	4.82	10.89

Table 3. **Standard lengths (mm) for different sexes of the Chinese sleeper populations**

Sample	Sex	N	Min	Max	Mean	Standard deviation	p
KA	Males	26	69.75	131.71	90.06	17.85	0.02 *
	Females	9	71.04	138.55	113.51	23.15	
SZ	Males	18	36.21	78.71	49.18	12.54	0.68
	Females	8	38.85	69.66	52.72	13.15	
RZ	Males	5	43.21	88.41	55.46	18.69	0.71
	Females	12	41.86	110.14	59.47	26.47	
ZB	Males	19	41.24	143.63	71.05	24.86	1
	Females	13	48.32	127.57	72.06	21.96	
PE	Males	2	40.00	66.85	53.43	18.99	—
	Females	1	40.04	40.04	—	—	
BE	Males	9	40.35	118.56	67.48	23.43	—
	Females	2	48.2	51.43	49.82	2.28	
RY	Males	15	48.34	121.42	67.66	22.42	—
	Females	3	61.28	116.05	94.56	29.23	
ZA	Males	4	39.71	56.69	47.91	6.98	—
	Females	2	40.93	51.21	46.07	7.27	

*$p < 0.05$.

for comparison (KA, SZ, RZ, ZB). Among those three samples, significant differences between length of males and females was found only in KA (Table 3).

The length-weight relationships (LWR) for examined samples:

PE $TW = 0.000059 \times TL^{2.68}$; $r^2 = 0.97$.
RY $TW = 0.000012 \times TL^{3.19}$; $r^2 = 0.99$.
ZA $TW = 0.000023 \times TL^{3.07}$; $r^2 = 0.99$.
RZ $TW = 0.000022 \times TL^{3}$; $r^2 = 0.99$.
KA $TW = 0.000025 \times TL^{2.99}$; $r^2 = 0.99$.
SZ $TW = 0.000037 \times TL^{2.92}$; $r^2 = 0.98$.
BE $TW = 0.000029 \times TL^{2.95}$; $r^2 = 0.96$.
ZB $TW = 0.000021 \times TL^{3.04}$; $r^2 = 0.98$.
$P << 0.05$ for all samples.

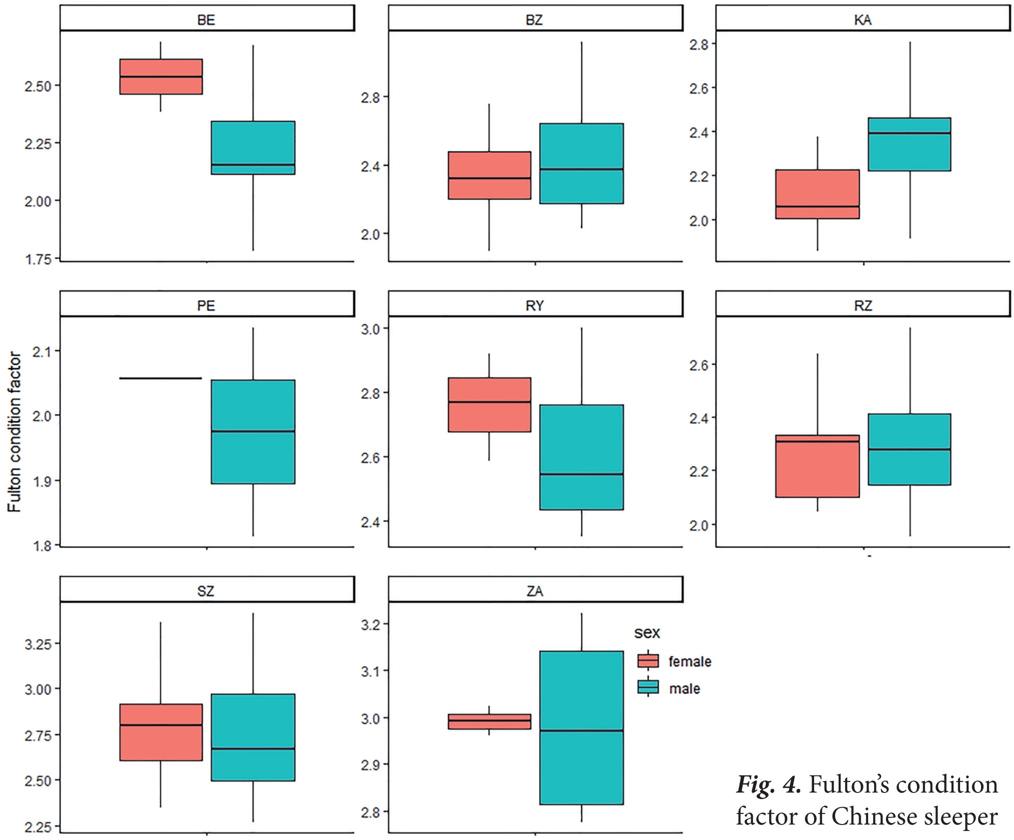

Fig. 4. Fulton's condition factor of Chinese sleeper

The *a* values varied from 0.000012 to 0.000059. The growth coefficient (*b*) ranged from 2.68 to 3.19. Chinese sleeper growth was isometric only in the RZ sample, while it was allometric in others. All LWR were highly significant ($p < 0.05$ for all samples), with coefficient of determination (r^2) values exceeding 0.95, indicating a strong positive correlation between length and weight across all samples.

Chinese sleeper becomes mature at age 1+ with length near 40 mm. We could not determine the age at maturity only in KA, because of absence specimens with length between 35 and 70 mm, but all small specimens there were immature. In the SZ sample, the smallest mature specimens had a length of 36 mm. In RY, RZ and ZB samples, there were some immature specimens with a length 40–47 mm, so we could assume that some Chinese sleeper could reach maturity a little bit later.

The age structure in each sample is shown in Appendix 2. The absence of the 0+ group in the RZ sample was due to the sampling time (May) when the spawning season of this species had not started yet.

In most samples, 0+ was the most common age group. All specimens at this age were immature. Older age groups were represented in small amounts. The standard length at age by sex is shown in Appendix 3, but no comparisons among age groups were provided due to their small sizes. Maximum age of the Chinese sleeper depended on the sample and varied from 3+ to 7+.

Von Bertalanffy's equation estimated parameters are shown in Table 4.

Table 4. **Von Bertalanffy equation for the Chinese sleeper populations**

Sample	PE	RY	ZA	RZ	KA	SZ	BE	ZB
N	20	21	22	32	43	59	76	87
L∞	111.34	189.11	73.74	188.75	246.17	119.33	178.96	276.21
K	0.24	0.12	0.33	0.11	0.11	0.14	0.13	0.05
t0	−0.89	−0.34	−1.36	-0.6	−0.96	−1.87	−0.32	−0.84

Fulton's condition factors for all samples are shown in Figure 4. Fulton's condition factor values varied from 0.01 to 0.07 in all samples.

Among our samples, half included more than 10 species (PE, BE, ZA, RY). We observed that Gibel carp *Carassius gibelio* (Bloch, 1782) was present in seven out of eight samples (absent only in KA). The crucian carp *C. carassius* (Linnaeus, 1758) was recorded in one sample (ZA). The full species list is shown in Appendix 4.

Discussion

Literature data show that the size of Chinese sleeper varies considerably in its geographic range. The largest specimens reach a total length of 250 mm and 10 years of age (Reshetnikov, 2003). In Central Europe, the fish were 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 at the Vistula River, Poland (Grabowska et al., 2011). In our samples the largest female was recorded in the KA sample (138.6 mm). The largest male was recorded in the ZB sample (143,6 mm). The smallest were fishes from two rivers (PE, BE) and one lake (ZA), the largest specimens from these three samples did not reach the size of 100 mm. Maximum length in other samples was 110 mm or more.

The obtained *a* values were smaller than those recorded in native areas (Liu et al., 2013, Huang et al., 2014), but fall within a range from $3*10^{-7}$ to $7*10^{-5}$ recorded for European populations (Czerniejewski et al., 2020; Nyeste et al., 2017; Skorić et al., 2017). The recorded *b* values fall within the range of 2.5–3.5, which is considered to be common (Froese, 2006). 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 varied from 2.92 to 3.32 (Grabowska et al., 2011; Nyeste et al., 2017; Skorić et al., 2017). All our samples except PE fell within European range, but PE result was closer to *b* value in native range ($b = 2.68$). All examined populations except RZ were characterized by allometric growth. In ZA, ZB and RY samples, the Chinese sleeper gained weight faster than length, while in others samples, Chinese sleeper grew faster in length than in weight.

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 higher than in native range (Grabowska et al., 2011). However, a decrease in length gain occurs in non-native populations sooner (predominantly after two years of life) (Nyeste et al., 2017) in comparison to native Chinese sleeper populations (Nikolsky, 1956). This probably results from a decrease in the length gain after the fish have reached maturity. The Chinese sleeper reaches maturity at the age of 2+ and 3+ in its native range (Bogutskaya & Naseka, 2002) whereas the age at maturity varies in non-native populations. According to Grabowska et al. (2011), females reached their maturity at the age of 1+ and males at the age of 2+, but according to Czerniejewski et al. (2020), both sexes reached their maturity at age 1+. However, in the Rakamazi-Nagy-Morotva, Carpathian basin, Hungary (Nyeste et al., 2017) 0+ specimens were mature. All specimens in our samples were mature at age 2+ for both sexes, the Chinese sleeper reaches maturity at age of 1+ with a length of approximately 40 mm.

Faster maturity, smaller sizes, short-life spawn, multiple spawning events, extended breeding season and care of the offspring are factors that help the Chinese sleeper to invade faster (Grabowska and Przybylski, 2015). There are data about growth differences between males and females during the first two years of life. In the Habdziński Canal, Poland (Czerniejewski et al., 2020), the Włocławek Reservoir, Poland (Grabowska et al., 2011) and the Danube River (Nyeste et al., 2017) males growth faster and are larger than females. It 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). In our study, there were small amounts of females to provide analysis, but only in one sample (KA) there were significant differences between length of males and females, where females were larger.

The sex ratio of Chinese sleeper in invasive populations is usually close to 1:1 (Grabowska et al., 2011; Nyeste et al., 2017). Only Czerniejewski et al. (2020) showed a different trend with males' dominance. The same trend was observed in all our samples, where females were were less abundant than males. All samples were taken in the nearshore area. Males guard their eggs until they hatch and defend the nest aggressively (Grabowska et al., 2011; Wałowski & Wolnicki, 2010), therefore they can be more easily caught by the dip net than females.

Rechulicz et al. (2015) found a correlation between the occurrence of *P. glenii* with *C. gibelio* and the spined loach *Cobitis taenia* Linnaeus, 1758. We can assume that our data confirms the correlation between the presence of *C. gibelio* and *P. glenii* in water bodies. Also, there are some data about Chinese sleeper`s impact on species richness (Rechulicz et al., 2015; Reshetnikov, 2003). In some oxbow lakes of the Wieprz valley (Rechulicz et al., 2015), in which Chinese sleeper was found, it accounted for a significant share of the ichthyofauna (40% of the total fish abundance). We had two samples with only these two species: ZB and RZ. Both are small lakes with areas less than 1 ha. RZ could have connection with the Dnipro River during spring floods, but ZB is a lake in the middle of the forest without connection with other water bodies. A low abundance of Gibel carp was recorded in this sampling site, so we can assume that there would be a monospecific population of Chinese sleeper one day.

Piscivorous species such as the northern pike *Esox lucius* Linnaeus, 1758 and European perch *Perca fluviatilis* Linnaeus, 1758 were recorded only in half of the samples. For example, *P. glenii* was observed in the diet of *P. fluviatilis* in the Kaniv Reservoir (Didenko & Gurbyk, 2016). Also, there is study about potential of *E. lucius* and *P. fluviatilis* being able to exterminate *P. glenii* due to their foraging on different-sized prey (Rakauskas et al., 2019).

Conclusion

Chinese sleeper is one of the most invasive alien species in Ukrainian waterbodies. It successfully spreads in new areas due to its biological characteristics. In all studied locations Chinese sleeper grows fast and reaches maturity with standard length around 40 mm at the second year of life. Immature specimens are the most common in populations, but maximum age varies from 3+ to 7+ depending on the sample. We can assume that our data confirms the correlation between the presence of *C. gibelio* and *P. glenii* in water bodies. Chinese sleeper can impact on the species richness; in two studied lakes there was a tendency to monospecific population of Chinese sleeper.

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