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# Body size, condition, growth rate and parasite fauna of the invasive *Perccottus glenii* (Actinopterygii: Odontobutidae) from small watercourse in the Vistula River basin, Poland

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**Abstract**

For the last few decades there have been reports not only of the occurrence of new invasive species of European watercourses, but also their increasing expansion. One of such species is the Amur sleeper (*Perccottus glenii*). The present work contains assessment of age and length distribution, condition as well as growth rate and analysis of the parasite fauna of the Amur sleeper from the waters of the Vistula River tributary in its middle course (the Habdziński Canal). During the catch performed in 2017 and 2019, the total of 177 Amur sleepers were recorded in the studied watercourse and a statistically significant sex structure disproportion was observed. Among the specimens caught in 2017 dominant were fishes with lengths of 50.1–60.1 mm whereas in 2019 the majority of the Amur sleeper specimens measured 30.1–50.0 mm. Six age groups were recorded among the caught fish with a clear prevalence of specimens aged 1+ (70.06%). The most frequently recorded parasite of *P. glenii* was non-quantifiable *Trichodina rostrata* ciliate for which the Amur sleeper from the Polish waters appeared to be a new host. Moreover, the presence of an acanthocephalan *Acanthocephalus lucii,* not recorded in Poland in this host before, was observed in the chyme. Also, accidental presence of larvae of the *Opisthioglyphe ranae* trematode, which is a parasite typical of amphibians, was also recorded. Despite unfavourable habitat conditions and increased volumes of biogenic substances in the waters of the Habdziński Canal, the Amur sleeper found convenient conditions to reside in this small watercourse.

**Key words:** *age and growth, Amur sleeper, Habdziński Canal, invasive species, parasites, population structure*

## INTRODUCTION

Invasions of expansive alien species is a serious global issue and, according to the International Union for Conservation of Nature, are one of the most significant threats to biodiversity due to unforeseeable effects that are caused by the appearance of a new species in the given area [COPP *et al.* 2005; GRABOWSKA *et al.* 2010]. The success of an alien invasive species depends on its high environmental tolerance and its life-history traits [GRABOWSKA, PRZYBYLSKI 2015]. In Europe the Amur sleeper, *Perccottus glenii* (Dybowski, 1877) and the stone moroko, *Pseudorasbora parva* [CZERNIEJEWSKI *et al.* 2019] are considered to be among the most invasive species of all freshwater fish [JURAJDA *et al.* 2006; RESHETNIKOV 2013; SKORIĆ *et al.* 2017]. The native range of *P. glenii* covers the Russian Far East, north-eastern China [KIRPICHNIKOV 1945; NIKOLSKIJ 1956], and the northern part of the Korean Peninsula [NYESTE *et al.* 2017]. The Amur sleeper was first observed on our continent in 1916 in the area of Saint Petersburg and it was later repeatedly introduced into the waters with Cyprinidae stocking material [BOGUTSKAYA, NASEKA 2002]. According to RESHETNIKOV [2013], the source of non-native Amur sleeper population in Europe could have been a fishing farm near Lvov from where the young of this species were brought to Poland (1993), Slovakia (1998), Hungary (1997), Serbia (2001), Romania (2001) and Bulgaria (2005) with stocking material [ANDRZEJEWSKI *et al.* 2011; BOGUTSKAYA, NASEKA 2002; GRABOWSKA *et al.* 2011; JURAJDA *et al.* 2006; KOŠČO *et al.* 2003a; RESHETNIKOV, FICETOLA 2011; SIMONOVIĆ *et al.* 2006; SKORIĆ *et al.* 2017]. Taking into consideration the fact that the Amur sleeper originates from areas similar to Europe and its high tolerance of diverse physiochemical conditions of water, it can be stipulated that Poland features good climatic conditions for reproduction, ontogenetic development and growth for this species [GRABOWSKA *et al.* 2010]. This is indicated by recently observed new habitats of this species situated west of the Vistula River reception basin, and in the Odra River basin, which in turn indicates its further expansion [ANDRZEJEWSKI *et al.* 2011; GRABOWSKA *et al.* 2010; NEHRING, STEIHOF 2015; WITKOWSKI 2012]. The presence of the Amur sleeper causes a range of frequently irreversible changes in trophic systems, species composition of macroinvertebrates, amphibians, fish and carrier of parasites in an ecosystem [BOGUTSKAYA, NASEKA 2002; RESHETNIKOV 2003]. This species is a predator with morphological features that enable hunting of a large variety of aquatic organisms with inclusion of relatively big prey items [MILLER, VASIL'EVA 2003], both macroinvetebrates and vertebrates would be potentially affected by the presence of this new predator. After abrupt impoverishment of large invertebrate fauna, the Amur sleeper can eliminate eggs, larvae and juveniles of native fish species. It has to be emphasised that, within its natural habitat, this fish is a host for 67 species of various parasites, but it is estimated that it might be a host for more than 100 species in new habitats [RESHETNIKOV 2013; SOKOLOV *et al.* 2014]. The consequences for the ecosystem connected with the occurrence of new habitats of the Amur sleeper and an increase in its range inspire numerous scientific studies and contribute to the growth of knowledge of its habitation area, invasion rate, ecology and habitats of this species both in waters of large rivers [LITVINOV, O'GORMAN 1996; SKORIĆ *et al.* 2017], large reservoirs and in aquarium conditions [PRONIN, BOLONEV 2006; GRABOWSKA *et al.* 2011]. However, scrutiny is required for the Amur sleeper occurring in small inland watercourses, which is probably associated with the difficulty in conducting field studies due to excessive volumes of water plants, high thickness of sediments and hydrology of these watercourses [RECHULICZ *et al.* 2015]. The present work intended to assess age and length distribution, condition as well as growth rate and analysis of the parasite fauna of the Amur sleeper from the waters of the Vistula river tributary in its middle course (central part of Poland). The presence of the Amur sleeper was first observed in the canal in 2017 and the research material used in the present work came from the catch in the early period of establishing a population by this species.

## MATERIAL AND METHODS

The catches were carried out in the creek called the Habdziński Canal located in the Vistula catchment area, in the centre of Poland (Fig. 1). The Amur sleeper were found in the lower reaches of the canal at 3 sites (1st located 0.04 km from its mouth, N 21°16'57.3", E 52°11'26.5"; 2nd located 1.05 km from its mouth, N 21°15'98.9", E 52°10'99.13"; 3rd located 9.04 km from its mouth, N 21°17'32.8", E 52°07'99.9") – Figure 1, Table 1.

The catches were carried out using approved electrofishing equipment type ELT 60 II GI according to the norm CEN EN 14011, 2003; PN-EN 14011, 2006 (power 32KW/impuls, impuls control 20–100 Hz) in June 2017 and July 2019. The operators waded upstream for 100 m and the catch covered the entire width of the riverbed.

177 Amur sleeper were caught (in 2017 – 64 ind., in 2019 – 113 ind.). In the laboratory, the fish were measured for total length (*TL*, mm) and standard length (*SL*, mm), with an accuracy to 0.1 mm, and weighed with an accuracy to 0.1 g, using an AXIS digital scale. Fulton's factor ($K_F = 100\ W\ SL^{-3}$) was calculated in order to evaluate the body condition of the fish [NYESTE *et al.* 2017]. Sex determination was performed by direct observation of gonads. The sex ratio was expressed as a proportion of females to all specimens (♀÷ (♀ + ♂)), and tested with chi-squared analyses ($\chi^2$). The weight-length relationship (*WLR*) in fish is usually expressed as $W = aSL^b$, where $W$ is body weight (g), $L$ is total length (cm), $a$ is a coefficient related to body form and $b$ is an exponent indicating isometric growth when equal to 3. Parameters $a$ and $b$ of *WLR* were estimated using the least-square method from logarithmically transformed data, and the correlation between weight-length variables was calculated from the determination coefficient ($R^2$). The statistical significance of $R^2$ and 95% confidence limits of parameters $a$ and $b$ were estimated [FROESE 2006]. The Student's *t*-test was used to test allometry in growth.

Six well-developed scales were removed from between the lateral line and the first dorsal fin of each specimen [GRABOWSKA *et al.* 2011]. The scales were cleaned using the alkaline immersion method [HUANG *et al.* 2015] and compressed between two glass slides for age determination by counting the number of completely developed annual rings using criteria from STEINMETZ and MULLER [1991]. Both the scale diameter and the annual increments were measured using a Nikon Eclipse E600 stereo microscope, equipped with an HD-video camera, and the Lucia image analysis software (Nikon). Back-calculation of *SL* at age was undertaken using the linear relationship between the scale radius and *SL* [FRANCIS 1990]. The growth curve in males and females was described by applying the von Bertalanffy equestion. The von Bertalanffy equestion coefficients were calculated by producing a Walford plot of total length +1 against Lt [OGLE, ISERMANN 2017]. The casual relationship of independent variable *TL* and dependent variable (scale diameter) was examined using ordinary linear regression modelling [RICKER 1975]. The index of growth performance ($\varphi'$) was also calculated on the basis of the formula provided by NYESTE *et al.* [2017]: $\varphi' = \log10\ (K) + 2\ \log10(L\infty)$.

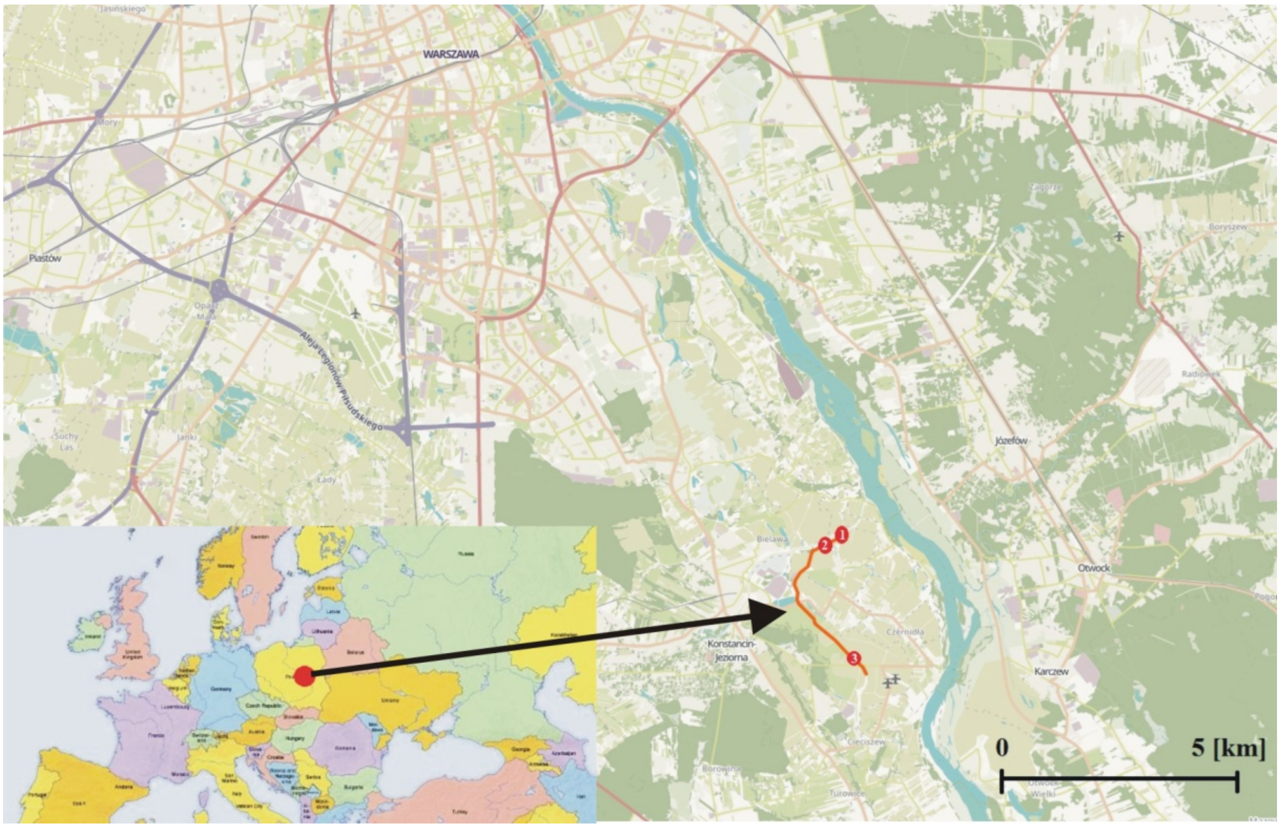


Fig. 1. Location of Amur sleeper habitat sites on the Habdziński Canal; own elaboration

**Table 1.** Basic hydrological parameters of Amur sleeper habitat sites in the Habdziński Canal

| Site | Length of sites (m) | Width of sites (m) | Macrophyte coverage (%) | Type of bottom | Flow velocity ($m \cdot s^{-1}$) |
|---|---|---|---|---|---|
| 1 | 100 | 6,5 | 88 | silt 90%, sand 10% | 0.04 |
| 2 | 100 | 8,0 | 91 | silt 80%, sand 20% | 0.06 |
| 3 | 100 | 3,5 | 89 | silt 100% | 0.02 |

Source: own elaboration.

Additionally, the catch per unit effort (*CPUE*) expressed as fish specimens per 1 square metre ($ind. \cdot m^{-2}$) and the population of the Amur sleeper in the structure of the caught fish were determined.

73 Amur sleeper specimens caught in 2019 were selected for parasitological tests. The fish were subjected to macroscopic examination. Next, perishable sections from nasal and oral swabs and scrapes from integuments, fins, gills and operculums were prepared. Sections from lenses, vitreous bodies, hearts, kidneys, urinary bladders, gonads, livers and pancreases were prepared. Also, the interior of the alimentary tract and the chyme were subjected to microscopic examination. All the observations were performed using an Olympus BV50 microscope equipped with an AxioVision camera and its software. The isolated parasites were preserved in 75% ethyl alcohol.

In order to determine their taxonomy, professional literature and specialist keys for species determination were used [NIEWIADOMSKA, POJMAŃSKA 2018; POPIOŁEK 2016] and their identification was based on a comparison of body sizes and morphological features. The percentage of infected fishes (prevalence) was calculated. The occurrence of non-quantifiable protozoa was determined as sporadic (<10 individuals), sparse (10–50 individuals), many (50–100 individuals), very many (100–150 individuals), mass (>150 individuals). The number of specimens comprised the total number of parasites in all visual fields of the section.

During the electrofishing, water samples were also collected at each site to evaluate hydrochemical conditions. Oxygenation, conductivity and pH studies were measured directly in the field. Oxygen concentration ($mg \cdot dm^{-3}$) in water was determined with a WTW multi-parameter meter Multi 3400 equipped with an oxygen probe Cellox 323. Electrolytic conductivity was measured ($\mu S \cdot cm^{-1}$) with a conductivity meter TetraCon 325. Other analyzes of biogenic compounds were performed in the ITP laboratory in Szczecin. Concentrations of ammonium-nitrogen ($NH_4$-N), nitrate-nitrogen ($NO_3$-N) and phosphorus ($PO_4$-P) were determined with a SLANDI multiparameter photometers LF 205 and LF 305. Water flow velocity was measured using a SENSA RC2 electro-magnetic meter equipped with an RV2 velocity probe.

STATISTICA 12.0 PL (StatSoft, Poland) was used for statistical computations. In order to compare mean values between the sexes and years of fish catching, the Student *t*-test was used, following testing the normality of distributions of the variables, using the Kolmogorov–Smirnov test, and the equality of variances, using Levene's test [SOKAL, ROHLF 2012]. The Spearman's rank correlation coefficient was used to determine a correlation between biological traits of the fish and the number of detected parasites.

**Table 2.** Sex structure of the Amur sleeper in the Habdziński Canal

| Year | Female | Male | Juvenile | Together | Sex ratio | $\chi^2$ | Degree of freedom *df* | Probability *p* |
|---|---|---|---|---|---|---|---|---|
| | individuals | | | | | | | |
| 2017 | 25 | 26 | 13 | 64 | 0.49 | 0.0196 | 1 | 0.888638 |
| 2019 | 24 | 80 | 9 | 113 | 0.23 | 30.1538 | 1 | 0.000001 |
| Together | 49 | 106 | 22 | 177 | 0.32 | 20.9611 | 1 | 0.000005 |

Source: own study.

**Table 3.** Lengths (*TL*, *SL*), unit weights (*W*) and condition coefficients ($K_F$) for the Amur sleeper between 2017 and 2019, including statistical analysis results

| Parameter | Sex | Together average ± *SD* | 2017 average ± *SD* | 2019 average ± *SD* | Student *t*-test value | Level of significance *p*[1)] |
|---|---|---|---|---|---|---|
| *TL* (mm) | female | 61.61±17.14 | 71.48±18.93 | 51.33±4.82 | 5.05190 | 0.000007 |
| | male | 54.11±10.11 | 63.62±13.50 | 51.03±6.22 | 6.51559 | 0.000000 |
| | juvenile | 34.41±3.62 | 33.61±3.23 | 35.56±4.03 | –1.25231 | 0.224904 |
| | together | 53.82±14.29 | 60.59±20.29 | 49.98±6.95 | 5.06734 | 0.000001 |
| *SL* (mm) | female | 50.45±14.47 | 59.08±15.59 | 41.46±4.23 | 5.34900 | 0.000003 |
| | male | 44.21±8.73 | 52.65±11.39 | 41.46±5.39 | 6.79130 | 0.000000 |
| | juvenile | 28.05±2.82 | 27.62±2.74 | 28.67±3.00 | –0.85428 | 0.403068 |
| | together | 43.98±12.06 | 50.08±16.87 | 40.52±5.93 | 5.46468 | 0.000000 |
| *W* (mm) | female | 4.55±4.80 | 7.67±5.94 | 2.25±0.66 | 3.70568 | 0.000555 |
| | male | 2.73±1.82 | 4.25±2.86 | 2.24±0.91 | 5.52773 | 0.000000 |
| | juvenile | 0.56±0.21 | 0.53±0.17 | 0.60±0.53 | –0.80000 | 0.433110 |
| | together | 2.98±3.11 | 4.47±4.69 | 2.13±0.90 | 5.16181 | 0.000001 |
| $K_F$ | female | 2.89±0.40 | 2.71±0.35 | 3.08±0.37 | 3.53625 | 0.000925 |
| | male | 2.90±0.41 | 2.58±0.19 | 3.00±0.41 | 5.05829 | 0.000002 |
| | juvenile | 2.45±0.43 | 2.45±0.36 | 2.44±0.53 | 0.06463 | 0.949110 |
| | together | 2.88±0.43 | 2.60±0.31 | 3.03±0.41 | 7.23519 | 0.000000 |

[1)] The level of significance of differences between values of the given parameters for the fish caught in 2017 and 2019.
Source: own study.

# RESULTS

## STRUCTURE OF SEX, LENGTH, WEIGHT AND CONDITION OF FISH

A statistically significant disproportion in the sex structure was observed among the 177 fishes caught in 2017 and 2019 (Tab. 2).

Fish length ranges were as follows: *TL* 29.00 – 118.00 mm, *SL* 23.00 – 95.00 mm, whereas the weight ranged from 0.30 to 24.90 g. Mean values of the parameters, including Fulton's condition factor ($K_F$) and standard deviations for the Amur sleeper, are presented in Table 3. A statistically significant linear correlation was observed for *TL* and *SL*: $TL = 2.1250 + 1.1755\ SL$ ($R = 0.99177$, $p < 0.001$). No statistically significant difference between the mean values of the aforementioned parameters in males and females (*t*-test, $p > 0.05$) were observed, but the differences were recorded when the fish were divided according to catch years (Tab. 3). Moreover, the specimens caught in 2017 prevailed in length groups (*SL*) of 50.1–60.1 mm whereas in 2019 the majority of the Amur sleeper specimens measured 30.1–50.0 mm (Fig. 2).

The estimated parameters for the length-weight regressions are presented in Table 4. The data indicated that both sexes and groups of fish caught in 2017 and 2019 demonstrated negative allometric growth.

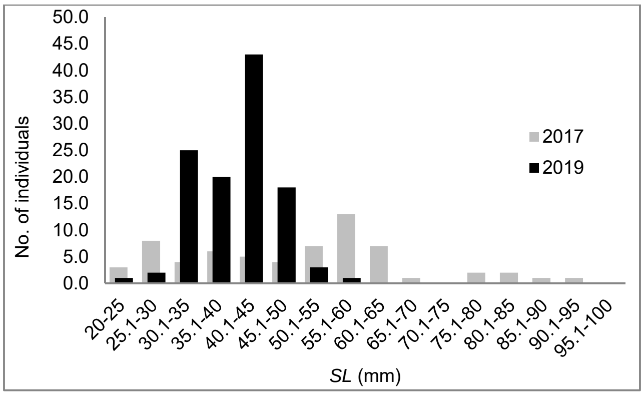


Fig. 2. Amur sleeper length (*SL*) structure from catches in 2017 and 2019; own study

**Table 4.** Standard length – weight parameters for the Amur sleeper in the Habdziński Canal

| Year/sex | Coefficient *a* | Coefficient *b* | $R^2$ | Student *t*-test value | Level of significance *p* |
|---|---|---|---|---|---|
| Full test | 0.00004 | 2.9262 | 0.96 | 67.26646 | 0.00 |
| 2017 | 0.00002 | 3.0670 | 0.96 | 40.86585 | 0.00 |
| 2019 | 0.00004 | 2.9149 | 0.91 | 34.15447 | 0.00 |
| Female[1)] | 0.00007 | 2.7695 | 0.97 | 40.14963 | 0.00 |
| Male[1)] | 0.00007 | 2.7584 | 0.93 | 37.56786 | 0.00 |

[1)] Individuals with undefined sex were rejected before analyses.
Explanations: *a* = coefficient related to body form; *b* = exponent indicating isometric growth when equal to 3; $R^2$ = determination coefficient.
Source: own study.

## AGE AND GROWTH OF THE FISH

Six age groups were recorded among the 177 caught fish with a clear prevalence of specimens aged 1+ constituting 70.06% of the fish (Fig. 3). After the fish were divided according to catch years, in 2017 fish aged 1+ and 2+ prevailed constituting 32.81% and 37.50% of the caught fish whereas in 2019 the 1+ group prevailed constituting as many as 91.15% of all the fish. Females were observed in all age groups (from 1+ to 5+) with a clear prevalence of female individuals aged 1+ and 2+ which constituted 63.27% and 26.53%, respectively. However, males were only observed in age groups from 1+ to 4+ with the greatest numbers in 1+ group (84.91%) and 2+ group (13.21%).

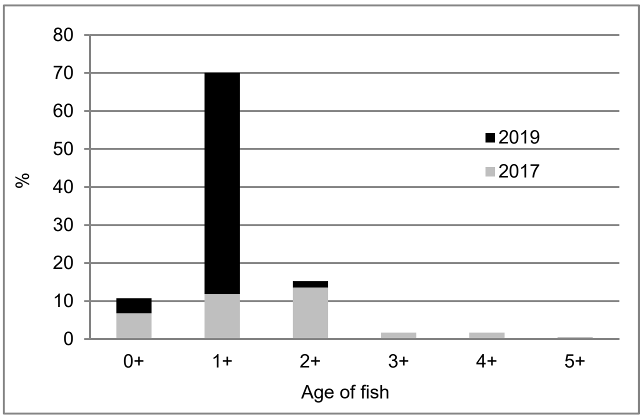


Fig. 3. Age structure of the caught fish; own study

The back-calculated standard length at age and the annual linear increments of the fish caught in 2017 and 2019 are presented in Table 5. The Student's *t*-test did not demonstrate any statistically significant differences in *SL* in each year of life between the catches ($p > 0.05$). However, after the fish were divided by sex, the mean *SL* at age values in the first and second years of life were significantly statistically greater in the males than in the females ($t = -9.29336$, $p < 0.0001$ and $t = -8.77332$, $p < 0.00001$, respectively) whereas in the four-year-old fish the females boasted a significantly statistically greater length ($t = 9.23568$, $p < 0.00001$) (Fig. 2). For both sexes, the average annual increments of *SL* decrease with age, but in the females the decrease in the annual increments of *SL* is smaller than in the males (Fig. 4).

**Table 5.** Mean back-calculated lengths-at-age, standard deviation (*SD*) and mean annual growth increments for Amur sleeper from the Habdziński Canal in 2017 and 2019

| Year | Age 1 | Age 2 | Age 3 | Age 4 | Age 5 |
|---|---|---|---|---|---|
| **Back-calculated body lengths at age (*SL*) ±*SD*** | | | | | |
| 2017 | 32.79±4.65 | 56.12±4.89 | 67.95±3.95 | 80.69±5.11 | 90.68±6.84 |
| 2019 | 35.91±4.91 | 54.69±4.99 | – | – | – |
| Together | 35.90±4.86 | 54.80±4.94 | 67.95±3.95 | 80.69±5.11 | 90.68±6.84 |
| **Mean *SL* increments (mm)** | | | | | |
| 2017 | 32.79 | 23.33 | 11.83 | 12.74 | 9.99 |
| 2019 | 35.91 | 18.78 | – | – | – |
| Together | 35.90 | 18.90 | 11.83 | 12.74 | 9.99 |

Source: own study.

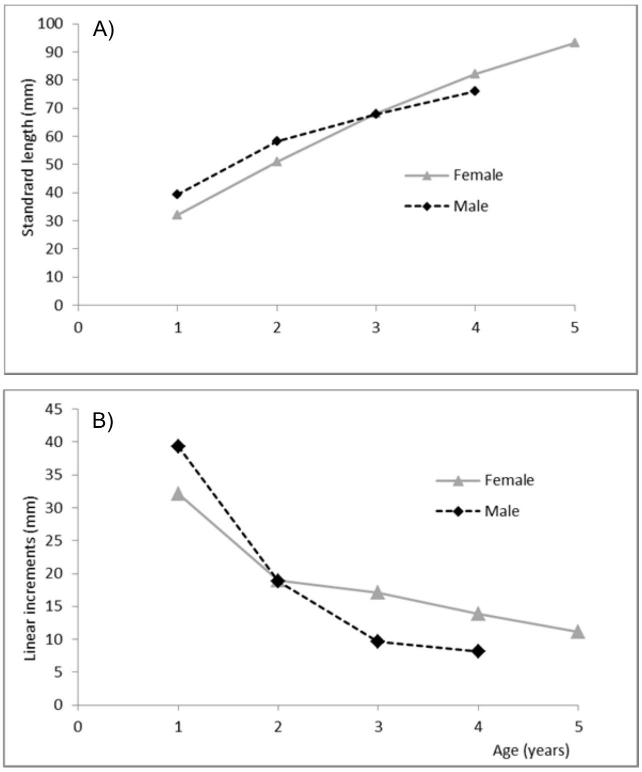


Fig. 4. Observed standard length (*SL*) for males and females of Amur sleeper from the Habdziński Canal at age (A), and changes in the annual linear increments (B); source: own study

The von Bertalanffy growth curves were fitted to the *SL* at age for females and males and both sexes together. The estimated parameters of von Bertalanffy equations were: $L\infty = 86.56$ mm (±16.63), $K = 0.485255$ (± 0.09), $t_o = -0.25576$ (±0.05) for the males, $L\infty = 154.26$ mm (±22.96), $k = 0.174527$ (±0.07), $t_o = -0.33072$ (±0.04) for the females, and $L\infty = 119.37$ mm (±19.98), $k = 0.244214$ (±0.07), $t_o = -0.47657$ (±0.06) for all the specimens. However, the index of growth performance for both sexes amounted to 3.54, but the females boasted a higher value $\varphi'$ (3.61) in comparison to the males (3.56) (test *t*, $p < 0.05$).

## PARASITES

The parasite community of *Perccottus glenii* comprised one species of uncountable parasites belonging to Protista and two species representing Metazoa.

The *Trichodina rostrata* (Kulemina, 1968) cilate was observed on gill filaments in 94% of the fish. The occurrence of this parasite species was observed to vary from sporadic to mass (Fig. 5). No significant correlations were acknowledged between the biological parameters of the fish (body weight, total length, standard length, Fulton's index) and the number of recorded protozoa ($p < 0.05$). *Trichodina rostrata* was observed in the Amur sleeper for the first time in Poland.

Another parasite species identified in the Amur sleeper was an acanthocephalan *Acanthocephalus lucii* (Müller, 1776) Lühe, 1911 which was also observed for the first time in the Amur sleeper occurring in Poland. One male was isolated from the central part of the alimentary tract.

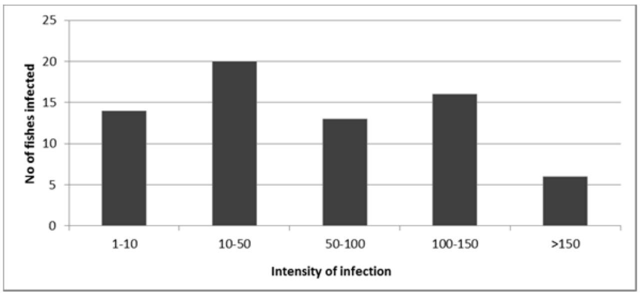


Fig. 5. Intensity of infection *Trichodina rostrata* in fish caught in 2019; source: own study

One larva (metacercaria) of digenea *Ophisthioglyphe ranae* (Frölich, 1971) was observed in the chyme of two fishes.

**HYDROCHEMICAL PARAMETERS OF THE HABDZIŃSKI CANAL**

The average depth at the catching site was 0,3–0,6 m, unit, both banks distinctly delimited, bed surface leveled, without major hollows or other hiding places for fish, bottom covered with a layer of mud. Hydrochemical parameters of water are presented in Table 6.

The analysis of water quality examination results for the Habdziński Canal indicated increased values of *EC*, $NO_3$-N and $PO_4$-P which failed to meet the requirements of the Regulation of the Ministry of Environment, dated 21st July, 2016 and were classified up to above class II. The $NH_4$-N values were lower, except for site 2. Low volumes of oxygen in water and a sparse flow velocity were observed (Tab. 6).

## DISCUSSION

The Amur sleeper belongs to small fish with a short life cycle. The biggest specimens reach *TL* 250 mm and 10 years of age [RESHETNIKOV 2003]. In Central Europe the fish were younger and characterised by smaller lengths [NYESTE *et al.* 2017; SKORIC *et al.* 2017] than in its natural range of occurence. The biggest males (130 mm *SL*, 7 years of age) and females (142 mm *SL* and 7 years of age) were observed in Włocławek Reservoir at the Vistula River, Poland [GRABOWSKA *et al.* 2011]. In the Habdziński Canal, a watercourse with significantly narrower and smaller habitats, the mean standard length and the unit weight for this species were lower than in other bigger rivers and water bodies in Europe. However, they fell within the range for these waters given by NEHRING and STEINHOF [2015], GRABOWSKA *et al.* [2011], and SKORIĆ *et al.* [2017]. Nonetheless, as opposed to the population from Włocławek Reservoir [GRABOWSKA *et al.* 2011] and the Danube [NYESTE *et al.* 2017], no statistically significant differences in lengths (*SL* and *TL*) and unit weights of males and females were observed. However, the differences were observed between catch years. The fish caught in 2017 were characterised by greater values of length, unit weight and Fulton's condition factor as compared to the fish caught in 2019. On the one hand, it might have resulted from an increase in the *CPUE* value and limitation of already small feed resources in the water body for this species. In 2017 the *CPUE* value for the Amur sleeper amounted to 0.04 ind.$\cdot$m$^{-2}$ and made up 38.07% of the catch whereas in 2019 the Amur sleeper was a dominant species (83.11% of the catch) and the *CPUE* amounted to 0.21 ind.$\cdot$m$^{-2}$. This value is greater for those (0.12 ind.$\cdot$m$^{-2}$) reported in the Wieprz River [RECHULICZ *et al.* 2015], similar (0.175–0.250 ind.$\cdot$m$^{-2}$) to a population from the Danube [SKORIĆ *et al*. 2017], but is lower than the *CPUE* value (0.38 ind.$\cdot$m$^{-2}$) for the Amur sleeper in the Vistula oxbow [GRABOWSKA *et al.* 2011]. Another cause might be expansion of this species in the Habdziński Canal. According to Brandner *et al.* [2013], individuals with better condition, predominantly females, occur in invasive fish species at the invasion front compared to the established population. However, it is males with smaller body sizes that prevail in established populations [MASON *et al.* 2016]. This is also indicated by the fact that in 2017 in the Habdziński Canal a similar number of males and females was observed whereas in 2019 males prevailed.

The weight–length relation allows the fish condition to be estimated and used in analyses of ontogenetic changes [FROESE 2006] and for comparisons of intra- and interregional life-history traits [MOREY *et al.* 2003]. The recorded *b* values fall within the range of 2.5–3.5, which is considered to be common. Our results demonstrated *b* values to be <3.0 indicating a negative allometric growth in both sexes. The values of this parameter obtained for both sexes of the Amur sleeper from the Habdziński Canal are slightly lower as compared to other populations introduced in Europe (2.94–3.32) [GRABOWSKA *et al.* 2011; NYESTE *et al.* 2017; SKORIĆ *et al.* 2017], which might indicate a relatively smaller weight gain in relation to the length of the fish. Nevertheless, the results fell within the range given for the studied species from waters of its natural habitation area (2.6–3.08) [HUANG *et al,* 2014; LIU *et al.* 2013]. This might result from a smaller feed supply for this species in the studied watercourse and a greater feed competition than in Włocławek Reservoir and the Danube [GRABOWSKA *et al.* 2011; NYESTE *et al.* 2017]. It has to be pointed out that the share of the Amur sleeper in the studied sections of the watercourses in both years exceeded 75% of the catch.

**Table 6.** Mean hyrochemical parameters of water in the Habdziński Canal in 2017 and 2019

| Amur sleeper habitat site | *T* (°C) | pH | *EC* (μS$\cdot$cm$^{-1}$) | Flow velocity (m$\cdot$s$^{-1}$) | Oxygen | $NO_3$-N | $NH_4$-N | $PO_4$-P |
|---|---|---|---|---|---|---|---|---|
| | | | | | (mg$\cdot$dm$^{-3}$) | | | |
| 1 | 19.0 | 7.20 | 588 | 0.04 | 4.14 | 6.68 | 0.16 | 0.45 |
| 2 | 19.1 | 7.25 | 603 | 0.06 | 4.85 | 7.14 | 0.42 | 0.64 |
| 3 | 19.1 | 6.82 | 527 | 0.02 | 3.09 | 5.04 | 0.10 | 0.75 |

Explanations: *T* = temperature; *EC* = electrolytic conductivity.
Source: own study.

The growth of the Amur sleeper is varied and dependent on availability and amounts of the feed and on the location of the given population (Tab. 7), which is typical of fish with a wide range of distribution [Mann 1991]. Data demonstrated in Table 7 and information from Grabowska *et al.* [2011] indicate that the increment of length in populations in an invaded area is greater than in the fish from a native range. However, a decrease in the increment of length occurs in non-native populations sooner (predominantly after two years of life) [Nyeste *et al.* 2017] in comparison to native Amur sleeper populations [Kirpichnikov 1945; Nikolskij 1956]. This probably results from a decrease in the increment of length after the fish have reached maturity. According to Bogutskaya and Naseka [2002], the Amur sleeper reaches maturity at the age of 2+ and 3+ in its natural habitation areas whereas in non-native populations females reached their maturity at the age of 1+ and males at the age of 2+ [Grabowska *et al.* 2011]. Sooner maturity as well as short maximum body length, short-life spawn, multiple spawning events, extended breeding season with larger amounts of spawn and care of the offspring enable the Amur sleeper to invade faster [Grabowska, Przybylski 2015]. Moreover, the differences in maturing between males and females might be the cause of differences in the growth rate between both sexes. In the fish caught in the Habdziński Canal, greater increments of length were observed in males in their first two years of life whereas from the third year the increments decreased in both sexes, but they were greater in females. The consequence was greater *SL* achieved by females from the fourth year of life than in males. A similar phenomenon was observed in the Amur sleeper from Włocławek Reservoir and the Danube [Grabowska *et al.* 2011; Nyeste *et al.* 2017]. Nyeste *et al.* [2017] implies that females achieve smaller length due to earlier development of gonads during the first two years, which is probably caused by the fact that the energy channelled into the gonads detracts from somatic growth [Kozłowski 1996].

Results of hydrochemical analyses and evaluation of habitat conditions in the Habdziński Canal demonstrated that this small watercourse is characterised by high volumes of biogenic substances but low oxygenation and slow water flow velocity. According to Rechulicz *et al.* [2015], despite unfavourable environmental parameters, the presence of the Amur sleeper in the studied watercourse indicates its great resistance, opportunities to expand further and, consequently, a major threat to the native fauna.

Although the Amur sleeper has been observed in the waters of Poland for more than 20 years, sources describing parasite fauna of *Perccottus glenii* in this area of Europe are sparse. So far research has only been conducted on fish caught in the area of Włocławek Reservoir [Mierzejewska *et al.* 2010; 2012; Ondračkova *et al.* 2012]. Compared with the results achieved by Mierzejewska *et al.* [2012], it can be stated that the parasite fauna of the Amur sleeper from the Habdziński Canal is poor. However, the studies demonstrated presence of two new parasites of this fish species in Poland.

*Trichodina* sp. (Protozoa) are common parasites of the Amur sleeper in Asia and Europe. Studies conducted by Kvach *et al.* [2013] revealed the presence of five species belonging to the aforementioned genus and it was the only one out of 15 confirmed taxa of *P. glenii* parasites observed at all the six study sities. Also, Zaichenko [2015]

**Table 7.** Standard lengths (*SL*) at age of Amur sleeper populations from the study area, and other introduced and native locations

| Location | Status | Observed *SL* at age (mm) | | | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | 1+ | 2+ | 3+ | 4+ | 5+ | 6+ | 7+ | |
| Suifun River, Russia | NAT | 32 | 55 | 77 | 85 | 111 | 123 | 136 | Kirpichnikov [1945] |
| Lower Amur River, Russia | NAT | 38 | 68 | 100 | 114 | – | – | – | Nikolskij [1956] |
| Moscow region I, Russia | INT | 66 | 94 | 110 | 130 | – | – | – | Spanovskaya *et al.* [1964]* |
| Moscow region II, Russia | INT | 66 | 90 | 100 | 125 | – | – | – | |
| Moscow region III, Russia | INT | 55 | 64 | – | – | – | – | – | |
| Moscow region IV, Russia | INT | 71 | 90 | 120 | 134 | – | – | – | |
| Moscow region V, Russia | INT | 45 | 66 | 72 | 85 | – | – | – | |
| Moscow region VI, Russia | INT | 60 | 104 | 149 | 151 | – | – | – | |
| Selenga River (Lake Baikal delta), Russia | INT | 39 | 68 | 94 | 112 | 140 | 167 | 188 | Litvinov and O'Gorman [1996] [a] |
| Penza region I, Russia | INT | 47 | 65 | 96 | 112 | – | – | – | Baklanov [2001] |
| Penza region II, Russia | INT | 34 | 63 | 88 | 106 | 149 | – | – | |
| Komi Republic, Russia | INT | – | 63 | 95 | 111 | – | | – | Boznak [2004] |
| Lake Glubokoke, Russia | INT | 40 | 70 | 79 | – | – | – | – | Dgebuadze and Skomorokhov [2005]* |
| Moscow region, pond, Russia | INT | 40 | 70 | 91 | 118 | | – | – | Dgebuadze and Skomorokhov [2005]* |
| Gusinoe Lake, Baikal basin, Russia | INT | – | 70 | 110 | 140 | 165 | – | – | Pronin and Bolonev [2006] |
| Selenga River delta Murzino bay, Lake Baikal basin, Russia | INT | – | 60 | 80 | 100 | 120 | – | – | |
| Flood plain of Bodrog River near Somotor River, Slovakia | INT | 31 | 45 | 62 | 84 | – | – | – | Koščo *et al.* [2003b] |
| Rakamazi-Nagy-morotva, Carpathian basin, Hungary | INT | 36 | 59 | 74 | 87 | 94 | 110 | – | Nyeste *et al.* [2017] |
| Wloclawski reservoir, Poland | INT | 37 | 53 | 69 | 83 | 97 | 112 | 122 | Grabowska *et al.* [2011] |
| Habdziński Canal, Poland | INT | 35.9 | 54.8 | 67.9 | 80.7 | 90.7 | – | – | own data |

Explanations: NAT = native range of occurrence, INT = introduction; * quoted after Grabowska *et al.* [2011].
Source: own elaboration.

observed *Trichodina* sp. in the Amur sleeper from all the studied water bodies. In the present study, *Trichodina rostrata* was observed nearly in every Amur sleeper. As in Włocławek Reservoir, *Trichodina domerguei* was the most frequently occurring parasite, particularly in spring and summer study seasons [MIERZEJEWSKA *et al.* 2012]. *Trichodina sp.* is frequently observed in the gill and on the body surface of fish and other water organisms. Although the harmful effect of these organisms is called into question by some researchers, it was proved that mass gill invasions might lead to reduced gas exchange, which has a negative impact on growth rate and condition of the fish [LOM 1995]. The threat from these protozoa mainly concerns farmed fish. However, there have been reports of worsening conditions of wild fish affected by this parasite [MADSEN *et al.* 2000]. Due to the fact that the Amur sleeper is a highly invasive species and, consequently, a competition for native fish populations, the mass occurrence of its harmful parasite could appear to be beneficial and conducive to inhibition of its reproduction by worsening the fish condition. Acanthocephalan *Acanthocephalus lucii* is a parasite common for various fish species, particularly Cyprinidae, but also for the whitefish, the pike and the eel [POPIOŁEK 2016]. The presence of *A. lucii* in the Amur sleeper is sporadic and so far it has been reported twice – in one fish caught in Ukraine [ZAICHENKO 2015] and one fish in Germany [KVACH *et al.* 2017]. So far the presence of *A. lucii* in *P. glenii* in Amur sleeper in Poland has not been reported.

The analysis of the chyme revealed the presence of larvae (metacercaria) of digenea fluke which was observed in two fishes. According to the checklist compiled by SOKOLOV *et al.* [2014] there are 12 Digenea species isolated from the intestine of the Amur sleeper. However, seven of them were recognized as species for which *P. glenii* is a nonpermissive host. Among them is *Opisthioglyphe ranae* observed in the fish caught in Russia [SOKOLOV *et al.* 2011]. By comparing morphology and body sizes of metacercaria found in the intestine of the Amur sleeper from the Habdziński Canal, the presence of *O. ranae* was confirmed. However, its occurrence in this host is purely accidental. In Poland, metacercaria of this species have been found in the oral cavity of adult frogs and cercaria have been observed in pond snails in the area of Warsaw [NIEWIADOMSKA, POJMAŃSKA 2018] from where the studied Amur sleeper originates.

The Amur sleeper from the Habdziński Canal were not hosts for species new to the parasite fauna in Poland and those observed are commonly observed in the ichthyofauna of the Mazowsze region. It has to be taken into consideration that invasive fish species can be hosts to parasites alien to the given region. An example can be the Amur sleeper caught in Włocławek Reservoir in which MIERZEJEWSKA *et al.* [2010] observed the presence of a tapeworm new to the Polish fauna, i.e. *Nippotaenia mogurndae* Yamaguti and Miyata, 1940. Parasites colonise new regions, for example, by adjusting their development cycle to the conditions found in a new environment. A consequence of this situation might be a transfer of parasites onto new hosts, which might have severe consequences due to the absence of effective defence mechanisms protecting them from invasion. Therefore, preventive procedures such as control of restocking material and exclusion of the so-called fish "weed" as well as permanent monitoring of parasitological threats in the region are needed.

## CONCLUSIONS

Despite the low quality of waters, increased levels of nitrogen and phosphorus compounds in the Habdziński Canal, this small watercourse located in the central part of Poland constitutes a good habitation area for the invasive Amur sleeper. Among 177 fish caught in 2017 and 2019 were 125 specimens aged 1+. The fish caught in 2017 were characterised by greater values of length, unit weight and Fulton's condition factor as compared to the fish caught in 2019. It might have resulted from an increase in the *CPUE* value (from 0.04 ind.$\cdot$m$^{-2}$ to 0.21 ind.$\cdot$m$^{-2}$) and limitation of already small feed resources in the water body for this species. However, there were no differences in fish growth between the years of fishing. These statistical differences were noted between females and males. It might be cause by differences of maturing between sexes.

So far, Amur's sleeper presence did not bring into Polish water any alien parasites, which can be potentially dangerous to local ichthyofauna. All collected species are typical fish pathogens, commonly occurred holarctic region. Nevertheless, *P. glenii* from the Habdziński Canal turned out to be the new host (in Poland) for two species of parasites (*Trichodina rostrata* and *Acanthocephalus lucii*), which may indicate good adaptation of fish to hydrological conditions in Europe.

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