

THE ICHTHYOFAUNA OF LITTORAL OF TWO SHALLOW LAKES ON BACKGROUND OF FISHERY MANAGEMENT AND ANGLING PRESSURE

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Summary. In two shallow lakes the species composition, structure and selected diversity indicators for fish fauna of littoral zone on the background of fishery management was determined. Fish data from restocking came from years 2007–2011 and the fish fauna assessment was based on results of angling more than 2360 records of catch fishing. Control fishing in both lakes was performed in the littoral zone three times in 2013 year using multi-mesh gillnet. Restocking of both lakes were similar. In abundance dominated the predatory fish fry and in the total biomass the various forms of carp. The results of angling fishing showed that in both reservoirs mainly Prussian carp, bream and roach were caught. The results of the control fishing in the littoral of both lakes revealed the presence from 4 to 13 fish species. The studied lakes the varied number (NPUE) and biomass (WPUE) of fish caught and low biodiversity was characterized. In the abundance of fish in littoral of Dratów lake the perch, roach, bleak, rudd and in the littoral of Krzcień lake the roach, sunbleak and bleak were dominated. In both lakes in the fish biomass, the same species like above were dominated, but in addition a alien species, the brown bullhead had a significant share (approx. 10%).

Key words: fish fauna, littoral, fishery management, angling

INTRODUCTION

In the light of the law the water reservoirs should be appropriate managed, which should manifest by conducting a rational fishery management. Such activities can be carried out through appropriate restock, protect valuable fish spe-

cies and verification of species composition by commercial fishing [Leopold 1968, Szczerbowski *et al.* 2008]. In most water bodies the usage is limited to fish stocking, and the fishing exploitation is limited to amateur angling [Wołos 2012]. The conducted fishery management on water bodies should be focused on restocking of relevant species for the relevant type of lake [Wołos and Falkowski 2003, Turkowski 2012].

In recent years, the angling is very highly developing area and can fulfill a number of human needs. The angling provides opportunities for relaxation, communing with nature, entertainment and sometimes big thrill and satisfaction [Pringle 1997, Aas and Ditton 1998, Arlinghaus *et al.* 2002, Wołos 2006]. Amateur fishing methods are usually selective and uncontrolled fishing on the waters may lead to their degradation by the pressure on the valuable species, significant for the proper functioning of the waters, eg. predatory fish [Wołos 2008, Czerniawski *et al.* 2010, Turkowski 2012].

The littoral zone is a very important area of the lake and is usually characterized by a very high diversity. It is the main place of spawning, feeding and refugium for juvenile forms of fish and habitat for many groups of aquatic organisms [Gliwicz and Jahner 1992, Lewin *et al.* 2004, Okun and Mehner 2005]. At the same time, this zone of lakes is the most exposed to angling pressure.

Knowing the fish fauna of littoral lake zone can give us valuable information about fish community and information concerning the possibility of their development in the reservoir. Hence the aim of this study was to investigate the composition of ichthyofauna of the littoral of two shallow lakes on the background of fishery management and angling pressure on the fish in these reservoirs.

MATERIALS AND METHODS

Investigations were conducted in two shallow lakes of Łęczna–Włodawa Lakeland (eastern Poland); Lake Dratów (N: 51°20', E: 22°56'; surface area 107,7 ha, maximum depth 3,3 m) and Lake Krzcień (N: 51°23', E: 22°56'; surface area 174.0 ha, maximum depth 5,2 m). The user of both reservoirs is PAS (Polish Angling Society) and fishery management is based on fish restocking and amateur angling.

In the study the data of fishery management shared by the user (PAS Lublin) was used. The results for the restocking fish came from the restocking protocols of both lakes in the years 2007 and 2011. The angling fishing results were obtained by analyzing the angling records from these two lakes (the number of registers: Dratów – 1060, Krzcień – 1300).

To determine the species composition of fish in the littoral zone of both studied lakes the control fishing using multi-mesh gillnet type (10, 60, 30, 6.25, 43, 22, 50, 33, 12.5, 25, 8, 38, 75, 16.5 mm) was conducted [Appelberg 2000,

CEN document 2005]. In both lakes the control fishing were carried out three times in 2013 year (spring, summer, autumn). All caught fish were determined to species, their total length (TL) (in cm) and body mass (W) (in g) were measured. The species richness, selected diversity indices (Shannon – Wiener, Simpson and Margalef) and the structure of domination in the abundance and biomass of fish were determined. The fish data obtained in control fishing were converted to catch per unit effort (NPUE and WPUE). For the abundance, the NPUE, it was the number per unit effort, i.e. number of fish individuals caught in the one net after 12 hour fishing), and for the fish biomass, WPUE, it was weight per unit effort, i.e. fish biomass (in grams) of the fish caught in one net after 12 hour fishing. The abundance and biomass of fish in the littoral zone from both lakes were compared using one-way analysis of variance (ANOVA). All analyzes were performed using program Statistica 6.0, at the significance level $p \leq 0.05$.

RESULTS

In the both lakes the carp (*Cyprinus carpio*) (mainly 2 years old) was a basic fish species in fish stocking material. This species accounted for 24% to 40% of abundance stocking fish, while from 55% to over 76% in the biomass of stocking material (Tab. 1). The pike (*Esox lucius*) fry was another important species, to stocking Dratów Lake in the study period (in numbers more than 82000 ind.). This species had a significant part in stocking material also in the lake Krzcień (5% abundance and more than 9% of the biomass of stocking material) (Tab. 1).

Table 1. Fish stocking (ind. and kg) performed in the Dratów and Krzcień Lakes in 2007–2011

Species	Form	Dratów Lake		Krzcień Lake	
		ind.	kg	ind.	kg
<i>Cyprinus carpio</i>	1 year old	37400	21614	8500	6030
<i>Cyprinus carpio</i>	commercial	0	1702	600	2150
<i>Tinca tinca</i>	1 year old	5800	864	2100	540
<i>Carassius carassius</i>	1 year old	5150	1190	5500	844
<i>Carassius a. gibelio</i>	1 year old	9000	575	-	-
<i>Carassius auratus</i>	1 year old	12400	1310		
<i>Ide</i>	1 year old			3100	260
<i>Esox lucius</i>	summer fry	82700	-	-	-
<i>Esox lucius</i>	autumn fry	2000	800	1000	1015
<i>Silurus glanis</i>	2 years old	-	150	-	100
<i>Perca fluviatilis</i>	1 year old	-	65		

Analysis of results of angling catches records showed that in both lakes Prussian carp (*Carassius gibelio*) and bream (*Abramis brama*) was dominated and these species accounted for more than 50% in abundance of caught fish (Fig. 1). A significant share in number of fish had also roach (*Rutilus rutilus*) (approx. 19.1% in Dratów Lake, and 11.5% in the Krzcień Lake). In addition, more than 6% of perch in fish abundance were in Dratów Lake. In the biomass of fish from littoral of Dratów Lake the bream dominated, but significant participation had also Prussian carp, carp and pikeperch (*Stizostedion lucioperca*). Whereas in Krzcień Lake the Prussian carp was a dominant in biomass of fish (46.9%) and a large share was also observed in the case of bream, roach and pike, 10%, 7.5% and 6.5%, respectively (Fig. 1).

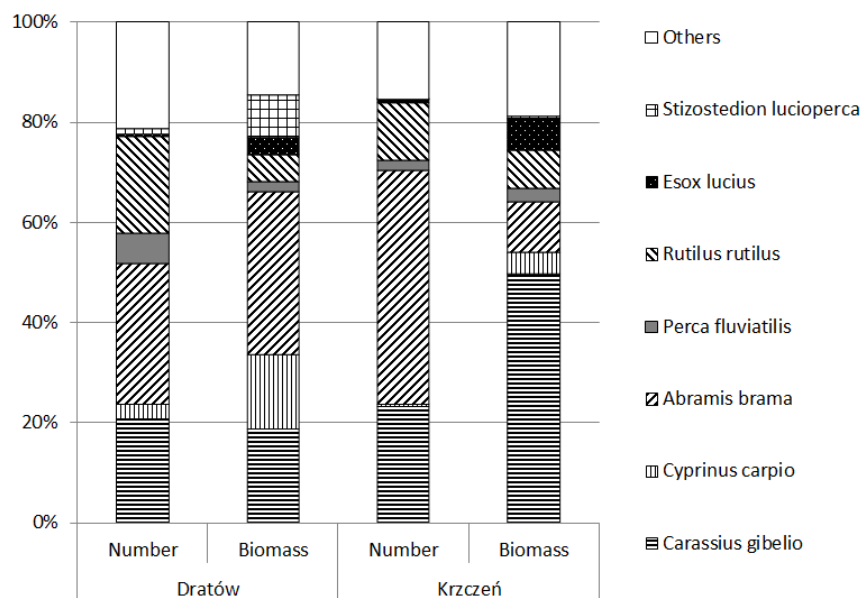


Fig. 1. The structure of domination in the abundance and biomass of fish caught by anglers in the Dratów and Krzcień Lakes in 2007–2011

In the results of control fishing in the littoral zone from 4 to 9 fish species in the Dratów Lake and from 8 to 13 fish species in the Krzcień Lake was determined. In both reservoirs the fish communities were characterized by low values of diversity (Tab. 2). The results of control surveys have shown four times higher number of fish (NPUE) and more than half of the higher biomass of fish (WPUE) in the Krzcień Lake, than in the Dratów Lake. But these differences were not significant (ANOVA, NPUE: $p = 0.320$, WPUE: $p = 0.717$) (Fig. 2).

Analysis of the results of control fishing in the littoral of Dratów Lake showed that in the abundance the bleak (*Alburnus alburnus*) and perch (*Perca fluviatilis*)

Table 2. Diversity indices for fish fauna in Dratów and Krzcień Lakes. S – species richness, H' – Shannon – Wiener, D – Simpsons diversity, R – Margalef index, SD – standard deviation

Lake		Diversity indices			
		S	H'	D	R
Dratów	mean	7.00	0.82	0.21	2.60
	SD	2.64	0.15	0.08	0.94
	range	4.00–9.00	0.60–0.95	0.10–0.27	1.30–3.47
Krzcień	mean	10.66	1.02	0.42	5.58
	SD	2.52	0.09	0.10	0.50
	range	8.00–13.00	0.90–1.11	0.30–0.54	5.07–6.25

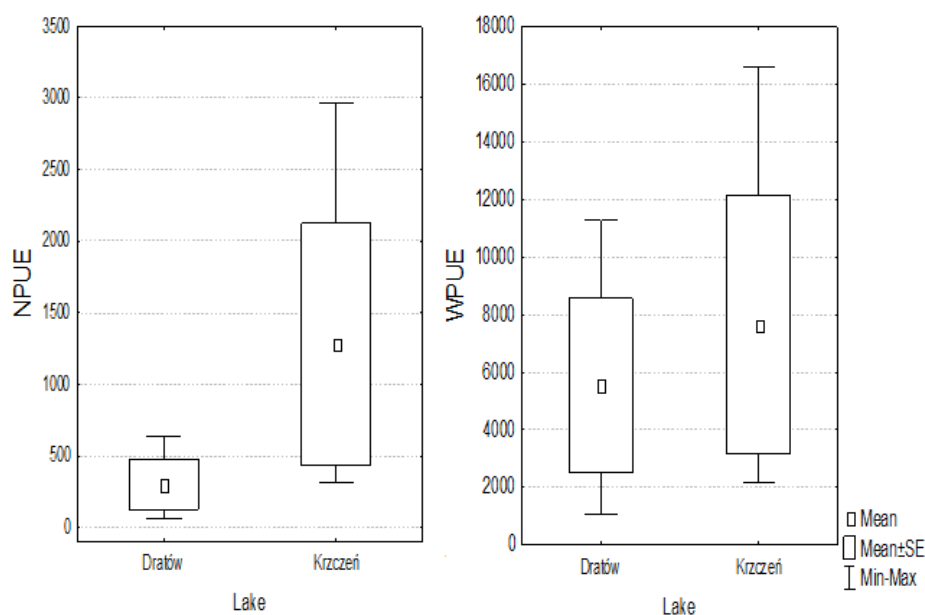


Fig. 2. Numbers (NPUE) and biomass (WPUE) of fish caught in control fishing in the littoral both studied lakes in 2013

was dominated (after approx. 30%) but also roach (17.5%) and rudd (*Scardinus erythrophthalmus*) (13%) had a significant share. In the Krzcień Lake the sunbleak (*Leucaspis delineatus*) was dominated (55.3%) but a significant share had also roach and bleak and perch, 21%, 11.4% and 8.4%, respectively (Fig. 2). In the littoral of Dratów Lake the largest share of the biomass had bleak, roach and rudd, while in the Krzcień Lake roach and sunbleak (Fig. 3). In total biomass of

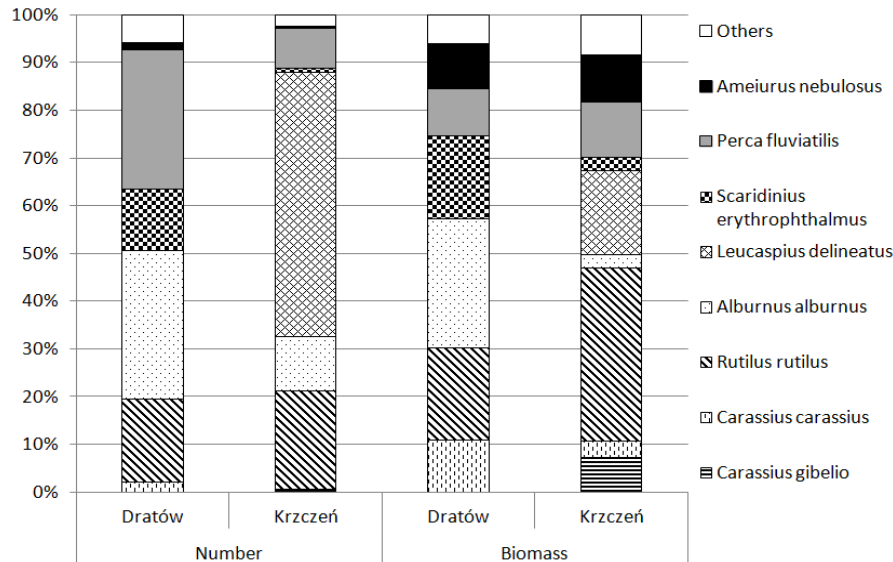


Fig. 3. The structure of domination in the abundance and biomass of fish caught in control fishing in the Dratów and Krzcień Lakes in 2013

fish a significant share of crucian carp in the Dratów Lake (10.7%) and Prussian carp (7.2%) in the Krzcień Lake was noted. Moreover, in both reservoirs, a similar participation in fish biomass of brown bullhead and perch (after approx. 9–11%) were found (Fig. 3).

DISCUSSION

Conducted research allowed determine the fish composition in the littoral zone of shallow lake, where fishery management is mainly based on fish restocking and amateur angling. According to Szczerbowski [2008] only on few water bodies in our country, both commercial fishing and angling is conducted (eg. reservoir Zegrzynski, Jeziorski, Siemianówka). But in most reservoirs an angling is the only form of exploitation. Research on fish in the Polish lakes mostly focused on understanding the biology and ecology of selected species [Czerniejewski and Rybczyk 2008, Kozłowski *et al.* 2010] than to identify their diversity [Hutorowicz *et al.* 2005, Rechulicz 2011]. For these reasons, the fish composition of many lakes is not sufficiently known. The knowledge of fish community of many water bodies based only on knowledge associated with commercial fishing or/and recreational fishing [Wołos 2006, Kapusta *et al.* 2012].

Fishing exploitation is an activity essential for the formation and maintenance of proper density and structure of the fish fauna of the water reservoirs

[Sych 1997, Erdmański 2000]. However improperly conducted can promote excessive growth of population of cyprinids fish. And this promotes the growth of water eutrophication [Wiśniewolski 2002].

In the studied lakes the fish stocking in the years 2007–2011 were based primarily on a various forms of carp (approx. 70% of stocking material) and a several other fish species (Tab. 1). According to Wołos [2012] a large number of carp in stocking material can lead to changes in the proportions of the trophic pyramid and growth of reservoir trophy. An increase of nutrients released from bottom sediments, the development of phytoplankton (blooms), the regression of submerged macrophytes and the oxygen deficiencies in profundal zone, may occur. In 2012 year in polish law appeared Regulation of 16 November 2012 [Rozporządzenie MRiRW... 2012] limiting the restocking of this species on water reservoirs. Thus, in the case of carp, the user of water should be change the structure of stocking material and adapt it to the requirements of the law.

In the case of a angling fishing, properly conducted registration of catch results should provide as much useful information, and often necessary, to the conduct of fishery management. They should show whether the fishery management is conducted in a rational way [Draszkiewicz-Mioduszevska and Wołos 2010]. Analysis of anglers fishing results showed that species such as Prussian carp and bream was the most caught fish species in the reservoirs (Fig. 1). This may indicate, on appropriate conditions in these reservoirs and on stable populations of this fish species. According to Wiśniewolski [2008] such species are characteristic for dam reservoirs and heavily degraded water bodies.

Interesting is the fact that, despite the dominance of carp in stocking material its participation in result of angling fishing was minimal in abundance. While in biomass this genre has reached dozen or so percent (Fig. 1). In turn, the results of control fishing have shown a significant share a few small cyprinids species (eg: roach, rudd, sunbleack), which anglers are not interested in. These species with large numbers of individuals can influence on water eutrophication indirectly through pressure on zooplankton [Wołos 2008].

For most species of fish littoral zone is an important habitat for at least periodically during their life cycle. According to Fischer and Eckamann [1997] in Lake Constance the 32 of the 33 fish species used the littoral zone as a habitat especially during the early stages of development. Also important is the fact that the young roach and bream in the littoral zone are a valuable natural food for predatory fish [Białokoz and Krzywosz 1979, Terlecki 1990].

In the present study fish community in the littoral zone of both lakes characterized by low biodiversity (Tab. 2) but was similar to that identified in several other lakes in the region [Rechulicz 2011]. Furthermore, despite the large difference in numbers fish caught (NPUE) in the area of both lakes, their dominance in the structure of the biomass was almost the same. It may indicate that reservoirs have similar character and similar way they use.

Control fishing also showed significant share, especially in the biomass (Fig. 3), of invasive species brown bullhead. In the angling fishing results the catch of this species probably was recorded as „other” (Fig. 1). In the Łęczna-Włodawa Lakeland reservoirs studied by several authors, this species was almost always present [Kolejko 1998, Kornijów *et al.* 2003, Rechulicz 2011]. This proves the stability of its population and regular his participation in fish communities in water bodies in the region.

CONCLUSIONS

1. The carp is a mainly species of stocking of Dratów i Krzcień Lakes. Predatory fish (mostly juveniles) was significant only in the total number of stocking material.

2. In results of angling fishing a not valuable fish species such as Prussian carp, bream and roach was dominated. Predatory fish were limited to a few to several percent of all caught fish.

3. Control fishing in littoral of both lakes showed that fish fauna was dominated by small cyprinids fish (roach, sunbleak, bleak and rudd). Predatory fish species were represented by small individuals of perch.

4. The results of control fishing of littoral of two studied lakes showed the presence of a brown bullhead, as a regular, unwanted invasive species in fish community.

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ICHTIOFAUNA LITORALU DWÓCH PŁYTKICH JEZIOR
NA TLE PROWADZONEJ GOSPODARKI RYBACKIEJ
I PRESJI WĘDKARSKIEJ

Streszczenie. W dwóch płytkich jeziorach określono skład gatunkowy, strukturę oraz wybrane wskaźniki różnorodności dla zespołów ichtiofauny ryb strefy litoralu na tle prowadzonych zarybień w latach 2007–2011 i wyników analizy ponad 2360 rejestrów połowów wędkarskich. Odłowy kontrolne w obu jeziorach przeprowadzono w litoralu trzy razy w roku 2013 przy wykorzystaniu sieci panelowych multi-mesh gillnet. Zarybienia obu jezior były podobne, w liczebności dominował narybek ryb drapieżnych, a w biomasie różne formy karpia. Wyniki połowów wędkarskich wykazały, że w obu zbiornikach odławiano głównie karasia srebrzystego, leszcza i płoć. Wyniki odłowów kontrolnych wykazały w litoralu obu jezior występowanie od 4 do 13 gatunków ryb. Badane jeziora charakteryzowała zróżnicowana liczebność (NPUE) i biomasa (WPUE) odłowionych ryb oraz niska różnorodność biologiczna. W strukturze liczebności ryb z litoralu jeziora Dratów dominowały okoń, płoć, ukleja i wzdręga, a jeziora Krzcień – płoć, słonecznica i ukleja. W strukturze biomasy ryb obu jezior współdominowały te same gatunki, ale dodatkowo odnotowano znaczący (ok. 10%) udział w biomasie gatunku obcego – sumika karłowatego.

Słowa kluczowe: ichtiofauna, litoral, gospodarka rybacka, wędkarstwo